NATIONAL NATURAL SCIENCEE FOUNDATION OF CHINA

2020 ANNUAL REPORT

Editorial Committee

FOREWORD

In 2020, under the guidance ofPresident 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 Chinese Communist Party and its Second, Third, Fourth and Fifth Plenary Sessions and the important statements of President Xi on scientific and technological innovation. In accordance with the decisions and arrangements of the CPC Central Committee and the State Council on strengthening basic research, NSFC systematically deepened the comprehensive reform on science funding, carefully developed the mediumand long-term plan and the 14th Five Year Plan, and successfully completed annual funding work--received a total of approximately 281,200 applications throughout the year, funded 45,700 projects based on merit-based selection with the total amount of about 28.303 billion yuan for the direct cost.

Timely deployment of prevention and control to support the fight against the COVID-19 pandemic. We strived to balance emergency and long-term research when launching related basic research programs, so as to focus on solving scientific problems. The emergency special program of "Basic Research on the Traceability, Pathogenesis and Prevention of Novel Coronavirus" was launched, and the major research plan of "Coronavirus-Host Immune Interaction Mechanism and Intervention Strategies" was initiated. We also supported decision-making by launching the special program "Response, Governance and Impact of Public Health Emergencies such as COVID-19". To cope with the emergency, we adjusted the deadline ofproposal submission, fully implemented paperless application, and set a separate deadline for all the front-line scientific research personnel of pandemic prevention and control. In the meantime, we actively promoted international cooperation to jointly tackle the challenges. Joint statements were issued with DFG and UKRI to callon international scientific community to cooperate in the fight against the pandemic. Joint research projects weresolicited with more than ten international partner agencies to support COVID-19 related research.

Initial results were achieved in some tasks as we deepened the comprehensive reform. We steadily advanced the pilot reform, and achieved initial results with the three major tasks. We also made solid progress in implementing the funding categories based on the four attributes of scientific problems, i.e. funding creative ideas to achieve excellence in science, focusing on the frontier of science in unique ways to lead at the cutting edge, supporting use-inspired basic research to translate excellent science toward application, encouraging transdisciplinary and convergent leading-edge research, with 42% (approx. 116.8 thousand proposals) of the applications going through pilot category-specific review.The reform of the evaluation mechanism featuring"Responsibility+Credibility+Contribution (RCC)" was steadily underway. In 2020, pilot review was conducted in 10 disciplines from the 8 scientific departments by guidingthe reviewers to be more responsible. In accordance with the principles derived from the logical structure of the knowledge system, promoting the convergence of knowledge and application, and highlighting transdisciplinarity, the first phase of optimizing disciplinary layout was completed. The application code

system was adjusted from three to two tiers, and the total number of codes was reduced from 3,542 to 1,389.

Adherence to the "four aspects" and strengthening the supporting role of basic research. We implemented the "four aspects" policy by funding 737 key projects, 45 major projects, launching 5 major research plans, and 13 basic science center projects, and increasedthe support of the R&D of original scientific research instruments and key components by funding a total of 88 national major scientific research instrument development projects.

Encouraging and supporting original innovation, and promotingtransdisciplinary convergence. We pilotedthe Original Exploratory Program, in which innovative management mechanisms such as double-blind review and pre-application were introduced. Among the 766 pre-applications for expert-recommended projects and 1,000 pre-applications for guide-guided projects received by NSFC, a total of 53 projects were funded. We also established the Department of Interdisciplinary Sciences, and developed interdisciplinary project funding management system and corresponding regulations, so as to promote transdisciplinarity and convergence.

Continuing fostering outstanding talents and consolidating the base of basic research talents. We accelerated the upgrade of the talent funding system, and actively cultivated and attracted outstanding young talents. The Excellent Young Scientists Fund and the National Science Fund for Distinguished Young Scholarsare open to researchers around the world. We continued pilotingthe application for the Excellent Young Scientists Fundinhost institutions in Hong Kong and Macao Special Administrative Regions. The implementation plan for the Research Fund for International Scientistswas formulated to attract overseas talents at multiple levels and in all areas to work in China.

Deepening the management reform of Programs of Joint Funds and actively attracting diversified investment. We actively guided local governments, enterprises, and industries to invest in basic research and jointly fund research on key scientific problems behind major needs. Since the reform of the Joint Funds management mechanism in 2018, a total of 9.174 billion yuan has been invested by the joint funders during the agreement period, an initial establishment of the diversified investment mechanism of the science fund. In 2020, 774 key projects were supported by the Joint Funds.

Strengthen the construction of work style and study style, and purify the ecological environment of scientific research. NSFC established a scientific research integrity system that integrates "education, motivation, regulation, supervision, and discipline", issued and implemented the "National Natural Science Foundation Scientific Integrity Construction Implementation Plan", amended the "Regulation on National Natural Science Fund Project Research Misconduct Investigation and Handling". We also effectively implemented the four-party commitment system for applicants/PIs, reviewers, host institutions and NSFC staff to create a good review environment, reinforced supervision and management of project funds, and seriously investigated and handled scientific research misconduct, and held relevant persons and host institutions accountable.

Expanding international cooperation network to build an open and collaborative National Natural Science Fund. NSFC strengthened strategic dialogue and high-level interaction with internationalscience funding agencies and the scientific community, and enhanced substantive collaboration and personnel exchanges by funding 818 international (regional) cooperation and exchange projects. We also steadily advanced the International SDGFunding Framework in areas such as sustainable development and

COVID-19 prevention and control.

Optimizing project fund management to create a favorable environment for scientific research. NSFC improved project funding management by continuingto pilot the "contract system" for the National Science Fund for Distinguished Young Scholars, and comprehensively increasing the proportion of indirect costs for Young Scientists Fund, Excellent Young Scientists Fund and Science Fund for Creative Research Groups. Project management procedures were optimized by simplifying application materials and preliminary review requirements, and further implementing the representative work evaluation system. We also reinforced the management of host institutions, by adoptingexpert review approach to select 151 research instituteseligible to register as host institutes for the first time, and expanding the scope of host institutions self-evaluation.

Strengthening results sharing and promoting the transfer of results. NSFC continuously promoted the sharing of results, with the National Natural Science Fund Shared Service Network having collected 374,000 completed projects and 4.183 million project results. We established Center for Science Communication and Achievement Transformation, and jointly held partnering meetings for NSFC-funded results with Beijing and Guangdong. We also enhanced the coordination and partnership with other national science and technology plans, and further strengthened macro coordination, project coordination and information sharing.

Seriously implementing the rectification tasks identified during inspection to reinforce strict governance. NSFC strictly adhered to the inspection requirements, and firmly carried out all the rectification tasks by combining special rectification work with audit rectification, thoroughly investigated hidden risks of scientific fund projects and fund management, and strengthened supervision and restriction of management power. We also implemented the general requirements of the Central Committee of the CPC by promoting the comprehensive and in-depth development of strict management.

2021 is the first year for China to embark on a new journey of building a modern socialist country in an all-round way and to move toward the forefront goal of an innovative country. NSFC will follow Xi Jinping's Thought on Socialism with Chinese Characteristics for a New Era as its fundamental guidance, fully implement the spirits of the 19th National Congress of Chinese Communist Party and its Second, Third, Fourth and Fifth Plenary Sessions and the important statements of President Xi on scientific and technological innovation and basic research, firmly grasp the strategic requirements of technological self-reliance and self-reliance, adhere to the "four aspects", continue to deepen the comprehensive reform, persevere in strengthening basic research, strive to achieve high-quality development of basic research, and effectively enhance the capability of original innovation, so as tocelebrate the 100th Anniversary of the Founding of the CPC with outstanding results.

Prof. Dr. Li Jinghai
President of NSFC

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Part 1

Overview

NSFC

2020 ANNUAL REPORT

I. Progress of NSFC Reform

Following Xi Jinping's Thought on Socialism with Chinese Characteristics for a New Era as its fundamental guidance, NSFC fully implements the spirits of the 19th National Congress of Chinese Communist Party and its Second, Third, Fourth and Fifth Plenary Sessions and the important statements of President Xi on scientific and technological innovation and basic research, accurately grasps the new requirements of the new era for basic research, closely focuses on achieving high-level self-reliance and deepening reforms, continuously improves the governance efficiency of science funds, strongly supports the high-quality development of basic research, and lays a solid foundation of original innovation for building a world science and technology power.

(I) Significant results achieved in the three major tasks of the NSFC reform

In 2018, NSFC formulated a preliminary reform scheme by proposing three major tasks, namely, identifying funding categories, improving evaluation mechanisms, and optimizing layout of research areas, and setting an objective as building a science fund governance system for the new era with "advanced concepts, standardized systems, and fairness and efficiency". As of today, initial results have been achieved in the three major tasks.

The first is the in-depth development of the funding categories of the National Natural Science Fund for the new era. The scope of pilot category-specific application and review based on the four attributes of scientific problemswas expanded to all General Program and Key Program. NSFC organized merit review according to the attributes of scientific problems, with 19,357 grants awardedout of 112,885 proposals for General Program, and 737 grants awarded out of 3,889 proposals for Key Program. In order to guide applicants to accurately select the attributes of scientific problems and organizehigh-quality category-specific review, NSFC produced a video to introduce the funding categories and category-specific application and review to applicants, reviewers, host institutions and NSFC staff. Meanwhile, 83 cases were carefully selected as a typical case database of four attributes of scientific problems for the reference of applicants.

The second is the steady progress of the pilot reform of the evaluation mechanism featuring "Resp onsibility+Credibility+Contribution (RCC)". In 2020, pilot "RCC" reviewwas carried out in 10 disciplines of 8 scientific departments. Statistics show that: 84.1% of applicants (including 80% of those who have not received funding) believe that it is necessary to take this reform measure; the rate of timely feedback from correspondence reviewers has increased by 36% year-on-year, and the quality of review comments have been significantly improved; The rate of satisfaction with review comments reached 87.3%, which is a remarkable achievement in guiding reviewers to perform their duties more responsibly and improving the quality of project review.

The third is the optimization of the layout of research areas to conform to the inherent logic of the knowledge system and promote the integration of knowledge and application. Based on the existing science fund application code, weoptimized and adjusted the application codes of the 8 scientific departments after sorting out the overall structure of the application codes and the logical structure of different tiers. The science fund application code system has been adjusted from three tiers to two tiers, and the total number of codes was reduced from 3,542 in 2019 to 1,389, which has been published in the "NSFC Application Codes (2020 Edition)" issued in November 2020.

(II) Emphasis on problem solving and coordination of a series of targeted reform measures

In 2019, in accordance with the latest arrangements of the State Council, we further refined the tasks and measures of NSFC reform and developed a systematic reform plan with the "three major reform tasks" as the core and "strengthening three constructions, improving six mechanisms, strengthening two key points, and optimizing seven aspects of management" as important measures, aiming to improve the system and mechanisms that encourage and support basic research and original innovation, and create a good environment conducive to innovation. As of today, some reform tasks and important measures have made significant progress.

The first is the improvement on the mechanisms of identifying scientific problems and establishing major types of programs. We studied and formulated "NSFC's Several Opinions on Improving the Mechanism of Establishing Major Types ofPrograms (for Trial Implementation)" and "Several Opinions on Strengthening the Mechanism of Identifying Scientific Problems Facing Major National Needs and the Frontiers of Science in the World (for Trial Implementation)" to sort out the funding system of major program types, strengthening the overall planning, identification of scientific problems, and effective competition, and improving multi-level management, so as toelevate the role of science fund in solving bottleneck problems.

The second is the progress of the Original ExploratoryProgram. NSFC officially launched the Original Exploratory Program,and introduced innovative management mechanisms such as double-blind review, pre-application, review result feedback and replies with the originality of research ideas and the leadership of expected results as the evaluation criteria.were introduced in the program.Funding for original ideas that are non-consensual,subversive and high-risk has been increased. In 2020, 53 original exploratory projects were funded with a direct cost of approximately 112 million yuan.

The third is the optimization of the Talent funding portfolio. NSFC strengthened the coordination between the National Science Fund for Distinguished Young Scholars and Excellent Young Scientists Fund Youth and other talent programs, so as to optimize the allocation of resources, and avoid duplication of support. The Excellent Young Scientists Fund and the National Science Fund for Distinguished Young Scholars are now open to global researchers, attracting more outstanding international scholars to carry out high-level scientific research in China. We also piloted a special programonscience and technology management, in an attempt to develop a funding mechanism for science and technology management talents.

The fourth is the interdisciplinary integration and convergence. NSFC established the Department of Interdisciplinary Sciences to coordinate the overall funding of the interdisciplinary research, promote the establishment of interdisciplinary funding and project review mechanismsacross disciplines and scientific departments, and throughout NSFC, and promote in-depth interdisciplinary integration and convergence. We emphasized the development of interdisciplinaryprograms, launched five new major research plans, and strengthened support for research areas that demonstrate interdisciplinary characteristics and are expected to lead future scientific and technological progress.

The fifth is the optimization of project management. NSFC continuously implement the requirements of "decentralization, management and service" by carrying out project management reform in three aspects. Firstly, wefully implemented paperless applications in response to the COVID-19 pandemic. Secondly,we reorganized and simplifiedthe list of ineligible proposal cases for preliminary review in accordance with the actual situation of paperless application, and the principle of simplification, to give full play to the auxiliary functions of the information system and expedite the preliminary review. Thirdly,we fully implemented the representative works evaluation system, eliminated the "List of Papers Published and Cited" in talent program applications, and strived to avoid the tendency in the evaluation that is solely based on publications, grants, awards and titles, toencourage capability, performance, and contribution.

The sixth isthe improvement of funding management. NSFC piloted the reform measure of increasing the ratio of indirect cost inknowledge-intensive and purely theoretical basic research projects, the scope of which expanded to all the grants of Excellent Young Scientists Fund, Science Fund for Creative Research Groups and Young Scientists Fund, in an attempt togive incentives to scientific researchers. We also steadily advanced the pilot "contract system" for the use of funds. The first batch of host institutions formulated internal implementation rules and filed them with the NSFC. Meanwhile, we carried out in-depth study on relevant principal investigators and scientific research management personnel at the host institutions, before planning for the next step, in order toguarantee scientific research personnel greater autonomy in the use of funds.

The seventh is the initial establishment of a diversified investment mechanism. Through top-level design and overall management, we further expanded the scope of joint funds in adherence to the orientation of problem solving and national demand. Up to now, under the joint fund model in the new era, a total of 9.174 billion yuan have been attracted from the joint funders during the agreement period, of which 20 provinces (autonomous regions and municipalities) joined the Joint Fund for Regional Innovation and Development with an investment of 6.29 billion yuan; 6 enterprises joined the Joint Fund for Corporate Innovation and Development with an investment of 1.294 billion yuan; 6 industry sectors established joint funds with NSFC with an investment of 1.59 billion yuan. The diversified investment mechanism has enhancedthe capacity to attract social investment in basic research.

The eighth is promoting the transfer and application of funding results. NSFC continued updating the science fund sharing service network and basic research knowledge database, to include results information, provide powerful tools for disseminating cutting-edge scientific and technological knowledge, and promote scientific and technological progress. We organized partnering meetings with Beijing Municipality and Guangdong Province for outstanding achievements funded by NSFC, held workshops on the transfer of basic chemical research results and corporate partnering, and bridgedNSFC-funded outstanding scientific researchers and funding results with local enterprises, venture capital institutions, and technology intermediaries, etc., so as to facilitate the transfer and translation of scientific achievements. We also establishedCenter for Science Communication and Achievement Transformation to provide organizational and institutional support for the transfer and transformation of NSFC-funded achievements.

The ninth is strengthening the management of host institutions. NSFC improved the registration management mechanism, strictly controlled the "entry" of the host institutions, emphasize their responsibilities, included scientific research integrity as an application requirement, and adopted the peer review method for the first time to select 151 scientific research institutes to register as host institutions. The qualifications of 221 host institutions were terminated and the dynamic management of host institutions was realized. We also strengthened publicity, education, supervision and management, explore the establishment of a reputation evaluation mechanism, and constantly consolidated the main responsibilities and supervision responsibilities of the host institutions, in order to improve the management of science fund.

(III) Research on the reform plan of layout of research areas in response to changes and open up new situations with deeper reforms

In 2020, guided by the spirits of the Fifth Plenary Session of the 19th CPC National Congress, in accordance with the requirements of the "four aspects", and the principles of "deriving from the inherent logic of the knowledge system, promoting the integration of knowledge and applications, and highlighting the transdisciplinary convergence", NSFC seized the opportunity of scientific and technological revolution and the paradigm shiftin scientific research to initiate the reform on layout of research areas after extensively soliciting opinions from the scientific community, on the basis of in-depth study and judgment

on the historical position of China's basic research development, and the deep understanding of the responsibilities and missions of Science Fund, and in adherence to the philosophythat "basic research is a research activity that proposes and solves scientific problems". The basic idea is to integrate the 9 existing scientific departments into four sections, i.e. basic sciences, technical sciences, life and health sciences, and convergence and integration. The basic sciences section is mainly composed of mathematics, mechanics, astronomy, physics, chemistry, and geosciences; the technical sciences section is mainly composed of information, engineering, and materials; the life and health sciences section is mainly composed of biology, medicine, and agricultural science; the convergence and integration section is mainly composed ofinterdisciplinary and management sciences. Through the new layout of research areas, we will strive to optimize the allocation of resources, stimulate the vitality and creativity of categorized management, promote the interaction and integration of knowledge and applications, persevere in strengthening basic research and promoting original innovation, and further improve the management of science funding, so as to boost the fundamental role of science fund in seizing the frontiers of world science and technology, addressing major national needs, supportingthe country's economy, and safeguarding people's lives and health.

II. Overview of Budget & Outlays and Funding

(I) Overview of Budget and Outlays

In 2020, the fiscal budget of NSFC was 28919.7736 million yuan[①], of which the budget for project funding was 28456.7718 million yuan. In 2020, NSFC completed the appropriation of project funds with a total amount of 24034.9849 million yuan, of which the direct cost was 24034.9849 million yuan, and the indirect cost was 4355.4517 million yuan. The fiscal budget statistics of NSFC in 2020 are shown in Table 1-2-1.

Table 1-2-1 2020 NSFC Fiscal Budget and Outlays

(in million yuan)

Type	Fiscal Budget	Annual Outlays
National Natural Science Fund	27355.0718	27307.5111
National Science Fund for Distinguished Young Scholars	1101.700	1082.9255
Total	28456.7718	28390.4366

(II) Overview of Funding

In 2020, NSFC invested a total of 33633.0424 million yuan to fund various types of projects, of which: the direct cost was 28302.5127 million yuan, and the indirect costs of 1,496 host institutions were 5330.5297 million yuan. The project funding statistics of NSFC in 2020 are shown in Table 1-2-2.

Table 1-2-2 2020 NSFC Project Funding Statistics

(in million yuan)

	Program Type	Number of Projects	Funding Amount		
			Direct Cost	Indirect Cost	Total
1	General Program	19357	11129.94	2143.3901	13273.3301
2	Key Program	737	2165.27	4100.203	2575.2903
3	Major Program	45	791.3938	147.6046	938.9984
4	Major Research Plan	460	873.9996	151.5106	1025.5102
5	International (Regional) Joint Research Program	368	826.1972	164.1395	990.3367
6	Young Scientists Fund	18276	4356.0800	1088.7200	5444.8000
7	Fund for Less Developed Regions	3177	1107.3800	215.8864	1323.2664
8	Excellent Young Scientists Fund	625	750.00	187.50	937.50
9	National Science Fund for Distinguished Young Scholars	298	1169.2	0.00	11692
10	Science Fund for Creative Research Groups (Newly Approved)	37	360.1	73.1	433.2
11	Programs for Joint Funds	1084	2387.5040	443.5631	2831.0671

① NSFC budget includes expenditures of housing, social security, and employment.

	Program Type	Number of Projects	Funding Amount		
			Direct Cost	Indirect Cost	Total
12	Special Fund for Research on National Major Research Instrument	88	944.9478	136.8823	1081.8301
13	Basic Science Center Program	13	770.00	93.5236	863.5236
14	Special Fund for Emergency Programs	521	477.1018	66.5308	543.6326
15	Tianyuan Fund for Mathematics	120	45.00	0.00	45.00
16	Research Fund for International Young Scientists	146	45.00	8.1584	53.1584
17	International (Regional) Personnel Exchange Program	551304	103.3985	0.00	103.3985
Total		4519245656	28302.5127	5330.5297	33633.0424

III. Overview of Concluded Projects

In 2020, 40,057 projects supported by NSFC were concluded, of which 16,670 from General Program, 600 from Key Program, 105 from Major Program, 496 from Major Research Plan, 16,076 from Young Scientists Fund, 2,830 from Fund for Less Developed Regions, 399 from Excellent Young Scientists Fund, 197 from National Science Fund for Distinguished Young Scholars, 39 from Science Fund for Creative Research Groups, 138 from Joint Research Fund for Overseas Chinese Scholars and Scholars in Hong Kong and Macao, 679 from Programs for Joint Funds, 66 from Special Fund for Research on National Major Research Instrument, 756 from Special Fund for Emergency Programs, and 1006 from International (Regional) Cooperation and Exchange Program. Among the numerous achievements coming out of the concluded projects, 1,026 international patents on invention and 40,108 domestic patents on invention were obtained, and 585 national awards and 4,194 provincial and ministerial awards, including 167 National Natural Science Awards, 316 National Science and Technology Progress Awards, and 103 National Technology Invention Awards were received.

The statistics of research achievements coming out of the concluded projects supported by NSFC in 2020 are shown in Table 1-3-1.

Table 1-3-1 Research Achievements Coming Out of the Concluded Projects Supported by NSFC in 2019

Research Achievements		Program Type													
		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 Research Fund for Overseas Chinese Scholars and Scholars in Hong Kong and Macao	Programs for Joint Funds	Special Fund for Research on National Major Research Instrument	Special Fund for Emergency Programs	International (Regional) Cooperation & Exchange Program
No. of Concluded Projects		16 670	600	105	496	16 076	2 830	399	197	39	138	679	66	756	1 006
Publications	Keynote Speeches at International Academic Conferences	4 287	1 073	414	398	751	118	335	498	246	81	357	173	58	536
	Keynote Speeches at Domestic Academic Conferences	5 536	930	277	311	920	303	343	361	155	63	403	128	89	243
	Journal Papers	212 463	28 070	6 534	7 732	102 323	25 641	6 635	7 285	4 776	1 117	13 153	2573	3764	9 746
	Conference Papers	27 413	3 109	1 187	769	12 572	2 184	865	767	423	197	2 191	415	154	1 147
	Included in SCI Index System	141 494	20 064	4 371	5 579	67 746	10 514	5 548	6 139	3 999	898	8 959	1987	942	7 231
	Included in EI Index System	22 327	2 520	932	570	11 513	2 241	668	608	311	100	1 854	365	104	816
	Monographs	2 404	340	196	52	1 363	516	69	113	62	11	165	29	53	104
Patents	International	474	90	17	24	145	26	35	50	15	0	68	40	0	42
	Domestic	19 360	2 556	837	477	8 850	2 404	548	1 015	873	54	1 821	637	54	622
Awards	National level	255	89	29	13	62	5	21	27	27	1	26	7	1	22
	Provincial/ Ministerial level	2 148	234	74	78	917	243	108	92	43	4	135	22	5	91
Talents Trained	Postdoctoral Fellow	1 381	390	128	154	528	35	66	138	68	13	164	33	16	181
	PhD	16 673	3265	899	946	3 522	506	532	865	626	72	1 085	311	65	1 111
	Master's	41 235	4 285	1 161	1 107	11 087	5 880	961	1 033	882	116	2 718	309	188	1 334

Note:
1. There were no projects concluded for Basic Science Center Program in 2020.
2. International (Regional) Cooperation & Exchange Program includes International (Regional) Joint Research Program, Research Fund for International Young Scientists, and International (Regional) Personnel Exchange Program.
3. Statistics of Tianyuan Fund for Mathematics are included in Special Fund for Emergency Programs

Part 2

The Funding statistics and selective introduction of projects supported by NSFC in 2020

I. Application and Funding Statistics

(I) General Program Projects

Function and Positioning: The General Program aims at supportingresearchers to select topics independently within the funding scope of NSFC, carry out innovative scientific research, and promote the balanced, coordinated and sustainable development of various disciplines.

In 2020, a total of 112,885 applications were received for the General Program. Based on the nature of the scientific problems, these applications were divided into four categories, including Category I ground-breaking applications, category II frontier-extending applications, category III challenge-solving applications, and category IV crossing-disciplines applications. 9.9% of the total applications were under category I, 39.78% under category II, 40.76% under category III, and 9.56% under category IV.

Table 2-1-1 Application and Funding Statistics of General Program Projects in 2020 (by Scientific Department)

(Unit: 10,000 *yuan*)

Scientific Department	Applications	Approved					Success rate (%)
		Projects	Direct Funding	Percentage of the total (%)	AverageFunding per Project①	Indirect Funding	
Mathematical and Physical Sciences	7799	1750	103090.00	9.26	58.91		22.44
Chemical Sciences	8889	1815	114374.00	10.28	63.02		20.42
Life Sciences	15503	3029	175672.00	15.78	58.00		19.54
Earth Sciences	8678	2000	116276.00	10.45	58.14		23.05
Engineering and Materials Sciences	20740	3309	192398.00	17.29	58.14		15.95
Information Sciences	12348	2064	119680.00	10.75	57.98		16.72
Management Sciences	5237	806	38784.00	3.48	48.12		15.39
Health Sciences	33691	4584	252720.00	22.71	55.13		13.61
Total or average	112885	19357	1112994.00	100.00	57.50		17.15

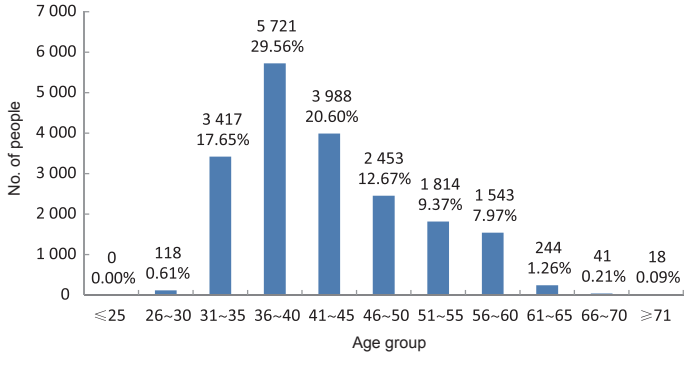


Chart 2-1-1 Age Distribution of Principal Investigators of General Program Projects in 2020

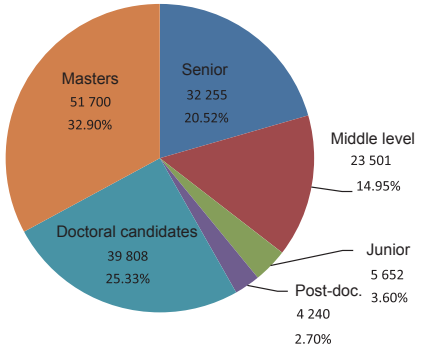


Chart 2-1-2 Professional Structure of Members of Research Groups for General Program Projects in 2020

① average direct funding per project=direct funding/project.
② funding rate =No. of approved/ No. of applications*100.

Table 2-1-2 Statistics of General Program Projects by Region in 2020

(Unit: 10,000 *yuan*)

No.	Region	Projects	Direct Funding	No.	Region	Projects	Direct Funding
1	Beijing	3385	194801.28	17	Jiangxi	70	3991.00
2	Guangdong	1850	105328.10	18	Henan	308	17742.00
3	Jiangsu	1974	113280.00	19	Jilin	348	20339.00
4	Shanghai	2057	117236.25	20	Yunan	124	7181.00
5	Hubei	1221	70190.00	21	Gansu	191	11178.00
6	Shanxi	995	57755.00	22	Guangxi	61	3540.90
7	Zhejiang	969	55624.80	23	Guizhou	38	2264.00
8	Shandong	889	51447.00	24	Shanxi	168	9850.00
9	Sichuan	696	40166.00	25	Hebei	179	10319.00
10	Hunan	660	37740.00	26	Xinjiang	31	1796.00
11	Liaoning	639	36959.47	27	Neimenggu	31	1778.00
12	Tianjin	576	33278.20	28	Hainan	24	1378.00
13	Anhui	475	27476.00	29	Ningxia	6	344.00
14	Fujian	477	27486.00	30	Qinghai	6	354.00
15	Heilongjiang	475	27398.00	31	Xizang	2	117.00
16	Chongqing	432	24656.00	Total		19357	1112994.00

(II) Key Program Projects

Function and Positioning: Key Program aims at supportingresearchers 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.

In 2020, a total of 3889 applications were received for the Key Program. Based on the nature of the scientific problems, these applications were divided into four categories, including Category I ground-breaking applications, category II frontier-extending applications, category III challenge-solving applications, and category IV crossing-disciplines applications. 8.46% of the total applications were under category I, 39.14% under category II, 45.02% under category III, and 7.38% under category IV.

Table 2-1-3 Application and Funding of Projects of Key Program Projects in 2020 (by Scientific Department)

(Unit: 10,000 yuan)

Scientific Departments	Application received	Awards	Direct Funding	Average funding per project*
Mathematical and Physical Sciences	371	90	26530	294.78
Chemical Sciences	307	70	21000	300.00
Life Sciences	607	113	33335	295.00
Earth Sciences	588	92	27500	298.91
Engineering and Materials Sciences	634	108	32400	300.00

(continued)

Scientific Departments	Application received	Awards	Direct Funding	Average funding per project*
Information Sciences	450	105	31500	300.00
Management Sciences	173	34	7140	210.00
Health Sciences	759	125	37122	296.98
Total or average	3889	737	216527	293.80

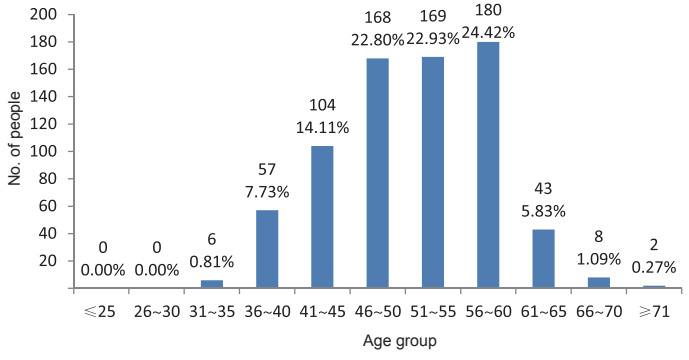


Chart 2-1-3 Age Distribution of Principal Investigators of Key Program Projects in 2020

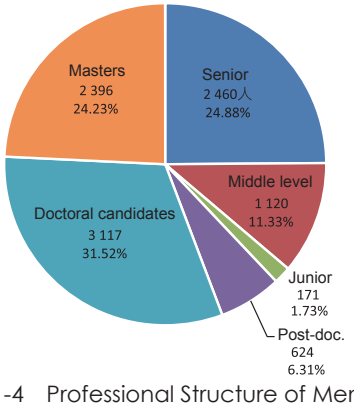


Chart 2-1-4 Professional Structure of Members of Research Groups for Key Program Projects in 2020

(III) Major Program

Function and Positioning: Major projects focus 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, gives full play to the supporting and leading role in enhancing China's original innovation ability of basic research.

Table 2-1-4 Funding of Major Program Projects in 2020

(Unit: 10,000 yuan)

No.	Title	PI	Home Institution	Direct Funding
1	Stochastic Methods in Dynamics	LvKening	Sichuan University	1789.00
2	Mathematical theory and technology for precise medical image analysis	Kong Dexing	Zhejiang University	1792.00
3	Chemomechanical coupled theory and method for reliability analysis and property modulation of high-temperature thermal protection material	Shen Shengping	Xi'an Jiaotong University	1760.00
4	Studies of Major Problems in Stellar Physics in the Era of Big Data	Han Zhanwen	Yunnan Astronomical Observatories, CAS	1710.00
5	Non-equilibrium statistical physics and dynamics in living systems	Ouyang Qi	Peking University	1777.00
6	Studies of Dark Matter Particles and Neutrinos with PandaX-4T Liquid Xenon Expeirment	Liu jianglai	Shanghai Jiaotong University	1753.00
7	The structure-activity regulation of unconventional excited dyes and the scientific basis of product engineering	Peng Xiaojun	Dalian University of Technology	1795.00

(continued)

No.	Title	PI	Home Institution	Direct Funding
8	Molecular Photonics Materials and Excited State Processes	Yao Jiannian	Institute of Chemistry, CAS	1771.50
9	The scientific fundamentals of the coupled hydrogen production and green chemical synthesis in water electrolysis	Wei Zidong	Chongqing University	1787.10
10	Structure controlling by chemical routes and enhancing the property in solids	Xing Xianran	University of Science and Technology Beijing	1765.00
11	Precise Measurement of Single Molecule and Single Cell based on Nanopores/Nanochannels' Charge Transfers	Xia Fan	China University of Geosciences (Wuhan)	1790.00
12	Metal-Organic Framework Material Design and Process Regulation for Major Chemical Separations	Yang Weishen	Dalian Institute of Chemical Physics, CAS	1795.00
13	Molecular Aspects of Arthropod-Borne Viruses Transmitting Plant and Human Diseases	Li Yi	Peking University	1795.80
14	Genetic and molecular basis of yield development in soybean	Kong Fanjiang	Guangzhou University	1796.00
15	Molecular mechanisms underlying the assembly of chromosomal machineries driven by phase separation and transition	Yao Xuebiao	University of Science and Technology of China	1797.50
16	Standardized xenograft heart transplantation construction and long-term survival mechanism research	Hu Shengshou	Fuwai Hospital, Chinese Academy of Medical Sciences	1800.00
17	Mechanisms in responses and adaptations of rodents to global change	Zhang Zhibin	Institute of Zoology, CAS	1770.00
18	Mechanisms of DNA replication-associated DNA metabolism in maintenance of genome homeostasis	Zhu Weiguo	Shenzhen University	1792.10
19	Theory and methodology of smart quantify remote sensing of land surfaces	Gong Jianya	Wuhan University	1740.13
20	Formation, evolution and enrichment mechanism of lacustrine shale oil in typical basins in central and western China	Jin Zhijun	Peking University	1796.68
21	Development of China's online coupled regional/global unified chemical weather forecasting system and atmospheric composition reanalyzing system	Zhang Xiaoye	Chinese Academy of Meteorological Sciences	1799.76
22	Coupling and ecological effects of marine environment and biological processes in the material and energy convergence center of the Indo-Pacific Convergent Area	Wang Fan	Institute of Oceanology, CAS	1800.00
23	Basic research on the prediction and forecasting of major landslides	Tang Huiming	China University of Geosciences (Wuhan)	1797.60
24	Process and regulation of soil biological co-contamination	Shen Qirong	Nanjing Agricultural University	1800.00
25	Environmental safety and secondary risk control during the major epidemic situation	Yu Gang	Tsinghua University	1996.00
26	Principle and technology of high-pressure regulation of material's structures and properties	Tian Yongjun	Yanshan University	1792.00

(continued)

No.	Title	PI	Home Institution	Direct Funding
27	Fundamental research of integrated structural and functional graphene fiber	Gao Chao	Zhejiang University	1792.00
28	Intelligent control basis of multi-physical field evolution and disturbance for the hot processing of aviation key metal components	XieJianxin	University of Science and Technology Beijing	1800.00
29	Manufacturing fundamentals of large-scale components by high-performance Carbon Fiber Reinforced Thermoplastic Composites	Jia Zhenyuan	Dalian University of Technology	1764.30
30	Fundamental study of distributed energy system with the complementation of multiple energy sources	Yang Yongping	North China Electric Power University	1800.00
31	Basic theory for resilience of deep underground space in megacities	Chen Xiangsheng	Shenzhen University	1800.00
32	arch on the Novel Architecture and Circuit Technology of High Speed RF A/D Converter	Yang Yintang	Xidian University	1800.00
33	Two-dimensional semiconducting materials and devices on Si-based platform	Yang Deren	Zhejiang University	1750.00
34	The Methodology and Key Techniques for Agile Design of Processor Chips	Sun Ninghui	Institute of Computing Technology, CAS	1793.40
35	Basic theories and key technologies of modular RF circuits for mobile communications	Liu Yuanan	Beijing University of Posts and Telecommunications	1783.00
36	Fundamental research on 3-5 μm high-power mid-infrared all-fibre lasers	Ning Yongqiang	Changchun Institute of Optics, Fine Mechanics and Physics, CAS	1800.00
37	Research on design theory and key technology of lidar chip	Song Junfeng	Jilin University	1800.00
38	Management Theories and Methodologies for Platform Supply Chains	Yu Yugang	University of Science and Technology of China	1306.70
39	Research on Major Theoretical and Practice Issues in Innovation-Driven Entrepreneurship	Cai Li	Jilin University	1342.00
40	Risk prevention and control on several risks of resilient city	Chen Bin	Beijing Normal University	1329.19
41	Study of the pathogic mechanisms underlying anxiety disorders and its clinical translation	Li Xiaoming	Zhejiang University	1800.00
42	Discovery of the pathogenesis and targets in the progression of early chronic obstructive pulmonary disease	Wang Chen	Institute of Basic Medicine, CAS	1791.70
43	Pathogensis and intervention of renal fibrosis	Zhao Minghui	Peking University	1784.30
44	Basic research on the mechanism and repair strategy of nerve injury in ischemic stroke	Yang Qingwu	The Third Military Medical University	1793.00
45	Intelligent precise surgical theranostics for liver cancer based on high dimensional data set	Dong Jiahong	Tsinghua University	1751.62
Total				79139.38

(IV) Major research plan

Function and Positioning: Major research projects follow 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.

Table 2-1-5 Applications and Funding of Major Research Plan Projects in 2020

(Unit: 10,000 yuan)

No.	Title of Project	Applications	Approved	Direct Funding
1	The neural circuits basis of emotion and memory	1	1	241.60
2	Mechanism and manipulation of mesoscales in multi-phase reaction processes	8	3	1080.00
3	Project-Dissection of Genetic Networks Controlling Yield Traits in Major Crops	2	2	1000.00
4	Tibetan Plateau land-air coupled system change and its impact on global climate	1	1	395.00
5	Fundamental Theory and Key Technology of Spatial Information Network	5	3	503.36
6	Basic research on turbulent combustion for engines	2	1	1500.00
7	Tissue and organ regional immunity and disease	90	6	900.00
8	Toxicology and health effects of fine particulate matter in the atmosphere	24	5	3900.00
9	Fundamental Research on the Causes and Coping Mechanisms of Compound Air Pollution in China	7	3	3400.00
10	Catalytic Science of Carbon-based Energy Conversion and Utilization	9	4	4300.00
11	Big data-driven management and decision-making research	176	26	1179.00
12	Runoff Variation and Adaptive Utilization in the Source Area of Southwestern Rivers	10	8	4668.00
13	Research on the basic theory and key technology of Tri-Co Robots robot	63	7	2900.00
14	Mechanisms of organ senescence and degenerative changes	204	27	3450.00
15	New light field control physics and application	81	21	2950.00
16	The driving mechanism of Hydrosphere microbes towards the circulation of earth's elements	83	20	1621.00
17	Formation, evolution and mechanism of turbulence structure	39	13	2890.00
18	Dynamic modification and chemical intervention of biomacromolecules	99	21	2010.00
19	Organelle interaction networks and their functions	80	11	1735.00
20	Tethys geodynamic system	35	14	3998.00
21	Accurate construction of multi-level chiral substances	112	24	2900.00
22	Spatio-temporal network regulation of glucose and lipid metabolism	170	32	4737.00

(continued)

No.	Title of Project	Applications	Approved	Direct Funding
23	Multi - ring interaction of the earth system in the western Pacific	35	14	3800.00
24	Molecular functional visualization of tumor evolution and diagnosis and treatment	300	19	2400.00
25	Scientific basis of high-temperature materials for aeroengines / advanced manufacturing and fault diagnosis	82	19	5001.00
26	Structural function and multistage evolution of clusters	270	32	4276.00
27	Strategic key metal supernormal enrichment ore dynamics	117	23	4300.00
28	Basic research on high-performance materials with functional element order	1	1	300.00
29	Basic research on new devices in post-moore era	65	15	2080.00
30	Construction and manipulation of the second-generation quantum system	69	23	3658.00
31	Scientific basis of electromagnetic energy equipment in extreme conditions	107	17	3432.00
32	The basic theory and key technologies of the future industrial Internet	62	17	2438.00
33	Information decoding and orderly regulation of tissue and organ regeneration and repair	371	27	3457.00
Total		2780	460	87399.96

(V) International (Regional) Cooperative Research Program

Function and Positioning: International (regional) cooperative research projects fund researchers to follow the international science frontiers, effectively use international scientific and technological resources, conduct substantive international cooperation research on the principle of equal cooperation, mutual benefit and resultssharing, and improve the scientific research and international competitiveness of China. International (regional) cooperative research projects include key international (regional) cooperative research projects and MoU-based cooperative research projects.

