Preface

In 2018, guided by President Xi Jinping's Socialist Thoughts with Chinese Characteristics for the New Era, the National Natural Science Foundation of China (hereinafter referred to as NSFC) thoroughly and earnestly implemented the spirits of the 19th National Congress of the Chinese Communist Party and its Second and Third Plenary Sessions, and the decisions and arrangements of the CPC Central Committee and the State Council. In accordance with the overall arrangements of the Ministry of Science and Technology, NSFC strengthened the Party's role, actively developed national science funding strategy, systematically deployed and deepened reforms, and successfully completed funding work for the year of 2018.

We consolidated the Party's leadership in science funding, and deepened comprehensive and strict governance of the Party. We strengthened the Party's political construction, by guiding Party members and officials to firmly adhere to political integrity and vision for overall situation, to follow the core leadership, to maintain confidence in the path, theory, system, and culture of socialism with Chinese characteristics, and to resolutely safeguard Xi Jinping as the core of the CPC Central Committee and the entire Party, and the authority and the centralized and unified leadership of the CPC Central Committee. We seriously implemented Xi Jinping's important statements and instructions on scientific and technological innovation, and carried out "careful study, extensive and in-depth survey and thorough implementation". We did our utmost to ensure the implementation of requirements from the central inspection and rectification, improved Party conduct and maintained clean and honest administration, signed "Liability Statement on Comprehensive and Strict Governance of the Party" and built a hierarchical liability system.

We systematically deployed the reform plan of science funding for the new era, and started with key tasks. By identifying four major funding categories in line with scientific natures of research as funding creative and timely ideas to achieve excellence in science, focusing on the frontiers of science in unique ways to lead the cutting edges, supporting application-driven basic research to enable breakthroughs, and encouraging transdisciplinary leading-edge research to promote convergence, we aim to establish an artificial intelligence-assisted category-specific peer review mechanism featuring "Responsibility, Credit and Contribution", and to formulate layout of research areas that stems from the inherent logic and landscape of the knowledge system and promotes knowledge and application integration, with the ultimate goal of building a science funding system for the new era that is guided by advanced concept, equipped by well-established mechanism and operated in a fair and efficient manner in the next 5 to 10 years, and making fundamental contribution to strengthening original innovation capacity to become world's leading science and technology power. At present, the systematic reform plan has been fully launched with various tasks making steady progress, which has received wide support from the scientific community.

We comprehensively deployed basic research in various disciplines and intensified support in key areas. A total of 44,500 projects from 1,530 host institutions were funded throughout the year, with the direct cost of approximately 26 billion yuan. We controlled the scale of overall funding, supported coordinated development of various disciplines, improved the effectiveness of funding, and focused on enhancing original innovation capabilities. We devoted tremendous efforts in specific key areas of basic research as financial risks prevention, poverty alleviation and pollution prevention, to provide scientific support for the three critical battles. We also promptly started basic research tasks in key areas, by increasing support for basic disciplines such as mathematics and physics, deploying five major research plans including basic research on aeroengine and gas turbine, and launching cluster program on integrated circuit basic research.

We optimized the funding mechanism for talents and research teams and strived to create a favorable innovation ecosystem. Focusing on the overall development of national S&T talents, we funded 17,671 projects for young scientist fund with an emphasis on nurturing young talents. We also optimized the funding mechanisms for Science Fund for Creative Research Groups and Basic Science Center Program, making the best of the relay effects of the chained talent programs, in hope of fostering excellent research teams. We issued "Open Letter on Avoiding the Alienation of Talent Programs" calling for scientific evaluation of talents. The number of representative publications listed in the resume of the application has been reduced from 10 to 5, guiding researchers to pay more attention to the originality of the results. We developed a work plan for pilot programs open to researchers in Hong Kong and Macao SARs.

We reformed the innovation management mechanism to achieve integrated effects of research outcomes. Through publishing the "NSFC Joint Fund Pilot Work Plan in the New Era", we established "Joint Fund for Regional Innovation and Development" and "Joint Fund for Enterprise Innovation and Development" to accelerate the establishment of a joint funding system for the new era with higher funding efficiency and to encourage diversified investment. A total of 1.825 billion yuan was invested in the National Natural Science Fund by setting up Joint Fund for Regional Innovation and Development with Sichuan, Hunan, Anhui, and Jilin provinces, and Joint Fund for Enterprise Innovation and Development with CETC, CNOOC, and Sinopec. We renewed agreements with Chinese Academy of Sciences to continue the Joint Funds of Large Scientific Facilities Research and Astronomy, and signed a framework agreement on "Joint Fund for Comprehensive National Science Center and Large Scientific Facilities Research" with National Development and Reform Commission, Chinese Academy of Sciences, Governments of Beijing and Shanghai Municipalities and Anhui Province, to strengthen support for comprehensive national science centers.

We expanded our international cooperation network and upgraded more cooperation to substantive level. We actively participated in the global innovation network and leveraged global innovation resources, increased high-level exchanges with partner science funding agencies, learned fund management experience from overseas counterparts, optimized international cooperation funding plan, and continued promoting substantive bilateral and multilateral cooperation. We funded 925 International (Regional) Cooperation and Exchange Programs under Agreements/MoUs, with direct cost of 648 million yuan.

"International Workshop on Science Funding Strategies and Policies" was successfully held in Paris. Among the attendees are leaders from 16 science funding agencies and relevant international organizations. We also actively responded to the "Belt and Road Initiative" by strengthening cooperation in key areas with countries along the Belt and Road, and jointly funded research projects with more than ten funding agencies from Thailand, Pakistan, Egypt, Mongolia, Sri Lanka, South Korea, Singapore, Israel, etc.

We emphasized the responsibility of the host institution and allowed host institutions to perform management functions. We strengthened and standardized science fund management of host institutions by formulating "Several Opinions of NSFC on Further Strengthening the Science Fund Management of Host Institution", and consolidating unified guidance and overall coordination of host institutions, which will be held accountable for supervision. We further decentralized the right of budget adjustment by formulating "Supplementary Notice on the Fund Management of Projects supported by the National Natural Science Fund".

We improved the supervision system and strengthened scientific research integrity. We organized all staff, host institutions, review experts, and applicants to sign a letter of commitment to impartiality, and reinforced risk prevention and control in key steps such as correspondence review, recommendation to the panel, and panel review, all of which effectively curbed misconducts in the review process. We advocated scientific research integrity and academic self-discipline in various ways, and investigated and handled complaints and reports in a highly serious manner. In response to the incident of "Human Embryo Gene-Editing Baby", we promptly stated our stance in an effort to uphold scientific ethics, and collaborated with relevant departments in the investigations.

2019 is the 70th anniversary of the founding of the People's Republic of China. It is the key year for China to build a moderately prosperous society in all aspects. It is also a decisive year for China to become an innovative country and the year for NSFC to comprehensively deepen reforms. NSFC will thoroughly implement the spirits of the Party's 19th National Congress and Second and Third Plenary Sessions under the guidance of President Xi Jinping's Socialist Thoughts with Chinese Characteristics for the New Era. With a sense of commitment and a sense of urgency to seize every minute in accomplishing new missions, we will strengthen our convictions, stay true to our mission and remember it well, and grasp the opportunities and make the best of the situation. We will focus on the core tasks as identifying funding categories, improving evaluation mechanisms, and optimizing layout of research areas, systematically advance reforms, boost the development of science funding, and motivate researchers and scientists by creating a research environment conducive to innovation, so as to exert unique influence on the national innovation system, to lay a solid foundation for building a world-class science and technology power, and to celebrate the 70th anniversary of the founding of the People's Republic of China with outstanding achievements.

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Part I

Overview

1 Deepening Reform

In 2018, according to the "Plan for Party and State Institutional Reform", NSFC became affiliated to the Ministry of Science and Technology. The Ministry of Science and Technology is authorized with legal obligations of macro management, overall coordination, supervision and evaluation over NSFC. NSFC, in accordance with the law, kept its due independence, and is responsible for the management of National Natural Science Fund, and the implementation of funding plans, project setup and review, project approval, and supervision. Guided by President Xi Jinping's Socialist Thoughts with Chinese Characteristics for the New Era, NSFC has been earnestly implementing the spirit of the Party's 19th National Congress, and Second and Third Plenary Sessions, and endeavoring to realize the important arrangements for institutional reform of the CPC Central Committee and the State Council, and the new tasks and new requirements for basic research in the new era. NSFC has been thoroughly carrying out Xi Jinping's important instructions, such as "Basic research is the source of the entire scientific system, and the key solution to all scientific and technological problems", and "Science and technology is the field that needs constant reform the most", strengthening the Party's leadership in science funding and deepening the reform.

1.1 Overall Objectives

Based on the scientific natures of research, we have identified four major funding categories as funding creative and timely ideas to achieve excellence in science, focusing on the frontiers of science in unique ways to lead the cutting edges, supporting application-driven basic research to enable breakthroughs, and encouraging transdisciplinary leading-edge research to promote convergence. We aim to establish an artificial intelligence-assisted category-specific peer review mechanism featuring "Responsibility, Credit and Contribution", and to construct layout of research areas that stems from the inherent logic and landscape of the knowledge system and promotes knowledge and application integration, with the ultimate goal of building a science funding system for the new era that is guided by advanced concept, equipped by well-established mechanism and operated in a fair and efficient manner in the next 5 to 10 years, and making fundamental contribution to boosting original innovation capacity which helps China become world's leading science and technology power.

1.2 Key Tasks

1. Identify funding categories

Based on the principle of resolving scientific problems, NSFC in the new era aims to advance basic research by supporting creative scientific ideas and concepts in a timely manner according to the funding categories derived from the attributes of scientific problems.

"Funding creative and timely ideas to achieve excellence in science". For this category, scientific problems stem from researchers' inspirations and new ideas with a distinctive feature of originality. It aims to support free exploration that is likely to produce original results from scratch.

"Focusing on the frontiers of science in unique ways to lead the cutting edges". For this category, scientific problems come from the hot topics, difficulties and emerging fields with a distinctive feature of leading and groundbreaking. It aims to achieve pioneering results through unique paths, and to lead or expand the frontiers of science.

"Supporting application-driven basic research to enable breakthroughs". For this category, scientific problems are derived from national critical demands and the main battlefield of economy, with a distinctive feature of being application-driven, problem-driven and goal-driven. It aims to address the core scientific problems behind technical bottlenecks, and to facilitate the transformation of basic research results.

"Encouraging transdisciplinary leading-edge research to promote convergence". For this category, scientific problems are common across multiple disciplines with a distinctive feature of transdiciplinarity. It aims to achieve major breakthroughs through transdisciplinary research, and promote convergence of knowledge system.

2. Improve evaluation mechanisms

To establish category-specific review mechanism. Application and review reform will be carried out in accordance with the four funding categories, and matching but differentiated criteria and methods of evaluation will be adopted.

To establish a peer review mechanism featuring "Responsibility, Credit and Contribution". The quality of the review will be regarded as a reflection of the experts' attitude toward science, and will be counted as work performance, so as to further encourage scientists to be responsible. Responsibility is to encourage review experts to carefully and responsibly make scientific judgments of the applications. Credit is to assess the impartiality, scientificity, accuracy, timeliness and persuasiveness of the judgments given by the review experts. Contribution is to encourage review experts to present valuable suggestions and important academic ideas during the review. The ultimate goal is to encourage review experts to promote the spirit of science, emphasize credit and make contributions.

To utilize AI-assisted review management to enhance efficiency. We have studied and developed an "intelligent review system construction plan" that makes full use of modern technologies such as artificial intelligence, and made arrangements regarding the basis of big data, expert knowledge system, and precision matching, in hope of providing support for intelligent review system in the future, which will better match review experts with applications, and improve the quality and efficiency of review in the context of rapid increase of the volume of applications.

3. Optimize layout of research areas

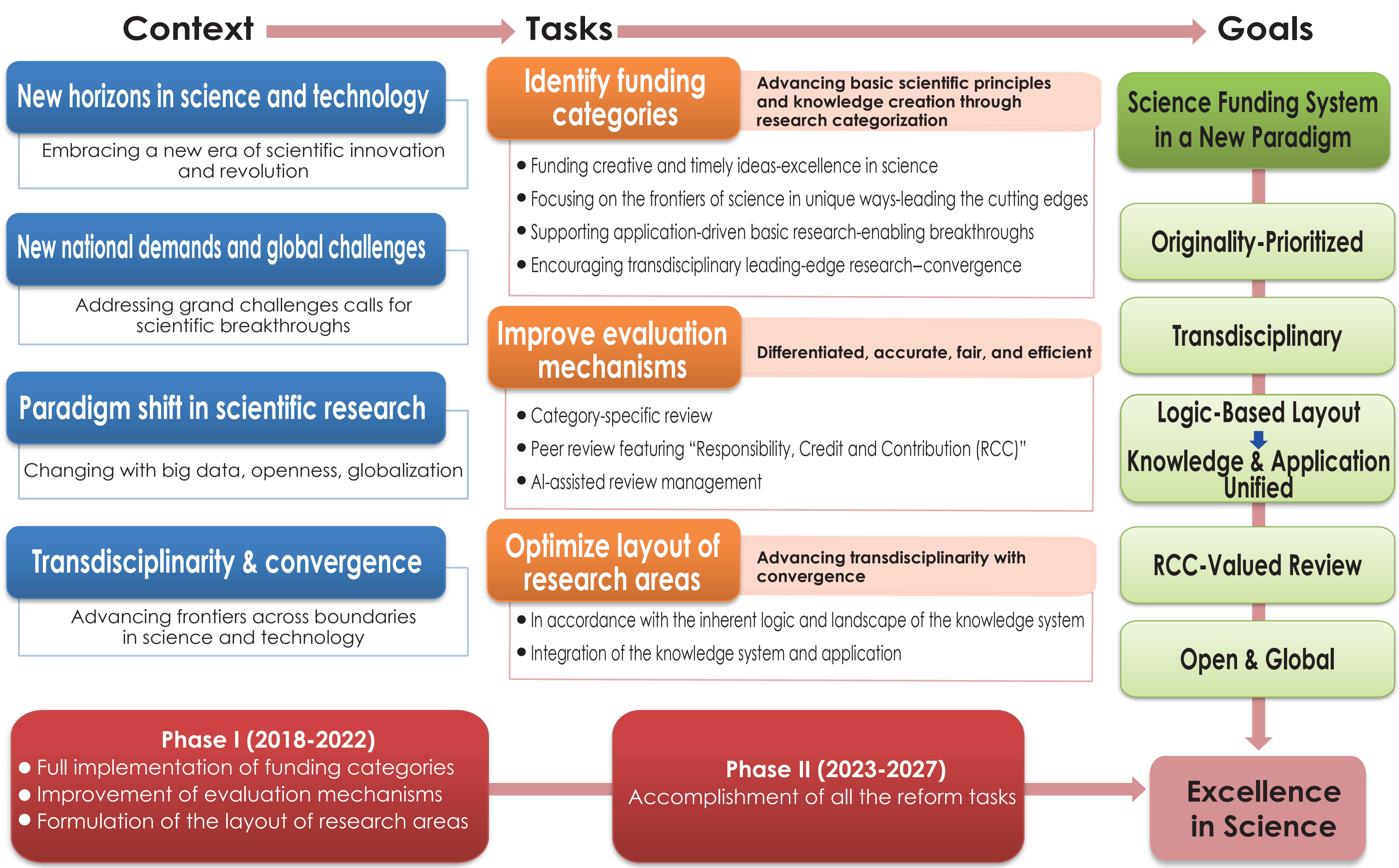
By constructing a layout of research areas that is “in accordance with the inherent logic and landscape of the knowledge system and promoting the integration of knowledge system and application”, NSFC will advance transdisciplinarity and convergence, foster the integration of knowledge and application, develop new research paradigms, and avoid duplication of research content and isolation between disciplines, in an effort to provide fundamental support for developing a sound layout of research areas and excellent talent teams.

In addition to the aforementioned three major reform tasks, NSFC will also identify priority funding areas, improve talent funding system, explore the use of breakthrough mechanisms, strengthen international cooperation, and reinforce scientific integrity, scientific research ethics, and scientific research environment culture.

1.3 Reform Roadmap

NSFC will adhere to a step-by-step reform strategy, launching pilot programs first, and implementing reform tasks in full swing. Funding categories and category-specific evaluation, essential to the accurate selection of innovative ideas and improvement of funding efficiency, are the priorities of the reform and will run pilot programs first. Based on the experience from pilot programs, we will move on to the more difficult and complicated parts of the reform, i.e., establishing an evaluation mechanism featuring “Responsibility, Credit and Contribution” and systematically adjusting the layout of research areas, to eventually achieve the goal of building National Science Funding System for the New Era. During the first phase which spans from 2018 to 2022, we will identify funding categories, carry out category-specific review, and formulate layout plan of research areas. The second phase spanning from 2023 to 2027 will see the completion of all the reform tasks.

Highlights of NSFC's Reform



2 Financial Statistics of NSFC's Funding in 2018

2.1 Financial Budget and Expenditure for NSFC in 2018

In 2018, the financial budget for NSFC was 28.05 billion yuan of which the budget for projects approved was 27.663 billion yuan. In 2018, the financial allocation for NSFC was 27.587 billion yuan with a total direct funding of 24.314 billion yuan and a total indirect funding of 3.273 billion yuan.

In 2018, the total funding for NSFC programs was 30.703 billion yuan with a total direct funding of 25.991 billion yuan and indirect funding of 4.712 billion yuan verified with 1,507 host institutions.

Statistics of Financial Budget for NSFC in 2018

(Unit: 10,000 yuan)

Type of Project	Financial Budget	Financial Expenditure
National Natural Science Fund	2,690,160	2,684,206
National Science Fund for Distinguished Young Scholars	76,090	74,483
Total	2,766,250	2,758,689

2.2 NSFC Funding for Projects Approved in 2018

Statistics of NSFC Funding for Projects Approved in 2018

(Unit: 10,000 yuan)

No.	Type of Project		Projects	Approved		
				Direct Funding	Indirect Funding	Total
1	General Program		18,947	1,115,289.00	214,026.32	1,329,315.32
2	Key Program		701	205,442.00	38,680.41	244,122.41
3	Major Program		36	68,722.48	12,459.68	81,182.16
4	Major Research Plan		513	88,320.70	15,363.47	103,684.17
5	Key International (Regional) Joint Research Program		430	83,435.66	15,854.35	99,290.01
6	Young Scientists Fund		17,671	417,644.00	79,945.18	497,589.18
7	Fund for Less Developed Regions		2,937	110,333.00	21,389.43	131,722.43
8	Excellent Young Scientists Fund		400	52,000.00	8,000.00	60,000.00
9	National Science Fund for Distinguished Young Scholars		199	68,285.00	9,755.00	78,040.00
10—a	Science Fund for Creative Research Groups	New Project	38	38,955.00	5,565.00	44,520.00
10—b		Extended Project	10	5,092.50	652.50	5,745.00
11—a	Joint Research Fund for Overseas Chinese Scholars and Scholars in Hong Kong and Macao	Two-Year Project	80	1,440.00	160.00	1,600.00
11—b		Four-Year Extended Project	22	3,960.00	420.00	4,380.00
12	Programs of Joint Fund		822	140,587.00	25,428.38	166,015.38
13	Special Fund for Research on National Major Research Instrument		89	83,590.56	12,360.51	95,951.07

No.	Type of Project	Projects	Approved		
			Direct Funding	Indirect Funding	Total
14	Basic Science Center Program	4	75,000.00	8,536.94	83,536.94
15	Projects of Emergency Management	802	25,891.03	1,818.76	27,709.79
16	Tianyuan Fund for Mathematics	62	3,500.00	0.00	3,500.00
17	Research Fund for International Young Scientists	140	4,500.00	818.56	5,318.56
18	International (Regional) Cooperation and Exchange Program	601	7,111.74	0.00	7111.74
Total		44,504	2,599,099.67	471,234.49	3,070,334.16

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Part II

Introduction of NSFC's Funding and Selected Awards in 2018

1 Application and Funding Statistics

1.1 General Program

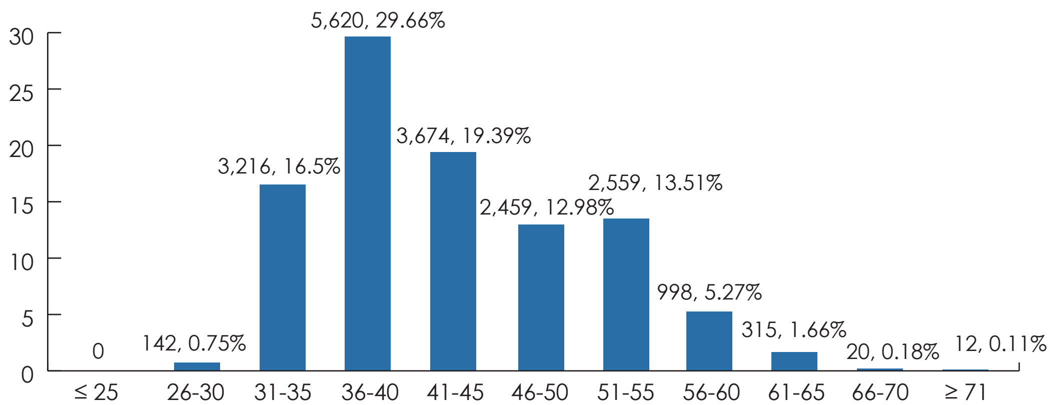
Function and Positioning: The General Program aims at supporting researchers to select topics independently within the funding scopes of NSFC, carrying out innovative scientific research, and promoting the balanced, coordinated and sustainable development of various disciplines.

Application and Funding Statistics of General Program in 2018 (by Scientific Department)

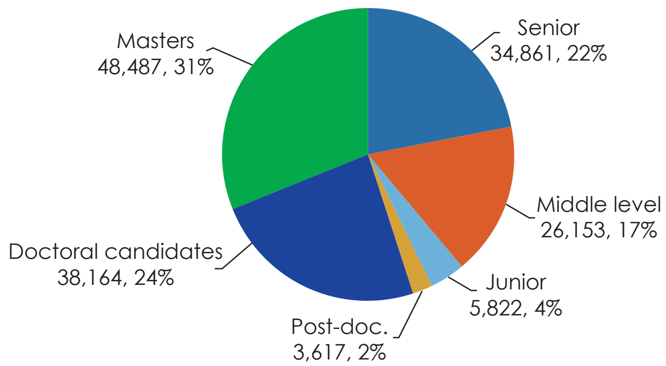
(Unit: 10,000 yuan)

Scientific Department	Applications	Approved					Success Rate (%)
		Projects	Direct Funding	Percentage of the Total (%)	Average Funding Per Project*	Indirect Funding	
Mathematical and Physical Sciences	6,544	1,743	104,640.00	9.38	60.03	19,526.44	26.64
Chemical Sciences	7,811	1,737	113,180.00	10.15	65.16	21,167.72	22.24
Life Sciences	12,664	3,048	177,470.00	15.91	58.23	34,683.27	24.07
Earth Sciences	7,111	1,895	117,210.00	10.51	61.85	22,401.21	26.65
Engineering and Materials Sciences	16,863	3,199	192,088.00	17.22	60.05	36,536.25	18.97
Information Sciences	10,558	2,007	120,037.00	10.76	59.81	22,364.06	19.01
Management Sciences	4,519	803	38,544.00	3.46	48.00	7,415.89	17.77
Health Sciences	26,552	4,515	252,120.00	22.61	55.84	49,931.48	17.00
Total	92,622	18,947	1,115,289.00	100.00	58.86	214,026.32	20.46

Note: average funding per project=direct funding/projects; success rate=No. of approved/No. of applications*100.
There were 67,609 proposals from male PIs and14,173 funded; 25,013 from female and 4,774 funded.



Age Distribution of Principal Investigators of General Program Projects in 2018 (No. of people, 19,037)



Professional Structure of Members of Research Groups for General Program Projects in 2018 (No. of people, 157,104)

Statistics of General Program in 2018 (by Region)

(Unit: 10,000 yuan)

No.	Region	Projects	Direct Funding	No.	Region	Projects	Direct Funding
1	Beijing	3,381	200,696.10	17	Jilin	354	21,350.00
2	Shanghai	2,060	120,135.57	18	Henan	286	16,361.00
3	Jiangsu	1,985	116,300.50	19	Gansu	182	10,943.50
4	Guangdong	1,622	94,540.40	20	Hebei	165	9,614.30
5	Hubei	1,207	70,928.93	21	Shanxi	147	8,675.50
6	Zhejiang	1,001	58,537.80	22	Yunnan	117	6,987.50
7	Shaanxi	936	55,240.00	23	Jiangxi	77	4,616.50
8	Shandong	811	48,151.70	24	Guangxi	59	3,538.00
9	Sichuan	698	41,092.30	25	Guizhou	46	2,833.00
10	Hunan	667	39,188.30	26	Xinjiang	34	2,024.00
11	Liaoning	645	38,200.00	27	Hainan	34	2,004.00
12	Tianjin	556	32,998.40	28	Inner Mongolia	20	1,086.00
13	Anhui	511	30,324.00	29	Qinghai	7	429.00
14	Heilongjiang	488	28,592.20	30	Ningxia	6	314.00
15	Fujian	443	26,222.50	31	Tibet	4	244.00
16	Chongqing	398	23,120.00				

1.2 Key Program

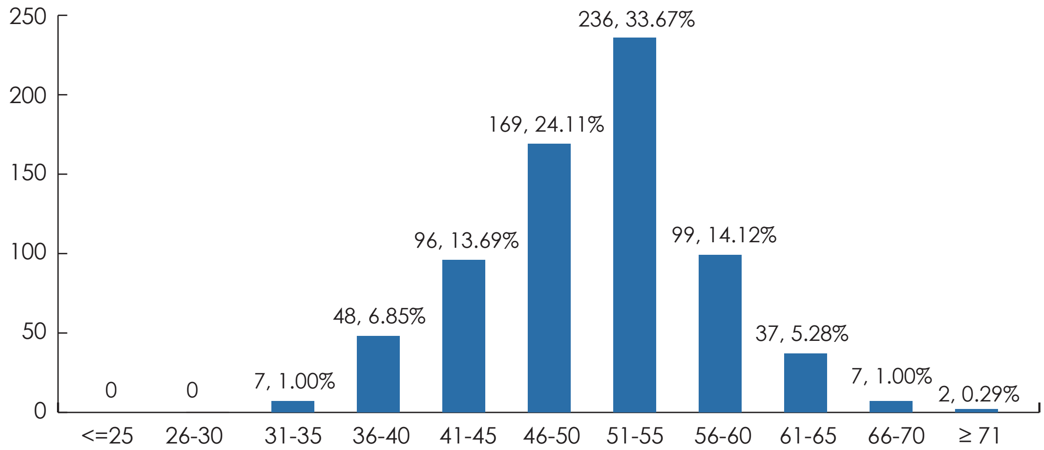
Function and Positioning: Key Program aims at supporting researchers to carry out in-depth and systematic innovation research on existing research directions or the new growing points of disciplines, promoting scientific development, and making breakthroughs in several important fields or scientific frontiers.

Application and Funding Statistics of Key Program in 2018 (by Scientific Department)

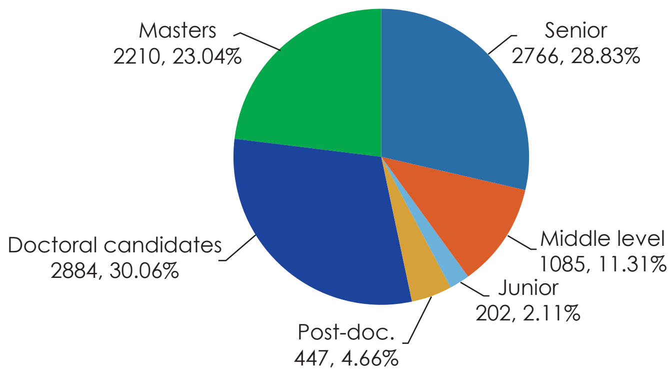
(Unit: 10,000 yuan)

Scientific Departments	Applications	Approved					
		Awards	Direct Funding	Percentage of the Total (%)	Average Funding Per Project*	Indirect Funding	Success Rate (%)
Mathematical and Physical Sciences	311	80	24,000.00	11.68	300.00	4,471.21	25.72
Chemical Sciences	277	62	19,500.00	9.49	314.52	3,481.98	22.38
Life Sciences	621	113	32,300.00	15.72	285.54	6,190.02	18.20
Earth Sciences	509	92	27,780.00	13.52	301.96	5,238.00	18.07
Engineering and Materials Sciences	476	102	30,600.00	14.89	300.00	5,742.40	21.43
Information Sciences	347	98	28,000.00	13.63	285.71	5,124.13	28.24
Management Sciences	138	34	7,992.00	3.89	235.06	1,533.75	24.64
Health Sciences	685	120	35,270.00	17.17	293.92	6,898.92	17.52
Total	3364	701	205,442.00	100.00	293.07	38,680.41	20.84

Note: 2,892 proposals from male PIs and 603 granted; 472 from female and 98 granted.



Age Distribution of Principal Investigators of Key Program Projects in 2018 (No. of people, 701)



Professional Structure of Members of Research Groups for Key Program Projects in 2018 (No. of people, 9,594)

1.3 Major Program

Function and Positioning: Major Program focuses on major scientific issues in the forefront of science and the major needs of national economic, social, technological development and national security. It supports multidisciplinary research and comprehensive research through deploying ahead, and gives full play to the supporting and leading role in enhancing China's original innovation ability of basic research.

Funding of Major Program in 2018

(Unit: 10,000 yuan)

No.	Title	PI	Home Institution	Direct Funding	Indirect Funding
1	Geometric structures and topological invariants	Tian Gang	Peking University	1,950.00	367.50
2	Model and method for mesoscopic structure superslip mechanics	Zheng Quanshui	Tsinghua university	1,950.00	186.34
3	Researches on theoretical system, measurement technology and standard specification of trans-scale mechanical behavior of advanced materials	Wei Yueguang	Peking University	1,966.00	381.46
4	Studying some of the key problems in understanding the formation of cosmic structures based on large spectroscopic surveys	Jing Yipeng	Shanghai Jiao Tong University	1,966.50	368.30
5	Manipulating phonons by solid-state microstructure and exploring its application in superconducting quantum chips	Chen Yanfeng	Nanjing University	1,944.00	339.44
6	Study of the QCD phase diagram and new-type topologic effect	Ma Yugang	Shanghai Applied Physics Institute, CAS	1,946.00	364.90
7	Bonding and reactivity of rare-earth organometallic complexes	Feng Xiaoming	Sichuan University	1,972.00	348.15
8	Controllable supramolecular polymerization system with covalent and non-covalent bonds	Liu Minghua	Institute of Chemistry, CAS	1,985.00	359.68
9	Precision diagnosis of tumor biomarkers and its molecular mechanism	Zhang Xueji	University of Science and Technology Beijing	2,000.00	359.40
10	Design and application of two-dimensional catalyst for key reactions at low-carbon energy conversion	Xie Yi	University of Science and Technology of China	2,000.00	334.75
11	Research on the functionalization of ionic liquids and the new green reaction/separation processes	Zhang Suojiang	Institute of Process Engineering, CAS	1,990.60	345.04
12	Porous coordination materials and derivatives for the activation and conversion of energy-related small molecules	Chen Xiaoming	Sun Yat-sen University	1,700.00	272.30
13	Investigation of structural tuning and oriented reorganization mechanism towards the efficient application of wood	Chu Fuxiang	Institute of Chemical Industry of Forest Products, CAF	1,644.00	322.60
14	Molecular mechanisms of meiotic recombination regulation	Shi Qinghua	University of Science and Technology of China	1,985.00	379.24
15	Carbon fixation and export in the oligotrophic ocean (Carbon-FE)	Dai Minhan	Xiamen University	1,984.90	360.37

No.	Title	PI	Home Institution	Direct Funding	Indirect Funding
16	Geodynamic processes of the ring-shape subduction system in the Southeast Asia	Li Jiabiao	The Second Institute of Oceanography, SOA	1,986.00	356.40
17	The research on the mutual feedback mechenism between the water cycle and the typical urban agglomeration in the middle and lower reaches of Yangtze River basin	Xia Jun	Wuhan University	1,929.52	367.23
18	Continental crust evolution and early plate tectonic	Zhai Mingguo	Institute of Geology and Geophysics, CAS	1,985.00	373.98
19	Ecosystem evolution during the Cambrian explosion	Zhang Xingliang	Xibei University	1,969.90	389.35
20	Key processes of the land-ocean interaction and their impacts on ecological security in the Guangdong-Hong Kong-Macao Greater Bay Area	Zhang Si	South China Sea Institute of Oceanology, CAS	1,971.35	356.19
21	Researches on expanding spectral regions of nonlinear optical crystals and their applications	Hu Zhanggui	Tianjin University of Technology	1,936.55	373.67
22	Multi-scales structural manipulation and function implementation of advanced optical film materials	Cheng Zhengdi	South China University of Technology	1,968.00	332.40
23	Fundamental research on intelligent electro-hydrostatic actuator	Yang Huayong	Zhejiang University	1,976.00	366.95
24	Investigation on the basic problems of bio-thermophysics for precision diagnosis and treatment of target lesions	Zhang Xinxin	University of Science and Technology Beijing	1,960.00	368.26
25	Fundamental theoretical research on the high performance and sustainable civil engineering material and structurals	Nie Jianguo	Tsinghua university	2,000.00	395.00
26	The softening theory of deep sea soil-structure interfaces and engineering safety	Kong Xianjing	Dalian University of Technology	1,945.00	351.18
27	Theory and application of active safety control for the high-performance aircraft engine	Sun Ximing	Dalian University of Technology	1,959.00	356.03
28	Basic theory and key technology of intelligent optimization operation in urban wastewater treatment process	Qiao Junfei	Beijing University of Technology	1,970.00	370.60
29	Basic theory and key technologies of function-oriented molecular material transistors	Liu Yunqi	Institute of Chemistry, CAS	1,957.00	357.55
30	High resolution optical imaging and visualization of brain connectivity	Li Pengcheng	Huazhong University of Science and Technology	1,981.33	318.53
31	Theory and method of multi-dimensional high resolution optical imaging for ocean monitoring	Jiang Huilin	Changchun University of Science and Technology	1,997.00	357.69
32	Basic theory and key technology of representation and reconstruction for space complex dynamic multi-objects electromagnetic characteristics	Liu Jiaqi	Beijing Aerospace Long March Vehicle Research Institute	1,775.00	310.95

No.	Title	PI	Home Institution	Direct Funding	Indirect Funding
33	Theories and methodologies of comprehensive transport system management for urban agglomeration under the new-type urbanization plan	Huang Haijun	Beihang University	1,404.63	268.53
34	Clonal heterogeneity and evolution in malignant hematopoietic diseases	Cheng Tao	Chinese Academy of Medical Sciences	1,679.20	323.16
35	The mechanisms and clinical translation of spinal cord injury repair	Dai Jianwu	Institute of Genetics and Developmental Biology, CAS	1,700.00	338.96
36	The geo-herbalism of Chinese material medicines	Huang Luqi	Chinese Academy of Medical Sciences	1,688.00	337.60
Total				68,722.48	12,459.68

1.4 Major Research Plan

Function and Positioning: Major Research Plan follows the basic principles of limited goals, stable support, integrated sublimation, and leapfrog development. It focuses on national major strategic needs and major scientific frontiers, strengthens top-level design, consolidates scientific goals, and gathers superior strengths to form relatively unified goals, thus forming project clusters with common goals or direction. It promotes the intersection and integration of disciplines, cultivates innovative talents and teams, enhances the original innovation ability of China's basic research, and provides scientific support for national economy, social development and national security.

Applications and Funding Statistics of Major Research Plan in 2018

(Unit: 10,000 yuan)

No.	Title	Applications	Approved	Direct Funding	Indirect Funding
1	Regulatory networks and molecular mechanisms of uncontrolled inflammatory malignant transformation *	1	1	157.50	0.00
2	Basic algorithm and computable modeling of high performance scientific computing	1	1	215.20	0.00
3	The neural circuits that underlie emotion and memory	1	1	270.00	0.00
4	Energy-oriented photoelectric conversion materials	21	7	5,500.00	805.14
5	Mesoscale mechanism and regulation in heterogeneous reaction process	12	3	3,000.00	487.97
6	Precision measurement physics	49	10	2,100.00	282.14
7	The change of coupling system and its global climate effect in Qinghai-Tibet plateau	38	12	3,300.00	630.60
8	Basic theory and key technology of spatial information network	17	4	1,039.00	184.06
9	Regulation of vascular homeostasis and remodeling	124	10	1,150.00	189.21
10	Basic research on turbulent combustion for engines	6	4	3,500.00	505.58
11	Tissue and organ regional immunity and disease	125	15	3,000.00	592.18
12	Toxicology and health effects of fine particulate matter in the atmosphere	2	2	2,500.00	378.68

No.	Title	Applications	Approved	Direct Funding	Indirect Funding
13	Basic research on the causes and coping mechanism of air pollution in China	5	2	963.00	91.48
14	The catalytic science of carbon-based energy conversion and utilization	209	17	2,100.00	361.23
15	Research on management and decision-making driven by big data	234	22	3,941.00	680.19
16	Runoff variation and adaptive utilization in source area of southwest river	3	3	1,100.00	155.20
17	Research on the basic theory and key technology of integrative robot	92	18	2,400.00	461.60
18	Mechanism of organ senescence and organ degeneration	321	45	3,700.00	685.96
19	New light field control physics and application	109	30	5,000.00	867.53
20	The driving mechanism of hydrosphere microbes towards the circulation of earth's elements	124	29	4,718.00	890.48
21	Formation, evolution and mechanism of turbulence structure	52	24	4,549.00	843.94
22	Dynamic modification and chemical intervention of biomacromolecules	280	40	3,800.00	721.91
23	Organelle interaction networks and their functions	112	33	4,732.00	916.17
24	Tethys geodynamic system	71	17	4,500.00	869.38
25	Accurate construction of multi-level chiral substances	207	33	3,995.00	733.78
26	Spatio-temporal network regulation of glucose and lipid metabolism	204	26	3,291.00	588.37
27	Multi-ring interaction of the earth system in the western Pacific	87	24	4,500.00	783.11
28	Molecular functional visualization of tumor evolution and diagnosis and treatment	372	31	4,000.00	720.60
29	High temperature material for aircraft engines/basic science of advanced manufacturing and fault diagnosis	468	49	5,300.00	936.98
Total		3,347	513	88,320.70	15,363.47

1.5 Key International (Regional) Joint Research Program

Function and Positioning: International (Regional) Joint Research Program funds researchers to base on the forefront of international science, effectively use international scientific and technological resources, conduct substantive international cooperation research on the principle of equal cooperation, mutual benefit and sharing of results, and improve the scientific research and international competitiveness of China. The program includes Key International (Regional) Joint Research Program and International (Regional) Cooperation and Exchange Programs under Agreements/MoUs.

The Key International (Regional) Joint Research Program funds scientific and technical personnel to research on priority funded areas of the National Natural Science Fund, the research areas that China urgently needs to develop, the international large-scale scientific research projects or programs that Chinese scientists organize or participate in, and large international (regional) collaborative research by use of large international scientific facilities.

The International (Regional) Cooperation and Exchange Programs under Agreements/MoUs extend bilateral and multilateral cooperation within the framework of inter-organizational agreements, make full use of the coordination mechanism of international scientific and technological organizations in transnational cross-border scientific research programs, promote Chinese scientists to participate in, plan and carry out regional cross-border research projects with important scientific significance, and actively advance cooperation with countries and regions along the "Belt and Road" area; and implement the central government's "one country, two systems" policy, and continue to strengthen cooperation and exchanges with scientists from Hong Kong, Macao and Taiwan.

Application and Funding Statistics of Key International (Regional) Joint Research Program in 2018

(Unit: 10,000 yuan)

Scientific Departments	Applications	Approved					Success Rate (%)
		Awards	Direct Funding	Percentage of the Total (%)	Average Funding Per Project	Indirect Funding	
Mathematical and Physical Sciences	29	5	1,200.00	4.67	240.00	225.68	17.24
Chemical Sciences	38	9	2,160.00	8.40	240.00	399.12	23.68
Life Sciences	101	16	4,080.00	15.88	255.00	799.42	15.84
Earth Sciences	67	10	2,310.00	8.99	231.00	443.88	14.93
Engineering and Materials Sciences	92	14	3,440.00	13.39	245.71	656.60	15.22
Information Sciences	83	14	3,480.00	13.54	248.57	598.22	16.87
Management Sciences	21	4	850.00	3.31	212.50	170.00	19.05
Health Sciences	254	34	8,180.00	31.83	240.59	1,597.61	13.39
Total	685	106	25,700.00	100.00	242.45	4,890.53	15.47

Application and Funding Statistics of International (Regional) Cooperation and Exchange Programs under Agreements/MoUs in 2018

(Unit: 10,000 yuan)

Scientific Departments	Applications	Approved					
		Awards	Direct Funding	Percentage of the Total (%)	Average Funding Per Project	Indirect Funding	Success Rate (%)
Mathematical and Physical Sciences	136	18	2,275.60	3.94	126.42	411.60	13.24
Chemical Sciences	150	23	3,450.20	5.98	150.01	633.32	15.33
Life Sciences	660	81	13,445.60	23.29	166.00	2,584.14	12.27
Earth Sciences	255	43	8,138.41	14.10	189.27	1,535.76	16.86
Engineering and Materials Sciences	599	71	13,242.90	22.94	186.52	2,462.34	11.85
Information Sciences	185	21	3,165.20	5.48	150.72	563.60	11.35
Management Sciences	158	7	1,140.00	1.97	162.86	271.04	4.43
Health Sciences	324	60	12,877.75	22.30	214.63	2,502.02	18.52
Total	2,467	324	57,735.66	100.00	178.20	10,963.82	13.13

1.6 Young Scientists Fund

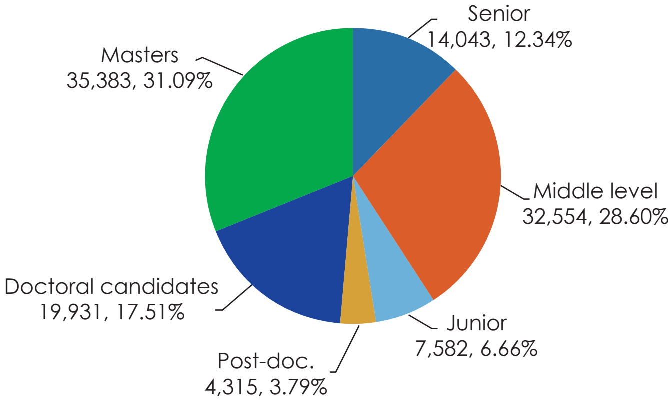
Function and Positioning: The Young Scientists Fund supports young science and technology personnel to select topics independently within the funding scope of the National Natural Science Fund, conduct basic research, train young science and technology talents to independently carry out research projects, conduct innovative research, and cultivate basic research talents.

Application and Funding Statistics of Young Scientists Fund in 2018 (by Scientific Department)

(Unit: 10,000 yuan)

Scientific Departments	Applications	Approved				Indirect Funding	Success Rate (%)
		Awards	Direct Funding	Percentage of the Total (%)	Average Funding Per Project		
Mathematical and Physical Sciences	6,054	1,748	43,630.00	10.45	24.96	8,043.27	28.87
Chemical Sciences	7,086	1,545	39,260.00	9.40	25.41	7,359.10	21.80
Life Sciences	11,481	2,350	58,240.00	13.94	24.78	11,470.39	20.47
Earth Sciences	6,490	1,763	43,220.00	10.35	24.52	8,210.12	27.16
Engineering and Materials Sciences	14,283	3,077	76,752.00	18.38	24.94	14,578.42	21.54
Information Sciences	8,280	2,111	52,054.00	12.46	24.66	9,632.34	25.50
Management Sciences	4,575	855	15,808.00	3.79	18.49	3,013.07	18.69
Health Sciences	27,793	4,222	88,680.00	21.23	21.00	17,638.47	15.19
Total	86,042	17,671	417,644.00	100.00	23.63	79,945.18	20.54

Note: 42,373 proposals from male PIs and 10,371 granted; 43,669 from female, and 7,300 granted.



Professional Structure of Members of Research Groups for Young Scientists Fund in 2018 (No. of people 113,808)

Application and Funding Statistics of Young Scientists Fund in 2018 (by Region)

Region	Applications	Approved					Success Rate (%)
		Awards	Direct Funding	Percentage of the Total (%)	Average Funding Per Project	Indirect Funding	
Beijing	9,042	2,389	56,480.51	13.52	23.64	10,751.78	26.42
Jiangsu	8,330	1,872	44,053.10	10.55	23.53	8,359.73	22.47
Guangdong	7,799	1,785	41,795.63	10.01	23.41	8,031.95	22.89
Shanghai	6,764	1,486	33,987.34	8.14	22.87	6,545.24	21.97
Hubei	5,073	1,125	26,697.70	6.39	23.73	5,155.68	22.18
Shandong	5,482	1,035	24,772.90	5.93	23.94	4,753.73	18.88
Shaanxi	4,818	1,020	24,679.00	5.91	24.20	4,719.00	21.17
Zhejiang	4,234	900	20,973.50	5.02	23.30	4,065.79	21.26
Sichuan	3,943	765	18,154.00	4.35	23.73	3,493.39	19.40
Hunan	2,799	608	14,361.10	3.44	23.62	2,771.85	21.72
Henan	4,087	561	13,395.22	3.21	23.88	2,582.90	13.73
Liaoning	3,031	506	11,993.10	2.87	23.70	2,285.46	16.69
Anhui	2,291	483	11,555.10	2.77	23.92	2,186.88	21.08
Tianjin	2,197	440	10,367.10	2.48	23.56	1,963.42	20.03
Chongqing	2,148	445	10,307.90	2.47	23.16	1,984.21	20.72
Fujian	1,990	400	9,464.80	2.27	23.66	1,784.05	20.10
Heilongjiang	1,843	359	8,581.20	2.05	23.90	1,655.33	19.48
Jilin	1,697	269	6,467.90	1.55	24.04	1,236.28	15.85
Shanxi	1,531	244	5,879.98	1.41	24.10	1,099.21	15.94
Hebei	1,475	205	4,908.60	1.18	23.94	942.44	13.90
Gansu	877	165	4,108.90	0.98	24.90	781.11	18.81
Yunnan	895	148	3,552.80	0.85	24.01	679.68	16.54
Jiangxi	1,035	142	3,399.40	0.81	23.94	651.83	13.72
Guangxi	834	100	2,352.90	0.56	23.53	445.69	11.99
Guizhou	618	80	1,944.70	0.47	24.31	364.93	12.94
Xinjiang	327	41	1,020.40	0.24	24.89	196.52	12.54
Hainan	242	40	969.50	0.23	24.24	190.11	16.53
Inner Mongolia	388	34	826.72	0.20	24.32	155.23	8.76
Qinghai	120	12	299.00	0.07	24.92	56.54	10.00
Ningxia	121	11	266.00	0.06	24.18	50.12	9.09
Tibet	11	1	28.00	0.01	28.00	5.10	9.09
Total	86,042	17,671	417,644.00	100.00	23.63	79,945.18	20.54

1.7 Fund for Less Developed Regions

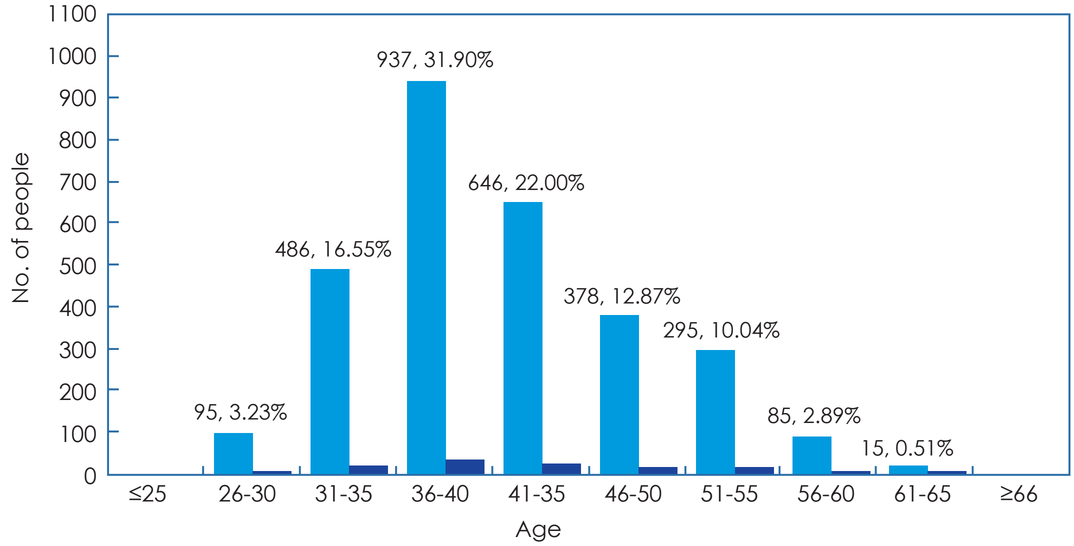
Function and Positioning: The Fund for Less Developed Regions supports scientific and technical personnel of host institutions in specific regions to carry out innovative scientific research within the scope of the National Natural Science Fund, cultivates and supports scientific and technical personnel in the region, and stabilizes and unites outstanding talents for the region, and serves the development of the innovation system and economic and social development.

Application and Funding Statistics of Fund for Less Developed Regions in 2018 (by Region)

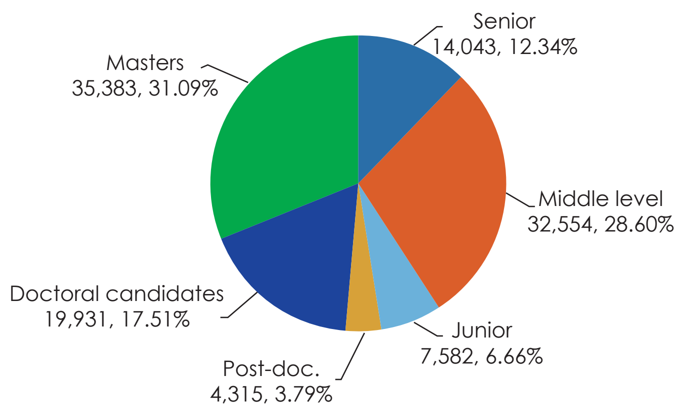
(Unit: 10,000 yuan)

Region		Applications	Approved					Success Rate (%)
			Awards	Direct Funding	Percentage of the Total (%)	Average Funding Per Project	Indirect Funding	
Jiangxi		3,248	618	23,071.40	20.91	37.33	4,456.84	19.03
Yunnan		2,899	437	16,384.80	14.85	37.49	3,196.40	15.07
Guangxi		2,596	406	15,093.25	13.68	37.18	2,923.04	15.64
Xinjiang		1,903	298	11,261.20	10.21	37.79	2,185.77	15.66
Guizhou		1,850	308	11,366.40	10.30	36.90	2,215.66	16.65
Gansu		1,542	249	9,617.90	8.72	38.63	1,842.13	16.15
Inner Mongolia		1,450	220	8,440.45	7.65	38.37	1,633.81	15.17
Ningxia		785	134	5,044.00	4.57	37.64	983.98	17.07
Hainan		594	118	4,416.70	4.00	37.43	863.44	19.87
Qinghai		341	44	1,678.00	1.52	38.14	323.96	12.90
Tibet		107	25	958.00	0.87	38.32	182.62	24.27
Shaanxi	Yan'an	74	17	640.70	0.58	37.69	184.32	22.97
	Yulin	118	8	321.00	0.29	40.13		6.78
Jilin	Yanbian	225	26	944.00	0.86	36.31	187.60	11.56
Hunan	Xiangxi	70	13	486.20	0.44	37.40	91.22	18.57
Hubei	Enshi	69	12	456.00	0.41	38.00	88.60	17.39
Sichuan	Liangshan	15	2	75.00	0.07	37.50	30.04	13.33
	Ganzi	2	0	0.00	0.00	0.00		0.00
	Aba	12	2	78.00	0.07	39.00		16.67
Total		17,900	2,937	110,333.00	100 .00	37.57	21,389.43	16.41

Note: there were 11,404 applications from male applicants, of which 1,952 were funded; and 6,496 from female applicants, of which 985 were funded.



Age Distribution of Principal Investigators of Projects of the Fund for Less Developed Regions in 2018 (No. of people, 32,937)



Professional Structure of Members of Research Groups for the Fund for Less Developed Regions in 2018

1.8 Excellent Young Scientists Fund

Function and Positioning: The Excellent Young Scientists Fund supports young scholars who have achieved good results in basic research to independently conduct innovative research, promotes the rapid growth of young science and technology talents, and cultivates a group of excellent academic talents who are expected to enter the forefront of world of science and technology.

Application and Funding Statistics of Excellent Young Scientists Fund in 2018 (by Scientific Department)

(Unit: 10,000 yuan)

Scientific Departments	Applications	Approved					Success Rate(%)
		Awards	Direct Funding	Percentage of the Total (%)	Average Funding Per Project	Indirect Funding	
Mathematical and Physical Sciences	637	47	6,110.00	11.75	130.00	940.00	7.38
Chemical Sciences	750	57	7,410.00	14.25	130.00	1,140.00	7.60
Life Sciences	775	58	7,540.00	14.50	130.00	1,160.00	7.48
Earth Sciences	558	40	5,200.00	10.00	130.00	800.00	7.17
Engineering and Materials Sciences	1,013	74	9,620.00	18.50	130.00	1,480.00	7.31
Information Sciences	869	60	7,800.00	15.00	130.00	1,200.00	6.90
Management Sciences	189	14	1,820.00	3.50	130.00	280.00	7.41
Health Sciences	630	50	6,500.00	12.50	130.00	1,000.00	7.94
Total al	5,421	400	52,000.00	100.00	130.00	8,000.00	7.38

Note: there were 4,387 applications from male applicants, of which 334 were funded; and 1,034 from female applicants, of which 66 were funded.

1.9 National Science Fund for Distinguished Young Scholars

Function and Positioning: The National Science Fund for Distinguished Young Scholars supports young scholars who have achieved outstanding results in basic research to independently conduct innovative research, promotes the growth of young scientific and technological talents, attracts overseas talents, and cultivates a group of academic leaders to enter the forefront of the international science and technology community.

In 2018, we received 2,974 applications for National Science Fund for Distinguished Young Scholars. After review, we funded 199 people. The total direct funding was 682.85 million yuan.

Awardees of the National Science Fund for Distinguished Young Scholars in 2018

(Unit: 10,000 yuan)

No.	Name	Title	Host Institution
1	Liu Weidong	Mathematical statistics	Shanghai Jiao Tong University
2	Xiang Hongjun	Theoretical study on multiferroicity	Fudan University
3	Qiao Bin	Intense laser-matter interaction	Peking University
4	Xiao Yunfeng	Ultra-high-Q microcavity optics	Peking University
5	Li Tiejun	Stochastic modeling and algorithms	Peking University
6	Guan Qian	Several complex variables	Peking University
7	Quan Haitao	Studies of nonequilibrium statistical physics of small systems	Peking University
8	Tian Hui	Solar physics	Peking University
9	Liu Xiang	Hadron physics	Lanzhou University

continued

No.	Name	Title	Host Institution
10	Zhang Jingrui *	Dynamics and control of the spacecrafts	Beijing Institute of Technology
11	He Jianjun	Nuclear astrophysics	The National Astronomical Observatories
12	Shi Yong	Star formation and SMBH's growth in galaxies	Nanjing University
13	Liu Xiongjun	New developments of quantum simulation for ultracold atoms	Peking University
14	Wang Yi	Differential equations and dynamical systems	University of Science and Technology of China
15	Yao Hong	Theoretical studies of strongly correlated systems	Tsinghua University
16	Xu Zhiping	Solid mechanics	Tsinghua University
17	Yu Pin	Partial differential equations	Tsinghua University
18	Zhou Quan	Buoyancy-driven turbulence	Shanghai Univerisity
19	Zhang Zhenlei	Geometric analysis	Capital Normal University
20	Wu Kehui	Atomic scale construction and properties of novel low-dimensional quantum materials	Institute of Physics, CAS
21	Wang Bo	Strength and lightweight design on aerospace structures	Dalian University of Technology
22	Yang Jiancheng	Innovative scheme and key technology for beam accumulation of high intensity and high power ion accelerator	Institute of Modern Physics, CAS
23	Kang Xi	Studies on galaxy formation and spatial alignment	Purple Mountain Observatory, CAS
24	Zhou Yufeng	Theoretical particle physics	Institute of Theoretical Physics, CAS
25	Gao Fuping	Offshore soil mechanics	Institute of Mechanics, CAS
26	Yang Sheng	Synthetic biocatalysts engineering	Shanghai Institutes for Biological Sciences, CAS
27	He Yao	Bioimaging analysis	Soochow University
28	Wang Shuao	Environmental radiochemistry	Soochow University
29	Wang Shuangyin	Electrocatalyst defect chemistry	Hunan University
30	Li Zhenyu	Theoretical study of mechanisms and properties at the molecular scale	University of Science and Technology of China
31	Yin Hang	Chemical biology	Tsinghua University
32	Peng Zhangquan	Interfacial electrochemistry of energy materials	Changchun Institute of Applied Chemistry, CAS
33	Zhai Tianyou	Synthetic chemistry of inorganic materials and optoelectronic devices	Huazhong University of Science and Technology
34	Zhang Qiang	Chemistry of energy materials	Tsinghua University
35	Du Haifeng	Asymmetric catalysis	Institute of Chemistry, CAS
36	Wang Yapei	Near infrared light responsive polymers based on photothermal conversion	Renmin University of China
37	Yi Chengqi	Nucleic acid chemical biology	Peking University
38	Chen Jun	Function oriented inorganic solids synthesis	University of Science and Technology Beijing

continued

No.	Name	Title	Host Institution
39	Li Yingwei	Metal-organic frameworks-based materials for industrial catalysis	South China University of Technology
40	Gong Xueqing	Theoretical studies of heterogeneous catalysis	East China University of Technology
41	Zang Shuangquan	Directional synthesis and property investigation of novel silver chalcogenolate clusters	Zhengzhou University
42	Sun Zhigang	Molecular reaction dynamics	Dalian Institute of Chemical Physics, CAS
43	Tan Yong	Catalytic chemistry at the surface/interface of nanocatalyst	Shanxi Institute of Coal Chemistry, CAS
44	Tian Changlin	Chemical biology studies on protein dynamic properties	University of Science and Technology of China
45	Fu Qiang	Surface and interface catalysis	Dalian Institute of Chemical Physics, CAS
46	Wang Yong	Membrane materials and membrane separations	Nanjing Tech University
47	Huang Yong	Synthetic organic chemistry	Peking University Shenzhen Graduate School
48	Jiang Lian	Synthetic ammonia catalyst engineering	Fuzhou University
49	Fan Chunan	Natural product synthesis	Lanzhou University
50	Huang Zheng	Organometallic complex-catalyzed transformation of saturated hydrocarbons	Shanghai Institute of Organic Chemistry, CAS
51	Liu Qian	Environmental analysis chemistry	Research Center for Ecological Environment, CAS
52	Sun Qingfu	Coordination supramolecular chemistry	Fujian Institute of Material Structure, CAS
53	Tan Bin	Catalytic asymmetric synthesis	Southern University of Science and Technology
54	Sun Yujie	Develop fluorescence imaging techniques to study chromatin structure and functions	Peking University
55	Peng Qiang	Design, synthesis and photovoltaic performance study of organic/polymer solar cell materials	Sichuan University
56	Jiao Yuling	Genetical and biomechanical regulation of lateral organs	Institute of Genetics and Developmental Biology, CAS
57	Wang Ertao	Nutrient exchange and engineering of plant-microbe symbioses	Shanghai Institutes for Biological Sciences, CAS
58	Shi Anbing	Endocytic recycling	Huazhong University of Science and Technology
59	Sun Yangang	Neural circuitry of the itch sensory processing	Shanghai Institutes for Biological Sciences, CAS
60	Xiao Bailong	Mechanosensitive ion channel	Peking Universtiy
61	Wang Hongwei	Cryoelectron microscopy	Peking Universtiy
62	Wu Beili *	Structural studies of G protein-coupled receptors	Shanghai Institute of Materia Medica, CAS
63	Sun Qiang	Non-human primate reproduction and development	Shanghai Institutes for Biological Sciences, CAS

continued

No.	Name	Title	Host Institution
64	Yang Zhimou	Preparation and biomedical applications of short peptide-based hydrogels	Nankai University
65	Cao Shengbo	Animal infection diseases	Huazhong Agricultural University
66	Cheng Gong	Mosquito-borne viral infection and transmission	Tsinghua University
67	Chen Zhucheng	Chromatin remodeling	Tsinghua University
68	Qian Wei	Plant bacterial pathogens	Institute of Microbiology, CAS
69	Ye Qing	Plant physiology and ecology	South China Botanical Garden, CAS
70	Tang Chaorong	Biology of rubber production	Hainan University
71	Zhou Yanhong *	Response and regulation of vegetable adversity	Zhejiang University
72	Liu Hongtao *	Plant light signal transduction	Shanghai Institutes for Biological Sciences, CAS
73	Nie Shaoping	Complex carbohydrates in food	Nanchang University
74	Ye Lilin	Immune response	Army Medical University
75	Yang Yuanhe	Global change ecology	Institute of Botony, CAS
76	Huang Zhiwei	The molecular mechanism by which a virus interacts with the host immune system	Harbin Institute of Technology
77	Li Menghua	Sheep germplasm resources and functional omics	Institute of Zoology, CAS
78	Huang Xuehui	Quantitative genetic studies in rice	Shanghai Normal Univeristy
79	Liu Qiaoquan	Genetics and improvement of rice grain quality	Yangzhou University
80	Chen Xuewei	Genetic exploration of rice resources with broad-spectrum resistance against blast and elucidation of their underlying molecular mechanisms	Sichuan Agricultural University
81	Dong Guanghui	Environment archaeology and environment change	Lanzhou University
82	Ni Huaiwei	Experimental petrology on melts and fluids	University of Science and Technology of China
83	Yan Junhua	Processes of land surface and environmental change	South China Botanical Garden, CAS
84	Yang Yunfeng	Soil microbiology	Tsinghua University
85	Xu Cheng	Petrological geochemistry	Peking University
86	Guo Huaming	Hydrogeology	China University of Geosciences
87	Yuan Honglin	Isotope geochemistry	Northwest University
88	Wang Qin *	Rheology and rock physics	Nanjing University
89	Zhang Xiaohong	GNSS precise point positioning methodology and its application	Wuhan University
90	Zhu Jianxi	Mineralogy	Guangzhou Institute of Geochemistry, CAS
91	Zhang Mingyi	Frozen soil and cold regions engineering	Cold and Arid Regions Environmental and Engineering Research Institute, CAS
92	Lin Qiang	Seahorse biogeographical patterns and environmental adaptation	South China Sea Institute of Oceanology

continued

No.	Name	Title	Host Institution
93	Chen Xianyao	Ocean decadal variability and its role in global climate change	Ocean University of China
94	Li Chao	Geobiology	China University of Geosciences, Wuhan
95	Sun Jianqi	Mid-to-high latitude climate system variability and short-term climate prediction	The Institute of Atmospheric Physics, CAS
96	Qi Shengwen	Rock mass engineering geomechanics	Institute of Geology and Geophysics, CAS
97	Wu Yonghong	Processes in phase interfaces and their effects	Institute of Soil Science, CAS
98	He Xianqiang	Ocean color remote sensing: Radiative transfer and atmospheric correction	Second Institute of Oceanography, MNR
99	Che Huizheng	Aerosol optical-radiation characteristics and its climatic and environmental effects	Chinese Academy of Meteorological Sciences
100	Liu Liangyun	Vegetation quantatitively remote sensing	Institute of Remote Sensing and Digital Earth, CAS
101	Yang Zhiming	Economic geology	Institute of Geology, Chinese Academy of Geological Sciences
102	Zeng Xiaoqin	Design and preparation of advanced magnesium alloys	Shanghai Jiao Tong University
103	Sheng Guoping	Water pollution control	University of Science and Technology of China
104	Zhou Hao	Multiphase flow combustion	Zhejiang University
105	Tian Fuqiang	Hydrological modeling and forecasting at watershed scale	Tsinghua University
106	Wei Haiqiao	Mechanism and optimized control of knock of the internal combustion engine	Tianjin University
107	Zou Ruqiang	Functional porous materials	Peking University
108	Li Yue	Periodic metal micro/nano-metamaterials and their optical properties	Hefei Institute of Physical Science, CAS
109	Liu Run *	Coupling action between offshore structures and subsoil	Tianjin University
110	Cao Bingyang	Micro/nano-scale heat conduction	Tsinghua University
111	Wang Liping	Mechanical tribology surface and interfaces under marine environment	Ningbo Institute of Materials Tecnology & Engineering, CAS
112	Hua Wei	Fundamental theory of novel flux-switching machine drives for electric vehicles	Southeast University
113	Lin Borong	Built environment and energy conversation in green buildings	Tsinghua University
114	Qu Changhai	Strong ground motions characteristics and building seismic fortification	Harbin Institute of Technology
115	Yang Zhongxuan	Soil mechanics and foundation engineering	Zhejiang University
116	Guo Baochun	Multiple network design and performance manipulation of rubber materials	South China University of Technology
117	Liu Yanhui	Amorphous alloys	Institute of Physics, CAS

continued

No.	Name	Title	Host Institution
118	Fu Shixiao	Experimental and theoretical study on fluid-structure interactions in ocean engineering	Shanghai Jiao Tong Universtiy
119	Gao Liang	Theory and method of shop scheduling	Huazhong University of Science and Technology
120	Qiu Lirong *	Theory, method, and technology for mechanical measurement and testing	Beijing Institute of Technology
121	Zhou Wei	Analysis and control of hydrodynamic performance of hydraulic structures	Wuhan University
122	Fu Qiang	Effect of soil and water environment of the farmland soil freeze-thaw process	Northeast Agricultural University
123	Liu Shaoqin *	Inorganic nonmetallic biomaterials	Harbin Institute of Technology
124	Tang Guihua	Micro- and nanoscale heat and mass transfer	Xi'an Jiaotong University
125	Chen Ruirun	Electromagnetic cold crucible melting and solidification	Harbin Institute of Technology
126	Ran Qianping	Toward high-performance cement-based materials	Jiangsu Research Institute of Building Science Co. Ltd
127	Wang Dong	Vessel high-power multiphase permanent-magnet electrical machine system	Naval University of Engineering
128	Wang Liwei *	Composite solid sorption properties and novel type low grade thermal energy conversion cycles	Shanghai Jiao Tong University
129	Sun Yanming	Organic optoelectronic materials and devices	Beihang University
130	Min Xiaobo	Non-ferrous metallurgical environmental engineering	Central South University
131	Zhang Tierui	Catalytic nanomaterials for energy conversion	Technical Institute of Physics and Chemistry, CAS
132	Cai Kaiyong	Surface/interface of biomedical materials	Chongqing University
133	Liu Gang	Solar-driven photocatalysts	Institute of Metal Research, CAS
134	Chen Yan *	Kinematics of spatial mechanisms and design of deployable and origami structures	Tianjin University
135	Ding Yi	Nanoporous metal energy materials	Tianjin University of Technology
136	Li Xingwen	Gas arc physics and characteristic control	Xi'an Jiaotong University
137	Huang Xiaoyu	Polymer brushes and their functinal materials	Shanghai Institute of Organnic Chemistry, CAS
138	Qin Botao	Prevention and control of thermal power disasters in coal mines	China University of Mining and Technology
139	Wang Kaiyun	Rail vehicle dynamics and service safety	Southwest Jiaotong University
140	Xu Xin	Robot autonomous control and learning	National University of Defense Technology
141	Liao Zhimin	Low dimensional material physics and functional devices	Peking University
142	Yin Jianwei	Service computing	Zhejiang University
143	Tang Jie	Knowledge discovery and knowledge engineering	Tsinghua University

continued

No.	Name	Title	Host Institution
144	Xu Ke	Internet traffic management and routing switching technology	Tsinghua University
145	Liao Xiaofei	Parallel and distributed computing	Huazhong University of Science and Technology
146	Tian Yonghong	Image and video analysis	Peking University
147	Chen Qidai	Femtosecond laser micro-nano fabrication	Jilin University
148	Feng Jing *	Organic semiconductor optoelectronics and optoelectronic devices	Jilin University
149	Zhao Qiang	Organic optoelectronics	Nanjing University of Posts and Telecommunications
150	Xing Mengdao	Synthetic aperture radar imaging	Xidian University
151	Wang Mi	Precision processing and intelligent service of high resolution satellite remote sensing image	Wuhan University
152	Zhu Tao	Ultra-narrow linewidth laser and sensing technology	Chongqing University
153	Pan Lijia	Semiconducting polymers and their application in sensors	Nanjing University
154	He Bin	Intelligent detection and computational perception	Tongji University
155	Li Zan *	Theory and key technology research on intelligent hidden communication	Xidian University
156	Zhou Minghui *	Open source software development	Peking University
157	Yang Lin	Silicon photonic integration	Institute of Semiconductors, CAS
158	Lin Yuan *	Stretchable and flexible inorganic thin film sensors	University of Electronic Science and Technology of China
159	Weng Jian	Public key cryptography	Jinan University
160	Liu Qingshan	Visual feature representation and learning	Nanjing University of Information Science & Technology
161	Hua Changchun	Nonlinear time delay system theory and application	Yanshan University
162	Chen Mou	Fundamental theory and application of intelligent control for super maneuver unmanned aerial vehicles	Nanjing University of Aeronautics and Astronautics
163	Jiang Haifeng	Fiber-based optical frequency combs and their applications in precision measurment	National Time Service Center, CAS
164	Fu Jun	Control and optimization of nonlinear dynamic systems	Northeastern University
165	Yuan Yuan *	Hyperspectral image analysis and processing	Xi'an Institute of Optics and Precision Mechanics, CAS
166	Liu Qi	Switching mechanism and performance modulation of resistive switching device	Institute of Microelectronics, CAS
167	Wang Yu	High-resolution wide-swath spaceborne SAR imaging	Institute of Microelectronics, CAS
168	Wang Junbo	Mems-based sensors	Institute of Microelectronics, CAS

continued

No.	Name	Title	Host Institution
169	Tian Xuan	Business administration	Tsinghua University
170	He Simai	Management science	Shanghai University of Finance and Economics
171	Zhang Bing	Environmental management and policy analysis	Nanjing University
172	Wen Zongguo	Environmental and ecological management	Tsinghua University
173	Yang Lixing	Management of railway traffic and transportation	Beijing Jiaotong University
174	Liang Zhe	Large-scale combinatorial optimization problems in civil aviation management	Tongji University
175	Wu Desheng	Risk-based decision theory and methodology in the complex management systems	University of Chinese Academy of Sciences
176	Zheng Junke	Biology of hematopoietic stem cells and leukemia stem cells	Shanghai Jiaotong University
177	Liu Wanli	The immune cell biology of b lymphocytes	Tsinghua University
178	Liu Cuihua *	Molecular mechanisms underlying pathogenic bacteria-host interactions	Institute of Microbiology, CAS
179	Gao Shaobing	Pharmacology on ion channels	Shanghai Institute of Materia Medica, CAS
180	Sun Jinpeng	Pharmacological research of GPCR biased signaling	Shandong University
181	Chang Yongsheng	Molecular mechanism of regulation of glucose and lipid metabolism	Tianjin Medical University
182	Liu Zhe *	Gene transcription regulation and tumor metastasis	Tianjin Medical University
183	Qi Lianwen	Chinese herbal medicines	China Pharmaceutical University
184	Chen Mingzhou	Molecular mechanism of RNA virus infection and pathogenesis	Wuhan University
185	Lin Tianxin	Oncology (clinical and basic research of lymphatic metastasis of bladder cancer)	Sun Yat-sen University
186	Lou Xin *	Imaging research on cerebrovascular disease	Chinese PLA General Hospital
187	Qin Jun	Epigenetic regulations in tumor biology	Shanghai Institutes for Biological Sciences, CAS
188	Yue Weihua *	Research on genetic susceptibility of schizophrenia	Peking University
189	Wang Hongyan *	Immune cell-mediated inflammatory diseases	Shanghai Institutes for Biological Sciences, CAS
190	Li Honglin	Methodologies and applications of drug design	East China University of Science and Technology
191	Jiao Jianwei	Mechanism study of brain development and diseases	Institute of Zoology, CAS
192	Wang Yilong	Neurology	Capital Medical University
193	Kuang Ming	Radiology (precise tumor ablation)	Sun Yat-sen University
194	Liu Cunzhi	Acupuncture and moxibustion	Beijing University of Chinese Medicine

continued

No.	Name	Title	Host Institution
195	Liu Wei *	Epidemiology of emerging vector-borne infectious diseases	Academy of Military Medical Sciences
196	Cai Jun	Hypertension	Fuwai Hospital, CAMS & PUMC
197	Ye Ling *	Dental pulp biology	Sichuan University
198	Tang Yida	Cardiovascular medicine	Fuwai Hospital, CAMS & PUMC
199	Hao Junwei	Inflammation in neurological diseases	Tianjin Medical University

Note: there were 2,613 applications from male applicants, of which 177 were funded; and 361 were from female applicants, of which 22 were funded; * female.

1.10 Science Fund for Creative Research Groups

Function and Positioning: The Science Fund for Creative Research Groups supports outstanding young and middle-aged scientists as academic leaders and research backbones, working together on an important research direction to conduct innovative research, cultivating and building a research community that has a role to play in the forefront of international science.

1. Newly Started Creative Research Groups

In 2018, we received 262 applications. After review, we supported 38 groups, with a total direct funding of 389.55 million yuan and indirect funding of 55.65 million yuan. Please refer to the following table for details.

Awardees in the Science Fund for Creative Research Groups in 2018

(Unit: 10,000 yuan)

No.	Group Leader	Research Direction	Host Institution	Direct Funding	Indirect Funding
1	Mao Shude	Galactic structure, formation and evolution	Tsinghua University	1,050.00	150.00
2	Li Chuanfeng	Quantum optics and quantum information	University of Science and Technology of China	1,050.00	150.00
3	Cai Ronggen	Particle physics and cosmology	Institute of Theoretical Physics, CAS	1,050.00	150.00
4	Guo Xu	Structural optimization	Dalian University of Technology	1,050.00	150.00
5	Fang Fuquan	Geometry and topology of manifolds	Capital Normal University	735.00	105.00
6	You Shuli	Organometallic chemistry directed towards transformations of hydrocarbons	Shanghai Institute of Organnic Chemistry, CAS	1,050.00	150.00
7	Liu Dongsheng	Tunable functional supramolecular systems	Tsinghua University	1,050.00	150.00
8	Su Chengyong	Coordination self-assembly and metal-organic materials	Sun Yat-sen University	1,050.00	150.00
9	Wu Kai	Surface physical chemistry involved in catalytic conversions	Peking University	1,050.00	150.00
10	Ma Guanghui	Vaccine oriented "biological particle design" and industrial transformation	Institute of Process Engineering, CAS	1,050.00	150.00
11	Zhao Shimin	Metabolic biochemistry	Fudan University	1,050.00	150.00

continued

No.	Group Leader	Research Direction	Host Institution	Direct Funding	Indirect Funding
12	Dong Chen	Inflammation biology and inflammatory diseases	Tsinghua University	1,050.00	150.00
13	Xiong Lizhong	Biology of green super rice	Huazhong Agricultural University	1,050.00	150.00
14	Li Jinsong	RNA regulation in reproduction	Shanghai Institutes for Biological Science	1,050.00	150.00
15	Wei Fuwen	Evolutionary conservation biology of endangered animals	Institute of Zoology, CAS	1,050.00	150.00
16	Hu Jianying	Ecological and health risks of regional environmental pollution	Peking University	1,050.00	150.00
17	Xie Shucheng	Geobiology	China University of Geosciences, Wuhan	1,050.00	150.00
18	Hao Fang	Hydrocarbon accumulation mechanism	China University of Petroleum	1,050.00	150.00
19	Cao Jinbin	Magnetospheric dynamics	Beihang University	1,050.00	150.00
20	Qiao Fangli	The development of new generation ocean coupled model and climate model	The First Institute of Oceanography	1,050.00	150.00
21	Sun Baode	Melt and solidification control of high performance metallic materials	Shanghai Jiao Tong university	1,050.00	150.00
22	Zhang Xiaohong	Controlled synthesis, interface engineering of organic/inorganic hybrid composite systems and related photoelectric functional devices	Soochow university	1,050.00	150.00
23	Yu Hanqing	Water pollution control and resource recovery	University of Science and Technology of China	1,050.00	150.00
24	Li Liang	Research on the advanced electromagnetic technology and its application	Huazhong University of Science and Technology	1,050.00	150.00
25	Liu Jun	Special sensing and dynamic measuring method in extreme environments	North University of China	1,050.00	150.00
26	Yang Yongping	Energy transfer and conversion and efficient power system	North China Electric Power University	1,050.00	150.00
27	Feng Dan	Big data storage system and technology	Huazhong University of Science and Technology	1,050.00	150.00
28	Gu Ning	Vascular information engineering	Southeast University	1,050.00	150.00
29	Zhang Chenghui	Optimization and control theory, technology and application for system of new energy power generation and high efficiency energy conservation	Shandong University	1,050.00	150.00
30	Liu Yuanan	Energy-efficiency oriented multi-frequency wireless systems	Beijing University of Posts and Telecommunications	1,050.00	150.00
31	Yu Haibin	Perception, control and coordination of robots	Shenyang Institute of Automation, CAS	1,050.00	150.00
32	Hua Zhongsheng	Service science and innovation management	Zhejiang University	735.00	105.00
33	Wang Hongwei	Managerial systems engineering	Huazhong University of Science and Technology	735.00	105.00
34	Geng Meiyu	Investigation of therapeutic stratification and resistance mechanism for anticancer drugs	Shanghai Institute of Materia Medica, CAS	1,050.00	150.00

continued

No.	Group Leader	Research Direction	Host Institution	Direct Funding	Indirect Funding
35	Huang Canhua	Redox signaling in tumorigenesis and progression	Sichuan University	1,050.00	150.00
36	Zhou Rongbin	Innate immune recognition and regulation	University of Science and Technology of China	1,050.00	150.00
37	Zhou Demin	Endogenous molecules-based biotherapeutic innovations	Peking University	1,050.00	150.00
38	Bian Xiuwu	The interaction of cancer stem cells with tumor microenvironment	Army Medical University	1,050.00	150.00
Total				38,955.00	5,565.00

2. Continued Funding for Creative Research Groups

Among the 30 creative research groups of 6-year funding, 22 of them applied for extended funding. After evaluation, 10 creative research groups obtained the second extension of funding. The total direct funding was 50.92 million yuan and indirect funding is 6.525 million yuan. Please see the following table for details.

Continued Funding for Creative Research Groups of 6-Year Funding

(Unit: 10,000 yuan)

No.	Group Leader	Research Direction	Host Institution	Direct Funding	Indirect Funding
1	Li Anmin	Mathematical physics	Sichuan University	367.50	52.50
2	Pan Jianwei	Physics and technologies of quantum information with photons and cold atoms	University of Science and Technology of China	525.00	75.00
3	Tan Weihong	The analytical basic research of chemo- and biosensors	Hunan University	525.00	0.00
4	Cheng Heping	Cellular calcium signaling	Peking University	525.00	75.00
5	Li Hejun	Physico-chemical process of preparation and service of ultra-high temperature composites for areonautic and astronautic applications	Northwestern Polytechnical University	525.00	75.00
6	Gao Deli	Basic research on drilling & completion of critical wells for oil & gas	China University of Petroleum-Beijing	525.00	75.00
7	Tan Jianrong	Basic research on mechatronic and hydraulic system	Zhejiang University	525.00	75.00
8	Liu Ming	Basic research on novel microelectronic devices integration	Institute of Microelectronics, CAS	525.00	75.00
9	Duan Shumin	Molecular mechanisms underlying synapse and neural circuit regulation and their involvement in neuropsychiatric diseases	Zhejiang University	525.00	75.00
10	Lu Lin	Neural plasticity mechanisms underlying psychiatric disorders	Peking University	525.00	75.00
Total				5,092.50	652.50

1.11 Joint Research Fund for Overseas Chinese Scholars and Scholars in Hong Kong and Macao

Function and Positioning: The Joint Research Fund for Overseas Chinese Scholars and Scholars in Hong Kong and Macao supports overseas Chinese scholars and Chinese scholars in Hong Kong and Macao under the age of 50 to work with Chinese mainland partners to conduct high-level collaborative research.

The Fund adopts the "2+4" funding model, which means that those 2-year projects with substantial cooperation and clear potential for future development will be renewed to another 4 years.

1. Two-Year Projects

Application and Funding Statistics of Joint Research Fund for Overseas Chinese Scholars and Scholars in Hong Kong and Macao in 2018 (by Scientific Department)

(Unit: 10,000 yuan)

Scientific Departments	Applications	Approved					Success Rate (%)
		Awards	Direct Funding	Percentage of the Total (%)	Average Funding Per Project	Indirect Funding	
Mathematical and Physical Sciences	23	7	126.00	8.75	18.00	14.00	30.43
Chemical Sciences	23	7	126.00	8.75	18.00	14.00	30.43
Life Sciences	28	10	180.00	12.50	18.00	20.00	35.71
Earth Sciences	9	3	54.00	3.75	18.00	6.00	33.33
Engineering and Materials Sciences	43	13	234.00	16.25	18.00	26.00	30.23
Information Sciences	69	19	342.00	23.75	18.00	38.00	27.54
Management Sciences	24	7	126.00	8.75	18.00	14.00	29.17
Health Sciences	44	14	252.00	17.50	18.00	28.00	31.82
Total	263	80	1,440.00	100.00	18.00	160.00	30.42

2. Continued Funding Projects (by Scientific Department)

Application and Funding Statistics of Joint Research Fund for Overseas Chinese Scholars and Scholars in Hong Kong and Macao in 2018 (by Scientific Department)

(Unit: 10,000 yuan)

Scientific Departments	Applications	Approved					Success Rate (%)
		Awards	Direct Funding	Percentage of the Total (%)	Average Funding Per Project	Indirect Funding	
Mathematical and Physical Sciences	7	2	360.00	9.09	180.00	40.00	28.57
Chemical Sciences	7	2	360.00	9.09	180.00	40.00	28.57
Life Sciences	14	4	720.00	18.18	180.00	80.00	28.57
Earth Sciences	6	2	360.00	9.09	180.00	40.00	33.33
Engineering and Materials Sciences	14	4	720.00	18.18	180.00	80.00	28.57
Information Sciences	11	4	720.00	18.18	180.00	80.00	36.36

continued

Scientific Departments	Applications	Approved					Success Rate (%)
		Awards	Direct Funding	Percentage of the Total (%)	Average Funding Per Project	Indirect Funding	
Management Sciences	1	0	0.00	0.00	0.00	0.00	0.00
Health Sciences	13	4	720.00	18.18	180.00	60.00	30.77
Total	73	22	3,960.00	100.00	180.00	420.00	30.14

Note: there were 280 applications from male applicants, of which 87 were funded; and 56 from female applicants, of which 15 were funded.

1.12 Programs of Joint Funds

Function and Positioning: The strategic positioning of the Joint Funds is "to face the needs of the country, guide diversified investment, promote resource sharing, and promote multi-party cooperation". It aims to give play to the guiding role of the National Natural Science Foundation of China, guide and integrate social resources such as government, industry, enterprises and individuals into basic research, attract and gather the strengths of scientific research in the country in view of the urgent needs of regions, industries and enterprises. It focuses on core scientific issues and major scientific issues in the emerging frontier cross-cutting fields, carries out forward-looking basic research, cultivates scientific and technical talents, jointly promotes the construction of regional innovation systems, and improves the independent innovation capability of industries and important fields.

Applications and Funding Statistics of Joint Funds in 2018 (by Project Type)

(Unit: 10,000 yuan)

No.	Project Type	Appli-cations	Approved					Success Rate (%)
			Awards	Direct Funding	Percentage of the Total (%)	Average Funding Per Project	Indirect Funding	
1	NSAF Joint Fund	103	46	4,200.00	2.99	91.30	800.63	44.66
2	Joint Fund for Iron and Steel Research	95	20	2,520.00	1.79	126.00	481.87	21.05
3	Joint Fund of Astronomy	203	49	5,040.00	3.58	102.86	924.45	24.14
4	NSFC-Guangdong Joint Fund	153	25	8,100.00	5.76	324.00	1,492.00	16.34
5	NSFC-Yunnan Joint Fund	193	23	4,914.00	3.50	213.65	947.28	11.92
6	Joint Fund of Large Scientific Facilities Research	477	113	10,080.00	7.17	89.20	1,864.89	23.69
7	NSFC-Xinjiang Joint Fund	269	52	6,720.00	4.78	129.23	1,263.20	19.33
8	NSFC-Henan Joint Fund	1,448	117	8,400.00	5.97	71.79	1,632.56	8.08
9	Joint Fund of Petrochemical Engineering, Type A	554	27	2,520.00	1.79	93.33	451.47	4.87
10	Joint Fund to Promote Cross-Straits Scientific and Techndogical Cooperation	95	18	4,090.00	2.91	227.22	764.78	18.95
11	NSFC-Shandong Joint Fund	127	30	8,400.00	5.97	280.00	1,587.19	23.62
12	NSFC-Guizhou Karst Science Center Project	6	3	7,560.00	5.38	2,520.00	1,079.49	50.00

continued

No.	Project Type	Appli-cations	Approved					Success Rate (%)
			Awards	Direct Funding	Percentage of the Total (%)	Average Funding Per Project	Indirect Funding	
13	NSFC-GenerTec Joint Fund for Basic Research	137	40	6,720.00	4.78	168.00	1,189.06	29.20
14	Joint Fund of Aerospace Advanced Manufacturing Technology Research	41	13	4,200.00	2.99	323.08	780.35	31.71
15	NSFC-Liaoning Joint Fund	41	17	4,250.00	3.02	250.00	785.50	41.46
16	NSFC-Zhejiang Joint Fund for the Integration of Industralization and Informatization	81	21	4,200.00	2.99	200.00	809.02	25.93
17	Joint Fund for the Innovation-Driven Development of China Automobile Industry	80	14	2,940.00	2.09	210.00	549.58	17.50
18	NSFC-Shanxi Joint Fund for Coal-Based Low-Carbon	277	38	4,120.00	2.93	108.42	790.32	13.72
19	NSFC-Guangdong Center for Big Data Research	22	8	10,620.00	7.55	1,327.50	1,571.79	36.36
20	Joint Fund for Civil Aviation Research	203	33	1,680.00	1.19	50.91	319.38	16.26
21	NSFC-Shenzhen Robotics Research Center Project	97	25	7,353.00	5.23	294.12	1,342.59	25.77
22	High-Speed Railway Joint Fund	72	11	2,520.00	1.79	229.09	483.50	15.28
23	Yalong River Joint Fund	35	12	2,520.00	1.79	210.00	454.08	34.29
24	Joint Fund for Smart Grid	49	15	6,720.00	4.78	448.00	1,172.97	30.61
25	Joint Fund for Space Science Satellite	33	19	1,800.00	1.28	94.74	321.10	57.58
26	Joint Fund of Seismological Science	71	11	2,520.00	1.79	229.09	477.04	15.49
27	Joint Fund of Nuclear Technology Innovation	82	22	5,880.00	4.18	267.27	1,092.29	26.83
Total		5,044	822	140,587.00	100.00	171.03	25,428.38	16.30

1.13 Special Fund for Research on National Major Research Instruments

Function and Positioning: The Fund is oriented for frontier of science and national needs, and is guided by scientific goals. It supports the development of original scientific research instruments and core components that play an important role in promoting scientific development, exploring natural laws and exploring research fields, thus enhancing the country's original ability to innovate.

In 2018, we received 601 applications for the Fund. After expert review, we funded 86 applications, with direct funding of 607.2694 million yuan and indirect funding of 95.7913 million yuan. The receiving departments recommended 51 applications. After review, we supported 3 projects, with total funding of 228.6362 million yuan and indirect funding of 27.8138 million yuan.

Projects Funded in Special Fund for Research on National Major Research Instruments (Open Application) in 2018

(Unit: 10,000 yuan)

No.	Title	Applicant	Host Institution	Direct Funding	Indirect Funding
1	Instrument for in-situ stress measurement in heterogeneous film-substrate material	Qiu Wei	Tianjin University	706.60	103.02
2	An ultra-high vacuum in-situ scanning superconducting quantum interference device microscope	Wang Yihua	Fudan University	688.00	123.43
3	Multi-mode ultrasound bone imaging method and instrument with multi-scale and high-resolution	Ta Dean	Fudan University	725.00	115.81
4	High-resolution imaging spectrometer of photon-electron-ion for cold strontium atom	Jiang Yuhai	Shanghai Advanced Research Institute, CAS	735.90	111.66
5	Development and construction of spherical torus plasma merging-compression experimental platform	Gao Zhe	Tsinghua University	684.00	103.90
6	The development of high accuracy 3D dynamic deformation measurement and analysis system for large structures	He Xiaoyuan	Southeast University	818.00	109.45
7	Development of high energy micro-focused X-ray source with high dose rate	He Xiaozhong	Institute of Fluid Physics, Chinese Academy of Engineering Physics	850.74	143.84
8	Development of the high-contrast imaging instrument for the detection of exoplanets around faint stars	Zhu Yongtian	Nanjing Institute of Astronomical Optics & Technology, CAS	670.00	125.50
9	GW ultra-strong terahertz source and application device	Li Yutong	Institute of Physics, CAS	735.00	115.75
10	Functional micro-reactor system	Fan Yubo	Beihang University	690.00	128.50
11	Stimulated emission depleted broadband femtosecond time-resolved spectroscopy	Xia Andong	Institute of Chemistry, CAS	738.75	90.75
12	Nanoscale electrochemistry: instrument, principles ans methods	Zhan Dongping	Xiamen University	725.00	99.00
13	Development of a structural mass spectrometer for protein steric structure analysis in complex matrices	Xu Wei	Beijing Institute of Technlology	534.70	95.30
14	Development of automated and multimode single cell analysis systems based on microfluidic droplet technique	Fang Qun	Zhejiang University	621.00	111.21
15	Equipment for single-round screening of functional nucleic acids	Tan Weihong	Hunan University	865.60	95.00
16	Highly sensitive and high-resolution laser absorption spectrometer for mid-infrared fingerprint spectra of transient molecules	Chen Yang	University of Science and Technology of China	685.00	93.20
17	Microfluidic instrument for visual screening of specific antibodies	Ju Huangxian	Nanjing University	780.00	127.60
18	The study of optical tweezers microscope for single-particle tracking and real-time manipulating in living cells	Tang Hongwu	Wuhan University	595.00	89.00

continued

No.	Title	Applicant	Host Institution	Direct Funding	Indirect Funding
19	In situ photocatalytic reaction characterization system with temporal and spatial resolution	Zhao Jincai	Institute of Chemistry, CAS	859.50	150.03
20	Time-resolved Muller matrix polarized fluorescence imaging system	Tian Yang	East China Normal University	720.00	58.00
21	Development of an instrumental system for separation and determination of micro- and nano-plastics	Liu Jjingfu	Research Center for Eco-Environmental Sciences, CAS	740.00	102.01
22	Mass spectrometer for analysis and studies of metal nanocluster coordination compounds	Zheng Lansun	Xiamen University	771.04	112.47
23	Photo-modulated force correlation spectroscopy system for single-molecule mechanochemistry	Zhang Wenke	Jilin University	702.00	107.45
24	The establishment of multifunctional particle ion mobility mass spectrometry	Nie Zongxiu	Institute of Chemistry, CAS	650.50	108.18
25	Single crystal X-ray diffraction system for the electronic structure of functional states of materials	Guo Guocong	Fujian Institute of Research on the Structure	765.51	106.08
26	Super channel-count and high spatiotemporal electrophysiological recording system for population neuronal activity	Li Chengyu	Shanghai Institutes for Biological Sciences	671.00	114.31
27	Nonlinear structured illumination super-resolution live cell imaging system	Li Dong	Institute of Biophysics	694.00	109.06
28	Clinical antimicrobial resistance ramanometry (CAMR-R)	Xu Jian	Qingdao Institute of Biomass Energy and Bioprocess Technology	620.00	118.00
29	Online atmospheric organic aerosol ultra-high resolution mass spcetrometer with desorption electrospray ionization	Yang Xin	Fudan University	554.55	87.51
30	The developing of a new equipment used for simulation of the marine corrosion environment	Hou Baorong	The Institute of Oceanology	736.80	111.67
31	An intelligent large microwave apparatus for fracturing hard rocks	FengXiating	Northeast University	785.42	124.29
32	Array focusing TFSAR EM imaging system for urban underground space detection	Lin Jun	Jilin University	601.10	108.42
33	Development of hydrothermal large-cavity high-temperature-pressure device combined with synchrotron radiation X-ray spectroscopy	Wu Xiang	China University of Geosciences, Wuhan	675.00	103.30
34	A high precision multi-wave collection system for internal information of rock-structure complex	Zhu Hehua	Tongji University	803.70	112.56
35	Miniaturized three-dimensional scanning lidar for the simultaneous observation of atmospheric carbon dioxide and methane	Gong Wei	Wuhan University	634.13	95.83
36	Developmement of monitoring equipment of multi-field parameters in whole-profile for landslide evolution	Tang Huiming	China University of Geosciences, Wuhan	630.43	106.60
37	Development of measuring instrument for tri-axial tyre-road interaction stress distribution	Zhou Xinglin	Wuhan University of Science and Technology	871.00	151.47

continued

No.	Title	Applicant	Host Institution	Direct Funding	Indirect Funding
38	Synthetic experimental system of radial jet drilling technology	Li Gensheng	China University of Petroleum-Beijing	749.96	136.76
39	Development of dual-wavelength flash Raman instrument for measuring thermal diffusivity	Zhang Xing	Tsinghua University	743.00	101.05
40	An integrated instrument of high temperature lead-based melt based on superconducting MHD flowmeter	Fang Youtong	Zhejiang University	754.46	115.19
41	Instrument development of internal and absolute stress measurement for steel members and joints of the large structures	Teng Jun	Harbin Institute of Technology	781.79	127.91
42	Pixel level light modulated navigation imaging and spectral integrated instrument for deep space exploration	Xing Fei	Tsinghua University	601.30	105.15
43	Precision counter-gravity casting equipment of large-sized complex metallic glass components	Sun Jianfei	Harbin Institute of Technology	834.20	110.62
44	A mechanical transmission error detection intelligent instrument iFMT that oriented the implicit error regularity of the ultra-precision worm gear pair	Peng Donglin	Chongqing University of Technology	606.00	98.20
45	Development of full spectrum magnetic thin film and powder ferromagnetic resonance line wide test instrument	Zhang Huaiwu	University of Electronic Science and Technology	680.40	113.92
46	Real-time on-line analytical system for burning process of polymers and its applications in investigating flame-retardant properties and mechanism	Wang Yuzhong	Sichuan University	798.10	127.02
47	Spectroscopy and imaging instrumentation system for the measurement of free radicals, particulate and gaseous products in combustion flames	Zhou Huaichun	North China Electric Power University	539.70	85.54
48	Ground analyzer of secondary electron emission and trap properties for spacecraft dielectrics	Zhang Guanjun	Xi'an Jiaotong University	616.11	83.36
49	The multi-field and multi-phase flow thermal vapor extraction test system for organic contaminated soil	Xue Qiang	Institute of Rock and Soil Mechanics, CAS	503.51	67.70
50	Inspection system of wheel-rail dynamic contact posture for high-speed railway based on high-precision structured-light technology	Gao Liang	Beijing Jiaotong University	858.46	139.52
51	The development of three-dimensional microscopic instrument based on optical field calculation	Dai Pu	Chinese PLA General Hospital	543.98	106.60
52	A super-resolution microscopy based on nonlinear focal spot modulation and virtual k-space demodulation	Kuang Cuifang	Zhejiang University	706.00	117.55
53	The development of label-free circulating tumor cell milimeter-wave analyzer	Sun Lingling	Hangzhou University of Electronic Science and Technology	730.00	131.80

continued

No.	Title	Applicant	Host Institution	Direct Funding	Indirect Funding
54	Parametric indirect microscopic imaging system for in situ super-resolution analysis of biological structural characteristics	Liu Xuefeng	Nanjing University of Science and Technology	843.00	136.53
55	Instrument of three-dimensional optical manipulation for nanometer scale objects beyond the diffraction limit	Li Baojun	Jinan University	568.00	81.40
56	Imaging and analyzing instrument of the brain interstitial system	Han Hongbin	Peking University	595.00	105.87
57	Photon counting Fourier transform Infrared fluorescence spectrometry	Sun Baoquan	Institute of Semiconductors, CAS	565.00	92.61
58	Development of wave powered ocean profile observation system	Guo Zhongyi	Ocean University of China	792.43	130.66
59	Development of unmanned aerial vehicle spectrum cognitive instrument	Wu Qihui	Nanjing University of Aeronautics and Astronautics	815.00	119.91
60	Key technologies and device for single-shot all-optical high-resolved imaging on atomic time scale	Li Jingzhen	Shenzhen University	621.40	71.28
61	Development and application of a preclinical bone dedicated 3D high-resolution quantitative spectral CT	Zhao Xing	Capital Normal University	689.00	103.86
62	Non-invasvie high temporal-spatial resolution equipment for detecting connection of cortical functional networks	Li Xiaoli	Beijing Normal University	600.00	112.03
63	Coded photography instrument in scattering scene	Ji Xiangyang	Tsinghua University	763.00	130.45
64	The research on high power, low time jitter mid-infrared fiber laser frequency comb	Hu Minglie	Tianjin University	534.95	95.52
65	Living single-cell analyzer based on light beam control and manipulation	Yuan Libo	Guilin University of Electronic Science and Technology	776.96	122.15
66	The multielement unmanned autonomous on-line monitering instrument for ecological environment in complex sea areas	Luo Jun	Shanghai University	736.75	120.96
67	Multi-component trace gas analyzer based on hollow-core microstructured optical fibers	Jin Wei	Shenzhen Research Institute, Hong Kong Polytechnic University	638.00	113.50
68	Research and development of the instrument for circulating tumor markers multidimensional rapid isolation and ultrasensitive detection	Peng Niancai	Xi'an Jiaotong University	830.00	149.50
69	Development of the integrated high-temperature vapor deposition system for fabrication of compliant substrates (CSS) and growth of GaN on CSS	Li Dabing	Changchun Institute of Optics, Fine Mechanics and Physics, CAS	840.00	128.65
70	Distributed fiber-optic strain measurement using dual-wavelength optical frequency-modulated continuous-wave interferometry	Dong Yi	Beijing Institute of Techonology	730.00	122.50
71	Ultra-wideband wavelength self-adaptive high-precision single-frequency laser linewidth tester for optical fiber laser	Yan Fengping	Beijing Jiaotong University	830.00	127.06

continued

No.	Title	Applicant	Host Institution	Direct Funding	Indirect Funding
72	The development of an integrated parametric measurement instrument for multicore fiber based on computed tomography and machine vision technology	Pei Li	Beijing Jiaotong University	708.00	115.75
73	High-spatial-resolution imaging system of microwave electric fields basing on Rydberg atoms	Jia Suotang	Shanxi University	669.19	106.33
74	Development of new equipment for online high-power laser beam diagnosis	Zhu Jianqiang	Shanghai Institute of Optics and Fine Mechanics	392.00	63.00
75	In-situ monitoring and analysis system of micro-area profile and performance for trans-scale femtosecond laser machining	Zhao Weiqian	Beijing Institute of Techonology	761.00	111.85
76	Quantitative measurement device for transient combustion field via incorporating laser induced fluorescence and absorption spectroscopy	Xu Lijun	Beihang University	792.06	108.86
77	Novel electromagnetic detection instrument based on pseudo-random coded pulse	Fang Guangyou	Institute of Electronics, CAS	698.78	108.14
78	Innovation of a robot system for precise interventional radiotherapy in multiple organ malignancies	Teng Gaojun	Southeast University	790.00	129.10
79	Development of dual-swept source-based multimodality intravascular optical coherence imaging system with multifunction	Yu Bo	Harbin Medical University	765.00	128.23
80	Development of a multi-modal system for accurate assessment of microwave tumor ablation	Qian Zhiyu	Nanjing University of Aeronautics and Astronautics	753.88	124.06
81	Development of atherosclerosis plaque multi-composition visualization system at microscopic scale	Chen Yundai	Chinese PLA General Hospital	703.67	116.42
82	Viscoelasticity intelligent analysis system for dynamic monitoring liver fibrosis	Zheng Rongqin	Sun Yat-sen University	705.00	101.20
83	Navigation instrument for liver minimally invasive surgery based on multimodal image fusion	Cai Xiujun	Zhejiang University	823.21	127.78
84	To develop a high-throughput and high-content array screening and imaging system for self-assembled cell microarray	Xi Jianzhong	Peking University	524.00	97.74
85	Multimodal acoustic-optic endoscopic imaging system for cholangio-pancreatic duct disease research	Ma Teng	Shenzhen Institutes of Advanced Technology, CAS	695.00	117.58
86	Ultrasonic system for cerebral small vessel imaging with super-resolution and dynamic multi parameters	Wan Mingxi	Xi'an Jiaotong University	796.72	121.60
Total				60,726.94	9,579.13

Projects funded in Special Fund for Research on National Major Research Instruments (by Recommendation) in 2018

(Unit: 10,000 yuan)

No.	Title	Applicant	Host Insitution	Direct Funding	Indirect Funding
1	In-situ fidelity coring and fidelity testing system for the deep rock	Xie Heping	Sichuan University	6,820.43	892.66
2	Typhoon tracking and measuring instrument	Zhang Jun	Beihang University	8,810.72	1,120.35
3	Whole brain surveying and mapping system for cell typing based on morphological and spatial omics information	Luo Qingming	Huazhong University of Science and Technology	7,232.47	768.37
Total				22,863.62	2,781.38

1.14 Basic Science Center Program

Function and Positioning: The Basic Science Center Program aims to concentrate and integrate domestic superior scientific research resources, target at the forefront of international science and advance deployment, give full play to the advantages and characteristics of the national science fund system. It relies on high-level academic leaders, attracts and unites outstanding scientific and technological talents. Efforts will be made to promote the deep integration of disciplines, support researchers to study and explore in a long term, and strive to break through the frontiers of science, produce a number of internationally leading original achievements, seize the commanding heights of international scientific development, and form a number of highlands with academically important international influences.

Applications and Funding Statistics of Basic Science Center Program

(Unit: 10,000 yuan)

No.	Title	PI	Host Institution	Direct Funding	Indirect Funding
1	Exploration of materials and mechanism of high temperature superconductors	Wang Nanlin	Peking University	18,750.00	2,028.51
2	Continental evolution and Earth's monsoon system	Guo Zhengtang	Institute of Geology and Geophysics, CAS	18,750.00	2,391.50
3	Energy ordered conversion	Guo Liejin	Xi'an Jiaotong University	18,750.00	2,037.43
4	Low dimensional information devices	Gao Hongjun	Institute of Physics, CAS	18,750.00	2,079.50
Total				75,000.00	8,536.94

1.15 Emergency Management Projects

Function and Positioning: The Emergency Management Projects fund innovative research, academic exchanges, strategic research projects, and other projects addressing special demands that are of scientific importance and need timely support, including the NSFC's General Management Projects, the NSFC's Departmental General Management Projects, and Soft Projects entrusted by NSFC's Functional Departments.

Applications and Funding Statistics of Emergency Management Projects (by Project Type)

(Unit: 10,000 yuan)

No.	Types	Awards	Direct Funding	Indirect Funding
1	NSFC's General Management Projects	28	6,440.00	1,188.66
2	NSFC's Departmental General Management Projects	690	16,451.03	630.10
3	Soft Projects Entrusted by NSFC's Functional Departments	84	3,000.00	0.00
Total		802	25,891.03	1,818.76

1.16 Research Fund for International Young Scientists

Function and Positioning: The Research Fund for International Young Scientists supports foreign young scholars to choose their own topics within the funding scope of the National Natural Science Foundation of China, and conduct basic research work in mainland China to promote long-term and stable academic cooperation and exchanges between foreign young scholars and Chinese scholars.

Application and Funding Statistics of Research Fund for International Young Scientists (by Scientific Department) in 2018

(Unit: 10,000 yuan)

Scientific Departments	Applications	Approved					Success Rate (%)
		Awards	Direct Funding	Percentage of the Total (%)	Average Funding Per Project	Indirect Funding	
Mathematical and Physical Sciences	82	21	613.60	13.64	29.22	103.85	25.61
Chemical Sciences	88	18	557.25	12.38	30.96	98.12	20.45
Life Sciences	154	28	1,030.25	22.89	36.79	199.25	18.18
Earth Sciences	46	11	318.04	7.07	28.91	58.22	23.91
Engineering and Materials Sciences	107	24	747.45	16.61	31.14	134.62	22.43
Information Sciences	81	18	561.09	12.47	31.17	94.52	22.22
Management Sciences	28	7	200.00	4.44	28.57	38.02	25.00
Health Sciences	66	13	472.32	10.50	36.33	91.96	19.70
Total	652	140	4,500.00	100.00	32.14	818.56	21.47

1.17 International (Regional) Cooperation and Exchange Program

Function and Positioning: The International (Regional) Cooperation and Exchange Program encourages the science fund project holders to carry out extensive international (regional) cooperation and exchange activities during the implementation of the project under the framework of the MoU agreements, and accelerate the steps of the research science fund project in improving innovation ability, personnel training, and development of disciplines, and improve the quality of the research funded by NSFC. Such projects can be classified into exchange projects based on mutual visits and academic workshop projects. The exchange project aims to maintain good bilateral and multilateral relations with foreign partners based on personnel exchanges, and lay a good foundation for further and deeper international cooperation in the future. The academic workshop project supports researchers to organize or participate in bilateral or multilateral academic conferences at home and abroad in the framework of MoU agreements, in order to strengthen researchers' understanding of international academic frontiers and research hotspots. It aims to establish and deepen the cooperative relationship between domestic and foreign counterparts, strengthen the dissemination of research results of scientific funds, and enhance the international influence of scientific research in China.

Application and Funding Statistics of International (Regional) Cooperation and Exchange Program in 2018 (by Project Type)

(Unit: 10,000 yuan)

Project Type	Applications	Approved					Success Rate(%)
		Awards	Direct Funding	Percentage of the Total (%)	Average Funding Per Project	Indirect Funding	
Exchange Program under Agreements/MoU	1,349	244	3,429.48	48.22	14.06	0.00	18.09
International Conference under Agreements/MoUs	325	309	740.76	10.42	2.40	0.00	95.08
Academic Conference under Agreements/MoUs	115	47	643.50	9.05	13.69	0.00	40.87
Sina-German Center for Research Promotion	1	1	2,298.00	32.31	2,298.00	0.00	100.00
Total	1,790	601	7,111.74	100.00	11.83	0.00	33.58

2 Introduction on Selected NSFC Grants

2.1 Major Program

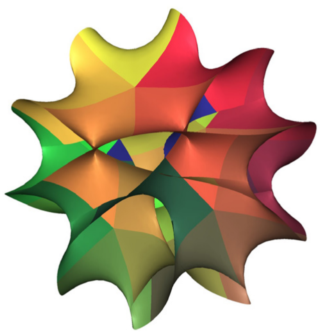
Geometric Structures and Topological Invariants

The Major Program project "Geometric Structures and Topological Invariants" was approved by NSFC in 2018 with a funding of 19.5 million yuan for 5 years. The project has three focused research topics: mirror symmetry conjectures and related problems, theory of moduli spaces and construction of geometric invariants, symplectic invariants and integrable systems. It is led by Academician Tian Gang of Peking University and main PIs include Academician Tian Gang, Academician Li Anmin of Sichuan University and Professor Liu Xiaobo of Peking University.

The study of global geometric structures and invariants of manifolds is a core research field in modern mathematical research. As a subject for studying properties of spaces, the development of geometry is always closely related to physics. On one hand, geometry provides necessary mathematical foundations and research tools for physics. On the other hand, the intuition and applications in physics have greatly stimulated the development of geometry and created new research directions. Many new geometric structures and geometric or topological invariants are closely related to theoretical physics, especially the string theory. Almost all branches of mathematics are involved in these invariants. Studies of these invariants have become core research directions in modern mathematics. They also have very important applications in theoretical physics. Strengthening research in this field has significant impact on the development of mathematics in China.

Core scientific problems of the project include: (1) study of the duality phenomena among various geometric invariants predicted by physicists, for example the mirror symmetry conjectures for Calabi-Yau manifolds and the Landau-Ginzburg/Calabi-Yau correspondence; (2) construction of new geometric invariants corresponding to closed and open string theories, for example, construction of Hamiltonian Gromov-Witten invariants, study on linear sigma models and construction of corresponding invariants, study of the structures and properties of moduli spaces needed to establish these invariants and computation of various geometric invariants; (3) study of the important connections between symplectic invariants and other branches of mathematics, especially the relations between Gromov-Witten invariants and integrable systems, and study of Virasoro conjecture and other important conjectures in this field.

The project aims to establish new mathematical theory through construction of new geometric and topological invariants and solve forefront scientific problems in mathematical physics. The team will strive for breakthroughs in a series of problems with significant international impact, such as mirror symmetry conjectures, Virasoro conjecture and Landau-Ginzburg/Calabi-Yau correspondence. The project plans to construct new invariants through studying various moduli spaces, improve the understanding of various geometric invariants, find effective methods for computation of these invariants, discover and study deep structures behind these geometric invariants, and study the relations among various invariants and their important applications in physics and other branch of mathematics.



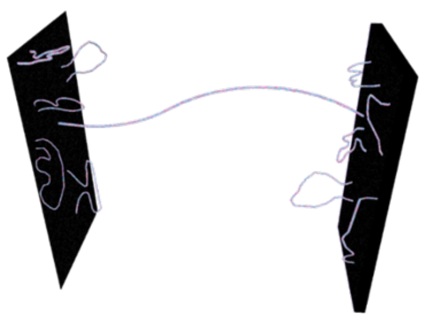


Figure 1. Geometric structures and topological invariants

Phase Structure of Quantum Chromo Dynamics and its Novel Topological Phenomena

The Major Program project "Phase Structure of Quantum Chromo Dynamics and its Novel Topological Phenomena" was approved by NSFC in 2018 with a funding of 19.46 million yuan for 5 years. The project has four subprojects. It is led by Academician Ma Yugang of the Shanghai Institute of Applied Physics, Chinese Academy of Sciences and main PIs include Academician Ma Yugang, Professor Liu Feng of Huazhong Normal University, Professor Zhuang Pengfei of Tsinghua University and Professor Liang Zuotang of Shandong University.