The key international (regional) cooperative research projects fund scientific and technical personnel to research on priority areas of the National 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 largeinternational (regional) collaborative research by use of large international scientific facilities and partners.

The MoU-based cooperative research project aims to extend bilateral and multilateral cooperation within the framework of inter-organizational agreements,makes full use of the coordination mechanism of international scientific and technological organizations in transnational cross-border scientific research programs, promotes Chinese scientists to participate in, plan and carry out regional cross-border research projects with important scientific significance, and actively advancescooperation with countries and regions along the "Belt and Road" area;implements the central government's "one country, two systems" policy, and continues to strengthen cooperation and exchanges with scientists from Hong Kong, Macao and Taiwan.

Table 2-1-6 Application and Funding of Projects of Key international (regional) cooperative research Program in 2020

(unit: 10,000 yuan)

Scientific Departments	Application received	Approved				Success Rate (%)
		Awards	DirectFunding	Percentage ofthe total (%)	Averagefunding per project	
Mathematical and Physical Sciences	19	5	1050.00	4.20	210.00	26.32
Chemical Sciences	26	6	1610.00	6.44	268.33	23.08
Life Sciences	72	16	4080.00	16.32	255.00	22.22
Earth Sciences	55	9	2310.00	9.24	256.67	16.36
Engineering and Materials Sciences	92	14	3440.00	13.76	245.71	15.22
Information Sciences Sciences	67	15	3480.00	13.92	232.00	22.39
Management Sciences	25	4	850.00	3.40	212.50	16.00
Health Sciences	120	33	8180.00	32.72	247.88	27.50
Total or average	476	102	25000.00	100.00	245.10	21.43

Table 2-1-7 Application and Funding of Projects of MoU-based cooperative research Program in 2020

(unit: 10,000 yuan)

ScientificDepartments	Application received	Approved				
		Awards	Direct Funding	Percentage of the total(%)	Averagefunding per project	Success rate(%)
Mathematical and Physical Sciences	145	29	10912.00	18.94	376.28	20.00
Chemical Sciences	136	13	1050.00	1.82	80.77	9.56
Life Sciences	495	81	16493.82	28.63	203.63	16.36
Earth Sciences	182	28	5407.00	9.38	193.11	15.38
Engineering and Materials Sciences	366	39	7724.00	13.41	198.05	10.66
Information Sciences	169	25	6127.00	10.63	245.08	14.79
Management Sciences	63	20	4764.90	8.27	238.24	31.75
Health Sciences	247	31	5141.00	8.92	165.84	12.55
Total or average	1803	266	57619.72	100.00	216.62	14.75

(VI) Projects for Young Scientists Fund

Function and Positioning: The Young Scientists Fund Project supports young science and technology personnel to conduct basic research on independently selected topics within the funding scope of the National Science Fund. It pays special attention to training young talents to conduct independent research and innovation, and cultivating new generations of talents for basic research.

Table 2-1-8 Application and Funding of Projects of Young Scientists Fund in 2020 (by Scientific Department)

(Unit: 10,000 *yuan*)

Scientific Departments	Application received	Approved				Success rate (%)
		Awards	Direct Funding	Percentage of the total (%)	Averagefunding per project	
Mathematical and Physical Sciences	7355	1813	43264.00	9.93	23.86	24.65
Chemical Sciences	9229	1582	37536.00	8.62	23.73	17.14
Life Sciences	14867	2446	58280.00	13.38	23.83	16.45
Earth Sciences	8321	1730	41112.00	9.44	23.76	20.79
Engineering and Materials Sciences	18771	3127	74560.00	17.12	23.84	16.66
Information Sciences	9559	2152	51312.00	11.78	23.84	22.51
Management Sciences	6177	921	22024.00	5.06	23.91	14.91
Health Sciences	38363	4505	107520.00	24.68	23.87	11.74
Total or average	112642	18276	435608.00	100.00	23.83	16.22

Note:54 ,795proposals from male PIs and 10,710 granted; 57847 from female, 7,566 granted.

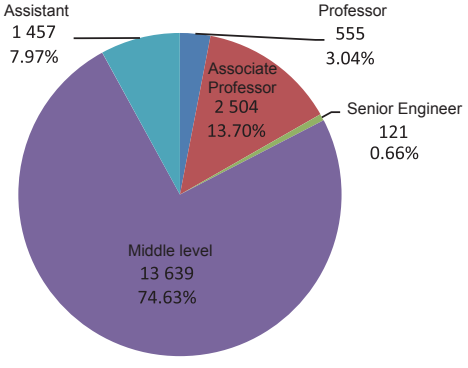


Chart 2-1-5 Professional Structure of PI of Research Groups for Young Scientists Fund in 2020

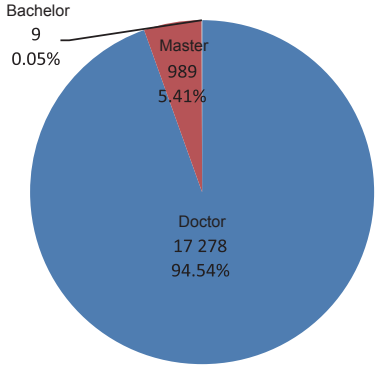


Chart 2-1-6 Academic degree of PI of Young Scientists Fund in 2020

Table 2-1-9 Statistics of Projects for Young Scientists Fund by Region in 2020

No.	Region	Application	Approved				Success rate (%)
			Awards	Direct Funding	Percentage	Average Funding	
1	Beijing	12011	2573	60960.00	13.99	23.69	21.42
2	Guangdong	11728	2231	52512.00	12.05	23.54	19.02
3	Jiangsu	10661	1832	43808.00	10.06	23.91	17.18
4	Shanghai	9396	1670	39816.00	9.14	23.84	17.77
5	Shanxi	5886	1059	25392.00	5.83	23.98	17.99
6	Shandong	7584	1029	24680.00	5.67	23.98	13.57
7	Hubei	5612	982	23440.00	5.38	23.87	17.50
8	Zhejiang	6332	974	23264.00	5.34	23.89	15.38

No.	Region	Application	Approved				Success rate (%)
			Awards	Direct Funding	Percentage	Average Funding	
9	Sichuan	4952	759	18184.00	4.17	23.96	15.33
10	Hunan	3765	648	15392.00	3.53	23.75	17.21
11	Henan	5098	560	13440.00	3.09	24.00	10.98
12	Liaoning	3096	482	11544.00	2.65	23.95	15.57
13	Tianjin	2822	461	11024.00	2.53	23.91	16.34
14	Anhui	2984	443	10624.00	2.44	23.98	14.85
15	Chongqing	2904	420	10016.00	2.30	23.85	14.46
16	Fujian	2309	358	8488.00	1.95	23.71	15.50
17	Heilongjiang	2041	329	7856.00	1.80	23.88	16.12
18	Jilin	1906	258	6192.00	1.42	24.00	13.54
19	Shanxi	1834	207	4960.00	1.14	23.96	11.29
20	Jiangxi	1695	194	4656.00	1.07	24.00	11.45
21	Hebei	1913	172	4128.00	0.95	24.00	8.99
22	Gansu	1023	157	3760.00	0.86	23.95	15.35
23	Guangxi	1312	119	2856.00	0.66	24.00	9.07
24	Yunnan	976	117	2808.00	0.64	24.00	11.99
25	Guizhou	1106	83	1992.00	0.46	24.00	7.50
26	Neimenggu	539	47	1128.00	0.26	24.00	8.72
27	Xinjiang	423	42	1008.00	0.23	24.00	9.93
28	Hainan	389	35	840.00	0.19	24.00	9.00
29	Ningxia	198	19	456.00	0.10	24.00	9.60
30	Qinghai	139	15	360.00	0.08	24.00	10.79
31	Xizang	8	1	24.00	0.01	24.00	12.50
Total or average			18276	435608.00	100	23.84	16.22

(VII) Projects of the 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 Science Fund, cultivates and support localscientific and technical personnel, and pools together outstanding talents, so as tofacilitate the development of the regional innovation system and its economy and society.

Table 2-1-10 Application and Funding of Projects of the Fund for Less Developed Regions by Funding in 2020

(Unit: 10,000 *yuan*)

No.	Region		Applications	Approved				Success rate (%)
				Awards	Direct Funding	Percentage of the total (%)	Average funding per project Average	
1	Jiang Xi		4183	666	23164.07	20.92	34.78	15.92
2	Yunnan		3271	473	16524.00	14.92	34.93	14.46
3	Guangxi		3382	438	15172.50	13.70	34.64	12.95
4	Xin Jiang		1897	273	9502.00	8.58	34.81	14.39
5	Gui Zhou		2840	404	14086.00	12.72	34.87	14.23
6	Gan Su		1908	265	9301.93	8.40	35.10	13.89
7	Neimenggu		1678	223	7846.00	7.09	35.18	13.29
8	Ning Xia		880	126	4384.00	3.96	34.79	14.32
9	Hai Nan		963	144	4994.50	4.51	34.68	14.95
10	Qing Hai		379	39	1370.00	1.24	35.13	10.29
11	Xi Zang		142	24	839.00	0.76	34.96	16.90
12	Shanxi	Yanan	87	15	542.00	0.49	36.13	17.24
		Yulin	133	20	704.00	0.64	35.20	15.04
13	Jilin	Yanbian	235	32	1107.00	1.00	34.59	13.62
14	Hunan	Xiangxi	93	22	753.00	0.68	34.23	23.66
15	Hubei	Enshi	105	9	311.00	0.28	34.56	8.57
16	Sichuan	Liangshan	39	3	105.00	0.09	35.00	7.69
		Ganzi	1	0	0.00	0.00	0.00	0.00
		Aba	6	1	32.00	0.03	32.00	16.67
Total or average			22222	3177	110738.00	100.00	34.86	14.30

Note: there were 14057applications from male applicants, of which 2100 were funded; and8165were from female applicants, of which 1077 were funded.

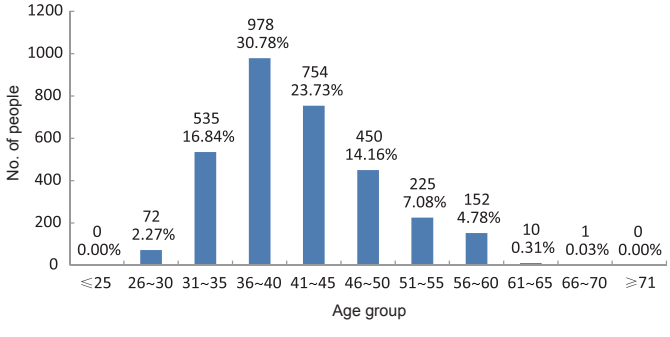


Chart 2-1-7 Age Distribution of Principal Investigators of Projects of the Fund for Less Developed Regions in 2020

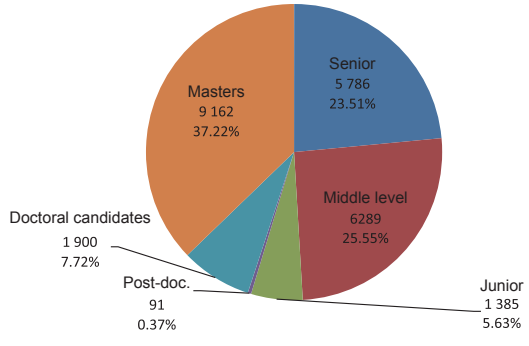


Chart 2-1-8 Professional Structure of Members of Research Groups for the Fund for Less Developed Regions in 2020

(VIII) Excellent Young Scientists Fund

Function and Positioning: The Excellent Young Scientists FundProject 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 science and technology.

To support the technological innovation and development of the Hong Kong Special Administrative Region and the Macao Special Administrative Region, to encourage high-quality and patriotic scientific and technological talents from Hong Kong and Macao to participate in the central financial science and technology plan, and to contribute to the building of a strong science and technology country, the National Natural Science Foundation of China continued to open the Excellent Young Scientists Fund to the scientific and technological talents of Hong Kong and Macao Special Administrative Region in 2020.

Table 2-1-11 Application and Funding of Projects of Excellent Young Scientists Fund in 2020 (by Scientific Department)

(Unit: 10,000 *yuan*)

Scientific Departments	Application received	Approved				
		Awards	Direct Funding	Percentage of the total (%)	Average funding per project	Success rate (%)
Mathematical and Physical Sciences	743	71	8520.00	11.83	120.00	9.56
Chemical Sciences	855	86	10320.00	14.33	120.00	10.06
Life Sciences	911	86	10320.00	14.33	120.00	9.44
Earth Sciences	656	59	7080.00	9.83	120.00	8.99
Engineering and Materials Sciences	1239	110	13200.00	18.33	120.00	8.88
Information Sciences	995	90	10800.00	15.00	120.00	9.05
Management Sciences	217	22	2640.00	3.67	120.00	10.14
Health Sciences	717	76	9120.00	12.67	120.00	10.60
Total or average	6333	600	72000.00	100.00	120.00	9.47

Note: there were 4,994applications from male applicants, of which 466 were funded; and 1339were from female applicants, of which 134were funded.

Table 2-1-12 Application and Funding of Projects of Excellent Young Scientists Fund for Hong Kong and Macao SARs in 2020 (by Scientific Department)

(Unit: 10,000 *yuan*)

Scientific Departments	Applications	Approved				
		Awards	Direct Funding	Percentage of the total (%)	Average funding per project	Success rate (%)
Mathematical and Physical Sciences	21	4	480.00	16.00	120.00	19.05
Chemical Sciences	24	3	360.00	12.00	120.00	12.50
Life Sciences	19	4	480.00	16.00	120.00	21.05
Earth Sciences	12	2	240.00	8.00	120.00	16.67
Engineering and Materials Sciences	26	4	480.00	16.00	120.00	15.38
Information Sciences	29	4	480.00	16.00	120.00	13.79

(continued)

Scientific Departments	Applications	Approved				
		Awards	Direct Funding	Percentage of the total (%)	Average funding per project	Success rate (%)
Management Sciences	11	1	120.00	4.00	120.00	9.09
Health Sciences	27	3	360.00	12.00	120.00	11.11
Total al	169	25	3000.00	100.00	120.00	14.79

Note: there were127 applications from male applicants, of which 18 were funded; and 42were from female applicants, of which 7were funded.

(IX) 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 2020, a total of 3749 applications were received for the National Science Fund for Distinguished Young Scholars. After peer review, 298 applicants got funded. The average funding amount was 4 million yuan per project, and 2.8 million yuan per project for for the Departments of Mathematical and Physical Sciences and Management Sciences. The total funding was 1.1692billion yuan and there was no longer indirect funding for this fund.

Table 2-1-13 Application and Funding of Projects of the National Science Fund for Distinguished Young Scholars in 2020

(Unit: 10,000 yuan)

Scientific Departments	Applications	Approved				
		Awards	Direct Funding	Percentage of the total (%)	Average funding per project	Success rate (%)
Mathematical and Physical Sciences	498	37	13720.00	11.73	370.81	7.43
Chemical Sciences	528	45	18000.00	15.40	400.00	8.52
Life Sciences	478	38	15200.00	13.00	400.00	7.95
Earth Sciences	394	32	12800.00	10.95	400.00	8.12
Engineering and Materials Sciences	658	57	22800.00	19.50	400.00	8.66
Information Sciences	583	43	17200.00	14.71	400.00	7.38
Management Sciences	138	10	2800.00	2.39	280.00	7.25
Health Sciences	472	36	14400.00	12.32	400.00	7.63
Total	3749	298	116920.00	100.00	392.35	7.95

Note: there were 3327applications from male applicants, of which 268 were funded; and 422 were from female applicants, of which 30 were funded.

(X)Science Fund for Creative Research Groups

Function and Positioning: The Science Fund for Creative Research Groups project 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.

In 2020, a total of281pplications were received for the Fund. After peer review, we supported 37 groups, with a total direct funding of 360.1 million yuan. The average direct funding is 10 million yuan per project and average indirect funding is 2 million yuan per project. Exceptionally, the direct funding per project for Departments of Mathematical and Physical Sciences and Management Sciences is 6.7 million yuan and indirect funding is 1.7 million yuan.

Table 2-1-14 Application and Funding of Projects for the Science Fund for Creative Research Groups in 2020

Scientific Departments	Applications	Approved				
		Awards	Direct Funding	Percentage of the total(%)	Average funding per project	Success rate(%)
Mathematical and Physical Sciences	32	4	3670.00	10.19	917.50	12.50
Chemical Sciences	32	5	5000.00	13.89	1 000.00	15.62
Life Sciences	36	5	5000.00	13.89	1 000.00	13.89
Earth Sciences	34	5	5000.00	13.89	1 000.00	14.71
Engineering and Materials Sciences	51	6	6000.00	16.66	1 000.00	11.76
Information Sciences	48	5	5000.00	13.89	1 000.00	10.42
Management Sciences	12	2	1340.00	3.72	670.00	16.67
Health Sciences	36	5	5000.00	13.89	1 000.00	13.89
Total or average	281	37	36010.00	100.00	973.24	13.17

(XI) Joint Funds

Function and Positioning: It aims to give play to the guiding role of the National Natural Science Fund, channel and integrate social resources into basic research,promote the cooperation between relevant government departments, industry, and higher education institutions and research institutes, train scientific and technological talents, and improve the independent innovation capability of regions, industries, and important fields.

Table 2-1-15 Application and Funding of Joint Funds in 2020

(unit: 10,000 yuan)

No.	Joint Funds	Applications	Approved			
			Awards	Direct Funding	Average Funding per project	Success rate (%)
1	Joint Fund forRegional Innovation and Development	1588	418	114954.00	275.01	26.32
2	Joint Fund for Corporate Innovation and Development	346	80	25075.40	313.44	23.12
3	NSAF Joint Fund	135	29	3780.00	130.34	21.48

(continued)

No.	Joint Funds	Applications	Approved			
			Awards	Direct Funding	Average Funding per project	Success rate (%)
4	Joint Fund of Civil Aviation Research	72	18	3780.00	210.00	25.00
5	Joint Fund for Yangtze River Water Science Research	112	24	5869.00	244.54	21.43
6	NSFC- Xinjiang Joint Fund	367	56	6720.00	120.00	15.26
7	NSFC-Guangdong Joint Fund	130	28	8100.00	289.29	21.54
8	NSFC-Shenzhen Robotics Research Center Project	93	17	7300.00	429.41	18.28
9	NSFC- Henan Joint Fund	1420	118	8448.00	71.59	8.31
10	NSFC-Yunnan Joint Fund	195	21	4687.00	223.19	10.77
11	NSFC-ShandongJoint Fund	153	30	8400.00	280.00	19.61
12	Joint Fund for Promoting S&T Cooperation between Both Sides of the Strait	103	16	4317.00	269.81	15.53
13	Joint Fund of Advanced Aerospace Manufacturing Technology Research	29	9	4200.00	466.67	31.03
14	Smart Grid Joint Fund	95	19	6720.00	353.68	20.00
15	Nuclear Technology Innovation Joint Fund	105	21	5880.00	280.00	20.00
16	High-speed Railway Joint Fund	107	11	2520.00	229.09	10.28
17	Joint Fund of Astronomy	243	61	5040.00	82.62	25.10
18	Joint Fund of Large Science Facilities	446	90	10080.00	112.00	20.18
19	Joint Fund for Space Science Satellite	28	9	360.00	40.00	32.14
20	Seismological Science Joint Fund	39	9	2520.00	280.00	23.08
Total or average		5806	1084	238750.40	220.25	18.67

(XII) The Special Fund for Development of National Major Research Instruments and Facilities

Function and Positioning: The special fund focuses onscience frontier 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 innovation ability.

In 2020, a total of 611 applications for the Special Fund for Development of National Major Research Instruments and Facilities were received. After peer review, 84 applications were funded, with a total direct funding of 596.3258 million yuan. The scientific departments recommended 49 applications and4of them got funded after peer review, with atotal funding of 348.622 million yuan.

Table 2-1-16 Projects funded in Special Fund for Development of National Major Research Instruments and Facilities(Open application) in 2020

(unit: 10,000 yuan)

No.	Title	Applicant	Host institution	Direct Funding
1	Development of shock-based experimental system for research on mechanisms of high-speed interfacial flow and turbulence	Si Ting	University of Science and Technology of China	682.60
2	Anglar-resolved ultrafast cathodoluminescence nanoscopy and spectroscopy system	Fang Zheyu	Peking University	645.00
3	An ultrafast photoacoustic-ultrasonic multiple-modal imaging system for complex biological tissue	Tao Chao	Nanjing University	563.00
4	Collinear resonant-ionization laser spectroscopy apparatus for studying basic properties of unstable nuclei	Ye Yanlin	Peking University	787.47
5	Study of key technologies and prototype development of High Energy cosmic-Radiation Detector facility	Zhang Shuangnan	Institute of High Energy Physics, CAS	773.00
6	X-ray differential phase contrast nanoscopy	Ge Yongshuai	Shenzhen Institute of Advanced Technology, CAS	646.29
7	Development of a compact focusing small-angle neutron scattering spectrometer with wide Q range and high intensity gain based on a compact neutron source	Wang Xuewu	Tsinghua University	774.81
8	Development of Dual-frequency Scanning Noise Microscope at Terahertz for Electronic Nano-thermometry Applications	An Zhenghua	Fudan University	665.00
9	Development of Micro-arcsec Astrometry Device Based on Differential Delay Interferometry	Cui Xiangqun	Nanjing Institute of Astronomical Optics and Technology, National Astronomical Observatories, CAS	711.10
10	Development of framing and energy-resolved flash radiography system with sequential hundreds of kilovolts pulsed X-ray	QiuMengtong	Northwest Institute of Nuclear Technology	786.00
11	Room-temperature high sensitivity vector atomic magnetometer and magnetoencephalography system	Xiao Yanhong	Shanxi University	683.45
12	Near Ambient Pressure Scanning Low Energy Electron Microscope (NAP-SLEEM)	Wan Weishi	ShanghaiTech University	788.00
13	Research and Development of Comprehensive Oxygen Control System for Liquid LBE	NiuFenglei	North China Electric Power University	731.38
14	Spectrometer of aerosols trapped by new optical tweezers	Liu Shilin	University of Science and Technology of China	597.82
15	Creating a new instrument for in situ study on multiple-component molecule interactions of single living cells	Ren Jicun	Shanghai Jiaotong University	641.00
16	Single Shot Imaging Mass Spectrometry	Hang Wei	Xiamen University	752.50
17	Nanopore single protein sequencing instrumentation	Long Yitao	Nanjing University	704.00
18	Scientific equipment for X-ray-excited luminescence spectrum and bioimaging analysis	Yang Huanghao	Fuzhou University	667.00

(continued)

No.	Title	Applicant	Host institution	Direct Funding
19	Construction of the interferometric plasmonic microscopy imaging system with the isotropic and super-resolution imaging capability	Li Jinghong	Tsinghua University	770.00
20	Novel Apparatus for Accurate Measurement Ambient Ion Mobility Constants and Study Mechanism of Mobility Selected Ion-Molecules Reaction	Li Haiyang	Dalian Institute of Chemical Physics, CAS	747.00
21	Burning rate measurement system of solid propellants under super-high pressure and high acceleration	Yang Rongjie	Beijing Institute of Technology	577.00
22	Development of in situ online gas chromatographic instruments for space exploration and space station cabin	Guan Yafeng	Dalian Institute of Chemical Physics, CAS	615.00
23	Femtosecond time-resolved fluorescence spectrometer based on optical parametric fluorescence amplification	Weng Yuxiang	Institute of Physics, CAS	659.68
24	Development of synchrotron radiation-based forfront platform for in situ, multi-modality and multi-scale characterization of biological effects of nanomaterials and their underlying mechanisms	Chen Chunying	The National Center for Nanoscience and Technology	768.00
25	Multifunctional Integrated on-line quality control system for PET molecular imaging probes	Zhang Hong	Zhejiang University	782.40
26	High Content Self-assembly Peptide Nanomaterials Screening and Analysis System	Hu Zhiyuan	The National Center for Nanoscience and Technology	725.00
27	Development and Application of the Synchronous Measurement System for the High Precision Aerosol Physical Optical Parameters	Han Yong	Sun Yat-sen University	574.38
28	The intelligent and real-time early warning instrument for transient electromagnetic advance detection while drilling in coal mine roadway-hole	Wu Qiang	China University of Mining and Technology (Beijing)	739.20
29	Development of loess vibration permeability instrument	Wang Jiading	Northwest University	664.36
30	Development of a new radar system for sea surface Current vector remote sensing	He Yijun	Nanjing University of Information Science and Technology	760.00
31	Research on the key technologies of marine absolute gravity measurement system	Zhong Min	Institute of Precision Measurement Science and Technology Innovation, CAS	706.11
32	FPGA-based 3-dimensional lightning mapping imager in the radio frequency band	QieXiushu	Institute of Atmospheric Physics, CAS	633.70
33	Development of ultralow-frequency three-dimensional vibration calibration system with full decoupling	He Wen	Zhejiang University	586.26
34	Megawatt-level controllable broadband impedance measurement and matching analysis instrument	He Zhengyou	Southwest Jiaotong University	685.50
35	A characterization system for MHz high-frequency performance of soft magnetic materials	Yan Mi	Zhejiang University	725.00

(continued)

No.	Title	Applicant	Host institution	Direct Funding
36	Nondestructive analysis instrument for 3D tomography of material microscale structures and physical properties based on high-precision time-space resolution ultrafast photoacoustic technology	Chen Yanfeng	Nanjing University	757.00
37	Development of multifunctional transparent soil model test system	Liu Jianglong	Chongqing University	785.00
38	Multifunctional magnetic / optical / electric integrated system with low temperature and vector strong magnetic field	Hou Yanglong	Peking University	780.00
39	Fabrication of a novel chemical oxygen demand (COD) analyzer based on the electrocatalytic oxidation of organic matter in a microfluidic reactor	Yu Hanqing	University of Science and Technology of China	575.00
40	Platform for the in-situ Characerization of Property-Structure Relation of Functional Materials under Multiple Fields	Shen Yang	Tsinghua University	783.00
41	Dual Beam Multifunction Polarized Infrared Spectroscope for Multistructure Study of Polymers	Yan Shouke	Beijing University of Chemical Technology	605.00
42	Research and development of liquid metal flexible sensor-based monitoring and early warning system for deep rock masses	Zhou Xiaoping	Wuhan University	730.35
43	Testing system for adhesion characteristics of wheel/rail under extreme conditions	Zhou Zhongrong	Southwest Jiaotong University	814.90
44	Intention-driven exoskeletal manipulator embedded in spacesuit enabling astronaut to dexterously perform extravehicular manipulation	XiongCaihua	Huazhong University of Science and Technology	761.40
45	Multifunctional ultrasonic lithium battery comprehensive analyzer	Huang Yunhui	Huazhong University of Science and Technology	650.00
46	In situ simulation system of accumulated deformation of subgrade under heavy traffic loads	Cui Xinzhuang	Shandong University	790.86
47	The Development of a Multi-Dimensional Dynamical Loading System with the Consideration of Real Complex Boundary Conditions	Li Hongnan	Dalian University of Technology	767.16
48	Screw melting and casting equipment of large-scale functional graded material	Li Jingyuan	University of Science and Technology Beijing	721.66
49	Development of a micro-combustion analysis instrument for levitated single-compound energetic material particles	Yang Fengqi	Xi 'an Institute of Modern Chemistry	605.93
50	In vivo multi-modal imaging flow cytometry for noninvasive, real-time and dynamic monitoring of circulating tumor cells	Wei Xunbin	Peking University	584.50
51	Research on hyperspectral imaging and automatic analysis instrument for medicine	Wang Yaonan	Hunan University	665.98
52	High-field and ultra-broadband time-resolved terahertz pump-terahertz probe spectrometer	JinBiaobing	Nanjing University	741.90
53	Wideband,highprecision,large dynamic range optical fiber differential mode delay monitoring analyzer	Wang Ruichun	Guangdong University of Technology	848.14

(continued)

No.	Title	Applicant	Host institution	Direct Funding
54	Multi-Parameter and High-Flux Label-Free Biomolecular Detection Instrument Based on Integrated Photonic Chips	He Jianjun	Zhejiang University	645.00
55	Robotic active patch clamp system for brain research in awake animals	Zhao Xin	Nankai University	774.91
56	A Large Field-of-View Neuromorphic Vision Measurement Device for High-Speed Moving Objects	Tian Yonghong	Peking University	672.10
57	Research on Broadband Measurement Technology and Instrument for Mobile Electromagnetic Environmental Effect of Internet of Vehicles	Li Erping	Zhejiang University	500.00
58	Near Field Scanning System for THz Integrated Systems	Gu Jianqiang	Tianjin University	537.68
59	Development of Railway-dedicated Test Instrument for Satellite-based Positioning	Cai Bogen	Beijing Jiaotong University	780.80
60	Instrument of Real Time Analysis of Optical Catastrophic Damage Process for High Speed Laser Chip	Zhao Jumin	Taiyuan University of Technology	800.00
61	Research on deep space communication channel emulator	Zhang Qinyu	Harbin Institute of Technology	691.36
62	Novel Instrument for Nondestructive Detection of Aeroplane Composite Material Via Holographic imaging of Millimeter-Wave Near-Field Synthetic Aperture	Xie Yongle	niversity of Electronic Science and Technology of China	573.00
63	Laser Heterodyne Interferometer with Large Field of View and High Dimension Environment Perception	Wang Chunhui	Harbin Institute of Technology	691.18
64	Development of Dynamic Time-Frequency-Dual-Mode Terahertz Channel Measurement Instruments	Chen Zhi	niversity of Electronic Science and Technology of China	853.00
65	Development of Nano-IC Marginal Defect Tester and Analyzer	Liang Huaguo	Hefei University of Technology	755.00
66	The Reserach on the HeartSound-Cardiogram-Ultrasound Multimodal Assistant Detection Device for Fetal Heart	Qin Zhiguang	University of Electronic Science and Technology of China	795.00
67	Low-orbit Spaceborne Passive Synthetic Aperture High-precision Radiation Source Location and Recognition Instrument	Tao Ran	Beijing Institute of Technology	810.00
68	A Master-Slave Detection Equipment for Underwater High-Dynamic-Range 3D Panoramic Perception	Luo Zhongxuan	Dalian University of Technology	676.00
69	Femtosecond time-resolved transient absorption and ultrafast fluorescence spectral micro-imaging system for microscopic regions	Si Jinhai	Xi'an Jiaotong University	705.00
70	Micro-nanoscale in-situ temperature field measurement instrument based on quantum dots specialty fiber probe	Wang Tingyun	Shanghai University	773.35
71	Small animal PET instrument for the dynamic imaging of sober and moving object	Xiao Peng	Huazhong University of Science and Technology	855.25

(continued)

No.	Title	Applicant	Host institution	Direct Funding
72	High Performance Neutron Detection System of Silicon Carbide Based on Micro-trench	Wang Ying	Hangzhou Dianzi University	653.81
73	Development of non-classical light source in sub-audio band	Zheng Yaohui	Shanxi University	764.60
74	Diamond Semiconductor Microcantilever Enhanced Photoacoustic Spectrometers	Shan Chongxin	Zhengzhou University	625.00
75	An Intelligent and Highly Sensitive Instrument for Microscopic Navigation and Manipulation Aiming at Precise Tumor Resection in Neurosurgery Scenarios	BianGuibin	Institute of Automation, CAS	835.00
76	On-line Trace Gas Detection Instrument for Sealed Pharmaceutical Vials under Open Environment based on Wave-Particle Synergistic Analysis	Yang Chunhua	Central South University	736.80
77	Development of an acoustic-optic endoscopy guided pulsed electric field ablation system for pancreatic cancer	Jiang Tianan	Zhejiang University	700.00
78	Development of Neuroprotective System Based on Selective Hypothermia for Brain Injury	Ji Xunming	Capital University of Medical	820.35
79	Integrated Minimally Invasive Diagnosis and Treatment Device for Intelligent Precision Hepatobiliary Pancreas Surgery	Li Hongen	Tsinghua University	736.10
80	An all-in-one equipment for capturing, labelling and retransfusing autologous circulating tumor cells to enable in vivo visualization study of tumor metastasis	Wang Qi	Dalian Medical University	580.00
81	Psychoradiology based Magnetic Resonance System with integration of diagnosis and treatment	Gong Qiyong	Sichuan University	760.00
82	The precise detection of living brain tumor' microenvironment for its image guided synchronous diagnosis and treatment	Wang Xuemei	Southeast University	721.00
83	Development of Memory Material Based Multi-dimensional Intelligent Imaging Cholangiopancreatoscope System	Zhang Shutian	Capital University of Medical	687.70
84	Development of a dedicated PET/MR/EEG/ET/NIRS (PMEEN) system for simultaneous multi-modal brain imaging	Li Sijin	Shanxi Medical University	837.80
Total				59632.58

Table 2-1-17 Projects funded in Special Fund for Development of National Major Research Instruments and Facilities(by recommendation) in 2020

(unit: 10,000 yuan)

No.	Title	Applicant	Host Institution	Direct Funding
1	Scientific instrument for in situ measurement of deformation and damage evolution inside the material at ultrahigh-temperature based on movable X-ray imaging system	Fang Daining	Beijing Institute of Technology	8 329.50
2	Compact Monoenergetic gamma-ray source	Tang Chuanxiang	Tsinghua University	8 904.80

(continued)

No.	Title	Applicant	Host Institution	Direct Funding
3	High throughput ultrastructure analysis system for cell atlas	Xu Tao	Institute of Biophysics, CAS	9 831.90
4	Development of in vivo multimodal tomographic imaging system for animals based on nonlinear response of magnetic nanoparticles	Tian Jie	Beihang University	7 796.00
Total or average				34862.20

(XIII) Basic Science Center Project

Function and Positioning: The Basic Science Center project 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 highland with academically important international influences.

Table 2-1-18 Application and Funding of Basic Science Center Project

(unit: 10,000 yuan)

No.	Title	PI	Host institution	Direct Funding
1	Research on Physics in Basic Energy Science	Sun Changpu	Graduate School of China Academy of Engineering Physics	6000.00
2	Artificial Photosynthesis	Li Can	Dalian Institute of Chemical Physics, CAS	6000.00
3	Functional mesoporous materials	Zhao Dongyuan	Fudan University	6000.00
4	Center of Inter-kingdom Information Flow on Biotic Interactions	He Zuhua	Shanghai Institute of Biological Sciences, CAS	6000.00
5	Systems-orientated Research on Multidimensions of the Proteome	He Fuchu	Academy of Military Medical Sciences	6000.00
6	Center for Climate System Prediction	Wang Huijun	Nanjing University of Information Science and Technology	6000.00
7	Extraordinary Modulation and Manufacture of Special Metallic Materials	Wei Bingbo	Northwestern Polytechnical University	6000.00
8	The Couplings among Multi-oceanic fields, Multi-body and Multi-scale, and Their Effects on the Performance and Safety of Ocean Engineering Equipment	Li Huajun	Ocean University of China	6000.00
9	Cognitive Computing	Dai Qionghai	Tsinghua University	6000.00
10	Autonomous Intelligent Unmanned Systems	Chen Jie	Beijing Institute of Technology	6000.00
11	The theory and application of resource and environment management in the digital economy era	Chen Xiaohong	Central South University	5000.00

(continued)

No.	Title	PI	Host institution	Direct Funding
12	Research on the origin and intervention of major heart diseases	Chen Yihan	Tongji University	6000.00
13	Energy metabolism and metabolic diseases	Ning Guang	Shanghai Jiaotong University	6000.00
Total				77000.00

(XIV) Special Projects

Function and Positioning: Support innovative research that requires timely funding, as well as scientific and technological activities related to the development of the National Science Fund. Special projects are divided into three subcategories: research projects, scientific and technological activities, and ground-breaking research projects. The research projects support the timely implementation of research related tostrategic deployment of the country 's economic, social, scientific and technological fields, and the study of key scientific issues involved in major emergencies, andtheinnovative and cutting-edge research with high potentials that requires timely funding; scientific and technological activities fund strategic and management research, academic exchanges, scientific communication, platform establishment and other activities related to the development of the National Science Fund.

The ground-breaking research projects fund researchers to propose original academic ideas and carry out original basic research work that is exploratory and risky, such as proposing new theories, new methods and revealing new laws, etc. The Fund aims tocultivate or produce original outputs from scratch, solve scientific problems, lead research directions or expandresearch fields, thus providing source supply for the high-quality development of basic research in China.

Table 2-1-19 Applications and Funding of Special Projects

(unit: 10,000 yuan)

No.	Types		Awards	Direct Funding
1	Research Projects	Comprehensive Research Projects of Scientific Departments	158	20140.00
		Emergency Projects of Department of Management Sciences	33	567.00
		Theoretical Physicsresearch Projects	63	3470.00
2	Scientific and Technological Activities	Comprehensive Scientific and Technological Activities of Scientific Departments	137	3584.00
		Theoretical Physics Research Projects	20	1030.00
		Shared Voyage Scientific Investigation Projects	12	5800.00
		Tasks and Soft Research Projects entrusted by Bureausand Offices	40	1535.00
		Special funds for poverty alleviation	3	150.00
		Shared Voyage Strategic Research Projects	2	200.00
3	Ground-breaking research projects	Ground-breaking research projects basedon Open Applications	18	4826.46
		Ground-breaking research projects recommended by experts	35	6407.72
Total			521	47710.18

(XV)Tianyuan Fund for Mathematics

Function and Positioning:Tianyuan Fund for Mathematics is set up to pool the collective wisdom of mathematicians, explore funding methods that meet the characteristics and development laws of mathematics, and promote the building of a powerful mathematical country. The Tianyuan Fund for Mathematics support scientific and technical personnel to combine the characteristics and needs of mathematics disciplines, develop scientific research, nurture young talents, promote academic exchanges, optimize the research environment, and disseminate mathematics culture, thereby the enhancing innovation ability of Chinese mathematics.

Table 2-1-20 Applications and Funding of Tianyuan Fund for Mathematics Projects

(unit: 10,000 yuan)

Category	Application received	Approved				Success rate (%)
		Awards	Direct Funding	Direct funding per project	Indirect Funding	
Tianyuan Fund for Mathematics	291	120	4500.00	37.50	0.00	41.24

(XVI) Research Fund for International Young Scientists

Function and Positioning: The Research Fund for International Young ScientistsProject supports foreign young scholars to choose their own topics within the funding scope of the National Natural Science Fund, 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.

Table 2-1-21 Application and Funding of Projects of Research Fund for International Young Scientists(by Scientific Department) in 2020

(unit: 10,000 yuan)

Scientific Departments	Application received	Approved				Success rate (%)
		Awards	Direct Funding	Percentage of the total (%)	Averagefunding per project	
Mathematical and Physical Sciences	163	38	1113	24.73	29.29	23.31
Chemical Sciences	157	17	560	12.44	32.94	10.83
Life Sciences	228	28	839	18.64	29.96	12.28
Earth Sciences	76	17	592	13.16	34.82	22.37
Engineering and Materials Sciences	217	22	660	14.67	30.00	10.14
Information Sciences	110	9	294	6.53	32.67	8.18
Management Sciences	85	5	160	3.56	32.00	5.88
Health Sciences	61	10	282	6.27	28.20	16.39
Total or average	1097	146	4500	100.00	30.82	13.31

(XVII) International (Regional) Exchange Program

Function and Positioning: The international (regional) exchange project 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 divided into exchange projects based on mutual visits and academic workshop projects. The exchange project aims to deepeningthe understanding of international academic frontiers, 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.

Table 2-1-22 Application and Funding of Projects of International (Regional) Exchange Program in 2020

(unit: 10,000 yuan)

Type	Application received	Approved				Success rate (%)
		Awards	Direct Funding	Percentage of the total(%)	Averagefunding per project	
Exchange Program under Agreements/ MOU	1249	234	9345.75	90.39	39.94	18.73
International Conference under Agreements/MOUs	35	12	131.1	1.27	10.92	34.29
Academic Conference under Agreements/MOUs at home	125	58	863	8.35	14.88	46.40
Total	1409	304	10339.85	100.00	34.01	21.58

II Selective Introduction of Major Research Plan Projects

(I) New Start-up Plan

Fabrication and manipulation of the second-generation quantum systems

The major research plan project *Fabrication and manipulation of the second-generation quantum systems* was launched in 2020, with a duration of 8 years and a total funding of 200 million yuan.

The second-generation quantum systems are based on the fundamentals of quantum mechanics, where the quantum states such as entangled states and superposition states can be measured and manipulated. Based on the second-generation quantum systems, future information technology including quantum computing, quantum communication, quantum sensing, quantum precision measurement and so on, are expected to break through the traditional technical bottlenecks and to significantly improve the computing power, information security, and measurement accuracy. The fabrication and manipulation of the second-generation quantum systems are the current frontier of fundamental science and key fields where transformative steps towards leadership will be taken. This project aims to carry out prospective and basic research in quantum information science and promote interdisciplinary research in mathematics and physics, information, engineering materials, chemistry, etc. via fabrication and manipulation of the second-generation quantum systems. It will lay a solid foundation for realizing the advanced quantum technologies such as quantum computers.

This project aims to address the following four key scientific issues.