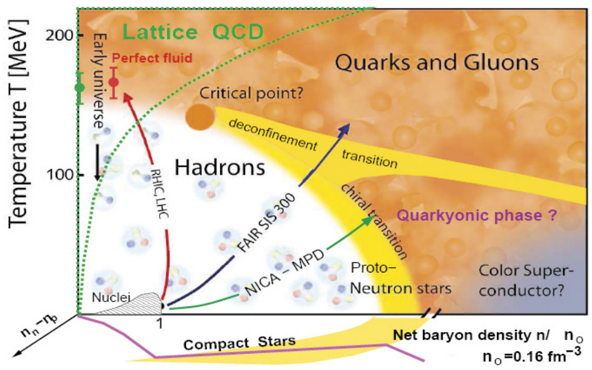


Figure 1. Theoretical phase diagram of nuclear matter in the dimensions of temperature T, baryonic density n/n0 and isospin density (nn-np). The different accelerators are also labeled in the figure

Studies of QCD (Quantum ChromoDynamics) matter and its phase structure are important research topics in high energy nuclear physics. Experimental data at relativistic heavy-ion collider at BNL (RHIC) support that the new state of QCD matter created at RHIC has a high chance to be a strong coupling quark matter which has long been a key problem in matter sciences. Studying quark matter by relativistic heavy ion collisions plays an important role in exploring the properties of QCD phase structure and the strongly coupled state. It also has far-reaching significance for improving matter science research in China. China has already acquired a world-class theoretical and experimental research team in the field of heavy-ion physics, focusing on the investigation of high temperature, high density and strong interacting physical state and phase transformation. In particular, the Chinese team of RHIC-STAR collaboration has been well recognized internationally for their remarkable achievements in STAR detector upgrading and antimatter nuclei observation and related physical research.

This project brings together experimental and theoretical scientists in the field of relativistic heavy-ion collisions in China and focuses on the following two core scientific issues: (1) the study of the QCD phase diagram and the search for the possible critical end point, (2) topological effects of QCD matter and their experimental manifestation. In a wide phase diagram region from high baryon density to high temperature, the experimental data of heavy-ion collider at LHC and RHIC will be systematically studied in depth, and some pre-research at FAIR, NICA, HIAF energies will be performed. It is expected that the project will lead to outcomes with a global impact.

Significant progress is expected through close cooperation between experimentalists and theorists on the two core scientific issues of the project. Possible breakthroughs include: (1) to experimentally confirm the QCD critical point, which is an end point from the first order transition between the hadronic matter to quark-gluon matter to cross-over region, based on several sensitive observations by a high statistical energy scan program, (2) to experimentally confirm the chiral topological effects in QCD matter (e.g., chiral electric separation and chiral magnetic wave, etc.) by heavy-ion collisions of the isobaric and the accurate measurement of QGP polarization. The realization of the two breakthroughs, or even any one of them, will be regarded as a major achievement in QCD physics. In addition, significant theoretical prediction and development are also expected along the project's key scientific direction.

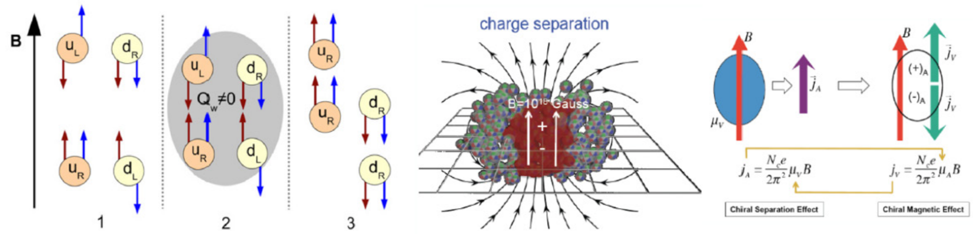


Figure 2. A qualitative picture of the chiral magnetic effect (CME) and its effect on charge separation

Design and Application of Two-Dimensional Catalyst for Key Reactions at Low-Carbon Energy Conversion

The Major Program project "Design and Application of Two-Dimensional Catalyst for Key Reactions at Low-Carbon Energy Conversion" was approved by NSFC in 2018 with a funding of 20 million yuan for 5 years. The project has four subprojects: (1) two-dimensional catalysts regulation and device construction for CO_2 reduction, (2) functional design and large-scale controllable preparation of two-dimensional catalysts, (3) two-dimensional nano-confined catalysis and low-carbon conversion of small energy-related molecules, and (4) surface and interface chemistry and application of selective hydrogenation catalysis of two-dimensional metal catalysts. It is led by Academician Xie Yi of University of Science and Technology of China and will be jointly undertaken by University of Science and Technology of China, Dalian Institute of Chemical Physics, Chinese Academy of Sciences and Xiamen University.

Energy crisis and environment pollution are two great challenges to the world. The scarcity of fossil fuel reserves and related environmental pollution have become the bottleneck for the development of human beings and a strategic problem that must be solved on China's way of building a moderately prosperous society in all aspects and pursuing the sustainable development of a "beautiful China". From the perspective of low-carbon energy, a high-efficiency catalyst system is the key to energy saving and pollutants emission reduction in the conversion and utilization of energy. Two-dimensional solid is a good option for catalysts in the low-carbon energy conversion because of its highly active atomic site and surface confinement effect.

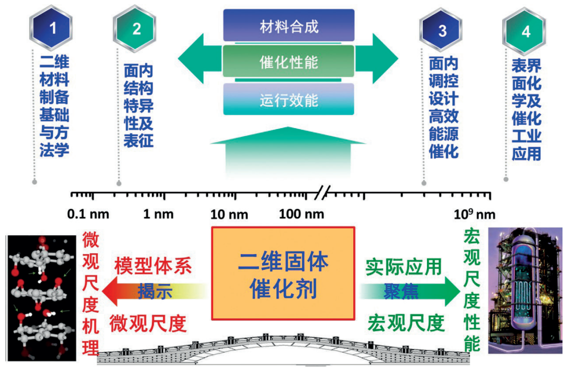


Figure 1. Scientific significance and practical use of two-dimensional catalyst

Based on previous research on two-dimensional catalysts in China and abroad, and national demands on new energy, the project will focus on the following scientific problems associated with the preparation, regulation and stability of two-dimensional materials. (1) Mass production of two-dimensional catalysts: to develop new synthesis techniques and clarify the mechanism of surface chemistry. (2) Characterization of catalytic performance: to develop new techniques to chemically tune the activities by in-situ characterization and explore the defect structure-property relationship. (3) Application of two-dimensional catalysts: to study the mechanism of stability of two-dimensional materials, and design stable functional catalytic system for energy conversion.

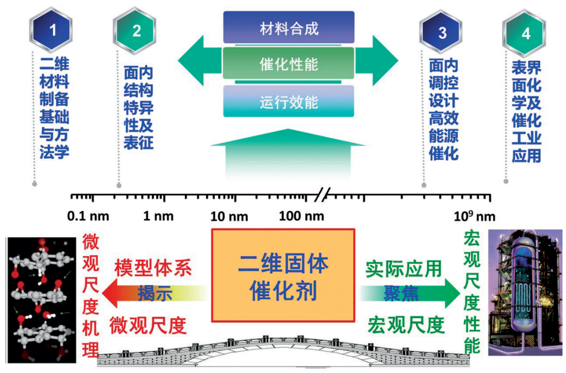


Figure 2. Opportunities and challenges of two-dimensional catalyst for key reactions at low-carbon energy conversion

The project aims at original innovation and breakthroughs in both science and technology on low-carbon energy catalytic conversion by combining the national demands with the research of two-dimensional solids, focusing on the reduction of CO_2 emission, catalytic hydrogenation and methane activation. The project will establish and develop the methodology of synthesis of two-dimensional solids and elucidate the process of electron transfer, chemical bond activation and selectivity enhancement in the two-dimensional catalytic system. This project also aims to discover new mechanism of catalysis and improve the current coordination theory. It is expected that new catalytic system will be set up and industrialized. Another objective of the project is to develop an internationally competitive research group, increasing the international impact of China in basic research of two-dimensional catalysis. The project will further develop the current theory of coordination chemistry as well as solid chemistry, and make contributions to solve the bottleneck problems in the energy and environment crisis.

Porous Coordination Materials and Derivatives for the Activation and Conversion of Energy-Related Small Molecules

The Major Program project "Porous Coordination Materials and Derivatives for the Activation and Conversion of Energy-Related Small Molecules" was approved by NSFC in 2018 with a funding of 17 million yuan for 5 years. The project has three subprojects: (1) porous metal-organic frameworks and derivatives for catalytic conversion of CH_4, (2) porous coordination materials and derivatives for CO_2 conversion, (3) porous coordination materials and derivatives for electrochemical water splitting and oxygen reduction. It is led by Academician Chen Xiaoming of Sun Yat-sen University and will be jointly undertaken by Sun Yat-sen University, Tsinghua University, Dalian University of Technology and the National Center for Nanoscience and Technology.

The sustainable development of modern society faces severe scientific challenges in energy, environment, materials, chemical industry and many other fields. Because of the unique structural and functional diversity, porous complexes and their derivatives have provided an important way to solve the challenges by providing efficient and green catalytic systems for the activation and conversion of energy-related small molecules such as water, methane and carbon dioxide.

Based upon traditional coordination chemistry, this project will combine the theoretical and experimental studies of synthetic chemistry, catalytic chemistry, materials science and nanoscience, and propose new concepts and strategies for the invention of new catalysts with porous complexes (especially metal-organic frameworks, or MOFs) and their derivatives. It is expected that these new catalysts can synergistically and efficiently adsorb/capture and activate energy-related small molecules such as methane, carbon dioxide and water, and meet the demand of atom economy and green synthesis.

The key scientific problems that the project aims to solve include: (1) new methods and concepts for the design, assembly and spatial integration of porous complexes and their derivatives for efficient activation and conversion of energy-related small molecules with the aid of theoretical simulations, (2) efficient activation and directional reorganization of chemical bonds to achieve precise and controllable synthesis of target products from energy-related small molecules by synergetic functions of confined space and action sites in porous complexes, (3) mechanisms of material transportation, energy and electron transfer, and the function synergy and structure-activity relationship of the catalytic processes by combination of theoretical and experimental studies.

The overall objective of this project is to construct new catalytic systems based on MOFs and other porous complexes and their derivatives for efficient activation and transformation of methane, carbon dioxide and water. New catalysts with efficient adsorption/capture and synergistic activation/conversion capabilities will be developed to tackle the problem of poor selectivity and low efficiency for the known catalysts. The accurate breakage and reconstruction of chemical bonds, as well as efficient reduction of the activation energy by the catalyst systems will be accomplished for efficient syntheses of target compounds from the above-mentioned small molecules. Ultimately, highly efficient, atom-economic and green catalytic conversion systems will be developed to enrich precise chemistry and meet the demand of sustainable development. The project aims to produce a series of catalysts with independent intellectual property rights, some of which can be industrialized.

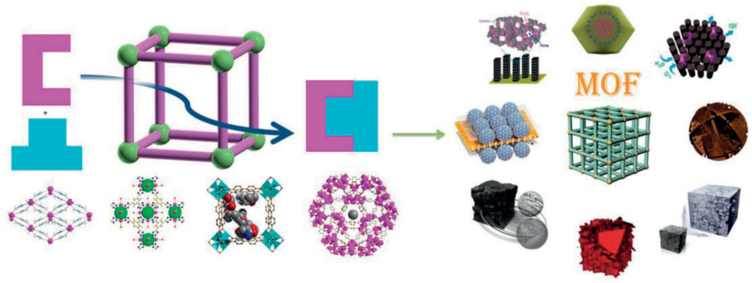


Figure 1. Assembly of MOFs and their derivatives

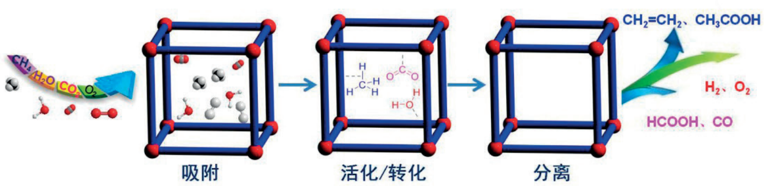


Figure 2. Functional integration catalytic system of MOF

Structural Tuning and Oriented Reorganization Mechanism Towards Efficient Utilization of Woody Materials

Woody resources are of great importance to the green development due to their distinctive advantages, such as carbon fixation ability, renewability and degradability. China is the largest producer and trader of forest products across the world. However, there is a serious discrepancy between the strong needs for the high quality woody materials and the supply. Most of precious hardwoods greatly rely on the imports. Furthermore, direct wood processing dominates in the wood industry. The lack of competitiveness leads to its position at the relatively low end of the global industrial chain. Therefore, how to use rich woody resources and change their structural shortage through technological innovation, is the key issue that must be resolved. These will be beneficial to realize the high value-added utilization of woody resource, promote upgrading of the industrial structure, and enhance the international competitiveness.

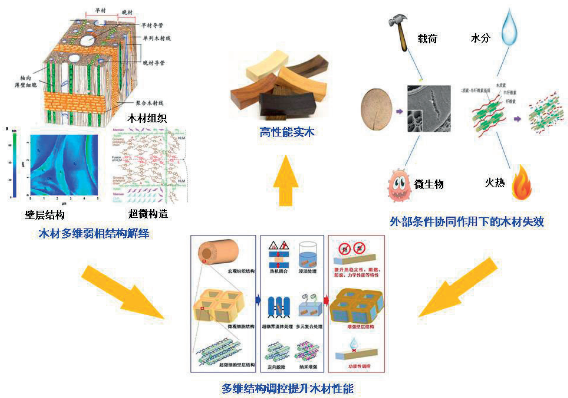


Figure 1. Multi-dimensional structure control mechanism of woody materials

During the natural evolution, complicated multi-dimensional structures and a significant anisotropy have been formed in the wood. Although the basic research framework for the wood utilization has been preliminarily established, the relevant mechanisms are not yet clear. In particular, the interaction between its internal multi-dimensional structures and the external influential factors, the precise disassembly of wood fibers, the evolution of supermolecule structure of wood components, and the oriented reorganization of wood macromolecules need to be systematically studied.

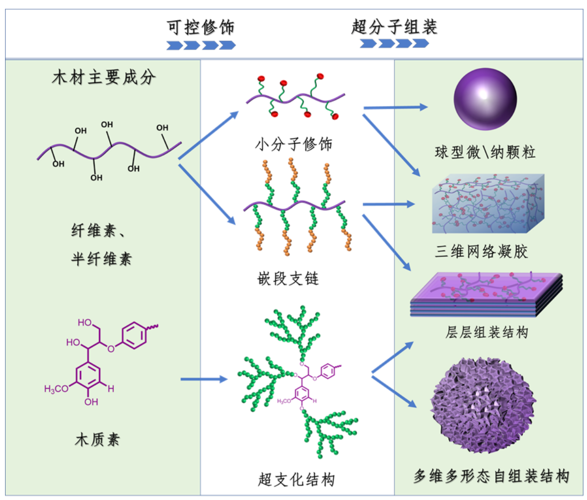


Figure 2. Supramolecular structure evolution mechanism of woody materials

Aiming at the significant theoretical problems about “the multi-level and high-valued utilization of woody resources”, the key scientific issues about the efficient utilization of wood, wood fibers and wood components, this project mainly investigates the interaction and regulation among multi-dimensional structures of the wood, the precise disassembly and interfacial regulation of wood fibers, the chemical modification of main components and the mechanism of supramolecular assembly, and the directional depolymerization and controllable reconstruction. Specifically, the program aims to explore the potential mechanism about multidimensionally structural regulation to improve the properties. Additionally, the new approach to separate woody fibers will be established. In order to enhance the development of chemical modification and functionalization of wood fibers, the directional conversion of the functional groups on the surface of fibers and the mechanism of interfacial molecular modification will be elucidated as well. Meanwhile, it will reveal the directional depolymerization and controllable reconstruction, to fully improve the utilization rate of woody resources.

The duration of the project is 5 years, and over 100 research papers are expected to be published. It will contribute to build a foundation for promoting the high-value and efficient utilization of woody sources, providing the theoretical support for transformation and upgrading of woody processing industry. The implementation of the program will eventually facilitate the green development and flourishing of the rural area, as well as boosting the improvement of independent innovation capability and sustainable development of forestry.

Molecular Mechanism for the Regulation of Meiotic Recombination

As an essential step for the generation of gametes, meiosis is the basic feature of all sexual reproduction organisms including humans. Recombination, exchanging genetic materials between homologous chromosomes during gametogenesis, is a key step of meiosis. It would introduce physical links between homologous chromosomes, which guarantees proper alignment of homologous chromosomes on equatorial plate of metaphase I and accurate segregation during anaphase I. Gametes with different genetic composition are generated through meiotic recombination, which is a major source of genetic diversity in offspring.

Research on human genetics showed that abnormalities on the number and localization of meiotic recombination would lead to gametes of poor quality (e.g., aneuploid gametes) or even the absence of gametes, which may cause infertility, spontaneous abortion or congenital birth defects. Defects in recombination of sex chromosomes are a major cause of germ cell abnormalities. Results from studies on model animals including mice not only indicate strict regulation in the number and distribution of crossovers, but also suggest different mechanisms underlying the regulation and formation of meiotic recombination between autosomes and the sex chromosomes. With the rapid development of research techniques, the dynamic characteristics of meiotic recombination, the molecular basis of difference in meiotic recombination between the regulation of autosome and the sex chromosomes, as well as the molecular mechanism of the regulation of meiotic recombination have developed into the frontier of research in cell biology and genetics, especially reproductive biology.

This project focuses on the molecular mechanism for the regulation of meiotic recombination, and funds the research addressing the questions on the formation and repair of programmed meiotic DNA double-strand breaks, the special mechanisms of recombination of the sex chromosomes, as well as molecular basis of reproductive defects caused by recombination abnormalities. The goal of this project is to support projects with well-conceived proposals, containing clear scientific questions, specific goals and feasible research plans. The overall funding is 19.85 million yuan over the time frame of five years (2019–2023).

Focusing on the core scientific issue, molecular mechanism of the regulation of meiotic recombination, this project plans to explore the regulatory mechanisms of meiotic recombination, using mice as the model animal, to find unknown key factors for the decision and regulation of the number and localization of meiotic recombination, uncover new biological mechanisms regulating the formation of meiotic DSBs, the selection of DSB repair pathways as well as resolution/dissolution of homologous repair intermediates. This project will also study the molecular basis and mechanism causing the meiotic abnormalities in azoospermic patients as well as the difference in recombination regulation between autosome and the sex chromosomes. The execution of this project is anticipated to improve original research on the regulation of meiotic recombination in China, achieve a series of research goals with significant international influence, as well as provide theoretical bases for the diagnosis and treatment of the related diseases.

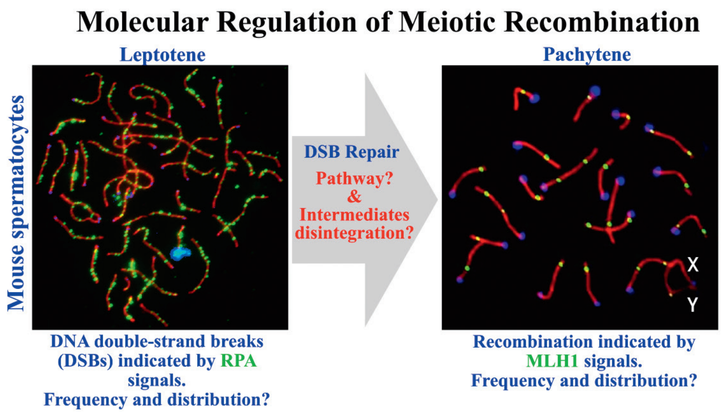


Figure 1. Regulation of meiotic recombination

Carbon Fixation and Export (Carbon-FE) in Oligotrophic Ocean

The oligotrophic ocean occupies about 30% of the ocean surface and has been conventionally regarded as ocean deserts. It is characterized by nutrient depletion in the surface waters and extremely low net biological production and hence, per unit area, contributes little to carbon export from surface to deep waters. Emerging evidence, most notably based on ocean time-series studies such as those at the Hawaiian Ocean Time-Series Station, has shown a dynamic range, wider than previously assumed, of nutrient inputs and biological responses in this oceanic system. This project selects the North Pacific Subtropical Gyre (NPSG), one of the world's largest oligotrophic regimes, as the study site to examine carbon fixation and export, or the biological pump in general, regulated by differently sourced nutrients including macronutrients (i.e., N, P, Si) and micronutrients (e.g., Fe). The main hypothesis of this project is as follows. Due to strong surface stratification in the NPSG, the nutricline is shallow and structures the euphotic zone into two distinct vertical layers: the upper nutrient-depleted layer (NDL) lacking nutrient supply from below, and the lower nutrient-replete layer (NRL). Interestingly, the NDL often features high, sometimes even the majority of primary productivity in the euphotic zone along with frequently observable net community productivity and/or export production. Such paradox could partly result from new N introduced into the NDL from such as biological N_2 fixation and atmospheric deposition. As the N_2 fixation could be limited by Fe and/or P, their sources would possibly drive the carbon export from the NDL. In the NRL, in comparison, the driver of the carbon export would be the subsurface nutrient supplies.

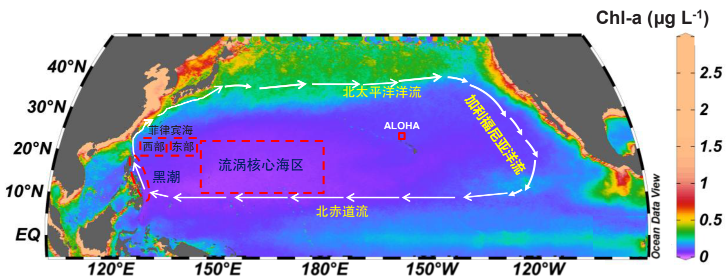


Figure 1. Schematic of the North Pacific Subtropical Gyre (NPSG). NPSG is formed by four prevailing ocean currents: North Pacific Current to the north, California Current to the east, North Equatorial Current to the south, and Kuroshio to the west. The background color indicates the long-term (1997–2010) climatological surface chlorophyll (NASA/GSFC OBPG). ALOHA represents the Hawaii Ocean Time-series station in the eastern NPSG

The major objectives of this proposal are thus (1) to determine the distribution of macro- and micro-nutrients, fingerprint their sources and estimate their fluxes into the NPSG, (2) to constrain the spatial-temporal variability of biological N_2 fixation and its limiting factors in the NDL, (3) to quantify the carbon fixation and associated planktonic community structure, (4) to constrain the export production from both the NDL and NRL, and (5) to simulate the biological pump and carbon sinks in the NPSG. This project can substantially improve our understandings to fundamental biogeochemistry in these climatically and ecologically important oligotrophic ocean systems.

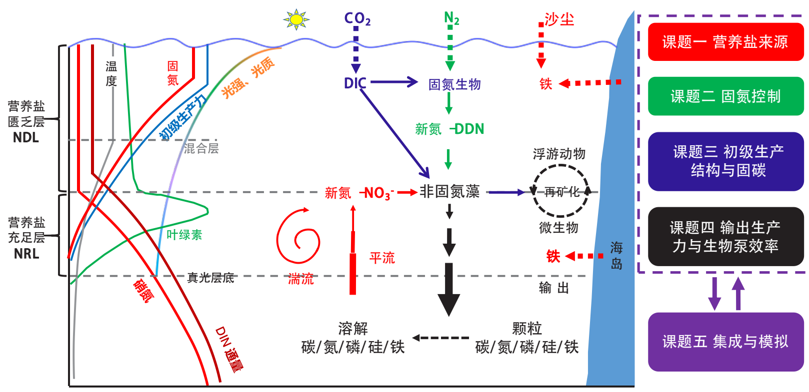


Figure 2. Schematic of major biogeochemical processes in the euphotic zone of the oligotrophic ocean (middle) and associated gradients in chemical and physical parameters (left; based on Du et al., 2017). The right panel indicates the five subprojects of this project. DDN denotes diazotrophic-derived nitrogen. Due to the strong thermal stratification, the surface mixed layer (SML) is typically shallower than the nutrient-depleted layer (NDL). The blue-green light that is more favorable to phytoplankton growth in the open ocean can penetrate deeper than the yellow-red light. The base of the "real euphotic zone" is thus usually deeper than that traditionally defined as the depth where photosynthetic available radiation (PAR) is 1% of its surface value. This implies that both light intensity and light quality should be taken into account when examining its effect on the biogeochemical processes in the oligotrophic ocean

Ecosystem Evolution During the Cambrian Explosion

The Major Program project "Ecosystem Evolution During the Cambrian Explosion" was approved by NSFC in 2018 with a funding of 19.699 million yuan for 5 years. It is led by Professor Zhang Xingliang from Northwest University and jointly carried out by Northwest University, Institute of Geochemistry of Chinese Academy of Sciences, University of Science and Technology of China, and Institute of Geology and Geophysics of Chinese Academy of Sciences.

During the Precambrian-Cambrian transition (~560–520 Ma), the earth's biosphere witnessed an abrupt diversification of bilateral lineages and the sudden appearance of most present animal phyla in a short time. This extraordinary biological evolution event was termed "Cambrian explosion". Descriptions of Cambrian explosion can be tracked back to more than 100 years ago, yet currently it is still one of the most important unresolved scientific issues.

In modern marine environments, the trophic level that ultimately supports all others in an ecosystem consists of autotrophs, the primary producers, above which are sequentially herbivores, carnivores and tertiary consumers. Trophic relationships determine the routes of energy flow and chemical cycling in an ecosystem, while detritivores or decomposers connect all trophic levels. Therefore, primary producers and decomposers play a central role in energy and material cycling, which flow through the trophic levels eventually to detritus and then cycle back to primary producers. Such complexity of marine ecosystems has been built since the Cambrian explosion with advents of diverse metazoans. However, previous investigations mostly focused on the evolution of animals (consumers) and oceanic redox conditions, and paid little attention on the microorganisms of decomposers and producers, energy flow or matter cycle within the ecosystem, which is an integrated system composed of biotic and environmental components.

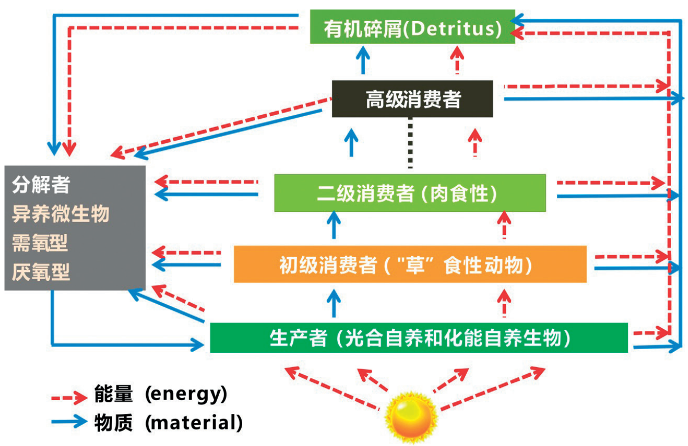


Figure 1. Modern marine ecology scheme

The project considers the ecosystem as an indivisible integration. Five subprojects are designed to systematically investigate (1) environmental changes, (2) biogeochemical cycles, (3) records of microorganisms (decomposers and producers), (4) ecological aspects of metazoans, and (5) diversity and phylogeny of metazoans during the Cambrian explosion, respectively.

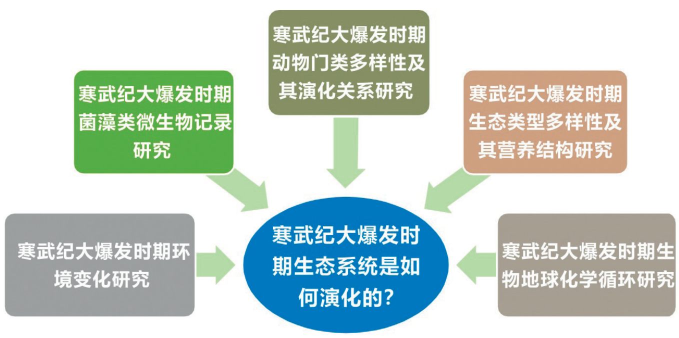


Figure 2. The core scientific issues of projects and project design scheme

The goal of the project is to reconstruct the ecosystem evolution in four dimensions by investigating spatial and temporal variations of marine ecosystems during the Cambrian explosion. A series of leading research achievements are expected from the project, which will promote the understanding of Cambrian fundamentally. Young scientists will develop excellent inter-disciplinary research capacities from this project and lead further research on Cambrian explosion in the future.

Multi-Scale Structural Regulation and Function Realization of Advanced Optical Film Materials

A normality of an information society is ubiquitous display. The new display produced by liquid crystal display (LCD) and organic light-emitting diode (OLED) is not only a window for information exchange, but also a command and control platform. It is an indispensable key device for high technology and national security as well as an essential part of daily routine. In 2017, the production capacity of the display panel in China mainland has surpassed South Korea, and been the topest in the world. Although the display industry in China is huge, it is still not competitively strong. The optical films used in the display industry, such as polarized and compensation films, determine the quality of display. However these films completely depend on import. It is an evidence of lacking core technology in the industry. Therefore, to turn China from a big producer to a manufacturing powerhouse of the display panel, basic research and core technology research and development of upstream critical materials are the only way.

In response to the basic scientific and technical issues in the manufacture of optical films, the National Natural Science Foundation of China has established a Major Program project "Multi-Scale Structural Regulation and Function Realization of Advanced Optical Film Materials". South China University of Science and Technology, Sichuan University, University of Science and Technology of China, Changchun Institute of Applied Chemistry of Chinese Academy of Sciences, and Hangzhou Normal University work together on the project on the following key topics:

Principle of inverse molecular design and precise synthesis of optical anisotropic materials.

Nonlinear rheological and non-equilibrium phase transition theory of precast optical films under coupled drive forces of concentration, temperature and flow field.

Relationship between structural coordinated orientation and optical anisotropy during stretching on multiple length-scales from functional groups, segments, whole chains, to condensed matter.

As planned, basic theory and technology of precise molecular design, precise structure control, and precision micro-machining are established. Then a system of basic theory and technology of self-owned optical film manufacturing is developed and the support for comprehensive localization of key display materials is provided. Furthermore, dominant research institutes and outstanding leading talents, and applied achievements of the basic research from leading optical film enterprises gathered in the project will be a realization of addressing major national needs with national funded basic research.

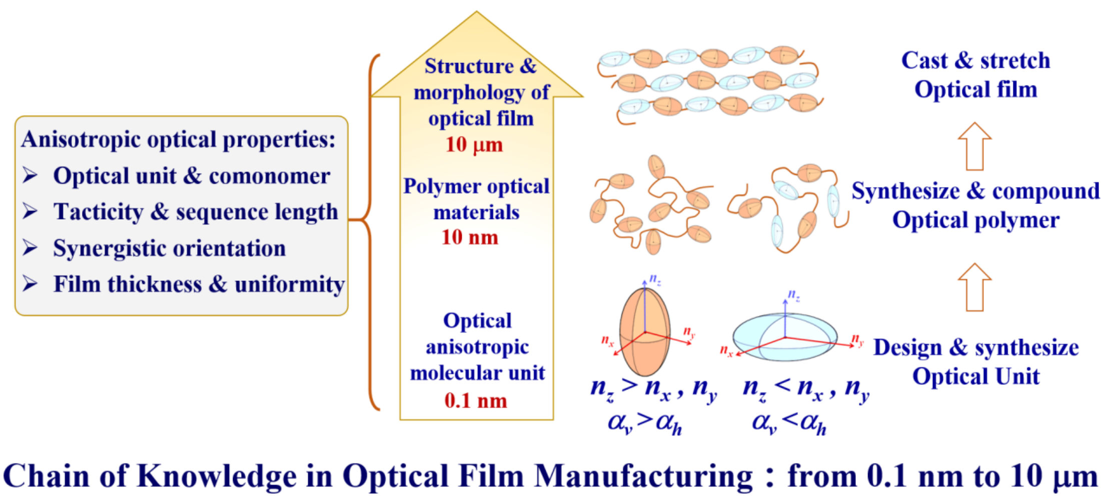


Figure 1. The amplification process of anisotropic optical properties of molecular units in optical film manufacturing

The Degradation Theory of Deep Sea Soil-Structure Interfaces and Engineering Safety

The Major Program project "The Degradation Theory of Deep Sea Soil-Structure Interfaces and Engineering Safety" is led by Kong Xianjing, who is an academician from Chinese Academy of Engineering and a professor from Dalian University of Technology. This project is cooperated among five universities, including Dalian University of Technology, Tianjin University, Hohai University, China University of Petroleum (East China), and Jilin University. The project, with the total funding of 19,450,000 yuan, will be implemented from 2019 and last for five years.

The project aims at emergent issues associated with the development of oil/gas resources in South China Sea and safety of deep sea engineering. Systematical investigations would be carried out to study the deep sea soil and the deep sea soil-structure interaction. Multi-disciplines, including the deep-sea engineering, geotechnical engineering, oil and gas engineering as well as geology engineering, are involved in the project. The key scientific issues, confining the oil/gas development from shallow to deep waters, should be abstracted in this project. Moreover, based on the comprehensive investigations, the project also aims to achieve independent innovations, major breakthroughs, and supporting developments.

The core scientific issue of the project is: the characteristics of the deep sea soil and the mechanism of the soil-structure interaction. The project will be implemented by involving three key scientific issues as follows.

(1) The internal structure evolution and coupled mechanism relating to the multi-phases of the deep sea soil. The complex mechanical mechanism of the deep sea soil at macro-scale essentially depends on the physical/mechanical/chemical mechanism of the soil under multi-phase and multi-field coupling at micro-scale. Therefore, intensive studies are required to investigate the thermal-fluid-mechanical properties, complex fabric, and evolution of cementation damage of the deep sea soil. Subsequently, constitutive models considering the multi-field coupling should be established and analytical approaches considering multi-phase and multi-field coupling should be developed for deep sea soils.

(2) The degradation mechanism for the deep sea soil-structure interfaces in deep sea engineering. Complex interactions and sophisticated mobilizations exist between the subsea structures and the surrounding soil and seawater. Therefore, it is urgent to illustrate the degradation mechanism for the deep sea soil-structure interfaces. Moreover, it is necessary to establish the analytical approach, which can consider the evolution mechanism at the soil-structure interface and the multi-phase coupling.

(3) Safety design and evaluation approaches for subsea structures. The failure mode and mechanism for the subsea structures, including the foundation systems, cables and pipelines, wells for hydrate production, the interface revolution mechanism under complex loading conditions will be illustrated. The safety design criteria and evaluation approach of subsea structures considering the sophisticated subsea structure-soil-fluid interaction will be developed.

The overall scientific aims of the project are summarized as follows. First of all, innovative developments will be achieved in the following three fields: (1) numerical models and simulating methods associated with the internal structure evolution and multi-phase coupling of the deep sea soil; (2) the degradation theory of soil-structure interfaces; (3) analytical theory or approach related to the soil-structure interaction under complex loading conditions. Secondly, stability analytical and safety design approaches should be used for subsea structures, and software systems with independent intelligent property right should be established for the sake of addressing deep sea geotechnical problems. The stability analytical and safety design approaches together with the software systems can be used to solve the critical problems that hamper the development of deep sea engineering, and provide scientific supports for the safety operation of deep sea engineering.

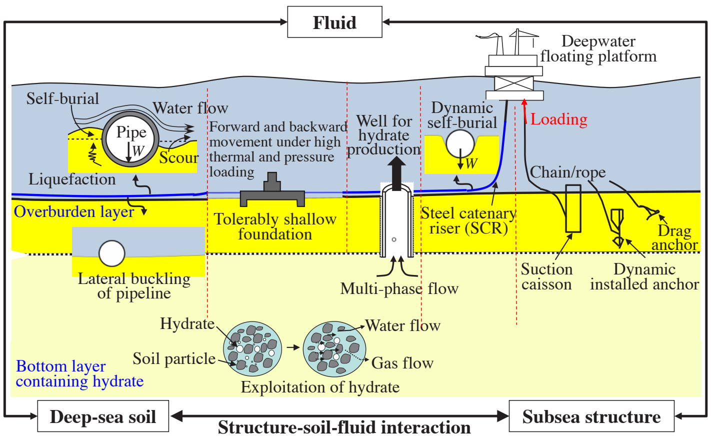


Figure 1. Key scientific issues

Theory and Application of Active Safety Control for High-Performance Aircraft Engines

The Major Program project "Theory and Application of Active Safety Control for High-Performance Aircraft Engines" will be launched in 2019, with the duration of 5 years and a direct funding of 20 million yuan.

The great merits of high-performance aircraft engines are their high stability, large thrust-to-weight ratio, outstanding acceleration performance and low fuel-consumption ratio. Simultaneously the engines possess more complex structures and adjustable components. However, traditional passive safety control with a preset fixed safety margin, combining with a switching control scheme between PID and Min/Max significantly restricts the high-performance aircraft engines to achieve a large controllable domain, high performance as well as fast response. It results in a great gap in thrust, response time and fuel consumption compared with the advanced international level. The project aims to substantially improve the aircraft engine performance through active control technology and to foster multidisciplinary and cross-disciplinary research.

The project is led by Dalian University of Technology, jointly with Beihang University, South China University of Technology, Northeastern University, and China Aviation Shenyang Engine Research Institute, forming an innovative basic research consortium. The project will be focused on the following three key scientific problems. (1) Identification and prediction for rotating stall and surge of high-performance aircraft engines. Surge security boundary changes in real-time, and the method of stall prediction and detection for dynamic characteristics of small nonlinear stall inception and rotating stall will be investigated. (2) Whole gas path dynamic adaptive model security domain parameters estimation of high-performance aircraft engines. High-precision and real-time modeling methods for aircraft engines will be developed. (3) Multi-modal and multi-objective active control of aircraft engines under quick response will be studied. The multi-objective dynamic optimization method and switched strategy based multiple mode active safety control method are studied under the influence of uncertainties, engine degradation, disturbances and coupling effects.

Experimental verification will be conducted on the platforms of the high-performance turbofan engine and the next generation high-performance aircraft engine. The main performance indicators such as the thrust and response speed will be improved significantly under safety operation of the engines. This project will provide both theoretical and technical support for the development of the advanced control system for aircraft engines.

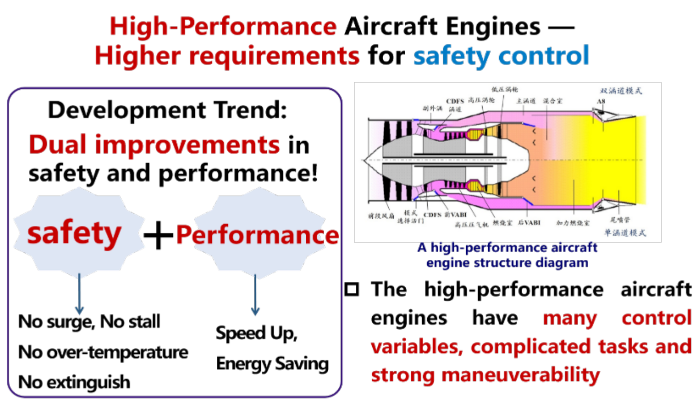


Figure 1. Meaning of the high-performance aero-engine active safety control

Basic Theory and Key Technologies of Functional-Oriented Molecular Material Transistors

The Major Program project "Basic Theory and Key Technologies of Functional-Oriented Molecular Material Transistors" was approved and initiated in 2018. The whole research period of this project is five years with a direct funding of 19.57 million yuan.

With the increasing demand of wearable and light portable applications, flexibility has become an important direction in the development of electronic devices. Molecular materials, with various physical and chemical properties, are one of the important functional systems for flexible electronic devices and have brought about some functional devices, such as organic field effect transistors, organic light emitting diodes and organic solar cells. Molecular material transistor (OFET) has broad applications in flexible display, information processing and other emerging electronic fields (Figure 1). Moreover, it is a typical example to study the basic problems of molecular devices.

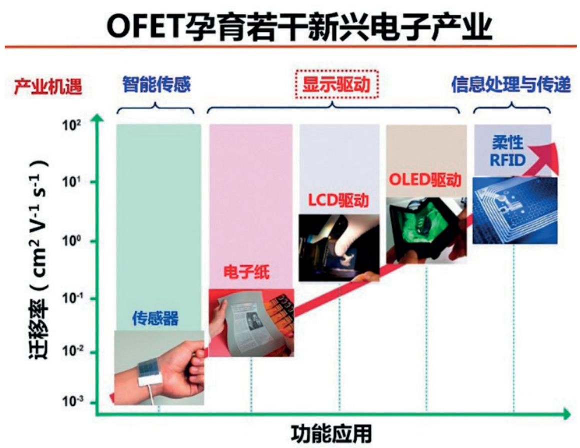


Figure 1. Some emerging electronics industries supported by OFET

Led by professor Liu Yunqi from Institute of Chemistry of Chinese Academy of Sciences, including researchers from Institute of Microelectronics of Chinese Academy of Sciences, Tsinghua University, Fudan University and Kunshan Institute of Technology, this project consists of four subprojects (Figure 2) and the research will be focused on the following five key scientific questions: (1) Multi-scale controllable assembly of highly ordered molecular aggregates. (2) Precise surface-interface controlling of device functional layer. (3) Solution processing technology for highly flexible OFET devices. (4) Device model and circuit construction of molecular material transistors. (5) Integration of flexible OFET driver circuit and organic light-emitting diode (OLED) screen.

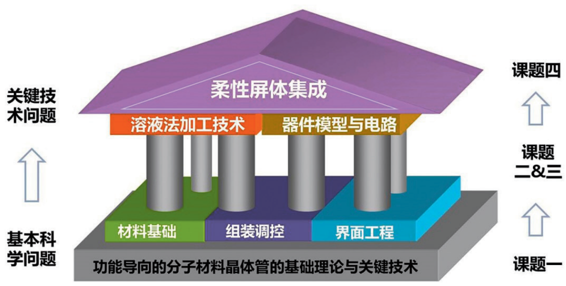


Figure 2. The relationship of the key issues and arrangement of subprojects

By solving the above scientific problems, the following goals are expected to achieve:

(1) to propose new technology and new methodology for the assembly process and interface controlling of organic molecular systems, develop molecular assembly method integrated with the device construction, reveal the factors affecting the performance of OFET, achieve multi-scale precise assembly of some ordered molecular aggregates, and obtain the devices with excellent performance to meet application requirements;

(2) to form a set of key technologies for fabrication and integration of flexible devices; the mobility of flexible devices exceeds 20 $cm^2 V^{-1} s^{-1}$, the curvature radius is 5 microns, and the bendable times are more than 10,000;

(3) to propose the controlling methodology of the device performance, achieve the law of the device function control, and develop the simulation models and parameter extraction software for OFET;

(4) to fabricate the OFET device with excellent performance, obtain the flexible display driving circuit, and develop a 5-inch display screen with the thickness of 1 mm and the curling radius of 1–3 mm.

It is anticipated that the implementation of this project will enhance the overall independent innovation capability of China in OFET research, and make OFET integrated modules successfully used in the application of OLED. Meanwhile, it will promote the rapid development of this field and bring up a team of outstanding scientists with international visibility.

Clonal Heterogeneity and Evolution in Malignant Hematopoietic Diseases

Among all kinds of tumors, the death rate of hematopoietic malignant is around 5/100,000. As one of the high fatality rate malignant tumors in China, hematologic tumors seriously affect family happiness and social stability. Tumor cell heterogeneity and clonal evolution are the core drivers of hematopoietic malignant development, progression and malignancy, and are also the source of refractory, drug resistance and recurrence. Acute myeloid leukemia (AML) is an aggressive malignancy of continuous accumulation of genetic alterations in hematopoietic stem/progenitor cells (HSCs/HSPCs), characterized by an uncontrolled proliferation of undifferentiated myeloid lineage. The origin, recurrence and drug resistance of AML are closely related to the heterogeneity of tumor cells and the process of cloning evolution, which is one of the best disease models to study the heterogeneity and cloning evolution of hematopoietic malignant cells. The study of the heterogeneity and clonal evolution of AML malignant cells not only contributes to the prediction, prevention and precise treatment of AML and other myeloid malignancies, but also guides the exploration and clinical transformation of the cloning and evolution law of other hematopoietic malignancies. The key aim of this project is to trace and depict the law of hematopoietic malignant cell heterogeneity and clonal evolution during the hematopoietic malignant development, progression and malignant transformation. The group also wants to highlight the mechanism under the influence of drug and bone marrow microenvironment on tumor cell heterogeneity and cloning evolution. In this study, we will dissect hematopoietic stem cells (HSCs) heterogeneity during ontogeny using single-cell techniques, including high-throughput single-cell transcriptomes and epigenomics. Based on acquisition of HSC heterogeneity, the study will further analyze the heterogeneity of hematopoietic malignant cells and its clonal evolution by monitoring transformation from chronic pre-leukemia diseases (e.g., Aplastic anemia, myelodysplastic syndromes and myeloproliferative neoplasms) to AML, so as to depict the premalignant mutational landscape of AML and identify the potential risk factors of developing AML. Additionally, the group will also investigate the intrinsic effects as well as extrinsic impacts from the microenvironment on clonal heterogeneity and evolution during therapy-induced AML relapse and drug resistance, which aids to unveil the underlying regulatory mechanisms. Ultimately, in aggregation of mutational landscape of AML and its regulatory molecular mechanisms, the study will conduct high-throughput drug screen and, eventually, accomplish clinical trials to develop novel therapeutic strategies for AML patients. In summary, this study will provide precision prevention and preventive intervention strategies for patients at high risk of progressing to AML as well as developing more efficient and safer therapy for AML patients.

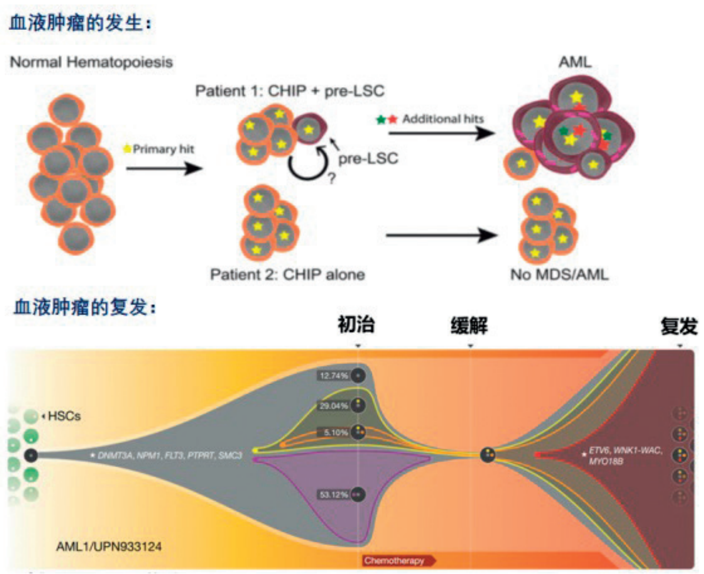


Figure 1. Heterogeneity and clonal evolution during hematological tumorigenesis and recurrence

The total research funding for this project is 17 million yuan, which is mainly intended to be used for (1) the multi-omics sequencing study of normal and leukemia cell heterogeneity and cloning evolution, (2) the construction of disease mouse model, (3) the cell heterogeneity and clonal evolution of microenvironment, and (4) the clinical transformation research.

The Geo-Herbalism of Chinese Material Medicines

Daodi-herbs are Chinese material medicines having a long history of clinical use, produced in particular areas, showing better quality and therapeutic effects than the same herb produced in other areas, and with good reputations and stable quality. Among the 500 popularly used Chinese material medicines, 200 species are daodi-herbs and show geo-herbalism. They account for 80% of the total amounts of all Chinese material medicines in clinical medications. The geo-herbalism theory of Chinese material medicines is an essence of traditional Chinese medicine (TCM) theories, which reflects the understanding of TCM on medications and the relationship of medications with the nature. It also reflects how ancient Chinese people view the quality of Chinese material medicines, the mode of quality control, and the relationships of herb quality with genetics and environment. The geo-herbalism theory is essentially a theory on good quality of Chinese material medicines. The geo-herbalism could be represented by the “adaptive phenotypes (advantage in appearance)” and “good quality (advantage in quality)” of geo-herbs (daodi-herbs), and by their “superior clinical efficacy (superior in clinical efficacy to non-daodi-herbs)”. Daodi-herbs, traditionally recognized as good quality herbs, are the embodiment of the geo-herbalism theory, and reflect the core of TCM theories. In this project, the study will elucidate the scientific explanation and the mechanism of formation for geo-herbalism mainly using *Panax* herbs (including Asian ginseng, Sanqi ginseng, and American ginseng) as a case. The project is divided into four subprojects, namely the chemical substance base, efficacy correlation, genetic causation, and environmental causation of the geo-herbalism of Chinese material medicines. This will be achieved from four aspects, namely genetic causation, environmental causation, chemical base, and therapeutic effects. Interdisciplinary methodologies and technologies in biology, molecular pharmacognosy, ecology, chemistry, and pharmacology will be combined to systematically study the geo-herbalism at multiple levels. The project aims to understand the genetic and environmental causation of geo-herbalism, and the mechanism of their interaction, as well as the chemical substance base and the efficacy correlation (relationship between geo-herbalism and therapeutic effects) of geo-herbalism. The natural, material, and pharmaceutical properties of geo-herbalism will be revealed and their correlations will be elucidated. Therefore, to establish a scientific quality evaluation system will pave the way to good manufacturing practice and sustainable use of Chinese material medicines, and will provide scientific evidences for their formulation and precise use in TCM clinical medication.

Figure 1. The development of Dao-di medicinal materials is the guarantee of the quality of Chinese medicinal materials

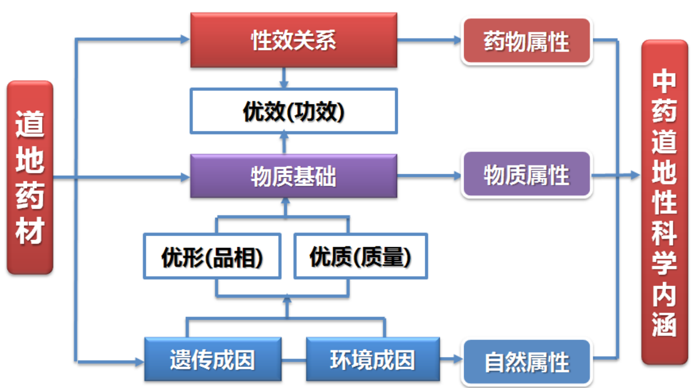


Figure 2. Key scientific questions and general research approaches of Chinese medicine research

2.2 Major Research Plan

Precise Construction of Chiral Matters at Multiple Levels

The Major Research Plan project "Precise Construction of Chiral Matters at Multiple Levels" was launched in 2018 and will last for eight years with a total funding of 200 million yuan.

The mission of this project is to address the key challenges in the area of chiral matters. The target developments include: new synthetic methodologies towards practical applications in the production of chiral drugs and agrochemicals, highly efficient strategy for obtaining enantiomerically pure chiral supramolecules and materials, and the corresponding characterization methods and theories. The outcomes of this project will provide key technologies which are applicable in the areas of medicinal science, pesticide industry, information science, and materials science. This project calls for the collaboration of outstanding scientists from the areas of chemistry, physics, materials science, and biology, and aims to promote the innovation capacity of China in chiral science.

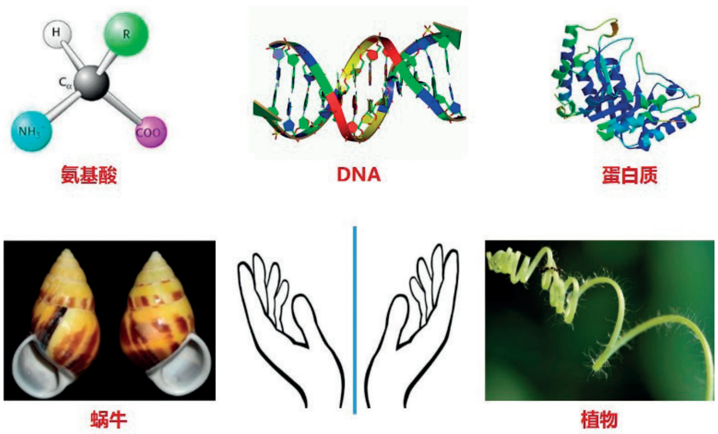


Figure 1. Precise construction of chiral matters at multiple levels

The chair of the scientific committee of this project is Professor Zhou Qilin of Nankai University. The focus of this project is how to realize the precise construction of chiral matters at molecular level and beyond. Breakthroughs in the following aspects are expected: high efficiency and selectivity in the precise synthesis of chiral molecules in their enantiomerically pure forms; regularity and controllability in the preparation of macroscopic chiral materials; molecular basis for modulating the performance of chiral functional materials; biological effects of chiral molecules. The implementation of this project will be focused on the following three key scientific issues.

(1) The precise construction of chiral molecules in their enantiomerically pure forms. Developing highly efficient chiral catalysts and novel asymmetric synthetic reactions, exploring the application of synthetic biology, big data and artificial intelligence in asymmetric synthesis, encouraging asymmetric synthesis based on cheap and readily available industrial feedstocks, providing transformative technologies for large-scale production of chiral chemicals and functional materials;

(2) The mechanism and rules of chirality transfer and amplification. Designing novel chiral macromolecules, chiral supramolecules and chiral materials, developing highly efficient methods for obtaining their enantiomerically pure isomers, investigating the chiral assembly and the structure of chiral materials beyond the molecular level, exploring the origin of chirality, and the mechanism and rules of chirality transfer, amplification, and control.

(3) The chiral effects and functionality of different enantiomeric isomers. Investigating the performance of chiral materials in physics and biology, exploring new principles, new technologies, new methods for the characterization of chiral materials, interpreting the relationship between the structures and performance of chiral materials, developing novel chiral functional molecules and materials.

The overall scientific objectives of this project include realizing highly efficient preparation of chiral matters at multiple levels (chiral molecules, chiral macromolecules, chiral supramolecules and chiral materials) in their enantiomerically pure forms by applying interdisciplinary new technologies, unraveling the origin of chirality, and the mechanism and rules of chirality transfer, amplification, and control, interpreting the relationship between the structures and performance of chiral materials, developing key technologies for large-scale preparation of chiral functional molecules and materials, and promoting the innovation capacity of China in chiral science.

Spatiotemporal Networks in Carbohydrate and Lipid Homeostasis

The Major Research Plan project "Spatiotemporal Networks in Carbohydrate and Lipid Homeostasis" was launched in 2018, with a period of 8 years and funding of 200 million yuan. This project focuses on metabolic homeostasis of the body at the individual, tissue, organ, cell and molecular levels. It systematically studies the spatiotemporal regulation of carbohydrate and lipid metabolism, and provides insights into the following key scientific questions: how the body and cells sense the changes of internal and external environment to regulate carbohydrate and lipid metabolism; how carbohydrate and lipid metabolites are transported and transformed intracellularly and extracellularly; how the tissues and organs coordinate to maintain metabolic homeostasis; and how metabolic remodeling occurs under physiological and pathological conditions.