1. The controllable preparation of key quantum functional materials and precise construction of quantum state systems. The main research contents include preparations of materials exhibiting dissipationless topological edge states (such as quantum anomalous Hall effect) at liquid nitrogen temperature, preparations of various high-quality heterostructures with Majorana zero mode and other non-Abelian anyons, and quantum bits construction based on various quantum states.

2. Experimental technology and theoretical methods for quantum state precise detection and manipulation. The main research contents include single quantum state measurement technology and methods when approaching the quantum limit, manipulation technology and solutions for quantum state entanglement and quantum gate, theoretical methods and quantum algorithm research on quantum computer error correction, independent development and integration of advanced refrigeration and ultra-low temperature quantum control measurement technology.

3. The research for superconducting and other solid-state quantum computation. The main research contents include fabrications of superconducting materials with long coherence time and high transition temperature, low-loss dielectric and Josephson junction structure, the improvement of fidelity of quantum gate manipulation and the integration of quantum bits.

4. Exploration of new quantum computing systems and implementation schemes. The main research contents include the conclusive demonstration of the non-Abelian properties of Majorana zero mode, and the physical realization of topological quantum bits.

The overall scientific goals of this major research plan are as follows: to explore and prepare high-quality materials that can be used for quantum computing and quantum detection, to achieve precise construction of quantum states and explore new quantum systems; to develop quantum state measurement and manipulation technologies, improve detection and control accuracy, explore new technical methods, and solve the bottle-neck technology problems; to carry out perspective research on fault-tolerant solid-state quantum computing, the mechanism of high-temperature superconductivity, topological quantum

systems and low-dimensional quantum systems, and make major scientific breakthroughs in several directions; to build a research team with international influence, and enhance independent innovation capability and international status of our country in the field of quantum science and technology.

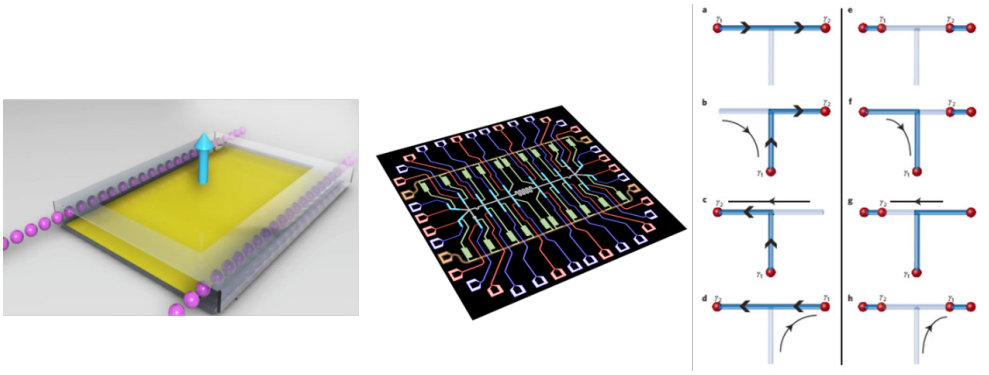


Fig. 2-2-1 Dissipationless topological edge states, quantum bits and Majorana zero mode braiding

Fundamental science of electromagnetic (EM) energy equipment under extreme conditions

The major research plan project *Fundamental science of electromagnetic (EM) energy equipment under extreme conditions* was launched in 2020, with a duration of 8 years and a total funding of 200 million yuan.

The EM energy equipment has incomparable advantages in the aspects of velocity, efficiency, controllability and full-lifetime cost. It is another revolution of energy utilization since the utilization of mechanical energy and chemical energy, and has strategic significance in shifiting the existing pattern in the fields of both military and civilian.The project focuses on the time and space evolution mechanism of interaction between EM energy and materials, and develops the equivalent test technology and new structure of EM energy material in material performance of EM energy equipment and dynamic characteristics of equipment. The purpose is to make breakthroughs in the modeling theory of EM energy equipment under extreme conditions, promote scientific research of EM energy equipment and meets the important strategic needs.

The project aims to address the following three key scientific issues (Fig.2-2-2).

1. Proposing the characterization principle of dynamic response of EM energy materials under extreme conditions. The main research contents include: revealing the physics in the process of test impacted by coupling of multi-fields, innovating the equivalent test method for EM energy equipment materials under extreme conditions, evaluating the dynamic response of EM energy equipment materials under extreme conditions.

2. Proposing the nonlinear structure-activity relationship and controlling the performance of EM energy material. The main research content is exploring the nonlinear response mechanism of EM energy equipment materials under extreme conditions, and researching on its performance regulation method, thus developing new materials used for EM energy equipmentto break the technological bottlenecks. .

3. Proposing the failure mechanism and designing of EM energy equipment under extreme conditions. The main research contents include: exploring the modeling theory for service of EM energy equipment under extreme conditions and the failure mechanism of service performance of EM energy equipment, realizing the design and evaluation of EM energy equipment, and solving the problem that the existing design patterns which are dominated by experiments.

The overall scientific objective of this project is focusing on the structure-activity relationship and physical evolution of EM energy equipment and materials under extreme impact of multi-field coupling. The materials include materials used in EM energy equipment, dielectric materials used in energy storage and metal materials used in linear propulsion.Based on the research of material controlling, the project targets at the long-term service using coupling test approach, to reveal the time and space evolution mechanism of interaction between EM energy and materials. It aims to lay the foundation for fundamental science of EM energy equipment under extreme conditions, and lead the research mode transformation from experiment-dominated to theory-dominated. It may deliver major ground-breaking innovative results, and secure the commanding height of EM energy technology.

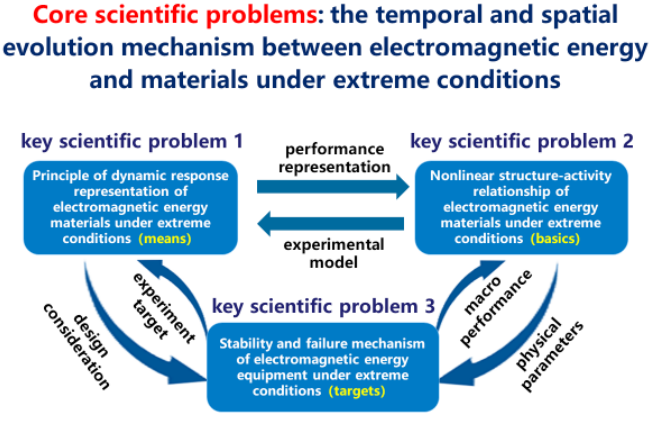


Fig. 2-2-2 Core and key scientific problems of electromagnetic (EM) energy equipment under extreme conditions

Fundamental Theory and Key Technology for Future Industrial Internet

The major research plan *Fundamental Theory and Key Technology for Future Industrial Internet*is launched in 2020 with a duration of 8 years and a total direct funding of 200 million yuan.

The future industrial internet represents the combination of brand-new industrial ecology, key infrastructure and new application mode, based on the in-depth integration of the new generation of ICT and industrial manufacturing. Through the safe and reliable intelligent connection of humans, machines and objects, it can realize the comprehensive connection of the whole production factors, the complete industry chain and the value chain. At the same time, it can promote fundamental changes in production and manufacturing, form the new industrial manufacturing and service system, and significantly improve the level of digitalization, networking and intelligence in the manufacturing industry. This research planaims at the national major strategic needs of the industrial Internet, focusing on the major core scientific issues of the future industrial Internet, opening up the "first kilometer" of basic research and original innovation of the future industrial Internet as well as the "last kilometer" of the scientific transformation, technological achievements, and industrial market-oriented applications. Generally, this research plan will strengthen the theoretical and technical foundation for the development of China's industrial Internet.

This research plan will address the following three key scientific problems are:

1. Structural organization mechanism of the whole factor interconnection: focuing on problems such as how to describe the connection and structural relationship of the whole factor interconnection in the future industrial Internet, and how to measure its complexity and how construct mutual control relationship.

2. Flexible construction theory and method for the manufacturing process: focusing on problems such

as how to accurately describe the error propagation in the whole manufacturing process of the future industrial Internet production chain, how to effectively identify the vulnerability of the manufacturing process, and how to quantitatively evaluate the convergence of the reconstruction of the production line.

3. The principle of networked regulation and control of industrial chain and value chain: focusing on problems such as how to establish a networked industrial chain model from the perspective of efficiency and a networked value chain model from the perspective of utility, how to realize multi-objective regulation and optimization for both the industry chain and value chain.

The overall scientific objectives of the research plan are aiming at the national major strategic needs of the industrial Internet, seizing the future development trend of the industrial Internet, innovating the basic theories and methods, such as the structural organization mechanism of the whole factor interconnection of the industrial Internet, the flexible construction mechanism for the production and manufacturing process, and the networked control principle of the industrial chain and the value chain, and making breakthroughs in a number of core key technologies. It will complete the integrated demonstration of more than three typical industrial manufacturing scenarios, deliver a number of important basic and ground-breaking achievements, cultivate a group of talents and teams with international influence, promote the paradigm change of industrial Internet application and service, lay the theoretical and technical foundation for the development of a new industrial ecology of interconnected and structured elements, production and manufacturing process, and industrial network systematization, and eventually lead the scientific development of the future industrial Internet.

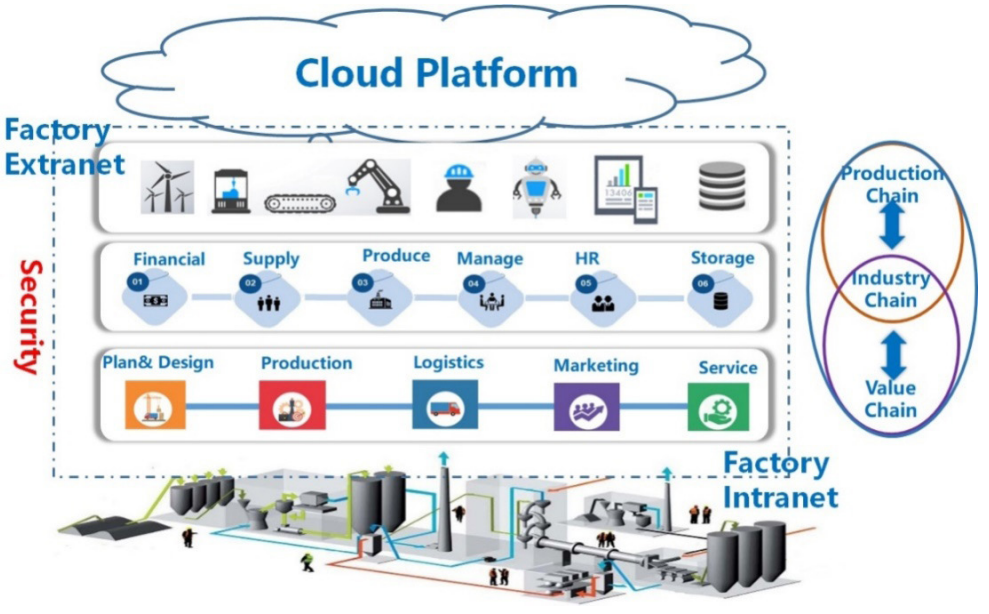


Fig.2-2-3 The Framework of Future Industrial Internet

Decoding of Organ Regeneration

The major research plan *Decoding of Organ Regeneration* is launched in 2020, with a period of 8 years and a total direct funding of 200 million.

This research plan is based on the development strategy of Healthy China Initiative, addressing the major national needs for the prevention and treatment of human vital organ dysfunction, and focusing on

the world's scientific and technological frontier issues in organ regeneration and repair. New breakthroughs in the field of regenerative medicine are expected to be achieved through the scientific paradigm revolution based on interdisciplinary integration.

This research planis expected to deal with the core scientific issue of the dynamic evolution of cell attributes in the process of tissue/organ regeneration and repair, the multi-dimensional information decoding of coordinated regulation, and the orderly regulation strategy that reverses regeneration and repair disorders and promotes regeneration. The research plan will be focus on the following four key scientific issues.

1. New models, new technologies and new methods for tissue/organ regeneration and repair: constructing new in vivo and in vitro research models for regeneration and repair, developing new technologies and new methods of multi-dimensional information and visualization of the key process of regeneration and repair, providing scientific evidence for related technologies in clinical regeneration.

2. Multi-dimensional network information decoding for tissue/organ regeneration and repair: identification of important functional cells, understanding of cell attribute evolution and lineage establishment in the process of tissue/organ regeneration and repair, the regulation and mechanism of microenvironment on tissue/organ regeneration and repair, the mechanism of initiation, development and termination of tissue/organ regeneration and repair, species/tissue differences in tissue and organ regeneration capacity.

3. Mechanism of tissue/organ regeneration and structural and functional remodeling disorder: the effects and mechanism of age, environment, and special pathophysiological conditions on tissue/organ regeneration, risk assessment and early warning of tissue/organ regeneration and repair disorders, mechanisms of regeneration and repair disorders of important tissues and organs.

4. Orderly regulation and intervention strategies for tissue/organ regeneration and repair: orderly regulation and intervention of tissue/organ regeneration in situ under pathological conditions, structural and functional reconstruction of alternative tissues and organs, intervention strategies to promote orderly regeneration and repair of tissues and organs.The overall scientific goals of this research plan are to build a new paradigm for regenerative medicine research, to break research bottlenecks through cross-disciplinary integration, to decode the dynamic evolution of tissue/organ regeneration and repair, to draw

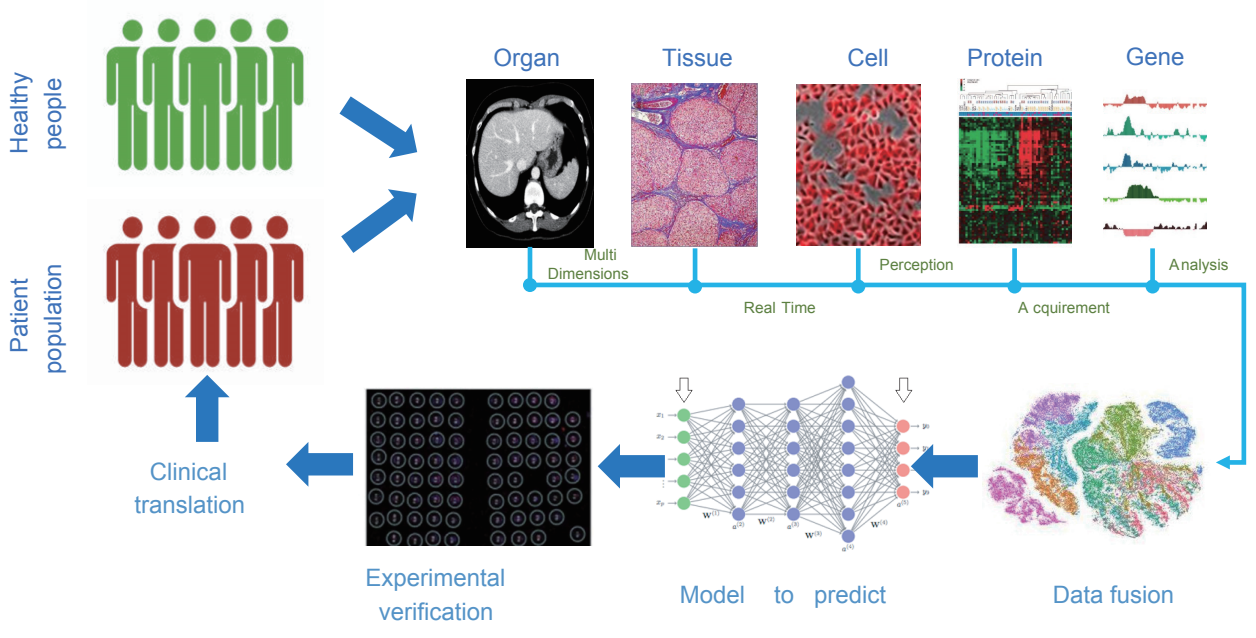


Fig.2-2-4 Information decoding and orderly regulation of tissue/organ regeneration and repair by interdisciplinary integration research.

a panoramic view of the key regulatory network for regeneration and repair, to clarify the pathological basis of regeneration and repair disorders, to achieve orderly regulation of the regeneration of important tissues and organs, to improve the research level in the field of regenerative medicine in China, and to promote the implementation of the Healthy China Initiative.

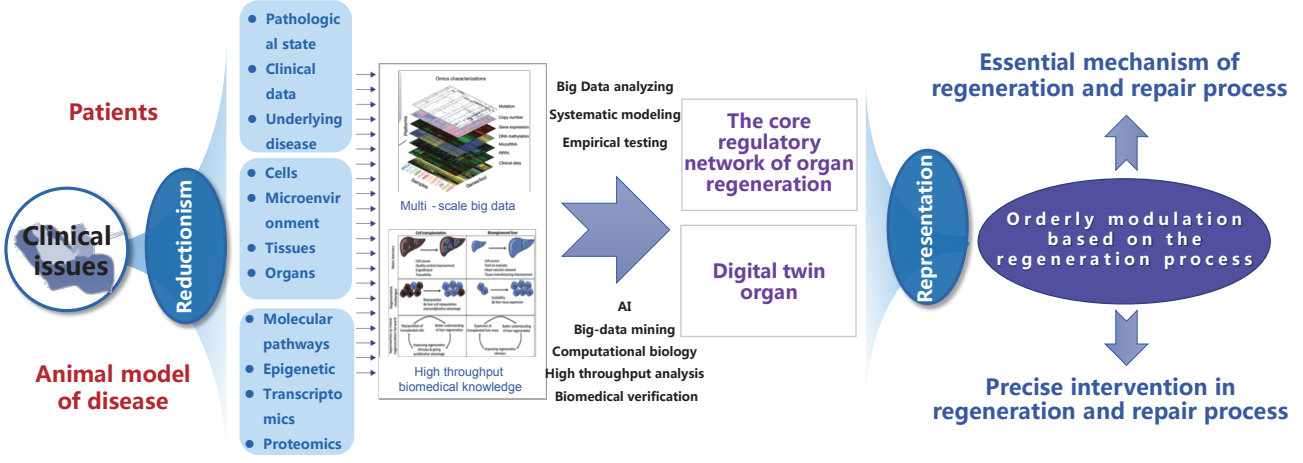


Fig. 2-2-5 New scientific paradigm combining reductionism and system theory.

Coronavirus-Host Dynamic Immunological Interactions and Intervention Strategies

The major research plan *Coronavirus-Host DynamicImmunological Interactions and Intervention Strategies* is launchedin 2020, with a duration of 8 years and a total funding of 200 million yuan.

In recent years, coronavirus infection has become an emerging viral infectious disease, and the COVID-19 pandemic posed a major global public health event threatening human health at present. Immune prevention and control is the most effective, economical and fundamental way to deal with viral diseases. The immune protection and damage dynamic balance produced by the interaction between the virus and the host is an important link which determines the outcome of the virus infection(Fig.2-2-6). Thisresearch plan focuses on the core scientific problem of the panoramic immunological mechanismbetween coronavirus and the host immune system.In view of the major national demands for the prevention and treatment of viral infectious diseases, the research plan aims to revealing themechanism of the interaction between coronavirus and the host immune system and developing a immune defense strategy using a novel research paradigm that is multi-dimensional, multi-scale, dynamic and panoramic. (Fig. 2-2-7): This paradigm concentrates on two factors, i.e., the virus (structure, function, replication characteristics) and host (pre-existing immunity, genetics, metabolism, gender, age, etc.), linking the three processes from infection and immune response, to disease dynamic evolution. Based on the two dimensions including the immune system and the infection target system, decoding will be carried out at tissue, cell, and molecule level based on multi-scales such as group, individual, organ tissue, cell, and molecule.

This research plan is expected to address the followingfive key scientific problems.

1. Virus infection route and its impact on the establishment of infection and immune responseinitiation and regulation.

2. The landscape mechanismsunderlyingvirus sensing andimmune responseinitiation.

3. The multi-dimensional systemic mechanisms of antiviral immune protection and immunological memory.

4. Thedynamic pathological mechanisms of virus-induced immune damage.

5. The establishment of novel approaches and strategies for disease surveillance, diagnosis, treatment, prevention and immune function evaluation.

The overall goal of this research plan is to analyze the dynamic regulatory networks and key nodes involved incoronavirus-host interaction; to elucidate the mechanisms underlying the balance between immune protection and immune damage and their clinical manifestations; to further developnew targeted treatment strategies against immune damage, therapeutic antiviral agents and prophylactic vaccines with persistent efficacy. This research plan also supports epidemiological studies of herd immunity. Furthermore, this planis expected to provide new theories and innovative technologies for the prevention and control of viral epidemic diseases, train high-level specialists and experts, boost innovation, andenhance the international competitiveness and leadership of China.

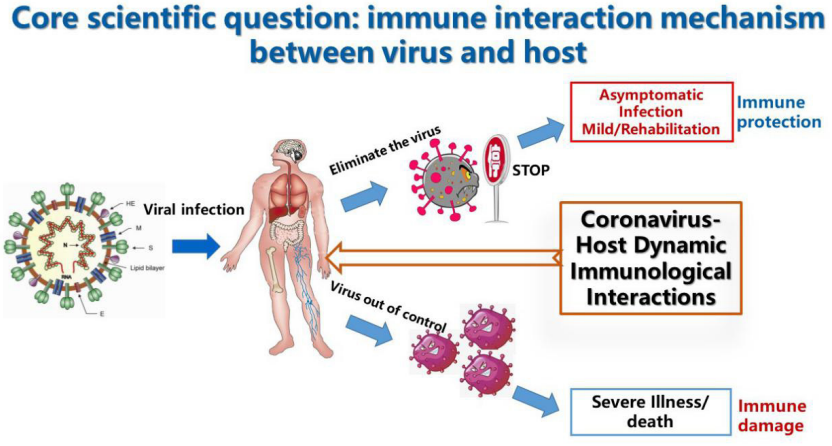


Fig.2-2-6 Coronavirus-host immune interaction mechanism and clinical outcome

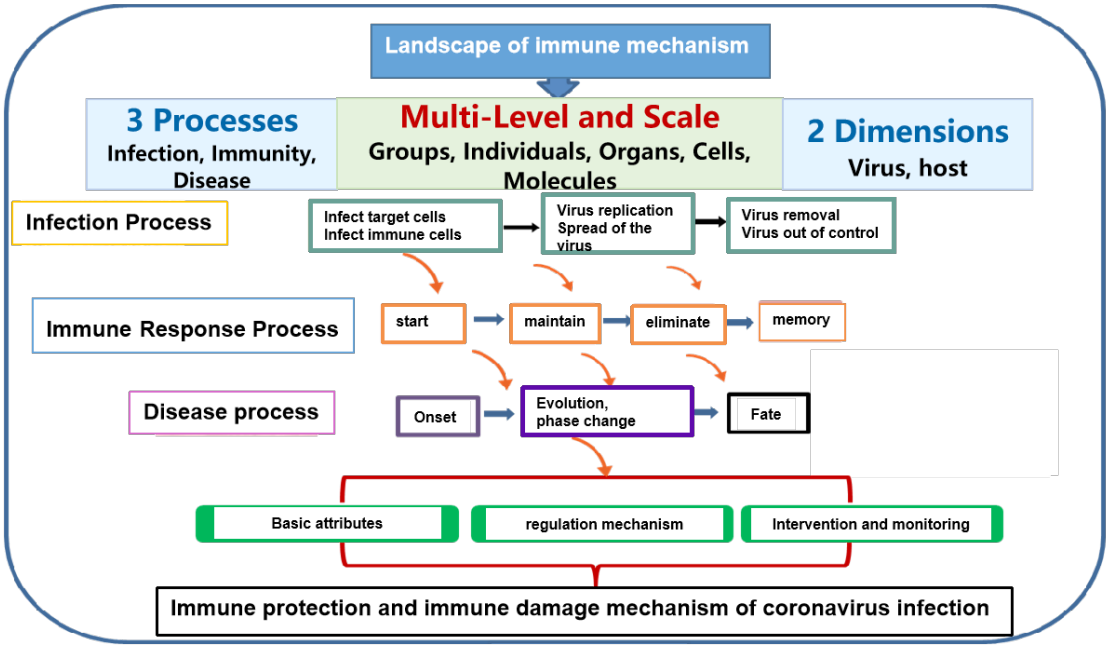


Fig. 2-2-7 Research strategy of coronavirus-host immune interaction mechanism

(II) Closing assessment Plan

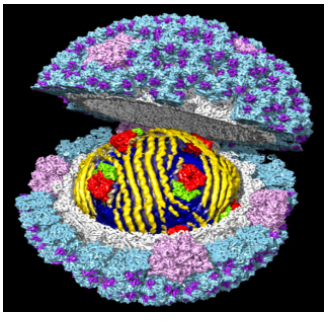
Fundamental Algorithms and Computable Modeling in High Performance Scientific Computation

The major research plan *Fundamental Algorithms and Computable Modeling in High Performance Scientific Computation* has supported 151 research projects with a total funding amount of 220million RMB. It includes 96 Cultivation Projects, 31 Key Projects, 19 Integrated Project and 5 Strategic Research Projects, and the corresponding total budget for each category is 59.39 million RMB, 89 million RMB, 44.8 million RMB and 14.15 million RMB, respectively. Fifty-nine research institutes are involved in this major research plan. 720principal investigators from well-known research institutes, universities and hospitals participated in this major research plan, including some oversea scholars.

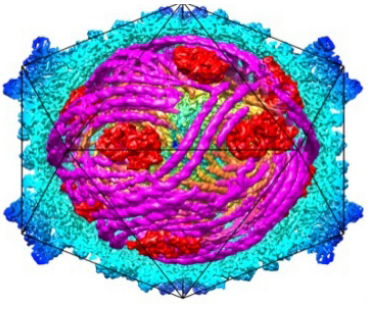
In line with the international research trend and driven by practical problems in national demands, this major research plan has focused on the scientific problems of fundamental algorithms and computable modeling through prospective and interdisciplinary studies. Clusters of projects were formed based on the categories of scientific problems, with special focus on modeling, algorithm, and numerical simulation. Through layout and guidance, the major research plan has mitigated the separation between basic algorithms and problem solving to a certain extent. The research fields include computational mathematics, computational physics, computational mechanics, materials science, biological information, atmospheric physics, high performance Computing software, aerospace, etc. The major research plan has helped to bring about a group of high-level research platforms and teams for interdisciplinary research. It also provided key numerical simulation technologies and methods to addressing the major scientific problems at frontiers and bottlenecks in meeting the national demands. The major research plan has achieved a series of important progresses with significant international impactsin fundamental algorithms, computable modeling, and the problem-driven implementation and validation of algorithms. It has also made great contributions in solving key computational problems in national major demands.

(1) The research plan has made breakthrough in the theory of finite element a posteriori error estimation for multiple eigenvalue problems and has made original contributions in the hyperbolic regularization theory of the momentum method for Boltzmann equations.

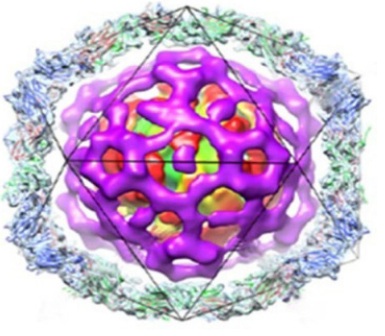
(2) The research plan has proposed a model reduction algorithm for simulating large scale integrated circuits, which plays a key part in the industry software and has introduced an original symmetry-mismatch three-dimensional reconstruction methodfor analyzing icosahedron virus based on the cryogenic electron microscope(Fig.2-2-8).



(a) Grass carp reovirus



(b) Structure of cytoplasmic polyhedrosis virus



(c) Hand-foot-and-mouth disease coxsackievirus A10

Fig2-2-8 Important virus structures in numerical analysis

(3) The research plan has proposed a novel heterogeneous domain decomposition algorithm, based on which, the project of the ten-million-core scalable fully implicit simulation of nonstatic force atmosphere dynamics has been awarded the ACM Golden Bell prize in 2016.

(4) The research plan has made great contributions in solving key computational problems in national demands including the hohlraum and implosion simulation in inertial confinement fusion(Fig 2-2-9), inversion of tight oil and gas using seismic data, and large scale parallel methods for aerodynamics covering various flow regimes with applications to aerodynamic characteristics of re-entry spacecraft module.

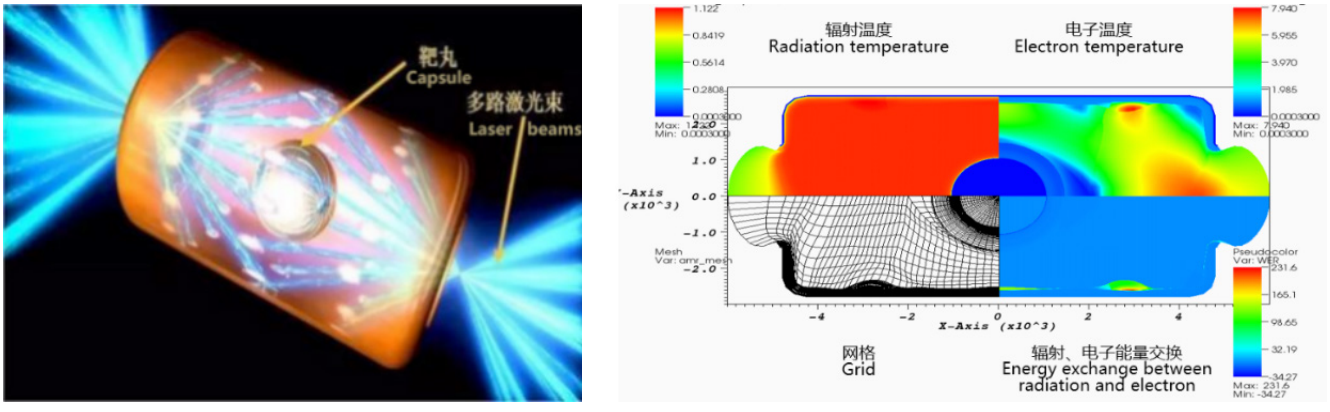


Fig2-2-9 Inertial Confinement fusion

There are 3251 scientific papers produced from this major research plan, including 2315 papers published in SCI journals and 264 papers in EI journals. In addition, investigators in this major research plan contributed 48 domestic patents and 4 international patents. They also won the Second Prize of the National Natural Science Award 1 time, Second Prize of the State Technological Invention Award 1 time, First Prize of provincial or ministerial rank award 7 times, Second Prize of provincial or ministerial rank award 11 times. The principal investigators (PIs) made 242 invited talks at major international academic conferences. With the support of this major research plan, China has emerged a group of outstanding scientists with international impact in the field of scientific computation. During the implementation of this major research plan, 5 investigators became the Academician of Chinese Academy of Sciences, 11 investigators became NSFC "Distinguished Young Scholars", 6 of them received the NSFC"Excellent Youth Scientists Fund", 1 became national leading talents in science and technology innovation under the "Ten Thousand Talents Plan". A total of 548 Ph.D, 523 postgraduate students and 95 postdoctoral associates were trained.

Multi-genetic Mechanism on Microevolution

The major research plan "Multi-genetic mechanism on microevolution" has supported 117 research projects with a total funding amount of 240 million RMB, which include 69 Cultivation Projects, 16 Key Projects, 28 Integrated Projects and 4 Strategic Research Projects, the corresponding budgets for each category is 70.36 million RMB, 53.6 million RMB, 108.24 million RMB and 8 million RMB, respectively. Thirty-four research institutes participated in this major research plan. More than 800 investigators from well-known institutes and universities participated in this major research plan, including some overseas scholars.

Through multidisciplinary studies, this major research plan conducted research onthe genetic & genomic basis of biological adaptation under environmental changes in the process of microevolution, and revealed the mechanism of phenotypic variation caused by genetic and epigenetic mutations,

and clarified network regulation and the molecular mechanism of multi-genetic interaction and their evolutionary significance. The core scientific question is how organisms can change their phenotypes or traits to adapt to environmental changes through genetic mutations and multi-genetic interactions at the genomic level.

The implementation of the major research plan aims at unsolved theoretical questions in the history of microevolution. Taking advantages of the tremendous opportunities and challenges brought to us by the genome era, this major research planconducted a comprehensive genome-wide study of biological phenotypic variation in the process of microevolution,clarified the genetic mechanism of complex phenotypic variation, improved important aspects of evolutionary theory, and built up a bridge between phenotypic and genetic variation. The core research layouts are as follows:

Innovative concepts and theoretical breakthroughs have been proposed to the evolutionary biology, for instance, genetic mechanisms of speciation, evolution of phenotypic adaptation and regulation, the occurrence of mutations and their driving effects, and so on (Fig. 2-2-10).

Taken advantages of evolutionary biology research in China, remarkable achievements and innovative contributions have been made in the fields of artificial selection, extreme environment, and admixture (Fig. 2-2-11).

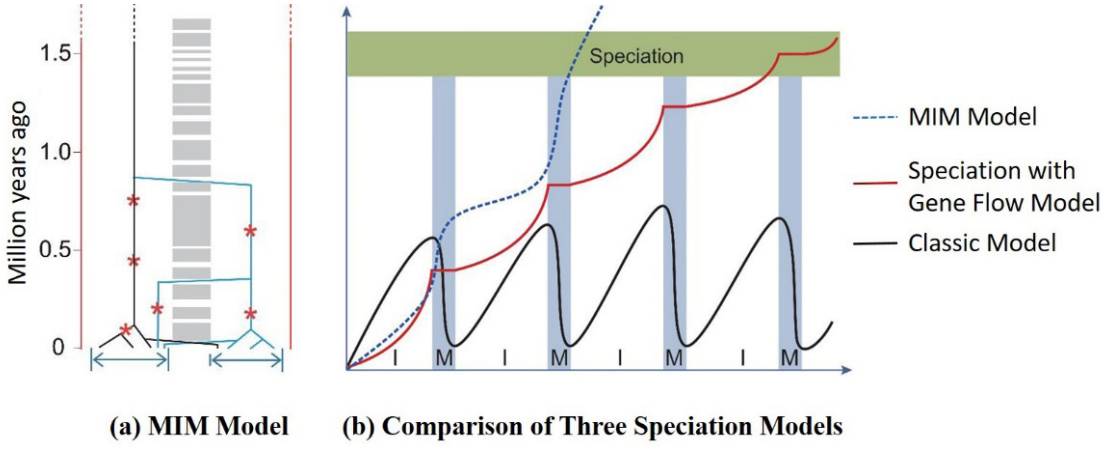


Fig 2-2-10 A new theoretical model of speciation has been proposed and verified: Mixing-Isolation-Mixing Cycles(MIM) model.

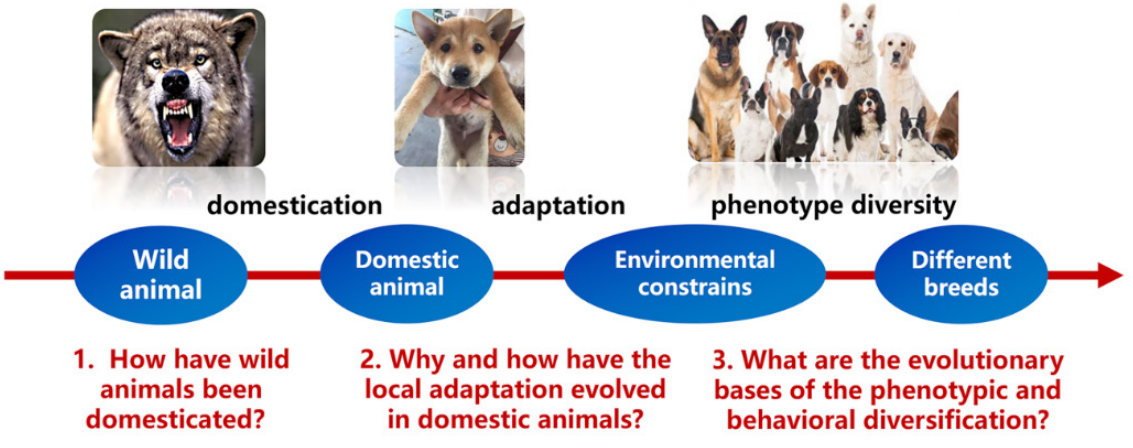


Fig 2-2-11 The origin of domestic animals and phenotypic evolution under artificial selection.

A new research field of "ultra-evolution" based on cell population evolution has been proposed, leading the international frontier.

With the combination of mathematics, physics, computer science, and other disciplines, new technologies and methods have been developed, not only on evolutionary biology, but also on many other fields of life sciences, for instance, medicine, agriculture, and computational biology.

Based on these theories, technologies, and innovations, and taking advantage of the interdisciplinary approach, a series of breakthrough research results with significant international influence have been achieved in areas of population health and major national demands.

The successful implementation of the Major Research Plan has promoted the foundation of evolutionary theory in China. There are a series of scientific papers produced from this major research plan, including 5 in *Nature*, 2 in *Science*, 5 in *Cell*, 46 in *Nature Series journals*, and 39 in *Molecular Biology and Evolution*, all of which indicate Chinese scientists' international leadership in the field of microevolution. In addition, investigators in this major research plan contributed 38 authorized invention patents. They also won the Second Prize of the National Natural Science Award 3 times,First-class provincial or ministerial natural science awards 3 times, First-class provincial or ministerial scientificand technological progress award 1 time. With the support of this major research plan, a group of outstanding scientists in Chinahave emerged with international impact in the field of microevolution. During the implementation of this major research plan, 4 investigators became the academician of Chinese Academy of Sciences, 1 became the academician of the United States National Academy of Sciences, 1 became the academician of the Academy of Sciences of the Developing Countries, and 1 became the academician of the TWAS Communication Youth, 14 of them received the National Science Fund for Distinguished Young Scholars, 8 of them received the national leading talents in science and technology innovation under the "Ten Thousand Talents Plan", 16 of them received the Excellent Young Scientists Fund of the National Natural Science Foundation of China, and 4 of them received the young top talents under the "Ten Thousand Talents Plan".

Deep Sea Processes and Evolution of the South China Sea

Although the South China Sea (SCS) has been mainly explored in the shelves and continental margins, the key to understanding its geological history lies in the central basin below 3500 m waterdepth. The Major Research Plan project*Deep Sea Processes and Evolution of the South China Sea* (2011-2020) supported by NSFC was the largest deep-sea research program in China. With a budget about RMB 205 million yuan, the research plan supported a total of 63 projects, of which 42 were Key projects with a direct funding of 145.1 million yuan, 8 were Cultivation projects with a direct funding of 7.45 million yuan, 10 were Integreated projects with a direct funding of 26.125 million yuan, and 3 were Strategic Research projects with a direct funding of 11.325 million yuan. A total of over 700 participants from 32 laboratories over the country participated in the major research plan. The implementation period of the program was fortunately coinciding with the adaptation of the national strategy to building China into a maritime power. Thanks to the joint efforts of scientists from various disciplines, the major research plan has achieved huge success far beyond the original expectations.

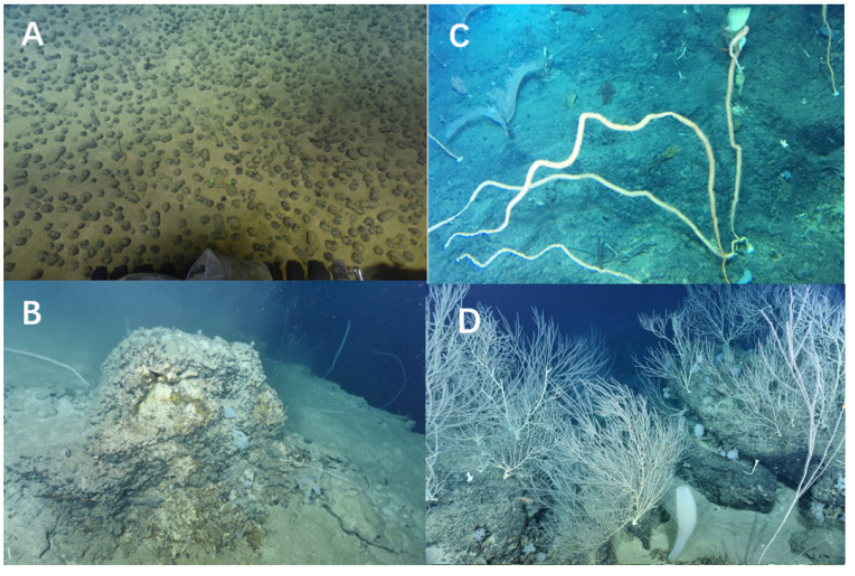
With a primary target to "trace the life history of a marginal sea", the overarching purpose of the program was to dissect this typical marginal sea by studying its history of evolution and its modern processes, including three major components: deep basin development, deep-water sediments, and biogeochemical processes. The Three technologies applied to exploring the SCS deep basin, included deep diving with submersible vehicles, deep-sea observation systems, and deep-sea drilling. Over the 8 years of its implementation, more than a hundred of deep-sea expeditions were executed, about 200

ocean bottom seismometers (OBS) deployed, and over 1220 km deep tow magnetic surveys completed. More significantly, three and a half IODP (International Ocean Discovery Program) drilling expeditions, and four HOV deep-diving cruises to the SCS were organized and implemented. The regional observation system of unprecedented size included hundreds of mooring series was set up for oceanography, mooring arrays and tripod systems for in-situ observations of deep sea sediment dynamics, as well as a network of sediment traps for biogeochemistry.

The program unveiled the deep-sea processes and their evolution characteristics for reconstructing the life history of the marginal basin, and its great successesled to a number of scientific breakthroughs. In the tectonic aspect, the exploration in the deepbasinandthe continent-ocean transition zone reveals a number of specific features that characterize the SCS as a marginal basin formed at the subduction zone in the Western Pacific. The features include active magmatism and rapid rupture of lithosphere through the basin formation process, and imply that "the SCS is not a mini-Atlantic" as they can be distinguished as "plate-edge rifting" and "inner-plate rifting" respectively, thus challenging the universality of the Atlantic model for passive margins.

In terms of paleoceanography, the sediment records demonstrate evidence that water and carbon cycling in the low latitude regions can directly respond to the orbital forcing, and subsequently nurture a new concept of low latitude forcing of climate changes, which challenges the classical wisdom of the overwhelming role played by the Arctic ice sheet in climate changes.

Many more discoveries can be assembled from long-term mooring observations and deep diving cruises in the deep SCS, such as the cyclonic nature of the deep-water circulation, deep-water sediment transport by contour currents and turbidites, manganese nodules, extinct hydrothermal vents, and cold-water coral forests (Fig. 2-2-12). Breakthroughs in biogeochemical research such as miniature biochar pumps and carbon and nitrogen coupling have also been made.



A. Manganese nodule field on seamount; B. Extinct hydrothermal vent near the relict mid-ocean ridge; C. Cold water coral forest

Fig.2-2-12 Discoveries of deep diving cruises to the SCS

The successful completion of this major research program has provided scientific support to the national strategy to "build a maritime power" and contributed to the scientific leadership in the SCS studies. Moreover, the scientific discoveries and knowledge accumulation have turned the SCS into a natural laboratory for marine sciences, and set an example for scientific researches of marginal basins.

Neural circuit basis of emotion and memory

High-order brain functions such as emotion and memory play an essential role in survival and adaptation of individuals to the environment. Dysfunction of emotion and memory is closely related to a variety of neurological disorders. Therefore, the formation and maintenance of the neural circuits of emotion and memory, and the relationship between abnormal circuit functions and diseases are the most advanced and active focus of current neuroscience. Since 2012, the National Natural Science Foundation of China has launched a major research plan program, namely *The Neural Circuit Basis of Emotion and Memory*. This program aims to research into neural circuits of emotion and memory, discuss the key nodes and paths of the neural circuits related to emotion and memory at multi-modal and multi-scale levels, hoping to reveal the changes of neural circuits in the occurrence and development of major neuropsychiatric diseases Laws, and carry out in-depth analysis of the pathogenesis of neuropsychiatric diseases.

Since the launch of the project, a total of 539 applications have been received, among which 170 projects are funded with a total funding of 240 million yuan. These including 22 key projects, 122 Training projects, 18 integrated projects and 8 Strategic Research projects, and the respective budget of direct funding are 67.2 million yuan, 99.7 million yuan, 46.1 million yuan, and 17.116 million yuan.

With successful implementation of the major research plan, many breakthroughs have been achieved. These included more than 10 key nodal nuclei for regulating innate fear, social, and aggregation behaviors were uncovered. The rational basis of pathological changes in 6 emotional and memory dysfunction-related diseases was revealed. Three potential treatment methods and drugs for addiction and anxiety were developed. Four state-of-the-art technologies for brain network imaging, virus tracking, and neurotransmitter probes were invented. The representative results are as following:

1) Uncovered new molecular and cellular mechanism of depression. The team from Zhejiang University discovered that the up- or down-regulation of astrocyte Kir4.1 functioncould bidirectionally regulate neuronal firing pattern in the lateral habenular and depressive phenotype.

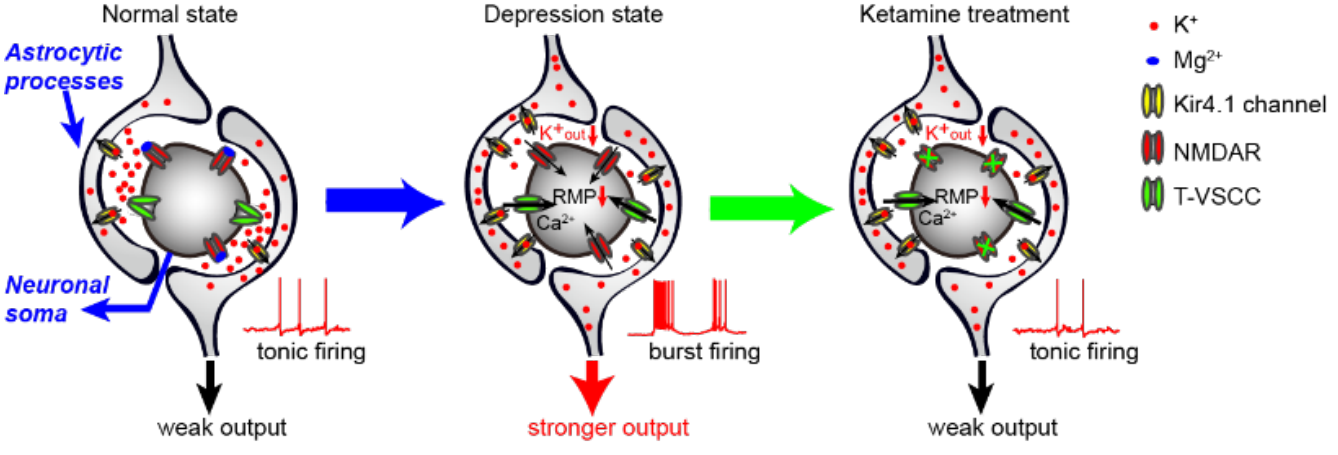
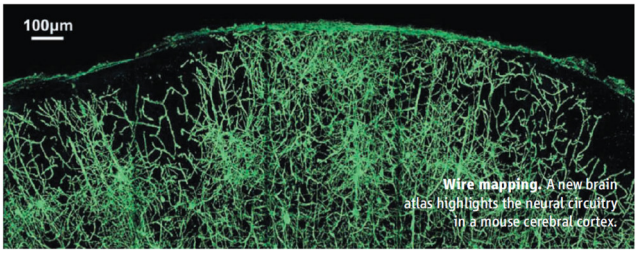


Fig. 2-2-13 Model diagram of lateral amygdala mechanism in ketamine antidepressant treatment

2) Invented fluorescence Micro-optical Sectioning Tomography (fMOST). A team from Huazhong University of Science and Technology has established a brain network imaging system, making it possible to obtain high-throughput brain-wide neural circuit images with single-cell and even single-fiber resolution.



NEUROSCIENCE

China's Brain Mappers Zoom In on Neural Connections

Fig. 2-2-14 Brain network imaging system of mouse cerebral cortex

Under the support of the major research plan, Chinese scholars have made a series of innovative achievements, including: (1) revealed the neural circuits' mechanisms of various emotion related behaviors such as innate fear, social and attack, (2) clarified the role of lateral habenular in the pathology of depression, (3) demonstrated the regulation rules in the development of the hippocampus and cortex, (4) exploredthe new molecular, cellular and circuitry mechanisms of memory, (5) discovered novel methodfor drug addiction treatment and developed new drugs to treat anxiety disorders, and (6) invented brain network imagingtechnique with single-cell resolutionand high-sensitive neurotransmitter probes.

These works have been published in academic leading journals, including Nature, Science, Cell, Nature Medicine, Nature Neuroscience, and Neuron. Additionally, 91 patents have been applied, of which 71 have been issued. During the execution of this project, 3 people were named as members of the Chinese Academy of Sciences, 6 were awarded as special professors of the Changjiang Scholars Award Program, 12 were funded by the National Natural Science Foundation for Distinguished Young Scholars project, 3 won the second prize of the National Natural Science Award, and 1 was awarded as the second prize of the National Technology Invention Award. By the time when the major research program was about to conclude, China's "brain program" is going to be officially launched. For more than 8 years, the implementation of this major research program has laid a solid foundation for the launching of China's Brain Program.

Funding Achievement Tour

Part 3

NSFC

2020 ANNUAL REPORT

Unlikely Intersection in Dynamics and Its Application

Unlikely intersection principle is one of the most common principles in mathematics. Supported by the National Natural Science Foundation of China (Young Scientists Fund: 11701508, General Program: 11971426), Prof. YE Hexi has systematically investigatedthe principle of unlikely intersection in dynamics.

Algebraic curves are important research objects in number theory and arithmetic geometry, which areusually embedded in their Jacobians to study the arithmetic properties. There are special points, called "torsion" points, sitting in algebraic curves, which are the intersection points of the curves in their Jacobians with the torsion points of the Jacobians. In the early 1980s, Raynaud proved the Manin-Mumford conjecture, asserting that each curve with genus greater than one intersects only exists finitely many torsion points in its Jacobian. Soon after, Barry Mazur proposed a uniform version of the Manin-Mumford conjecture, i.e., fixing an integer g greater than one, the number of intersection (torsion) points can be uniformly bounded for all curves with genus g. In the late 1990s, Prof. Ullmofrom IHES proved the Bogomolov conjecture for algebraic curves, stating that there are only finitely many small points on a curve defined over a number field with genus greater than one (torsion points are of height zero). In the meantime, Prof. ZHANGShouwuproved a general version of the Bogomolov conjecture.

Employing a quantitative version of arithmetic equidistribution along with tools in dynamics, through collaboration, Prof. YE Hexiproved a uniform bound for the number of common preperiodic points of two arbitrary maps in a family of Lattès maps, and then concluded that for a family of genus two curves, there exists a uniform bound for the number of torsion points on each of such curves. Moreover, a uniform Bogomolov type statement also holds for the same family of curves defined over algebraic number field, and in the meanwhile a conjecture about the torsion points of elliptic curves proposed by Bogomolov-Tschinkelhas been partially settled. These results were published in the journal of*Annals of Mathematics*, and the paper won the 2020Alexanderson Award of American Institute of Mathematics.

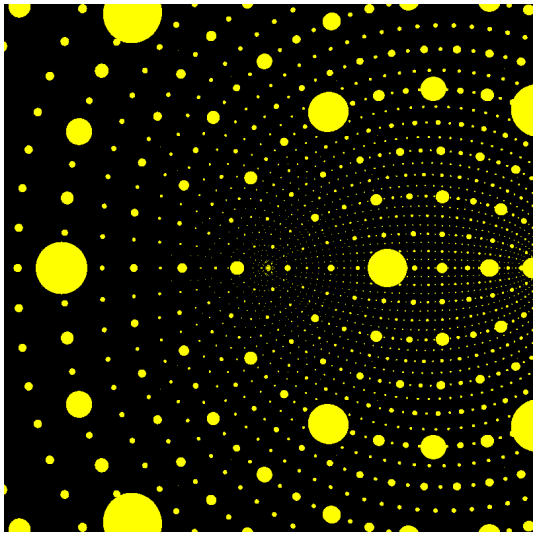


Fig.3-1-1 Some common preperiodic points of two arbitrary maps in a family of Lattès maps

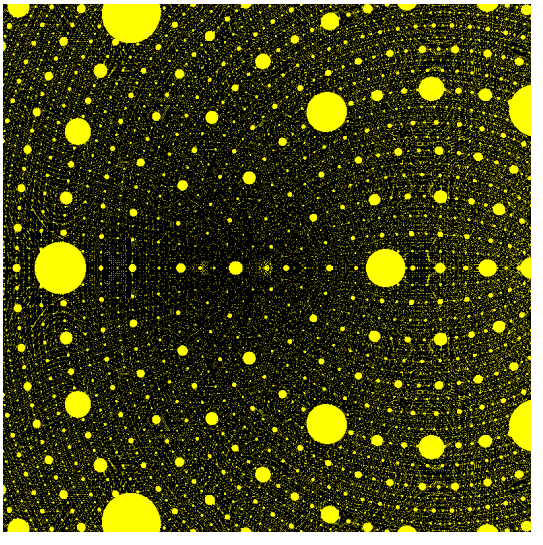


Fig.3-1-2 More common preperiodic points of two arbitrary maps in a family of Lattès maps

Shear-banding in Metals Regulated by Heterogeneous Structures

Shear-banding describes the localization instability of plastic deformation, which is a ubiquitous phenomenon in the field of nature and industry. After more than 100 years of research, the thermoplastic shear-banding theory has been established, with thermal softening as the core mechanism. Due to the lack of consideration of inherent structural effects, however, the thermoplastic shear-banding theory meet unprecedented challengeswhen it comes to various advanced metals with micro/nanoscale heterogeneous structures. Supported by the National Natural Science Foundation of China (National Science Fund for Distinguished Young Scholars:11725211;Major Program:11790290;Excellent Young Scientists Fund:11522221; General Program:11472119), the research group led by Prof. DAI Lanhong from the Institute of Mechanics of the Chinese Academy of Sciences has made long-term efforts to address key scientific issues on how the core mechanism of the thermoplastic shear-banding theory can be deeply affected and even totally changed by micro/nanoscale heterogeneous structures. A series of original results have been achieved. The primary discoveries (Fig.3-1-3) are highlighted as below.

(1) The "positive" and "negative" dual-effect of micro-particle size on the plastic deformation of the particle-reinforced metal-matrixcompositeswasexperimentally demonstrated, that is, the yield strengthening and the shear-banding softening. A theory of thermoplastic shear-banding was developed by taking the strain-gradient effectinto account. It was revealed that the micro-particle size as an inherent structural effect is a strong driving force for the shear-banding formation in the composites.

(2) A shear-banding theory for amorphous alloys with inherent nanoscale structural heterogeneities was established. The criterion of shear-banding instability was obtained. It was revealed that the shear-banding in amorphous alloys is dominated by the structural free-volume-softening, in which the thermal softening only plays an assistant role. Collective evolution dynamics of multiple shear bands was further demonstrated, and the shear-banding thickness was theoretically predicted.

(3) A new model for atomic-cluster motion, "tension transformation zone", was proposed in amorphous alloys. It was clarified that the energy dissipation during shear-banding-induced fracture is determined by two competing elementary processes, viz. shear transformation zone and tension transformation zone ahead of the crack tip, respectively.

Above mentioned achievements have been granted the Second-Class Award of the National Natural Science, the John S. Rinehart Award and won the prize for the James Clerk Maxwell Young Writers. The representative publications have been widely cited by scientists including the Timoshenko Medal winner and the Rodney Hill Prize winner and were highly evaluated. The relevant discoveries have been presented as the solo section by authoritative review papers and supported by other experiments, clarifying the long-standing controversy over the shear-banding origin of amorphous alloys. This project significantly promotes the scientific knowledge of shear-banding and the development of related theory. Based on these discoveries, the research group has successfully designed and developed a new type of tungsten high-entropy alloy with outstanding shear self-sharping capability (Fig.3-1-4), which shows promising applications potentials in related areas.

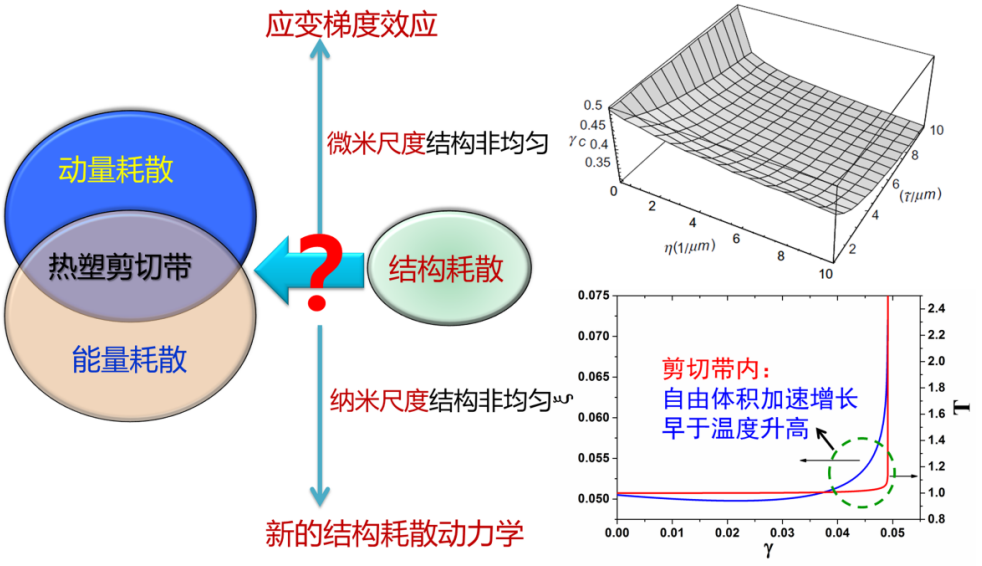


Fig.3-1-3 The mechanism for shear-banding instability in metals regulated by heterogeneous structures

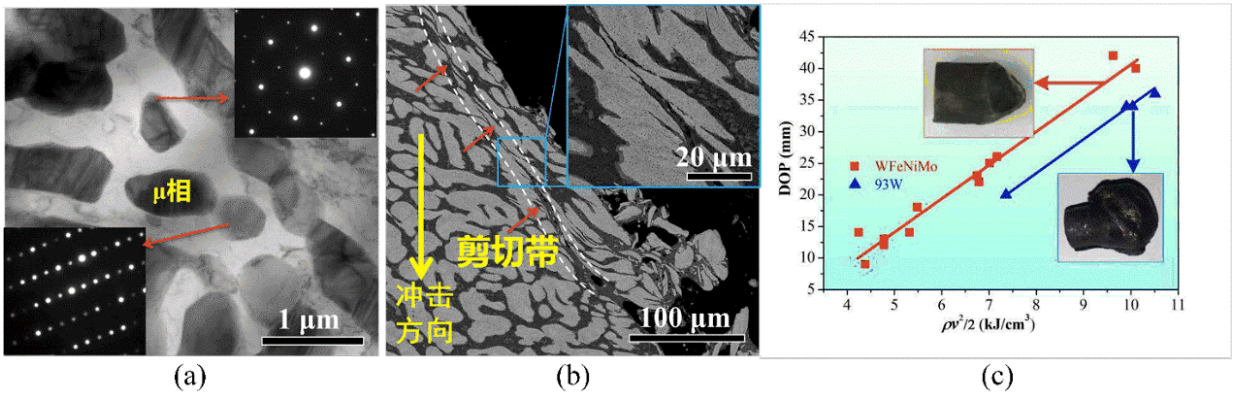


Fig.3-1-4 A new type of tungsten high-entropy alloy with outstanding self-sharping capability: (a) ultra strong μ phase precipitations, (b) shear-banding induced by high strain gradient, (c) this new alloy achieves the 10-20% larger penetration depth than 93W.

Precise Prediction of the Internal Structure of Dark Matter Haloes with a Full Mass Range Using Super Computational Simulation Cosmic Zoom

Around 85% of the matter in the Universe is dark and completely different innature from the matter which makes up stars and planets. Galaxies formed and grew when gas cooled and condensed at thecentre of enormous clumps of this dark matter, the so-called darkmatter haloes. Astronomers can infer the structure of big dark matterhaloes from the properties of the galaxies and gas within them, butthey know little about haloes that might be too small tocontain a galaxy due to limited methods. Such small haloes would be extremely numerousbut they were remain “dark” throughout cosmic history. The masses ofthe smallest dark matter haloes are hypothesised tobe about the mass of the Earth by the currently popular theories forthe nature of the dark matter.

Supported by the National Natural Science Foundation of China (Basic Science Center Program:11988101;General Programs:11373029 and 11873051; Special Key Program:11851301), an

international team led by Prof. WANG Jie from National Astronomical Observatories, Chinese Academy of Sciences, with the collaboration of scientists from the Durham University in UK, Max Planck Institute for Astrophysics in Germany, and the Harvard University in the US, tookfive years to develop, test and carry out their cosmic zoom whichcovers a range of 10 to the power 30 (that is a 1 followed by 30zeroes) in mass. It enabled them to study the structure of dark matter haloes ofall masses between that of the Earth and that of a big galaxycluster. From this cosmic zoom simulation, they gained the following discoveries:

(1) All haloes, despite of their mass, have very similarinternal structure: very dense at the centre, becoming increasinglydiffuse outwards, and with smaller clumps orbiting in their outerregions.

(2) Particles of darkmatter can collide near the centres of haloes, and may, according tosome theories, annihilate in a burst of energetic (gamma) radiation. The new zoom simulation allows the expected amount ofradiation to be calculated for haloes of differing mass. Much couldcome from haloes too small to contain stars.

Based on these results, the researchers could observe the gravitational effect of these small haloes, e.g. gravitational lensing, and dynamical perturbation, to constrain the nature of the dark matter. Furthermore, future gamma-ray observatories might be able to detect this emission, making the smallobjects individually or collectively "visible". The results published in *Nature*has received wide attentions, with 27 citations in three months. These achievements were also reported in many domestic and foreign medias,such as Xinhua Press, The People Daily, CCTV, and Sputnik.

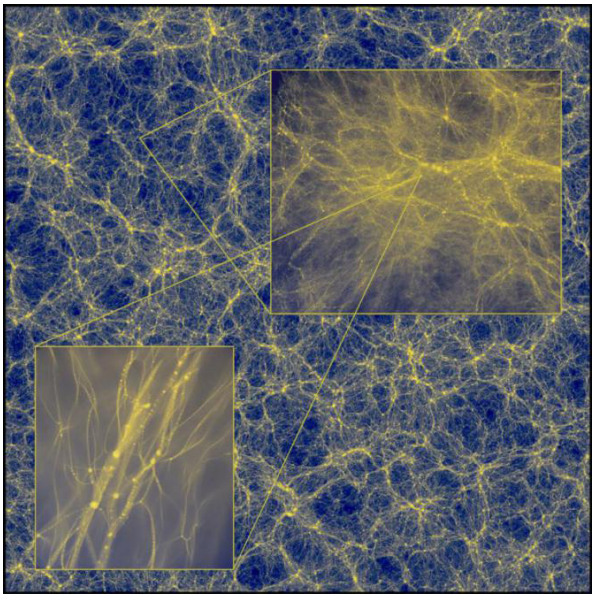


Fig.3-1-5 Dark matter density in the super computational simulation "cosmic zoom".

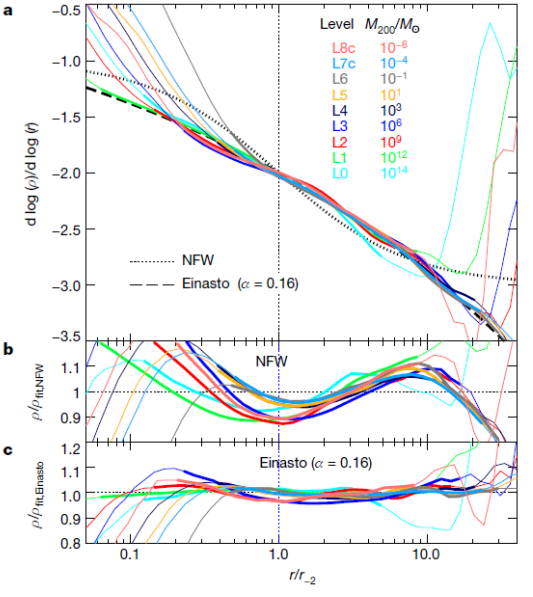


Fig.3-1-6 Density profiles for haloes with mass between that of the Earth andthat of a rich galaxy cluster

High-Dimensional Quantum Entanglement Based on Metasurface

Quantum information is one of the most advancedand active research fields in the world. With the development of quantum information technology, the existing entangled quantum sources based on nonlinear optical processes are facing many problems, such as complex optical system, low integratability and weak stability in dimension scalability and photon number increasing, which cannot meet the requirements of high-dimension and multi-photon number for quantum source in quantum communication,

quantum computing and quantum metrology. This restricts the large-scale integration of quantum information processing.Recently, metasurface, a kind of film nanostructure material, has been introduced into quantum optics, which provides a new path for the development of quantum source and quantum information technology. Supported by the National Natural Science Foundation of China (Science Fund for Creative Research Group:11621091; Key Program: 11834007;Excellent Young Scientists Fund:11822406; General Program: 11774164), the jointed group led by Prof. ZHU Shining and Prof. WANG Zhenlin has obtained progress on high-dimensional quantum entanglement source based on metasurfaces. The research group has achieved the following major scientific breakthroughs and discoveries.

(1) A10×10metalens arraywas designed and fabricated, which divided the pumping laser into 100 parts. Combining the metalens array with the nonlinear crystal, BBO crystal, the 100 paths pumping light can simultaneously produce a 100-path spontaneous parametric down-conversion photon source, which theoretically can be considered as a 100-dimensional quantum entanglement. This is the highest dimension in all reported quantum entangled states. Moreover, the entanglement dimension can be further increased by simply increasing the scale of themetalenses array.

(2) Such system can be used to work as a simple and compact multi-photon source. Using the femtosecond laser as the pumping light, this system can produce 4 photon state and 6 photon state. By measuring the 4 photon Hong-Ou-Mandel interference, the high interference visibility further proves the good quality of the produced multi-photon state.

(3) The meta-quantum source composed of metasurface and nonlinear crystal successfully produced the phase encoded high-dimensional entanglement and multi-photon state, which introduces new ideafor quantum source and quantum information processing.

On Jun 26th 2020, the results on metalens array-based quantum source has been published in *Science*, entitled with "Metalens-array-based high-dimensional and multi-photon quantum source".By introducing the emerging metasurface into the quantum information processing,the meta-based high-dimensional entanglementsource breaks the technology bottleneck in the existing quantum source and the limitation of the dimension of entanglement. The achievement is expected to be applied in high-dimensional quantum communication, quantum computation, quantum storage, and other fields, and it is of great significance for the development of quantum information technology with higher information capacity and higher security.

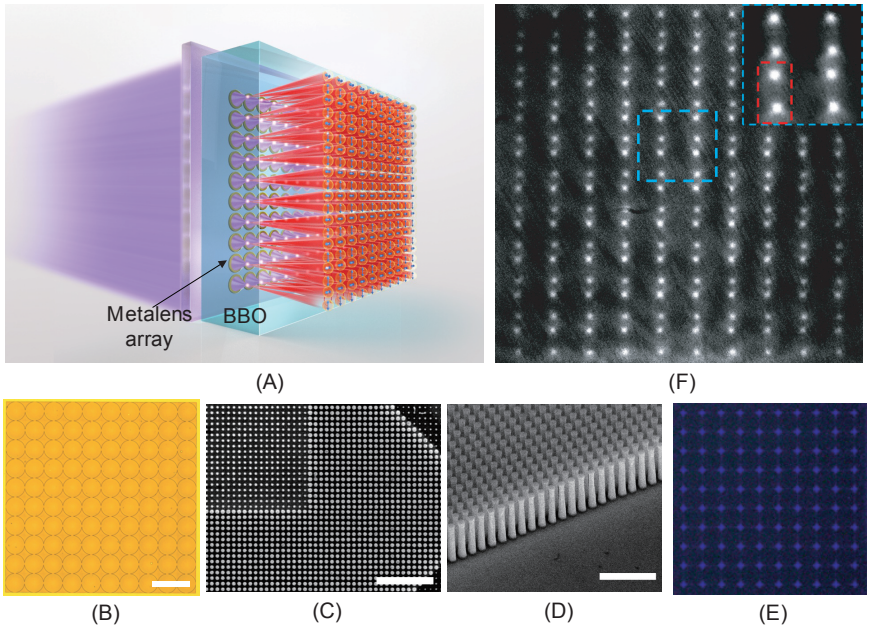


Fig.3-1-7 The high-dimensional entanglement based on metalens array.

Measurements of Anti-Strange Quark Hypernucleus and Property of Exotic Hadrons

Ultra-relativistic heavy-ion collisions is the only experimental tool to study the new state of matter of the early universe: Quark Gluon Plasma, and it is also the ideal lab to test the basic symmetry of matter and antimatter. The absence of antimatter in nature is a major scientific mystery today, and it is of great significance to detect antimatter nucleus from the laboratory to understand the symmetryof CPT and the property strong interaction. With the support by the National Natural Science Foundation of China (Science Fund for Creative Research Group: 11421505; Major Program: 11890710), the research team led by Prof. MA Yugangat the Fudan University has carried out a long-term study on the key scientific problems of antimatter mysterythrough the experimental detection of antimatter nucleus. The following innovative results have been achieved:

(1) The masses of hypertriton and antihypertriton were accurately measured, and the mass difference betweenhypertriton and antihypertritonis zero were measured for the first timewith 10^{-4} precision. The equal mass values of hypertriton and antihypertritonverified the CPT symmetry in a nucleus with strangeness.

(2) The Lambda binding energy of the hypertriton were measuredaccurately, which updated the data of nearly 50 years ago in the field. The new data answers the Dalitz'sopen question on hypertriton binding energy.

(3) The measurements of multi-strange hadron cross section throughthe Beam Energy Scan program were completed. It was found that its yield ratio was relevant to the phase structure and transition ofQuantum Chromodynamics (QCD) matter.

(4) The interaction of multi-strange hadron and proton were measured andthe prediction of those exotic hadrons in heavy-ion collisions were made. It was found that there was strong attraction between nucleon and Omega baryon with 3 strange quarks, which could lead to the formation of strange dibaryon state.

These results have been published in several high impact academic journals, including one in *Nature Physics*, three in *Physics Letters B*, two in *Physical Review C* as Editors' suggestion and Rapid Communication. These resultshave greatly deepened human's understanding of the basic laws of nature. For example, the data of the mass difference betweenhypertritonand antihypertriton can be used as a tool to check CPT symmetry with the heaviest antimatter so far. In addition, the results will place constraints to the parameters of Standard Model Extension.The binding energy is clearly larger than 0, which provides first-hand experimental data for theoretical calculations of hyperon-nucleon interaction. The published data has gained wide attention from their international peers instantly.*Physics Today*introduced their work with

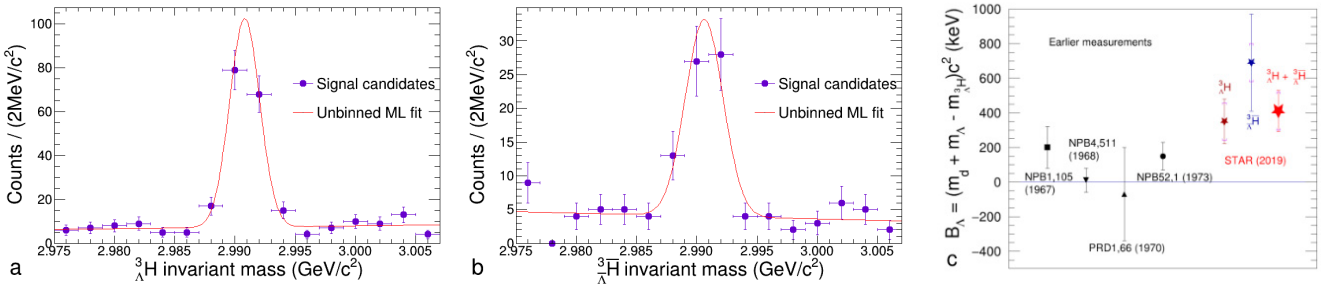


Fig.3-1-8 The mass distributions and binding energy of hypertriton and antihypertriton were constructed by combing the 2-body and 3-body decay channels. (a) the hypertriton invariant mass distributions from a combined analysis of its 2-body and 3-body decay channels, (b) is the corresponding distributions on antihypertriton. In the Figures, solid points respresentsingnal candidates and solid lines are max likelihood fits. (c) is the binding energy from new measurements in comparison with early data.

a feature article *Strange matter interacts with strongly with nucleons*, and the ALICE collaboration applied the same method for the measurement of proton-Omega interaction in Au+Au data to proton-proton data. Their results also support their conclusions and was published in *Nature* (2020).

Experiments confirm the existence of two-dimensional ice

Water is one of the most widely distributed substances in nature, and ice is a common state formed by regular arrangement of water molecules. Its structure and nucleation play a crucial role in many fields, such as material science, tribology, biology and atmospheric science. After nearly 100 years of research and exploration, 18 kinds of three-dimensional ice phases have been discovered, among which the most common ice phase in nature is the hexagonal Ih phase. However, there has been much controversy about whether ice can exist stably in the two-dimensional limit. Supported by the National Natural Science Foundation of China (National Science Foundation for Distinguished Young Scholars Project 21725302, 11525520, Basic Science Center Project 11888101, Key Project 11634001), a research team led by Professor Jiang Ying of the Center for Quantum Materials, School of Physics, Peking University, has carried out research on the structure and growth mechanism of two-dimensional ice The research on atomic scale has been carried out and the following main innovations have been achieved.

(1) By precisely controlling the temperature and water pressure, a two-dimensional monolayer ice structure was successfully grown on the surface of hydrophobic Au(111), which could be completely covered with the substrate.

(2) The submolecular resolution imaging of two-dimensional ice was achieved by using nonintrusive AFM imaging technology. The intrinsic 2-D ice structure of "interlocking type" is determined by theoretical calculation. This was the first experimentally confirmed two-dimensional ice structure, and the researchersofficially named it two-dimensional ice Phase I (Figure 3-1-9).

(3) It is determined that the boundary of two-dimensional ice is composed of unreconstructed jagged boundary and reconstructed armchair boundary. The intermediate state structures in the ice growth process were captured on the boundary, and the "bridging" growth mechanism of zigzag boundary and "seeding" growth mechanism of chair-like boundary were proposed by combining theoretical calculation and simulation (FIG. 3-1-10).

The research results were published in Nature on January 2, 2020 under the title "Atomic Imaging of Edge Structure and Growth of a Two dimensional Hexagonal Ice". The discovery of two-dimensional ice has changed the traditional understanding of ice phases for more than 100 years, opened the door to exploring the two-dimensional ice family series, and provided a new picture of ice morphology and growth under low and confined conditions. At the same time, two-dimensional ice has potential significance in many applications. For example, two-dimensional ice on the surface can promote or inhibit the formation of threedimensional ice, which has a guiding role in the development of anti-icing materials. All the hydrogen bonds of water molecules in two-dimensional ice are saturated, so the interaction with the surface is minimal, which can reduce the friction between materials and play the role of super lubrication. In addition, twodimensional ice itself can also be used as a special two-dimensional material, which provides a new platform for high-temperature superconductivity, deep ultraviolet detection, cryoelectron microscopy imaging and other studies.

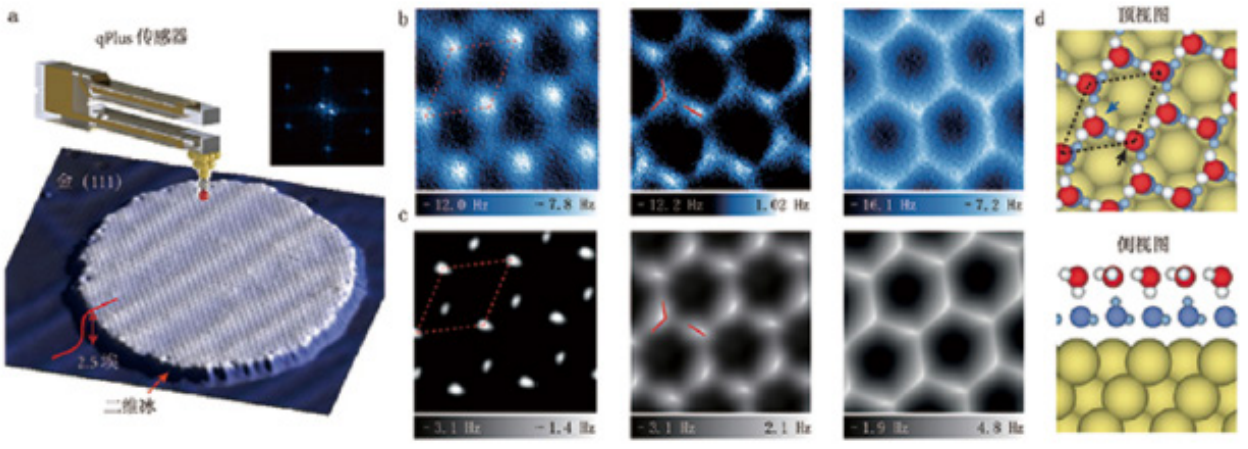


Fig.3-1-9 Schematic diagram of experimental setup, AFM experimental results and simulation of twodimensional ice, and atomic model of two-dimensional ice "interlocking" structure.

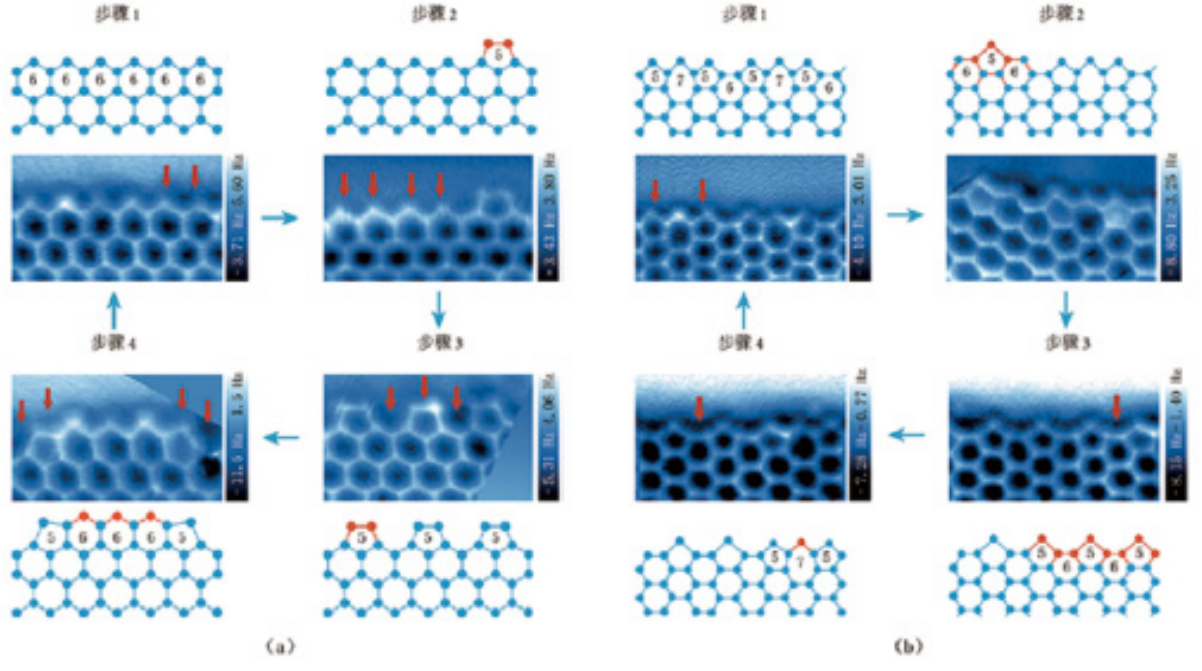


Fig.3-1-10 The "bridging" growth mechanism of the jagged boundary and the "seeding" growth mechanism of the chair-like boundary of the two-dimensional ice.

Radiopharmaceuticals-MediatedBioorthogonal Cleavage Chemistry Reveals the Antitumor Immune Function of Pyroptosis

Tumor immunology has played an increasingly critical role in cancer immunotherapy, but the location of function, triggering machanism, and the interactions of active proteins are intricate to understand. Therefore, the realization of tumor-selective manipulation of a target protein is the prerequisite and a valuable tool of studying the relation of phenotype, function, and mechanism of a target protein during antitumor immune function. Supported by the National Natural Science Foundation of China (Programs of Joint Fund: U1867209;General Program:21778003;Basic Science Center Program: 81788104), the anti-tumor immune function of cell caustic death was revealed for the first time by a novel biological orthogonal system by theresearchteam ofLIU Zhiboat Peking University in collaboration with SHAO Feng's laboratory at Beijing Institute of Life Sciences.

In the previous work, the research team prepared a class of amino acid mimetics, boramino acids (BAAs) that can be used as cancer imaging in Boron Neutron Capture Therapy (BNCT). The boron trifluoride group on boronine can directly desilylates silane, enabling the probe function of the phenylalanine trifluoroborate (Phe-BF_3) (Probing to Perturbing), and forming the boronine-mediated bioorthogonal shearing system at the cellular and in vivo level. Using Peking University's Zr-89 radionuclide in combination with PET molecular imaging, it was found that probe phenylalanine trifluoroborate (Phe-BF_3) was concentrated in tumor and kidney, while Zr-89-labeled protein carriers and antibody prodrugs were enriched in tumor and liver (Fig.3-1-11). These concentrations at the tumor has realized "in-tumor and only in-tumor" targeted protein modulation and drug release. The "dual-targeted" bio-orthogonal shear system can be applied widely, and the system shows advantages for proteins that require selective release within tumor cells. In collaboration with SHAO Feng's lab, this "dual-targeted" bio-orthogonal system was applied to the study of Gasdermin protein regulation and drug release to achieve controlled in situ tumor cell pyroptosisto clear the tumor (Fig.3-1-12).