The project is directed by a group of supervising experts, led by Professor Song Baoliang from Wuhan University. This project aims to address fundamental molecular mechanisms of carbohydrate and lipid metabolism under physiological and pathological conditions, emphasizing on the spatiotemporal network regulation. It focuses on the following 4 key scientific issues:

(1) Spatiotemporal sensing mechanism of nutrition and energy levels. Focusing on the sensing mechanism of nutrients, carbohydrate and lipid metabolites and the energy status at cell or organ levels, the major contents of this subject include the identification of the signaling small molecules, protein sensors and the mechanism of signal transduction; analysis of the crossover regulation between different sensing pathways of nutrients and energy homeostasis; identification of new mutations in genes that cause

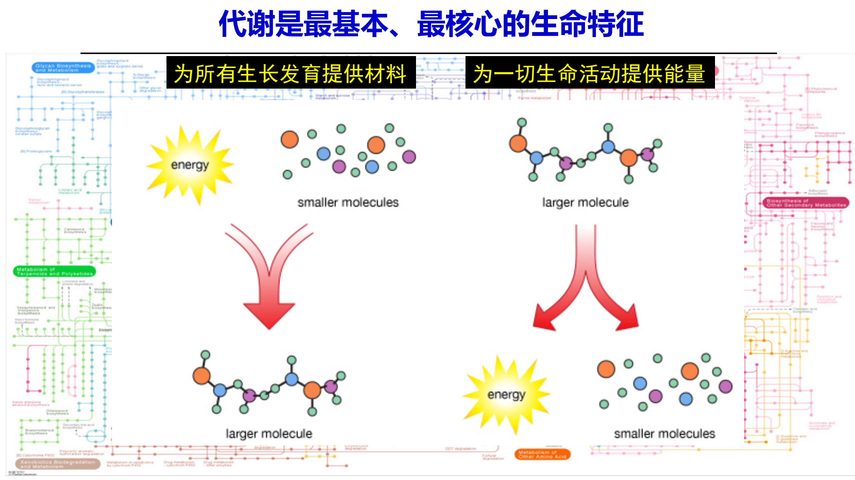


Figure 1. Metabolism is the most basic and core life feature

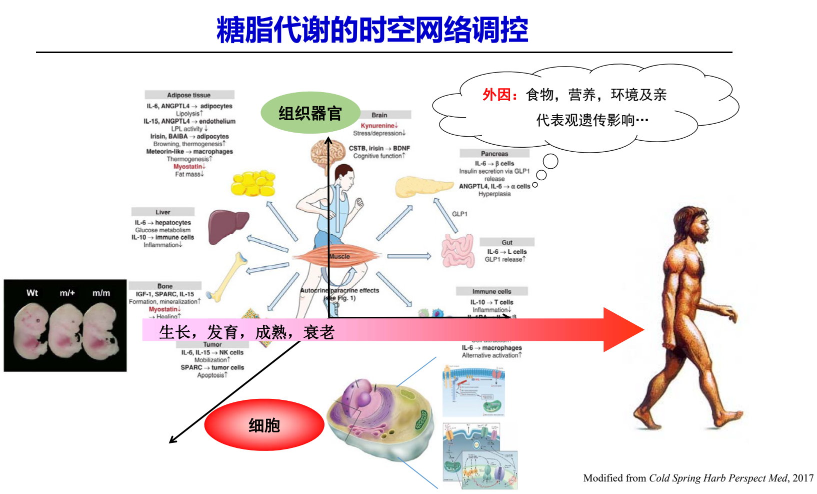


Figure 2. Spatiotemporal networks in carbohydrate and lipid homeostasis

abnormal carbohydrate and lipid metabolism in humans, and carrying out functional and mechanistic studies with different animal models.

(2) Production, transportation and transformation of carbohydrate and lipid metabolites. Focusing on the regulation mechanism of the production, transportation and transformation of metabolites, and centering on the dynamic changes of metabolites in carbohydrate and lipid metabolism, the major contents of this subject are the development of new techniques and tools to identify new metabolites and to study the spatiotemporal networks in carbohydrate and lipid metabolism; systematic analysis of the spatiotemporal dynamic changes of metabolites and metabolic networks; and to reveal the evolutionary rules of carbohydrate and lipid metabolism.

(3) Tissues and organ communication on metabolic information and regulation network. Focusing on the functional role of tissue and organ communication in the homeostasis of carbohydrate and lipid metabolism, the major contents of this subject are the metabolic coordination network, interaction model and information exchanging mechanism between tissues and organs; using bioinformatics, artificial intelligence, big data processing technology, etc., to establish models of metabolism homeostasis maintenance; discovering the specific metabolic signaling molecules (including exosomes, RNA, peptides, metabolites, etc.) and their functions; exploring the effects of gut microbiota on metabolism of the body and mechanism of interaction with other tissues and organs.

(4) Remodeling of carbohydrate and lipid metabolism in physiological and pathological processes. Focusing on the remodeling of carbohydrate and lipid metabolism in physiological and pathological processes of the body, the major contents of this subject are the mechanisms of physiological and pathological changes of the body caused by persistent metabolic remodeling, including dysfunctional regulation of central appetite, islet β cell compensation, peripheral changes of nutrients and energy metabolism, tumor growth, etc.; revealing the cellular heterogeneity of metabolic remodeling and its effects on the function of major metabolic tissues (liver, muscle, adipose tissue or related endocrine organs); real-time quantitative analysis of spatial distribution of carbohydrate and lipid metabolites in different tissues or subcellular structures, as well as their changes in the metabolic remodeling process.

The overall scientific goal of this project is centered on the spatiotemporal network regulation of carbohydrate and lipid metabolism, to reveal the sensing and response mechanisms of carbohydrate and lipid metabolism in the body, organs and cells; to analyze the dialogue between tissues and organs and its coordinated regulation network that regulates metabolic homeostasis; to discover the path and regulation mechanism of the production, transportation and transformation of important carbohydrate and lipid metabolites; to discover new rules of carbohydrate and lipid metabolism regulation and homeostasis maintenance; to clarify the roles of spatiotemporal metabolic changes in environmental adaptation and life health maintains; to reveal the fundamental mechanisms of loss of metabolic homeostasis in the development of a variety of metabolic diseases, and to develop new strategies for healthspan maintenance.

Inter-Sphere Interactions of the Earth System in the West Pacific Ocean

The Major Research Plan project “Inter-Sphere Interactions of the Earth System in the West Pacific Ocean” was launched in 2018 with a total funding of 200 million yuan, and will be completed in 8 years.

It focuses on the frontiers of Earth sciences and addresses national needs in this field. Regarding the West Pacific as a natural laboratory with great scientific value, this project seeks to explore the multi-sphere dynamical processes linked by fluids as well as cycle of energy and material. A multi-scale comprehensive research with multiple disciplines will be implemented to provide scientific and technical support to solve the major challenges related to climate, resource and environment issues.

Academician Wu Lixin from Ocean University of China serves as the Chair of Steering Committee. The essential scientific issue of this major research plan is the multi-sphere dynamics and energy and material cycle in the West Pacific. In particular, the project aims to address the following three key problems:

(1) Impact of the complex topography on ocean dynamics and climate system in the West Pacific.

The West Pacific is adjacent to Eurasian continent, possessing the complex topography and the most typical trench-arc-basin system in the world. The project will explore how this unique topography system influences ocean dynamics and climate system.

(2) Inter-sphere exchange of energy and materials on the sea floor in the West Pacific.

There are plenty of terrestrial inputs, active submarine hydrothermal and cold springs, and extensive fissures on the sea floor in the West Pacific, making the area an essential place to investigate the inter-sphere exchange of energy and materials. The project aims to reveal how this inter-sphere energy and material exchange influences the lithosphere evolution and abyssal circulation.

(3) Plate subduction and fluid-solid Earth interactions in the West Pacific.

The West Pacific is a natural laboratory for plate subduction and deep Earth processes. The fluid-solid Earth interactions are important to deep mantle cycle and evolution of lithosphere, which are also relevant to natural resources and environment. This scientific question is crucial for complement of plate tectonics and development of new theories of Earth sciences.

This project aims to reveal the multi-scale ocean dynamics and plate subduction process in the West Pacific, the mechanisms underlying the energy and material exchange, the dynamical linkage between Earth’s surface layer and deep layer, and the role of fluids in multi-sphere dynamics. By extending the Earth system science from the Earth’s surface layer to deep layer and conducting the multi-scale and multidisciplinary research, this project will lay a multi-sphere framework for the Earth system science.

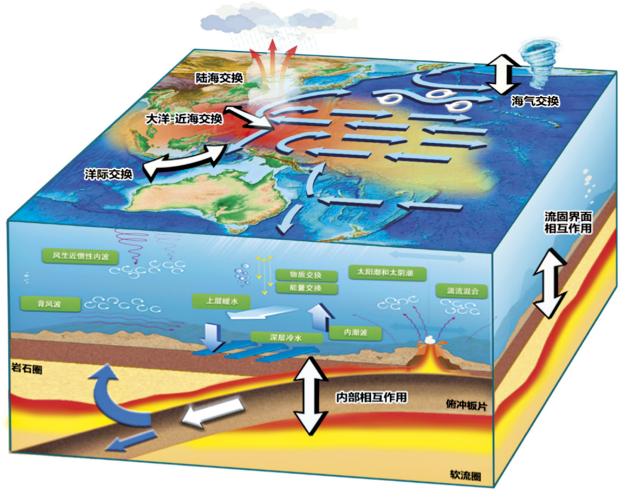


Figure 1. Inter-sphere interacations of the earth system in the West Pacific Ocean

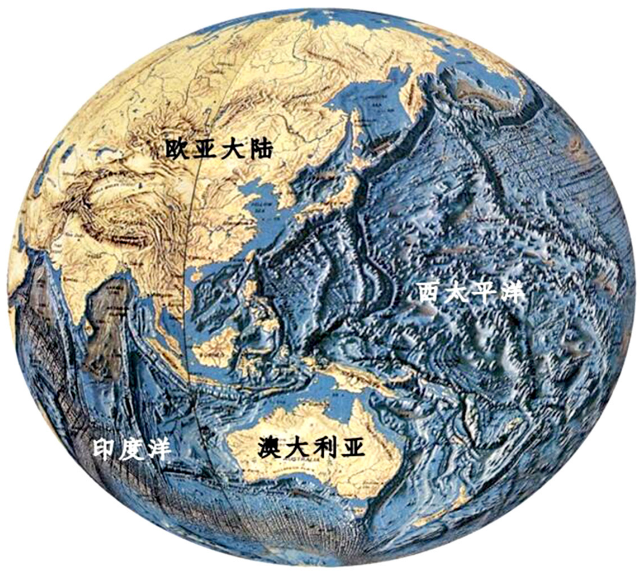


Figure 2. West pacific ocean area

Fundamental Research on High-Temperature Materials, Advanced Manufacture and Fault Diagnosis for Aero-Engines

The Major Research Plan project "Fundamental Research on High-Temperature Materials, Advanced Manufacture and Fault Diagnosis for Aero-Engines" has been launched in 2018. The funding cycle is 8 years with a funding of 200 million yuan. Professor Xu Huibin, an academician of Chinese Academy of Engineering working in Beihang University, is the director of the steering expert group.

As the aero-engine is a pillar of great power in China, rapid breakthroughs in this area are of great significance for promoting national economic development and elevating core competitiveness. Because the aero-engine's long-term service under the environments of high temperature, high pressure, strong torsion, alternating load, etc., as well as significant complexity in the materials preparation and manufacturing techniques of key component, the safety assurance of aero engine during operation becomes extremely crucial. However, the national fundamental scientific research on high-temperature materials, advanced manufacture and fault diagnosis is severely inadequate, which strongly restrict the development of aero-engines in China. The project will focus on the scientific foundation embedded in the three major bottleneck problems in aero engines, i.e., high-temperature materials, advanced manufacture and fault diagnosis. It will also emphasize the demand-goal orientation and achievement-application connection. Thus it supplies the original innovations and scientific supports to national technical progress and industry development of aero-engines.

The project is to address the following three key scientific problems:

(1) The performance optimization and long-life service stability of the high-temperature material in aero-engines. The major directions include: (a) the composition design and phase optimization of high-temperature materials in aero-engines as well as the relationship between the microstructure evolution and the high-temperature performance under service conditions; (b) the generation, cross-scale characterization and control of the structural defects in the high-temperature materials used for aero-engines under preparation and service conditions; (c) the exploratory research on new types of high-temperature materials for aero-engines.

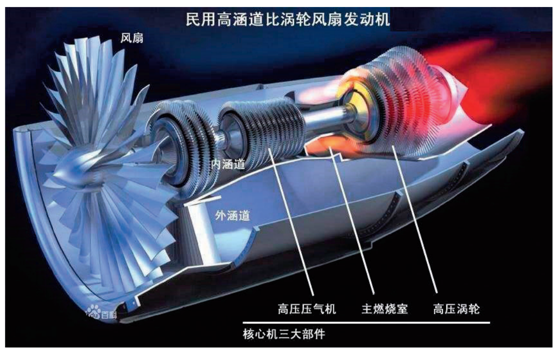


Figure 1. Turbine engine with high bypass ratio for civil use scheme

(2) The coordinative control mechanism of shape and performance in manufacturing the key components in aero-engines. The major directions include: (a) the forming mechanisms and accuracy control principles of the key components in aero-engines; (b) the action mechanisms of special/multiple energy fields on the high-temperature materials in aero engines; (c) the mechanisms for the evolution and control of the surface states of the key components in aero engines.

(3) The principles of the information perception and intelligent diagnosis & prediction of aero engines state. The major directions include: (a) the theories and methods of the information perception and detection of aero-engines; (b) the artificial intelligence based diagnosis techniques and big data information fusion methods oriented by aero-engine malfunctions; (c) the fault-tolerant control theories and less-points state measurement methods.

The overall scientific goals of the project lie in: facing the national strategical objective, aiming at the research frontiers of the high-temperature materials, advanced manufacture and fault diagnosis in aero engines. Research on the relevant fundamental scientific problems is to be carried out through interdisciplines and deep integration in order to improve the original innovation ability and international influence of the fundamental research on high-temperature materials, advanced manufacture and fault diagnosis in aero engines. Through the relatively stable and the stronger support of the plan, an international-leveled team relevant to the fundamental research of aero engines will be gathered and trained.

Functional Visualization of Molecular Events in Tumor Progression, Diagnosis and Therapy

The Major Research Plan project "Functional Visualization of Molecular Events in Tumor Progression, Diagnosis and Therapy" was launched in 2018, with a period of 8 years and a funding of 200 million yuan.

The project aims to provide a new perspective for the malignant nature of tumors by functionally visualizing the key molecules of tumor progression, diagnosis and therapy. The project will focus on screening the key molecules in tumor progression and identifying their function, characterizing molecular network and phenotypic spectrum, exploring the strategies for tumor diagnosis and evaluation of therapeutic outcomes based on functional visualization of key molecules. The project will also elaborate the molecular basis of tumor imaging, and the dynamic evolution mechanism of tumors and their microenvironment heterogeneity. The results of this project are expected to clarify the biological characterization and malignant nature of tumors at various stages of their progression, and determine the significance of imageological-pathological-histological fusion diagnosis. Implementation of this project will accelerate the transformation of tumor basic research achievement to clinical diagnosis and treatment, and provide scientific basis for improving the five-year survival rate and reducing the mortality rate of cancer patients in China.

The steering team guiding this project is headed by Academician Bian Xiuwu from the Army Medical University. The key scientific question of this project is to extract information of key molecules during tumor progression, identify their characteristics, visualize their function and explore their diagnostic and therapeutic significance. The organization and implementation of this project will focus on the following five scientific issues:

(1) Imaging and molecular image characterization of early tumors: based on functional and quantitative characteristics of tumor-specific molecules, this project aims to study visual identification of early tumors, develop new molecular imaging markers, establish accurate correlation between image signals and molecular functions, develop new molecular image methods for early detection of curable early tumors, and provide new approaches for the preventive intervention of early tumors.

(2) Visualization of the evolution of tumor immune and metabolic microenvironment: using multi-mode molecular imaging technology, this project aims to develop new molecular imaging techniques to visualize the evolution of tumor immune processes and metabolic microenvironment, analyze dynamic changes of the interaction between tumor cells and stromal cell, as well as different immune inflammatory cells during

Figure 1. Functional visualization of molecular events in tumor progression, diagnosis and therapy

tumorigenesis and tumor progression. This project also aims to visualize the metabolic status of tumor cells or immune cells using molecular imaging technology from the perspective of tumor metabolism, and analyze the mechanism of interaction between cells and changes of metabolic activity affecting tumorigenesis and tumor progression.

(3) Intelligent diagnosis based on combination of imaging, pathological and multi-omics of tumors: using artificial intelligence technology and big imaging data of tumors, this project aims to develop new radiomics methods, mine deep quantitative information from big imaging data to reflect tumor biological information including pathological features and genetics changes, and explore the application mode of radiomics in accordance with the clinical needs of tumor diagnosis and therapy. In addition, based on in vivo imaging and in vitro pathological and multi-omtics information (including proteomics, genomics, metabonomics and so on) of tumors, this project aims to develop intelligent fusion analysis technology characterized by macro-meso-microcomplementarity, in vivo and in vitro binding, and structure-function-molecule superposition, to make tumor diagnosis, evaluate therapeutic effect of tumors and predict prognosis of tumor patients.

(4) Molecular classification of tumor heterogeneity based on functional visualization of molecules: this project aims to visualize heterogeneity of tumor cells and main components of tumor microenvironment (such as vessels, lymphatic vessels, fibroblasts, immune cells and extracellular matrix, etc.) using novel in vivo molecular imaging techniques, extract image features for functional classification based on molecular information, construct functional classification system of tumor molecular imaging by combination of histopathology, molecular pathology and clinical manifestations of tumors, and explore "non-invasive" pathological diagnosis techniques.

(5) Molecular image monitoring for sequential treatment of tumors: this project aims to establish accurate correlation between image signal and the expression of drug targeting molecule by using new molecular imaging technology, visualize the active state of drug targets, and guide the selection of anti-tumor drugs. During drug treatment, multi-mode molecular imaging technology will be used to constantly monitor the active state of drug targets so that the dosage of drugs and sequential treatment plan could be adjusted in time. In addition, this project aims to visually analyze the functional status of tumor cells, stromal cells, immune cells and inflammatory cells, investigate the interaction between tumor cells and microenvironment in the course of drug treatment, and investigate the effects of drug therapy on cell metabolism, immune microenvironment and drug target activity, to guide sequential treatment of tumors.

2.3 Science Fund for Creative Research Groups

Structural Optimization: Theory, Method and Application

The research group of "Structural Optimization: Theory, Method and Application" was granted the Fund for Creative Research Groups by the National Natural Science Foundation of China in 2018. The group is led by Professor Gu Xu of the Department of Engineering Mechanics and the State Key Laboratory of Structural Analysis for Industrial Equipment in Dalian University of Technology and key members include Professor Cheng Gengdong (CAS Academician), Professor Liu Shutian, Professor Li Gang, Professor Kang Zhan and Professor Wang Bo, all from Dalian University of Technology.

The group's works in structural optimization have produced a long-term academic impact in the field. The research work on regularization of solid elastic thin plates is widely recognized as the ground-breaking work of modern structural layout optimization theory, which has sparked off the entire field of structural topology optimization. The group have also effectively addressed the long-standing challenges on the study of singular optimal solution of structural topology optimization, which is considered as a "milestone contribution". In recent years, a new structure topology optimization framework based on an explicit geometric description has been systematically established by the group members, which provides a novel approach for resolving challenging problems in related fields.

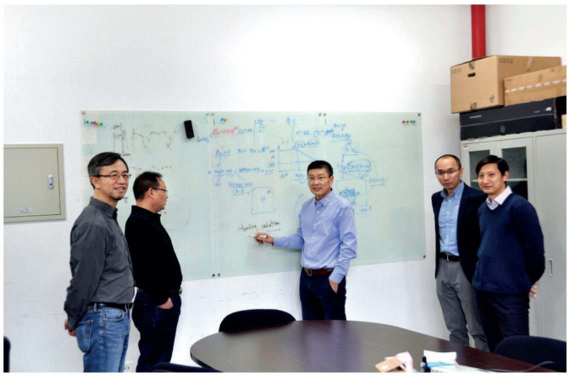
With the support of the Fund for Creative Research Groups, the group is going to lay their research focus on the study of large-scale structural topology optimization, advanced materials/structure-oriented optimization design, structural optimization theory and method considering uncertainty and data-driven intelligent optimization design. The group aims to initiate several research directions leading the research trend in structural optimization, push forward the frontiers of the research area and provide solid theoretical foundations, methodological supports and self-designed software tools to resolve the pivotal challenges in structural optimization arising from the innovative design of nationally demanding equipment and structures.

Galactic Structure, Formation and Evolution

The research group of "Galactic Structure, Formation and Evolution" was granted the Fund for Creative Research Groups by the National Natural Science Foundation of China in 2018. The group is led by Professor Mao Shude of the Tsinghua Center for Astrophysics at Tsinghua University and other members include Professor Cui Wei, Professor Mo Houjun, Professor Li Cheng, Professor Feng Hua, and Associate Professor Mao Yi.

Astronomy has now entered the precision cosmology era. Although a basic framework for the formation of cosmic structures and galaxies has already been in place, many key questions still remain unanswered: How do filamentary large-scale structures and the diverse population of galaxies emerge? Where are the "missing" baryons in the local Universe? What is the nature of dark matter which dominates the evolution of galaxies and the Universe? To answer these questions, many next-generation large surveys and telescopes from space and ground have been proposed, often led by the US and European countries, the traditional powerhouses in astronomy. The innovation group will also attempt to shed light on these issues.

With the support of the NSFC, this group will use multi-wavelength observational data and different theoretical methods, combined with expertise on instrumentation development, to study the internal structure, formation and evolution of galaxies on three scales: galaxies, groups/clusters of galaxies and large-scale structure. First, this group will study the internal physical processes within galaxies using their observed properties, and probe the chemo-dynamics, star formation, gas accretion processes and physics of active galactic nuclei of galaxies and their statistical properties. Second, the group will perform theoretical studies of the evolution of the large-scale distribution of galaxies, using both numerical simulations with constrained initial conditions and semi-analytic techniques. Finally, the group will study the circum-galactic, inter-galactic media and reionization processes and their influences on galaxy formation. The group will also perform feasibility studies for the proposed satellite mission "Hot Universe Baryon Survey" (HUBS) and optimize its science goals and designs.



The group will join their efforts in order to make significant advances in this field. They will propose science-driven missions and instrumentations for the future and endeavor to achieve breakthroughs in this frontier field of astronomy.

Surface Physical Chemistry Involved in Catalytic Conversions

The research group of "Surface Physical Chemistry Involved in Catalytic Conversions" led by Professor Wu Kai from the College of Chemistry and Molecular Engineering of Peking University was granted the Fund for Creative Research Groups by NSFC in 2018. Key members of the team include Professor Liu Haichao, Professor Ma Ding, Professor Wang Yuan, Professor Xu Dongsheng, Professor Gao Yiqin and Professor Zheng Junrong.

To tackle key issues such as structural and dynamic evolution of active sites and interaction of reactants with the sites during catalytic processes in energy industry, this project is to carry out combined experimental and theoretical studies on rational design and synthesis of catalysts, catalytic performances, surface active sites, reaction mechanisms and energy variations. By using methodologies for preparation of supported transition metal catalysts previously developed by the team, the investigation will be made on low temperature catalytic activation and conversion of the C-O bonds involved in low-carbon molecules such as CO, CO_2 and C_1-C_3 polyols. The key point of this project is to explore at the atomic and molecular levels the physico-chemical processes on the surfaces of practical and model catalysts by using ultra-high spatio-temporal resolution techniques. Enhanced sampling method developed by the team members will be employed to theoretically analyze various yet complex inter-molecular interactions. A combination of QM/MM calculations and the sampling methodology allows fast mapping of the reaction free energy surfaces without pre-defined reaction coordinates and search for intrinsic reaction pathways. These theoretical calculations would help disclose surface catalytic reaction mechanisms of small molecules. The whole project is to provide scientific basis for the development of novel catalysts for the activation of the C-O bond in small molecules involved in energy industry. In the past five years, this team made remarkable breakthroughs in catalysis and published more than 260 papers in prestigious journals including *Science* and *Nature*.

In 2018, the group achieved the following major advances in research: (1) Thermally stable Au single-atoms supported by monolayered CuO grown at Cu(110) were successfully prepared. And it was confirmed that the charge transfer from the CuO support to single Au atoms plays a key role in tuning the activity for CO oxidation. (2) A highly selective catalyst composed of highly dispersed iron species on TiO_2 was found for the transformation of methane to methanol. (3) A new strategy was developed for selective hydrogenation of acetylene in the presence of abundant ethylene, in which a defective nanodiamond-graphene (ND@G) was used to prepare an atomically dispersed Pd catalyst. (4) The group found that molybdenum carbides and nitrides preferentially activate C=O and C-OH bonds in liquid-phase hydrogenation of bioderived furfural, leading to highly selective formations of furfuryl alcohol (FA) and its subsequent hydrogenolysis product (2-methyl furan (2-MF)). Pure-phase α-MoC is the most active catalyst for furfural hydrogenation. (5) A photo-driven FTO process was realized over Fe_5C_2 catalyst under photoirradiation. The unique slight oxygen-modulated Fe_5C_2 structure formed in situ under the photo-irradiation condition, resulting in high selectivity to olefins. (6) The catalytic synthesis of multi-carbon alcohols (MCA, $C_nH_{2n+1}OH$, $n \geqslant 3$) and higher hydrocarbons from CO_2 and H_2 under low or even ambient temperature were realized over a prepared bimetallic catalyst composed of nanoparticles of Pt and Ru supported on Fe_3O_4. (7) By employing ultrafast mid-infrared microspectroscopic probes to detect excitonic internal quantum transitions, direct monitoring of the interplay between free carriers and insulating interlayer excitons between two atomic layers was realized. (8) The molecular structure of a catalytically active key intermediate was determined on a phosphorus–nitrogen PN^3P–Ru catalyst in solution by employing 2D IR spectroscopy measuring vibrational cross-angles.

Biological Particle Design for Vaccines and its Industrial Application

The group "Biological Particle Design for Vaccines and its industrial Application" was granted the Fund for Creative Research Groups by NSFC in 2018. The group is led by Professor Ma Guanghui of the Institute of Process Engineering, Chinese Academy of Sciences and key members include Professor Ge Wei, Professor Wang Dan, Professor Su Zhiguo, Professor Wang Wei and Professor Yan Xuehai.

The group is supported by two state key laboratories (one in biochemical engineering and one in multi-phase complex system) and has already made internationally influential research findings in construction of uniform and controllable particles, interactions between particle and protein molecules, and multi-scale structural simulation and flow field analysis of particles. Members of the group have been awarded one Second Prize of the State Technological Invention Award, six provincial and ministerial awards (first prize), three China International Science and Technology Cooperation Award, second Awards for Asian Youth Outstanding Contribution in Biotechnology by the Asian Federation of Biotechnology (AFOB), the TWAS-TWOWS-Elsevier Young Women Research Award, and three Hou-De-Bang Prize of Chemical Engineering Technology. In recent 5 years, the team published 281 SCI-indexed papers in which 35 were selected as ESI top 1% highly-cited paper, and 51 books/chapters including the 20th section in the famous *Perry's Chemical Engineers' Handbook* (8th). The group has been authorized 6 international patents and 164 Chinese patents and completed many industrialized projects with clinical application and production licenses in collaboration with industrial partners.

The group aims at the vaccine industry which plays a major role in the prevention and treatment of infectious diseases and cancer. The big challenge is that most of the new generation vaccines (virus-like particle, VLP) are unstable in production, transportation and utilization. To solve this problem, the group proposes innovative strategies especially in biological particle design and production process design. The key scientific problems to be solved include: (1) the inactivation mechanism of vaccine particles in production and application which is the main obstacle for quality control of vaccines, (2) strategy for vaccine particle storage at room temperature, (3) systematic knowledge for particulate adjuvant construction, (4) new theory and simulation methods for soft biological particles with the characteristics of deformability and fluidity.

The project expects to provide theoretical and technological support to vaccine stabilization in the industrial production and clinical application of novel vaccines products and contribute to the improvement of vaccine quality and reduction of health risks.

Evolutionary Conservation Biology of Endangered Animals

The Creative Research Group for "Evolutionary Conservation Biology of Endangered Animals", which is led by Professor Wei Fuwen, academician of CAS, in Key Lab of Animal Ecology and Conservation Biology, Institute of Zoology, CAS was funded by NSFC in 2018. This group is composed of four core teams in this key lab which are related and also have different research scopes, and its members include Professor Li Ming, Professor Du Weiguo, Professor Zhan Xiangjiang and Professor Hu Yibo.

This group proposes to probe the mechanisms of evolution, adaptation and response to environment change of flagship endangered animals in China under the theoretical context of evolutionary conservation biology, and further to conduct the forecast analysis of their extinction risk. The group aims to make systematic and original contributions for conservation biology of endangered animals based on this project in the future. This group systematically carried out conservation biology and evolutionary biology of endangered animal in China such as giant panda and snub-nosed monkeys based on a variety of omics and ecology methods, which clarified evolutionary history, population demographic histories, endangered mechanism and evolutionary potential of endangered animals and also revealed their ecological and genetic mechanisms of adaption to different environments based on studies of morphological, behavioral, diet, physiological, genetic, and gut microbiota. These important scientific achievements indicated this group has made great contributions in phylogenomics, population genomics, metagenomics, ecological and genetic mechanisms of adaption of endangered animals. These major findings have been published in high profile journals such as *Science*, *Nature Genetics*, *Proceedings of the National Academy of Sciences of the United States of America*, *Biological Reviews*, *Current Biology*, *Molecular Biology and Evolution*, *Molecular Ecology* and *Ecology*.

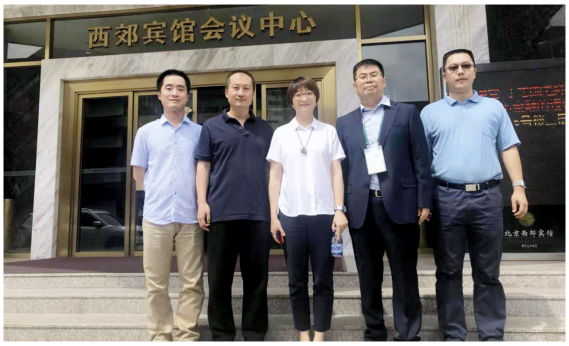
This group will focus on evolutionary process, ecological and genetic mechanisms of adaption to environment, adaptive strategies and response to global climate change, and forecast of extinction risk of endangered animals based on the multi-level and multi-dimensional integration of macro and micro research in the era of big data, which will clarify endangered process and mechanism and help design scientific strategies of conservation and management for endangered animals. This group will make a breakthrough in strategies of adaption and response to environment change, interspecific effect on adaptive strategies, and the forecast of extinction risk under global climate change, which will make a great contribution to conservation biology in the future.

Metabolic Biochemistry

The Creative Research Group for "Metabolic Biochemistry" to study intracellular metabolites signaling was funded by NSFC in 2018. Headed by professor Shimin Zhao from the Obstetrics & Gynecology Hospital of Fudan University, group members professors Yanhui Xu and Dan Ye from Institutes of Biomedical Sciences (IBS), professor Xiaohui Wu from Institute of Developmental Biology and Molecular Medicine (IDM), professors Huiru Tang and Wei Yu from School of Life Sciences, Fudan University, Shanghai, China, will work together to achieve their projected goals.

In their previous studies, group members identified and confirmed cell signal controlling functions of a number of intracellular metabolites, among them include a-ketoglutarate, 2-hydroxylglutarate and acetyl-coenzyme A. They had further developed methods in detecting metabolites sensing proteins that non-covalently or covalently interact with specific intracellular metabolites. This enabled them to study metabolites signaling systematically. They had successfully found that tRNA synthetases are sensors of amino acids and amino acids signals can be transmitted through tRNA synthetases–mediated lysine amniacylations, paved ways to understand pathologic mechanisms of diseases that are linked to amino acids deregulation and showed the potential to study metabolites signaling cell wide.

Aiming to elucidate a comprehensive intracellular metabolites signaling network, the members of this group will first focus on metabolites that are deregulated in such human diseases as cancers, diabetes and cardiovascular diseases, identify their sensory proteins, explore the cellular signaling pathways that are regulated by them. Their long-term goal is to make breakthroughs in understanding molecular mechanism of metabolites signaling systematically and exploring novel intervening approaches to diseases based on interfering metabolites signals.



Magnetospheric Dynamics

The Creative Research Group on "Magnetospheric Dynamics" led by Professor Cao Jinbin at the MIIT Key Laboratory of Space Environmental Monitoring and Information Processing at Beihang University was granted the Fund for Creative Research Groups by NSFC in 2018. Key members of the group include Professor Malcolm Dunlop, Professor Fu Huishan, Professor Yu Yiqun, Professor Liu Wenlong, and Professor Keizo Fujimoto.

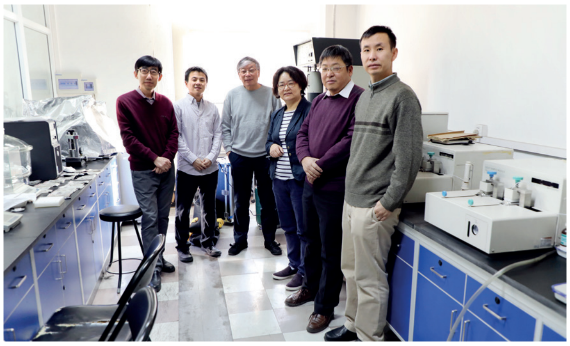
The Earth magnetosphere, in-between the solar wind and ionosphere/thermosphere, is an important orbiting area for all kinds of application satellites and space station. Hazardous space weather, such as magnetic storms/sub-storms and particle storms, poses severe threats to the space-borne assets. The key scientific questions in the magnetospheric dynamics lie in how the magnetic storms occur and how the solar wind-magnetosphere-ionosphere system couple with each other. This project will not only unveil the mystery of various space weather phenomena in the fully coupled system, but also improve comprehensive numerical modeling of the system for a better prediction of the hazardous space whether in order to prevent disastrous impact of the space weather on human activities.

This group originates from the "Space Environment Science and Technology" creative research group of Beihang University with rich collaboration experience among the members. The group has long been devoted to the study of magnetospheric dynamics and has made significant achievements in research of dynamic of magnetosphere and magnetosphere-ionosphere coupling. Contributions include revealing for the first time the dynamic process of energy transport in the magnetotail, revealing the controlling mechanism of the dynamic variation of radiation belt electrons, proposing the new idea that the energy conversion during magnetic reconnection happens at O line, discovery of the new mechanism of electron

acceleration of electrons during reconnections, discovery of the mechanism of dipolarization front formation, discovery of the rising-tone magnetosonic wave, proving the observational evidence of the coupling of current between magnetosphere and ionosphere, and establishing an accurate empirical model of plasmapause location. In the past five years, this group published 178 peer-reviewed SCI journal papers, including 117 papers on *Journal of Geophysical Research* and *Geophysical Research Letters*. Research results were highlighted for 9 times either by American Geophysical Union or by international spacecraft missions. Group members received 12 awards from International Academy of Astronautics, International Space Research Council, NASA, European Space Agency and International Union of Radio Science.

With the support of NSFC, this group will focus on the key issues of magnetospheric dynamics and modeling based on the ground-based and in situ observations of the solar-terrestrial space environment, and strive to achieve scientific breakthroughs in the basic physical processes such as magnetotail reconnection, triggering of Earth's megnetospheric storms, coupling between solar wind, magnetosphere and ionosphere. This group aims to become an active and influential research team in the international academic community for magnetospheric dynamics, and will participate actively in international space exploration missions.

Ecological and Health Risks of Pollutants in Regional Environment



The environmental processes and risks of pollutants in regional environment have attracted worldwide attention. In order to reveal the ecological and health effects of trace environmental pollutants, it is necessary to carry out a comprehensive study on the environmental process of pollutants from discharging to disposition in different media and subsequent toxicological effects. Therefore, the College of Urban and Environmental Sciences of Peking University introduced Dr. Hu Jianying from Japan in 1999 to lead the studies on the ecological and health risks of pollutants in regional environment. After nearly 20 years, the research group "Ecological and Health Risks of Pollutants in Regional Environment" led by Professor Hu Jianying, was granted the Fund for Creative Research Group by NSFC in 2018. Key members include Professor Tao Shu, Professor Wang Xuejun, Professor Wang Xilong, Dr. Liu Junfeng, and Dr. Wan Yi.

With the rapid development of economy in China, environmental pollution becomes more and more serious, and the relationships between environmental pollution and ecological/health risks deserve more attention. Carrying out systematic research on the regional environmental process of pollutants and subsequent ecological and health effects, the group has clarified the occurrences and fates of the pollutants in the regional environment, and successfully modeled the multimedia fates of the pollutants in the national scale. In the biological processes of the pollutants, the group has elucidated the behaviors and mechanisms of trophodynamics of numerous pollutants, and discovered a new metabolic mechanism of pollutants to exhibit toxicities. The ecological effects and toxicological mechanisms of typical pollutants under low concentration and long-term exposure were systematically elucidated. The impacts of pollutants on the fishery resources and health of endangered species in China were comprehensively assessed. Meanwhile, the new health issues of pollutants were revealed and a new method of toxicity evaluation for wildlife in regional environment was provided.

On the basis of the previous research, the group aims at solving the major issues of environmental pollutions in China, and takes the identification of ecological health risk factors in regional environment as the main scientific problems. The group will further quantify the emission, transport, evolution and deposition of pollutants at different spatial and temporal scales, develop the simulation technologies of pollutant migrations in the regional environment, and establish a comprehensive exposure assessment method for trace pollutants. It is expected that a high-throughput diagnostic method for systematically identifying the health status of aquatic animals and a high-throughput identification technique for screening toxic chemicals in environmental samples will be developed to reveal the causal agents related with the health problems observed in wild animals.

With the support of NSFC, the group aims to establish a world-class research platform for studying behaviors and ecological health effects of pollutants in regional environment. The group will make use of their expertise and interdisciplinary advantages, striving for new discoveries and breakthroughs in the research on ecological and health effects of pollutants in regional environment. The group also aims to establish a comprehensive scientific system in the field of ecological and health risks of pollutants in regional environment to provide a technical basis for environmental management, and finally build this research group into a first-class and high-level influential team in the world.

Advanced Electromagnetic Technology and its Application

The Creative Research Group “Advanced Electromagnetic Technology and its Application” was approved in 2018 with a total funding of 10.5 million yuan and a execution period of six years. With the support from the State Key Laboratory of Advanced Electromagnetic Engineering and Technology, Huazhong University of Science and Technology, the group attracts and gathers the talents in high magnetic field, pulsed power supply, energy storage and electromagnetic measurement, including academician of the Chinese Academy of Sciences, and winners of the National Science Fund for Distinguished Young Scientists, Chang Jiang Scholars Program and the Program for New Century Excellent Talents in University. The group focuses on the research in the field of the fundamental theories, key technologies and applications of advanced electromagnetic system. A plenty of breakthroughs have been achieved in pulse power, magnetic field with high intensity and complicated distribution, optimization and control of complex electromagnetic system. Furthermore, the group has accomplished many top research projects, such as the pulsed high magnetic field facility ranked in the first class in the world, the unique Tokomak experimental equipment in the domestic universities, the energy system with the largest scale in Asia for inertial confinement fusion equipment, the world’s first mechanical high voltage DC circuit breaker for flexible DC power grid which has been in operation, and the developed electrical signal measurement equipment of photoelectric type, which has a leading performance in the world and whose core components have been adopted by all manufacturers internal and exported to ABB in batches. The group has made outstanding achievements, which brings the research to the top of the world.

By the support from Science Fund for Creative Research Group, the group will focus on advanced electromagnetic technology and its applications, investigate the basic theoretical research under extreme electromagnetic conditions, reveal scientific discoveries under extreme electromagnetic conditions, carry out engineering technology research to challenge the limits, build large scientific facilities with the highest performance, carry out engineering application research with major innovations, and solve key bottleneck problems based on the national demand.

Wastewater Treatment and Resource Recovery

The research group "Wastewater Treatment and Resource Recovery", led by Professor Yu Hanqing from University of Science and Technology of China, was granted the Fund for Creative Research Groups by the National Natural Science Foundation of China in 2018. The main group members include Professor Fu Yao, Professor Sheng Guoping, Professor Mu Yang, Professor Li Wenwei and Professor Liu Xianwei.

With the support from NSFC, the group aims to solve the key problems on the accurate identification and selective conversion of various pollutants in wastewater treatment for resource recovery. This project will develop the methods for in-situ characterizations of pollutants in wastewater, reveal the pollutant conversion pathways and molecular mechanisms, explore the sustainable techniques and theories for resource and energy recovery from wastewater, develop the highly selective and efficient methods for the removal of micro pollutants from wastewater. The research results will provide the theoretical and technical supports for the sustainable wastewater treatment, safe discharge and reuse of wastewater. It will promote the scientific and technical innovation capabilities in the field of wastewater treatment and resource recovery in China.

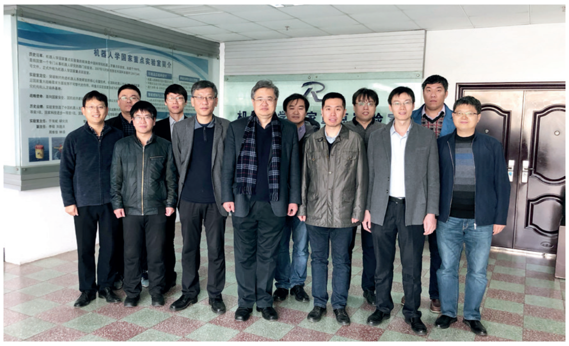
Big Data Storage System and Technology

The research group "Big Data Storage System and Technology", led by Professor Feng Dan of Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology, was awarded the Fund for Creative Research Groups by the National Natural Science Foundation of China in 2018. The main group members include Professor Xie Changsheng, Professor Miao Xiangshui, Professor Zeng Zhigang, Professor Zhou Ke and Professor You Long, et al.

The group relies on a number of important bases, such as Wuhan National Laboratory for Optoelectronics, Key Laboratory of Information Storage System of Ministry of Education (MOE), and Engineering Research Center of Data Storage System and Technology of MOE. In the last ten years, the group has carried out systematic research on the theory and key technologies of mass storage system. A new heterogeneous fusion active-object-based architecture for mass storage system was proposed, which made storage system intelligence with capability of self-organization and self-management. Efficient and low-energy storage self-optimization methods were proposed to achieve high efficiency for mass storage system, and self-healing methods for fast data reconstruction and security technologies based on active objects are proposed to improve the reliability and security of the system. The group also developed the high-speed phase-change memory function chip, heterogeneous multi-channel high-speed disk array, magnetic and optical hybrid device for cold data storage, and PB-level active object storage systems to promote applications in enterprises, such as Huawei, Inspur, ZTE, XMC and so on. The group took the lead in formulating three national standards and three standards of electronic industry for data storage, which have played an active role in promoting the development of storage industry in China. The group has won two second-class prizes of national technology invention, five first-class prizes of provinces and ministries, and one Finalist Award of international storage competition.

Under the support of NSFC, the group aims to serve the national demand and focuses on the frontier of data storage technology. To solve the new storage architecture and data organization model for demands of complex big data applications, which is the fundament problem for data storage, the group will explore the theory and method of big data storage by developing new storage technologies. Research contents are as follows: exploring new methods to overcome the bottleneck of von Neumann architecture on storage mechanism and architecture, developing high-speed storage controller technology, large-scale storage system construction method, on-demand adaptation resource organization method, etc. It involves data storage medium, devices, systems and other aspects. The main aim of the group is to overcome the challenge issues in data storage, develop key technologies with independent intellectual property rights, and become one of the important technologies source providing for our data storage industry.

Robot Perception, Control, and Collaboration



The research group "Robot Perception, Control, and Collaboration", led by Professor Yu Haibin, the head of Shenyang Institute of Automation, Chinese Academy of Sciences, has received the National Natural Science Foundation of China's 2018 Fund for Creative Research Groups. The main group members include Professor Zhou Weijia, Professor Liu Lianqing, Professor Zeng Peng, Professor Liu Kaizhou, and Professor Cong Yang.

The group provides tools to meet the major needs of our nation in marine scientific research, deep-sea resource exploration, intelligent manufacturing, people's livelihood, and public security. The group focuses on three frontier directions of robotics, including intelligent perception, autonomous control, and cluster collaboration. The group has made a breakthrough in the development of robots, especially robot perception in a dynamic environment, robot control in an extreme environment, and collaboration of swarm robots. For micro-nano operation robots, special mobile robots, and industrial robots, the group has achieved systematic innovations in system theory and methods, and independent core technologies.

With the financial support of the fund, the group plans to perform fundamental research focusing on the prospective theories and intends to develop common technologies and methodologies shared by the three types of advanced robot systems. Based on the development trend of robotics, the group considers applying the data science, information science, and intelligent science that will revolutionize the robotics technology into its fundamental research theme. Besides that, the group also aims to solve the fundamental issues of robot perception, control and collaboration. The group's research on common technologies and methodologies includes basic theories to integrate the life system and the electromechanical system, develop distributed control technology with collaboration of edge computing and cloud computing, multi-domain shared sensing, and methods for integrated intelligent collaboration. The aim is to create future robots represented by BioSyncretic Robot, Collaborative Operating Robots, and Swarm Autonomous Robots.

Service Science and Innovation Management

The Creative Research Group "Service Science and Innovation Management", under the leadership of Professor Hua Zhongsheng, has been supported by the National Natural Science Foundation of China (NSFC) in 2018.

Professor Hua Zhongsheng is the winner of National Science Fund for Distinguished Young Scholars and Chang Jiang Scholars Program. He also serves as the Vice President of the Chinese Society of Management Science and Engineering, and Associate Director of the Zhejiang Provincial Engineering Research Center of "modern service and e-service". Up to now, he has published more than 90 papers in SCI and/or SSCI indexed academic journals.

To support the demand for China's strategic emerging industries, economic restructuring and industrial upgrading, the group has performed research in the areas of service science and innovation management, and obtained a set of achievements at the international standard on service participant behavior, service resource organization, business model innovation, logistics and supply chain, etc. The group forms naturally in its long historical cooperating process among the key members, who were funded by National Science Fund for Distinguished Young Scholars, Chang Jiang Scholars Program and Chang Jiang Young Scholars Program. Key members of the group have published 10 papers in UTD 24 journals (e.g., OR, POM, JOM and MSOM), and their papers have 1,414 SSCI citations by other scholars in the last five years.

The main research achievements of the group in recent years include: (1) on service science, they focus on new service models emerging under the Internet and mobile communication conditions, investigate the behavior of service participants and organization of service resources, and have obtained a series of international level research results; (2) on service innovation, they focus on catching up strategy of latecomers in the global innovation network, and reveal the interactive integration and innovation of knowledge intensive service industry and manufacturing industry; (3) on integration and optimization of service system, through the long term commitment to the design, optimization and integration of production service systems such as logistics and supply chain, a series of theoretical and applied achievements have been achieved.

Considering the impact of Internet and big data on traditional service behaviors, relationships, patterns and systems, the group will develop theories and methods for improving service capabilities, improving service quality and efficiency for the major demands of related fields in the country, and will actively combine theoretical results with practical applications, to achieve exemplary and leading application results in areas such as health care and platform services.

Management System Engineering

The research group of "Management System Engineering" was granted the Fund for Creative Research Groups by the National Natural Science Foundation of China in 2018. The group is led by Professor Wang Hongwei of the School of Management, Huazhong University of Science and Technology, and key members include Academician Ding Lieyun, Professor Xu Xianhao, Professor Deng Shiming, Professor Hu Peng and Professor Xu He.

The group is formed in the course of close collaboration for more than 30 years. It is dedicated to the study of multi-entity, dynamicity and non-linear interaction of management systems, contract design and product pricing in supply chain management, security management and emergency decision making, with a special expertise in the safe operation of management systems. The group has researchers in supply chain management, system engineering and engineering management, including one Academician of the Chinese Academy of Engineering, one grantee of the National Science Fund for Distinguished Young Scholars, one Chang Jiang Distinguished Professor, one grantee of the Excellent Young Scientists Fund, one grantee of the National New Centrury Millions of Talents Program, and four grantees of New Century Excellent Talent of the Ministry of Education. In the past 5 years, the group received one second prize of the State Scientific and Technological Progress Award, one first prize of the Scientific and Technological Progress Award of the Ministry of Education and one first prize of the Scientific and Technological Progress Award of the Hubei Province.

The group has made a series of research achievements in the dynamic decision making, multi-entity coordination and game theory and system security management, including: (1) a general theory for dynamic decision making system and a data-driven nonparametric optimization algorithm which depicts the interaction of dynamic pricing and user behaviors and can be applied to dynamic pricing problems in the context of stochastic demand and unknown parameters; (2) an emergency decision-making approach based on hierarchical task network, and an emergency drill simulation platform and national economy mobilization simulation system which has been applied to national economy mobilization activities and the aircraft dispatching system for aircraft carrier; (3) an energy coupling theory of metro construction engineering system safety and an integrated management and pre-warning platform for metro safety which has been applied to about 500 projects in 10 cities.

The group will focus on national demands and carry on their research in management system engineering, especially the theories and methods for operation management in the "Internet+" environment, including: (1) Internet-based management coordination; (2) data-driven intelligent logistics; (3) system safety management in the "Internet+" environment; and (4) "Internet+" management innovation: engineering construction platform.

Interaction of Cancer Stem Cells with Tumor Microenvironment

The Creative Research Group "Interaction of Cancer Stem Cells with Tumor Microenvironment" was funded by the National Natural Science Foundation of China in 2018. The group leader is Professor Bian Xiuwu and the group members include Professor Zhu Bo, Professor Wang Yan, Professor Liu Xindong, Professor Jin Guoxiang and Professor Yu Shicang.

To uncover the role of cancer stem cell (CSC) in tumor progression and the underlying mechanism, the group focuses on the origin and biological phenotypes of CSC, the interaction between CSC and microenvironment, and the development of new diagnostic and therapeutic strategies. Through more than 20 years of collaborative work, they put forward the concept of tumor vascular pathology and set up the related technical system. They also discover the "Three Approaches" mediating the promoting effects of CSC on tumor vascularization and the underlying mechanism. In addition, they identify CSC as the initiator of tumor invasion, metastasis and relapse, and expand new research field of tumor immune microenvironment. They establish the Key Laboratory of Tumor Immuno-Pathology of Ministry of Education, the National New Drug Development Platform for CSC Research. They undertake 12 national research

projects, including the National Basic Research Program of China (973 Program) and the National Key Science and Technology Program of China. In recent five years, the team has published 124 SCI papers (including 13 papers with the impact factors greater than 10) on high-impact journals like *Nature*, *Cell Stem Cell* (2 papers), *Nature Immunol*, *Journal of Clinical Investigation* and *Nature Communications*, with 5,857 times of citation by peers. The team has won a First Prize of State Scientific and Technological Progress Award and 5 First Prize of Provincial and Ministerial Science and Technology Awards.

In the future, they will investigate the molecular mechanism and therapeutic significance underlying the interaction between cancer stem cells and their vascular microenvironment and immunological microenvironment. Their studies are expected to achieve a science breakthrough in uncovering the mechanism of tumorigenesis and tumor development, and exploring new diagnostic and therapeutic strategies targeting cancer stem cells and their vascular microenvironment and immunological microenvironment.

Investigation of Molecular Biomarkers and Resistance Mechanism of Anticancer Drugs

The Creative Research Group "Investigation of Molecular Biomarkers and Resistance Mechanism of Anticancer Drugs" was funded by the Natural Science Foundation of China in 2018. The group is led by Professor Geng Meiyu from Shanghai Institute of Materia Medica, Chinese Academy of Sciences, with key group members including Professor Ding Jian, Professor Li Jia, Professor Luo Cheng, Professor Tan Minjia and Professor Huang Min from the same institute.

This group aims to pursue resolutions for the major challenges faced by molecularly targeted anticancer therapies in the clinical treatment, in particular the limited clinical response and frequently encountered drug resistance. The team previously built a pipeline of nearly 20 innovative anticancer drugs developed in-house, established an integrative research platform for biomarker discovery, and achieved pioneer findings in understanding the molecular mechanisms of cancer therapy. This study will continue to explore the cutting-edge areas of targeted cancer therapy such as immunomodulators and epigenetic and metabolic inhibitors. The project aims to understand the in-depth mechanisms confering the response and resistance to anticancer agents, and in turn identified molecular biomarkers for targeted therapies and combinational therapies to overcome drug resistance of anticancer drugs in these areas. By carrying out these studies, this group hopes to gain the conceptual advancement in molecularly targeted cancer therapy, to provide basis for personalized cancer therapy, and to bridge the laboratory research to anticancer drug development and clinical treatment.

2.4 Special Fund for Research on National Major Research Instruments (by Recommendation)

Coring and Testing System for Maintaining In-situ Conditions of Deep Rocks

The project "Coring and Testing System for Maintaining In-situ Conditions of Deep Rocks" is led by Sichuan University and cooperated with Shenzhen University, China University of Mining and Technology, China University of Mining and Technology (Beijing) and China Jinshi Drilltech Co., Ltd. This project focuses on the research and development of coring and testing system for maintaining in-situ conditions of deep rocks within the framework of Special Fund for Research on National Major Research Instruments of the National Natural Science Foundation of China. A number of talents and scholars from various fields, including energy, civil engineering, geology, hydropower engineering, mechanics, precise instrument, material science and mechanical science, are involved in this project. The research team has accumulated rich experience for the project by independent constructing experimental devices, such as a closed-type gas hydrate coring system, a true triaxial loading system and a synchronous CT system. These previous studies have laid a solid foundation for research and development of coring and testing system for maintaining in-situ conditions of deep rocks.

Obtaining space and resources from deep earth is a national strategic demand, especially the scientific foundation of the rock characteristics under the in-situ conditions. However, regular cores by deep drilling, which have already released its original qualities such as the pressure, temperature and pore water, are used in the current research. For this reason, the original characteristics of the cores under the in-situ conditions cannot be obtained. The lack of fidelity core would result in fragment of the cores, the error to assess oil and gas reserves, the death of living organisms in deep rocks and the loss of in-situ physical and mechanical behaviors at different depths. It is urgent to acquire "fidelity core" to construct "deep in-situ rock mechanics" and even explore the mystery of future science. However, almost no method, technology or facility can achieve in-situ fidelity coring, fidelity testing and fidelity analysis. Therefore, research and development of coring and testing system for maintaining in-situ conditions of deep rocks is firstly proposed to realize the concepts of so-called five guarantees (to guarantee the five kinds of properties of rock, i.e., the osmotic pressure, property, humidity, temperature and light).