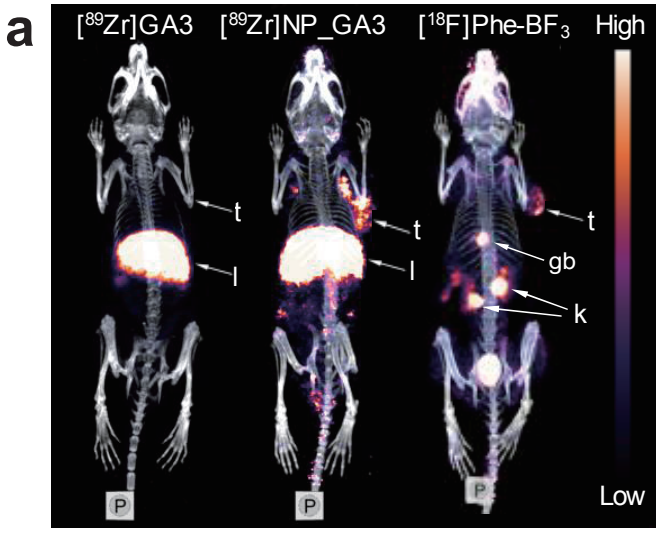


Fig. 3-1-11 PET-computed tomography images of mice demonstrate "dual-targeted" bio-orthogonal shear system

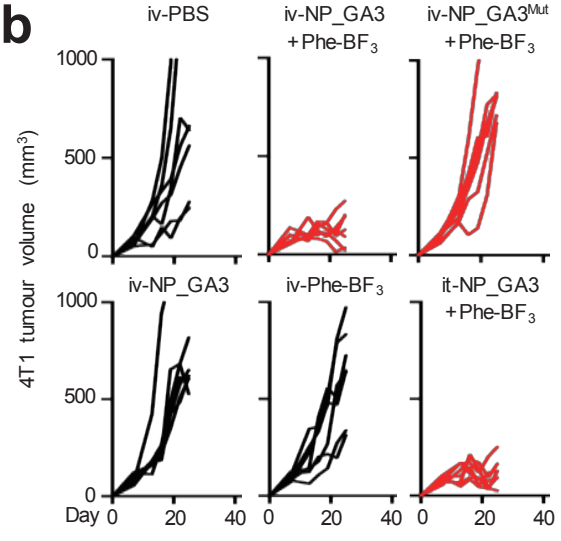


Fig.3-1-12 NP–GSDMA3 and Phe-$BF_3$of bio-orthogonal shear system releases Gasdermin, causing tumor regression in mice.

This work demonstrates the advantages of a "dual-targeted" bio-orthogonal shear system with high efficiency and good tumor targeting for radiomolecular image navigation. The study also demonstrates the great potential for controlled release in vivo of molecular probes into activators (probing-to-perturbing), providing a new direction for the development of prodrugs and drug delivery systems such as protein-coupled drugs. The study, titled "A BioorthogonalSystem Reveals AntitumourImmune Function of Pyroptosis", was published online in Nature on 11th March, 2020.

Research on High performance transistors mediated by Biological Selfassembly

Biological self-assembly systems, represented by self-assembled nucleic acid framework structures, have high precision and complex three-dimensional morphology, and their structural resolution is less than the resolution limit of traditional nanoprocessing methods such as lithography. Using biological self-assembly system as structural template to accurately control the assembly of semiconductor materials has the potential to break through the restriction of lithography resolution and promote the miniaturization of highperformance devices. Although micron-scale biological self-assembly templates have been used to mediate the fabrication of semiconductor arrays with sub5-nm node structure characteristics, the complex composition of the composite functional interface between biomolecule and semiconductor materials results in the performance of bioassembled transistors often far behind that of similar devices fabricated by etching or thin film methods. At the same time, the order degree of the array structure is only in micron size, which is orders of magnitude different from that of the centimeter order semiconductor device. At present, there is still a lack of effective methods to solve these key problems in the world. Supported by the National Natural Science Foundation of China (general Project 21875003, 21775128, major Project 21991134, 21435004), Sun Wei's team of researchers at Peking University, Zhu Zhi of Xiamen University, Tang Jianshi of Tsinghua University, and Dr. Ming Zheng of National Institute of Standards and Technology (NITE), collaborated to assemble the surface of nucleic acid templates As a model system, equally spaced and parallel carbon nanotube arrays have been used to investigate the key scientific issues involved in the regulation of bio-carbon nanotube functional interfaces and large area surface assembly, and the following innovative results have been achieved.

(1) An interface engineering method based on fixed-one elution strategy is constructed. On the basis of not changing array ordering, the effective regulation of biology-CNT interface composition is realized, and the mechanism of the influence of biomolecules and metal ions on the charge transport properties of CNT is elucidated (Figure 3-1-13).

(2) The performance of carbon nanotube transistors is restricted by biological self-assembled templates. In single-channel transistors, the electrical properties of solution-phase semiconductor carbon nanotubes are raised to the same level as those of CVD carbon nanotubes, which is close to the physical property limit of the material. High on-state and fast switching are achieved simultaneously in a single multichannel transistor. The performance of key devices is superior to similar devices and close to the performance level of siliconbased devices with similar technology nodes.

(3) A domain-limited assembly method for a large area of substrate surface was developed to realize the positioning and orientation arrangement of bio-carbon nanotube arrays on the centimeter-level substrate surface, revealing the influence of key structural parameters on the accuracy of surface assembly (Fig. 3-1-14). This study explores the potential application of self-assembly chemistry in high-performance devices with ultra-small nodes, promotes the development of the intersection between high-performance electronic devices and high-precision biomolecular self-assembly, and concludes with "DNA-directed

Nanofabrication of high-performance Carbon" "Nanotube Field-Effect Transistors" is published in Science.

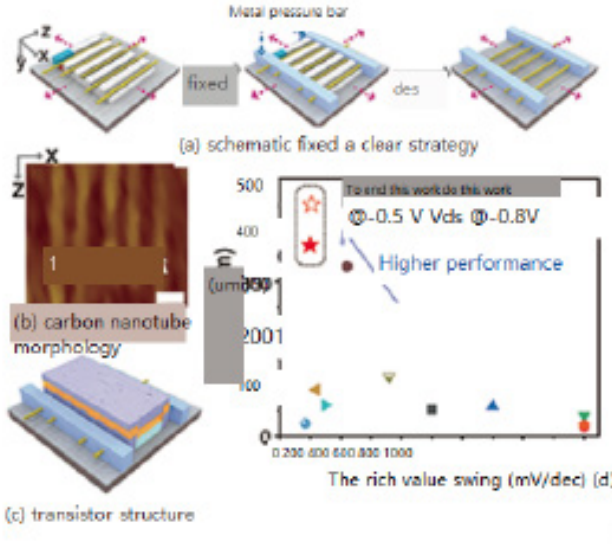


Fig. 3-1-13 Interface engineering method based on fixed-one elution strategy and construction of high-performance transistors mediated by biomolecules.

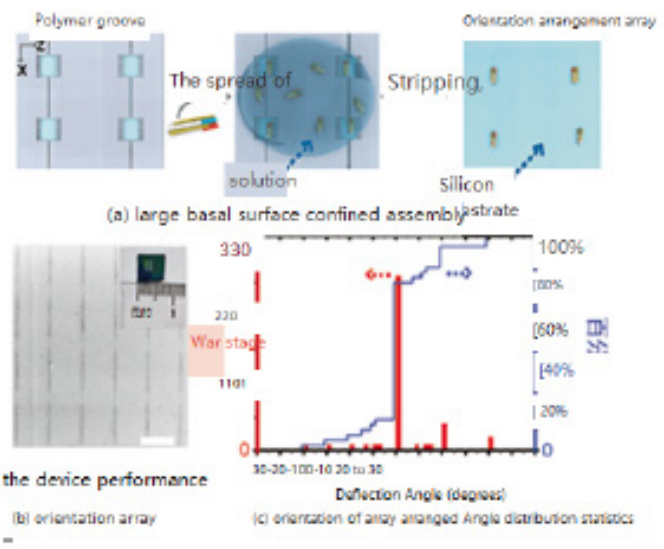


Fig.3-1-14 Limited domain assembly strategy for large area substrate surface and orientation arrangement of bio-carbon nanotube arrays.

Research on the Fatigue Resistance of Carbon Nanotubes

Materials with super-strong strength, toughness, and fatigue-resistance are in great demand in many fields, including aerospace, body armor, sports equipment, and artificial muscle. Carbon nanotubes (CNTs) have typical one-dimensional nanostructure. In the last two decades, the strength and toughness of the macro-length CNTs have been rapidly improved by orders of magnitude compared with the best carbon fibers available. However, due to the tiny size and the difficulty in mechanical test, how to test the fatigue behavior of single CNTs is still unsolved for a long time, which hinders the applications of CNTs. Because fatigue can occur when the stress level is much lower than the static fracture strength, exploring the fatigue behavior and failure mechanism is of great significance for the application and long-term life design of new materials. With the support of the National Natural Science Foundation of China (Key Program: 21636005), the team led by Prof. WEI Fei and Associate Prof. ZHANG Rufan from Tsinghua University tested the fatigue resistance of a single CNT through experimentfor the first time.

To test the fatigue behavior of a single centimeter-long CNT, the research team designed and built a non-contact acoustic resonance testing nano electromechanical system (ART-NEMS)at the scale of 2 nm through a two-step bottom-up self-assembly approach (Fig.3-1-15) . Unlike common nanomaterial testing systems that use an electron microscope, the newly developed ART system not only avoids the potential for defect formation that can be caused by an electron beam, but also enables the testing of samples that are orders of magnitude longer and overcomes the measurement difficulties for nanomaterials, such as specimen gripping and large cycles of tension loading.

This study has found that CNTs exhibit excellent fatigue resistance, which is superior to all current engineering materials. Different from the progressive damage in conventional materials, the fatigue failure of CNTs is global and catastrophic without progressive damage. The lifetime of a CNT is virtually dominated by the time of the first defect creation. In addition, its fatigue resistance is affected by temperature and a higher temperature results in a lower fatigue resistance.

This work reveals the bright future of ultra-long CNTs being used in the manufacture of super-fatigue-resistant fibers, and provides an important reference for the life design of CNTs in many application fields.

Relevant results were published in Scienceentitled "Super-durable Ultralong Carbon Nanotubes".

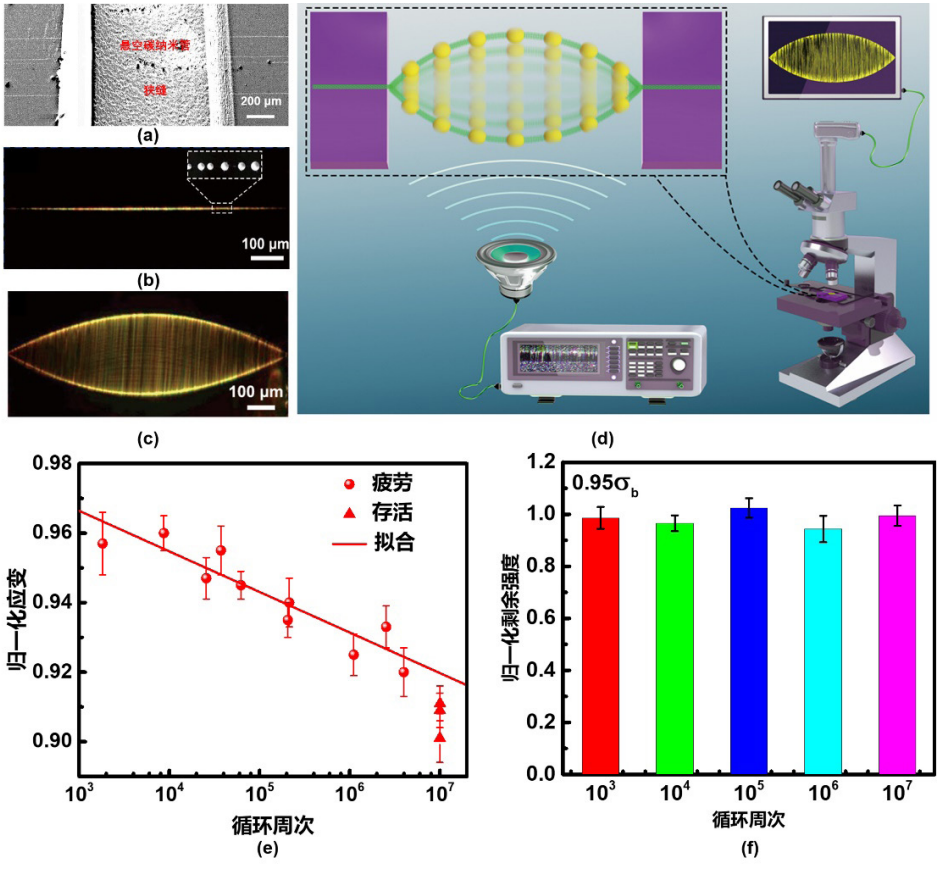


Fig.3-1-15 Super-durable ultralong carbon nanotubes.

Research on the Geometric Phase Effects in a Chemical Reaction

The study ofthe chemical reaction dynamics is of great help to the understanding of how a reaction proceeds at a microscopic level. Supported by the National Natural Science Foundation of China (Basic Science Center Program: 21688102; Key Program: 21590800, National Science Fund for Distinguished Young Scholars:21825303, ExcellentYoung Scientists Fund: 21822305), the research team led by YANG Xueming, ZHANG Donghui, SUN Zhigang and XIAO chunleifrom Dalian Institute of Chemical Physics, Chinese Academy of Sciences, discovered significant new quantum interference in the chemical reaction of H + HD ® H_2 + D, and revealed the existence of the geometric phase effect in the reaction.

Among all chemical reactions,H + H_2 and its isotopologues are the simplest ones. The reaction involves only three electrons, which facilitates the accurate calculations of the potential energy during the reaction. With the potential energy surface available, one would be able to solve the Schrödinger equation which describes the nuclear motion of the reaction. The research team found in its previous theoretical work of quantum dynamics that there are beautiful and regular oscillations as a function of collision energy for some specified ro-vibrational state of the product H_2, which was laterconfirmed by the experimental observation.

Topological theory analysis suggests that these oscillations in the backward scattering result from

interference between the products generated from two paths. Both paths have significant and comparable contributions to the backward scatterings, which do not vary much as a function of collision energy. However, their phases vary quite differently as a function of collision energy: One increases linearly with increasing collision energy whereas the other one decreases linearly. As a result, the backward scattering oscillates regularly and drastically (Fig.3-1-16).

Quasi-classical trajectory theory reveals that, one of the paths corresponds with the usual direct reaction path, but the other one proceeds via a roaming-like reaction path. These two paths reach the product channel along different direction around the conical intersection. Therefore, the geometric phase effectmust be considered to correctly reproduce the interference pattern between these two paths.Only about 0.3% of the total reactivity occurs via roaming-like path. Thanks tothe strong quantum interference, such small reactivity can be revealed through the combined theoretical and experimental study (Fig.3-1-17).

This work, entitled "Quantum interference in H + HD → H_2 + D between direct abstraction and roaming insertion pathways"was published online on *Science* on May 15,2020. Professor Aoiz,a renowned Spanish Physical Chemistwrote a Perspective about the work, underlining the findings on the same magazine with the tittle "How Interference Reveals Geometric Phase".

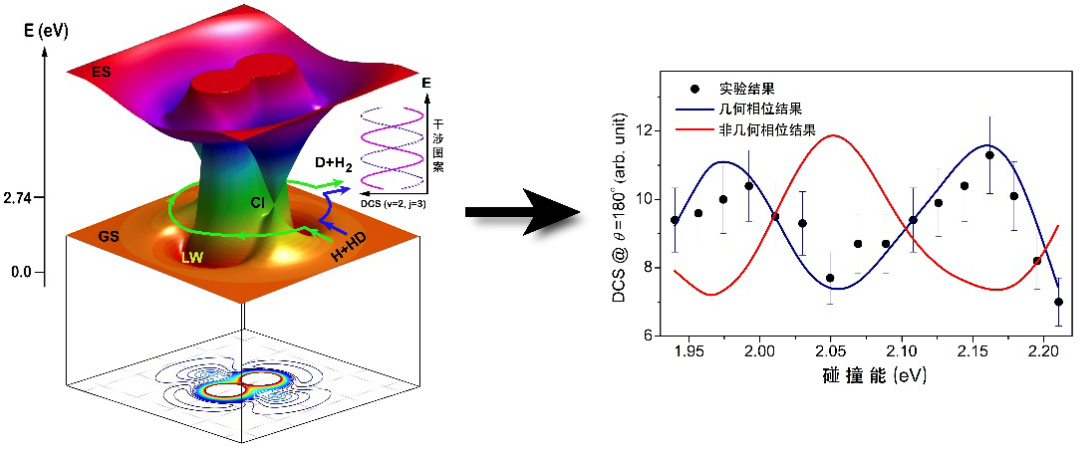


Fig.3-1-16 Left: interference between the products generated from two paths. Right: oscillations from interference through theoretical and experimental study

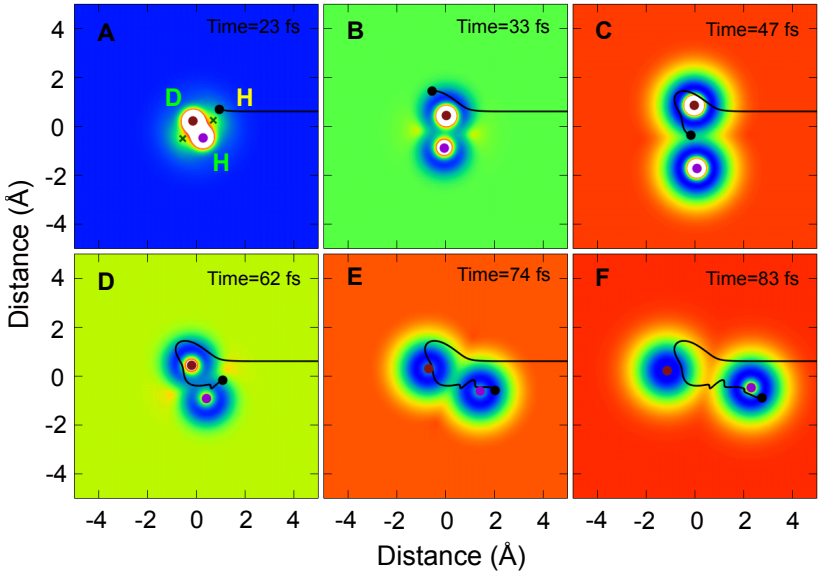


Fig.3-1-17 Snaps of the trajectories at a series of times for the roaming path of the H+HD reaction.

New Technology for Studying Non-coding RNA's Higher-order Structure and Target

Non-coding RNA research is emerging as a new frontier in life sciences due to their critical roles in maintaining the hemostasis of life and health. Unlike protein-coding mRNAs, non-coding RNAs usually need to form intricate tertiary structures and then interact with other targets of RNA molecules to achieve the regulatory functions. However, due to lacking experimental methods, deciphering the *in situ* higher-order structure and targets of non-coding RNAs is still a fundamental challenge in the RNA field. Supported by the National Natural Science Foundation of China (Major research Plan: 91740201, 91940306; Excellent Young Scientists Fund: 31522015), the team led by Prof. XUE Yuanchao from the Institute of Biophysics, Chinese Academy of Sciences, invented an RNA *in situ* conformation sequencing technology (RIC-seq) for global profiling of the higher-order structure and target of non-coding RNA in situ, providing new tools for the further research on the function and mechanism of the dynamic structural change of non-coding RNA. Notably, this study also sheds light on how the super-enhancer-derived long non-coding RNA regulates transcription, representing a significant conceptual advance in the field (Fig. 1). The main innovative results are summarized as follows:

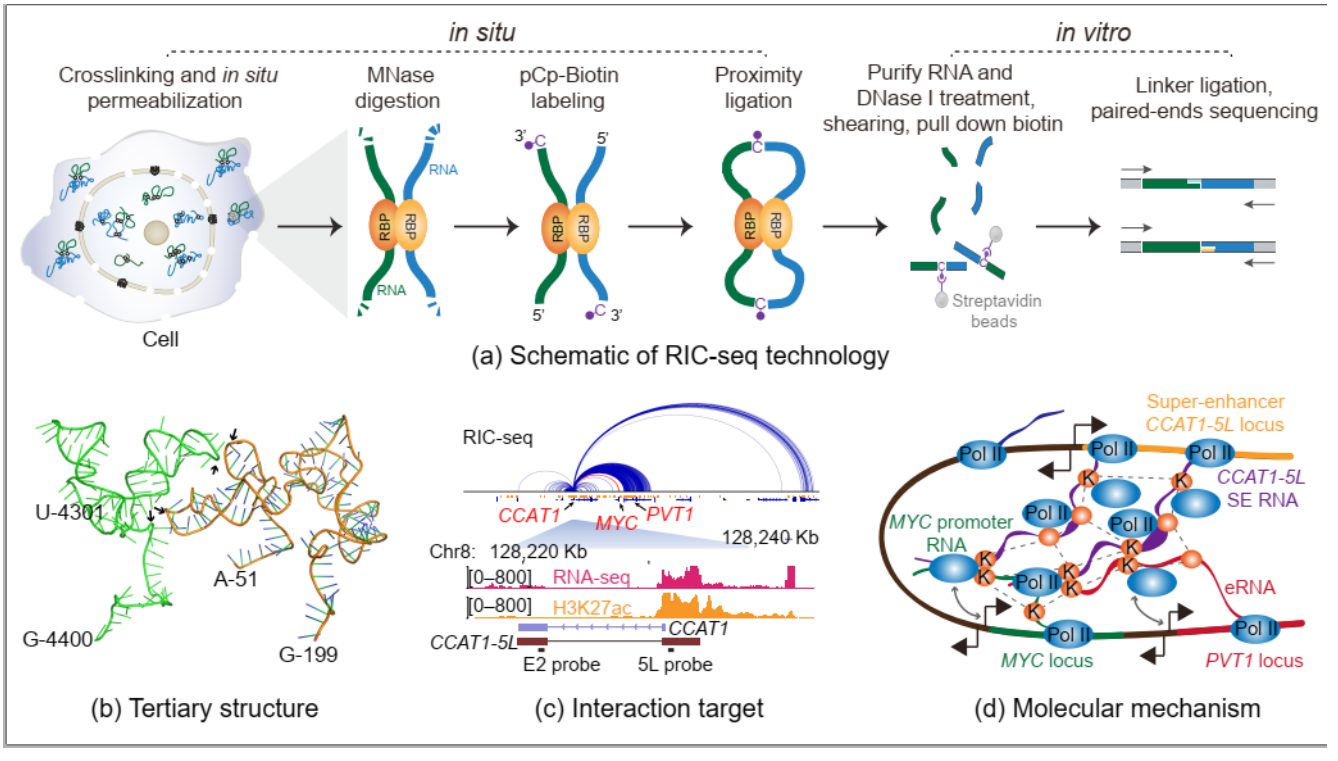


Fig.3-1-18 RIC-seq flowchart and its application in the study of the structure and mechanism of non-coding RNA.

(1) RIC-seq technology for global mapping of RNA in situ conformations was invented. On this basis, the team successfully mapped the higher-order structures and targets of various non-coding RNAs in the cell. Additionally, using the RIC-seq data, RNA topological domains and RNA interaction hubs were defined for the first time. The teamalso found that the RNA-

binding proteins may be the driving force for forming these complex RNA configurations. (2) Extensive interactions between promoters- and enhancers-derived non-coding RNA were revealed. The teamwas the first to prove that the interaction between promoter- and enhancer-derived non-coding RNA could be used to infer their connectivity. On this basis, they constructed a genome-wide enhancer-promoter connectivity map and recapitulated each chromosome's territory in the cell. These results have laid the foundation for studying enhancer RNA's function in the 3D nucleus.

(3) The team identified a novel super-enhancer long non-coding RNA CCAT1-5L which interacts with the RNA-binding protein hnRNPK, as well as RNA derived from the MYC promoter and enhancer, to boost MYC transcription by modulating long-range chromatin looping.

This study has invented an original and innovative technology for analyzing the higher-order structure and target of diverse RNA molecules in situ, revealing the critical roles of RNA-RNA interaction in gene expression regulation.Additionally, the identified RNA-RNA interactions also lay the foundation for understanding the pathological roles of massive casual mutations resided in the human genome's non-coding regions. Furthermore, RIC-seq technology also provides a powerful tool for studying the genome structure of RNA viruses. This study was published in *Nature* with the title "RIC-Seq For Global in Situ Profiling of RNA-RNA Spatial Interactions".The research results were quickly confirmed and used by international colleagues and highlighted by many journals such as *Nature Methods*, *Nature Reviews Cancer*, and *Trends in Genetics*.

Researchonthe Mechanismof Neural Control of Sleep Homeostasis

Sleep is a universally observed phenomenon among the animal kingdom. Humans spend about one-third of their lives asleep. Adenosine is a prominent mediator of sleep homeostasis, which is believed to suppress neural activity and increase sleep pressure during wakefulness. It's has been proved that the glutamatergic neurons in the basal forebrain (BF) play a critical role in the forming of sleep pressure. However, it is largely unknown how neural activity underlying the sleep-wake cycle controls adenosine release and sleep homeostasis. Supported bythe National Natural Science Foundation of China (General Program: 31871074, 91832000, 31871051), the collaboration team led by Dr. XU Min (Institute of Neuroscience, Chinese Academy of Sciences) and Dr. LI Yulong (Peking University) designed a new adenosine sensor to record the neurological activities and yielded the following findings:

There's an activity-dependent rapid increase in extracellular adenosine in the BF during the sleep-wake cycle. Optogenetic activation of glutamatergic neurons in the BF can contributed to the adenosine increase. Mice with selective ablation of BF glutamatergic neurons exhibited a reduced adenosine increase, impaired sleep homeostasis regulation with reduced sleeping pressure and increased waking time (Fig.3-1-19).

This work has revealed the mechanism of neural control of sleep homeostasis, providing references for treatment of sleep disorders and laying the foundation for the further study on the neural mechanism of sleep homeostasis. This work was published on *Science* in September 2020 with the title of "Regulation of Sleep Homeostasis Mediator Adenosine by Basal Forebrain Glutamatergic Neurons".

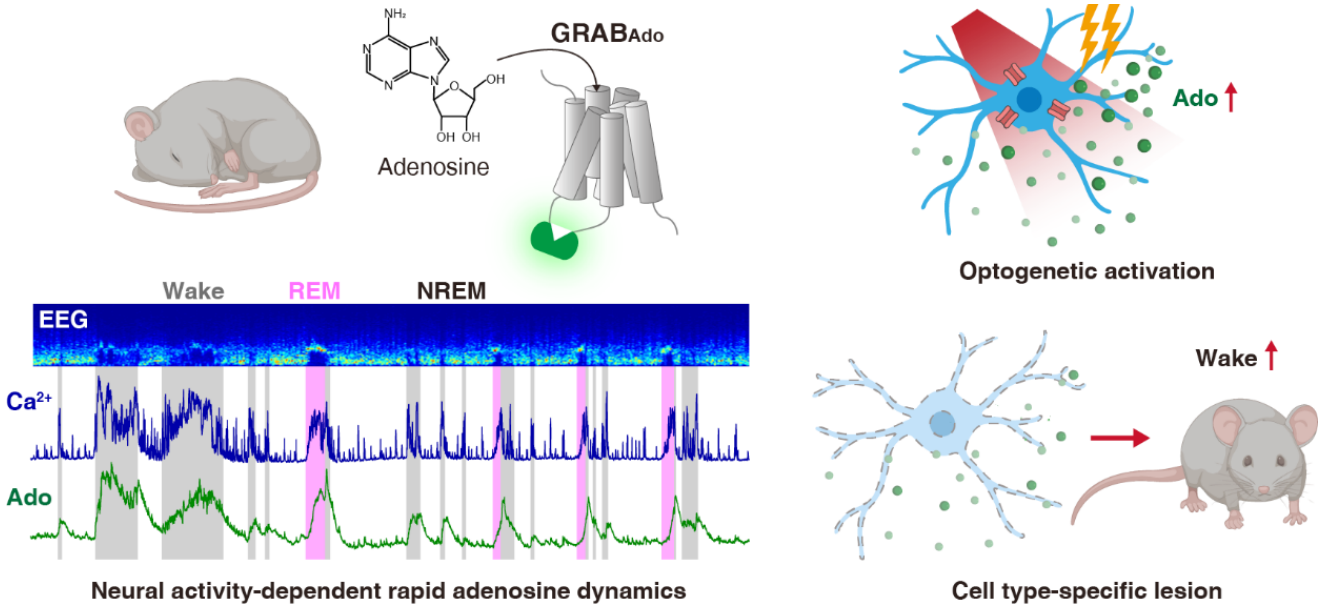


Fig.3-1-19 Neural control of rapid adenosine dynamics and sleep homeostasis

Researchon the Regulatory Mode and the Mechanism of RNA Pol II Mediated Transcription Onset During Mammalian Zygotic Genome Activation

Human life begins with a fertilized egg. How a fertilized egg develops into a complex organism is one of the greatest challenges in the field of life sciences. Zygotic genome activation (ZGA) is the first transcription event in the life of mammals.Understanding how ZGAoccurs is crucial to elucidate how life begins.However, due to the limited research materials fromearly embryos, the molecular mechanism underlying mammalian ZGA remains poorly understood.Supported by the National Natural Science Foundation of China (Basic Science Center Program: 31988101; Key Program: 31830047;National Science Fund for Distinguished Young Scholars: 31725018), Prof. XIE Wei's group at Tsinghua University developed a new detection method with high sensitivity– Stacc-seq andinvestigated the binding landscapes of the key player in transcription – RNA polymerase II (Pol II) in mouse oocytes and early embryos, and its critical roles in ZGA. The main innovative results are summarized as follows:

The research team has developed a new detection method with high sensitivity forlow input samples, Stacc-seq (Fig.3-1-20), to detect protein DNA interaction genome-wide. Only requiring the 10^2 cells, this method can replace the conventional ChIP-seq which requires 10^7-10^6cells, solving the bottleneck problem of limited experimental materials.

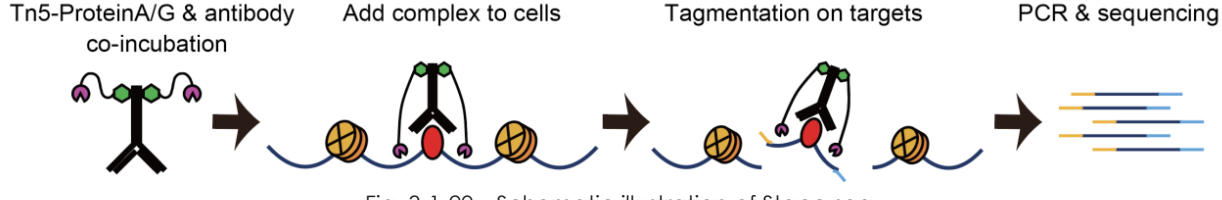


Fig. 3-1-20 Schematic illustration of Stacc-seq

The research team has investigated the binding dynamics of Pol II in mouse oocytes and early development by Stacc-seq.These data revealed that Pol II undergoes three stages of "loading, pre-configuration, and production" during ZGA (Fig.3-1-21). After fertilization, Pol II is preferentiallyloaded to CG-

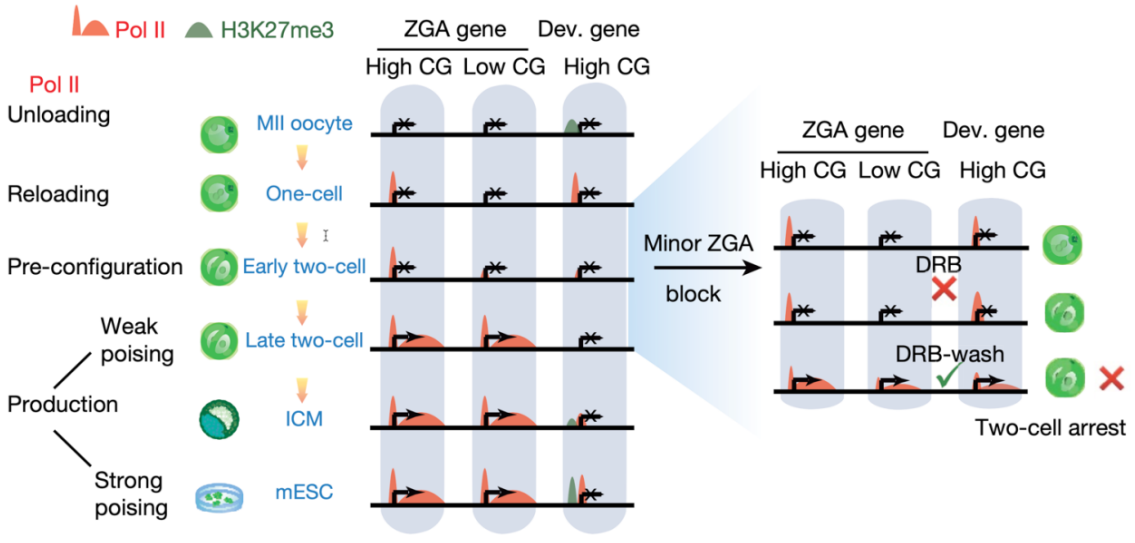


Fig.3-1-21 The stepwise transition of RNA polymerase II during mouse ZGA

rich promoters and accessible distal regions in 1-cell embryos ("loading"), in part shaped by the inherited parental epigenome as shown for maternal DNA methylation. Interestingly, Pol II already initiates the re-location to future gene targets prior to genome activation ("pre-configuration"), before it later engages in full transcription elongation upon major ZGA ("production").

The research team has further revealed that blocking Pol II elongation during minor ZGA impairs the pre-configuration of Pol II and leads to developmental arrest, accompanied by aberrant retention of Pol II and ectopic expression of one-cell Pol II targets upon major ZGA. Hence, this finding reveals a key role of minor ZGA in the pre-configuration of transcription machinery for genome activation.

These research findings were published in *Nature* on October 28, 2020, entitled "The Landscape of RNA Pol II Binding Reveals A Step-Wise Transition During ZGA".This study has not only improved our understanding of the fundamental mechanism underlying the onset of ZGA, the first transcription event in life,but alsolaid the theoretical foundation for future clinicalresearch on early development-related diseases and assisted reproduction.

The Stem CellsMediated Broad-Spectrum Antiviral Immunity in Plants

Stem cells are the origin of all organs during post-embryonic development in plants, which are strictly protected to safeguard the integrity of the cells from biotic or abiotic stresses. Plant viruses have become the second most serious disease-causing pathogens damaging almost all plants, causing severe losses in crop production and quality, even harvest extinction. However, there are no effective drugs targeted at the prevention and control of plant viruses. So far, meristem tip culture has become the most effectively and widely employed technology for the eradication of various viruses in plants. Since the 1950s, this technology

has been widely used in agriculture to develop virus-free cultivars in a wide range of crops, demonstrating a conservative broad-spectrum antiviral feature in plants. This technology is based on the observation that there are few or even no viruses in the shoot apical meristem of plants, yet its mechanism was largely unknown.

With the support of National Natural Science Foundation of China (General Program: 31870264; Young Scientists Fund: 31400251), the research team of Pro. ZHAO Zhong of the University of Science and Technology of China, has achieved important breakthroughs in the molecular mechanism of the broad-spectrum antiviral immunity in plant stem cells. The main research findings of this study are as follows:

(1) Inspired by the traditional technology of meristem tip culture, a key factor in broad-spectrum antiviral immunity in plant stem cells, WUSCHEL (WUS), was identified through the multi-discipline research onplant developmental biology and plant virology.

(2) The stem-cell regulator WUS responds to viral infection and moves ectopically to the surrounding daughter cells to safeguard plant stem cells and their nascent daughter cells from viral invasion (Fig.3-1-22), which explains a long-standing biological mystery why the tips of plant are virus free.

(3) It was revealed that WUSinhibits viral protein synthesis by repressing the expression of plant S-adenosyl-L-methionine-dependent methyltransferases, which are involved in rRNA processing and ribosome stability (Fig.3-1-23).

(4) It was demonstrated that the ectopic expression of WUS protein in leaves could protect the whole plant from virus infection, which provides a new strategy in breeding to obtain broad-spectrum antiviral crop varieties in the future.

The research results were published in *Science* on October 9, 2020, receiving highly-rated peer review opinions that this study is "groundbreaking in bringing together the fields of plant pathology and plant development and solving a longstanding problem in focus" the research findings have been recommended in Faculty opinions (F-1000) as the highest rating: exceptional. Soon after the publication, this study has been widely reported by CCTV news channel, Xinhua news agency, Science and Technology Daily, China Youth Daily, People Daily, CGTN, Phys.org, EurekAlert and SciTech daily.

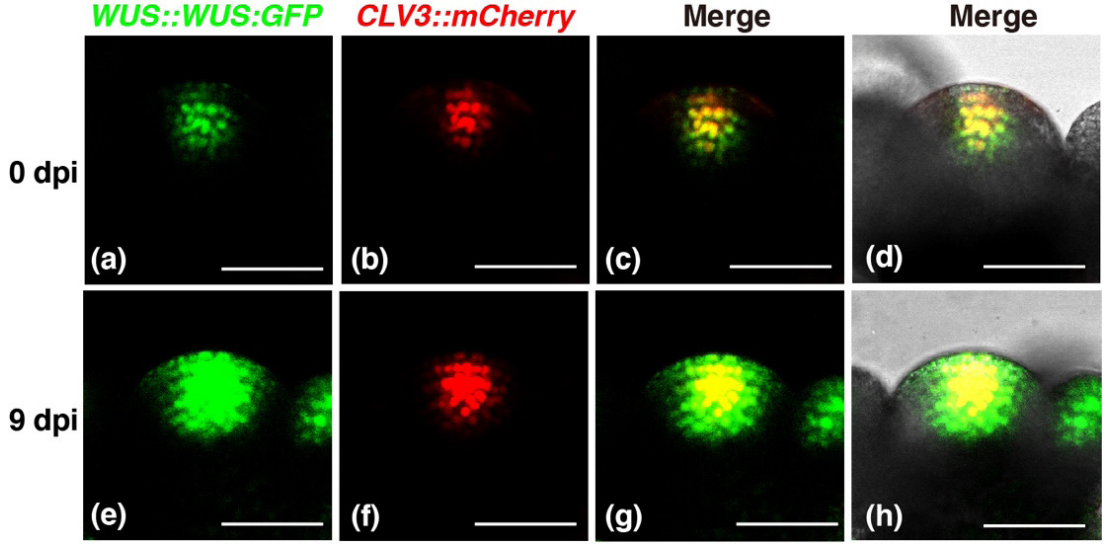


Fig. 3-1-22 WUS protein was induced and moved ectopically to protect the shoot apical meristem from virus infection.

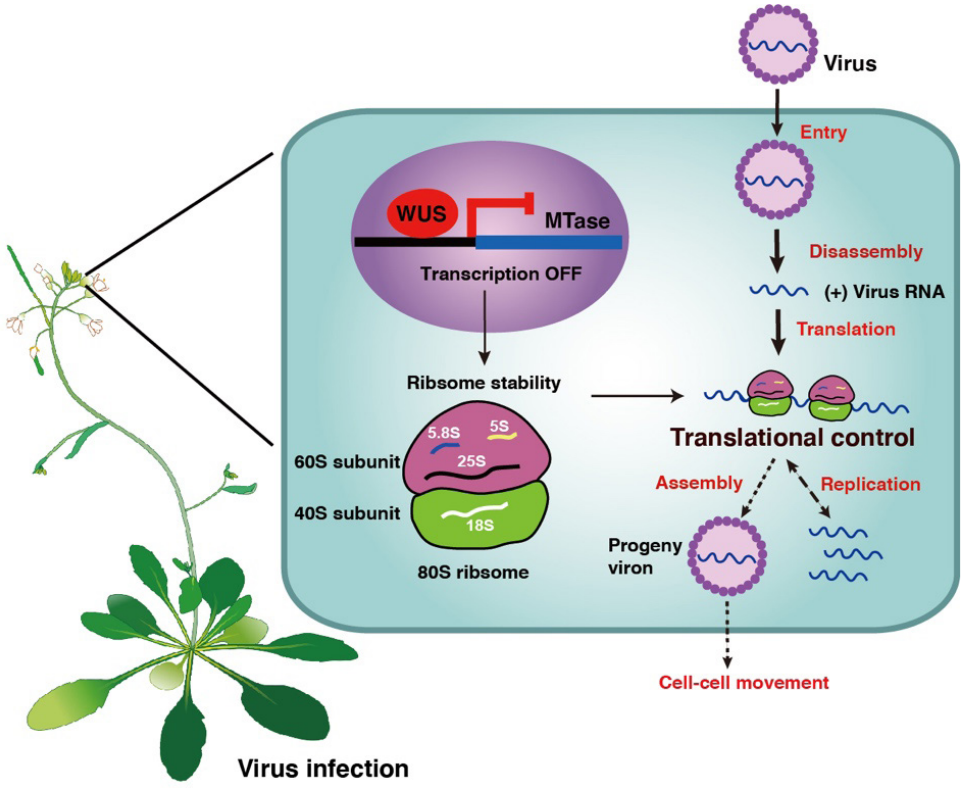


Fig. 3-1-23 Molecular mechanism of WUS-triggered stem-cell antiviral immunity in plants.