This project mainly includes the construction of borehole coring system for maintaining in-situ conditions of deep rocks, which will achieve fidelity coring from deep earth by maintenance of the original properties, transfer and storage of the original cores, specimen preparation and physical-mechanical testing under in-

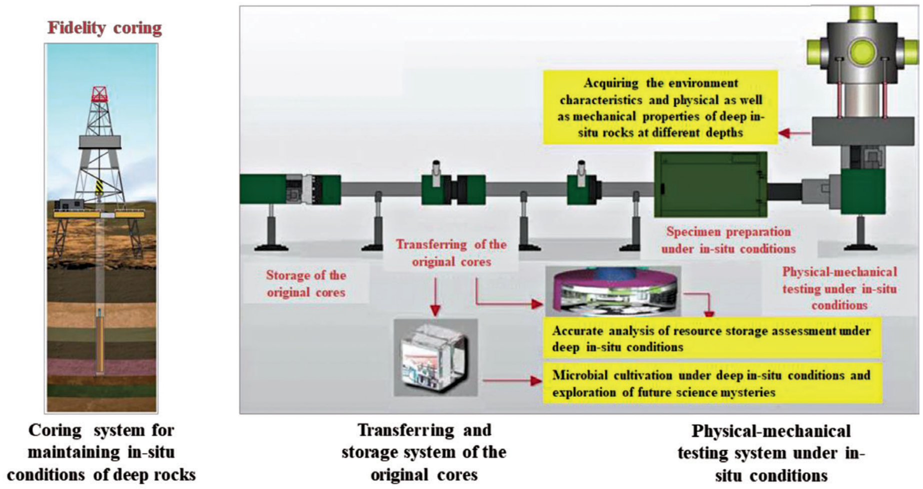


Figure 1. Schematic diagram

situ conditions. Based on the geometry of square cover and mechanical theory, precise control technology with a self-triggering gravitational type, real-time monitoring and compensation technology of in-situ environment is proposed to implement the automatic sealing and controlling of pressure and temperature. Meanwhile, according to the theory of mass transfer and phase transformation, a self-adaptive principle of phase transformation sealing is proposed. Furthermore, the triggering and sealing technology for solid phase in-situ transformation to film is independently developed to achieve in-situ fidelity coring (moisture and light preservation). On the basis of the similar simulation principle, the in-situ fidelity environment reconstruction and transformation technology is proposed to implement the movement and specimen preparation of the fidelity core. An independent developed true triaxial loading system which generates original environment is designed to conduct real-time and in-situ physical and mechanical tests.

The system will overcome the in-situ coring problem in essence. A new deep in-situ rock mechanics theory will be established, which would help to firstly establish new theories and technologies for deep in-situ rock mechanics. It will systematically acquire the environment characteristics and physical as well as mechanical properties of deep in-situ rocks at different depths. Deep engineering science theory will be developed so as to comprehensively improve the ability to acquire deep resources and discover the new mysteries in the deep earth.

Typhoon Tracking and Detection Instrument

"Typhoon Tracking and Detection Instrument", supported by the Special Fund for Research on National Major Research Instruments, is led by Beihang University with four partners, including the Chinese Academy of Meteorological Sciences, Beijing InfSpace Technology Co. Ltd., Beijing Institute of Technology and Nanjing University.

Strengthening typhoon investigation and particularly improving the accuracy of typhoon forecasting is of great strategic significance, considering the fact that China is one of the countries suffering most from typhoon disasters. The key scientific goal is to understand the mechanism for the structural evolution of a typhoon's core by performing long-term, refined and multi-faceted direct measurements of typhoons. Existing typhoon measuring instruments, however, fail to provide such long-term, continuous, and direct observation data, resulting in inadequate typhoon evolution models and inaccurate predictions. This project proposes a new near-space airship typhoon measuring instrument, referred to as the typhoon tracking and detection instrument. The overall design framework is outlined as follows: The instrument is carried by a near-space airship, which can fly above the typhoon with an approximate height of 20 km. It is capable of conducting direct and continuous tracking. In addition, it can combine the external and internal measurements of typhoons simultaneously.

The typhoon tracking and detection instrument consists of four core components: refined measurement (M), information transmission (T), flight control (C) and assimilation simulation (A) (see Figure 1). Specifically, refined detection includes near-space airship typhoon detection radar, floating dropsondes and directional dropsonde dispenser. Information transmission includes near-space airship communication receiver and broadband data link. Flight control refers to flight controller for typhoon tracking, while assimilation simulation supports high-resolution digital typhoon simulation system. These four core components constitute a complete typhoon tracking and detection instrument. It is carried by a near-space airship, which can fly at a height of approximately 5 km above the typhoon, providing a direct typhoon measurement. This near-space airship can fly for more than seven days, obtaining a long-term and continuous measurement and recording the entire life cycle of typhoon. Meanwhile, the radar can measure the 3D-wind field, and the spatial-temporal 2D-distribution of cloud water particles in the typhoon eyewall. The dropsondes can record several key parameters of the typhoon, such as temperature, humidity, wind and pressure in the typhoon eye and eyewall. The combined measurement achieves multi-faceted and refined analysis of the typhoon core area.

Once the instrument is developed successfully, it will pioneer a long-term, multi-faceted, refined and direct measurement of typhoons, leading towards top-level instrument systems with an independent intellectual property. The developed instrument will help reveal unresolved scientific questions regarding typhoon formation, evolution, and intensity distortion, by synthesizing a high-resolution digital typhoon system with a vertical resolution of 50 meters, a horizontal resolution of 200 meters, and a temporal resolution of seconds. This project enables China to enter the world's top-level research team in the area of accurate detection, understanding and accurate forecasting of typhoons, thus enhancing the country's defense ability against natural disasters, and also contributing to the country's maritime transportation, aviation safety and national security to list a few.

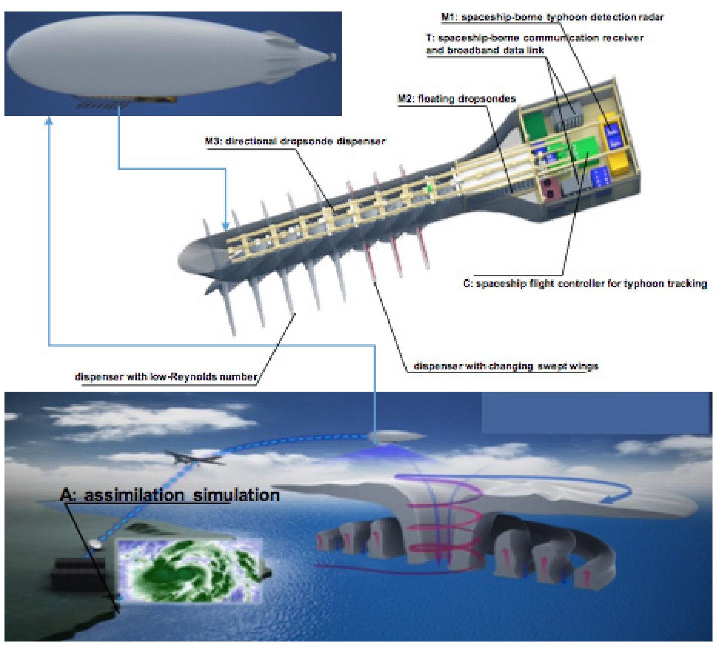


Figure 1. Instrument workflow scheme

Whole Brain Surveying and Mapping System for Cell Typing Based on Morphological and Spatial Omics Information

"Whole Brain Surveying and Mapping System for Cell Typing Based on Morphological and Spatial Omics Information", supported by Special Fund for Research on National Major Research Instruments (recommended by the national departments), is led by Huazhong University of Science and Technology, cooperating with Fudan University, Southeast University, and Shanghai Institute for Biological Sciences, Chinese Academy of Sciences. The project team gathered talents in the fields of bio-optical imaging, neurobiology, proteomics, mass spectrometry, etc., with the solid background of biomedical engineering, computer science and technology, software engineering, electronic engineering, and machinery design. This project is based on the existing whole-brain mesoscopic connectome imaging system, and the matched series technologies such as sample preparation, micro-optical sectioning tomography, neuronal recognition and reconstruction, big data processing and analysis. By integrating techniques of transcriptome and proteome research, this project is to develop the whole brain surveying and mapping system for cell typing based on morphological and spatial omics information.

Census of neuronal cell types is one of the most important basic scientific questions in brain science. Cell census research is limited by not only techniques, but also two basic methodologies. One is accuracy: How to confirm the right cell types? The other is completeness: How to classify all the cells? Therefore, one of the most challenging work is to establish accurate technical criteria for cell typing. Morphology, transcriptomics, and proteomics may provide evidence for cell typing. But such prediction based on only one source of information is deficient. Morphological plus omics information and even more combinations will contribute to the identification of neuronal cell types and subtypes more accurately. And the combination of neuronal morphological and spatial omics information will help set up more accurate cell typing criteria.

This project will take the cases of cholinergic and dopaminergic neurons in a whole mouse brain. We will accomplish a precise surveying and mapping of the brain-wide neuron morphology with the accuracy of 1-micron space positioning. By conquering a series of technical problems, such as precise micro-area sampling with space positioning information, spatial information addressing of the cell transcriptomics, high-resolution imaging of RNA information in thick tissue, high-sensitive detection of single cell proteomics, and multi-dimensional information integration and visualization, we will establish a whole brain surveying and mapping system for cell typing based on morphological and spatial omics information, which features with an integration of whole brain imaging and sampling, transcriptomics measurement, RNA in-situ imaging, proteomics mass spectrometry, and spatial information integration. The development of this system is expected to fulfill a more accurate cell typing and demonstrate the 3D visualization of the morphological and omics information of neurons in brain wide, which may provide new tool for multi-dimensional information acquisition and integration.

The successful development of this instrument will establish more accurate criteria for cell typing at single cell resolution based on brain-wide neuron morphologies and molecular features of transcriptomics and proteomics, and will provide strong supports for mapping mesoscopic brain connectome and applications in clinical diagnosis and treatment or brain-inspired artificial intelligence.

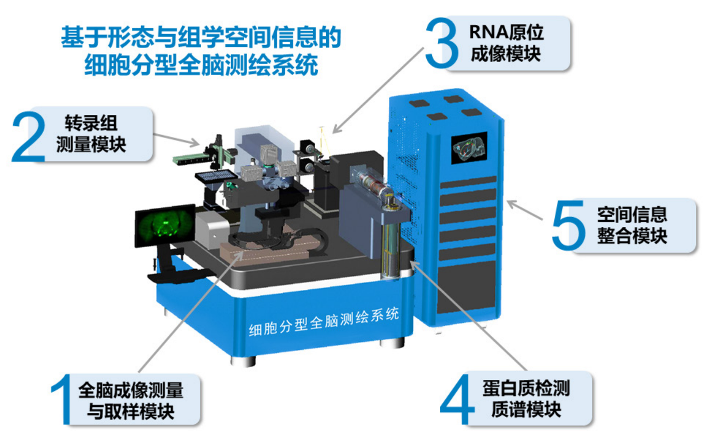


Figure 1. Whole brain surveying and mapping aystem for cell typing based on morphological and spatical omics information

2.5 Basic Science Center Program

High-Temperature Superconductors: Materials and Mechanism

The Basic Research Center Program "High-Temperature Superconductors: Materials and Mechanism", with a funding of 187.5 million yuan, is led by Professor Wang Nanlin from Peking University. Other principal investigators (PIs) include Academician Wang Enge, Professor Wang Jian and Professor Jiang Ying from Peking University, Academician Xiang Tao, Professor Ding Hong, Professor Zhou Xingjiang and Professor Hu Jiangping from the Institute of Physics of Chinese Academy of Sciences, Academician Chen Xianghui from the University of Science and Technology of China, and Professor Feng Donglai from the Fudan University. All are eminent Chinese scientists in the forefront of high-temperature superconductivity research and have international influences. Academician Zhao Zhongxian, recipient of the 2017 Highest Science and Technology Award, is the project consultant.

The microscopic mechanism of high-temperature superconductivity is one of the foremost unsolved problems in condensed matter physics. The study on the mechanism of high-temperature superconductivity has not only significantly advanced the research on strongly correlated electron systems and quantum many-body theory, but also has greatly promoted the innovation and development of cutting-edge experimental techniques and methods. Furthermore, the realization of superconductivity at higher transition temperatures or even at room temperature, has long been a dream in the exploration of superconducting materials. It is expected that the wide application of high-temperature superconductors will promote the progress of technology and civilization as much as the application of bronze, iron and silicon in the history.

China has made great efforts and investment in the superconductivity research and achieved remarkable progress and success in particular in the past two decades. It was well reflected in the groundbreaking study of iron-arsenic based superconductors in 2008. Researchers in China have made original and extensive contributions to the field in terms of a substantial increase of the superconducting transition temperature, discovery of new iron-based high-temperature superconducting materials, characterization and understanding of the physical properties and elucidation of the high-temperature superconducting mechanism. The leading role played by Chinese researchers has won a high reputation internationally. In recent years, significant progress has also been made in exploring and studying other new superconducting materials and their mechanisms.

The project will continue the exploration of new high-temperature superconductors and the study of high-temperature superconducting mechanism with a focus on extensive materials explorations, crystal/thin film growths, physical properties characterizations and theoretical studies. The goals are to find new unconventional superconductors or superconductors at higher transition temperatures, to develop new cutting-edge measurement techniques, to discover new quantum effects/phenomena and ultimately to make breakthroughs in the mechanism of high-temperature superconductivity and the quantum many-body theory.

This project includes 10 active leading experts with varied expertise in high-temperature superconductivity. They will make synergistic efforts in both theory and experiment to solve critical issues in this field and make breakthroughs. The implementation of this project will further improve the worldwide influence and competence of China in high-temperature superconductivity.

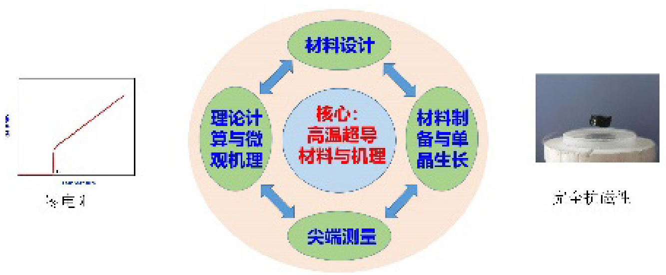


Figure 1. Focusing on the core research objectives of high temperature superconductivity and mechanism, we are committed to making breakthroughs in the exploration and mechanism of high temperature superconducting materials through the collaborative research of material design, material preparation (single crystal growth, MBE film), tip measurement, theoretical calculation and micro-mechanism.

Continental Evolution and Earth's Monsoon System

The Basic Research Center Program "Continental Evolution and Earth's Monsoon System" is led by Academician Guo Zhengtang of Institute of Geology and Geophysics, Chinese Academy of Sciences, with a fundng of 187.5 million yuan. The co-investigators are from the Institute of Geology and Geophysics, Chinese Academy of Sciences, China University of Geosciences (Beijing), Peking University, and Xi'an Jiaotong University.

The Earth's monsoon system is the dominant engine that powers energy and hydrological cycles of the global climate system, exerting profound impact on global environment, climate and societies. Today, the lives of nearly 70% of the world population are still intricately intertwined with the vagaries of monsoonal rainfall and there is a growing and compelling body of evidence, suggesting that the past variations in monsoon may have also played an influential role in shaping many chapters of human civilizations throughout the history. Thus, understanding future changes in the Earth's monsoons, particularly within the Asia-Africa-Australia monsoon system and associated arid-semiarid regions, is critical to human habitability and social development—and remains a major research initiative for many important plans such as that of the 'Belt and Road Initiative' proposed by the Chinese government.

This project aims at bringing together outstanding research teams that are extensively engaged in a wide range of state-of-the-art research to understand the nexus between continental evolution and Earth's monsoon origin and evolution through novel interdisciplinary approaches. In particular, the evolution of Earth's monsoon systems will be systematically explored in the context of the dynamic process from Pangea breakup to the subsequent reassembly of the future Amasia supercontinent. An integrated study of interactions between the solid and surficial Earth systems will be explored with emphasis on the role of the Earth's interior processes on the Earth's monsoon origin and evolution. This study will explore answers to a number of key scientific issues, such as how the habitable Earth originated, how the Earth's monsoon system has advanced to the modern state, and how the evolution of the continent and accompanied process modulated changes in the monsoon system on geological to human-society timescales (see Figure 1).

The implementation of the project will facilitate the establishment of a world-class center in the research field of continental evolution and the Earth's monsoon system. It is expected that the project will bring new advances in elucidating the control mechanism of solid Earth evolution on the origin and development of Earth's monsoon systems, which may ultimately lead to fundamental breakthroughs in the Earth system sciences and improve our understanding of future climate changes in the vast monsoon regimes.

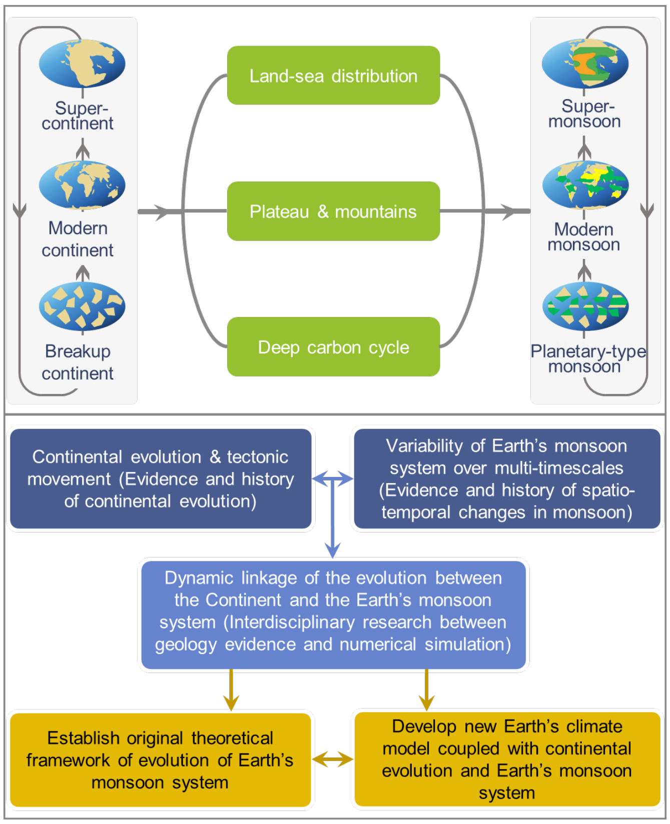


Figure 1. Outline of the project

A Novel Mode of Energy Conversion Orderised to Multi-Objectives Coordination and Design Optimization with Clean, Low-CO_2, High-Efficiency Simultaneously

The Basic Research Center Program “A novel Mode of Energy Conversion Orderised to Multi-Objectives Coordination and Design Optimization (MOCDO) with Clean, Low-CO_2, High-Efficiency Simultaneously (CLHS)”, led by Professor Guo Liejin, the Academician of CAS, relies on State Key Lab of Multiphase Flow in Power Engineering, Xi’an Jiaotong University, with three allies including Institute of Engineering Thermophysics (CAS), Nanjing University of Aeronautics and Astronautics, and Nanjing University of Science and Technology. The funding for the project is 200 million Yuan. There are other principal investigators who are young or middle-aged scientists with international influence working in the frontier research field of energy science, including CAS Academician Professor Jin Hongguang, CAS Academician Professor Xuan Yimin, CAS Academician Professor He Yaling, Professor Huang Zuohua, Professor Yan Junjie, Professor Li Qiang, Professor Bai Bofeng, Professor Qu Zhiguo and Professor Hao Yong.

Energy shortage and environmental pollution are major long-term bottlenecks that restrict China's economic, social and ecological development. Based on the characteristics of energy resources and consumption in China, the traditional coal utilization approaches must be changed and renewable energy must be greatly developed to substantially increase its proportion and improve the energy consumption structure to solve these problems. Therefore, China's energy science is facing two major challenges: (1) innovating the transformative principles for coal conversion (2) developing original theories for low cost, high efficiency and large-scale renewable energy conversion. It will be an important breakthrough for China to grasp the opportunities and play a leading role in the global scientific and technological competition. For this reason, it is of great strategic significance for the sustainable development of human beings and the protection of energy security in China to create new theories and methods for ordered energy conversion through basic scientific research, realize leapfrog development of energy science and promote energy technology revolution and industrial transformation.

Figure 1. General situation of the project

The project will focus on the theories and methods for ordered energy conversion as the core scientific topic. The key scientific problems, such as the principle of energy potential matching between energy releasing end and receiving end, the highly matching and complementarity of multi-phase energy flow/material flow in space-time and multi-sub-coupling, the organic correlation mechanism of material and energy conversion, as well as the construction principle of thermodynamic cycle and hydrocarbon cycle will be solved in this project.

Solving the scientific problmes reasonably and comprehensively matches the energy potential at the energy releasing and receiving ends. Energy conversion is the core of energy science research and technological innovation. How to minimize the disordering in energy conversion processes, connect energy and matter conversion, match and couple energy potential complementarily at time-space scale and during dynamic evolution, and then create the theory and methods for ordered energy conversion, is the core scientific problems for this project, which includes: (1) how to transfer from the energy source to the end product; (2) how to make multiphase energy and matter flow highly complementary to each other at both time and space scales; (3) how to organically correlate matter conversion with energy conversion, construct hydrocarbon cycle, and control pollution generation and CO_2 emission from the source?

Through 5-10 years' efforts, the project intends to create a new trinity energy ordered conversion theory for clean, low-carbon and high-efficiency fossil and solar energy conversion, realize the leap-forward development of energy science, establish innovative and original methods for coordinated transformation of fossil energy and solar energy as well as control of CO_2 source, form subversive technology of energy conversion, as well as promote energy technology revolution and industrial transformation. This project will also promote the establishment, development and improvement of the new system of energy science, technology and industry in China, which favors for taking the leadership in international competition and cooperation. This project will make great contributions to the scientific theory creation and innovative technology breakthroughs to realize the strategic goal of sustainable development in China as well.

The project has brought together a group of first-class scholars and superior teams with innovative consciousness in the field of engineering thermophysics, energy conversion and utilization in China. Through close cooperation and mechanism innovation, it will build a team with top scientists in basic research of energy conversion, form a world-class scientific research highland for energy conversion, perform world-class scientific research, produce research results of great importance, and lead the development of international energy science in related fields.

Information Devices Based on Low-Dimensional Materials

The Basic Research Center Program entitled "Information Devices Based on Low-Dimensional Materials" is led by Professor Gao Hongjun (CAS member) from the Institute of Physics, CAS, with a funding of 200 million yuan. The co-principle investigators include CAS members Li Shushen, Wang Weihua, Liu Ming and Professors Peng Lianmao, Gu Changzhi, Zhang Guangyu, Du Shixuan, Li Ling, Shen Guozhen from the Institute of Physics, CAS, the Institute of Semiconductors, CAS, the Institute of Microelectronics, CAS and Peking University. They are working at the frontier of condensed matter physics, materials sciences and microelectronics.

The development of the information industry based on microelectronics in our country is far behind compared to Europe and the US. To become the leader in this field, it is necessary to resolve the key problems at the frontier of basic science. These problems have created a bottleneck for progress in this strategically important area of future technologies.

The extraordinary properties of low-dimensional materials and devices relate closely to the atomic arrangement at the edges, interfaces and surfaces of these materials. The project focuses on low-dimensional materials and explores their potential for information devices in the future.

This project aims at solving the following key scientific issues: (1) how to realize atomically precise construction and control of the low-dimensional information materials and their heterostructures, based on an efficient combination of theoretical design and experiments; (2) how to demonstrate the quantum properties of low-dimensional information materials at the level of single electrons and spins, and how to control design and manipulation of the devices based on optical and electronic effects; (3) how to

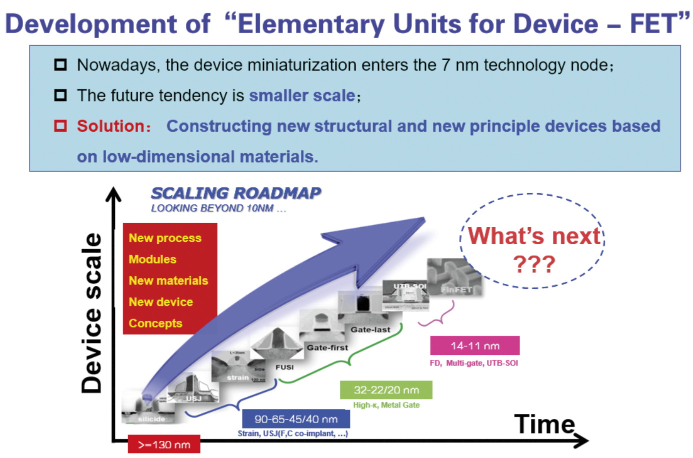


Figure 1. Research background

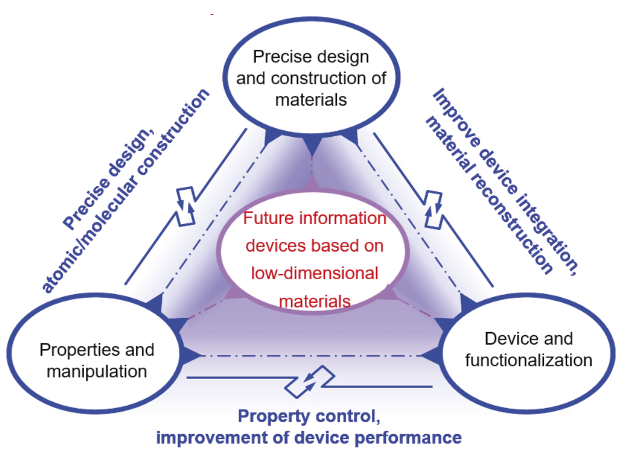


Figure 2. Research perspectives and their connections

achieve breakthroughs in device performance, and how to develop an atomic-level precise and high-throughput device fabrication that is compatible with current semiconductor technology.

The project focuses on the cutting-edge scientific problems of information devices in the future, through the theoretical design of low-dimensional information materials, to develop construction and manipulation of these materials with atomic-scale precision, and to integrate these materials in information systems in the future. Major scientific and technological breakthroughs are expected based on close collaboration of this team.

The tasks planned to be accomplished in this ambitious project include: establishing new methods and techniques for atomic construction, designing and producing globally unique scientific instruments, predicting and fabricating several novel low-dimensional information materials, developing new research directions and leading the field in these directions, constructing new device architectures by taking advantage of single-electron transport, topological edge states and optical spin valve control, constructing high-quality, wafer-scale low-dimensional information materials and realizing controllable fabrication, realizing prototype devices such as FETs, optical detectors and flexible sensors.

We expect to train a group of highly-distinguished scholars for information technology in the future and create a world-leading research team, which will establish an internationally acclaimed research center. We also aim at turning our research results into real applications and establish new, internationally competitive industries.

03

Part III

Introduction of Selected Projects of National Natural Science Fund Completed in 2018 and Project Review

1 Overview of the Concluded Projects

In total 39,693 NSFC projects concluded in 2018, including 16,004 of the General Program, 534 of the Key Program, 106 of the Major Program, 436 of the Major Research Plan, 16,380 of the Young Scientists Fund, 2,490 of the Fund for Less Developed Regions, 400 of the Excellent Young Scientists Fund, 198 of the National Science Fund for Distinguished Young Scholars, 40 of the Science Fund for Creative Research Groups, 136 of the Joint Fund for Overseas Chinese Scholars and Scholars in Hong Kong and Macao, 527 of the Joint Funds Programs, 853 of the International (Regional) Cooperation and Exchange Programs, 34 of the Special Fund for Research on National Major Research Instruments, 38 of the National Fund for Fostering Talents in Basic Research, 253 of the Tianyuan Fund for Mathematics, 50 of Special Grants for Scientific Instruments in Basic Research, 16 of the Excellent State Key Laboratory Research Programs, 10 of NSFC President's Fund, 1 of Soft Project, and 1,187 of Emergency Management Projects.

Projects completed in 2018 published 416,212 journal articles and 60,149 conference papers, among which 243,824 papers are indexed in SCI. 8,038 people from these projects presented their works in invited talks at international conferences.

Projects concluded in 2018 obtained 703 patents in foreign countries and 38,796 patents in China. 577 national awards and 3,781 provincial awards have been granted to these projects, among which 169 were the State Natural Science Awards, 281 were the State Scientific and Technological Progress Awards, and 127 were the State Technological Invention Awards.

Research Outputs of NSFC Projects Concluded in 2018

Programs / Outcomes		General Program	Key Program	Major Program	Major Research Plan	Young Scientists Fund	Fund for Less Developed Regions	Excellent Young Scientists Fund	National Science Fund for Distinguished Young Scholars	Science Fund for Creative Research Groups	Joint Fund for Overseas Chinese Scholars and Scholars in Hong Kong and Macao	Joint Funds Programs	International (Regional) Cooperation and Exchange Programs
Projects Concluded		16,004	534	106	436	16,380	2,490	400	198	40	136	527	853
Publications	Invited Talks at International Conferences	3,249	1,136	335	440	662	76	370	445	289	62	181	515
	Invited Talks at Domestic Conferences	3,961	661	189	235	771	255	318	284	294	27	151	284
	Journal Articles	207,483	25,507	7,387	7,533	103,408	25,098	6,355	6,238	4,349	1,308	7,842	6,767
	Conference Papers	31,357	3,651	610	949	15,883	2,685	905	714	362	167	1,083	1,011
	SCI-Indexed Articles	118,028	17,561	5,406	5,621	61,230	8,247	5,195	4,582	3,499	948	4,724	4,490
	EI-Indexed Articles	28,099	3,805	436	658	15,356	2,596	664	728	433	132	1,196	707
	Monographs	2,700	354	82	60	1,566	501	100	63	97	18	126	89
Patents	Foreign Patents	348	49	14	21	105	14	13	30	25	0	42	20
	Chinese Patents	18,148	2,565	639	478	10,289	2,002	667	841	717	40	976	483
Awards	National Awards	258	74	14	17	80	8	24	29	23	2	8	24
	Provincial& Ministerial Awards	1,889	225	37	49	961	198	90	82	50	6	88	64
Researcher Training	Post-Docs	1,169	332	82	100	480	51	49	118	100	13	50	105
	Doctoral Students	15,334	3,412	920	853	3,926	552	386	790	832	110	532	888
	Master Students	38,842	4,052	651	900	11,864	5,996	751	950	846	141	1,356	993

2 Introduction of Selected Projects of National Natural Science Fund Completed in 2018

2.1 Selective Introduction of Major Research Plans

Single Quantum State Detection and its Interaction

The Major Research Plan "Single Quantum State Detection and its Interaction" has a total number of 107 projects including 61 initial research projects, 26 key projects, 16 integration projects and 4 strategic study projects. The total funding reaches 200 million yuan, with 42.1 million yuan for the initial research projects, 84.45 million yuan for the key projects, 61.95 million yuan for the integration projects and 11.5 million yuan for the strategic study projects. Thirty-five research units participated in this major research plan. Academician Xie Sishen from the Institute of Physics, Chinese Academy of Sciences, served as the Chair of the Steering Committee.

The plan aims to eliminate the obstacles caused by the mixing of multiple quantum states and the influence of statistical fluctuations through the preparation and precise detection of purified single quantum state systems so as to better understand the microscopic quantum phenomena and laws. The project applies interdisciplinary research methods and emphasizes the development of new ideas, technologies and methods. It aims at the realization of extreme conditions and high detection accuracy, and has achieved a series of important progress with significant international impacts, providing scientific basis and support for the development and application of energy, information and materials science in the future:

(1) In the exploration of new phenomena, theories and concepts, researchers of the major research plan found novel quantum phenomena and effects, such as quantum partial wave resonance states, forbidden luminescence, new energy gap structure of iron-based superconductors, topological semi-metallic state, quantized anomalous Hall effect in magnetic topological insulators, and anomalous decoherence effect of single electron. Besides they established new theoretical models to describe the interaction of quantum states with environment and external field to predict and explain some new quantum effects and new quantum phenomena and mechanisms in chemical reactions.

(2) In the research of new techniques and methods for single quantum state, researchers developed single-molecule surface enhanced Raman scattering, joint technology using scanning tunneling microscopy and electron spin resonance, ultra-high resolution molecular beam scattering detection, tetra-atomic state-state quantum scattering theory, molecular beam epitaxy growth of oxides and high resolution in situ electronic structure measurement technology, and put forward feasible schemes of prototype devices based on quantum effect of single quantum state.

(3) In the aspect of purification and construction of single-quantum state system, high-quality thin films with coexistence of topological insulation and superconducting effect have been prepared, as well as other structures and materials with single-quantum state characteristics. Researchers of the major research plan have found superconducting states of topological insulators under high pressures, theoretically predicted new binary three-dimensional topological insulators, and synthesized low-dimensional Kondo latticesby magnetic molecules.

2,321 scientific papers have been published on journals in China and abroad, including 19 on *Science*, 3 on *Nature*, 66 on *Nature* sub-journals, 114 on *Physical Review Letters*/*Physical Review X*, 10 on *Journal of the American Chemistry Society*, 22 on *Advanced Materials*, and 12 on *Proceedings of the National Academy of Sciences of the United States of America*. The highest citation of a single paper reaches 2,221. 10 papers have over 500 citations and 50 papers have over 100 citations. 63 domestic patents and 2 international patents have been granted. Investigators of this major research plan were awarded the First Prize of the State Natural Science Award twice, the Second Prize of the State Natural Science Award for 11 times, and Second Prize of the State Technological Invention Award twice.

With the support of the Major Research Plan, a group of outstanding scientists have emerged in the research field of single quantum state in China and have made world-leading research results. During the implementation of the plan, 7 of the steering committee members and Principal Investigators were elected as Academicians of the Chinese Academy of Sciences. 11 PIs were granted the National Science Fund for Distinguished Young Scholars. 17 PIs were granted the Excellent Young Scientists Fund. 4 PIs won the title of Chang Jiang Scholars. 9 PIs became national leading talents in science and technology innovation under the "Ten Thousand Talents Plan". 5 became Young Chang Jiang Scholars. 10 became academic leaders of the NSFC Creative Research Groups, and 7 became the heads of National Major Research Instruments projects.

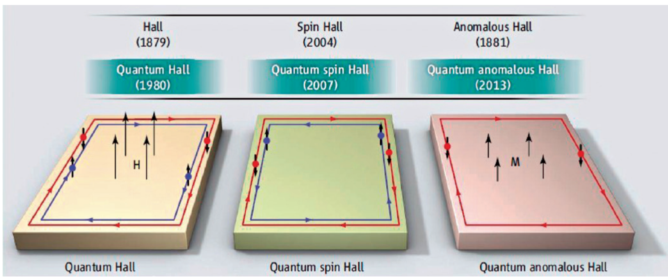


Figure 1. The first experimental observation of the quantum anomalous Hall effect

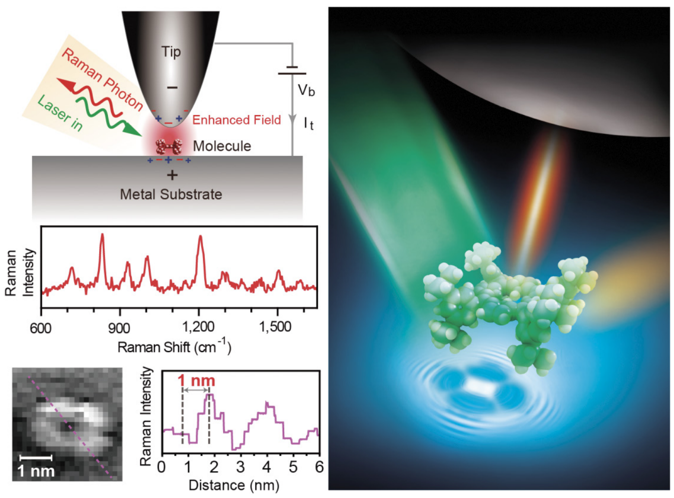


Figure 2. TERS Raman photonfrom a single Porphyrin molecule

Fundamental Research on Nanomanufacturing

Aiming to explore the potentials and prospects of nanomanufacturing in leading developments and improvements in China, the Major Research Plan "Fundamental Research on Nanomanufacturing" was approved by National Natural Science Foundation of China (NSFC). In the plan, 153 research projects have been funded under the supervision of NSFC in a total financial budget of 190 million yuan, including 121 cultivating projects (62.31 million yuan), 24 key projects (62.4 million yuan), 4 integrated projects (55 million yuan), and 4 strategic research projects (9.8788 million yuan). 74 academic organizations with diverse research interests and backgrounds are enrolled to participate in this plan and to collaborate with each other. Directed by Professor Lu Bingheng (from Xi'an Jiaotong University), more than 1,200 key academics join this major research plan, mainly from domestic research institutes and universities. Some oversea scholars are also actively involved to share their experiences in the field of nanomanufacturing.

With multidisciplinary and cross-disciplinary collaboration, this plan primarily aims to explore new principles and methodologies for nanomanufacturing based on fundamental physics/chemistry, to unveil the surface/interface and scale effects in the processing, forming, modification and multi-scale manufacturing in nanoscale, to elucidate the mechanisms for structural evolution of materials, to establish high-precision characterization and measurement protocols in nanomanufacturing. In addition, it develops several original techniques and apparatus for nanomanufacturing and achieves batch production with high consistency. It will provide the theoretical basis for elevating the overall level of nanomanufacturing in China.

It is gratifying and inspiring that a series of significant breakthroughs in the principles and methods have been obtained during the implementation of this plan, mainly in the field of atomic material removal, nanostructure forming, new principle for femtosecond laser manufacturing and cross-scale mass production. Some high-end equipment localizations have also been successfully realized and commercialized to overcome and break the technical monopolies and blockades. These results provide inspiring and prospective solutions for resolving national major science/engineering issues, such as high-precision lens polishing for lithography equipment, micro-hole array manufacturing for target ball, meter-level two-dimensional metering grating for advanced equipment, spacecraft surface with multi-level micro/nano structures. The representative breakthroughs are as follows:

(1) The chemical-mechanical mechanism for atomic-level material removal has been revealed. Specially, wafer flattening equipment and lens polishing equipment for lithography machine have been formed, which enable to provide promising solutions and significant supports for electronic chip manufacturing industries to overcome the technique limitations abroad.

(2) New principles of interface charge control based nanoimprinting technique have been proposed for the first time in the world. Beneficial with advantages of this methodology in generalizing engineering applications towards industry, it has already presented promising potentials in national major projects, national defense military, consumer electronics and other fields.

(3) New principles of femtosecond laser manufacturing based on electron/charge dynamic regulation have been proposed. Importantly, the active control of the localized electrons has been realized for the first time in the world.

(4) The local selective multi-reconstruction and mass manufacturing methods for microstructured surfaces have been developed, which makes it possible that relatively complete nano-manufacturing method and process system have been established.

Funded by this plan, 3,813 academic articles in total, indexed by SCI, have been published in international pioneering journals. Among them, 19 papers are published in top journals, such as *Nature Nanotechnology*, *Nature Materials*, *Nature Physics*, etc., and 91 papers are ESI most cited. In addition, 935 patents (including 11patents in US/UE districts) have been authorized. In terms of high-end equipment developments, 17 sets of advanced equipment have been commercialized and domestically produced. Supported by this plan, the researchers have been rewarded by the Second Prize of the State Natural Science Awards six times, the Second Prize of the State Technological Invention Awards five times, and the Second Prize of the State Scientific and Technological Progress Award once. In addition, the scientists in the plan are rewarded by Ho Leung Ho Lee Awards twice and National Defense Science and Technology Innovation Team Award once.

With the support of this plan, some outstanding and world-class scientists have emerged in the field of nanomanufacturing. During the implementation, six members of the expert steering committees and project leaders have been elected as academicians of the Chinese Academy of Sciences, and two members have been recruited in Chinese Academy of Engineering. In addition, four project leaders have been awarded by the members of the American Society of Mechanical Engineers (ASME), Institute of Electrical and Electronics Engineers (IEEE). Eighteen researchers have been awarded by National Science Fund for Distinguished Young Scholars, fifteen scientists worked as Chang Jiang Scholars Distinguished Professor by the Minister of Education, and six young scholars have been funded by Excellent Young Scientists Fund.

In the future, it is urgent to extend the manufacturing scale towards the atomic scale, and explore the fundamental theories and key technologies for supporting atomic-level manufacturing. New processes and apparatus will be developed based on the above principles, and several pioneering theories and technologies will be implemented in nanomanufacturing. Hence the status of the scientific community of China will be improved.

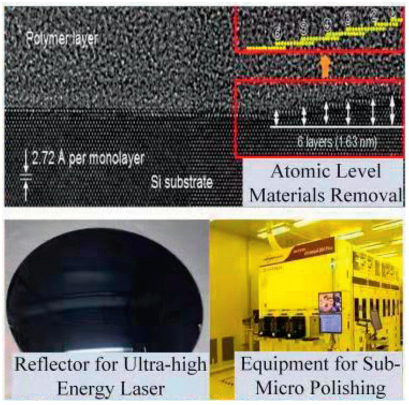


Figure 1. Nano-precision manufacturing

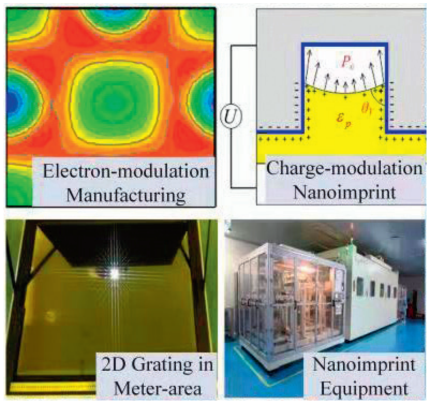


Figure 2. Nano-scale manufacturing

Cognitive Computing of Visual and Auditory Information

The Major Research Plan "Cognitive Computing of Visual and Auditory Information" was officially launched in August 2008 with a total funding of 190 million yuan. A total of 97 research projects were funded, including 5 integrated projects, 30 key projects, and 62 fostering projects. Professor Zheng Nanning from Xi'an Jiaotong University was served as the leader of the Steering Group of Experts.

The scientific goal of this plan is to explore three key scientific problems "perceptual feature extraction, representation and integration", "machine learning and understanding of perceptual data" and "collaborative computing of multi-modal information" by concentrating on the basic scientific problems of "representation" and "computation" of human cognitive processes and based on the human's mechanisms of visual and auditory cognition and neural mechanism. In addition, it also aims to develop new computational models and algorithms to improve the computer's comprehension ability for unstructured visual and auditory perception information as well as its processing efficiency for massive heterogeneous information.

The machine understanding and processing of human visual and auditory information have been an important research topic in the field of artificial intelligence and play very important roles in the domains of social development, national economy and national security. In the last decade, this plan has achieved a series of landmark achievements in the cognitive theory and models, the auditory and visual information processing, as well as the natural language (Chinese) understanding. Among them, the cognitive basic theories and models such as the topological definition of perceptual objects and the topological explanation of the attention blink were proposed in the aspect of cognitive mechanism research. The visual attention learning model and method were established and the new theory of salient object detection was formed in the aspect of visual and auditory information processing. In the aspect of natural language (Chinese) understanding, the new theoretical framework and method for Chinese semantic computing were created, and a series of language interaction systems were developed for public security.

The research results of cognitive mechanisms can be verified by experiments of biology and cognitive psychology. While the computable models inspired, abstracted and simplified by the cognitive mechanisms and neuroscience can be only substantiated with artificial systems. Therefore, two major integrated innovation verification platforms were built for the unmanned intelligent vehicles and the brain-computer interfaces. These verification platforms not only act as the integrated innovation verification for the research results obtained by the related key and fostering projects, but also bring the research results from the laboratory to the real world. A verifiable physical carrier is provided. Moreover, the "China Intelligent Vehicles Future Challenge" competition was established and consecutively held for ten years. The integrated verification platform of unmanned intelligent vehicles is not only a physical verification carrier for unstructured environment perception and behavior decision-making capabilities of unmanned intelligent vehicle, but also a comprehensive verification carrier for the future Internet, car networking, intelligent transportation, smart sensors and new computer tools.

This plan has significantly improved the overall research level and international influence of China in the field of cognitive computing, visual and auditory information processing. The research results related to cognitive mechanisms were published in famous journals such as *Proceeding of the National Academy of Sciences of the United States of America*. New models and algorithms for visual cognitive mechanism were highly evaluated by international scholars, especially the proposed learning-based salient object detection method published on *IEEE Transactions on Pattern Analysis and Machine Intelligence* and commented by international scholars as "a second wave of interest", and it has become an internationally recognized representative work of visual attention testing with statistical learning methods. Chinese text labeling specifications were adopted by the national standard of "General Technical Specification of Chinese Speech Synthesis System". The results related to brain-computer interface were selected as two highlights papers by the *Journal of Neural Engineering*. The world's first on-orbit test platform of brain-computer interactive space was selected as one of 16 space medical experiments of "Tiangong No. 2" in 2015. "China Intelligent Vehicles Future Challenge" competition is known as the "Whampoa Military Academy" of China unmanned intelligent vehicle technology. Simultaneously, plenty of outstanding young and middle-aged talents have been trained during the implementation period of this plan, especially about 50% members of the expert group of the new generation artificial intelligence of the Ministry of Science and Technology were funded by this major project. It promotes the national strategy of new generation artificial intelligence in China.

The relevant achievements of this project won 4 Second Prizes of the State Natural Science Award, 1 Second Prize of State Technological Invention Award, 2 Second Prizes of State Scientific and Technologcal Progress Award, and 5 provincial and ministerial First Prizes. Moreover, some research achievements were implemented in the fields of unmanned intelligent vehicles, manned spaceflight, medical health and public safety.

Figure 1. China intelligent vehicles future challenge 2018

2.2 Introduction of Special Fund for Research on National Major Research Instruments Projects

Shanghai In-Situ Characterization Platform for Energy and Environmental Materials

"Shanghai In-Situ Characterization Platform for Energy and Environmental Materials" (known as ME^2) was approved by National Natural Science Foundation of China in 2012 as one of the Special Fund for Research on National Major Research Instruments projects. The total funding to this project was 148 million yuan for five years (from January 2013 to December 2017). The ME^2 project was jointly carried out by the Shanghai Institute of Microsystem and Information Technology (SIMIT), CAS, Shanghai Institute of Applied Physics (SINAP), CAS, Shanghai Institute of Optics and Fine Mechanics (SIOM), CAS and Fudan University. The leading PI was Professor Liu Zhi from SIMIT.

Energy and natural environment are fundamental for the survival and development of human beings. However, the energy overconsumption and environmental issues such as pollutions and global warming have become the common challenges to human society. From the material point of view, the key to solve these challenges relays on whether we can find a way to control materials' electronic structure and produce materials with tailor-made properties. To achieve this goal, a new generation of material electronic structure characterization facilities must be developed to overcome the limitations of traditional characterization tools and provide new tools and solutions to the investigation of energy and environmental materials. ME^2 project integrates the cutting-edge sample growth techniques with high-precision electronic structure characterization techniques. It aims at performing in-situ and operando measurement under various ambient conditions by incorporating near ambient environments. Furthermore, ME^2 is also designed to detect electronic structure of surface, bulk and interface by using both tunable synchrotron X-ray and tunable laser. Lastly, ME^2 is capable of studying the ultrafast behavior of material electronic structure.

Over the past 5 years, the ME^2 workgroup has successfully delivered all the tasks listed in the project proposal and finished the construction of the two beamlines and three endstations. All 23 machine parameters are achieved. In particular, the unique design and installation of the first ever APPLE-KNOT undulator has provided a solution to the heat load issue and enabled the implementation of low energy beamlines at a high energy ring. This EPU beamline is one of the best beamlines in the world in term of the photon flux and energy resolution. For the bending magnetic beamline of ME^2, several innovative designs are used to increase the photon flux and enhance the performance of ambient pressure measurements. Its ambient pressure photoelectron spectrometer also obtains the highest spatial resolution. These innovations in beamline and endstations make the ME^2 platform one of the most comprehensive and high-performance characterization facilities.

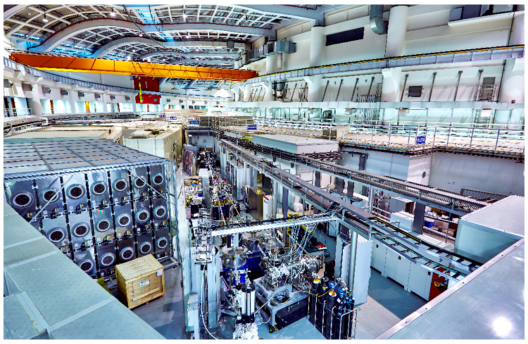


Figure 1. Shanghai in-situ characterization platform for energy and environmental materials

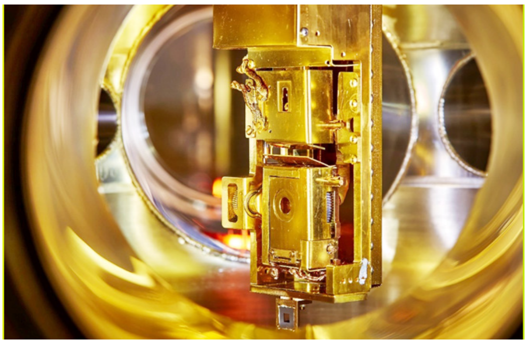


Figure 2. Multi-axis low temperature sample stage

With the completion of the ME^2 project, an international leading high performance material in-situ characterization platform is now available to users in China and aboard. It will not only enhance the material research capability at SSRF, but also benefit the international research community. In addition, many excellent researchers have emerged from the ME^2 R&D. Several of them have become the leaders in respective fields and provided a solid foundation for future facility R&D in this direction.

Development of Pulsed Multi-Frequency Single Spin Magnetic Resonance Spectrometer

"Development of Pulsed Multi-Frequency Single Spin Magnetic Resonance Spectrometer" was funded by NSFC in 2012 as one of the Special Fund for Research on National Major Research Instruments projects. The total funding to this project was 56 million yuan and the funding period was from January 2013 to December 2017. The project was carried out by Professor Du Jiangfeng and his team from University of Science and Technology of China.

Figure 1. Pulsed multi-frequency single spin magnetic resonance spectrometer

Spin magnetic resonance is an important subject in modern science and a very useful tool for various research. The Nobel Prize has been awarded for six times to scientists working in the field of spin magnetic resonance. It has been widely applied to frontier science and our daily life and production. However, conventional magnetic resonance, such as MRI used in medical diagnosis, can only measure the collective signals from about ten billion molecules distributed in millimeter-scale area. It is a huge challenge to realize the magnetic resonance of a single molecule. This project aims to develop a novel magnetic resonance spectrometer with single-nuclear spin sensitivity. The spectrometer can detect a single molecule and analyze its structure, functions and dynamics, which fulfills the cutting-edge demands of modern science. The magnetic resonance spectrometer is completely original and so far no similar spectrometer has been invented in the world.

After 5 years of hard work, the project team successfully developed the spectrometer through innovations in both detection method and technology. They developed experimentally the new detection method of single-spin quantum interferometer, instead of using the traditional induction detection. They also developed the multi-band high-fidelity control technologies and corresponding hardware, which can realize the high fidelity control of the sensor spin and target spins. The new spectrometer has four major units: the optical confocal unit, the multi-band synthetical unit, the microwave and radio-frequency pulses unit, and the console unit. Besides the successful detection of single-nuclear spin, it meets all the important indicators in the proposal: the quantum coherence time of the sensor spin (electron spin) is 3.37 millisecond; the fidelity of initial state preparation is 99.5%; the fidelity of the readout state is 93.5%; the typical gate time is 8.42 nanosecond; the phase modulation accuracy is 0.05 degree; the amplitude modulation accuracy is 0.001 decibel; and the spin manipulation fidelity is 99.67%. The performance of the spectrometer is at the top level in the world.

The project team also innovated the development process by combining frontier science research with the development of the spectrometer. By doing so, they improved the spectrometer according to the various requirements of different scientific areas and explored the potential applications of the spectrometer. The team has made fruitful research achievements in microscale magnetic resonance and its crossover areas with biology, physics and information science, and published 66 papers indexed in SCI, including one in *Science*, one in *Nature*, nine in *Nature* series journals, and 15 in *Physical Review Letters*. The finding of "magnetic resonance of a single protein molecule" was highly appraised by *Science* as "an important milestone", and was selected as one of the top 10 researches of Chinese science and one of the top 10 scientific progress of Chinese universities in 2015. The "single-molecule magnetic resonance technology based on single-spin sensor" was awarded the grand prize by the China Association for Instrumental Analysis (CAIA) in 2015.

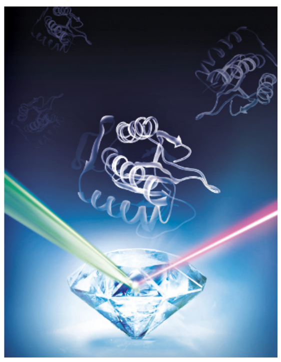


Figure 2. Realization of single protein magnetic resonance (Science 347, 1135 (2015))

The successful accomplishment of this project shows that China has reached the top level in single-molecule magnetic resonance. The spectrometer successfully improves the magnetic resonance sensitivity from ten billion-molecule level to single-molecule level and the resolution from millimeter level to nanometer level. It marks the realization of single molecule detection and the analysis of its structure, functions and dynamics using magnetic resonance with no destructive effect on the molecule itself. The spectrometer promises broad applications in research of physics, biology, medicine, chemistry and material sciences. It is also expected to have remarkable market potentials.

Multi-Channel Superconductor Single Photon Detector System

"Multi-Channel Superconductor Single Photon Detector" was approved by National Natural Science Foundation of China in 2012 as one of the Special Fund for Research on National Major Research Instruments projects with a total funding of 49 million yuan. The finding period was from January 2013 to December 2017. The project was led by Academician Wu Peiheng from Research Institute of Superconductor Electronics at Nanjing University.

Information transmission and computation using the quantum states of single photons has become an important topic in modern science and technology. Therefore the efficient and sensitive detection of single photons is one of the fundamental technical requirements nowadays. The project proposes a novel superconducting single photon detection (SSPD) apparatus based on superconductivity. Making full use of previous research results, the team aims to make new innovations in the quantum efficiency, response speed and wavelength range, photon number resolving and cryogenics so that the new apparatus can work in the wavelength range from 200 nm to 2,000 nm (hopefully 200 nm to 4,000 nm) with low dark count (<1cps), high efficiency (> 20% at 1,550 nm), high response speed (> 100MHz) and the ability to resolve up to 6 photons.

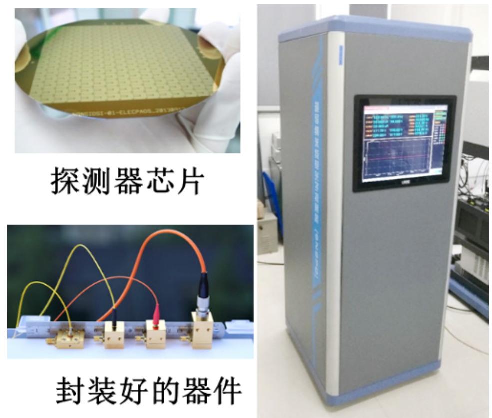


Figure 1. Multi-channel superconductor single photon detector (detector wafer, packaged devices and the apparatus)

After five years of hard work, the project team has acquired all the core technologies ranging from the growth of superconducting thin films to the design of chip structure and the development of fabrication technology. Through continuous innovation and technological breakthroughs, the project team developed several generations of apparatus models and finally completed the apparatus of "multi-channel superconducting single photon detector" whose performance reached or even exceeded the original target. The apparatus has six optical detection channels, which enables single photon detection from 200 nm to 2,700 nm. The maximum system detection efficiency is 90% (working wavelength 1,550 nm). With six photon number resolution capabilities, the detection rate reaches 300 MHz and the detection efficiency reaches 48% under the condition of dark counting of 1 cps. Its comprehensive performance index is the best among all results reported internationally.

During the development process, the project team also actively promoted the apparatus's applications. SSPDs adapted to different applications were developed and applied to the research fields of satellite/space debris detection, laser radar target location, fluorescence imaging of living organism tissue, quantum optics and quantum information. Especially to meet the demand of space exploration in China, the SSPD was applied to the 1.2 m Astronomical Optical Telescope system in cooperation with Yunnan Observatory, and the high precision laser ranging of satellite/space debris in 1,064 nm band was realized for the first time. The debris (named Surcal Debris 1520) with a radar cross section of 0.04 m^2 up to 1,500 km was detected and the ranging accuracy reached millimeter order. The apparatus has travelled more than 20,000 kilometers and spent more than 10,000 hours in outfield experiment. It has withstood all kinds of harsh conditions and has been unanimously praised by the cooperation institutions.

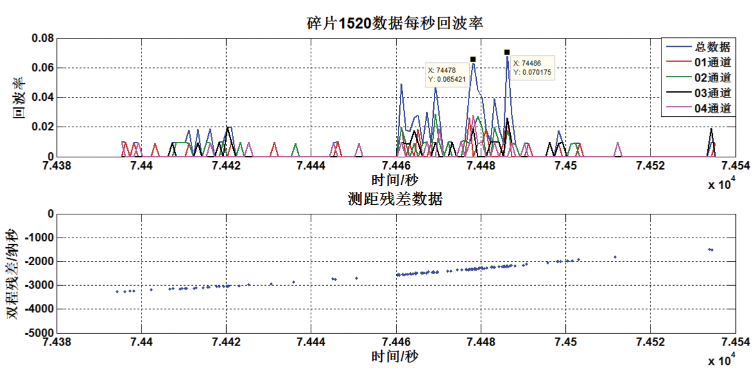


Figure 2. The echo signal of space debris 1520 detected by multi-channel superconducting single photon detector

Comprehensive Experimental Research Equipment Base on Tunable EUV Coherent Light Source

"Comprehensive Experimental Research Equipment Base on Tunable EUV Coherent Light Source " was funded by NSFC in 2011 with a funding of 103 million yuan for 5 years (from January 2012 to December 2017). The project was led by Academician Yang Xueming and jointly carried out by Dalian Institute of Chemical Physics and Shanghai Institute of Applied Physics, Chinese Academy of Sciences.

DCLS (Dalian Coherent Light Source) is the first Free Electron Laser (FEL) user facility in China, and also the only FEL facility operating exclusively in the extreme ultraviolet (EUV) wavelength region all over the world. Free electron laser, also called the Fourth Generation of Advanced Light Source, is a kind of large-scale scientific facility that can generate coherent short-wavelength radiation with ultra-high brightness and ultra-short pulse duration and dramatically improve the temporal and spatial resolution of scientific research. These outstanding properties will enable scientists to probe the microscopic world at the atomic and molecular level and on a femtosecond time scale, especially in studies of the electronic dynamic motion, molecular structure and evolution, and material phase transition. The EUV wavelength region is an ideal light source for excitation of valence electrons and ionization of molecular systems with high efficiency. The EUV light source will greatly promote the studies of important dynamic progress in the areas of energy, chemistry, physics, materials, etc.

Over the past six years, the project team has made a lot of important technique breakthroughs and successfully built the light source facility. DCLS has emitted the first EUV light beam based on the close cooperation between the two research institutes. The gain curve and spectrum of self-amplified spontaneous emission (SASE) and high gain harmonic generation (HGHG) FEL were both measured, and tapering undulator helped to increase the power by almost 100% when the FEL output saturated. It successfully delivered the optical beam from 50nm to 150nm in picoseconds or 100 femtoseconds for such research. A single pulse contained more than 10^{14} photons.

In the future, DCLS is expected to be a cutting-edge tool to promote the development of science and technology in China. 90% of the devices and equipment in DCLS are independently developed in China, showing that China has reached the international advanced level in this field and has the ability to lead the development of FEL in the world.

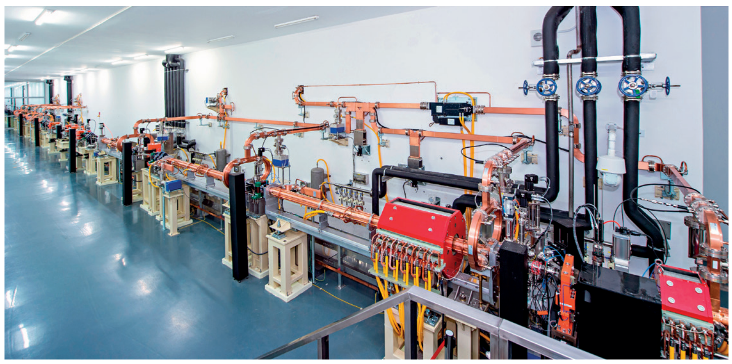


Figure 1. Electron linear accelerator of Dalian Coherent Light Source

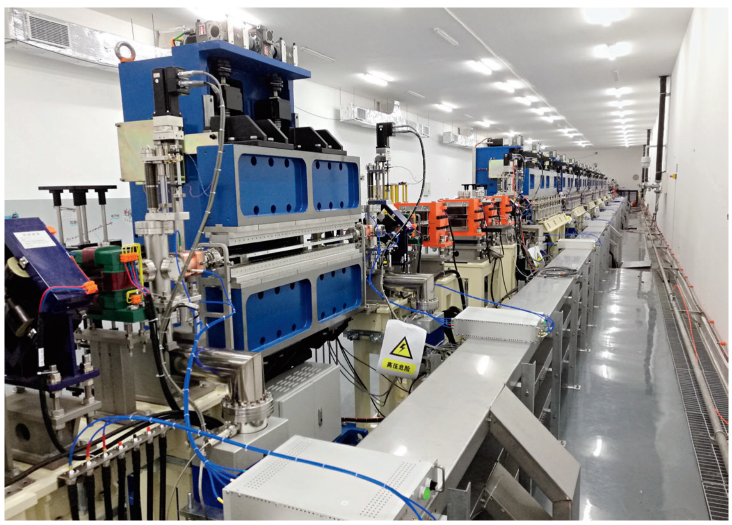


Figure 2. High order harmonic amplifier of Dalian Coherent Light Source

In-Situ Geomechanical Testing Facility Featured by High Energy Linear Accelerator CT Scanning and Multi-Field Coupling

The project "In-Situ Geomechanical Testing Facility Featured by High Energy Linear Accelerator CT Scanning and Multi-Field Coupling" was funded by NSFC in 2012 as one of the Special Fund for Research on National Major Research Instruments projects. The total funding for this project was 56.5 million yuan. The project run from January 2013 to December 2017. The Principal Investigator is Professor Li Xiao from the Institute of Geology and Geophysics, Chinese Academy of Sciences.

Geomechanical tests are essential in the areas of geosciences and geological engineering. The conventional geomechanical testing facility can only obtain the macroscopic mechanical parameters of rocks. It is impossible to observe the fracture evolution and gas-liquid migration inside rocks. It is also difficult to reveal the intrinsic driving force for the deformation and failure of the geological body. It has always been a dream for scientists to open the black box of geomechanical tests and transparentize the interior of rocks as glasses. The project is proposed to satisfy this important scientific requirement. The goal is to develop a rotatable servo controlled rigid geomechanical testing facility equipped with a high energy linear accelerator CT scanner.

In order to realize CT scanning and three-dimensional imaging, the testing unit must be rotated with high precision under the axial force as high as 2,000 KN. Since no such prototype exists at home and abroad, the research team has to start from scratch. Through five years of endeavor, the research team made several attempts, failed twice, manufactured three prototypes, and finally employed a "limited displacement oil cylinder-liquid floated support rotation" scheme. This particular design solves the following technical problems: the high-precision rotation and control technique of the testing unit under 2,000 KN axial force, as well as liquid-gas supply in the conditions of high temperature and high pressure. Benefited from the aforementioned technique break-through, a rotatable servo controlled rigid geomechanical testing facility was successfully created. In addition, to replace the embargoed linear electron accelerator with high X-ray energy above 2 MeV, the team independently designed 6 MeV accelerating tube, utilizing a linear electron acceleration technology through the side-coupling stationary wave. The whole processes, including physical design, mechanical design, processing and manufacturing, whole tube welding, microwave deployment and performance testing, are all independently accomplished by the research team. A highly stable beam with high energy and small focal spot is obtained, enabling the high-quality imaging of large-sized samples. Based on the aforementioned research and development, the project was successfully developed and achieved the following testing goals for the first time worldwide: testing the large-scale samples, simulating the deep underground temperatures and stresses, and observing the whole process of the rock damage and rupture. The comparisons of the main features with the state of art are listed in

Comparisons of the Main Features with the State of Art

Features	State of Art (2018)	New Facility
Rock Sample Diameter (mm)	25	100
Axial Force (KN)	70	2200
Confining Pressure (MPa)	7	60
Fluid Seepage Pressure (MPa)	7	60
Temperature (℃)	−20~160	−45~220
Energy	300 kV	6 MeV
Fracture Detection Resolution (mm)	0.05	0.05
New Features		
Gas Seepage Pressure (MPa)	N/A	55
Axial and Lateral Extensometer	N/A	Accuracy 0.1 μm
Independent Closed-Loop Electro-Hydraulic Servo Control	N/A	Accuracy ±0.1% FS
Loading Frame Stiffness (GN/m)	N/A	56
Post-Peak Behaviors of Rocks	Not capable	Capable

the table.

With the in-situ geomechanical testing facility featured by high energy linear accelerator CT scanning and multi-field coupling, the damage and rupture evolution process of geomaterials, such as rock, soil, concrete and ceramic, under various environmental force fields (stress, temperature, and fluid, etc.) can be obtained. It is useful for revealing the mesoscopic motivation of the macroscopic mechanical behaviors (deformation and failure) for geomaterials and establishing a scientific and rational constitutive model, which has important scientific significance. The research team has performed a large number of experiments using the aforementioned facility. The test results have been applied to the research works in the fields of shale gas exploitation, dry hot rock exploration, and highly radioactive nuclear waste geological disposal. Besides geosciences, the testing facility can also be applied to military, aerospace, materials, and machinery, etc.

Figure 1. In-situ geomechanical testing facility featured by high energy linear accelerator CT scanning and multi-field coupling

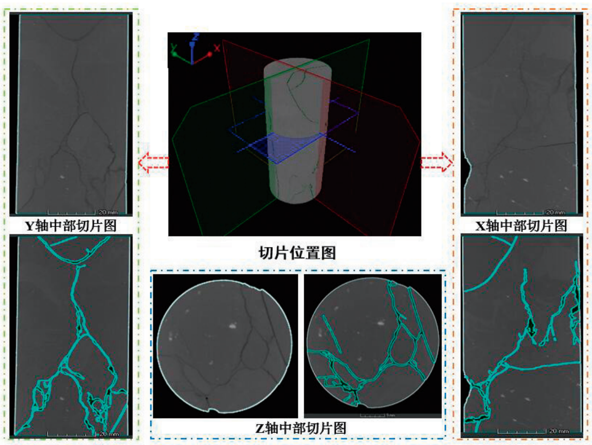


Figure 2. Fracturing pattern analysis for rocks

Atmospheric Profiling Synthetic Observation System

The project "Atmosphere Profiling Synthetic Observation System (APSOS)" was funded by NSFC as one of the projects of the Special Fund for Research on National Major Research Instruments in 2011. The project received a funding of 93 million yuan, and ran from January 2012 to December 2017. The principal investigator is Academician Lyu Daren from the Institute of Atmospheric Physics, Chinese Academy of Sciences. The project was jointly undertaken by researchers from the Wuhan Institute of Physics and Mathematics of Chinese Academy of Sciences, the University of Science and Technology of China, the Anhui Institute of Optics and Fine Mechanics of Chinese Academy of Sciences, the Purple Mountain Observatory of Chinese Academy of Sciences, Wuhan University and Anhui Sun Create Electronics Co. Ltd.

Climate change, environmental change and human activities are influencing the human sustainability. In decades, observation-based studies in atmospheric science highly rely on meteorological satellites and weather stations. However, there exist strong demands for vertically profiling atmospheric parameters, continuously making long-term observations, extensively investigating the interactions within atmospheric layers, and comprehensively understanding the atmospheric responses to solar activities, as well as natural and anthropogenic influences.

In the past six years, the team has endeavored for developing this Atmosphere Profiling Synthetic Observation System, the first ground-based observatory in Tibet to measure the whole (neutral) atmosphere from the surface up to the lower thermosphere. Utilizing world-class lidar, radar, and terahertz technologies, APSOS is a unique fusion of active and passive remote sensing instrumentations, providing measuring capabilities with fine vertical resolution and high temporal resolution. Five lidars of APSOS yield range-resolved profiles of 11 atmospheric variables (temperature, water vapor, density, wind, sodium density, ozone, CO_2, SO_2, NO_2, cloud, and aerosol). The telescope assembly of APSOS achieves an equivalent aperture of 2 meter using advanced optical technology. APSOS also includes the first ground-based superconducting terahertz radiometer and the first ground-based W-band cloud radar in China.

APSOS has been deployed at Yangbajain (4,300 m MSL), Tibet since October 2017. It has become a world-class atmospheric observatory, located at the highest altitude, and equipped with the most comprehensive atmospheric sounding instrumentations. The success of APSOS development has demonstrated that Chinese researchers have possessed frontier technologies for monitoring atmosphere and space environment. The state-of-art technical expertise and important observational data from APSOS will make great contributions to the atmospheric research over the Tibetan Plateau.

Figure 1. Aerial view of APSOS at Yangbajain, Tibet

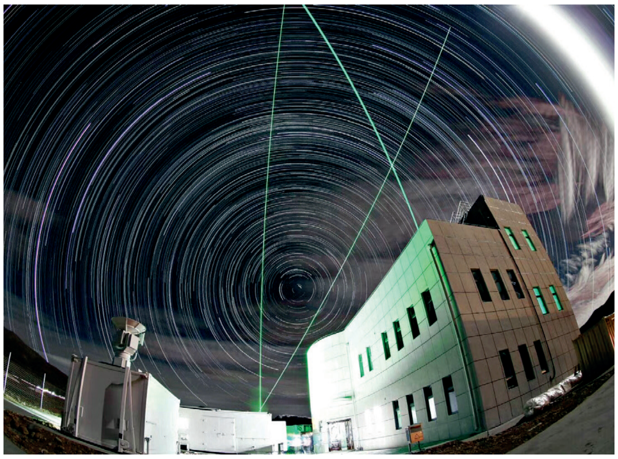


Figure 2. APSOS in operation at night

Small Animal Optical Multimodality Molecular Imaging System

From January 22 to 26, 2018, the National Natural Science Foundation of China (NSFC) organized the expert team to complete the acceptance of the project "Small Animal Optical Multimodality Molecular Imaging System" (chief scientist: Professor Tian Jie, project funding: 85,000,000 yuan, execution time: January 2013 to December 2017), which is one of the Special Fund for Research on National Major Research Instruments projects. Professor Gu Ying, the academician of Chinese Academy of Sciences, and Mrs. Yanying Xu, the deputy director of the Medical Science Division in NSFC, co-chaired this one-week project evaluation and acceptance meeting.

It took Professor Tian's team five years to accomplish the research and development of this *in vivo* animal molecular imaging system (Figure 1). Furthermore, a series of applications and investigations were conducted by this system in a wide range of biomedical research, which demonstrated its capability in imaging sensitivity and accuracy. It integrates five different imaging modalities into one scanner (four simultaneous + one sequential imaging acquisition), including bioluminescence tomography, fluorescence molecular tomography, Cerenkov luminescence tomography, X-ray computed tomography, and magnetic resonance imaging (Figure 2). Meanwhile, it can merge the photoacoustic tomography and optical projection tomography by self-developed registration algorithms. Because of such advanced multimodality data acquisition ability, a new imaging principle, the optical-radiotracer combined super-sensitive imaging principle, was successfully developed and implemented, which achieved a breakthrough of the micro-tumor detection limitation. The smallest tumor that can be visualized *in vivo* was dramatically improved from 5 mm in diameter into less than 2 mm. The major specifications of the system are: 3 mm optical resolution, 30 μm spatial resolution, 50 mm imaging depth, 120 mm×120 mm field of view, and less than 5 mins whole body scan time. Comparing with other animal multimodality imaging systems existing in the world, this newly developed system shows apparent superiorities in tumor 3D positioning error (0.2 mm vs. 1 mm), 3D reconstruction time (10 s vs. >1 min), spatial resolution (0.3 mm vs. 0.5 mm), and hybrid number of imaging modalities (5 vs. 2-3).


Figure 1. The small animal optical multimodality molecular imaging system

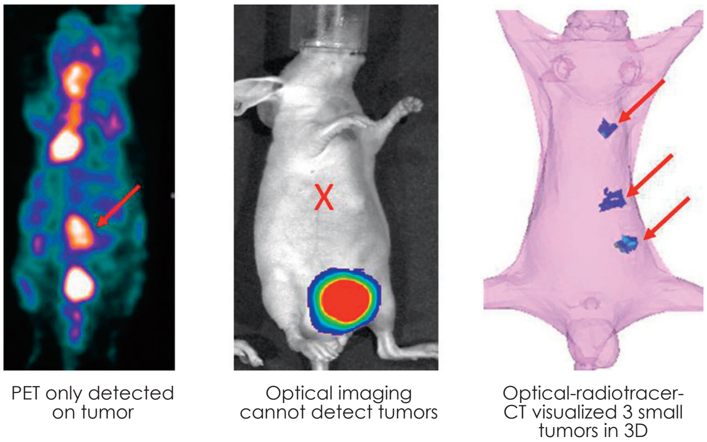


Figure 2. The comparison between single imaging modality and optical-radiotracer-CT multimodality imaging of a breast cancer bearing mouse model

This project achieved technological breakthrough in multimodality imaging and successfully developed the small animal optical multimodality molecular imaging system. It verified the optical-radiotracer combined super-sensitive imaging principle and realized submillimeter-level tumor molecule imaging, as well as more comprehensive imaging data acquisition. It showed a great promise in accelerating the progress of basic biomedical research in oncology and many other diseases. The promoted application of optical multimodality molecular imaging technology is highly expected, which may facilitate the generation of new directions of the fundamental research and application in the fields of information science, chemistry, biology, medicine, and many other disciplines.

Magnetic Resonance Imaging Instrument System for Research on Major Diseases of the Human Lungs

The "Development of Magnetic Resonance Imaging Instrument System for Research on Major Diseases of the Human Lungs" is one of 11 Special Fund for Research on National Major Research Instruments projects (recommended by the national departments) approved by the National Natural Science Foundation of China in 2012. This project was funded 44 million yuan in total, and it was accomplished on time (January 2013–December 2017) by the team led by Professor Zhou Xin at National Center for Magnetic Resonance in Wuhan, Wuhan Institute of Physics and Mathematics (WIPM), Chinese Academy of Sciences.

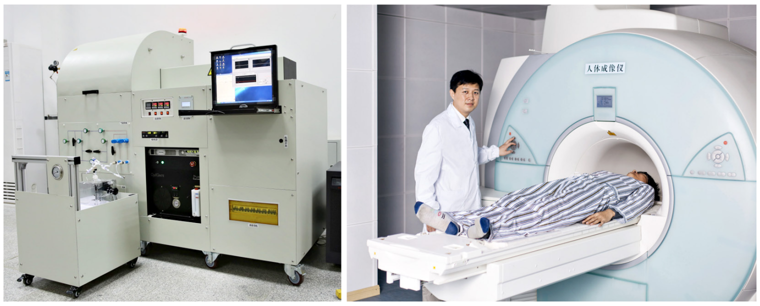


Figure 1. Hyperpolarized ^{129}Xe human lung gas magnetic resonance imaging instrument system

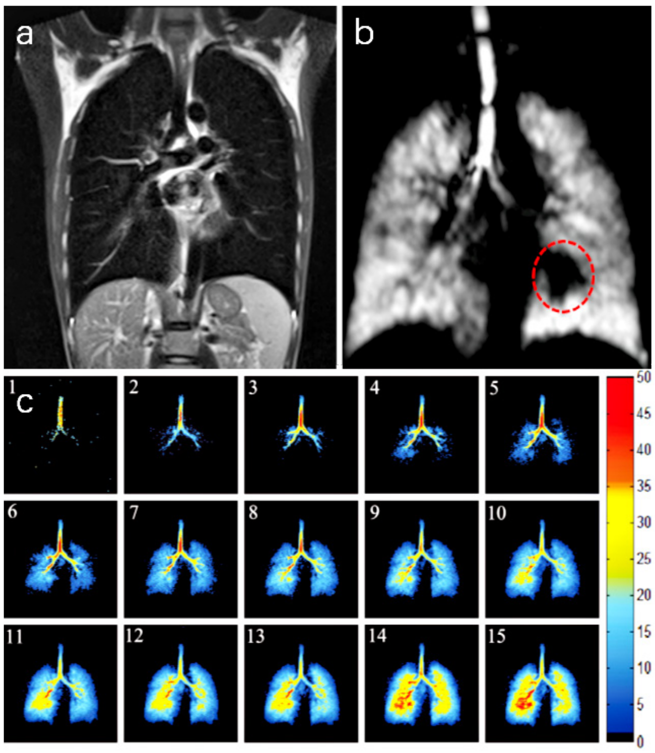


Figure 2. The conventional proton lung MRI (a), which could not visualize the lung airspace. Hyperpolarized ^{129}Xe gas lung MRI is able to detect the lung ventilatory defects that CT cannot detect (b), as well as dynamically and quantitatively assess the microstructure and function of the human lungs in real time (c).

The burden of lung diseases in China is really serious. Lung cancer is a kind of malignant tumors with the highest morbidity and mortality in China, and about one in the four dead cancer patients was caused by lung cancer on average. China accounts for about 40% of the global chronic obstructive pulmonary disease (COPD) patients, and the number is up to 99.9 million populations. Unfortunately, the current clinical pulmonary imaging modalities (such as chest X-ray, CT, and PET) are unable to evaluate pulmonary structure and gas-blood exchange function without ionizing radiation quantitatively. Lung's airspace is a "blind hole" for the clinical proton magnetic resonance imaging (MRI) due to its special cavity structure, greatly hindering the comprehensive study of major lung diseases at the early stages. Accordingly, it is vital to develop a scientific instrument that is able to not only visualize the pulmonary structure, but also quantify the pulmonary gas-gas and gas-blood exchange functions with a high sensitivity. The project is aimed at this major scientific issue, and the goal is to develop an MRI instrument system based on hyperpolarized $_{129}$Xe gas, which will enhance the sensitivity of the gas MRI signal by more than 50,000 times with a productive rate of more than 600 ml/h, resulting in a lung gas MRI resolution of better than 2 mm. With this scientific instrument, the pulmonary microstructure and function can be evaluated quantitatively regionally without radiation and invasion.

After five years of scientific research, the research team successfully developed a set of human lung gas MRI instrument, which solved the key technical problems in the lung gas MRI. A number of original results have been achieved in the core technology innovations, including xenon gas polarizer, gas signal detection in the human lungs, and the compatibility of new technique in the conventional whole body MRI system. By using this instrument, xenon gas MRI signal is enhanced by more than 57,000 times, and the problems of inability to image the lung due to low MRI signal intensity are solved in China; the high-resolution human lung gas dynamic MRI with fastest sampling rate (202 milliseconds per frame) are obtained, which improves the dynamic evaluation technology in the lung gas inhalation process. Besides, the techniques of compatible with conventional human MRI systems, innovative wearable lung imaging probes and plug-in variable frequency imaging systems, enable commercial MRI instruments to have the capacity of human lung gas imaging.

The achievements of this project won the "National Wang Tianjuan Magnetic Resonance Award", the "China Patent Excellence Award" in 2016 and 2017, and the "First Prize for Technological Invention in Hubei Province" in 2018 (publicized). During the "two sessions" (2018), this project was reported as a special coverage by *People's Daily*, and was recommended by the Ministry of Science and Technology to participate in the National Science and Technology Innovation Achievement Exhibition in 2018, and the "InnoTech Expo 2018" in Hong Kong and Macao.

The successful implementation of the project makes China become one of four countries owning such key technology in this field, and the core technical parameters are internationally advanced. Novel medical imaging instrument for the lung diseases greatly help doctors discover, diagnose and treat the early lung diseases. Based on the pioneering results of the instrument, the project team continues to make great efforts and strive to make further breakthroughs in the basic research of major diseases of the lungs, and then establishes a new standard for clinical gas imaging evaluation of COPD in China. At the same time, they are trying to accelerate the localization of this medical equipment, and make this innovative instrument serve the public health industry in China more deeply and extensively.

3 Project Review in 2018

In 2018, the scientific research teams funded by the National Natural Science Fund have made remarkable achievement on innovation and major breakthroughts in various areas of basic research.

A Key Breakthrough in the Arithmetic Study of Special Values of L-Functions

Langlands program is a series of far-reaching conjectures in mathematics, known as the Great Unified Theory of Mathematics. It points out that number theory, algebraic geometry and representation theory of algebraic groups, the three branches of mathematics that have developed relatively independently, are closely related, while the bonds that connect these branches of mathematics are L-functions. The Riemann hypothesis and the BSD conjecture, two of the seven famous "Millennium Prize Problems" in mathematics, are about L-functions. The arithmetic property of the special values of L-functions is one of the key problems of Langlands program and arithmetic algebraic geometry.

Period integrals are fundamental in the study of L-functions. There are two types of period integrals which are widely studied, namely, the Rankin-Selberg periods and the linear periods. In the arithmetic study of special values of L-functions by Rankin-Selberg method, there is an obstacle known as the nonvanishing hypothesis. The hypothesis was first proposed by D. Kazhdan and B. Mazur in the 1970s. Before Kazhdan-Mazur's nonvanishing hypothesis was proved, at least 10 important papers had been published based on this hypothesis.

With the continued funding of the National Natural Science Foundation of China, Professor Sun Binyong, at the Academy of Mathematics and Systems Sciences, Chinese Academy of Sciences, completed the proof of Kazhdan-Mazur's nonvanishing hypothesis. The paper has been published in the *Journal of the American Mathematical Society*. A referee pointed out in the review comments that "this nonvanishing is a fundamental sticking point in all the work on the subject".

The work has been called "Sun's breakthrough". K. Prasanna and A. Venkatesh (Fields medal winner) commented that "a key breakthrough on nonvanishing has now been made by Sun". M. Harris, Professor of Columbia University, commented in his ICM report that "Sun's recent proof of this conjecture has revived interest in the problem and one can expect rapid progress in the next few years".

The arithmetic properties of L-functions are reflections of the topological properties of arithmetic manifolds, and the topological properties of arithmetic manifolds are captured by cohomological representations of Lie groups. Based on previous works and his doctoral thesis, Sun introduced the analytic method of constructing local periods of cohomological representations, which is a key ingredient in the proof of the Kazhdan-Mazur's nonvanishing hypothesis. As a supplement to this analytic method, Sun also introduced an algebraic method for constructing local periods of cohomological representations. This construction has been called "Sun's cohomologically induced functionals". Using this algebraic construction, Sun also proved the nonvanishing hypothesis for linear periods. The paper was published online in *Duke Mathematical Journal* in 2018.

Observation of Majorana Bound States in an Iron-Based Superconductor

Majorana fermions (MFs) are spin-1/2 particles with the intriguing property of being their own antiparticles proposed by Ettore Majorana in 1937. Recently, the search for Majorana bound states (MBSs) has attracted tremendous interest owing to MBSs' potential application as topological qubits to perform fault-tolerant quantum computation aided by their non-Abelian characteristics.

Under the condensed matter framework, a number of platforms for detecting MBSs have been proposed. However, the experimental observation of MBSs is still challenging. In the past few years, supported by the National Natural Science Foundation of China, a joint research team led by Professor Ding Hong and Professor Gao Hongjun (Institute of Physics, Chinese Academy of Sciences) carried out systematic studies on the structural and topological properties of iron-based two-dimensional superconducting materials by using angle resolved photon electron spectroscopy (ARPES) and scanning tunneling microscopy/spectroscopy (STM/STS).

Taking advantage of scanning tunneling microscopy/spectroscopy (STM/S) with ultra-low-temperature and strong-magnetic-field, Professor Gao's group and Professor Ding's group observed Majorana zero modes, which turned out to be Majorana anyons, on $FeTe_{0.55}Se_{0.45}$ surface. $FeTe_{0.55}Se_{0.45}$ naturally hosts a spin-helical Dirac surface state with an induced full superconducting gap and a small Fermi energy. These properties provide suitable conditions for observing a pure MBS that is distinctively isolated from other non-topological Caroli-de Gennes-Matricon bound states (CBSs). Inspired by the above hypothesis, the research team carried out a high-resolution STM/S experiment on the surface of a high-quality $FeTe_{0.55}Se_{0.45}$ sample supplied by Professor Gu Genda's group in Brookhaven National Laboratory in USA. They observed a sharp zero-bias peak (ZBP) inside a vortex core which did not split when the tip was moving away from the vortex center. The ZBP was observed under conditions across a large range of magnetic field (0.5 T to 6 T) and temperature (0 K to 3 K). The decay of the ZBP intensity with the tip moving out of the vortex center matches the theoretical models proposed by Professor Fu Liang from Massachusetts Institute of Technology, USA. The evolution of the peak under varying magnetic field, temperature and tunneling barrier is consistent with the tunneling to a nearly pure MBS, distinguished from non-topological bound states. This is the first time of the observation of MBSs in a single material. In comparison with previous reports on the observation of MBSs, the combination of high-Tc superconductivity and Dirac surface states in a single material offers clear advantages for detecting and manipulating MBSs. Therefore, this work provides a potential platform for realizing and manipulating MBSs at a relatively high temperature. Furthermore, the high transition temperature and large superconducting gap in this material provide a promising platform to fabricate robust devices for topological quantum computation. The finding has been published online in an article entitled "Evidence for Majorana bound states in an iron-based superconductor" in *Science* on August 16, 2018.

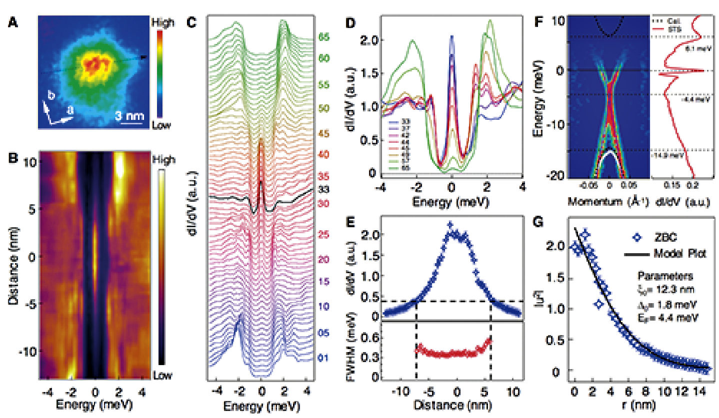


Figure 1. Energetic and spatial profile of ZBPs

A New Member in the Family of Perovskite: Discovery of the Organic Perovskite Ferroelectric

As the frontier of functional material research, inorganic perovskite materials have long been the focus of condensed matter physics and material sciences. Because of their extraordinary physical properties, such as superconductivity, giant magneto resistance, piezoelectricity and ferroelectricity, inorganic perovskite materials have been widely utilized in applications on energy, communication and information. Besides inorganic perovskite, another important branch of the perovskite family is organic-inorganic hybrid perovskite, also known as the "wonder material". In such a hybrid form, both low cost and flexibility can be achieved with high light-electricity conversion efficiency in both photovoltaic and light-emitting applications. In contrast with the rapid development of the above two types of perovskite materials, organic perovskite (metal-free perovskite), the last member of perovskite family, has not been reported. Organic perovskite is not only free from the toxicity of metal elements, but also possesses advantages similar to hybrid perovskite such as low cost, flexibility and simple film preparation. Without the constraint of metal elements, organic perovskite has much more flexible composition and structure, and more importantly, it makes the realization of chirality possible. For these reasons, organic perovskite is very attractive to researchers in related fields. As early as in 2002, "Research Highlight" of *Science* has predicted the importance and great potentials of organic perovskites, but no breakthroughs were made in the 16 years after that.

In 2018, researchers from Southeast University and Nanchang University reported the discovery of organic perovskite materials, under the support of NSFC. Their research shows that 17 different organic perovskite materials display good ferroelectricity. Among them, MDABCO-NH_4I_3 not only possesses a saturated polarization comparable to inorganic barium titanate (BTO), but also has a Curie temperature higher than that of BTO for about 50 K. These newly discovered organic perovskite ferroelectrics also possess multiple polar-axes, similar to their inorganic analogs. For example, MDABCO-NH_4I_3 has fourfold polar axes with eight possible polarization directions, which shows great potential in thin-film related applications. More interestingly, with proper molecular design and rational synthesis, researchers introduced chiral centers that is impossible to achieve with inorganic perovskites. They reported several optically active non-centrosymmetric organic perovskites, such as R-3AQ-NH_4Br_3, S-3AQ-NH_4Br_3, R-3AP-NH_4Br_3 and S-3AP-NH_4Br_3. Combining good ferroelectric performance and feasible optical activation, this system would play an irreplaceable role in the relative applications such as optoelectronics, biocompatible devices, and flexible devices. More importantly, such a new system may shed some light on the design and synthesis of functional perovskites and break the ice of current development.

This work was published in *Science* as a research article on July 13, 2018 (*Science*, 2018, 361: 151–155) with title of "Metal-free three-dimensional perovskite ferroelectrics". The work has not only confirmed the prediction of *Science* in 2002 and proven the existence of organic perovskites, but also marked the important development of China in the field of molecular materials.

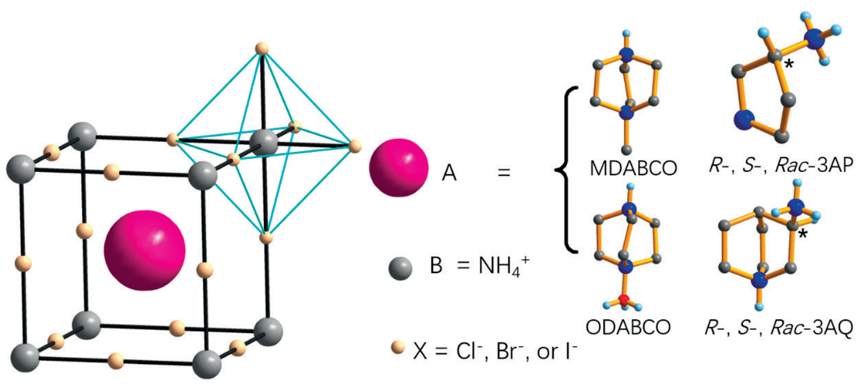


Figure 1. Illustration of new organic perovskite ferroelectric materials

Mechanisms for Urban Atmospheric New Particle Formation Revealed by Chinese Scientists

Atmospheric new particle formation (NPF) is ubiquitous around the world. It has a significant contribution to the number concentrations of atmospheric aerosol particles and cloud condensation nuclei, and imposes an important impact on the regional and global climate. Mechanisms for NPF events have recently been proposed for a few locations with low background aerosol loadings, but the mechanism underlying urban NPF events is still a puzzle because of the extreme chemical complexity of the urban atmosphere, especially in a Chinese urban city. In-situ, real-time measurements of atmospheric gaseous precursors and critical clusters for NPF events with mixing ratios less than 10^{-12} represent a major experimental challenge. With the support from NSFC, the team led by Professor Wang Lin from Fudan University and their research partners conducted continuous NPF observation from March 2014 to February 2016. They measured the number size distributions of atmospheric particles between ~1.2 nm and 700 nm, from which the particle formation rate ($J_{1.7}$) and growth rates were derived. They also deployed an atmospheric pressure interface−Time of flight-mass spectrometer and a nitrate-chemical Ionization−time of flight-mass spectrometer to detect atmospheric naturally-charged and neutral species including clusters during the winter of 2016.

The collaborative research leads to the following results.

(1) Measurements of gaseous precursors at a molecular level were achieved. The highest mass spectrometric signals of sulfuric acid dimer ($H_2SO_4 \cdot HSO_4^-$), ever measured in an ambient atmosphere, were evident. A series of key sulfuric acid-DMA clusters were identified as well (see Figure 1).

(2) The observed particle formation rates during the ambient campaign were consistent with those in the sulfuric acid-dimethylamine-water ternary nucleation experiments from Cosmics Leaving Outdoor Droplets Chamber.

(3) The observed concentration of sulfuric acid was high enough to explain the particle growth rates up to ~3 nm under the very high condensation sink, and the subsequent higher growth rates beyond this size is believed to result from the added contribution of condensing organic species.

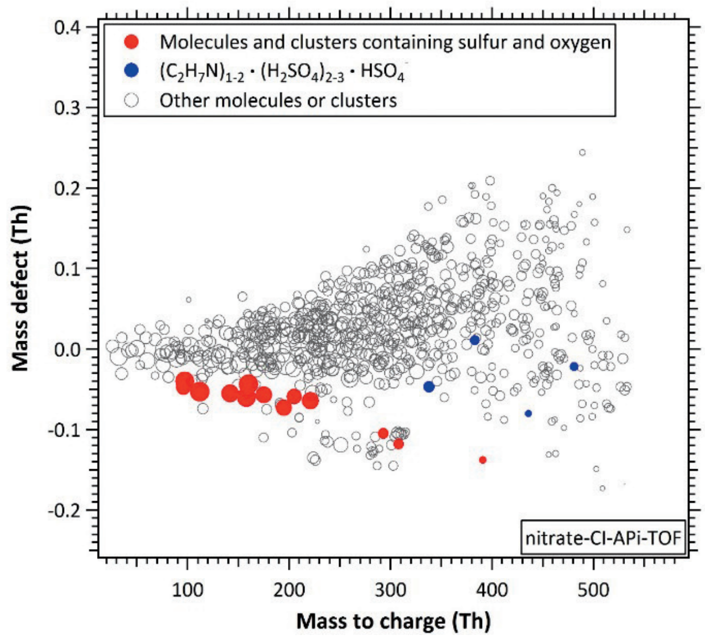


Figure 1. Mass defect plot of detected trace species

It is the first time that sulfuric acid-dimethylamine-water NPF mechanism has been observed and confirmed in an ambient atmosphere. On July 20, 2018, this finding, titled "Atmospheric new particle formation from sulfuric acid and amines in a Chinese megacity", was published in *Science*. This mechanism can be potentially applied to explain NPF events in other urban areas in China, and provide scientific evidences to Chinese policy makers to frame regulations to reduce secondary aerosol formation in China. In addition, this finding will help to improve the performance of global climate models to better predict the future climate.

Important Progress in the Neural Mechanism of Thalamic Control of Wakefulness

Wakefulness is fundamental to sensory, motor, emotion, consciousness and so on. Poor wakefulness state causes decreased vigilance, damaged attention and declined cognition. Therefore, exploring the neural mechanism of wakefulness control has been the key but difficult point of neuroscience. Thalamus has long been thought to be an important component of the dorsal pathway of the ascending arousal system. Clinical observations indicate that patients with paramedian thalamus stroke show decreased wakefulness or even sleep-like coma, which suggest that the paramedian thalamus is critical node for wakefulness. The paramedian thalamus consists of a large number of tiny nuclei with complicated anatomical structures and input-output organizations. However, the specific nucleus and circuitry controlling wakefulness has not yet been identified.

With the support by National Natural Science Foundation of China, the research group led by Professor Hu Zhian at the Department of Physiology & Collaborative Innovation Center for Brain Science, Army Medical University, evaluated the role of thalamus in wakefulness control by integrating multiple methods at molecular, neural, circuit and behavioral level.

The research group first mapped the activities of different thalamic nuclei during sleep-wake cycle and observed that the activity of the paraventricular thalamus (PVT) is tightly coupled with wakefulness. To examine the role of the PVT in wakefulness control, the group used chemogenetic method and found that reversible inhibition of PVT neurons induced a significant reduction of wakefulness, along with fragmentation of wakefulness. In addition, selectively ablating PVT glutamatergic neurons continuously reduced wakefulness and increased EEG δ power. Optogenetic activation of PVT glutamatergic neurons during sleep induced fast transitions to wakefulness (Figure 1). Additionally, optogenetic activation of the PVT not only increased the activities of cortical neurons but also accelerated the emergence from isoflurane-induced unconsciousness. Further studies showed that PVT glutamatergic neurons projected to multiple cortical and subcortical regions, the wakefulness-controlling function was mediated by the PVT to nucleus accumbens (NAc) pathway but on PVT to cortex pathway. Optogenetic activation of PVT-NAc pathway induced transitions from sleep to wakefulness whereas inhibition of this pathway decreased wakefulness. Moreover, the PVT received and was regulated by inputs from hypocretin (Hcrt) neurons in the lateral hypothalamus (LH). Inputs from Hcrt neurons increased PVT neuron's activity, which was important for wakefulness control (Figure 1).

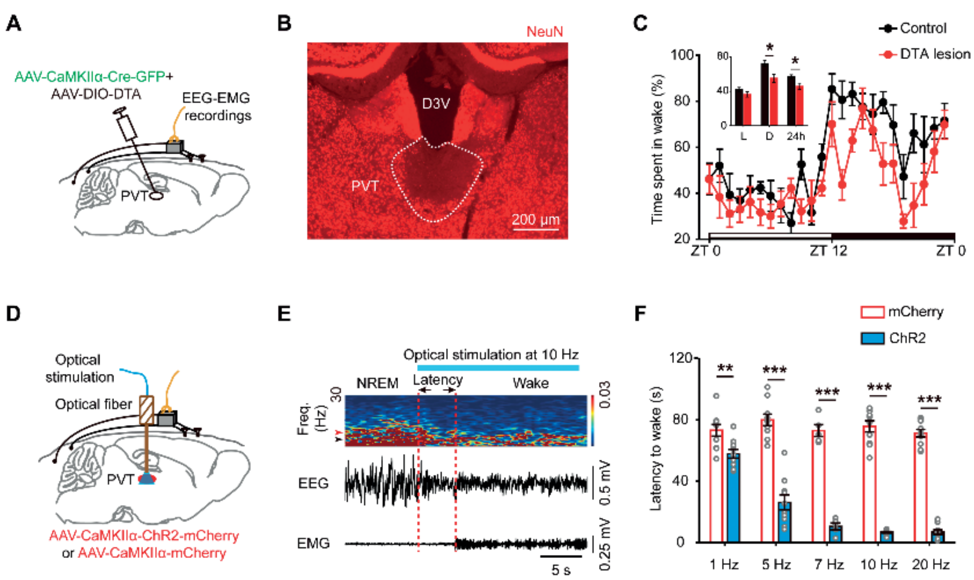


Figure 1. The critical role of the paraventricular thalamus in wakefulness control

Taken together, this study demonstrated that the PVT is critical for wakefulness control and determines the circuit mechanism from anatomical and functional aspects. The discovery of key mechanism of wakefulness control provides a better understanding of the working principle of brain and the clinical symptoms of diseases with thalamus injuries. Importantly, the discoveries are expected to provide precise targets for the treatment of wakefulness disorders, such as sleepiness and coma. This study was published in *Science* in October 2018.

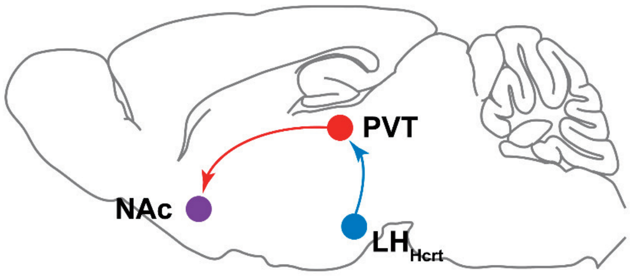


Figure 2. The working model of the LH_{Hcrt}→PVT→NAc circuitry in wakefulness control

Structural Insights into Precursor TRNA Processing by Ribonuclease P

With the support from the National Natural Science Foundation of China, the research team directed by Professor Lei Ming at Shanghai Institute of Precision Medicine, the Ninth People's Hospital, School of Medicine, Shanghai Jiao Tong University recently reported the structural insights into precursor tRNA processing mechanism by eukaryotic RNase P, which was published as two research articles in *Science* and *Cell*.

Ribonuclease P (RNase P) is a ribozyme that processes transfer RNA (tRNA) precursors and is conserved in all three kingdoms of life. Unlike bacterial RNase P, which contains only one small protein cofactor, archaeal and eukaryotic nuclear RNase Ps have evolved considerably more complex protein subunits: 5 in archaea and 9 to 10 in eukarya. The role of protein components and the reason for the increased complexity of the protein moieties in eukaryotic nuclear RNase P are still poorly understood. It is still largely enigmatic how the pre-tRNA was recognized and processed by RNase P. High-resolution structures of eukaryotic RNase Ps are required to answer these key questions.

Professor Lei's group determined the cryo-EM structures of *Saccharomyces cerevisiae* and human RNase P holoenzymes alone and in complex with pre-tRNA. The structures reveal that all the protein subunits form an interconnected hook-shaped architecture that tightly wraps around the extended single-layered RNA subunit and stabilizes RNase P into a "measuring device". This "measuring device" employed two fixed anchors to recognize the L-shaped structure rather than specific sequences of pre-tRNA substrates. The binding of pre-tRNA substrate induces a large conformational change in the active center. Two catalytically important magnesium ionsin RNase P are coordinated in the catalytic center by a highly conserve duridine and the phosphate backbone of the catalytic RNA, together with the scissile phosphate and the O3' leaving group of pre-tRNA. Moreover, simulation analysis visualizes the mechanistic details of phosphodiester bondhydrolysis of pre-tRNA, which is a two-Mg^{2+}-ion–mediated S_N2 reaction. The structures also provide an evolutionary model depicting how such a simple ribozyme evolved into much more complex protein components in higher organisms.

This study represents a major step forward for mechanistic understanding of the function of eukaryotic RNase P and supports that all RNase Pribozymes share an RNA-based, substrate induced catalytic mechanism of pre-RNA processing.

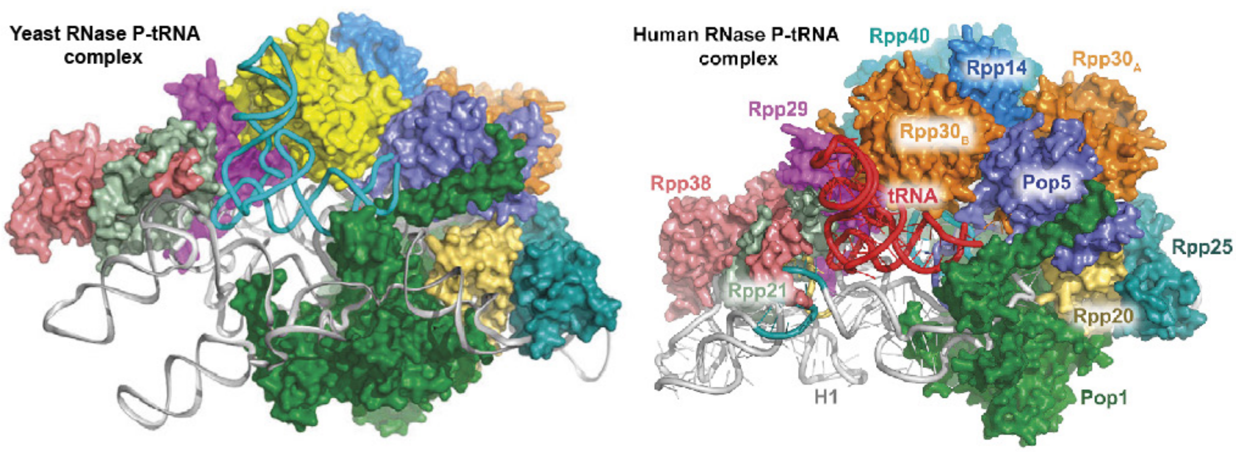


Figure 1. Cryo-EM structures of yeast and human RNase P bound with pre-tRNA substrate

Significant Progress in the Use of Magnesium Isotopes to Trace Recycled Surficial Materials

To explore “How does Earth’s interior work?” is a core task of modern Earth science. Understanding the chemical composition and evolution of the mantle, together with the material cycling between the Earth’s deep mantle and its surface, is exceptionally important to answer this question. Ocean island basalt (OIB) provides a window into the Earth’s deep mantle. Previous radiogenic isotope studies of OIBs have revealed that the Earth’s mantle is highly heterogeneous in chemical composition, and defined several mantle end-members such as EM1, EM2 and HIMU. Although it is believed that the formation of these mantle components is related to the recycling of Earth’s shallow materials, there is still a great controversy as to which kind of recycled materials these mantle components represent. In particular, the fight over the origin of EM1 is the longest-running and most heated debate. EM1 is thus considered to be the most “enigmatic” mantle component.

With the support of National Natural Science Foundation of China, the research team led by Professor Chen Lihui from the School of Earth Sciences and Engineering, Nanjing University, together with their foreign partners, focused on the controversial issue about the origin of EM1. They chose the most typical EM1-type OIB samples as research objects, which were collected from the Pitcairn Island (an island produced by partial melting of the Pitcairn mantle plume about 0.95~0.45 million years ago). High-precision analysis of Mg, Sr, Nd, Pb, and Hf isotopes of these samples were carried out, in addition to conventional major and trace elements.

This research team found that the Mg isotopic compositions of the typical EM1-type OIB samples (Tedside) are significantly lighter than that of the normal peridotitic mantle (Figure 1). The correlation between Mg stable isotopes and radiogenic isotopes of EM1-type OIBs further suggests that the light Mg isotopic compositions of the EM1-type OIBs are inherited from the EM1 component in the mantle source. The low δ^{26}Mg value of EM1, combined with previously published evidence yielding exceptionally unradiogenic Pb as well as sulfur isotopes affected by mass-independent fractionation, suggests that the Pitcairn EM1 component is most likely derived from late-Archean (2.5~2.6 Ga) subducted carbonate-bearing sediments. This finding indicates that some sediments, which once lay on the Earth’s surface in the Archean, have traveled from the Earth’s surface to the core-mantle boundary (~2,900 kilometers deep in the Earth) and ultimately came back to the surface to serve as ingredients of the Pitcairn volcanic island, after a period of ~2.5 billion years staying down below (Figure 2).

The research result was published in *Proceedings of the National Academy of Sciences of the United States of America*. The main achievements of this research include: (1) it provided a clear constraint on the origin of the enigmatic EM1 component; (2) it offered a novel idea to explore the material cycling between the Earth’s deep mantle and its surface by combining non-traditional stable isotopes and conventional radiogenic isotopes; (3) it enriched the application of non-traditional stable isotopes in exploring high-temperature geological processes.

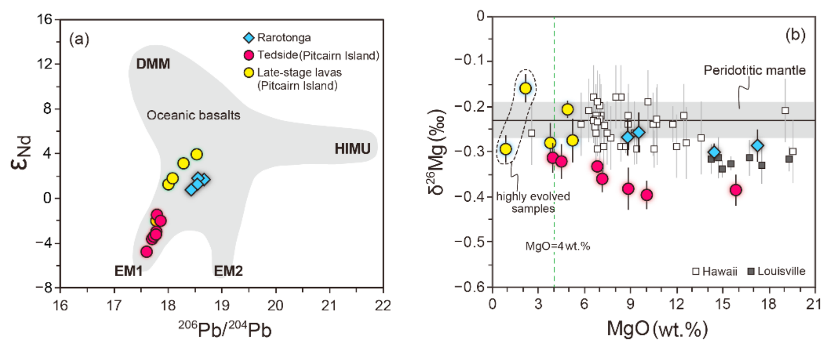


Figure 1. (a) ε_{Nd} vs. $^{206}Pb/^{204}Pb$ and (b) δ^{26}Mg vs. MgO for Pitcairn OIB samples

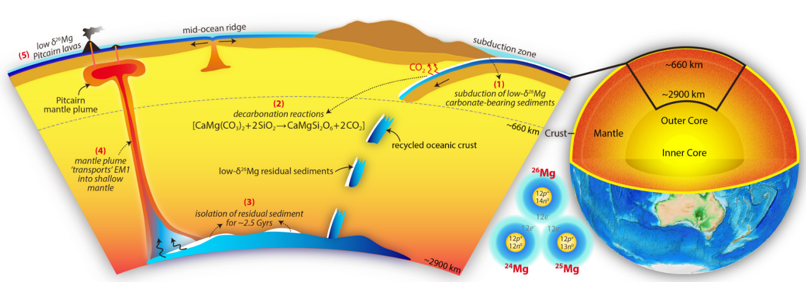


Figure 2. Cartoon showing the whole cycle of the residual components of ancient carbonate-bearing sediments. The sediments traveled from the Earth’s surface to the core-mantle boundary and ultimately came back to the surface to serve as ingredients of the Pitcairn volcanic island.

Major Progress in Understanding the Plasma Irregularities in Ionosphere Over Southern China

The Earth's ionosphere is a partially ionized region at ~60-1000 km altitude. It plays an important role in the transfer and dissipation of energy between different regions of the solar-terrestrial system. It can also be affected by an influx of extraterrestrial material. Under the influence of external sources, plasma irregularities with different scale sizes can be generated in ionosphere, producing ionospheric scintillations that seriously affect the performance of satellite-receiver radio links. Study of the plasma irregularities can provide important information in mitigating/overcoming the effects of scintillation, and improve our understanding of the fundamental aspects of the solar terrestrial coupling system.

With the support of the National Natural Science Foundation of China, a research team led by Professor Li Guozhu from the Institute of Geology and Geophysics, Chinese Academy of Sciences, is dedicated to the observation (campaign) and research of the plasma irregularities in ionosphere over southern China using radar and other instruments, with special focus on the generation and evolution characteristics of plasma irregularities and the potential seeding sources for development of F region irregularity producing scintillation.

Their main achievements include: (1) Development of Sanya radar imaging for irregularity fine-scale structures. Design of the Sanya radar interferometry antenna array system and realization of phase calibration with optical meteors have allowed the radar to measure the dynamic behavior of irregularity structures over Southern China (Figure 1). (2) Generation and evolution characteristics of irregularities. A class of range-spread trail irregularity echoes was observed at altitudes up to ~170 km, where the formation of trails could be related with fast and/or low-melting-point meteoroids. The background neutral wind could drive the spatial structural evolution of long duration trail irregularities, and help to determine the altitudes where the longest portion of the irregularity echo is located. Most of the F region irregularities observed over Southern China could be generated around 100°E. (3) Possible mechanisms underlying the ionospheric irregularity. The F region bottom-type irregularity layer generated before sunset was likely caused by the gradient drift instability driven by gravity waves, instead of by the equatorial plasma shear vortex flow. The equatorial plasma bubble bifurcation associated polarization electric fields were suggested to explain the simultaneous observations of low latitude E region irregularity disruption and valley region irregularity generation. (4) Potential seeding sources for F region irregularities. Daytime F region irregularities triggered by rocket exhaust-induced ionospheric hole were observed for the first time, which added further evidence to the possibility of artificial triggering of large-scale ionospheric irregularities. The seeding source for natural F region irregularity development over Southern China could be located at the intertropical convergence zone where deep atmospheric convection occurs (Figure 2).

The research results were published in journals such as *Journal of Geophysical Research: Atmospheres* and *Geophysical Research Letters*. The results reveal the potential seeding sources and onset locations of F region irregularities observed over Southern China, which have great importance to the forecast of ionospheric scintillation. The observed high altitude trail irregularities pose challenging questions on the characteristics of meteoroids producing high altitude trails/irregularities in ionosphere and will promote the interdisciplinary study on meteor astronomy and ionosphere.