Research on the Gonadal Differentiation and Gametogenesis of Fish

To study fish reproductive development and its regulatory mechanism is not only of great theoretical significance, but also of great importance for fish genetic breeding and population expansion. To conduct systematic and in-depth study on fish gonadal differentiation and gametogenesis is the key to reveal the reproductive regulation mechanism of fish, to establish reproductive manipulation-based breeding technology and to generate new breeding stocks. Supported by the National Natural Science Foundation of China (Science Fund for Creative Research Group: 31721005 and General Program 31671501), the Innovation Research Team led by Prof. HU Wei of the Institute of Hydrobiology, Chinese Academy of Sciences has made important progress on fish gonadal differentiation and gametogenesis and the major findings are as follows.

In collaboration with Prof Vance L. Trudeau of the University of Ottawa, Canada, the research team has found a novel reproductive endocrine hormone, Secretoneurin (SN), in the animal kingdom. Mechanically, SN acts through the classical GnRH-LH system, and plays an important role in zebrafish reproduction and sexual behavior (Fig.3-1-24).

The research team has revealed a novel mechanism of totipotency-related factor, Nanog, in regulating the egg quality and embryonic development. Nanog binds to TCF to prevent the embryo from global activation of maternal *β*-catenin and hyperdorsalization (Fig.3-1-25).

The research team has found a novel function of GnRH3 in regulating the proliferation of embryonic primordial germ cells and sex differentiation and revealed its action mechanism.

The research team has utilized a genetic model to demonstrate that 11-Ketotestosterone is the most potent androgen to promote the development of Leydig cells and normal spermatogenesis in males, and

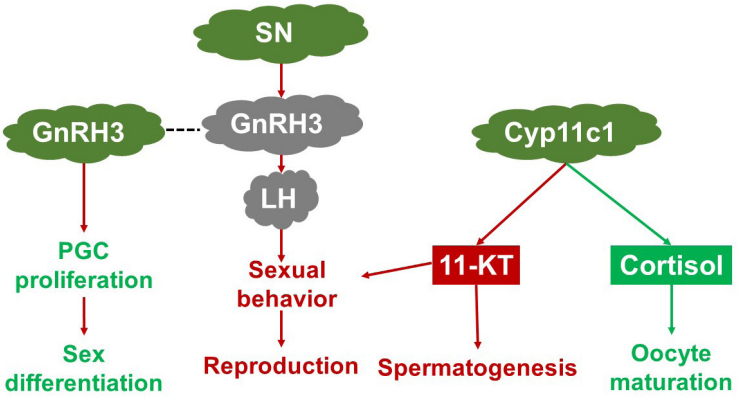


Fig.3-1-24 New findings related to the regulation of sexual behavior and gametogenesis of fish by a novel hormone SN.

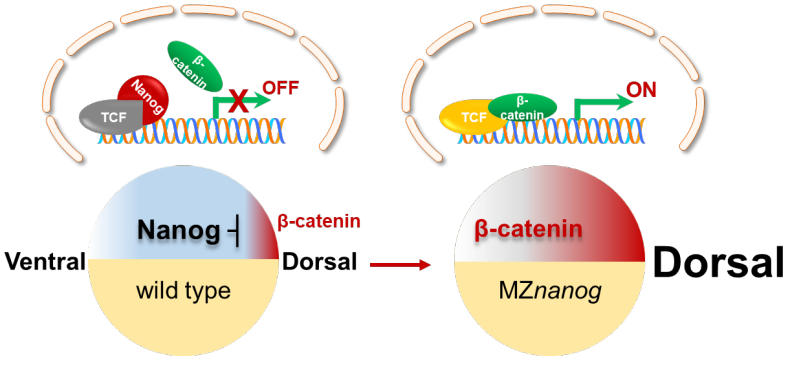


Fig.3-1-25 Nanog prevents the embryo from global activation of maternal β-catenin and hyperdorsalization

cortisol is an important hormone for promoting oocyte maturation and ovulation of females.

The above-mentioned research findings have been published in some reputable journals, such as *Proceedings of the National Academy of Sciences of the United States of America*, *PLOS Biology* and *Endocrinology* between January and July of 2020. These findings have received high evaluations from the international peers. For example, the work on SN as a novel reproductive endocrine hormone was regarded as a "milestone", and "the results on the effect of SNs on sexual behavior may represent the starting point for further studies on different experimental models including mammals".

Researchon Evolution and Effects of Social-Ecological Systems

The dynamic evolution of social-ecological system (SES) is a key area in the research of human-environemnt interaction and also a frontier problem in the research of earth science. A SES perspective provides an integrativeframework that could lead to better understanding of the interactionsbetween human and natural systems. Regime shifts, i.e.large, abrupt, and persistent changes in system structure, function,and feedback, occur across a wide range of SES. Identifying the regime shifts (evolutionary phases) that have their foundations in intertwinedsocial-ecological dynamics is critical to successful future systemmanagement and remains a scientific challenge of SES research. The SES regime shifts

identified in current research are mainly basedon the change points of a single social and/or ecological component,with the interactions between them often being neglected. In addition, current regime shift studies focus mainlyon the local effects and ignore spillover effects.

With the support of the National Natural Science Foundation of China (Key Program: 41930649; Excellent Young Scientists Fund: 41722102), the research team led by Professor FU Bojie from the Research Center for Eco-EnvironmentalSciences, Chinese Academy of Sciences, proposed a framework in collaboration with their partners, for identifying the regime shiftsof a SES based on the changes of interactions between components ofsocial-ecological system and analyzing the evolution over the past 1000 years of the SES in China's Loess Plateau (LP).

Using statistical survey data, historical period reconstruction data and relevant literature, this research analyzed the changes of interactions between population, cropland area, and forest coverage. Five evolutionaryphases of the SES in the LP were identified during the past 1000 years (Fig.3-1-26). The empirical links between the state of the SES to its political, climatic, and socioeconomicdrivers and local and spillover effects including grain production in the LP, thesediment load and natural runoff of the Yellow River (YR), YR delta area changes, and natural breaches of the lower YR were established. The analyses indicate that the SES practices focused on food security in the first three phases, resulting in local environment degradation and generating negativespillover effects in distant coupled systems. The soil erosion controlmeasures and revegetation in the LP reduced soil erosion and sedimentload in the YR but these measures also contributed to the shift of the YR delta intoan erosion state.

This study has provided temporal lens for understanding the dynamics of SES. Lessons of LP highlight the necessity of an integrated and systemicperspective in future SES management, which switchesthe focus from pursuing a single goalto considering social-ecological interaction, and from focusingon local effects

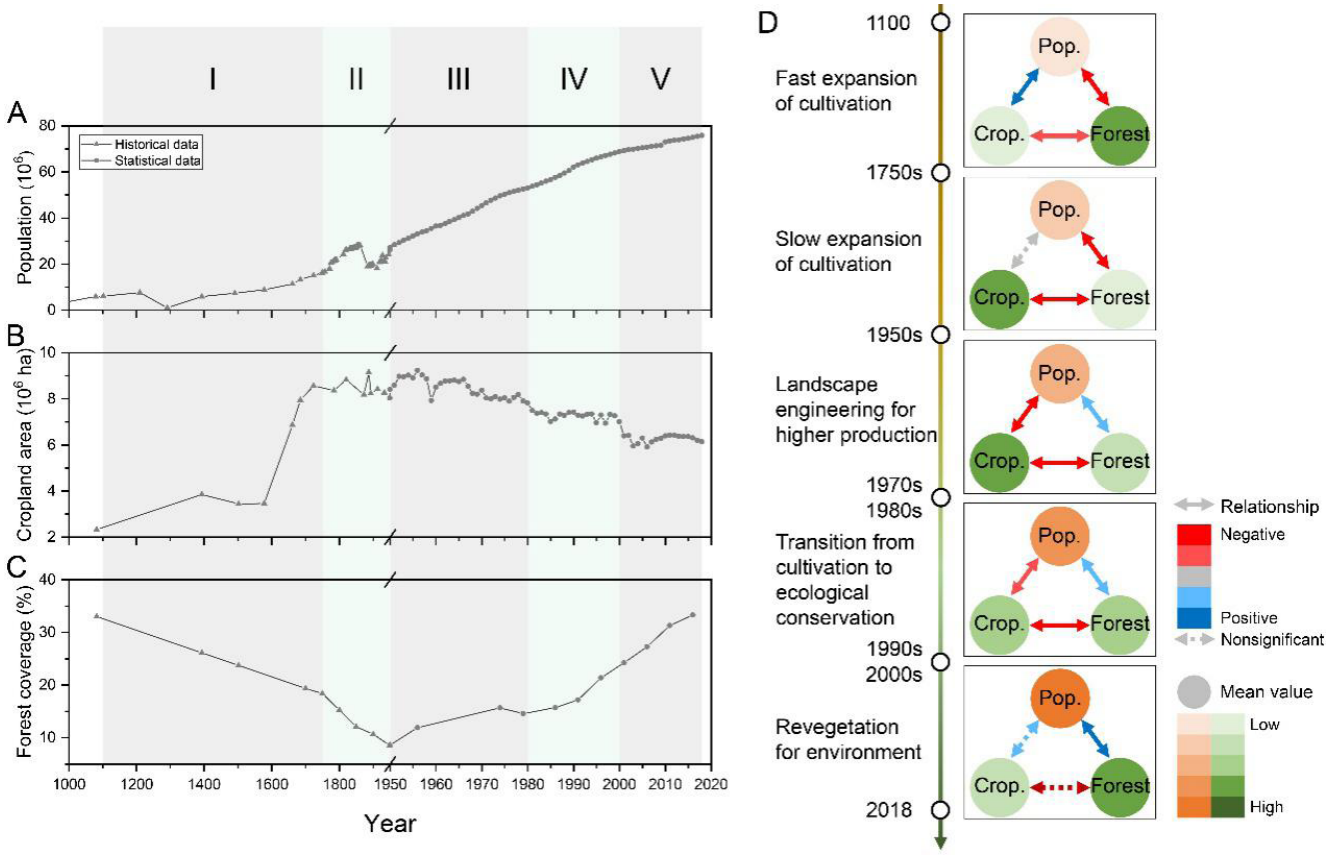
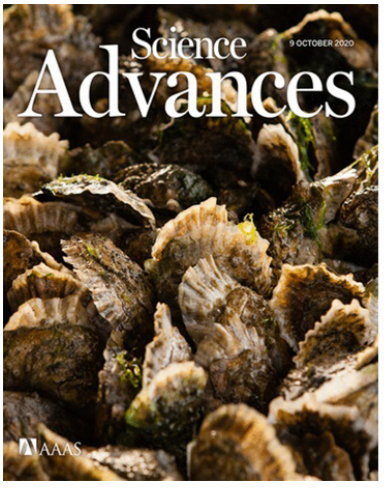


Fig. 3-1-26 Evolutionary phases of the social-ecological system in the Loess Plateau.

to considering cross-scale effects. These research findings are significant for the policy-making and human-land system management and regulation. This study was published in *Science Advances* in October, 2020, with the title of "Evolution and Effects of The Social-Ecological System over a Millennium In China's Loess Plateau"(Fig.3-1-27).



SCIENCE ADVANCES | RESEARCH ARTICLE

ECOLOGY

Evolution and effects of the social-ecological system over a millennium in China's Loess Plateau

Xutong Wu[1,2], Yongping Wei[3], Bojie Fu[2,4]*, Shuai Wang[4], Yan Zhao[3], Emilio F. Moran[5]

Understanding the regime shifts of social-ecological systems (SES) and their local and spillover effects over a long time frame is important for future sustainability. We provide a perspective of processes unfolding over time to identify the regime shifts of a SES based on changes in the relationships between SES components while also addressing their drivers and local and spillover effects. The applicability of this approach has been demonstrated by analyzing the evolution over the past 1000 years of the SES in China's Loess Plateau (LP). Five evolutionary phases were identified: "fast expansion of cultivation," "slow expansion of cultivation," "landscape engineering for higher production," "transition from cultivation to ecological conservation," and "revegetation for environment." Our study establishes empirical links between the state (phase) of a SES to its drivers and effects. Lessons of single-goal driven and locally focused SES management in the LP, which did not consider these links, have important implications to long-term planning and policy formulation of SES.

Fig. 3-1-27 Cover of the magazine.

Research on the Triggering Mechanisms of the Late Ordovician Mass Extinction

Wiping out around 85% of marine species globally, the Late Ordovician Mass Extinction (LOME) of about 440 million years ago has been ranked as the second greatest dying in the past 540 million years. However, the trigger and causes of the LOME remain elusive. Supported by National Natural Science Foundation of China (Science Fund for Creative Research Group: 41721002,International Regional Joint Research Program:41520104007), a research team led by SHEN Yanan at the University of Science and Technology of China, examined multiple S-isotopic compositions of pyrites from the Late Ordovician – Early Silurian sedimentary rocks in South China. The high-precision S-isotopic data show that the S-isotope mass-independent fractionation (S-MIF) anomalies appeared during the time of intense volcanic eruptions but vanished when the volcanisms were gone (Fig. 1). Therefore, the research team suggested that stratospheric volcanic eruptions may have triggered the LOME.

According to the study, the Late Ordovician volcanic eruptions may have ejected large amounts of S-bearing gases and volcanic materials into the stratosphere where sulfate aerosols were formed (Fig. 2). The stratospheric sulfate aerosols can backscatter incoming short-wave solar radiation and absorb outgoing long-wave radiation, leading to global cooling at the Earth's surface. At or above the ozone layer in stratosphere, photochemical reactions of the S-bearing gases produce S-MIF that may have deposited to the Earth's surface environments. After short-term cooling, emission of greenhouse gases may have resulted in global warming, ocean acidification and anoxia. Therefore, the synergetic global climate changes and oceanic environmental deterioration may have led to the LOME.

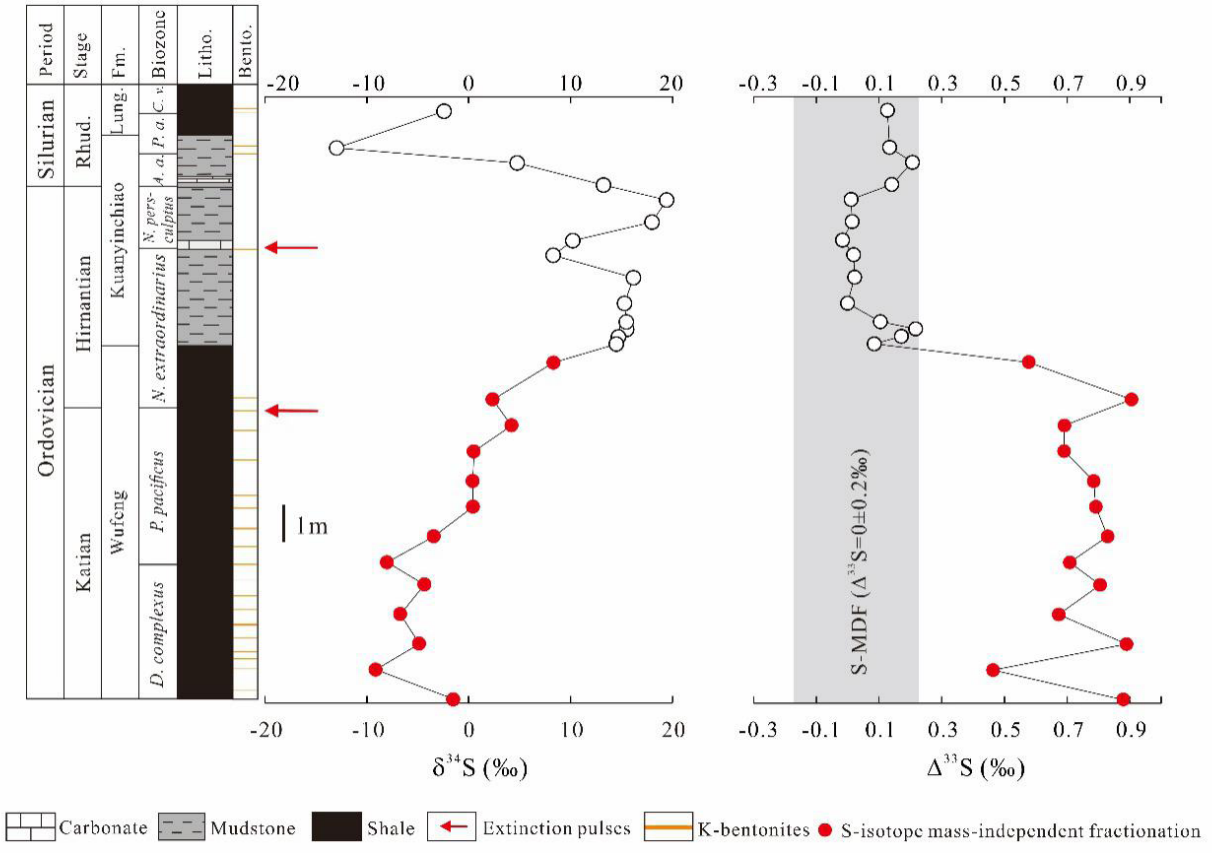


Fig.3-1-28 S-isotopic data of Late Ordovician – Early Silurian pyrites from South China.

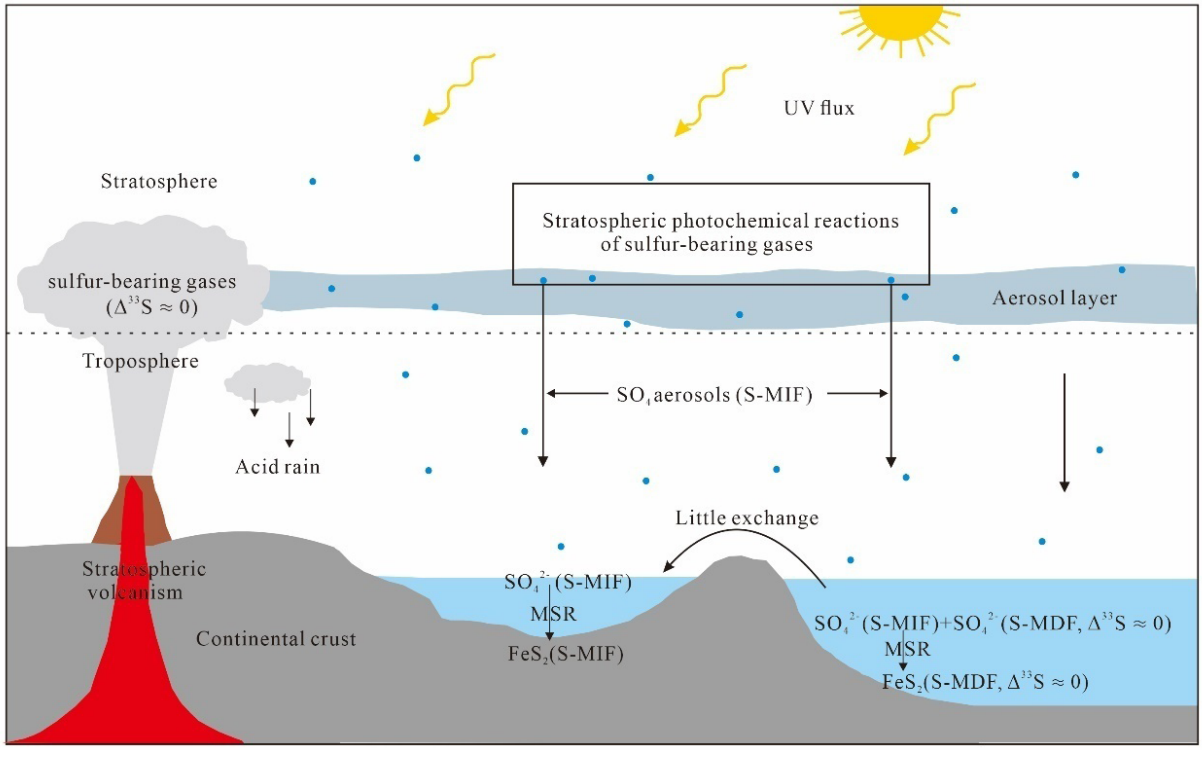


Fig.3-1-29 Proposed sulfur cycle for the stratospheric volcanic eruptions. UV: ultraviolet, S-MIF: S-isotope mass-independent fractionation, S-MDF: S-isotope mass-dependent fractionation, MSR: microbial sulfate reduction.

The S-MIF anomalies in the Late Ordovician rocks provide new insights into our understandings of the LOME, and the findings also contribute to our understanding of today's climate changes. The satellite observational data indicate that sulfate concentration in stratosphere has risen continuously in the past 50 years. The rise of sulfate concentration in stratosphere can be attributed to the emission of S-bearing gases by human activities. But there are researches suggest that the cause could be the continuous emission of volcanic eruptions. The high-precision S-isotopic analysis of aerosols may help to better understand the sources of increasing sulfate in the stratosphere. The study entitled "Large Mass-Independent Sulphur Isotope Anomalies Link Stratospheric Volcanism to the Late Ordovician Mass Extinction" was published in *Nature Communications*.

Research on the New Mechanism of the Formation of Multiple Transpolar Aurora Arcs

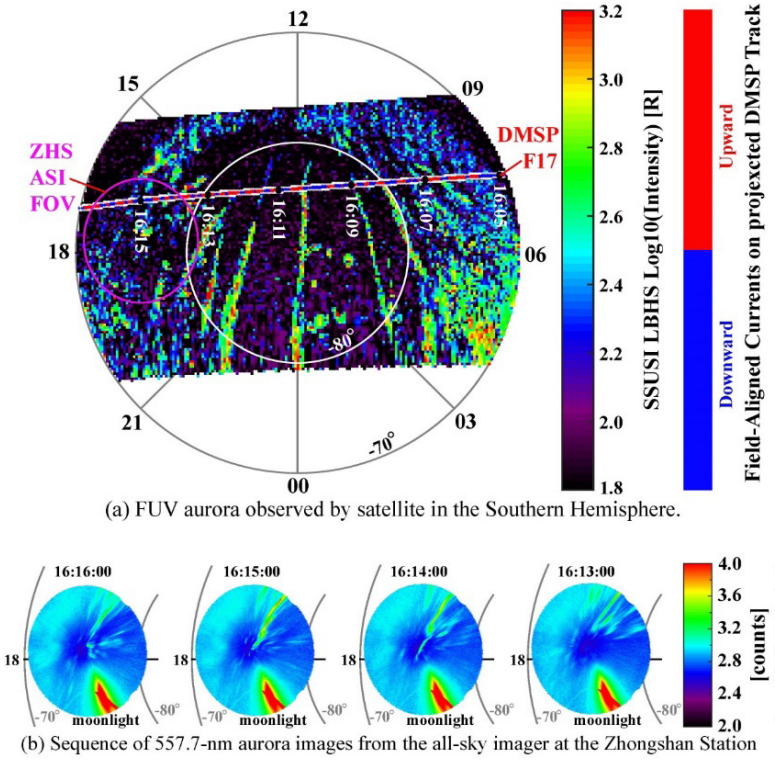
Transpolar aurora arcs appear in the extremely high latitude ionosphere of the Earth generally under a quiet geomagnetic condition, which is a typical tracker of the coupling processes of solar wind-magnetosphere-ionosphere. However, until now the formation mechanism of the transpolar arcs, in particular the multiple transpolar arcs, is still unclear due to the scarce observations within the gigantic region of magnetosphere and ionosphere as well as the bare polar region.

Supported by the National Natural Science Foundation of China (General Program: 41874170, 41574138;Young Scientists Fund: 41604139, Key Program: 41431072), an international research team, led by Prof. ZHANGQinghe from the Shandong University, Prof. WANGChi from National Space Science Center of Chinese Academy of Sciences, and Prof. ZHANGYongliang from the Applied Physics Laboratory of Johns Hopkins University, has revealed a new formation mechanism of multiple transpolar aurora arcs by comparing the observations from DMSP satellites and All-sky image at Zhongshan station with the 3-dimension simulations.

With the focus on the frontier topics of the coupling of magnetosphere and ionosphere over the polar region and space weather, the research team reported a novel mechanism of forming the bright multiple transpolar aurora arcs by using the ground/satellite-based joint-observation and PPMLR-MHD simulations. On 7 September 2017, at least six bright transpolar aurora arcs were observed in the polar cap simultaneously, with some arcs even brighter than the main auroral oval. These observations and simulations showed that a couple of stretched flow shear sheets were generated from the interaction of the strong solar wind and magnetosphere during this quiet period, which produced multiple extended field-aligned current sheets in the magnetotail (as long as dozens or even hundreds of Earth's radii). These field-aligned current sheets can effectively accelerate the magnetospheric electrons to move along the magnetic field lines and precipitate into the polar ionosphere, forming multiple transpolar aurora arcs. Furthermore, the team further discovered that this formation mechanism can be used to explain almost all aurora arcs in the polar region.

This study discovered a new mechanism of the formation of aurora arcs and unveiled the mystery of multiple transpolar aurora arcs over the Earth's north and south poles, significantly improving our understanding of the formation of aurora arcs.

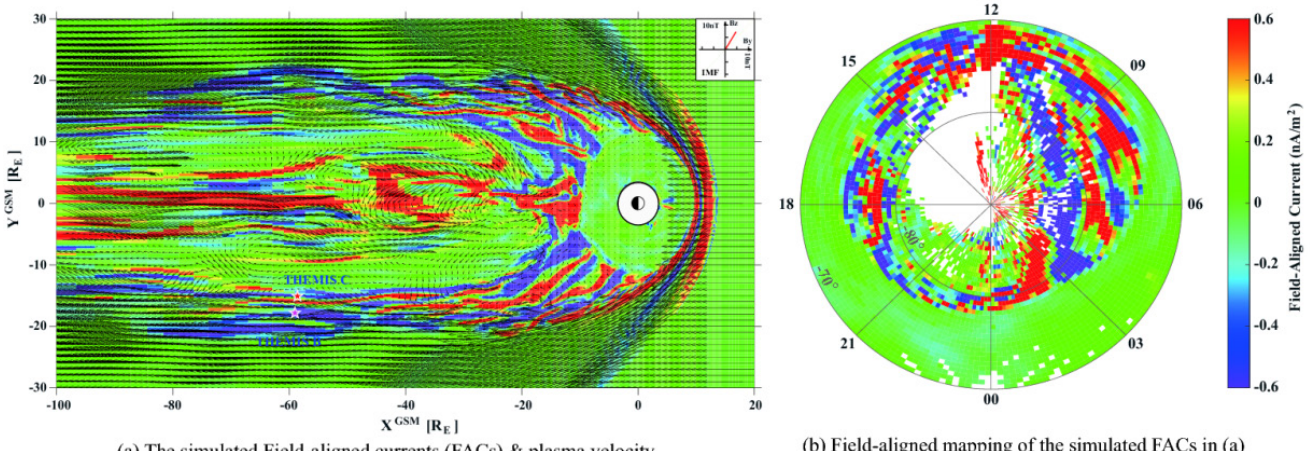
The research results, entitled "Multiple Transpolar Aurora Arcs Reveal Insight about Coupling Processes in the Earth's Magnetotail",were published on the journal *Proceedings of the National Academy of Sciences of the United States of America*on 29 June,2020 .



(a) FUV aurora observed by satellite in the Southern Hemisphere.

(b) Sequence of 557.7-nm aurora images from the all-sky imager at the Zhongshan Station

Fig.3-1-30 Satellite and ground-based observations of aurora and Field-aligned-currents (FACs) in the Southern Hemisphere between 16:05:00-16:16:00 UT on 07 Sep 2017.



(a) The simulated Field-aligned currents (FACs) & plasma velocity

(b) Field-aligned mapping of the simulated FACs in (a) to the ionosphere in the Southern Hemisphere

Fig.3-1-31 The FACs and plasma velocity vectors in the Earth's magnetospheric equatorial plane at 16:10:00 UT on 07 Sep 2017 simulated by PPMLR-MHD model at NSSC CAS, and the field-aligned mapping of these FACs to the ionosphere in the Southern Hemisphere.

Significant progress has been made in the study of the causes of heavy haze pollution during the COVID-19 Lockdown in China

Even though the COVID-19 has caused enormous restrictions to the social and economic activities, the fact that the eastern part of China still faces serious haze pollution has aroused the high concern of the government and the public, and also created an opportunity to re-understand the mechanism of atmospheric composite pollution formation and evaluate the effectiveness of prevention and control measures in China. Funded by the National Natural Science Foundation of China (Outstanding Youth Fund Project 41725020, 4162502020, Excellent Youth Fund Project 41922038, Major Research Plan Project 41921005), the research team led by Prof. Aijun Ding of Nanjing University and Prof. QiangZhang of Tsinghua University, etc., discovered the causes of air pollution during the COVID-19 epidemic based on methods such as emission estimation, field measurement and satellite data, as well as numerical modeling, and put forward control measures.

The study found that during the lockdown period, the intensity of man-made activity represented by transportation decreased significantly, resulting in a decrease in the concentration of nitrogen oxides and primary particulate matter, but the nonlinear response relationship of ozone to nitrogen oxides led to a significant increase in ozone concentrations in the entire eastern region of China including the Beijing-Tianjin-Hebei and the Yangtze River Delta area. The subsequent increase in atmospheric oxidants (such as daytime hydroxyl free radicals and nighttime nitrogen trioxide free radicals) accelerated the conversion of gaseous pollutants to secondary particulate matter throughout the region. Therefore, under the worse meteorological conditions, the accumulation of secondary particulate matter was obviously more than the reduction of particulate matter. Based on the systematic analysis of the nonlinear response of ozone and secondary particulate matter to nitrogen oxides and volatile organic compounds (VOCs)reduction, this study puts forward that there is an urgent need to consider "cross-regional and multi-pollutant emission reduction" in the prevention and control of atmospheric composite pollution in autumn and winter.On one hand, comprehensive consideration should be given to the coordinated control of ozone and $PM_{2.5}$ by reducing emissions of different pollutants, and the effective control of nitrogen oxides should also increase the intensity of emission reduction of VOCs. Unbalanced single source emission reduction is prone to

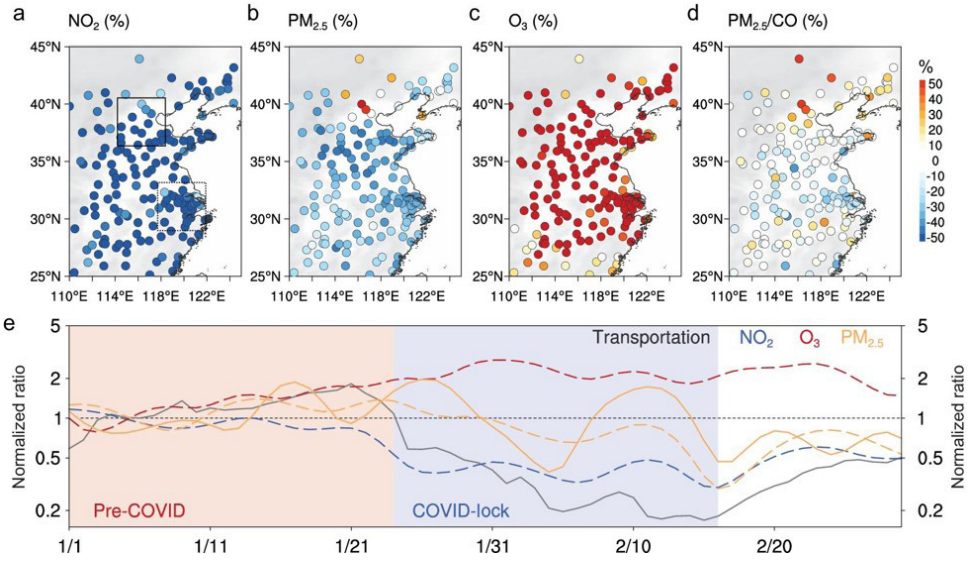


Fig. 3-1-32 Changes in air quality before and during the COVID-19 lockdown in eastern China

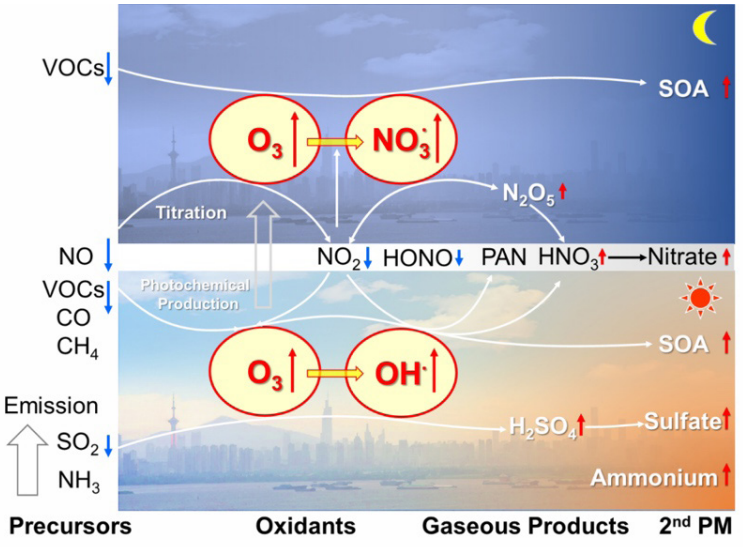


Fig. 3-1-33 Conceptual model showing how the secondary formation offsets the reduction of primary pollutions in China with different processes during the day and night.

increased atmospheric oxidation, but offset the local and even the entire region pollution source emission control and air quality improvement results.

This research, published in *National Science Review* entitled "Enhanced secondary pollution offset reduction of primary emissions during COVID-19 lockdown in China", show the nonlinearity and complexity of air pollution in China by direct observational evidences, and propose the strategy of "cross-regional organic linkage and multi-pollutant co-emission reduction", which provides an important scientific basis for the prevention and control of atmospheric pollution complex in eastern China, especially the $PM_{2.5}$ and ozone co-control, and indicates the future direction of emission reduction in China.

Microbial siderophore robustly predict soil health

Soil-borne pathogens are a major threat for the global food supply, reducing both yield and quality. Before pathogens invade the roots of crops, the rhizosphere microorganisms of crops can compete for resources, especially for scarce key nutrients, to inhibit the invasion of pathogens, though the relevant evidence is still lacking and the mechanism is unclear. Supported by the National Natural Science Foundation of China (Talent Youth project 41922053, Youth project 41807045), the research team of rhizosphere Micro-ecology (LorMe) led by of Professor Zhong WEI from the Nanjing Agricultural University have made a breakthrough in the domain of microecology and rhizosphere health. In collaboration with scientists from Switzerland, the Netherlands and the United Kingdom, Prof. WEI and his team has revealed competition for iron as a universal mechanism to predict the ability of the rhizosphere microbiome to protect plant from pathogen infection. Main results are as follows.

1. The growth ability of more than 2000 strains of bacteria isolated from rhizosphere soil under iron-restricted and iron-rich culture conditions and their influence on the growth of pathogens were studied, and it was found that Fe3+ is the core scarce resource that rhizosphere microorganisms and soil-borne pathogens compete for. And secretion of low-molecular-weight compounds that can chelate Fe3+-siderophore is a common mechanism for bacteria to adapt to the iron-deficiency environment and competition from pathogens (Fig. 3-1-34).

2. Through the research on the interaction characteristics of more than 40,000 groups of microorganisms in the room and the comprehensive analysis of the big data of the soil microbiome in the field, it was found that the bacteria that produce inhibitory siderophores have strong coexistence and competition ability with pathogenic bacteria in the crop rhizosphere, and produce convenient iron. The carrier's rhizosphere bacteria and pathogenic bacteria have a weak coexistence and competition ability, which supports the importance of siderophore-mediated microbial-pathogen interaction for the invasion of rhizosphere pathogens and crop health.

3. Through a large-scale greenhouse pot experiment, it was further discovered that by adding beneficial microorganisms with high yield and siderophores to the rhizosphere soil during the seedling stage of plants in advance that would not be 'stolen' by pathogens, it can win the battle for scarce iron resources in the rhizosphere□prevent the invasion of soil pathogens, and protect plant health (Fig. 3-1-35).

The work was published in *Nature Microbiology*entitled "Competition for iron drives phytopathogen control by natural rhizosphere microbiomes"on May 11, 2020. This study has been widely reported by a range of Chinese and international news agencies, including China Science News, Xinhua News Agency, Science.com, etc. Dr. Otto Cordero from the Provincial Institute of Technology gave a highlight comment in the same edition, saying as quoted *this research has bridged theoretical research and practical applications, and opened up a new idea of "iron carrier targeted therapy" for beneficial microorganisms*. This study has further inspired scientists in Switzerland and the UK to use microbial siderophore targeted therapy in the field ofgut microbiology and human health.

Fig. 3-1-34 Iron competition between pathogen and microbes (illustrated as two Chinese traditional image of dragons) in rhizosphere soil

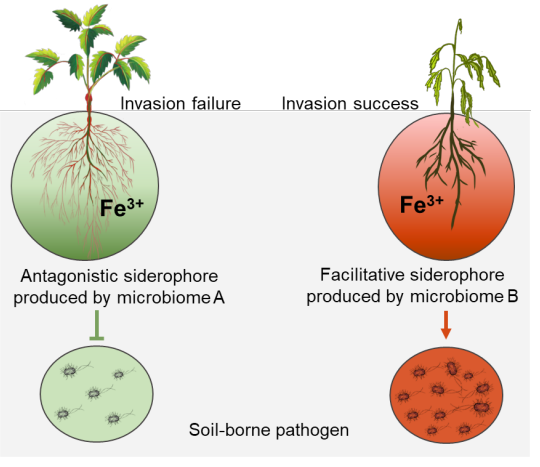


Fig. 3-1-35 Siderophore mediated iron competition between bacteria and pathogen in the rhizospheredetermines plant health

High strength and high toughness metallic materials

Lightweight yet cost-efficient structural materials with superior mechanical properties are continually sought after in engineering applications to meet the demands of sustainable economy development. Unfortunately, attaining high strength is usually at the expense of deteriorating toughness, which invariably is a major concern for safety-critical applications. In particular, it is very difficult to further improve the toughness of metallic materials when their yield strength beyond 2 GPa. Material scientists and engineers are continually seeking to develop new generation steel materials which are higher in resistance to

deformation (strength) and fracture (toughness), light in weight and low in production cost.

Supported by the National Natural Science Foundation of China (Grant No. U1764252), the Super Steel project led by Professor Huang Mingxin at the Department of Mechanical Engineering of the University of Hong Kong (HKU), with collaborators at the Lawrence Berkeley National Lab (LBNL), has made major breakthrough in greatly enhancing the fracture resistance of super strong metallic materials.

(1) An ultra-strong deformed and partitioned (D&P) steel with breakthrough strength-toughness combination was developed. D&P steel has a high yield strength of ~2GPa and a superior fracture toughness of 102MPa m½. Compared with maraging steels used in aerospace (e.g., Grade 300 Maraging Steel with a yield strength of 1.8 GPa and a toughness of 70 MPa·m½) , the low-cost D&P steel demonstrates a much higher yield strength but maintaining a much better toughness (Fig. 3-1-26).

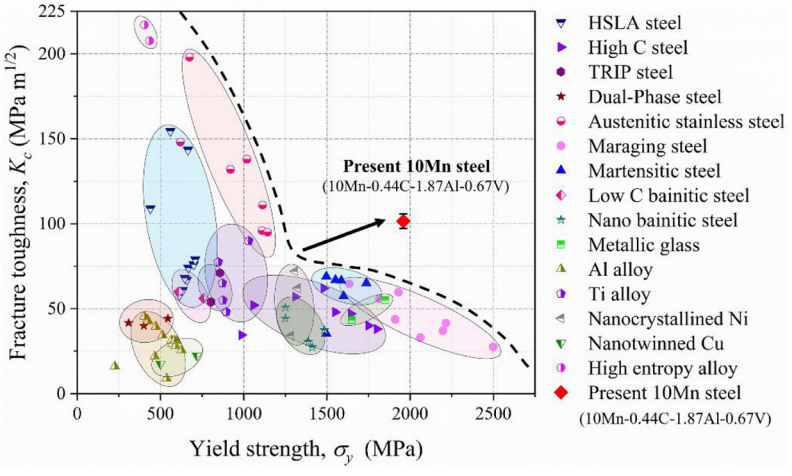


Fig. 3-1-36 Yield strength-toughness and of the present breakthrough D&P steel compared with other existing high strength metallic materials.

(2) A novel "high-strength induced multi-delamination" toughening mechanism was developed, breaking the traditional view that improving strength deteriorates toughness (Fig. 3-1-27). The super steel has a unique fracture feature in which multiple micro-cracks are formed below the main fracture surface. These micro-cracks can effectively absorb energy from externally applied forces, resulting in the steel's much higher toughness resistance compared with existing steel materials. The new science can be widely applied to optimize the mechanical performance of materials with ultrahigh strength.