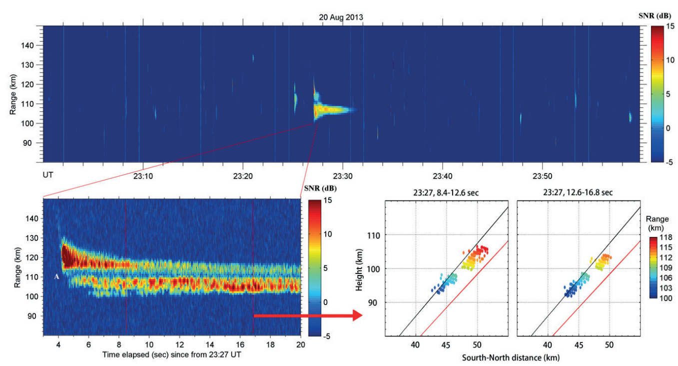


Figure 1. Sanya VHF radar interferometry observations of irregularity fine-scale structures

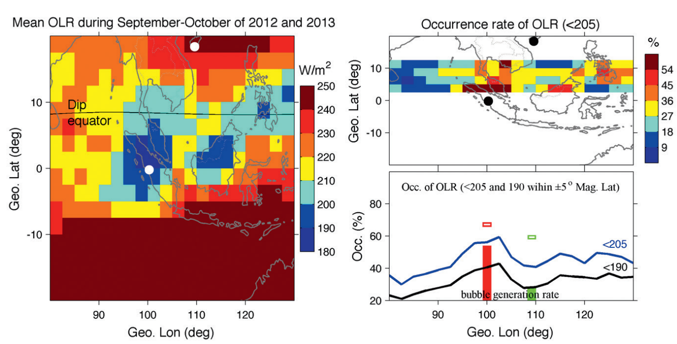


Figure 2. The potential seeding source for F region irregularity observed over Southern China

Fundamental Research on the Synthesis and Applications of High-Quality Graphene Materials

Graphene has attracted more and more interests since 2004 because of its unique structure. Many fascinating properties and promising applications are emerging recently. The properties of graphene materials strongly depend on their structure, such as the number of layers, defects, grain size, and functional groups. Therefore, the synthesis of high-quality graphene materials with controlled structure is essentially important not only for fundamental studies but also for technological applications. Supported by the NSFC, including the Science Fund for Creative Research Groups and the National Science Fund for Distinguished Young Scholars, since 2007, the research team led by Professor Ren Wencai and Professor Cheng Huiming at the Institute of Metal Research, Chinese Academy of Sciences, has systematically studied the synthesis of high-quality graphene materials by chemical vapor deposition (CVD) and chemical exfoliation, and explored their potential applications in energy storage, composites, optoelectronics, etc.

Until the end of 2013, more than 40 peer-reviewed papers have been published in *Nature Materials Nature Communications, PNAS, Advanced Materials, JACS*, etc., and 16 patents have been granted. Professor Ren Wencai and Professor Cheng Huiming have been invited to write a "News and Views" editorial for *Nature* in 2013 and a commentary article entitled "The Global growth of graphene" for Nature Nanotechnology in 2014. The 8 representative papers have been cited 4,464 times by others researchers (Web of Science) in *Science, Nature,* Nature *Materials, Nature Nanotechnology, Advanced Materials, Chemical Society Reviews, Progress in Materials Science,* etc. The related main discoveries are summarized as follows, which have been awarded the Second Prize of State Natural Science Award in 2017:

(1) They have invented a template-directed CVD method for the synthesis of a novel graphene foam macrostructure with a three-dimensional (3D) interconnected network, and demonstrated its use in high-performance elastic conductors and flexible lightweight electromagnetic interference shielding materials. The template-directed CVD method provides a general strategy for fabricating a wide class of 3D macroscopic graphene structures of determined shapes with excellent properties, which will expand the applications of graphene materials. So far, the graphene network has been widely shown to be useful for applications in many areas, such as lithium ion batteries, supercapacitors, aluminium-ion batteries, thermal management, fuel cells, solar cells, biosensors, and gas sensors.

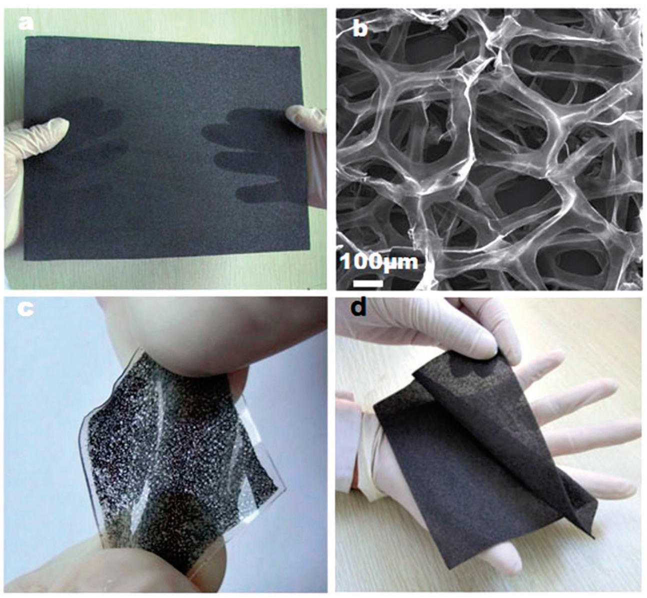


Figure 1. Graphene foam with a three-dimensional interconnected network structure and its applications in elastic conductors and flexible lightweight electromagnetic interference shielding materials

(2) They have developed an ambient-pressure CVD method with Pt as the substrate to achieve the growth of millimetre-size hexagonal single-crystal graphene domains, and found the edge-dependent growth kinetics of graphene. Moreover, they have developed a universal nondestructive electrochemical H_2 bubbling method to transfer CVD-grown graphene to arbitrary substrates, which allows the repeated use of the metal growth substrates. This bubbling technique has been granted Chinese, US, European, Japanese, and Korean patents. Currently, it is widely used for the transfer of graphene and other 2D materials grown on metal substrates, and has been developed by some companies for the continuous production of large transparent and conductive graphene films at a low cost.

(3) They have developed a hydrogen arc discharge exfoliation and reduction method for the synthesis of graphene sheets with excellent electrical conductivity and good thermal stability. Moreover,

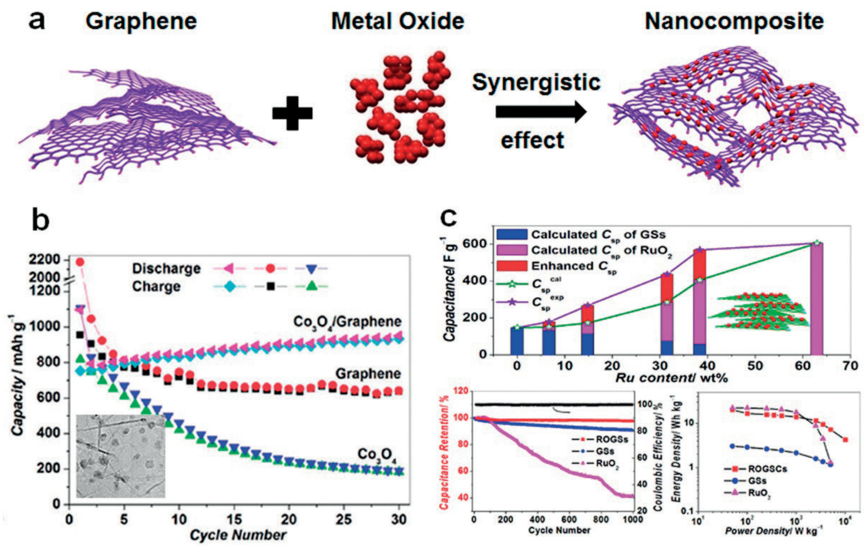


Figure 2. Graphene sheets/metal oxide nanoparticle composite materials for electrochemical energy storage applications

a simple but highly-efficient hydrohalic acid reducing method has been invented to reduce graphene oxide films into highly conductive graphene films without destroying their integrity and flexibility based on a nucleophilic substitution reaction. This reducing method has been recognized as one of the most effective approaches to remove the oxygen functional groups in graphene oxide sheets and restore their conjugated structures. It is widely used for the synthesis of graphene oxide-based highly conductive fibers and membranes, highly impermeable barrier films and protective coatings, and ultra-strong composites, etc.

(4) They have designed and fabricated a series of graphene sheet/metal oxide nanoparticle composite electrode materials to greatly improve the performance of lithium ion batteries and supercapacitors, and elucidated the synergistic effect between the graphene sheets and metal oxides in the composites. These findings provide valuable information and helpful guidance for the use of graphene for high-performance electrochemical storage.

A Great Breakthrough in Design and Fabrication of Nanofiltration Membranes Has Been Achieved by Chinese Scholars

Nanofiltration is the most advanced membrane technology for water treatments today, and its technical core lies in nanofiltration membrane. Due to the prominent crisis of water resources, development and utilization of unconventional water resources have been recognized as the main way to ease acute water shortages. Therefore, high-performance nanofiltration membranes will play an essential role in unconventional water treatment. Nanofiltration membranes are commonly prepared by interfacial polymerization. However, due to the intrinsically rapid reaction and the lack of enough understanding of the mechanism, it is difficult to achieve targeted regulation on interfacial polymerization, resulting in the failure to overcome the bottleneck problem of "trade-off effect" between permeability and selectivity during the development of high-performance nanofiltration membranes.

Alan Turing, the father of computer, predicted in 1952 that, periodic time-space stationary structures might originate from "reaction-diffusion systems" deviated from the thermodynamic equilibrium and serve as the prototype for studying the formation of pattern structures in living systems. Over the past 30 years, various two-dimensional and three-dimensional Turing structures have been discovered in chemical and biological systems. However, Turing's reaction-diffusion theory has not ever been realized in the field of application.

Supported by the National Natural Science Foundation of China, Professor Zhang Lin and his colleagues from Zhejiang University have been committed to the research on the design and preparation of high-performance nanofiltration separation membranes for years. *Via* the in-depth study on the mechanism of interfacial polymerization, they put forth a thesis that the preparation of nanofiltration membranes by interfacial polymerization is a typical "reaction-diffusion" process. On basis of the revelation of "reaction-diffusion theory", Zhang's group implemented directional adjustment and control of the traditional nanofiltration membrane preparation process. By adding hydrophilic polymer in aqueous solution to inhibit the diffusion of piperazine aqueous monomer, the difference in the diffusion coefficients between the aqueous and organic molecular reaches more than an order of magnitude, thus giving a Turing-type nanofiltration membrane with bubble or tube structures. The water permeation of these Turing-type membranes is 3 to 4 times of the traditional nanofiltration membranes on the premise of high salts rejection.

This result breaks the bottleneck of "trade-off effect" between permeability and selectivity and obtains the high-performance nanofiltration membrane of real potential in unconventional water resources treatment. Meanwhile, it also pushes Turing's "reaction-diffusion theory" from mechanism research to application field, and the prepared membrane has great application potential in the development and utilization of unconventional water sources. The work, published in *Science*, has attracted world-wide attention from the scientific research community. Many internationally renowned journals and media, such as the *Nature News*, *Chemistry World*, *Economist* and *New York Times*, highlighted the research work. It also has become the ESI highly cited paper half a year after publication. At present, the achievement is under cooperation with some enterprises and striving to realize industrialization as soon as possible.

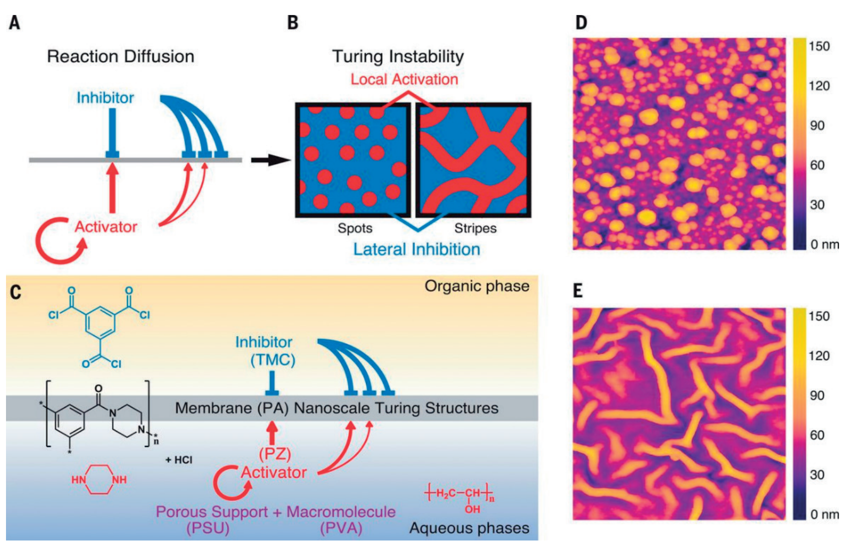


Figure 1. Formation mechanism of Turing-structured nanofiltration membranes

Significant Research Progress on Electromagnetic Compatibility of Complex Systems

Complex systems represented by the next generation stealth aircrafts and early warning (EW) aircrafts have large geometrical dimensions, complex infrastructures, and numerous electronic devices and antennas. Electromagnetic compatibility (EMC) of those aircrafts is extremely complicated, which seriously affects the technical and tactical performance of the aircraft, and even threatens the flight safety. Supported by NSFC, the team led by Professor Su Donglin of Beihang University discovered the evolutional mechanism between physical excitation sources and external electromagnetic emissions in complex systems, after more than ten years of deep mining and scientific cognition of thousands of measured data.

Based on this, four major problems in the current EMC field are solved.

(1) Eneration and transmission mechanism of electromagnetic inference (EMI) are obtained. The "four elements" theory of EMC is proposed and rigorously verified through mathematical and physical methods. The EMI feature set, including the mixed signal base, digital signal set, pulse signal set and mismatched signal set, is discriminated. Based on this theory, electromagnetic environment (EME) is characterized by the alternation of multiple variables, such as electromagnetic excitation sources and electromagnetic boundary conditions of the system.

(2) EME is scientifically characterized. A new concept based on physical excitation sources is proposed for characterizing the basic elements of EME. Moreover, the evolutional mechanism, which is extremely broadband and strongly coupled between the internal excitation sources and the external EME is obtained. By applying "four elements" theory, the quantitative mapping of the excitation-response pairs, the far-field characteristics of the equipment in preset scenarios, and the discrimination of the physical excitation sources within the equipment are built. In addition, an analysis and recurrence equipment of the "four elements" is successfully developed.

(3) Dynamic EMC modeling and design method are obtained. By applying "four elements" theory, a unified modeling method of the electrical and EMC performance, and evaluation criteria of equipment compatibility on system compatibility are proposed. The dynamic constraint design technology under preset EME is solved and an engineering design software is successfully developed.

(4) Accurate discrimination and location of EMI sources are obatined. In the highly integrated and modular system, the finished product layout is extremely dense (pitch < 2 mm). Therefore, traditional EMC test method cannot be applied to the modules. With the "four-element" theory, the multi-channel-in-situ-automatic conductive emission (CE) measurement method, non-standard component calibration method, miniaturized and broadband electromagnetic field detection method with low field perturbation characteristics, etc., are developed. Moreover, a pin-type module CE detection system is developed, which has one order of magnitude higher sensitivity than the foreign probes of the same type. A set of small and broadband electromagnetic field probes and EMI detection system in situ are invented. The above-mentioned theories, methods, techniques, engineering software, and detection systems have played an irreplaceable role in the development of a variety of new and large-scale complex systems.

This progress not only provides a new idea for the cognitive and control methods for electromagnetic emission in complex systems, but also plays an important role in the field of EME characterization and design.

A monograph was published and more than 50 national invention patents were granted based on the research, winning the First Prize of 2018 State Technological Invention Award.

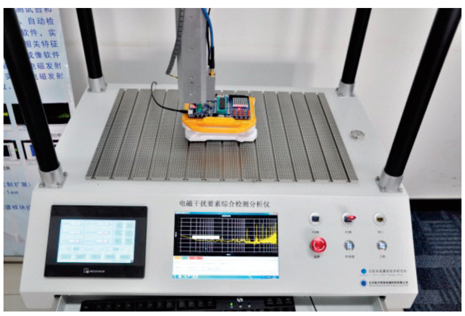


Figure 1. Testing and positioning equipment for basic elements of electromagnetic emissions

Figure 2. Engineering software for quantitative EMC design

Major Advances Made in Hetero-Epitaxy of Nitride Semiconductors with Large Mismatch

The III-nitride semiconductors are key materials for realizing short-wavelength light-emitting devices and high-frequency large-power electronic devices. They have great applications in solid state lighting, next-generation mobile communications and defense industry, which is one of the key areas of global high-tech competition and strategic emerging industries. The epitaxial fabrication of nitride semiconductors is the basis for developing the devices and application systems. So far, the main way to fabricate nitride semiconductors is the hetero-epitaxy on foreign substrates such as sapphire and silicon. The large lattice mismatch and thermal expansion coefficient mismatch between them lead to a high density of defects in nitride epilayers, which is a key bottleneck in the development of nitride semiconductors. Supported by the Creative Research Group and Key Program of NSFC, the research team led by Professor Shen Bo, from Peking University, has focused on the research of the large-mismatched hetero-epitaxy of nitride semiconductors. The major advances obtained are presented as follows:

(1) In AlN epitaxial fabrication on sapphire substrates, a novel way of "small-coalescence-area lateral epitaxial growth" on nano-patterned sapphire substrate (NPSS) has been developed for AlN epitaxy, which effectively solves the problems on the large coalescence thickness and serious distortion of crystal orientation of AlN on the PSS. The XRD rocking curves for (002) and (102) of AlN epilayers are reduced to 134 and 159 arcsec, respectively, and the corresponding dislocation density is 2.3×10^{8} cm^{-2}. Furthermore, the AlGaN-based MQWs of high-quality have been fabricated with an emission wavelength of 280 nm and an internal quantum efficiency of 85%.

(2) In InN epitaxial growth on sapphire substrates, the research team has set up a way named "boundary-temperature-controlled epitaxy" to effectively suppress the defects in InN, which solves the problem of the crack with increased thickness of InN epilayer under large mismatch conditions and finally improves InN crystal quality significantly. The InN electron mobility at room temperature has increased to 3,580 cm^2/Vs. At the same time, the "lattice-asymmetry-driven effect" in InN epitaxial growth has been found.

(3) In GaN epitaxial fabrication on Si substrates, the "large lattice-mismatch induced stress control" way has been developed for GaN epitaxy. The GaN epilayers with continuous 8 μm in thickness and the AlGaN/GaN hetero-structures with the 2DEG mobility of 2,260 cm^2/Vs at room temperature have been realized on Si (111) substrates. SiO_2/graphene interlayer has been developed for GaN epitaxy on Si (100) substrates, which solves the serious problem of surface reconstruction-induced two equivalent domain structure growth of GaN on Si (100). Meanwhile, two local vibrational modes of C impurities in GaN have been observed. The experiment and calculation results indicate that the C impurities in GaN mainly exist in the form of C_N.

The research achievements have obtained 25granted invention patents, published 53 SCI papers, including ones in Physical Review Letters, Advanced Materials, Nano Letters, and a cover paper in *CrystEngComm*. There are more than 20 invited talks in the international conferences. Advances have been highlighted for three times by prestigious international semiconductor review website "Semiconductor Today", and highly evaluated by the internationally renowned scholars in this field. The work has promoted the scientific research and technological development of nitride semiconductors in China.

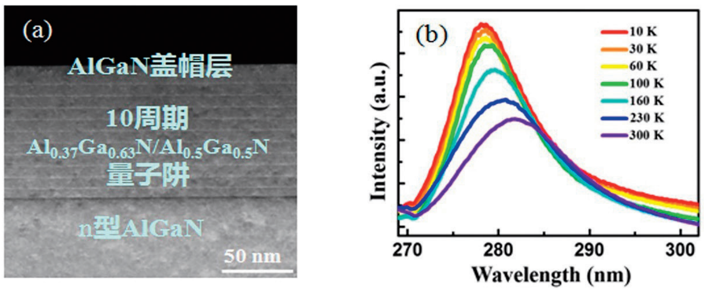


Figure 1. (a) The structure schematic diagram of AlGaN-based deep-ultraviolet MQWs on AlN/sapphire substrate; (b) The optical spectrum of AlGaN-based deep-ultraviolet MQWs with an internal quantum efficiency of 85%

Chinese Scholars Have Made an Important Scientific Breakthrough in the Abusive Supervision Research

In complex and changing external environment nowadays, leaders' decisions and behaviors are the most critical factors that determine the development and success of organizations. Therefore, leadership is a particularly important and hot research area in management. Meanwhile, due to the pursuit for rapid success, organizations often breed a series of unethical behaviors, which will have extremely negative impacts on the long-term development of organizations. Particularly, leaders' unethical behaviors have very negative impacts on employees, and even may cause a devastating blow to organizations. Furthermore, due to its sensitivity and complexity, our understanding of leaders' ethics-related behaviors is relatively rare and lagging. Therefore, scholars and practitioners urgently call for employing rigorous and cohesive theorizing and design to deepen the theoretical understanding of leaders' ethics-related behaviors.

In leadership and ethics fields, Tepper pioneered the concept of "abusive supervision" and the basic theoretical framework. Abusive supervision refers to the extent to which leaders engage in non-physical aggressive behaviors toward subordinates. It is a very typical and common unethical behavior of leaders within organizations. Since the concept of abusive supervision was developed, it has received great attention by scholars. It has become a new hot spot in management research and one of the new driving forces for the development of leadership and ethics research. The existing abusive supervision literature mostly focuses on subordinates who are exposed to such behaviors, that is, studies consequences of leader behaviors for recipients, and draws a relatively consistent conclusion that abusive supervision will have a variety of negative effects on subordinates. However, why do leaders still engage in abusive supervision since it has all sorts of detrimental consequences? The existing literature provides very limited insights to this question.

In 2018, a research team, composed by Qin Xin in Sun Yat-sen University, Huang Mingpeng in University of International Business and Economics, R. E. Johnson in Michigan State University, Hu Qiongjing in Peking University and Ju Dong in Beijing Normal University, first found the abusive supervision behaviors' immediate beneficial effects for supervisors from an actor centric perspective via two experiments and a diary study. This research has been published on *Academy of Management Journal*, which is the flagship journal of American Management Association. Specifically, this research found that engaging in abusive supervisory behavior was associated with improved recovery level. Moreover, abusive supervisory behavior had a positive indirect effect on work engagement through recovery level. Interestingly, supplemental analyses suggested that these beneficial effects were short-lived because, over longer periods of time (i.e., one week and beyond), abusive supervisory behavior was negatively related to supervisors' recovery level and engagement. The strength of these short-lived beneficial effects was also bound by personal and contextual factors (see Figure 1). Since this article was published, it has received extensive attention from scholars and practitioners, and has been reported by a variety of well-known international media such as *Science Daily* (one of the world's largest popular science news websites).

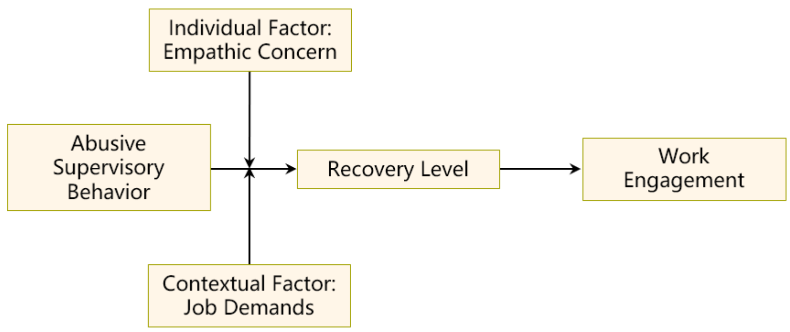


Figure 1. Theoretical model

This research provides two key contributions to extant abusive supervision and conservation of resource theories. First, by focusing on supervisors as actors (vs. subordinates as recipients), this research first answers the fundamental question of "What are proximal beneficial consequences of abusive supervisory behavior for perpetrators?" Existing literature on abusive supervision primarily focuses on recipients and concludes that abusive supervision is always bad and costly. It challenges this prevailing conclusion by suggesting that abusive supervision may actually have some immediate benefits for supervisors, which helps explain why such behavior persists even though it is harmful for subordinates. Second, this research found that abusive supervisory behavior helpes protect and build supervisors' resources in the short term, but it consumes supervisors' resources in the long term. Thus, whether a particular behavior is resource-generating or resource-consuming may depend on the window of time considered. Therefore, window of time should be incorporated into conservation of resource theory as a key boundary condition.

This research reveals the different immediate and long-term effects of abusive supervision on actors, and in turn develops the time-window model of resource conservation, largely expanding abusive supervision and conservation of resource theories. It is in the international leading position among related studies. Furthermore, this research provides several important managerial implications. Given that abusive supervisory behavior has detrimental impacts on subordinates, engaging in such behavior is not a first choice for resource recovery. In fact, organizations should provide alternative options to leaders for conserving and gaining resources that do not have detrimental effects on subordinates. This research was largely supported by the National Natural Science Foundation of China.

Chinese Scholars Made Significant Breakthroughs in the Study of the Model Averaging Under Complex Data

In the studies on economics and management, multiple candidate models are often encountered, which yield uncertainty, i.e., model uncertainty. In parameter inference, if model uncertainty is ignored, inference would be incorrect which may lead to a wrong decision in practice. In forecasting, if model uncertainty is ignored, useful information would be lost and forecast would be unstable, which leads to an inefficient forecasting. Model averaging, putting on weights on candidate models, is one of main methods handling model uncertainty. As early as 1969, G. Granger, the Nobel laureate in economics, proposed using model averaging when forecasting aviation demand. In recent years, model averaging has become a hot research field in the international econometrics field and many econometricians including Nobel Prize winners L. Hansen and T. Sargent are active in this research field. Under the support of the National Natural Science Foundation of China, Associate Professor Zhang Xinyu and his research team in Center for Forecasting Science, Academy of Mathematics and Systems Sciences, Chinese Academy of Sciences, carried out an in-depth study of the optimal weight choice and parameter distribution for model averaging under complex data and achieved significant breakthroughs.

Functional data refer to data derived from a function, such as learning curves in management science, and quality indicators in statistical process control. The team used the Karhunen-Loève method to decompose functional independent and dependent variables. The difference in the degree of decomposition produces model uncertainty. They proposed a cross-validation method for weight choice in model averaging, established its asymptotical optimality in prediction, and proved for the first time the consistency property of the resulting model average estimator under complex data, which provides theoretical support for economic interpretation.

In the study of model averaging for panel data, the team proposed a leave-subject-out cross-validation weight choice method, solved the problem of building optimality for model averaging under dependent data, and deeply studied the related issues produced by the group structure of random errors. This method was used to forecast the CPI of China. The following figure shows the in-sample and out-of-sample forecasts. The black curve is the real value, the red one is the existing optimal forecast, and the blue one is from the new method. It can be seen that the forecasting accuracy of the new method is significantly improved compared with other methods, especially in the period of large economic fluctuations. Furthermore, under the panel data with discrete response, the team comprehensively studied the theoretical properties of parameter estimation and model selection under the misspecified models, which provides a theoretical basis for proposing an optimal model averaging method under such complex data.

Zhang Xinyu's research was published in 2018 in the top journals of econometrics and statistics: *Biometrika*, *Journal of Econometrics* and *Journal of the Royal Statistical Society: Series B*. His works have important academic influences, were cited by papers of academicians from the United Kingdom, the Netherlands and other places, and were commented publicly as "important progress" and "influential papers".

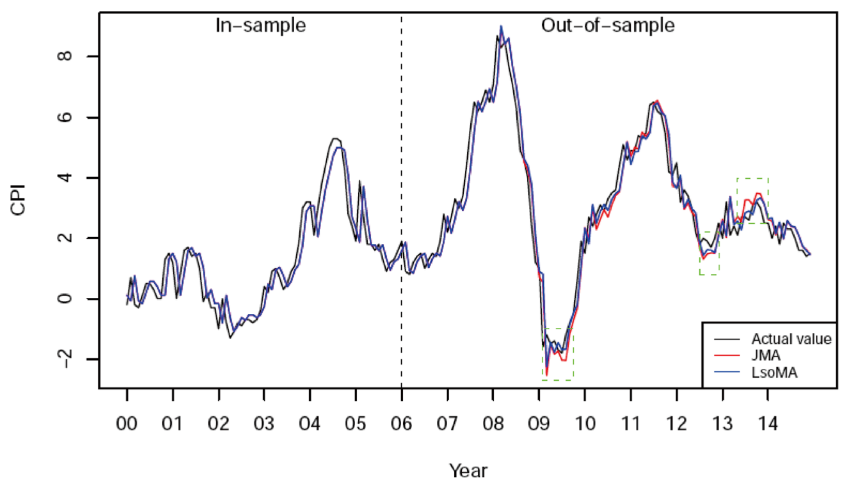


Figure 1. Forecast CPI using model averaging methods

Successful development of the direct transformation method of turning live viruses into vaccines

A live, genetically modified flu virus can infect animals and trigger a strong immune response, but cannot multiply in its host's cells. Such modified viruses could one day be used to improve current vaccines. Vaccines made of live viruses elicit stronger protective immune responses than inactivated vaccines, but, because they can replicate, they have the potential to cause disease. To overcome this, Zhou Demin and his colleagues at Peking University genetically altered the influenza A virus so that it could be produced efficiently by special transgenic cells, but could not replicate in normal cells or in infected animals. When compared with a commercially available inactivated flu vaccine, the modified virus stimulated stronger immune reactions in mice, ferrets and guinea pigs. Mice given the new vaccine and then infected with the unmodified flu virus survived, whereas all unvaccinated mice died. These types of virus vaccines can be potentially adapted to almost any virus as long as their genome could be manipulated and packaged in a cell line. The conversion of life-threatening viruses into live but virulent vaccines represents a revolution in vaccinology.

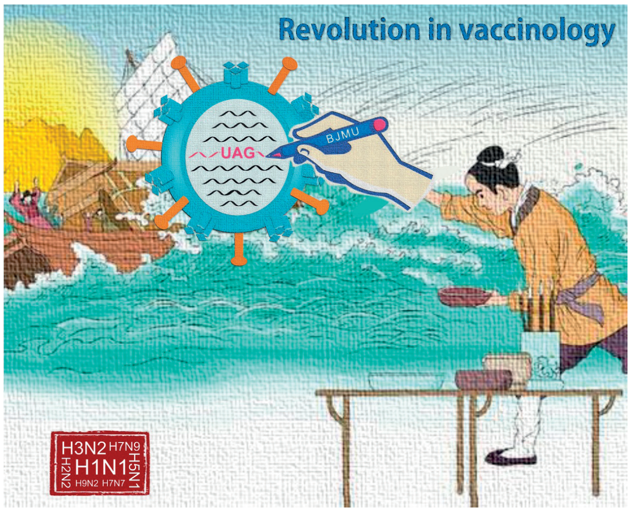


Figure 1. Conversion of live virus into vaccine

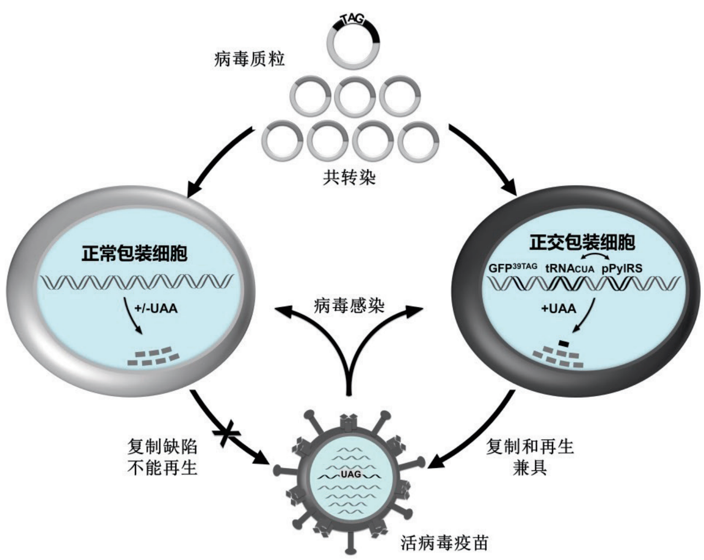


Figure 2. Core technology of converting live virus into vaccine

Tumor Immunology and Immunotherapy: New Aspects

In 2018, the Nobel Prize in Physiology or Medicine was awarded to James P. Allison and Tasuku Honjo for their discovery of cancer therapy by inhibition of negative immune checkpoint. Despite the central role of T cells in tumor immunotherapy, mechanisms of T cell antitumor immunity remain incompletely understood, preventing most cancer patients from obtaining benefit from current immunotherapy. To this end, the National Natural Science Foundation of China launched the National Science Fund for Distinguished Young Scholars for tumor immunology and immunotherapy on January 2013. The project was led by Professor Huang Bo from the Institute of Basic Medical Sciences of the Chinese Academy of Medical Sciences.

The goal of the project is to use immunology, molecular biology, animal models, and clinical sample analysis to elucidate the molecular mechanism through which immune checkpoint PD-1 is upregulated in tumor-infiltrating T lymphocytes (TILs), and the mechanism of the memory formation and maintenance in $CD8^+$ T cells. After 4-year collaborative research, the team passed the project assessment organized by the National Natural Science Foundation of China in December 2016 and made the following achievements:

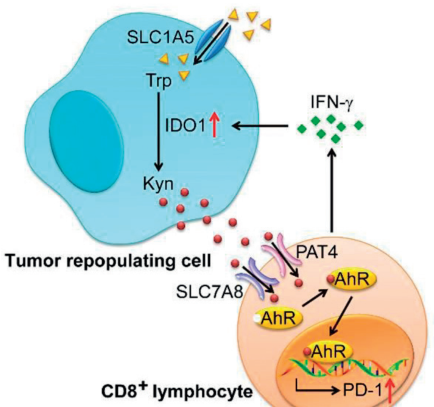


Figure 1. Molecular mechanism by which TILs upregulate PD-1 expression

(1) The molecular mechanism by which TILs upregulate PD-1 expression is elucidated. Interacting with tumor cells, T cells only kill differentiated tumor cells, but not undifferentiated so-called cancer stem cells. This subset of cells is called tumor repopulating cells (TRCs). Further studies find that IFN-γ produced by T cells stimulates the release of high levels of kynurenine (Kyn) produced by TRCs, which is transferred into adjacent TILs via the transporters SLC7A8 and PAT4. Then, Kynbinds activates AhR and thereby upregulates PD-1 expression. These results were published in *Cancer Cell* and were highlighted in *Cancer Discovery* as Research Watch, and this work was also recommended and commented by F1000Prime.

(2) Mechanism of the memory formation and maintenance in $CD8^+$ T cells is elucidated. Glucose metabolism is crucial in controlling T cell homeostasis including Tm cells. However, the mechanism linking metabolic signals to memory formation and maintenance remains elusive. Huang's team finds that $CD8^+$ Tm cells markedly upregulate cytosolic phosphoenolpyruvate carboxykinase (Pck1), the hub molecule regulating glycolysis, tricarboxylic acid cycle and gluconeogenesis, to increase glycogenesis via gluconeogenesis. The resultant glycogen is then channeled to glycogenolysis to generate glucose-6-phosphate and the subsequent pentose phosphate pathway (PPP) that generates abundant NADPH, ensuring high levels of reduced glutathione in Tm cells. Abrogation of Pck1–glycogen–PPP decreases GSH/GSSG ratios and increases levels of reactive oxygen species (ROS), leading to impairment of $CD8^+$ Tm formation and maintenance. Importantly, this metabolic regulatory mechanism could be readily translated into more efficient T-cell immunotherapy in mouse tumor models. These results were published in *Nature Cell Biology*.

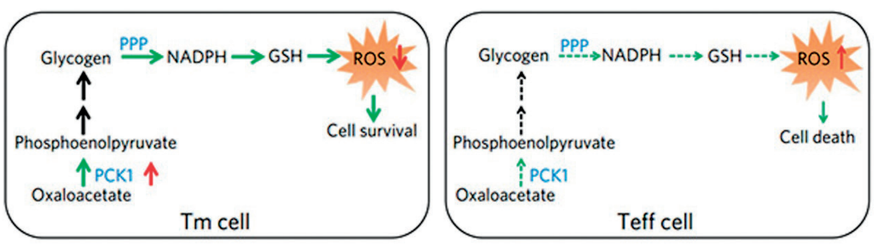


Figure 2. Mechanism of the memory formation and maintenance in CD8+ T cells

Under the funding, this project achieved fruitful production, including 15 publications in high quality journals such as *Cancer Cell*, *Nature Cell Biology*, *Cell Research*, and *Cancer Research*. Tumor immunology and immunotherapy have become hotspots and focuses in biomedical research. Scholars from China mainland need to conduct multidisciplinary cooperation and make original innovation to establish their own new theory and technology in tumor immunology and immunotherapy.

04

Part IV

International (Regional) Cooperation and Exchange

1 Promoting the Construction of Strategic Platform for Open and Shared International Cooperation

1.1 Actively planning for the "Belt and Road" substantial cooperation

In order to implement the grand Belt and Road Initiative of General Secretary Xi Jinping, we should further deepen the cooperation between research funding institutions and on the basis of "International Symposium on Funding Science and People Cooperation for a Prosperous Belt and Road" encourage cooperation in basic research, promote collaborative innovation in scientific research, realize complementary advantages of all countries, and solve common problems of mankind. The research on risk management of major projects along the Belt and Road has been included in the third phase of the 2018 emergency management project "Application for Pre Decision and High Quality Development Research of Major Projects in China". At the same time, NSFC has actively worked out substantive cooperation with the countries along the Belt and Road to promote South-South cooperation and peripheral cooperation and serve the national strategy.

In 2018, NSFC has established funds with more than ten countries along the Belt and Road including Thailand, Pakistan, Egypt, Mongolia, Sri Lanka, South Korea, Singapore, Israel, Russia, Poland, Czech Republic, Chile, and Argentina, carried out substantial cooperation work in key areas of interest to both parties, and has reached consensus cooperation with the Iranian Science Foundation and the call will be officially launched in 2019. In 2018, NSFC continued to launch joint call for cooperative research projects with NRCT and TRF in Thailand, resulting in a total of 12 projects, and joint call with PSF in Pakistan, resulting in about 10 projects in life sciences. NSFC also continued to fund 18 multilateral research projects with funding institutions in BRICS countries, and initiated a new round of call for cooperative research projects. NSFC also successfully completed the joint funding with Egypt and Sri Lanka. Following the signing of the cooperation agreement in 2017, NSFC and the Czech Academy of Sciences (CAS) first launched a two-year cooperation and seminar project in the fields of "mathematics, physics, earth sciences, life sciences and chemistry" in 2018. On the basis of continuing to fund Sino-Russian cooperation and exchanges with the Russian Foundation for Basic Research (RFBR), both organizations plan to jointly fund cooperative research projects in the medical field in 2019. NSFC and the National Science and Technology Research Council of Chile (CONICYT) and the National Science and Technology Council of Argentina (CONICET) firstly launched calls in the field of "natural disaster management" and "water resources management" in 2018.

1.2 Organizing the International Workshop on Science Funding Strategies and Policies for the New Era

In order to publicize the reform initiatives of NSFC, and listen to the opinions and suggestions of funding agencies from various countries, NSFC organized the International Workshop on Science Funding Strategies and Policies for the New Era. The conference was successfully held in Paris, France on September 6, 2018. More than 30 representatives from 16 scientific funding agencies and relevant international organizations and related personnel attended the meeting. President Li Jinghai gave a keynote speech entitled "Science Funding Organization under the New Paradigm of Science", and introduced the reform plan and strategic measures of NSFC in the new era to the participants, which was highly appraised by the funding agencies. The conference also reached broad consensus in themes of "promoting the organic integration of free exploration and goal-oriented", "promoting interdisciplinary research", "improving the project review mechanism which is in line with basic research rule, professionalism, transparency, fairness and integrity", "improving international exchanges, deepening bilateral and multilateral cooperation" and "adjusting evaluation orientation and creating a good academic atmosphere", laying solid foundation for strategic dialogue and cooperation between Chinese and European science funding agencies.

1.3 Organizing the Third Biennial Strategic Meeting of the National Natural Science Foundation of China and the UK Research and Innovation

The Third Biennial Strategic Meeting between NSFC and UKRI on November 9, 2018

The Biennial Strategic Meeting is a biennial high-level meeting and consultation and decision-making mechanism established by the Natural Science Foundation of China (NSFC) and the UK Research and Innovation (UKRI) in 2013. Since 2014, the two sides have successfully held two strategic meetings in China and the UK. The third strategy meeting was successfully held in Beijing on November 9, 2018. Vice President Xie Xincheng and Andrew Thompson, the head of UKRI International Cooperation and Chief Executive of AHRC presided over the meeting. A total of 30 representatives from the Science Departments, the Bureau of International Cooperation, and the nine funding agencies of UKRI and the UKRI China Office attended the meeting.

Vice President Xie Xincheng and Professor Thompson presented the reform initiatives of their respective institutions on behalf of the NSFC and URKI. The meeting also reviewed the cooperation highlights of the two parties over the past two years, and reported and discussed issues such as the policy challenges NSFC and UKRI faced together, the priority areas of cooperation in the next two years, and new cooperation models and mechanisms, determining the direction for the next two years. The outstanding feature of the meeting was the addition of more policy discussions. The Natural Science Foundation of China introduced the ideas and initiatives for funding interdisciplinary research. Surrounding the issue of how grant institutions can promote the impact of basic research on the economy and society, UKRI introduced relevant concepts, existing problems and related measures. In terms of the future cooperation model, the two sides are no longer limited to project cooperation, but agree to convene an international policy seminar, thereby enhancing the strategic level and depth of cooperation between the two parties.

1.4 Organizing a High-Level Dialogue Forum for Young Talents

The High-Level Dialogue Forum for Young Talents was successfully held on June 21, 2018 in the Sino-German Center for Research Promotion. Vice President Xie Xincheng attended the forum and delivered a speech. The special guests such as Academician Xu Zhihong and Academician Zhu Zuoyan of Peking University and Academician Yang Wei of Zhejiang University and the selected students attending the Lindau Nobel Laureates Conference conducted a dialogue on topics of common interest such as young talent growth and career development. They held full and enthusiastic discussion on issues such as the impact of Lindau Meeting on the academic growth of young scientists, how to improve the international influence of Chinese young scientists, how to balance the relationship between good articles and high impact factors, etc., guiding the future development of young scholars. At the subsequent certificate presentation ceremony, Vice President Xie Xincheng awarded the honorary certificates to 30 Chinese outstanding Ph.D. students who were selected for the 2018 Lindau Nobel Laureates Conference.

High-Level Dialogue Forum for Young Talents on June 21, 2018

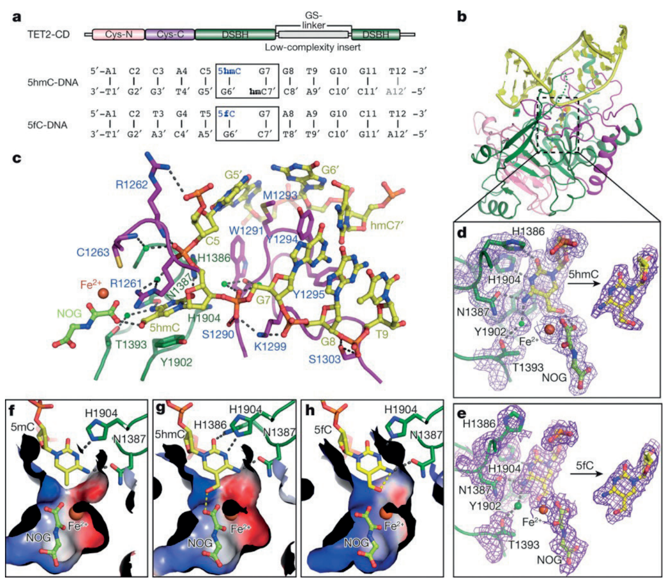
2 Progress of International (Regional) Cooperation and Exchange Programs

In 2018, the Natural Science Foundation of China received 5,594 applications for various International (Regional) Cooperation and Exchange Programs, and funded 1,171 projects. The direct cost is 950 million yuan. The funding statistics is as follows: Funding of 106 key international (regional) cooperative research projects, with direct costs of 257 million yuan; Funding of 324 international (regional) cooperative research projects under MoUs with direct costs of 577 million yuan; funding of 245 cooperation and exchange projects under MoUs (including Sino-German Center projects) with direct costs of 57 million yuan; funding of 356 bilateral or multilateral conference projects with direct costs of 14 million yuan; funding of 140 Research Fund for International Young Scientists projects with direct costs of 45 million yuan.

3 Typical Results of International (Regional) Joint Research Projects

3.1 Small Molecule Intervention Study of Epigenetic Regulation

"Small Molecular Intervention Study of Epigenetic Regulation" funded by Key International (Regional) Joint Research Program is jointly undertaken by Professor Xie Yan nan of the Shanghai Institute of Materia Medica, Chinese Academy of Sciences and Professor He Chuan of the University of Chicago.



TET2-5hmC: DNA Complex structure

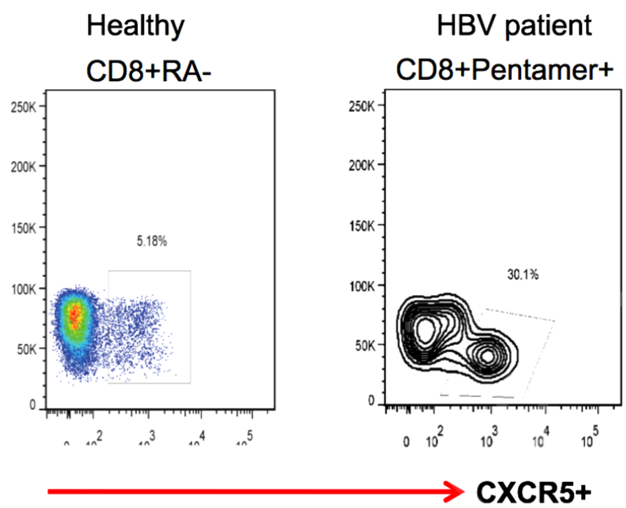
Epigenetics is one of the most cutting-edge scientific research fields. It integrates the advantages of Shanghai Institute of Materia Medica, CAS, Peking University and the University of Chicago, and conducts extensive domestic and international cooperation. It uses multidisciplinary means to target a variety of epigenetic importance. The researchers deployed means of interdisciplinary, aimed at a variety of important epigenetic targets, focused on various epigenetic important targets, established compound screening and confirmation technology systems, piloted compound discovery and chemical intervention studies, and achieved important research results: clarified the substrate preference of DNA active demethylase TET mechanism; historically discovered the small molecule compound of RNA demethylase FTO, resolved its complex structure, elucidated its molecular mechanism and carried out chemical intervention research; found the first m6A demethylase of Arabidopsis thaliana; found the dimerization mechanism of tyrosine transferase I; for a series of important epigenetic targets such as DNMT1, polycomb inhibition complex PRC2, PRMT1, found the small molecule inhibitors and studied the mechanism of action.

The research paper “Structural insight into substrate preference for TET-mediated oxidation” was reviewed by *Nature*. The TET family of proteins mediates the continuous oxidation of 5-methylcytosine (5mC), which ultimately leads to demethylation of DNA. Biochemical experiments show that although TET2 can continuously catalyze the oxidation of 5mC, 5hmC and 5fC, its catalytic efficiency for different substrates is significantly different. The catalytic efficiency for 5mC is high and the efficiency for 5hmC and 5fC is low. This property may be important for maintaining the stability of the 5hmC marker in the genome. However, experiments have shown that TET2 has no significant difference in binding ability to different substrates. Since the oxidation reaction step catalyzed by TET2 is complicated and has various intermediate products, it is difficult to directly measure the reaction efficiency of each step by an experimental method. The researchers used the QM/MM calculation method to investigate the catalytic oxidation of different substrates by TET2. The calculation results show that the difference in energy barrier of hydrogen extraction reaction may be mainly due to the different orientations of different substrates in the reaction intermediate. Further experimental results verify the computational hypothesis: the isotope kinetic effect experiment confirms that the hydrogen extraction step is the rate-limiting step of the whole reaction; the retention spectroscopy experiments confirm that the difference in catalytic efficiency of TET2 for different substrates is derived from the different reaction rates of the hydrogen extraction step. This study provides important clues for an in-depth understanding of the regulatory mechanisms of methylation and demethylation in epigenetics and the design of specific small molecule inhibitors for the catalytic mechanism of TET proteins.

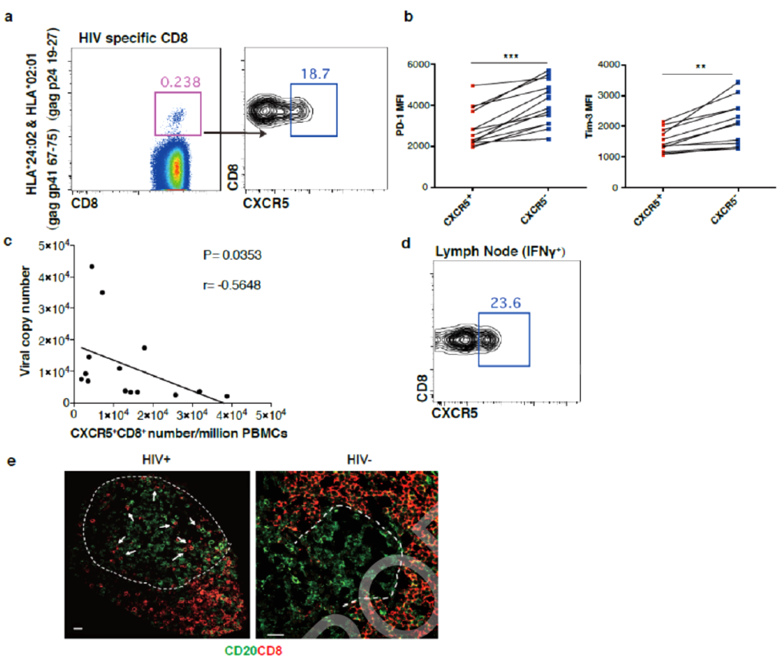
3.2 Mechanism of Single-Cell Transcriptome Technique for Liver Infiltration T Cells in Chronic Hepatitis B

“Mechanism of Single-Cell Transcriptome Technique for Liver Infiltration T Cells in Chronic Hepatitis B” funded by Key International (Regional) Joint Research Program was jointly undertaken by Professor Wu Yuzhang of Army Medical University and Professor Song Jianli of Pennsylvania State University.

Previous studies have shown that hepatitis B virus (HBV)-specific T cell responses play a central role in viral clearance and pathological damage, but this understanding does not guide the development of appropriate immune interventions. Therefore, it is necessary to explore the relationship between HBV-specific T cell responses and immune protection (viral clearance) and immune damage (liver injury) at a more in-depth level, distinguish between protective immunity and invasive immunity, and find prognostic markers or therapeutic targets. In view of the lack of suitable animal models for hepatitis B virus infection, the study used HBV chronic infection as the research object, and single cell research technology as the main means, from the peripheral and liver complex T cell phenotype and function, to analyze the HBV specificity. The complex heterogeneity of T cells is linked to clinical phenotypes and outcomes, elucidating



Expression of CXCR5 on HBV-specific CD8+T cells



Detection of CXCR5 high CD8 T cell subsets in HIV-infected patients

the characteristic T cell pool profiles associated with viral control and HBV seroconversion, as a preliminary indicator of prognostic markers and therapeutic targets. A new subgroup of CD8+ T cells was discovered, which demonstrated a key viral control role in chronic persistent infections. At the same time, important regulatory effects and mechanisms of complement and epigenetic regulation on hepatitis B virus infection were investigated.

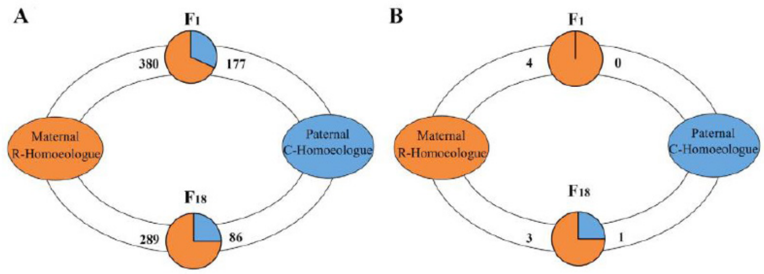
The important results include: (1) Antigen-specific cell localization, single cell capture, and single-cell transcriptome technology in tissues was established, and a T cell library detection method based on high-throughput sequencing technology was established. (2) Through a study of T cell heterogeneity, a new group of cell subsets was discovered and its mechanism of inhibition of viral replication was elucidated. After the article was published, it was reviewed by *Nature*, *Science*, *Cell*, etc., and it was found that cells that could clear the latent virus database are the target of current treatment points. (3) It was found that HBV regulates the expression of a series of genes in hepatocytes through epigenetic regulation mechanism and promotes the occurrence of HBV-related diseases. (4) The complement C5a/C5aR pathway was found to play an important role in MHV-3-induced fulminant hepatitis in mice, providing a potential target for the treatment of fulminant hepatitis. (5) The correlation between T cell immune system damage and liver cancer in CHB patients was further analyzed, and the continuous increase of serum TBA was founded to be the main and independent risk factor for HCC in patients with CHB who receive antiviral therapy regularly. One person was selected as a leading talent in the "Ten Thousand Talent Plan", one was selected as the leading youth of the "Ten Thousand Talent Plan", one became a Chang Jiang Young Scholar, and one person was awarded the "National Excellent Science and Technology Worker".

3.3 Establishment of Allotetraploid Fish Lines and Their Exploration and Utilization

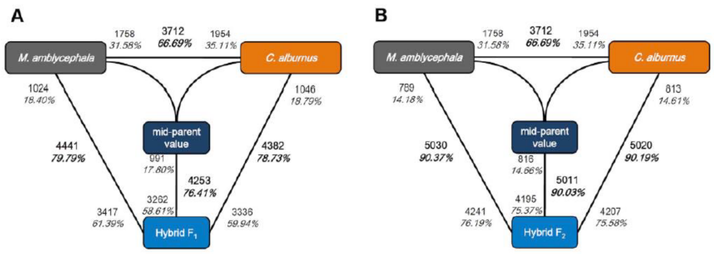
"Establishment and Excavation of Heterotetraploid Fish Lines" funded by Key International (Regional) Joint Research Program was jointly undertaken by Professor Liu Shaojun of Hunan Normal University and Associate Professor Hong Yunhan of the National University of Singapore.

Distant hybridization can promote the formation of polyploids. The widespread phenomenon of natural fish species and natural polyploid fish indicates that distant hybridization plays an important role in the formation of polyploid fish and fish evolution. Distant hybridization can transfer the genome from one species to another, resulting in changes in the phenotype and genotype of the hybrid offspring. If distant hybridization can form a fertile heterologous line, it provides important germplasm resource library for genetic breeding.

Based on the allogeneic tetraploid fish, such as the amphoteric fertile allotetraploid and heterotetraploid, which have been established by distant hybridization, the project has carried out a series of research and obtained a series of results. (1) Through long-term systematic research, the law of distant hybridization to form different ploidy fishes was summarized. (2) The phenomenon of rapid changes in genomic DNA in allotetraploid ticks was found. (3) It was first demonstrated that chimeric genes are important genetic characteristics common to hybrid fish lines. (4) The sequencing of liver or gonad transcripts of carp, red crucian carp, white crucian carp, blunt bream, tilting mouth red carp and other hybrid parents, as well as crucian carp, crucian carp, carp, bream and other hybrid fish was completed, which are important targets for a variety of epigenetic. The main biological characteristics of different ploidy hybrid fishes were systematically studied. (5) The genome sequencing of Carassius auratus was preliminarily completed (in cooperation with Yunnan University). (6) Cell fusion was found to be one of the possible reasons for the formation of undesirable gametes in the gynogenetic diploid crucian carp hybrid cloning system (GDH). (7) The relationship between HPG axis and Piwi-piRNA signaling pathway was revealed for the first time, which provided important clues for understanding the molecular mechanism of sterility in triploid fish. (8) In F1 of carp (♀) ×blunt bream (♂), white crucian carp (♀) ×blunt bream (♂) and other different cross combinations, a new heterotropic tetraploid fish was innovatively obtained, and a homologous tetraploid fish strain (F2-F12) was established and extended in red crucian carp (♀) blunt bream (♂). The homologous tetraploid fish strain (F2-F12) was used to cross with diploid carp. The new allotriploid carp has the advantages of infertility, fast growth, good meat quality and strong stress resistance.



Full-gene expression bias and growth-related regulatory gene expression bias in F1 and F18 homologous genes of crucian carp and allotetraploid crucian carp



Distribution of non-additive expression genes in F1 and F2 of allodiploid silver carp

The project systematically studied the formation regularity of allotetraploid fish strains and their main biological characteristics, and continued to develop androgenic tetraploid fish strains. It provided more germplasm resources for large-scale preparation of sterile triploid fish, which is of great significance in fish genetics and breeding. Relevant research achievements have won the National Innovation Competition Award, Hunan Province First Prize for Technological Invention, Hunan Guangzhao Science and Technology Award, Hunan Province "Furong Scholar Program" Achievement Award, the 10th North Agricultural Science and Technology Award for Fisheries Science Award, and published a monograph "Fish Distant Hybridization".

3.4 Studying the Production of Heavy Taste in the Relativistic Heavy Ion Collision and Searching for Strange Particle States and Antimatter Nuclei

"Research on the Production of Heavy Taste and the Search for Strange Particle States and Antimatter Nucleuses in the Relativistic Heavy Ion Collision" funded by Key International (Regional) Joint Research Program was jointly undertaken Professor Ma Yugang from the Shanghai Institute of Applied Physics, Chinese Academy of Sciences and Professor Tang Aihong from Brookhaven Laboratory.

The study of quark gluon plasma (QGP) new material morphology and the search for rare events such as antimatter are the main targets of relativistic heavy ion collision physics. Singular quark dynamics and heavy-duty physics, antimatter interactions, and odd particle states, chiral electromagnetic effects, etc., are important probes for studying the properties of QGP and the nature of strong interactions.

In terms of physics, the project has carried out systematic research work closely on the above issues, and has made important progress and achievements in experimental measurement and theoretical research. The relevant research conclusions are published in international authoritative academic journals such as *Nature*, *Physical Review Letters, Physical Review C*, *Physics Letters B*. The RHIC-STAR high-level trigger (HLT) plays a crucial role in the search for rare cases such as heavy-duty physics. The HLT hardware has been upgraded since the project was implemented, and high-order flip-flops (HLT) and STAR have been successfully implemented. Data Acquisition System (DAQ) stripping; HLT software construction, mainly built track, vertex reconstruction and TPC space charge automatic calibration software, and made it independent of STAR offline software framework, the operation results are stable, to quickly find special rare cases An important contribution. One of the results was selected for the "Top Ten Progress of Science in China" in 2015. The responsible person of the Chinese side was elected as an academician of the Chinese Academy of Sciences during the implementation period, and the person in charge of the US was promoted to be a lifetime researcher of BNL. Some of the research results won the second prize of the 2017 State Scientific and Technological Progress Award: the antimatter detection in the relativistic heavy ion collision and the hadron spectroscopy and collective nature of the quark matter.

3.5 Study on the Structure and Function of Histone Chaperone

"Study on the Structure and Function of Histone Chaperone" funded by Key International (Regional) Joint Research program was jointly undertaken by Professor Xu Ruiming from the Institute of Biophysics, Chinese Academy of Sciences and Associate Professor Zhang Zhiguo from the Mayo Medical Center of the United States.

The project uses a combination of structural biology, biochemistry, and cell biology to select functional histone chaperones for research purposes, and to reveal their mode of action and specificity with their respective histone ligands. Molecular mechanisms deepen our understanding of the basic biological processes of eukaryotes.

Important results include: (1) analyzed of four important histone chaperones including DAXX-H3.3-H4, MCM2-ASF1-H3-H4, Rtt109-ASF1-H3-H4 and NASP and the three-dimensional crystal structure of protein complexes, through the study of the relationship between structure and function, and revealed the molecular mechanisms by which these important histone chaperones specifically recognize histones and histone variants. (2) Co-developed CENP-A serine phosphorylation modification to regulate its mutual recognition with the partner HJURP, as well as the high-level structure of CENP-A nucleosome and the recognition of other important factors of centromere. Regarding the functional study of histone variant H3.3, the project has achieved a prominent result. Zhang Zhiguo and Xu Ruiming have jointly studied the mechanism of an H3.3 mutation on the development of tumorigenesis. A mutation in the 36th lysine to methionine residue of the histone variant H3.3 (K36M) was detected in 90% of chondroblastomas, and the results clarified the passage of the H3.3K36M mutant protein, which affects the activity of two major histone H3.3K36 methyltransferases, which in turn down-regulates the level of histone H3K36 methylation in the genome, resulting in abnormal expression of tumor-associated genes and triggering tumorigenesis. Some of the results of the project were published in *Science* in 2016.

3.6 Strong Interaction Quantum Chromodynamic Symmetry and its Material Structure

"Strong Interaction Quantum Chromodynamic Symmetry and its Material Structure" International (Regional) Cooperation and Exchange Programs under Agreements/MoUs was joint undertake by Professor Zou Bingsong of the Institute of Physics, Chinese Academy of Sciences and Professor Ulf Meissner of the University of Bonn. foased important research progress in the field of strong interaction physics, especially in the search for the hotspot of the multi-quark new strong state. The mutual promotion of theory and experiment has made China in the forefront of the world in the study of the multi-quark new strong state.

The *Physics Journal*, edited by the American Physical Society, has selected more than 40 important annual highlights since 2013. The two best interactions are: (1) BES III experiment with major Chinese scientist participation in 2013. The group found the Z_c (3900) four-quark state. (2) The LHCb experimental group that with great contributions by Chinese scientists in 2015 found two P_c five-quark states. The members of the Sino-German cooperation project first gave the theoretical predictions of their existence before the discovery of these multi-quark states. After the experimental discovery, they gave the first theoretical explanation. The relevant theoretical work has received extensive attention from international counterparts. Zou Bingsong, Zhu Shilin, Zhao Qiang, Guo Fengkun, et al., have made special guest conference reports on the multi-quark state in relevant important international series meetings before and after the experimental discovery of these multi-quark states. In 2016, Zhu Shilin and others were invited to write a long review of the hidden and multi-quark state for the top review journal *Physics Reports*. The experimental and theoretical developments in this field were compared, and the unsolved problems and future experiments were pointed out. The direction of theoretical efforts has been cited 352 times; in 2018, Guo Fengkun, Hanhart, Meißner, Wang Qian, Zhao Qiang, and Zou Bingsong were invited to write a review article on hadron molecular states for *Review of Modern Physics*, the top review journal of physics. From the experimental signs to the theoretical framework, the current research status and development direction of the hadron molecular state are comprehensively reviewed. This is the first article published in the journal by the Chinese scientific research institution as the first unit in the field of particle physics and nuclear physics. After one year, it has been quoted 178 times. Experimental physicists are conducting further searches and research on the multiquark state based on our new recommendations.

The implementation of the project also promoted the growth and cultivation of talents. Seven people, such as Guo Fengkun, Wang Wei, Wang Yuming, Chen Wei, Wu Jiajun, Yang Yibo, and Wang Qian, who have been participating in this project, have been selected into the National Youth Thousand Talents Program and returned to China to work. The project members were invited to serve as members of the international advisory committee of more than ten international conferences: Zhu Shilin was selected as a member of the editorial board of the internationally renowned academic journal *European Physical Journal A* in 2015; Zou Bingsong was invited as the co-editor of the internationally renowned academic journal *Nuclear Physics A* in 2018; Huang Mei was awarded the National Outstanding Youth Fund in 2014 and 2017 respectively; Zhao Qiang and Zhou Shangui were selected as national leaders in science and technology innovation in 2018; Professor Meißner, the head of German, was selected as the international distinguished scholar in "International Talent Program" of the Chinese Academy of Sciences in 2018.

05

Part V

Research Integrity and Oversight of Project Funds

1 Continued Efforts Put in NSFC Research Integrity System Construction

Firstly, keep a problem-oriented mindset and continue to innovate the working mechanism so as to improve the effectiveness of supervision. Focusing on the current situation of intertwined violation of scientific ethics in program funding and breaches of rules and disciplines in the review process, which presents a more complex and diversified trend, NSFC strives to innovate its working mechanism by promoting full coverage of supervision and strengthening cooperation, with a view to enhance supervision effectiveness. (1) Set up the work link of warning and commitment in advance by organizing all NSFC staff, awardee institutions, review experts, and applicants to sign a impartiality commitment letter to achieve full coverage of the warning education for all parties involved in NSFC funding activities, which is conducive to nurturing a positive review atmosphere and a sound academic ecology. (2) Achieve full coverage of the objects of supervision and strengthen the supervision of NSFC staff during panel review meetings through coordination with the discipline inspection department, planning management department and various science departments to strengthen coordinated internal supervision. (3) Promote innovation of working mechanism and learn from the successful experience of discipline inspection and supervision. In the process of investigating allegations of misconduct, consultations are added to intensify the supervision and investigation of misconducts and violations of laws and regulations, with the role of warning education being better played. (4) Strengthen the main responsibility of the awardee institutions by standardizing their management of NSFC funded projects. In order to promote the healthy development of the National Natural Science Fund, NSFC issued "Opinions of the National Natural Science Foundation of China on Further Strengthening Awardee Institutions' Management of NSFC Funded Projects". Besides, when issuing the decisions on scientific misconducts, NSFC urges the awardee institutions to seriously implement the rectifications.

The 1st Plenary Session of the 5th Supervision Committee of NSFC held in Beijing

Secondly, maintain the rigor of investigation and punishment of research misconducts. In 2018, NSFC accepted a total of 370 allegations and clues of problem, an increase of 38% over the year of 2017. Among them, 343 were daily complaints and 27 clues to high-similarity problems. NSFC Supervision Committee held 3 plenary sessions and deliberated 113 cases, with a total of 99 respondents being punished, 23 projects withdrawn, and 33 persons debarred from applying for NSFC programs for a period of 1-7 years. Besides, 7 responsible persons were notified of criticism, 49 persons were internally notified of criticism, 35 persons received written warnings, and 8 persons received oral warnings. Eight awardee institutions received notifications or internal notifications of criticism, written or oral warnings. NSFC Supervision Committee has always regarded the serious investigation and punishment of scientific misconduct as the last resort for the effective operation of NSFC research integrity system, and maintained high-pressure investigation and punishment of the misconduct cases, which played an key role in ensuring a healthy academic ecology.

Thirdly, focus on key work procedures and effectively implement active supervision. (1) Before the start of annual review of proposals, NSFC leaders organize special meeting on the prevention and control of integrity risks in proposal reviews. This is one of the key initiatives taken by NSFC Party Group to study and implement the spirit of the 19th National Congress of the Communist Party of China (CPC) and Xi Jinping Thought on Socialism with Chinese Characteristics for a New Era, implement the requirements of comprehensive self-discipline of the Party, and strengthen Party leadership and construction so as to maintain the good reputation of the National Natural Science Fund and create a fair review environment and sound academic atmosphere. It takes good iron to make good products. The special meetings play a key role in asserting uniform requirements for NSFC staff to resolutely curb possible systematic integrity risks in NSFC review work. (2) Actively carry out project similarity checking before mail review. In 2018, a total of 27 pairs of high-similarity projects were investigated and the respondents received due disciplinary actions. Statistics show that since the similarity checking system was put into use in 2012, the problem of duplicate application has been effectively curbed. (3) Continue to conduct on-site supervision during panel review meetings. In 2018, a total of 62 people were dispatched and participated in the supervision of 225 NSFC panel review meetings, and 3,399 expert reviewers were organized to assess the fairness among themselves in review meetings. The supervision teams reviewed the whole process of the meeting, listened to opinions and suggestions from the science community, and received allegations and complaints. The phenomenon of soliciting help or seeking personal connections during the review process drew due attention of NSFC leadership, and warning meetings were held on the sites of panel review meetings. Relevant violators were debarred from the review capacity in line with NSFC policies and procedures. Practice has proven that on-site supervision helped panel reviewers raise their awareness of self-discipline and played a key role in maintaining the accountability of NSFC's review system. (4) The Discipline Inspection and Supervision team dispatched by the CPC Central Commission for Discipline Inspection to Ministry of Science and Technology strengthened the guidance and re-supervision. Leaders of the discipline inspection and supervision team conducted in-depth front-line investigation and evaluation of NSFC's supervision of panel review meeting, and guided NSFC to strengthen building its system of research integrity and supervision.

Fourthly, gear up research integrity education through popularization and interagency cooperation. Under the normalized mechanism of popularization, full advantage of varied working meetings and training workshops was taken to publicize research integrity, raise the awareness of academic self-discipline, and strengthen consciousness of responsibility in the management and use of NSFC funds. Besides, lectures on code of conduct, conflict of interest, and confidentiality were also arranged during the on-site supervision of panel review meetings, requiring all panel reviewers to strictly abide by relevant regulations and properly perform their duties. As one of the deputy leader unit of the National Leading Group on Scientific Ethics and Academic Norms Popularization and Education, NSFC takes an active part in all working meetings, forums and workshops organized by the leading group. In 2018, NSFC leaders participated in holding the annual Scientific Ethics and Academic Norms Popularization and Education Conference and delivered special reports at the 5th National Seminar on Scientific Ethics and Academic Norms and the 1st Workshop on Graduate Student Supervisors' Education of Scientific Ethics and Academic Norms. In addition, NSFC took active part in a series of workshops and public lectures held by relevant departments and agencies on scientific ethics and research integrity, with an eye to promoting brainstorming and joint popularization and education.

Fifthly, step up institutionalization and informatization of research integrity. In 2018, NSFC issued such regulations as Preliminary Plan on Strengthening NSFC's Supervision System in light of Opinions on Further Strengthening Research Integrity Construction by the General Office of the CPC Central Committee and General Office of the State Council, NSFC Party Group's Opinions on Preventing Issues of Pseudo-Innovation, and Rules on Implementing NSFC On-Site Supervision of Panel Review Meetings, drafted the revised versions of Regulations on Adjudicating Research Misconducts Related to NSFC-Funded Projects and Charter of NSFC Supervision Committee, and started formulating the Interim Procedures of Overseeing and Inspecting NSFC Awards.

In furtherance of the informatization of research integrity, NSFC completed correlated marking of research misconducts and punishment information of applicants, review experts, awardee institutions and NSFC funded projects in the Internet-based Science Information System, which will provide important reference data support for the next-step establishment of a credit file system.

2 Strengthen the Oversight and Inspection of Awarded Funds

Firstly, innovate oversight and inspection methods to strengthen supervision. Great efforts were put in studying and implementing the spirits of the central government policies on the management of central finance funded projects and grants since the 19th National Congress of the Communist Party of China (CPC), which led to the formulation of 2018 Annual Plan of Overseeing and Inspecting NSFC Awarded

Funds. Besides, NSFC innovated and improved its oversight and inspection methods by combining regular spot check, targeted inspection and random spot checks, in order to continuously enhance the supervision effect.

Secondly, adhere to the goal orientation and promote regular spot checks. In 2018, NSFC conducted regular oversight and inspection of 154 NSFC funded projects in Shandong Province, totaling about 200 million yuan.

Thirdly, adhere to the problem orientation and carry out targeted inspections. Combined with the clues of problems reflected in complaints and reports, NSFC innovated work mechanism by increasing oversight and inspection methods for targeted inspection. During 2018, NSFC completed targeted inspections of 31 projects from 5 awardee institutions in Guangdong and Hunan provinces, and formed inspection reports and advice on disciplinary actions, including circulating a notice of reprimand of respondent awardee institutions. At the same time, NSFC started the targeted inspection of 21 projects from 5 awardee institutions in Shandong province.

Fourthly, utilize information technology to plan random checks. Through analysis of the type, quantity and total amount of funds of awarded projects by NSFC in 2017, NSFC completed classification of project categories for spot check. According to the characteristics of the project types, weight was given to each type of project to determine the number of project sampling, based on risk and problem-oriented principles. According to the overall regional distribution of different project types, random sampling areas are determined. Currently, relevant program writing and operation verification have been completed.

2018 ANNUAL REPORT

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Part VI
Organizational Chart

1 Organizational Chart

- **National Natural Science Foundation of China**
  - Supervisory Committee
  - General Office
  - Bureau of Planning
  - Bureau of Science Policy
  - Bureau of Finance
  - Bureau of International Cooperation
  - Bureau of Personnel
  - Office of Research Integrity Development
  - Office of Party Committee
  - Department of Mathematical and Physicals Sciences
  - Department of Chemical Sciences
  - Department of Life Sciences
  - Department of Earth Sciences
  - Department of Engineering and Materials Sciences
  - Department of Information Sciences
  - Department of Management Sciences
  - Department of Health Sciences
  - Service Center for Administrative Affairs
  - International Exchange Center
  - Science Foundation of China Publication Department (Center for Science Communication)
  - Sino-German Center for Research Promotion

2 Members of the 8th Council of NSFC

President: Li Jinghai
Vice Presidents: Zhang Xi, Gao Fu, Xie Xincheng, Hou Zengqian, Gao Ruiping, Wang Chengwen
Secretary-General: Han Yu
Members: Wang Hongyang, Wang Enge, Zhu Rixiang, Ren Zhiwu, Liu Changsheng, Sun Changpu, Yan Chunhua, Du Zhanyuan, Song Jun, Zhang Guangjun, Zhang Liangrui, Chen Zuoning, Chen Xiaohong, Zhao Xiaozhe, Kang Le, Tong Aiping

3 Members of the 5th Supervisory Committee of NSFC

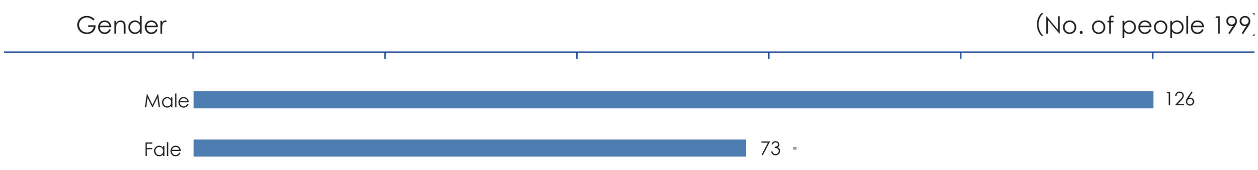
Director: Chen Yiyu
Deputy Director: Zhu Zuoyan, He Minghong
Members: Wang Yizheng, Zhu Bangfen, Zhu Weitong, Liu Ming, Liu Zhihua, Yan Shouke, Su Xianyue, Li Zhaohu, Li Zhenzhen, Zhou Xingshe, Zheng Yongfei, Yao Zhujun, Huang Haijun, Cui Xiang, Jiao Nianzhi

4 NSFC Staff

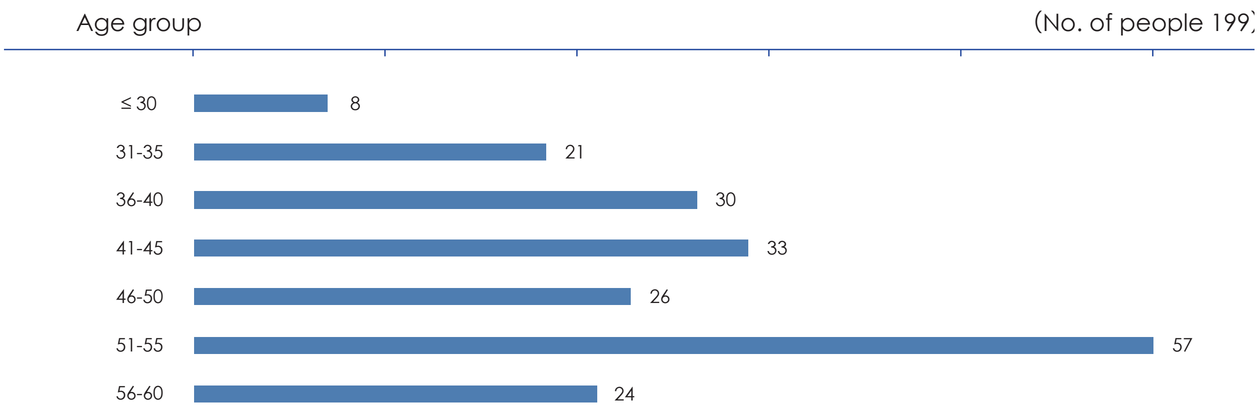
(1) Full time staff

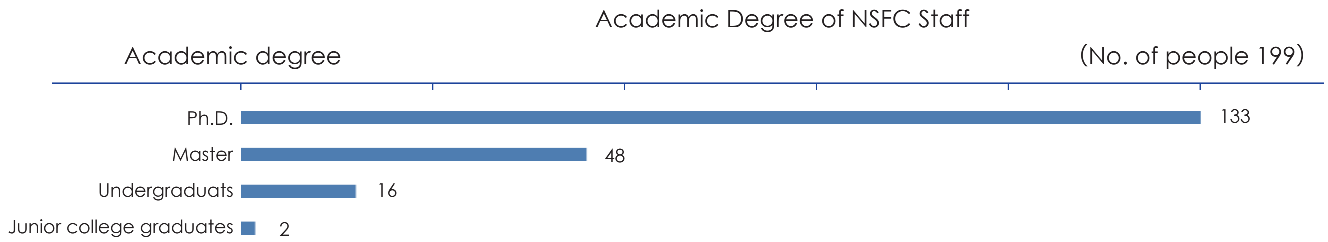
By December 31, 2018, NSFC has 199 full time staff, with 126 males and 73 females and 189 with professional and technical titles. The average age is 46.

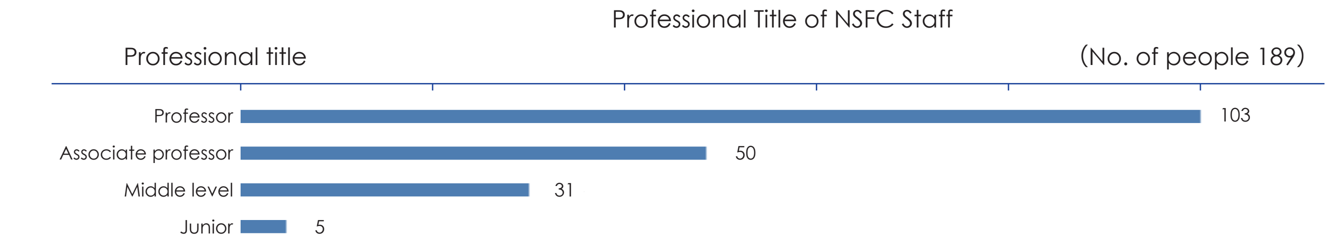
Gender Distribution of NSFC Staff



Age Distribution of NSFC Staff







(2) Rotational Program Directors

By December 31, 2018, there are 101 Rotational Program Directors on duty, and 100 of them have a Ph.D. degree. Among the Rotational Program Directors, 74 are males and 27 females; 39 are professors or research fellows, 60 are associate professors and 2 have middle level professional titles.

5 Leaders of NSFC's Bureaus, Departments and Subordinate Unit

Leaders of NSFC's Bureaus and Departments

(by December 31, 2018)

Unit	Leaders
General Office	Meng Qingguo, Lv Shumei (F), Liu Ke (Director of Information Center)
Bureau of Planning	Wang Changrui, Che Chenwei, Sun Ruijuan (F), Wang Yan (F)
Bureau of Science Policy	Zou Liyao, Yu Sheng
Bureau of Finance	Zhang Xiangping (F), Xing Hairu (F)
Bureau of International Cooperation	Yang Junlin, Fan Yingjie
Bureau of Personnel	Zhou Yanze, Wang Cuixia (F), Liu Ning
Office of Research Integrity Development	Guo Jianquan, He Jie
Office of Party Committee	Han Zhiyong, Fang Yudong
Office of Discipline Inspection Commission	Guo Jianquan
Department of Mathematical and Physical Sciences	Jiang Song (concurrently), Dong Guoxuan
Department of Chemical Sciences	Yang Xueming (concurrently), Chen Yongjun
Department of Life Sciences	Li Peng (F, concurrently), Feng Xuelian (F), Gu Ruisheng
Department of Earth Sciences	Guo Zhengtang (concurrently), Wang Qidong, Guo Jinyi
Department of Engineering and Materials Sciences	Qu Jiuhui (concurrently), Li Ming, Gao Tiyu, Wang Guobiao
Department of Information Sciences	Hao Yue (concurrently), Zhang Zhaotian, Li Jianjun
Department of Management Sciences	Wu Qidi (F, concurrently), Gao Ziyou (F), Yang Liexun
Department of Health Sciences	Zhang Xuemin (F, concurrently), Xu Yanying (F), Zhu Weitong (F)

Leaders of NSFC's Subordinate Unit

Unit	Leaders
Service Center for Administrative Affairs	Feng Wenan, Yang Tao, Shi Xinghe, Yuan Youxin
International Exchange Center	Shi Xinghe (concurrently)
Science Foundation of China Publication Department (Center for Science Communication)	Tang Longhua, Yang Xinquan, Peng Jie, Sun Ruijuan (F)
Sino-German Center for Research Promotion	Fan Yingjie (F, concurrently)

07

Appendix Ⅰ

Important Activities of National Natural Science Foundation of China in 2018

January

January 24–25

The 14th plenary meeting of the 4th Supervisory Committee of the National Natural Science Foundation of China was held in Beijing. During the meeting, participants listened to and reviewed the report of the Office of the Supervisory Committee on the investigation of relevant cases and the *Rules for the Implementation of the Supervisory Work of the Resident Meeting for the Assessment and Evaluation of National Natural Science Foundation of China Funded Projects (Draft)*. Chen Yiyu, Director of the Supervisory Committee, presided over the meeting. Members of the Discipline Inspection and Supervision Group of the Ministry of Science and Technology, all staff of the Office of the Central Discipline Commission and relevant personnel of the science departments attended the meeting.

February

February 9

The National Natural Science Foundation of China convened a general meeting of officials at or above the Deputy Division Director level. The relevant leaders of the Central Committee announced the composition of the new leading group of the National Natural Science Foundation of China.

February 13

Liu Yandong, the Vice Premier of the State Council, visited the National Natural Science Foundation of China. Li Jinghai, Secretary of the Party Leadership Group, and NSFC President reported on the progress of the work of the Science Fund since the 18th National Congress and the working ideas for 2018. Jiang Xiaojuan, Deputy Secretary-General of the State Council, members of the leading group of the National Natural Science Foundation of China, members of the Seventh National Natural Science Foundation Council, members of the Fourth Supervisory Committee, and responsible persons from all departments of NSFC attended the survey meeting.

March

March 19

Party Secretary and President Li Jinghai, Party Members Zhangxi, Hou Zengqian, Gao Ruiping, Wang Chengwen, and Secretary-General Han Yu inspected the application site for centralized acceptance of the National Natural Science Foundation of China in 2018.

March 22

Li Jinghai, member of the Standing Committee of the 13th National People's Congress, Secretary of the Party Group and President of the National Natural Science Foundation of China, chaired the conveying meeting of the spirit of the "two sessions" and conveyed the spirit of the first session of the 13th National People's Congress. Yang Wei, member of the 13th CPPCC National Committee and consultant of the National Natural Science Foundation Committee, and Gao Fu, member and Vice President of the National Natural Science Foundation Committee conveyed the spirit of the 13th CPPCC National Conference.

March 28

Li Jinghai, Party Secretary and President, met with Zbigniew Bocki, President of the Polish National Science Center (NCN), and Janusz Janeczek, President of the Council. Vice President Xie Xincheng attended the meeting and on behalf of the National Natural Science Foundation of China signed the

Memorandum of Understanding on Cooperation between the National Natural Science Foundation of China and the Polish National Science Center with Zbigny Brocchi.

March 30

Wang Zhigang, Secretary of the Party Leadership Group and Minister of the Ministry of Science and Technology, visited the National Natural Science Foundation of China for investigation and discussion with members of the leading group of the National Natural Science Foundation of China. Li Jinghai, Secretary of the Party Group and President of the National Natural Science Foundation of China, delivered the report on the relevant issues. Wang Binyi, member of the Party Group and head of the discipline inspection and supervision group of the State Supervision Committee of the Central Discipline Commission in the Ministry of Science and Technology, Li Meng, member of the Party Group of the Ministry of Science and Technology and deputy minister and Miao Shaobo, deputy secretary-general of the Ministry of Science and Technology, participated in the investigation. NSFC vice presidents and Party Members Zhang Xie, Gao Fu, Hou Zengqian, Wang Chengwen and Xie Xincheng, and Secretary-General Han Yu attended the symposium. Officials at or above the deputy bureau level attended the symposium.

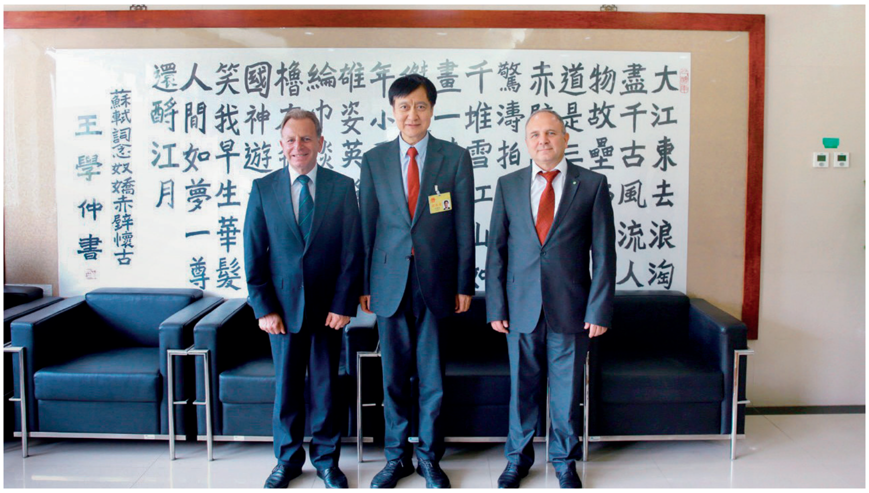
April

April 17

The National Natural Science Foundation of China convened a special meeting on the prevention of risks in the evaluation, to exchange successful experiences and effective practices of strengthening the leadership of the Party and promoting the Party's construction and business. Gao Ruiping and Wang Chengwen, members of the Party Leadership Group and vice presidents, Xuan Hongyun, deputy chairman of the discipline inspection and supervision group of the Ministry of Science and Technology of the Central Discipline Commission, attended the meeting. In accordance with the requirements of the meeting, all the staff members of the National Natural Science Foundation of China signed the "Staff Commitment" on the construction of a clean and honest Party style and work discipline.

April 26

Li Jinghai, Secretary of the Party Group and President, and Xie Xincheng, Vice President, met with Nikolai Lazarov, Chairman of the Bulgarian National Science Foundation, and Georgi Vayssilov, Vice Chairman, to reach agreement on establishing cooperative relations and signing bilateral cooperation agreements.



May

May 14–18

The special training course of "Learning to Implement the Spirit of the Nineteenth National Congress" of the National Natural Science Foundation of China was opened. Li Jinghai, Secretary of the Party Group and President attended the opening ceremony and made a mobilization speech. Wang Chengwen, member of the Party and Deputy President presided over the opening ceremony. Over 190 officials at or above the department level and some backbone members of the Committee participated in the training course.

May 18

The National Natural Science Foundation convened the Conference on Party Construction and Party Style, Clean Government Construction and Anti-Corruption. The Party Member of the Ministry of Science and Technology and Chairman of Discipline Inspection and Supervision Group Wang Binyi and Secretary of the Party Group of the National Natural Science Foundation and President Li Jinghai made important

speeches. Gao Ruiping, member of the Party Group of the National Natural Science Foundation Committee and Vice President, chaired the meeting. Vice President Zhang Xi, Gao Fu, Hou Zengqian, Wang Chengwen, Vice President Xie Xincheng, Party member and Secretary-General Han Yu, Vice President Xuan Hongyun of the Discipline Inspection and Supervision Group of the State Commission for Discipline Inspection in the Ministry of Science and Technology, and Standing Deputy Secretary of the Party Committee of the Ministry of Science and Technology, Li Guihua and other relevant leading comrades attended the meeting. All officials and staff of the National Natural Science Foundation Committee attended the meeting.

June

June 19

Vice Premier Liu He of the State Council and members of the Eighth National Natural Science Foundation Committee held a forum in Zhongnanhai and made an important speech. Secretary of the Party Group and President, Li Jinghai, reported on the idea of deepening the reform of the National Natural Science Foundation of China. Leading members of the Committee, consultants of the Committee, directors of the Supervisory Committee and part-time directors of the Ministry of Science attended the meeting.

June 19

The first plenary committee meeting of the Eighth National Natural Science Foundation Committee was held in Beijing. Wang Zhigang, Secretary of the Party Group and Minister of the Ministry of Science and Technology, attended the meeting and delivered a speech. Li Jinghai, Secretary of the Party Leadership Group and President made a report entitled “Building a New Era Science Funding System to Strengthen the Foundation of a World Power in Science and Technology”. Wang Binyi, member of the Party Leadership Group of the Ministry of Science and Technology and Chairman of the Discipline Inspection and Supervision Group of the Central Commission for Discipline Inspection in the Ministry of Science and Technology, and members of the Eighth National Natural Science Foundation Committee attended the meeting. Relevant Leaders of the Discipline Inspection and Supervision Group of the Ministry of Science and Technology of the Central Committee for Discipline Inspection, the Ministry of Human Resources and Social Affairs, and the National Commission for Discipline Inspection of the Central Committee for Discipline Inspection, attended the Fifth Meeting of the Supervisory Committee.

June 20

The first plenary committee meeting of the fifth supervisory committee of the National Natural Science Foundation of China was held in Beijing. Participants listened to and considered the Report of the Office of the Supervisory Committee on the Investigation of High Similarity Cases in 2018. Chen Yiyu, Director of the Supervisory Committee, presided over the meeting. Wang Chengwen, member of the Party Group and Vice President, attended and addressed the meeting. Relevant comrades of the Discipline Inspection and

Supervision Group of the Ministry of Science and Technology, all staff of the Office of the Central Discipline Commission and relevant personnel of the Scientific Departments attended the meeting.

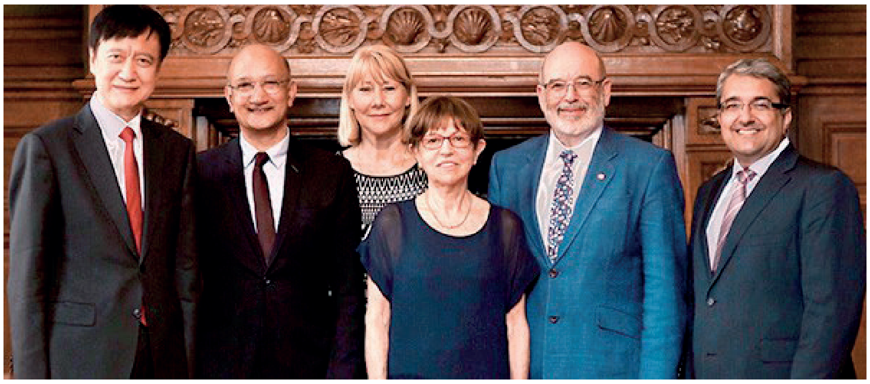
June 28

Li Jinghai, Secretary of the Party Leadership Group and President, gave a lecture in the Party Committee under the theme of "Guided by Xi Jinping's socialist ideology with Chinese characteristics in the new era, never forgetting his original intention, keeping in mind his mission, and striving to open a new journey for the cause of science funding".

July

July 4

At the first plenary session of the International Science Council (ISC), Li Jinghai, Secretary of the Party Group and President was elected Vice Chairman of the ISC. International Council for Science (ISC) is made up of Former International Council for Science (ICSU) and former International Council for Social Sciences (ISSC) in 2017. It is the most comprehensive scientific and technological organization with the widest membership and the most comprehensive disciplines in the world.



July 30–31

In 2018, the evaluation meeting of Special Fund for Research on National Major Research Instruments (recommended by departments) was held in Beijing. Li Jinghai, Secretary of the Party Group and President, attended the meeting and made a speech. The opening ceremony of the meeting was presided over by Gao Ruiping, member of the Party Group and Vice President.

July 31–August 3

Wang Chengwen, member of the Party Leadership Group and Vice President, Xing Bo, Deputy bureau-level discipline inspector of the discipline inspection and supervision group of the Ministry of Science and Technology of the Central Discipline Commission, and six other delegates went to Naiman Banner, a poverty alleviation county, to conduct on-the-spot investigation and research on the poverty alleviation work of the NSFC, the implementation effect of poverty alleviation projects, the use of funds and the performance of officials.

August

August 2–3

Li Jinghai, Secretary of the Party Leadership Group and President, attended and spoke at the joint working meeting of 2018 NSFC-Shandong Joint Fund, NSFC-Yunnan Joint Fund, NSFC-Guangdong Joint Fund, NSFC-Xinjiang Joint Fund, NSFC-Zhejiang Joint Fund, Joint Fund to Promote Cross-Straits Scientific and

Technological Cooperation, NSFC-Henan Joint Fund and NSFC-Liaoning Joint Fund. The meeting was chaired by Gao Ruiping, member of the Party Leadership Group and Vice President, and attended by members of the joint fund management committees and management offices, heads and coordinators of relevant scientific departments.

August 8

The Editorial Committee of *China Science Foundation* and the Seventh Editorial Committee Meeting were held in Beijing. Li Jinghai, Secretary of the Party Leadership Group and President, attended the meeting and delivered a speech. Han Yu, member of the Party Leadership Group, Secretary-General and executive vice-editor of the Seventh Editorial Committee, presided over the meeting. He Minghong, Director of the Sixth Editorial Committee, and members of the Seventh Editorial Committee and more than 70 experts and scholars attended the meeting.

August 20–22

Party member and Secretary-General Han Yu attended the "Seminar on Sustainable Development of Mongolian Pharmaceutical Characteristic Industries and Naiman Banner and the Second Development Strategy of Mongolian Medicine and Mongolian Medicine in Zhanbradore" and delivered a speech at the opening ceremony. From National Natural Science Foundation Committee, State Administration of Traditional Chinese Medicine, Chinese Academy of Traditional Chinese Medicine, Inner Mongolia, nearly 600 experts and representatives from Naiman Banner, related research institutes, universities and enterprises of the autonomous region participated in the meeting.

September

September 1–7

Wang Chengwen, member of the Party Group and Vice President, attended and delivered a speech at the 2nd National "Artificial Intelligence and Underwater Vehicle Summit Forum and Underwater Vehicle Target Grabbing Competition" sponsored by the National Natural Science Foundation of China and the Dalian Municipal Government.

September 6

Li Jinghai, Secretary of the Party Leading Group and President, attended the International Workshop on Science Funding Strategies and Policies for the New Era held by the Natural Science Foundation in Paris, and made a keynote speech on the topic of "Science Funding Organizations under the New Scientific Paradigm". More than 30 people from 16 scientific funding organizations and relevant international organizations participated in the meeting.

September 12–13

The second plenary committee meeting of the fifth supervisory committee of the National Natural Science Foundation of China was held in Beijing. The meeting listened to and considered the report of the Office of the Supervisory Committee on the investigation of complaints and daily complaints reported by applicants of projects sponsored by the Science Fund for Distinguished Young Scholars

in 2018 during the period of publicity. The meeting was chaired by Chen Yiyu, Director of the Supervisory Committee, and attended by Wang Chengwen, member of the Party Group and Vice President. Relevant members of the Discipline Inspection and Supervision Group of the State Supervision Committee of the Central Commission for Discipline Inspection in the Ministry of Science and Technology, all staff of the Office of the Supervisory Committee, relevant bureaus and relevant personnel of the Ministry of Science attended the meeting.

September 21

In 2018, the Science Fund for Distinguished Young Scholars Assessment Committee Meeting was held in Beijing. Li Jinghai, Secretary of the Party Leadership Group and President, attended the meeting and made a speech. Gao Ruiping, member of the Party Leadership Group and Vice President, attended the meeting.

September 25

The National Natural Science Foundation of China organized a symposium on appointed officials. Li Jinghai, Secretary of the Party Leadership Group and President, Wang Chengwen, member of the Party Leadership Group and Vice President, attended the symposium. The appointed officials of the whole committee, the responsible comrades of the office, the personnel bureau, the Disciplinary Commission of the organs and the departments where the appointed officials are located attend the meeting.

October

October 15

Wang Chengwen, member of the Party Leadership Group and Vice President, attended the 2008 National Conference on Scientific Ethics and Learning Style Construction, co-sponsored by the Chinese

Association of Science, the Ministry of Education, the Chinese Academy of Sciences, the Academy of Social Sciences, the Academy of Engineering, the Natural Science Foundation Committee and the Beijing Municipal Government.

October 17

The National Natural Science Foundation of China organized an educational conference of the whole committee. Li Jinghai, Secretary of the Party Leadership Group and President, attended the meeting and delivered an important speech. Hou Zengqian, member of the Party Leadership Group and Vice President, reported typical cases of violations of discipline and law. Wang Chengwen, member of the Party Leadership Group, and Vice President presided over the meeting. Party members, Vice Presidents Gao Fu, Wang Chengwen, Vice President Xie Xincheng, Party member and Secretary-General Han Yu, Deputy Chairman Xuan Hongyun of the Discipline Inspection and Supervision Group of the Ministry of Science and Technology of the Central Commission for Discipline Supervision, Deputy Secretary of the Party Committee of the directly affiliated organs of the Ministry of Science and Technology, Jin Jianmin and other personnel attended the meeting. Nearly 400 officials and staff of the Party Committee participated in the meeting.

October 20

Li Jinghai, Secretary of the Party Leadership Group and President, went to Naiman Banner, Tongliao City, Inner Mongolia to investigate the Precise poverty alleviation and assistance work, and on-the-spot inspected the progress of the implementation of the designated poverty alleviation project commissioned by the National Natural Science Foundation of China and the situation of poverty alleviation among poor households.

October 22–26

The National Natural Science Foundation of China held a special seminar on "Frontier Perspective and Improvement of Comprehensive Literacy" in Peking University in 2018. More than 40 officials at and below division director level participated in the seminar.

October 29

The 2018 All-Staff Games of the National Natural Science Foundation of China were held in China University of Geosciences in Beijing. Li Jinghai, Secretary of the Party Leadership Group and President, delivered an opening speech. Wang Chengwen, member of the Party Leadership Group and Vice President, presided over the opening ceremony.

November

November 1

The National Natural Science Foundation of China organized a constitutional swearing-in meeting for new staff members. Li Jinghai, Secretary of the Party Group and President, presided over the swearing-in ceremony.

November 7

Wang Chengwen, member of the Party Group and Vice President, led more than 60 officials at or above the division director level of the National Natural Science Foundation of China and staff at key positions to Beijing Party Warning and Education Base for studying in an all-round way.

November 13–15

The National Natural Science Foundation of China convened the 2018 annual Party Group (Expanded) Conference. Li Jinghai, Secretary of the Party Leading Group and President, made a key-note report on "Reflections on Deepening the Reform of the National Natural Science Foundation of China". Xuan Hongyun, Vice-Chairman of the Discipline Inspection and Supervision Group of the Ministry of Science and Technology, Consultant of the Party Committee, Director of the Supervision Committee, part-time director of the science departments and officials at or above the deputy bureau level of the Committee attended the meeting.

November 15

The National Natural Science Foundation of China held a symposium to commemorate the 100th anniversary of Professor Shi Changxu's birth to recall and learn his patriotic struggle spirit and noble life style. Li Jinghai, Secretary of the Party Leadership Group and President, presided over the Symposium and delivered the commemorative speech. Zhang Xi, and Gao Fu, members of the Party Leadership Group and Vice Presidents, Hou Zengqian,

Gao Ruiping, Party members and Secretary-General Han Yu, and National Natural Science Foundation advisor Yang Wei attended the meeting. Part-time directors of various science departments and offficials at or above the deputy bureau level of the whole committee attended the meeting.

November 16–18

Han Yu, member of the Party Group and Secretary-General, attended the "China Smart Car Future Challenge 2018" and delivered a speech at the opening ceremony. 27 teams from universities, scientific research institutions and enterprises entered the competition.

November 20

The National Natural Science Foundation of China held the Spiritual Communication Meeting and Reform Mobilization Meeting of the 2018 Party Group (Expansion) Conference. Li Jinghai, Secretary of the Party Group and President, conveyed the spirit of the Party Group (Expanded) Meeting in 2018 and mobilized for reform. Xie Xincheng, Vice President, Gao Ruiping and Wang Chengwen were present at the meeting. Han Yu, Party member and Secretary-General, presided over the meeting. All the staff of the National Natural Science Foundation of China (including the director of the rotating program directors and part-time staff) attended the meeting.

December

December 12

In 2018, the National Natural Science Fund Management Conference was held in Beijing. Li Jinghai, Secretary of the Party Group and President, made a report entitled "Deepening the Reform of Science Funds and

Constructing a New Era Science Funds System". Xie Xincheng, Vice President, Gao Ruiping and Wang Chengwen attended the meeting. Han Yu, member of the Party Group and Secretary-General, presided over the meeting. The conference issued "Some Opinions on Further Strengthening the Management of Scientific Funds Dependent on Units".

December 16

The National Natural Science Foundation of China held a symposium on strengthening multi-input in basic research and the signing ceremony of the agreement of the National Natural Science Foundation of China Regional/Enterprise Innovation and Development Joint Fund in Beijing. Wang Zhigang, Secretary of the Party Group and Minister of the Ministry of Science and Technology, Li Jinghai, Secretary of the Party Group and President of the National Natural Science Foundation of China, attended the meeting and made important speeches. Gao Ruiping, member of the Party Group and Vice President of the National Natural Science Foundation of China, chaired the Symposium and signed the agreement. Wang Chengwen, member of the Party Group and Vice President, and Han Yu, member of the Party Group and Secretary-General, attended and presided over the signing ceremony. Sichuan, Hunan, Anhui and Jilin provinces joined the joint fund for regional innovation and development. Peng Yuhang, Vice Governor of Sichuan Provincial People's Government, Chen Fei, Vice Governor of Hunan Provincial People's Government, Deng Xiangyang, Standing Vice Governor of Provincial Committee of Anhui Provincial People's Government, and Jilin Province joined the joint fund for regional innovation and development.

The deputy governor of the People's Government, An lijia, attended the Symposium and signed the agreement of the joint fund for regional innovation and development; China Electronic Science and Technology Group Co., Ltd., China Ocean Petroleum Group Co., Ltd., China Petrochemical Co., Ltd. joined the joint fund for enterprise innovation and development; Xiong Qunli, Chairman of China Electronic Science and Technology Group Co., Ltd., and Chairman of China Petrochemical Group Co., Ltd. Dai Houliang and Wang Dongjin, general manager of CNOOC, attended the Symposium and the signing ceremony.

December 21

The Discipline Inspection and Supervision Group of the State Commission for Discipline Inspection in the Ministry of Science and Technology of the Central Commission for Discipline Inspection held a communication meeting with the Party Group of the National Natural Science Foundation of China to inform the situation of the accreditation and supervision, and made a special study on the work of the National Natural Science Foundation of China in overall stringent governance of the Party, the construction of a clean and honest Party. Wang Binyi, member of the Party Leadership Group of the Ministry of Science and Technology and head of the Discipline Inspection and Supervision Group of the State Supervision Committee of the Central Commission for Discipline Inspection in the Ministry of Science and Technology, attended the meeting and made a speech. Li Jinghai, Party Secretary and President presided over the meeting. Party members and Vice Presidents Gao Fu, Hou Zengqian, Gao Ruiping and Wang Chengwen, Vice President Xie Xincheng, Party member and Secretary-General Han Yu, and Deputy Chairman Xuan Hongyun of the discipline inspection and supervision group of the State Commission for Discipline Inspection in the Ministry of Science and Technology of the Central Discipline Commission attended the meeting.

December 27–28

Han Yu, member of the Party Leadership Group and Secretary-General, attended and delivered a speech at the "Yunnan Nujiang Green Spice Industry Development Strategy Seminar". More than 30 experts from more than 20 institutions, such as universities, scientific research institutes, trade associations, enterprises and National Natural Science Foundation of China, attended the meeting.

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Appendix II Shuangqing Forum

"Shuangqing Forum" is a high-level strategic academic exchange platform established by the National Natural Science Foundation of China aiming at creating a relaxed academic environment, promoting interdisciplinarity and integration, promoting the construction of innovative culture, and serving the development of basic research. Based on the funding of the NSFC, the Forum focuses on scientific frontiers with highly interdisciplinary characteristics or major basic scientific issues oriented to national strategic needs, or major management and policy issues conducive to the development and improvement of the science funding system.

In 2018, the Shuangqing Forum took the deepening reform of the National Natural Science Fund as an important opportunity, insisted on the organic combination of free exploration and facing the country's major needs, implemented the funding orientation of the New Era Science Fund into the selection of priority areas, promoted the optimization of discipline layout, and scientifically planned the blueprint for the development of basic research. A total of 25 sessions of the Shuangqing Forum (196–220) and 2 sessions of the Symposium on Poverty Alleviation Strategy were held throughout the year. There were 1,049 participants, including more than 145 academicians, 24 sessions sponsored by the Ministry of Science and 3 sessions sponsored by functional bureaus. The theme covers 15 issues of basic science at the frontier of science, 8 issues of deep-seated science oriented to the needs of national development strategies, 2 issues of major policies and management for developing and improving the science funding system, and 2 issues of industrial poverty alleviation development strategies.

Topic Catalogue of "Shuangqing Forum" in 2018

◎ No. 196: Western Pacific Dynamics
(April 7–8, 2018)

◎ No.197: Earth Surface System Science and the Sustainable Development of the " Belt and Road"
(April 13–14, 2018)

◎ No.198: Cell and Molecular Basis of Organ Development and Regeneration
(April 26–27, 2018)

◎ No. 199: Engineering Management of High-End Equipment Manufacturing under the New Generation Information Technology Environment
(May 9–10, 2018)

◎ No. 200: Fine Measurement Technology and Characterization Evaluation Method of Full-Field Mechanical Parameters in Materials
(May 12–13, 2018)

◎ No.201: Theory and Empirical Research on Innovative Management of Enterprise Operation and Service in the Digital Economy Era
(May 17–18, 2018)

◎ No.202: Exploring New Measures for International Cooperation and Funding of Science Foundation in the New Period
(June 12–13, 2018)

◎ No. 203: Basic Science of Aeroengine
(June 21–22, 2018)

◎ No.204: Key Frontier Basic Science Problems in Seismic Resistance and Toughness Urban Construction
(July 27–28, 2018)

◎ No. 205: Sustainable Development and Reuse of Nonferrous Metals
(August 6–7, 2018)

◎ No. 206: Frontier Theory, Method and Application of Econometrics in the Age of Big Data
(August 9–10, 2018)

◎ No. 207: Key Technologies for Marine Equipment Development in the South China Sea and Polar Regions
(September 26–27, 2018)

◎ No. 208: Traditional Non-Drug Rehabilitation and Nerve Repair
(October 11–12, 2018)

◎ No. 209: Frontiers and Challenges of Tissue Engineering Research
(October 23–24, 2018)

◎ No. 210: Basic Research on Accurate Diagnosis and Treatment of Medical Optics
(October 24–25, 2018)

◎ No. 211: Design, Preparation and Physical Property Control of Novelty Quantum Systems
(October 29–30, 2018)

◎ No. 212: Scientific Problems and Scaling-up Principles of Metallurgical and Chemical Reactors
(November 14–15, 2018)

◎ No. 213: Key Scientific Issues of Major Foundations of Forestry Based on Demand Orientation
(November 8–9, 2018)

◎ No. 214: China's Strategic Mineral Resources Security and Management in the New Era (November 22–23, 2018)
◎ No. 215: Policies and Practices of Open Science (November 24–25, 2018)
◎ No. 216: Challenging Scientific Problems and Subversive Technologies of Artificial Intelligence (December 12–13, 2018)
◎ No. 217: Strategic Key Mineral Resources (December 8–9, 2018)
◎ No. 218: Electrochemical Energy (December 9–10, 2018)
◎ No. 219: Limits of Synthetic Chemistry (December 12–13, 2018)
◎ No. 220: Regulation of the Development and Outcome of Cardiac Remodeling (December 13–14, 2018)

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Appendix III

Administrative Normative Document System of the National Natural Science Foundation of China

Administrative Normative Document System of the National Natural Science Foundation of China

Organization and Management

- National Natural Science Foundation of China Regulations
- Regulations of the Supervisory Committee of the National Natural Science Foundation of China
- Management Measures for National Natural Science Foundation of China's Support Unites
- Working Methods of the Expert Advisory Committee of Scientific Departments in National Natural Science Foundation of China
- Management Measures for Evaluation Experts of the National Natural Science Foundation of China

Procedure Management

- Management Measures for General Program of the National Natural Science Foundation of China
- Management Measures for Key Program of the National Natural Science Foundation of China
- Management Measures for Major Program of the National Natural Science Foundation of China
- Management Measures for International (Regional) Cooperative Research Program of the National Natural Science Foundation of China
- Management Measures for International (Regional) Exchange Program of the National Natural Science Foundation of China
- Management Measures for Fund for Less Developed Regions of the National Natural Science Foundation of China
- Management Measures for the Young Scientists Fund of the National Natural Science Foundation of China
- Management Measures for Excellent Young Scientists Fund of the National Natural Science Foundation of China
- Management Measures for National Science Fund for Distinguished Young Scientists
- Management Measures for the Research Fund for International Young Scientists
- Management Measures for Tianyuan Fund for Mathematics of National Natural Science Foundation of China
- Management Measures for Science Fund for Creative Research Groups of the National Natural Science Foundation of China
- Management Measures for the Joint Funds of the National Natural Science Foundation of China
- Management Measures for Major Research Plan of the National Natural Science Foundation of China
- Management Measures for Special Fund for Research on National Major Research Instruments of the National Natural Science Foundation of China
- Management Measures for Special Projects of the National Natural Science Foundation of China

Fund Management

- Measures for Fund Management of the National Natural Science Foundation of China
- Supplementary Notice of Minister of Finance on Issues Relevant to Fund Management of National Natural Science Foundation Funded Projects
- Supplementary Notice of the National Natural Science Foundation of China on the Fund Management of National Natural Science Foundation Funded Projects
- Notice of the National Natural Science Foundation of China on Recovery of the Balance Funds of the Finished Projects in 2015

Supervision and Guarantee

- Management Measures for Information Disclosure of the National Natural Science Foundation of China
- Measures for Evasion and Confidentiality Management in Project Evaluation of the National Natural Science Foundation of China
- Measures for Project Review Management of the National Natural Science Foundation of China
- Measures for the Management of Research Achievements of National Natural Science Foundation Funded Projects
- Rules for the Implementation of the Supervisory Work of the National Natural Science Foundation Subsidized Projects Assessment Meeting

Other

- Code of Conduct for Project Evaluation Experts of the National Natural Science Foundation of China
- Rules for the Management and Implementation of the Regional Liaison Network of the National Natural Science Foundation of China
- Rules for the Implementation of the Registration Administration of Dependent Units of the National Natural Science Foundation of China