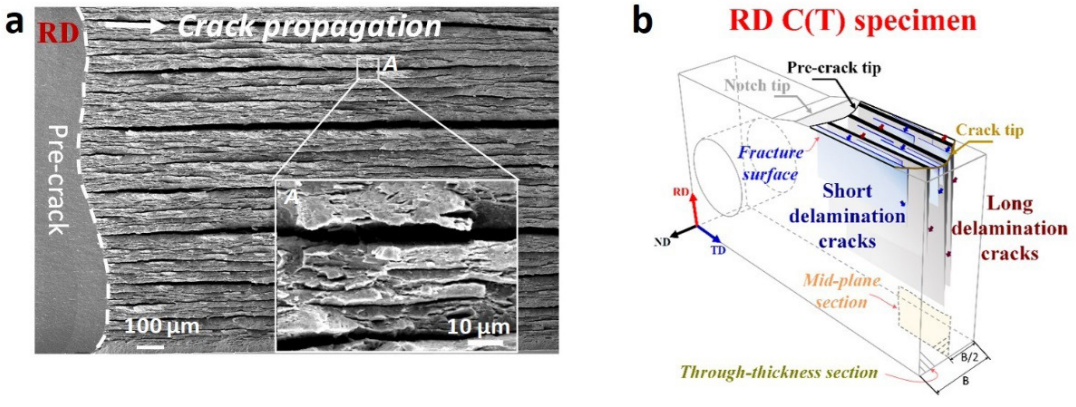


Fig. 3-1-37 The fracture surface and schematic diagram of toughening mechanism of D&P steel. (a) The fracture surface of D&P steel, showing intensive delamination cracks. (b) The schematic diagram of the D&P C(T) specimen, showing the direction of delamination.

The findings were published in *Science* on May 8, 2020 entitled "Making Ultrastrong Steel Tough by Grain-Boundary Delamination". The Advanced Alloys group lead by Prof. Huang's has published more than 100 SCI journal papers, including 2 Science papers and 16 Acta Materialia papers, and have been cited more than 3,300 times and has an H-index of 29. The in-depth research on D&P steel, TWIP steel and Mg alloy developed by Prof. Huang's group sheds light on the new science of metallic structural materials. Moreover, the research group has been collaborating with industrial partners such as General Motors and Baosteel, providing scientific support for the innovation of advanced metallic materials.

Research progress in the preparation technology of meter-scale high-index single-crystal copper foil library

As a key material in the context of technologgical development, copper is not only widely used in traditional power equipment and electronic devices, but also an important growth substrate in research of novel two-dimensional materials. However, most of the copper we currently use is polycrystalline: on one hand, there are numerous grain boundaries, causing the significant reduction of its intrinsic electrical and thermal conductivity; on the other hand, the surface orientation of polycrystalline copper is unaligned, and cannot be used to grow two-dimensional single crystal as the epitaxial substrate.At present, although single-crystal copper ingots can be prepared by the Czochralski method, and specific facets of as-prepared single-crystal copper can be obtained through mechanical cutting, such single-crystal copper usually comes with the drawbacks of small size, high cost, and limited facets, making it hard to be promoted and applied. Therefore, it is urgent to develop the preparation technology of large-size single-crystal copper with various facets, to lay an important material foundation for the advanced manufacturing industry in China. Supported by the National Natural Science Foundation of China (Grant No. 51991340, 51522201), a Peking University – Songshan Lake Materials Laboratory – Southern University of Science and Technology joint research team led by Academician EngeWang, Academician Dapeng Yu and Prof. KaihuiLiu has developed a serial preparation technology of single crystal-copper foil with the collaborators, and realized the preparation of single-crystal copper foil library with the high-index facets more than 30 kinds, as well as the size of A4 paper (~ 0.2 m ´0.3 m). Also, they have achieved the following important innovations:

(1) Brand-new "nucleation" mechanism of single-crystal copper is proposed. It transforms the traditional surface energy driven growth into the interface energy driven process, and thereby breaks the absolute advantage of low-index facets during the annealing, leading to preparation of single-crystal copper foil library with the high-index facets (shown in Fig. 3-1-38).

(2) The "genetic" growth technology of single-crystal copper foil is developed. As-prepared high-index single-crystal copper is used as the "seed crystal", to directly induce the "nucleation" of polycrystalline copper foil for growth, so as to realize the directly replication preparation of single-crystal copper foil with the targeted facet(shown in Fig. 3-1-39).

This research has achieved the preparation of meter-scale high-index single-crystal copper foil library for the first time in the world, providing a new technological path for single crystal-copper manufacturing. At the same time, the proposed mechanism and method are universal that can be applied to the manufacture of other single-crystal metals and alloy materials. The research results are published in *Nature* on May 27, 2020, entitled "Seeded growth of large single-crystal copper foils with high-index facets". So far, the pilot production lines of this manufacturing technology areunder rapid construction. In the future, they will be able to fully supply the highly customized single-crystal copper materials for the manufacturing of advanced power equipment, research and development of high-end electronic devices, and the preparation of meter-scale two-dimensional single crystals in China.

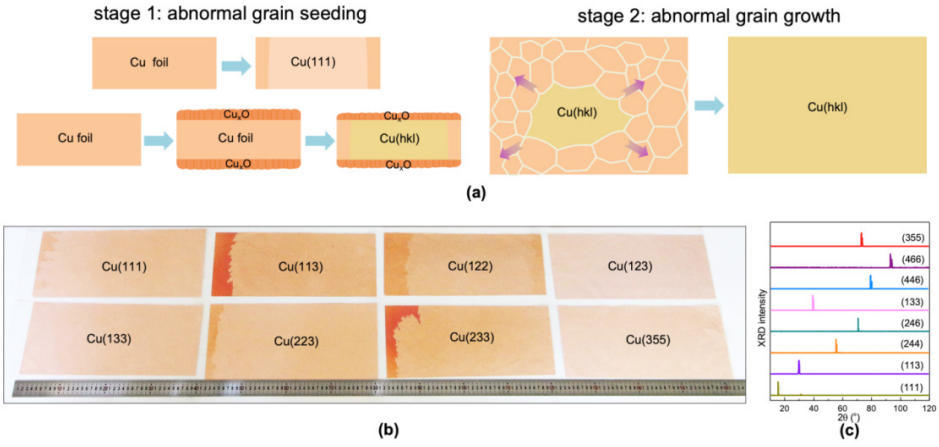


Fig.3-1-38 Preparation of large-size single-crystal copper foil library

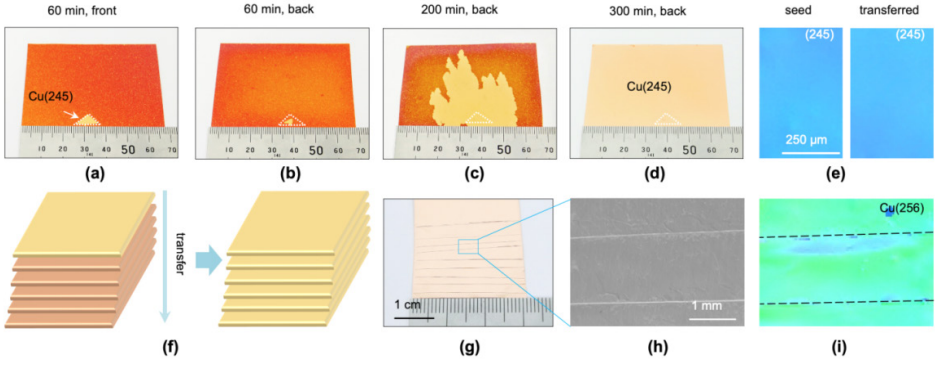


Fig.3-1-39 Replication preparation of single-crystal copper foil with targeted facet

Oil and gasflowtheory in unconventional reservoir

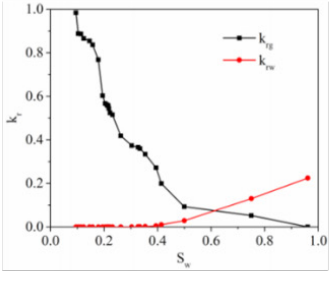
Supported by the National Natural Science Foundation of China (Grant No. 51234007, 52034010, 51490654), the research team led by Prof. Jun Yao at China University of Petroleum (East China) conducted simulation research on fluid flow in porous media at different scales including nano-scale (molecular level), micro-scale (pore level), centi-scale (core level), meter-scale (Darcy level), and fracture-vug scale (hectometer level). The multi-scale-multi-field coupled modern oil and gas flow theory is established by upscaling and the combination of continuous medium model and discrete medium model. The established theory has put forward the advances of oil and gas engineering technique and led to the development of oil and gas flow mechanics internationally. The major scientific discoveries which are made by the research group include:

(1) In view of the characteristics of multi-scale and multi-migration mechanism of unconventional oil and gas reservoirs, the "electric resonance" phenomenon, with a controllable flow rate, was discovered at nano-scale (Fig. 3-1-40). Nano-micro pore level fluid flow simulation method was established based on multi-scale digital rock and pore network model, which has solved the bottleneck problem of coupling the nano-micro fluid transport mechanisms with macro-scale flow pattern. A novel numerical simulation method of unconventional oil and gas reservoirs has been established on this basis, and substantial contribution has been made to the development of Fuling and Pengshui shale gas reservoirs in China.

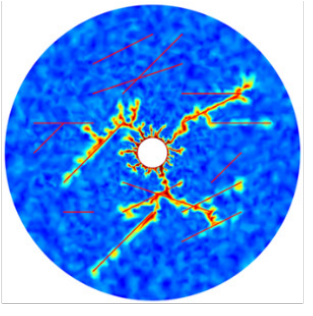
(2) My country's fracture-cavity carbonate rock has a huge amount of oil and gas resources, with many types of voids (pores, fractures and caves), large scale differences, strong heterogeneity, and the coexistence of seepage and cave free flow. The discrete fracture–vugnetwork (DFVN) model was proposed for the first time to solve the problem of coupling between flow in porous media and free flow which cannot be described by conventional mechanics of flow in porous media. The fracture-vug carbonate reservoirs in China are abundant with oil and gas resources and have the characteristics of multiple storage type (pore, fracture, vug), notable scale difference, strong heterogeneity and multiple flow regimes (porous media flow coupled with free low), etc. Based on the proposed model, a new generation of numerical simulation method has been established for fracture-vug carbonate reservoirs, which laid the theoretical foundation and technical support for the development of Sinopec Tahe and CNOOC Tarim fracture-vuggy carbonate reservoirs.

The work has won the second prize of National Scientific and Technological Progress Award, second prize of National Award for Technological Invention and the first prize of the Natural Science Award from the Ministry of Education. 8 monographs including 2 monographs in English and many papers have been published in the past years. According to Web of Science statistics, the amount of published SCI papers BY Prof. Jun Yao's research group rank 1th in in terms of the theme of "shale digital rock/pore network model" and "fractured vuggy carbonate reservoir numerical simulation". Prof. Jun Yao has given 15 invited talks on international academic meetings and serves as member of the academic committee of International Society for Porous Media (INTERPORE), director and founder of INTERPORE China chapter, co-founder of International Centre for Carbonate Reservoirs, group leader of flow mechanics in porous media in the Chinese Society of Theoretical and Applied Mechanics and director of Ministry of Education "Cheung Kong Scholars" innovation team. It is for the first time that the meeting is held outside the European and American countries. Prof. Jun Yao has won the highest award "SPE honorary membership" of Society of Petroleum Engineers (SPE) in 2020, = as the first Chinese scholar to win this prize since its inception in 1941. There are only 156 awardees for SPE honorary membership globally to date. Prof. Jun Yao's research group has won the competition as the host of INTERPORE 2020 annual meeting, which is the top international meeting in the field of seepage mechanics.

Shale multi-scale pore network model Resolution: 12nm, Throat amount:624537, Pore amount:307820
Physical size: 14.4μm ×14.4μm×14.4μm



Calculated shale gas-water relative permeability curve based on pore network model



Extension of dissolved wormholes caused by acid fracturing in shale gas reservoir

Fig.3-1-40 Pore scale and macro scale fluid flow simulation and application in unconventional oil and gas reservoirs

Innovation for Key Technologies of Healthyand Energy-Efficient Environment for Public Buildings

In order to fulfil the international commitment for emissions to peak by 2030 and carbon neutralization by 2060, and carry out the new people-oriented urbanization development,China's construction industry is faced with the dual challenges of energy conservation and emission reduction and environmental quality improvement, where the development of green buildings is the key. The research team led by Prof. Lin Borong team at Tsinghua University has been focusing on the research of indoor environment improvement and energy conservation in green buildings. Supported by the National Natural Science Foundation of China (National Outstanding Youth Science Foundation 51825802), the team has carried out research on the basic theory and key technology in the aspects of influence mechanism between indoor environment and human, the integration of space energy saving and system energy saving, and the innovation of new environmental control system. Important improvement regarding the method and key technological innovation have been achieved.

(1) A new method of constructing dynamic indoor environment in green public buildingswas proposed. The influencing factors and coupling mechanism of energy consumption, indoor environmental parameters and user satisfaction were revealed. The method of constructing dynamic indoor thermal environment by scientifically combining key elements including non-uniform thermal parameters, dynamic airflow, space streamline and time was proposed, and it could achieve 20%-40%energy saving in air conditioning system, and was adopted by many national standards and applied to new products of many air conditioning enterprises.

(2) A key technology has been adopted to optimizing thedesign for public green buildingsfeaturing performance improvement.A new model for rapid prediction of building heating, air-conditioning and lighting energy consumption in the project phase was proposed. The method of design facilitation that works both onwards and backwards anda new technology that draws and simulates simultaneously (Fig. 3-1-41) have been developed for the first time, with the purpose of improving environment and energy consumption performance. As a result, the calculation time is saved by 40%, the design efficiency is increased by more than 30%, and the energy-saving rate of the building itself exceeds 60%. And a standardized method for building green performance simulation calculation and a new platform for collaborative design of mechanical and electrical equipment systems based on BIM have been established, contributing to one of the industry standards as the main compiler.

(3) Environmental health and safety identification and diagnosis, risk early warning and guarantee technologies based on analysis of spatial and temporal distribution characteristics of indoor environmental parameters were developed. A new identification and diagnosis method based on the dynamic field characteristics of indoor environment was proposed, which revealed the spatial and temporal distribution characteristics and dynamic regulations of typical indoor environmental parameters. The technology of real-time warning on the health and safety risk of indoor environment for typical public building space (Fig .3-1-42) was developed, which promoted the informatization of building health risk prevention and control and the environmental retrofit of key areas.

In the past years, more than 30 SCI papers were published, and 4 patents and 3 computer software copyrights were granted.The findings have been expanded in more than 10 large Grade A architectural design institutes in China, fully applied in more than 40 high performance green public building projects, and directly supported the green design and operation of a number of major projects such as Beijing Daxing International Airport, China Zun (Beijing Supreme Building) and so on. The findings were used for the design of designated hospitals such as Huo Shen Shan, Lei Shen Shan and JinYintan in Wuhan, , helping

to quickly and accurately identify and exclude 15 high-risk areas of the virusinfection (including isolation/ protection areas, ICU areas and isolation wards), which provided scientific and technological supports for the safety of first-line medical staff. This achievement is also the second project introduced at the press conference on anti- COVID-19 researches of Tsinghua University on April 2. As the first accomplisher, Prof. Lin won the second prize of the National Science and Technology Progress Award at 2019, China Changjiang Scholars Distinguished Professor of Ministry of Education at 2019and 2020 "Xplorer Prize".

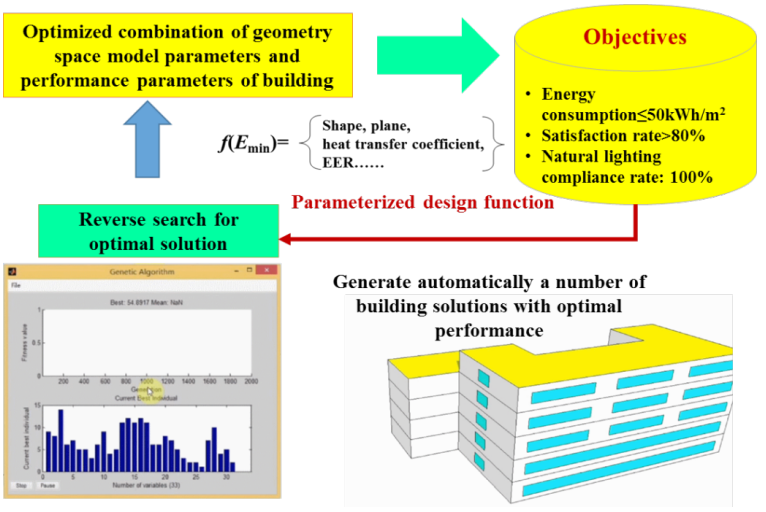
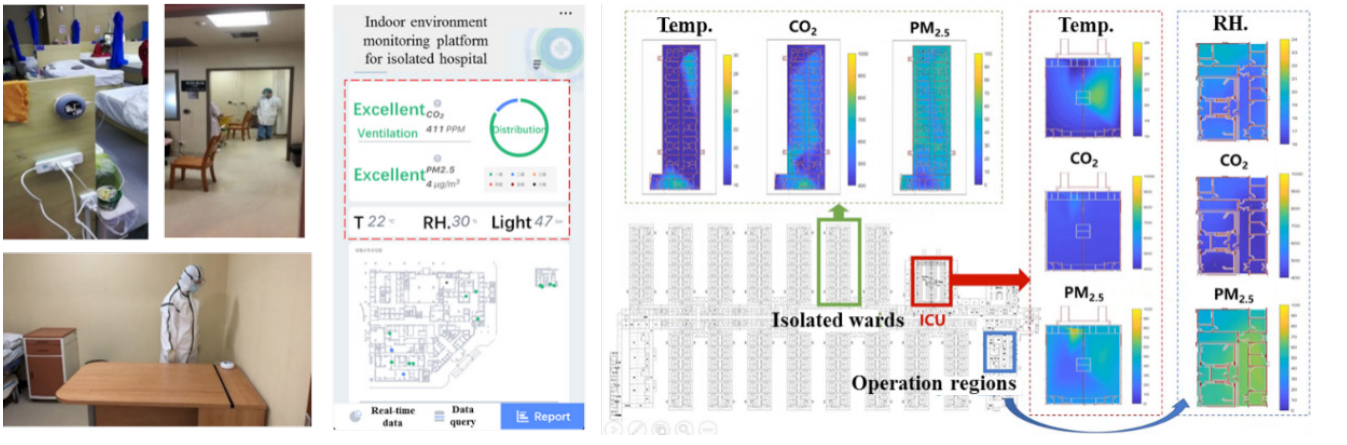


Fig. 3-1-41 Reverse generation method of construction scheme with energy saving as target



(a) Environment monitoring in isolated hospitals

(b) Data visualization and early warning platform

(c) Assist medical staff to quickly and accurately identify areas at high risk of the virus

Fig.3-1-42 Real-time warning technology for environmental health risks in buildings and its application in isolated hospitals

Cascade hydropower reservoirs impact on river biogeochemical cycling

There hasbeen a long dispute worldwide on the effects of river damming on biogeochemical cycling of biogenic elements and emission of greenhouse gas from reservoirs. Such disputes have caused a bottleneck in sustainable hydropower development, and even jeopardized regional geopolitical cooperation. Supported by the National Natural Science Foundation of China (Grant No. 91547206,

51425902), the research team from Nanjing Hydraulic Research Institute, together with international colleagues, has made novel achievements in these challenging issues as follows.

(1) Revealed the changes in fluxes and forms of major nutrients (nitrogen, phosphorus, carbon and silicon) as well as the associated mechanisms along the cascade reservoirs in the Lancang-Mekong River. It is discovered that a cascade of reservoirs along the upper Mekong River increased downstream bioavailability of nitrogen and phosphorus, despite possible interception of total nitrogen and phosphorus. The core mechanism is the synergic effect of increased hydraulic residence time and the development of hypoxic conditions due to stratification and organic matter accumulation, which results in release of nutrients from the sediment and subsequent accumulation of ammonium that are dispatched downstream from the base of the reservoirs (Fig. 3-1-43).

(2) Highlighted river damming impacts on biogeochemical cycling of biogenic elements and the consequent effects in source-to-sea material fluxes at a global scale. Systematically reviewed the changes in nutrients ratios, greenhouse gas emission, nutrient regime changes in reservoirs and downstream, as well as the associated mechanisms. Particularly, the study developed a method to quantify these effects and proposed suggestions to reservoir planning and operations: design and manage hydraulic residence time to mitigate nutrient sedimentation and greenhouse gas emission, which should be implemented during the whole life span of a reservoir (Fig. 3-1-44).

The development of hydropower is a key strategy to securing national energy safety and improving energy structure to meet the treaty on carbon neutrality as well as poverty relief in mountainous regions. However, the impacts of river damming, especially in international rivers such as Lancang-Mekong, Brahmaputra, Amazon and Nile, on biogeochemical cycling and the eco-environmental consequences have received increasing concerns from public. These groundbreaking findings might overturn the long-

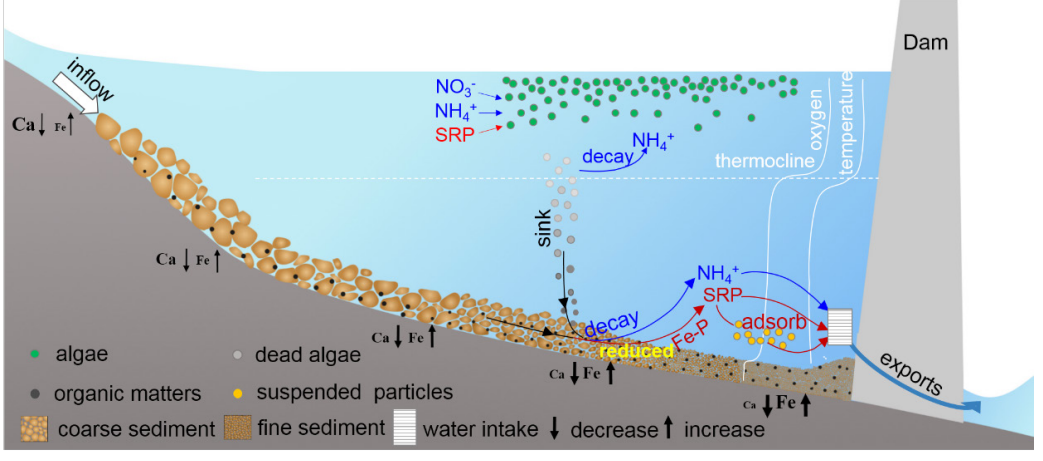


Fig.3-1-43 Transfer and transport of nitrogen and phosphorus in large reservoirs

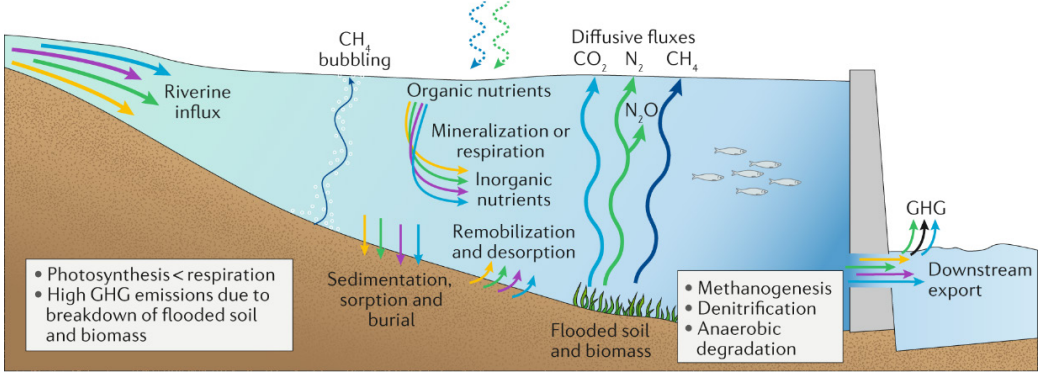


Fig.3-1-44 Biogeochemical cycling of biogenic elements during reservoir life span

term perception on the effects of hydropower development on nutrient regimes in dammed rivers, which could provide a brand-new perspective to support the Lancang-Mekong geo-political collaborations and sustainable hydropower development worldwide.

The study has been published in series in prestigious journals, including *National Science Review*, *Nature Reviews Earth & Environment*. The publications have received broad attention worldwide, and were dedicatedly commented by Prof. Jack Middelburg, Geochemistry Fellow and member of the Royal Netherlands Academy of Arts and Sciences. Owing to the achievements, the primary investigator, Prof. Qiuwen Chen, has received the 20th Arthur Thomas Ippen Award from International Association for Hydro-Environment Engineering and Research, and the Xplorer Prize in 2020.

The innovation and application of key technology of otology imaging

Tinnitus, deafness, dizziness are the three main symptoms of otological diseases. The number of patients with these three symptoms reach 220 million, 110million and 70 million in our country, respectively. Otological diseases, with a high disease incidence and severe harm to the physical and mental health, are major health problems affecting people's livelihood. The otological diseases are usually featured by deep anatomical location and small size. CT is the only way to reveal bony diseases. However, limited by the resolution, general type of CT cannot reveal small sized disease.

Supported by the National Natural Science Foundation of China (Grant No. 61527807, 61931013, 61801311, 81701644), the research team of professor Wang Zhenchang from Beijing Friendship Hospital, Capital Medical University, in cooperation with the research team of professor Zhang Li from Tsinghua University, developed a CT (Type Ultra3D) with ultra high spatial resolution (50μm), . which can be used in temporal bone imaging, and proposed the medical imaging guideline for pulsatile tinnitus in China(the only one in this field).

In view of the clinical demand, they optimized voltage multiplier circuit, improved the high voltage control system, developed X-ray generator with small focus and high power. While designing the whole instrument, they proposed to use double X-ray sources-double detectors, realized the precise location with ultra high resolution with small field imaging. In order to overcome the truncate problem induced by the ultra high resolution with small field imaging, the research team innovated the truncation algorithm. Meanwhile, the research team combined innovated algorithm and hardware platform to overcome the problem of scattering blur and motion artifact. They developed an Ultra3D CT with a better spatial resolution 6 times higher compared with general type of CT. As a revolutionary development of otological imaging instrument, it is a "sharp weapon" for research and clinical diagnosis and treatment of otological diseases. Also, the team innovated a special imaging plan featuring single examination, double CT scanning and triple reconstructions, created the hypothesis that "the multi-factor linkage between the blood flow, bone, conduction and brain activity is the mechanism of tinnitus handicap. They proposed and clarified the heterogeneous characteristics of the brain network of the brain centralization of pulsatile tinnitus, and developed a multi-level biomechanical model based on image information for multi-angle verification, providing the theoretical basis

Fig. 3-1-45 CT equipment for temporal bone imaging with ultra high spatial resolution

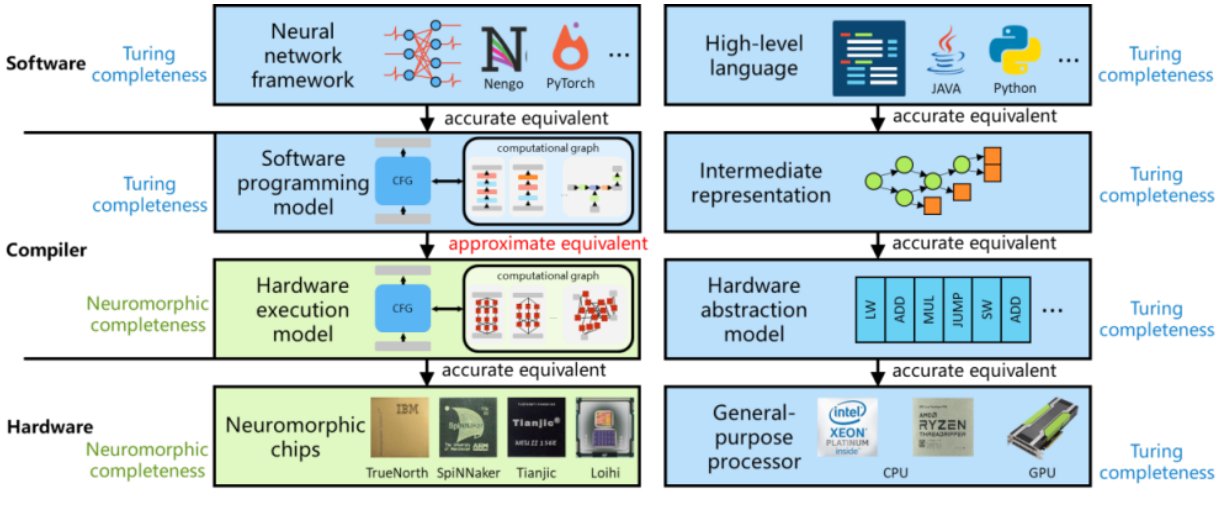
for clinical treatment decision-making. The results clarified the whole chain mechanism of pulsatile tinnitus, established a multi-factor imaging evaluation system for pulsatile tinnitus, and formulated the "Guidelines for Imaging Examination Methods and Pathways of Pulsatile Tinnitus", leading the frontier research in the field of tinnitus. The study, with 15 patents granted and a number of articles published, has greatly promoted the development of otological imaging.

Brain-inspired Computing Completeness

Brain-inspired computing refers to the general term of computing theory, computer architecture, chip design, and application models and algorithms that are inspired by the information processing mode and structure of the biological nervous system, which is believed to beone of the key paths for the development of the new generation of artificial intelligence. Further, the brain-inspired computing system is considered to be a new type of computer architecture with great potential. Its importance is as pointed out by the European Union's Human Brain Project (HBP): "In the next 10 to 20 years, whoever wants to lead the world economy must lead in this field."

Funded by the National Natural Science Foundation of China (Grant no.: 61836004), the research team led by Zhang Youhui the Department of Computer Science and Technology of Tsinghua University and the research team led by Shi Luping, together with their collaborators, published a paper entitled "A system hierarchy for brain-inspired computing" in *Nature*, putting forward the theory of "brain-inspired computing completeness" (also known as "neuromorphic completeness") and the corresponding hierarchy of brain-inspired computing system.

This is the first paper published by Chinese researchers in the field of computer architecture in *Nature*. In view of the current tight coupling of software and hardware, and the unclear application range, the authors were inspired by the hierarchy of general-purpose computers(Fig.3-1-46(b)) and proposed the "completeness of brain-inspired computing" and the corresponding hierarchy of brain-inspired computing systems (Fig. 3-1-46(a)).The authors proved the hardware completeness and compilation feasibility of the proposed system through theoretical demonstration and prototype experiments, expanded the application range of brain-inspired computing systems to support general-purpose computing, and further expanded the system optimization space by introducing a new system design dimension, which is conducive to greatly



System hierarchy of brain-inspired computing　　System hierarchy of general-purpose computing

Fig. 3-1-46　The comparison of brain-inspired computer hierarchy with the general-purpose computer hierarchy

improving computing efficiency. The review article published by *Nature* claimed that this is "a breakthrough solution" and will help "unite the work carried out by the many industrial and academic research groups in the field of neuromorphic computing."

Brain-inspired computing is currently in its infancy, and internationally recognized technical standards and solutions have not yet been formed. This achievement fills in the gaps in completeness theory and the corresponding system hierarchy, laying the foundation of feasibility and design method for the development of a new generation of brain-inspired computer architecture.

Memristor-based computing-in-memory (CIM)

The increase of computing power plays a critical role in the resurgence of artificial intelligence (AI). With deeper neural network models being deployed and larger number of parameters being used, higher requirements were raised on the power consumption and performance of computing chips. However, conventional hardware faces a performance bottleneck due to the physical separation between the data processing unit and memory unit. Novel memristor-based CIM is promising to address this issue by merging the processing and memory function in a single device, i.e. the memristor. With such CIM architecture, it saves tremendous latency and energy cost from shuttling data between computing units and memory units as in traditional von Neumann hardware, and hence is promising for a completely new computing paradigm. Research on memristor hardware so far has been mainly focused on the CIM functional demonstrations with single memristor array and also limited to fully connected neural networks for vector-matrix multiplications. Memristor-based implementation of convolutional neural network (CNN) is still missing, and it remains challenging to implement complex neural networks on multiple memristor arrays. Firstly, on the device level, it requires highly uniform and reliable memristor arrays. Secondly, on the system level, the intrinsic non-ideal effects of memristor would degrade the computing accuracy. Finally, on the architecture level, the convolution layers require sliding to continuously sample and compute multiple input patches, which is unable to match the computing efficiency of the fully connected layers.

To tackle the above challenges, the research team led by Prof. Huaqiang Wu at Tsinghua University, supported by NSFC (Grant No. 61851404), has made a breakthrough in the field of memristor-based CIM.

(1) Through innovations in the device, architecture and system perspectives, they developed memristor fabrication processes for large-scale integration and designed hybrid training method to compensate the system accuracy loss caused by the non-ideal device characteristics, which enabled the fully hardware implementation of memristor CNN.

(2) By developing and optimizing CMOS-compatible fabrication process of memristor devices, they improved the reliability of analog switching characteristics and fabricated chips with multiple (8) memristor arrays, which were then used to build a complete CIM hardware system that implemented a five-layer CNN (LeNet5).

(3) To address the issue of system accuracy loss caused by the non-ideal device characteristics, they developed hybrid training algorithm for CIM. They further developed spatial parallel technique to increase the computing efficiency on memristor arrays, where the same kernels were replicated in multiple groups of memristor arrays to boost the computing parallelism and speed up the system.

These results were published in *Nature* (issue of January 30th, 2020) entitled "Fully hardware-implemented memristor convolutional neural network". In this work, the implemented memristor CIM system (shown in Fig. 4) could achieve 110 times higher energy efficiency than Tesla V100 graphics processing units (GPU) under comparable image recognition accuracy. This work provides a new approach to address the inter- and intra-array error accumulation problem caused by nonideal memristor device characteristics,

and also pave a new way to break the memory wall bottleneck in existing computer architectures.

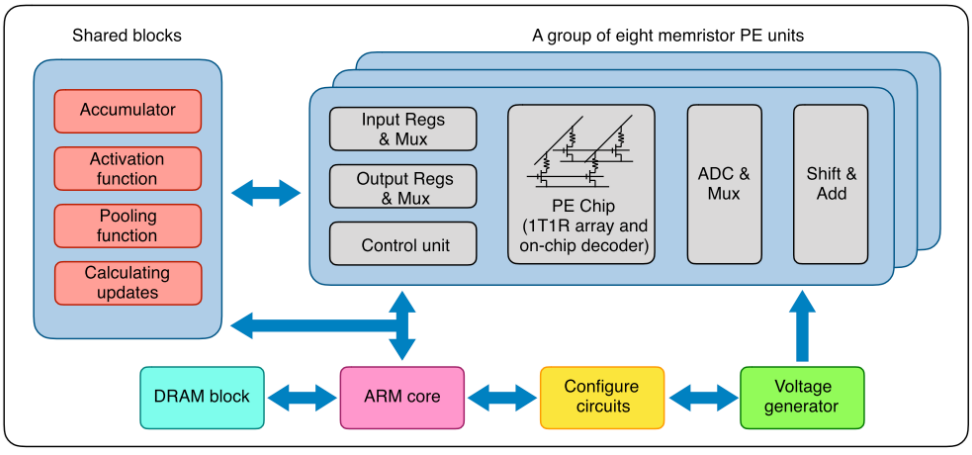


Fig. 3-1-47 System architecture of memristor-based CIM

Research upon optical unidirectional radiation

All-optical interconnection with high density, high speed and high capacity is an urgently needed technology for many applications such as high-speed communication systems, data centers, and high-performance computing. However, the transmission capability of optical links is restricted by their losses. For integrated devices particularly, a considerable portion of the losses comes from the omnidirectionality of radiation, since only part of the light can be effectively utilized. Currently, most efforts for realizing unidirectional radiation have been made upon specular reflections, such as distributed Bragg mirrors and metal mirrors. Unfortunately, the mirrors themselves are lossy and dispersive, and they are also limited by their large volume, structural complexity and fabrication difficulties, which are not friendly for photonic integrations. Therefore, realizing a compact and nondispersive on-chip device for unidirectional radiation is the key to remarkably lower the losses of optical connections and promote the scale of the integration.

To address the goals presented above, the research team led by Professor Chao Peng from Peking University (supported by National Natural Science Foundation of China, No. 61922004) and his collaborators proposed a new technology to realize unidirectional radiation upon single-layer silicon platforms without bottom mirrors:

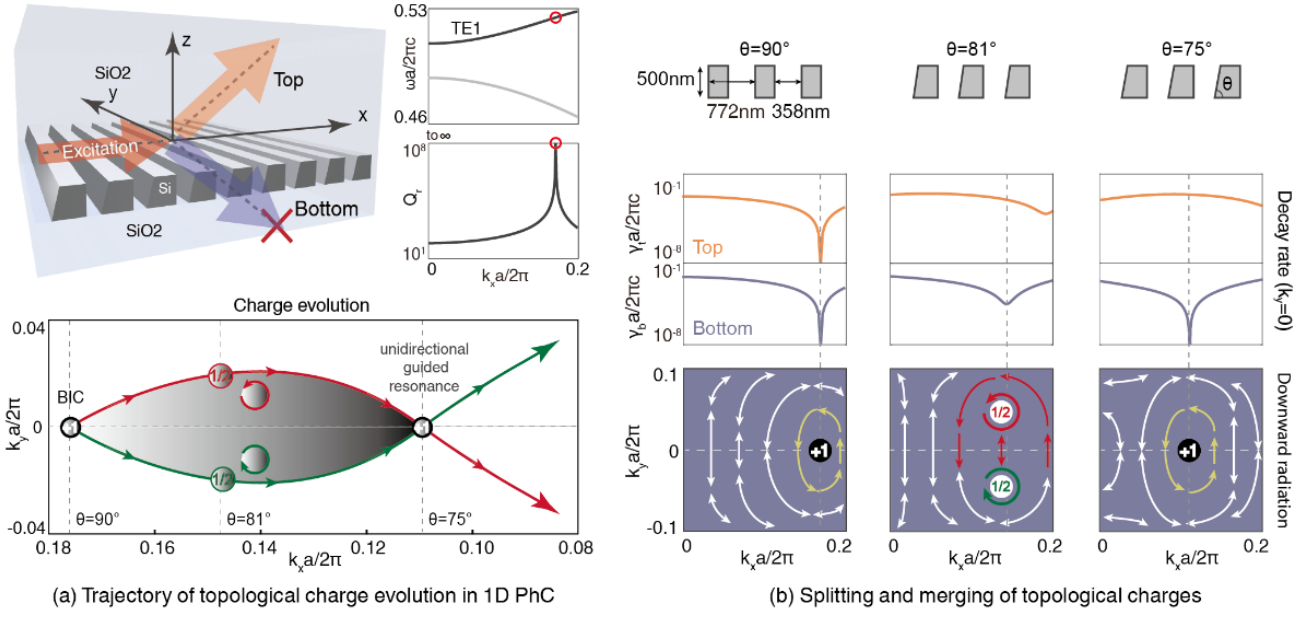
(1) By manipulating the topological charges, the researchers realized a novel type of resonance in photonic crystal (PhC) slab: unidirectional guided-resonance (UGR).

(2) In a one-dimensional (1D) photonic crystal (PhC), both vertical and in-plane symmetries are broken by tilting the side walls, which splits the integer topological charge carried by the bound states in continuum (BIC) into a pair of half-integer topological charges, thus generating unequal radiations from top and bottom surfaces. Further by tuning the tilted angles, the paired half-integer charges on the bottom-side merge and restore an integer topological charges merely upon downward radiation, which forms a so-called UGR state that only radiate towards one (upward) direction.

(3) Researchers developed a wedged-etching technology to fabricate the 1D PhC samples, and experimentally measured the asymmetric radiation ratio of 27.7 dB, which is an improvement of 2 orders of magnitude compared to conventional designs, thus validating the effectiveness of UGR states.

This research work has been published online in *Nature* on April 22, 2020 titled of "Observation of topologically enabled unidirectional guided resonances". This study broadens the horizon of realizing

effective manipulation of the optical radiation, and it is expected to significantly reduce the insertion losses of the on-chip optical ports (namely the optical IOs), and boost the development of high-density optical interconnection and photonic integration chip.



(a) Trajectory of topological charge evolution in 1D PhC (b) Splitting and merging of topological charges

Fig. 3-1-48 Unidirectional guided resonance from manipulating the evolution of topological charges

Solutions and applications to some challenging problems of linear quadratic optimal control

Linear quadratic optimal control (LOR) is one of the basic problems of modern control theory, many scholars have half a century that the problem is widely constant attention, but there are still some basic problems to be further research, such as irregular LOR, delay case random LOR, its solvability conditions and feedback controller design problem cannot be solved for a long time, lead to the other Therefore, the research of related problems is faced with obstacles, such as the feedback stabilization of NCS under packet loss/delay and the optimal control of asymmetric information.

In national natural science foundation of China (61633014) key projects funded by, huan-shui zhang of shandong university professor and professor juan-juan xu research team conducted a long-term research for the optimal control problem, put forward the general is backward differential/difference equation (FBDEs) decoupling method, realize the breakthrough of the optimal feedback control design method, solves the irregular LQR and delay The systematic random LOR problem includes the necessary and sufficient conditions for solving the problem and the analytical solution of the controller based on the new Riccati equation. FBDEs solution of the team put forward material method to directly promote a series of complicated problems to solve optimal control field, such as packet loss/delay feedback stabilization of networked control systems under the necessary and sufficient conditions, the average field stochastic system feedback stabilization of game control, social optimality necessary and sufficient conditions, as well as the information asymmetric optimal control problem. The results are published in *IEEE Transactionson Automatic Control, Automatica* and *SIAM Joumal on Controland Optimization*.

AFBDEs decoupling method is proposed by the team is further improving the traditional control method, make up for the deficiencies of traditional methods in the face of complex control problems, promote the development of the theory of LOR, such as robots, unmanned vehicle to track the actual control system performance boost provides effective theoretical methods and technical means, this symbolized our country based on the LQR theory research of the problem It is at the forefront in the world (Figure 3-1-49).

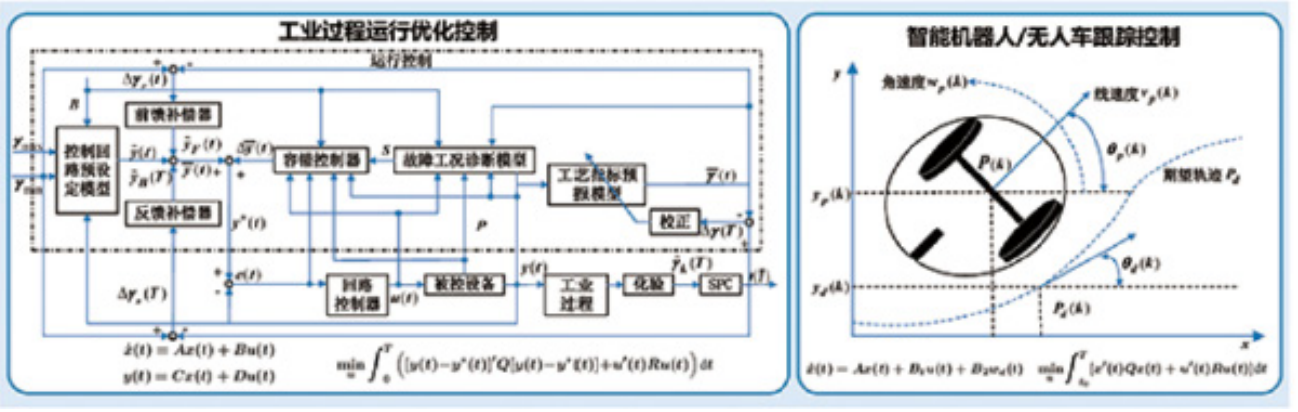


Fig. 3-1-49 Application of linear quadratic optimal control

Rapid Airline Recovery in Aviation Operations Management

Airline industry plays a key role in the development of Chinese economic system. However, airlines are faced with a series of problems in operation. For example, disruptions exert a great financial impact on the airline industry. It is critical to develop smart decision support tools for airlines to deal with widespread disruptions and obtain high-quality recovery solutions in real time. Supported by the National Natural Science Foundation of China (71825001), Professor Liang Zhe (Tongji University) and his team studied on the rapid recovery problems in aviation operation and have made the following innovative contributions:

When flight disruptions happen, the Airline Operation Center is responsible for making decisions, re-scheduling airline resources (i.e., aircraft, flights, pilots, flight attendants, and ground crews), and re-accommodating passengers with the objective of restoring the airline's operation back to the planned schedule with minimized cost. This rescheduling process is usually done manually by the flight controller, which could be very time consuming. Since the flight network has grown drastically in China in the last decade, it is important for airlines to manage these disruptions effectively to control irregular operation costs and guarantee service qualities. To resolve this problem, Prof. Liang's research team proposed an integrated airline recovery model that reschedules aircraft, pilots, cabin crews, and passengers simultaneously. They proposed an exact solution algorithm that integrates the traditional Operations Research with emerging AI methods. This method can obtain the optimal and near optimal solutions for the large-scale flight recovery problems with more than 2,000 flights in less than 30 minutes. This model with the solution algorithm has been applied into Xiamen airline and China Eastern airline with huge economic and social effect yielded. This is the first Chinese flight recovery system with Independent Intellectual Property Rights, which broke the long-term monopoly of the domestic flight recovery system by the European and American markets.

Flight delay, the main reason causing inconvenience to people's travels, can be classified into non-propagated delay and propagated delay. Propagated delay, which occupies over 30% of the

overall delay, is caused by the previous flight delay. To reduce the propagated delay in the operational stage, Prof. Liang's research team proposed a robust aircraft scheduling model (Fig. 3-1-50) and a two-stage column generation based algorithm. This model with solution algorithm is capable to obtain optimal flight plans for the large and mid-size airlines in China.

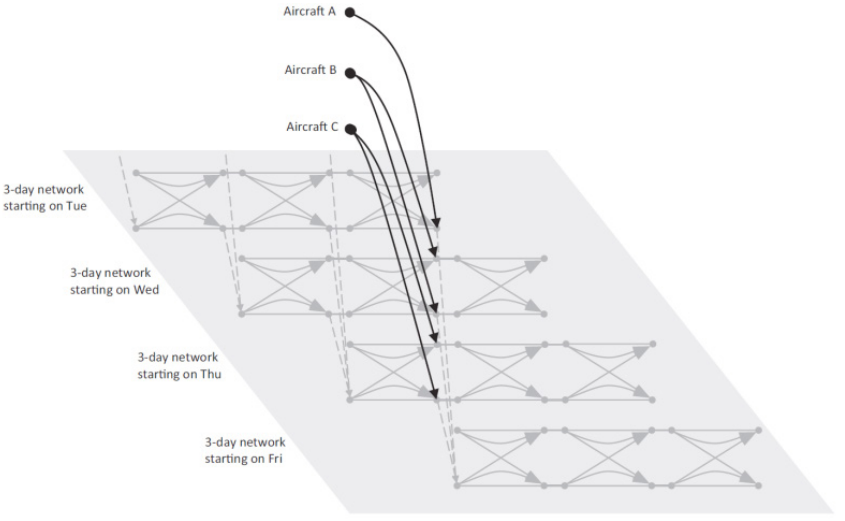


Fig. 3-1-50 A robust aircraft scheduling network

The above-mentioned research were published in leading journals in transportation and algorithm area, such as *Transportation Science*, *Transportation Research Part B*, *INFORMS Journal on Computing*, etc. These models and solution algorithms have been successfully applied into many Chinese airlines to reduce flight delay, improve service quality and increase revenue.

Achievements on How Capital Market Liberalization Fosters Long-term Benefits to One Economy

The gradual removal of limitations of foreign investments to domestic financial institutions in recent years illustrates that we are now experiencing an increasing speed in the journey of capital market liberalization. Recent studies show that capital market liberalization is beneficial to the economic growth of one country. However, there is a lack of universal understanding of how this growth will continue. Funded by the National Natural Science Foundation of China (Grant No: 71790591,71825002,91746301). The research team led by Prof. Xuan Tian s focus their attention on how stock market liberalization changes the technology development of the country, the single most important factor providing long-run persistent growth. They have achieved the following major scientific breakthroughs and discoveries (Fig.3-1-51).

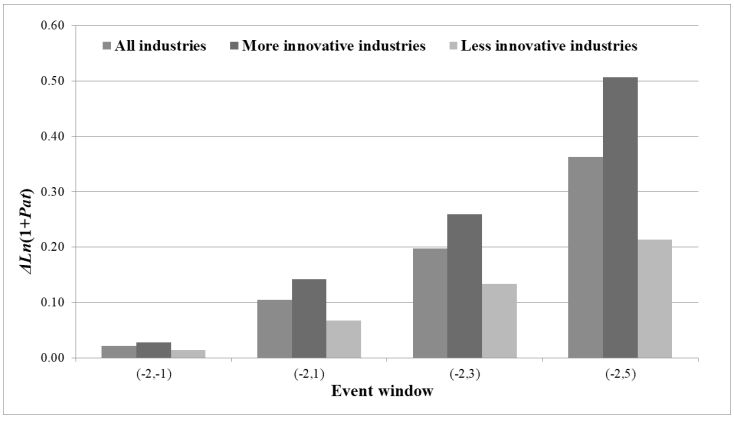
The understanding of the underlining mechanism for the long-term benefit of capital market liberalization has been furthered. In particular, they find that economies that have experienced stock market liberalization exhibit a higher level of innovation output after liberalization, and this effect is disproportionately stronger in more innovative industries.

Illustrate the mechanisms regarding how foreign investors improve innovation from the perspective of project selection and risk-sharing. Their research shows that the relaxation of financial constraints and the enhanced risk-sharing between domestic and foreign investors are plausible channels that allow stock market liberalization to promote innovation.

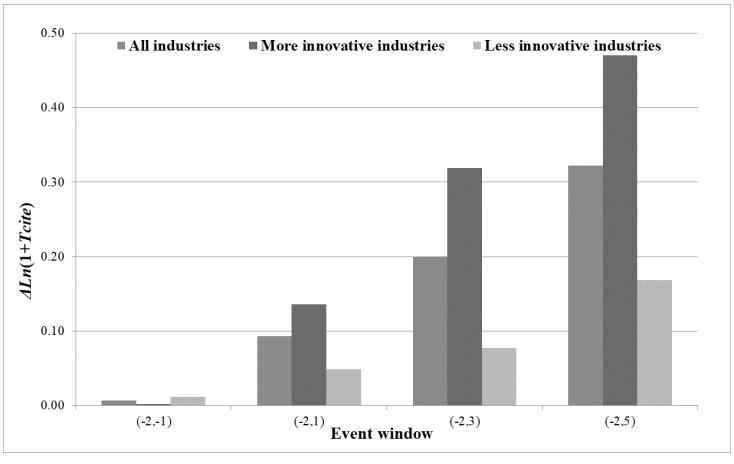
Identify how foreign investors improve corporate governance and help us understand the long-term benefit from the firms' perspective. They find that foreign investors use higher standards to shape their investment firms due to their information disadvantage. By doing so, they improve the quality of corporate governance and project selection of firms and thus improve firms' innovation in the long-run.

The research is published in *Journal of Financial Economics* in 2020, one of the most prominent journals in the finance and management field. More importantly, the research provides new insights into the

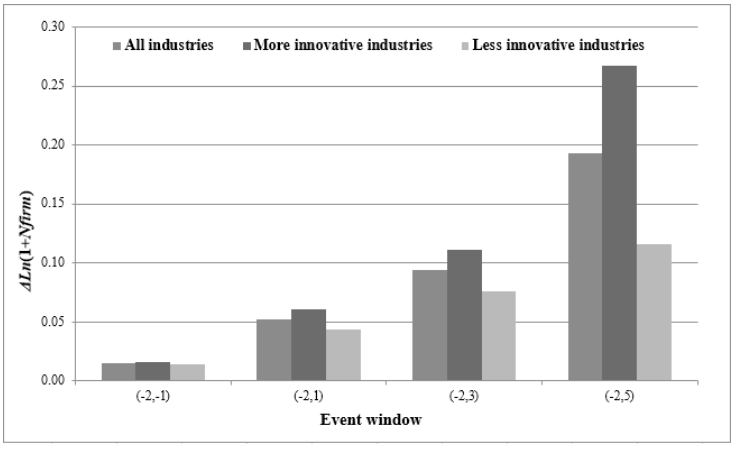
real effects of stock market liberalization on productivity growth and the economy, and provides direct implications for our capital market liberalization policy-making.



(a) Average changes in the number of patents around stock market liberalization



(b) Average changes in the number of patent citations around stock market liberalization



(c) Average changes in the number of innovative firms around stock market liberalization

Fig.3-1-51 Average changes in innovation around stock market liberalization

A Spatio-temporal Model of COVID-19 Epidemic Spread and Risk Monitoring

Supported by the National Natural Foundation of China (Grant No. 71490722, 72042009), the research team, led by Professor Jianmin Jia at the Chinese University of Hong Kong, Shenzhen, used behavioral economics and big data analytics to investigate key scientific and emergency issues of the COVID-19 spread characteristics and monitoring methods. The major results are as follows:

1) A spatio-temporal benchmark hazard model was proposed based on population outflow from risk epicenters (in this case, Wuhan) to other prefectures in mainland China before the lockdown, topredictthe spatio-temporal spread of COVID-19 epidemic across China. Such a model can be used to rapidly assess the epidemic risk of different regions and to serve as a reference for government decisions on emergency resourceallocations.

2)A risk index for COVID-19 transmission in communities was developed based on the deviation between confirmed cases and the prediction of the benchmark model. This principle was used to createa risk monitoring toolkit that can detect risk and track the spread oftheepidemic for different locales. In particular, the index can serve as an epidemic warning system to identify and track which regions have a high level of community transmission risk during early stages of the COVID-19 pandemic such as Wenzhou, which provides support for government decision making.

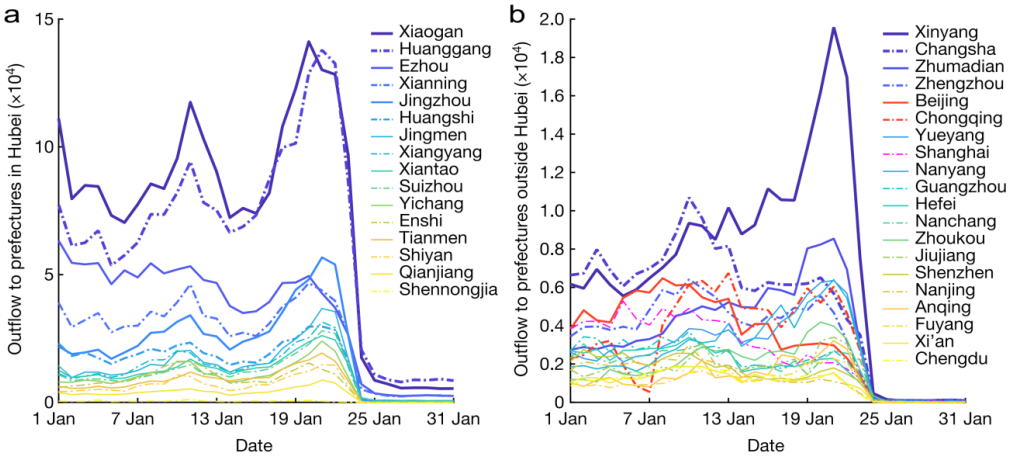


Fig. 3-1-52 Population outflow from Wuhan to Hubei (a) and other prefectures (b)

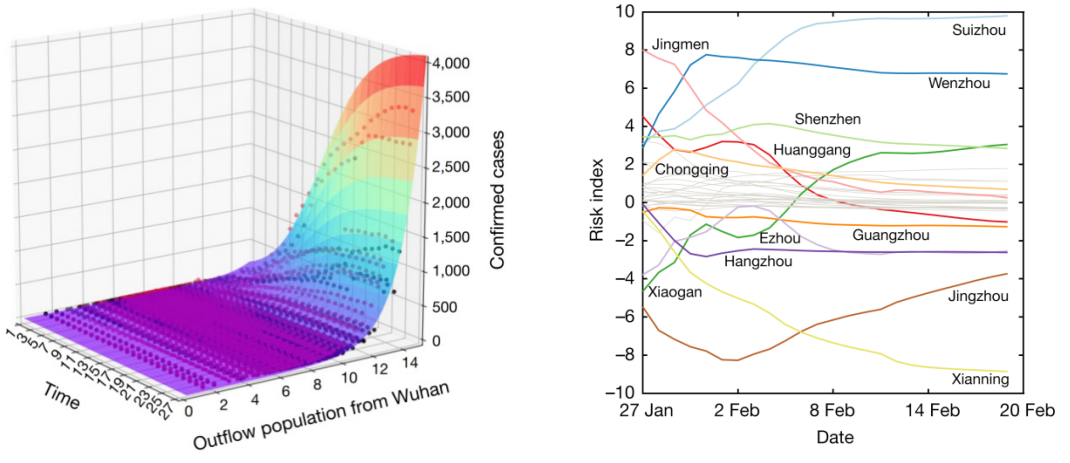


Fig. 3-1-53 Confirmed cases and model fitted surface (left) and risk index of selected prefectures over time (right)

3)The toolkit was applied to identify vulnerable as well as high risk populations.Statistical models and machine learning approaches that can assess heterogeneities in risk sources of population outflows and test the relative contributions of different risk sources on the spread of COVID-19 were adopted; for example, the relative contribution of population outflow from Wuhan city vs. from Hubei province (excluding Wuhan) were estimated, and the timeliness and effectiveness of the lockdown were demonstrated.

During the early stages of the outbreak, the research team members conductedemergency policy research on tackling COVID-19 and provided several epidemic analysisand policy reports to the General Office of the State Council, the Publicity Department of the CPC Central Committee, and Guangdong government. This effort wasinitiated with the Department of Management Science, the National Natural Science Foundation of China (NSFC).After submitting the emergency analysesand report, our research team developed more detailed models suitable for academic research, and publisheda research articlein *Nature*:"Population flow drives spatio-temporal distribution of COVID-19 in China". This article was reported widely by major national and international media, including BBC, Science Daily, Medical Xpress, EurekAlert, Asian Scientist, China Daily, Global Times, China Science Daily, Wenhui Daily, and China News. The Ministry of Foreign Affairs also cited the article as scientific evidence to support the report: "Reality Check of US Allegations Against China on COVID-19". This report was reprinted by Xinhua News Agency, People's Daily, and Guang Ming Daily.

Global Supply-chain Effects of COVID-19 Control Measures

Supported by the National Natural Science Foundation of China (Grant No. 71988101), Prof. Dabo Guan of Tsinghua University has used the newly developed global disaster footprint accounting model, combined with the global trade and industry chain database, to quantitatively assess the economic impact of an epidemic on more than 140 countries/regions and key industry chains from a series of scenarios. This research has achieved the following major scientific discoveries:

(1) Fact that the stringency of outbreak control measures is not the most important cause of economic losses, but rather the duration of control measures is an important driver was revealed. The conclusion that strict and effective control measures are being taken in China, at great economic cost, to contribute positively to the prevention and control of global epidemics was verified.

(2) Externality of COVID-19 control measures and their impact on the local economy further along the chain to other countries/regions was raised. The severe impact on global supply chains and the fact that recovery of key industries is highly dependent on active control results in supply chain countries/regions was revealed (Fig 3-1-55).

(3) Progress and capacity to control the COVID-19 varies from country to country, and the conclusion that a gradual easing of the global embargo measures would prevent the re-emergence of the epidemic and reduce economic losses compared to rapid unblocking was highlighted. The efficiency of restarting the global economy depending on the last country/region to achieve effective control measures was proved (Fig 3-1-56).

The above-mentioned study, titled Global Supply Chain Effects of COVID-19 Control Measures, has been published in *Nature Human Behaviour*. This research is a comprehensive evaluation of the global economic impact of COVID-19 control measures in the early stages of the global outbreak. The results of this research provide timely and powerful reference and support for the CPC Central Committee to win the battle against the epidemic. Focusing on economic recovery in the post-epidemic era, this research revealed the role of economic interdependence between industrial chains, more accurately depicted the transmission mechanism of exogenous shocks in the supply chain, and provided a new modelling approach

and framework for future disaster assessment. Furthermore, it has profoundly revealed the impact of the epidemic on the global economy, and supported the economic value and scientific validity of the China's anti-epidemic efforts. This research is a timely reference for governments in formulating their response to the COVID-19 and provides a scientific basis for restarting and accelerating the recovery of the global economy in the post-epidemic era.

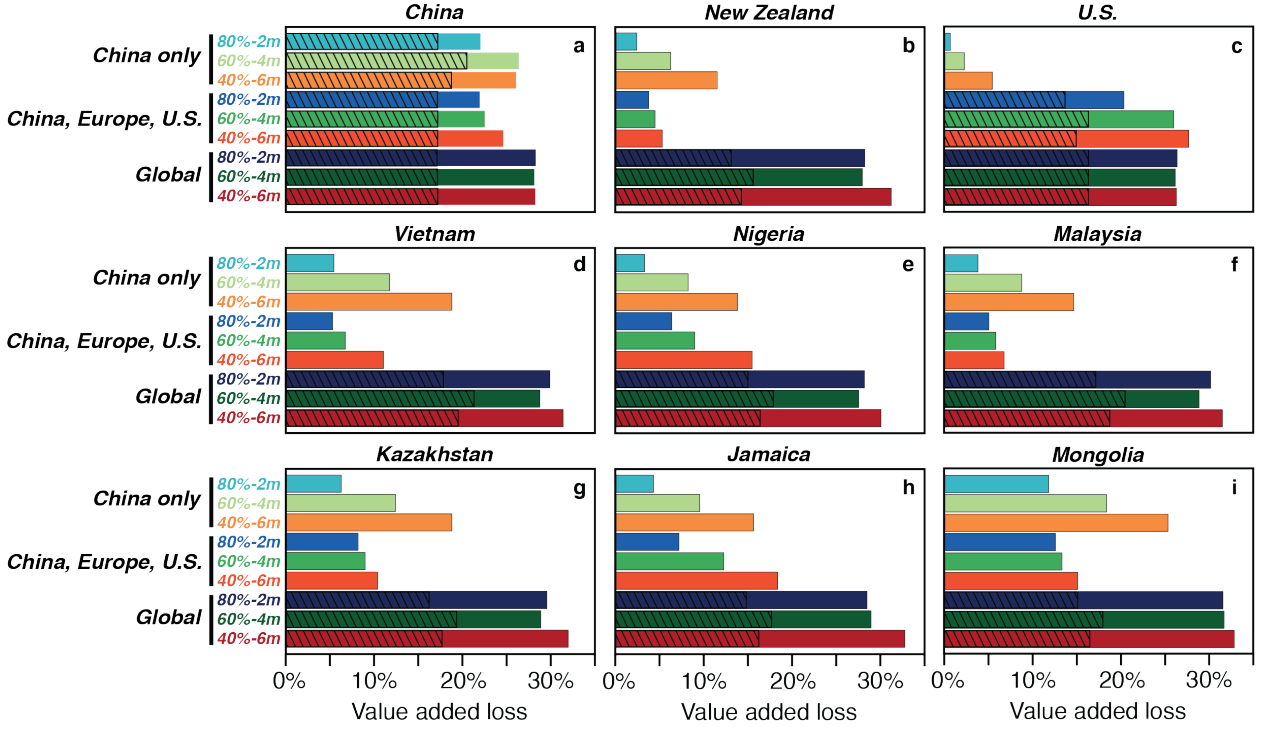


Fig.3-1-55 Direct and indirect value-added losses of COVID-19 in selected countries under 9 scenarios.

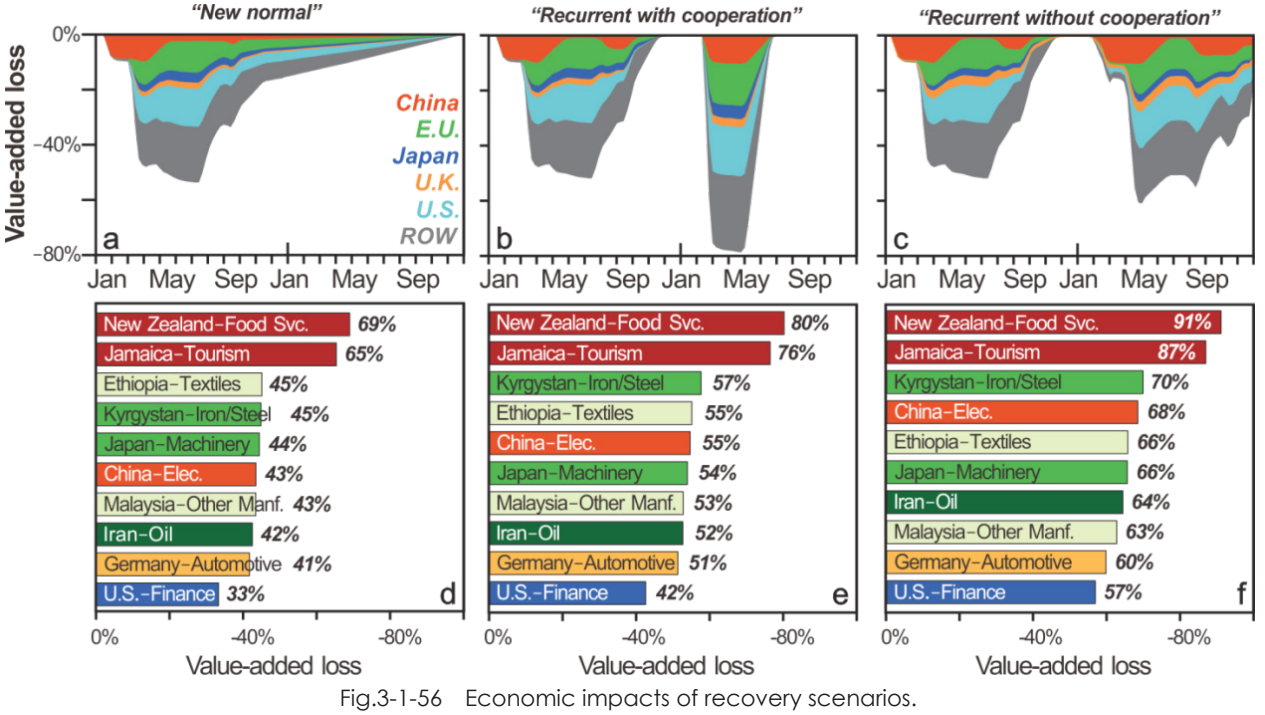


Fig.3-1-56 Economic impacts of recovery scenarios.

Achievements on Collaborative Governance Between Government and Social Organizations

Supported by the National Natural Science Foundation of China (71704156), the research team led by Prof. Jianxing Yu from Zhejiang University and Assistant Professor Yuan Cheng from University of Minnesota, has achieved new progress on the research area of government and social organizations cooperation. This research is the first to evaluate how community-based organizations worked with their local governments to coproduce responses to COVID-19, which was a key determinant of whether containment strategies were effective at the local level. The study contributes a new insight for the response to COVID-19 as a perfect example of why coproduction and community-based solutions are important. It highlights the importance of the active response of citizens to the government's call for action, their self-discipline, and community-based management. Major scientific breakthroughs and discoveries are as follows:

(1) Stage One-Comprehensive epidemic prevention and control: mobilizing volunteers to trace the source and spread of COVID-19, collecting donations and supplies for epidemic control, providing necessary social and community services.

(2) Stage Two-Balancing epidemic prevention and social functioning: mobilizing volunteers to trace the source and spread of COVID-19, offering welfare services, assisting enterprises with production resumption.

(3) Stage Three-Normalization of epidemic prevention and control: mobilizing volunteers to trace the source and spread of COVID-19, exerting psychological counselling and social work, and building collaboration platforms to promote sustainable economic development.

The above-mentioned study, titled "Coproducing Responses to COVID-19 with Community-Based Organizations: Lessons from Zhejiang Province, China", has been published in *Public Administration Review*. It has attracted wide attentions once the article is published online. The research team deeply engages in the local practice of government and social organizations collaboration, provides the theory bases and policy support for the sustainable public service delivery in the local practice. The research team has also published many academic articles in international journals, and their several policy reports have been adopted by government.

Table 3-1-1 The Critical Roles of Community-based Organizations in China'sResponses to COVID-19

Stage of COVID-19 Response	Key Roles of Community-based organizations	Examples of Community-based organizations
Stage One: Comprehensive Epidemic Prevention and Control	• Mobilizing volunteers to trace the source and spread of COVID−19 • Collecting donations and supplies for epidemic control • Providing community services to help people staying at home receive basic life support.	• Emergency response organizations: Dolphin Emergency Rescue Team of the Hangzhou Dishui Commonwealth Service Center; Yueqing Blue Sky Rescue Service Center. • Charitable organizations: Zhejiang Provincial Charity Federation; Red Cross Society of China Zhejiang Branch. • Community service organizations: Yuanqiao Township Community Service Center in Huangyan District.
Stage Two: Balancing Epidemic Prevention and Social Functioning	• Mobilizing volunteers to trace the source and spread of COVID−19 • Providing welfare services • Assisting enterprises with production resumption	• Community service organizations: HaichuangCommunity Service Center in Yinzhou District. • Industrial associations: Wenzhou Glass Industrial Association. • Business associations: Wenzhou Clothes Business Association.

(continued)

Stage of COVID-19 Response	Key Roles of Community-based organizations	Examples of Community-based organizations
Stage Three: Normalization of Epidemic Prevention and Control	• Mobilizing volunteers to trace the source and spread of COVID-19 • Psychological counseling and social work • Building collaboration platforms to promote sustainable economic development	• Community service organizations: Deqing Association for Mental Health; Wenling Medical Association. • Industrial associations: Yuhang Metal Products Industry Association. • Business associations: Wenzhou Shoe Leather Business Association.

Self-Developed Lung Gas MRI Provides Scientific and Technological Support for COVID-19 Prevention and Control

Lung diseases are the major threats to the lives and health of people in China. However, pulmonary airspace is a blind area in the clinical proton magnetic resonance imaging (MRI) due to its special cavity structure. Unfortunately, the current clinical pulmonary imaging modalities, such as chest CT, X-ray, and PET, are unable to quantify ventilation and gas-blood exchange function without ionizing radiation.It requires urgent action to solvethe key technical problem of non-invasive, quantitative and visual evaluation of major lung diseases. With the support of NSFC (special fund for research on national major research instruments81227902,national science fund for distinguished young scholars 81625011,major research plan 91859206 and science fund for creative research groups 21921004),a research team led by Zhou Xinfromthe Innovation Academy for Precision Measurement Science and Technology (former Wuhan Institute of Physics and Mathematics), Chinese Academy of Sciences, developed the first home-made human lung gas MRI instrument which has been used in quantifying and visualizing lung function in discharged COVID-19 patients.

In the fighting against COVID-19, the gas MRI was applied in Wuhan Jinyintan Hospital and Tongji Hospital. For the first time in the world, lung injuries caused by COVID-19 in discharged patients were identified non-invasively using gas MRI (Fig. 3-1-57, Fig. 3-1-58). By gas MRI, Xin Zhou et al. found that discharged COVID-19 patients had higher ventilation defects percentage, unchanged microstructure, longer gas-blood exchange time, and reduced RBC/TP compared with healthy subjects. Fortunately, the ventilation and gas-blood exchange function improved in most of the discharged COIVD-19 patients with moderate symptoms.

The finding offers a new perspective to support the rehabilitation of discharged COVID-19 patients, and also provides an important supplement to the conventional clinical imaging techniques. The finding was published in an article titled *Damaged Lung Gas Exchange Function of Discharged COVID-19 Patients Detected by Hyperpolarized* ^{129}*Xe MRI*in *Science Advances*. The independently developed gas MRI instrument, which broke through the technical bottleneck of high-performance medical imaging systems, has been granted more than 60 intellectual property invention patents. Ithas beenselected as one of the 12 representative achievements on display at the 25thanniversary forum of the National Science Fund for Distinguished Young Scholars chaired by Premier Li Keqiang. For the contribution to epidemic prevention and control of COVID-19, the applications of gas MRI have been reported by CCTV, the magazine of QiZhiand other mainstream media. Additionally, the team and instrument won the 2020Xplorer Prize, the National Innovation Award, and the China International Industry Fair Award. By using the key instrument, medical xenon gas generator, MRI signal of noble gas can be enhanced by more than 63,000 times. The medical xenon gas generator has been approved by national medical products administration,obtaining

the first medical device registration certificate of gas MRI for clinical applications. Prof. Zhou's team is now cooperating with many well-known tertiary hospitals, such as the 301 Hospital and Wuhan Jinyintan Hospital, for continuousindependent innovation, cutting-edge research and clinical applications.

Fig.3-1-57 Noninvasive, quantitative, and visual detection of lung function by gas MRI in discharged COVID-19 patients

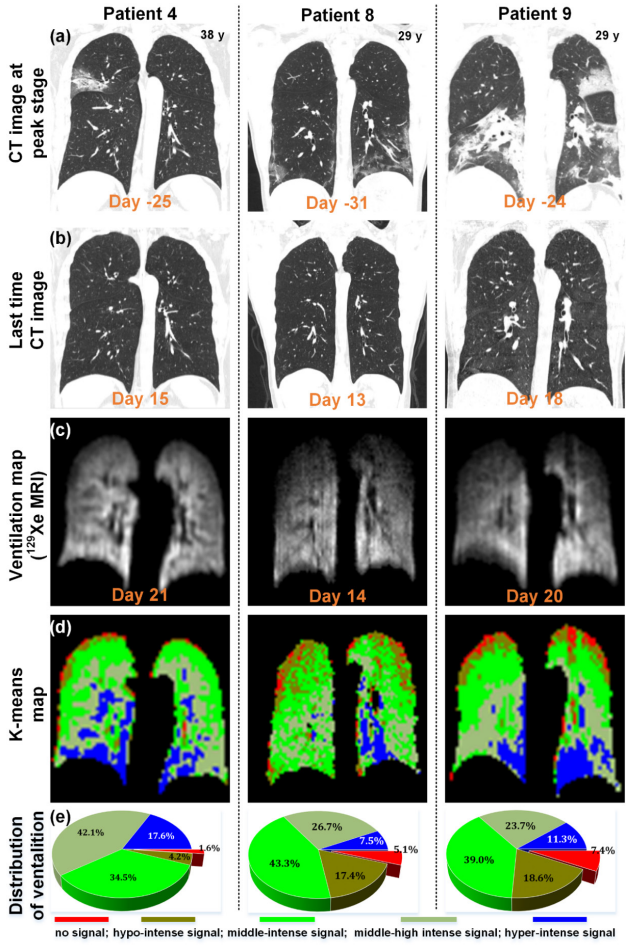


Fig.3-1-58 Lung images for three representative discharged patients. (a)Chest CT images at the peak stage of COVID-19; (b) final CT images (upon discharge); (c) corresponding pulmonary ventilation maps from hyperpolarized gas MRI; (d) &(e) k-means map showing distribution of ventilation intensity.

Branched-Chain Amino Acid Catabolism Promotes the Occurrence and Development of Pancreatic Ductal Adenocarcinoma

Metabolic remodeling is one of the ten hallmarks of cancer. Therefore, it is an essentialquestion in cancer research to elucidate the role and mechanism of metabolic remodeling in tumor evolution, especially at the tumor initial stage, which will provide novel strategies for early prevention and treatment of cancer. Pancreatic ductal adenocarcinoma (PDAC) is highly malignant and lacks targets for early diagnosis and treatment. The 5-year survival rate is less than 8%. Previous studies have shown that the level of plasma branched-chain amino acids (BCAA) is abnormally elevated 5-10 years before the early diagnosis in PDAC patients. Nevertheless its effect on PDAC development and underlying mechanism remains elusive. With the support of NSFC (major program 81790250/81790253, major research plan 91959202, and general program 81872240), collaboratively, Prof. Lei Qun-Ying of Fudan University, Prof. Zhang Zhi-Gang of Shanghai Jiao Tong University, Prof. Su Danof Zhejiang Cancer Hospital, and Zou Shao-Wu, Associate Chief Physician of the Tenth People's Hospital of Tongji University, have systematically explored the effect of BCAA catabolismon PDAC development and its molecular mechanism using animal models and clinical samples. The major findings are listed below (Fig. 3-1-59).

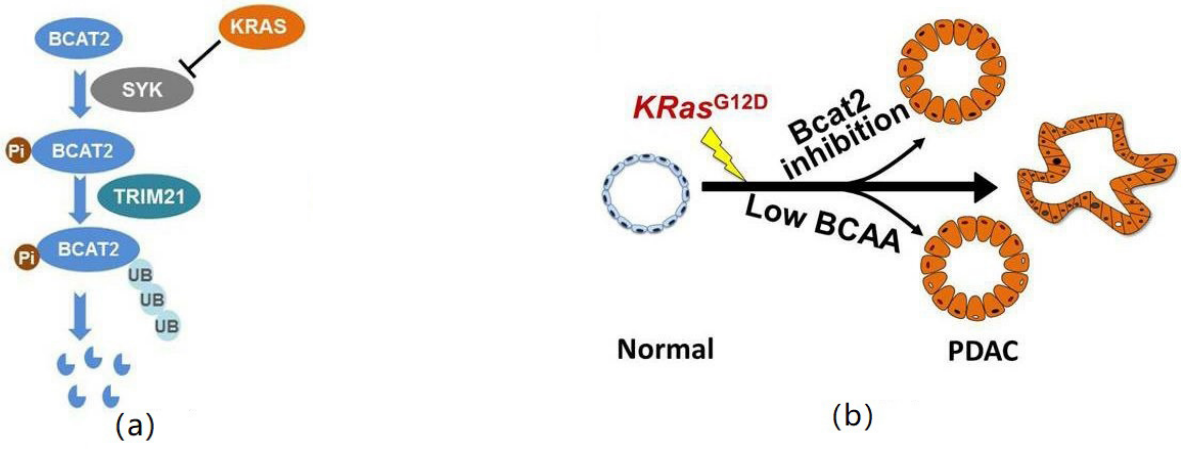


Fig.3-1-59 Molecular mechanism and function of KRAS-BCAA-BCAT2 metabolic axis rewiring in PDAC development.
(a) KRAS inhibits phosphorylation of BCAT2 catalyzed by tyrosine kinase, SYK, leading to dissociation between TRIM21, the E3 ubiquitin ligase, and BCAT2 and stabilization of BCAT2 protein;
(b) Treatment with BCAT2 inhibitor and/or low-BCAA diet disrupts Kras-BCAA-BCAT2 metabolic axis and prevents PDAC development. BCAA: branched-chain amino acid; BCAT2: branched chain amino acid transaminase 2; Pi: phosphoryl group; UB: ubiquitin; PDAC: pancreatic ductal adenocarcinoma.

The team found theupregulation of protein level of branched-chain amino acid transaminase 2 (BCAT2) in pancreatic intraepithelial neoplasia(PanIN) and tumor tissues of PDAC and further defined the key role of BCAT2-driven catabolismof BCAA, supplying carbon and nitrogen for cell growth and proliferation, in PDAC development, especially accelerating PanIN progression, using stable isotope tracing, functional study with cell lines and organoids as well as *in vivo* experiment withmice.

Disruption of BCAA catabolism by inhibiting BCAT2 activity with specific inhibitors or feeding with low BCAA diet significantly impedes PDAC development.

In terms of molecular mechanism, the team found that KRAS activating mutation blocked kinase SYK-mediated phosphorylation of BCAT2 at tyrosine residue (Tyr228), leading to prevention of ubiquitination

of BCAT2 by dissociating interaction of BCAT2 and TRIM21, the E3 ligase, and the followed degradation of BCAT2via proteasome.

The findings reveal the drivingrole of KRAS-remodeled BCAA-BCAT2metabolic axis in PDAC developmentand uncover the underlying molecular mechanism. Notably, the team demonstrates that intervention of BCAA catabolismby targetingBCAT2 activation or BCAA restriction in diet effectively slow down the progress of PDAC in animal experiment. The study, titled with*BCAT2-mediated BCAA catabolism is critical for development of pancreatic ductal adenocarcinoma*, waspublished in Nature Cell Biology. A commentary article published in the same issue of Nature Cell Biology, titled*The KRAS-BCAA-BCAT2 axis in PDAC development*, further highlighted the study.

Pathogens escape immune surveillance by hijacking host cell mitochondrial autophagy

Mitophagy (mitochondrial autophagy) is a selective autophagy process, which completes the regulation of cell metabolism and fate determination by specifically degrading damaged or excess mitochondria in the cell. However, it is urgent to find out which substances can induce the mitochondrial autophagy response under physiological or pathological conditions, and which molecules specifically mediate the activation of the mitochondrial autophagy pathway. With the support of NSFC (major research plan 91842306, key program 81430036), Prof. Qian Youcunand his team from the Shanghai Institute of Nutrition and Health, Chinese Academy of Sciences discovered that the intracellular pathogen (Listeria monocytogenes) could induce mitophagy toescape the killing of host macrophages. Their findings include:

For the first time in the world,this study found that intracellular pathogens (Listeria, etc.) can induce mitochondrial autophagy in host cells, and further clarified that Listeria's virulence protein hemolysin O (LLO) induces calcium ion influx in macrophages to damage mitochondria and mitophagy, thereby reducing the production of mitochondrial reactive oxygen species (ROS) (ROS can kill pathogenic bacteria), resulting in immune escape.

The study identified a new mitochondrial autophagy receptor NLRX1, and found that it mediates the host cell mitophagy process induced by Listeria and its virulence protein LLO. Further mechanism studies have found that the LRR domain and NACHT domain of NLRX1 interact intramolecularly in the resting state to form a stable monomeric state, which blocks the combination of LIR and LC3. Besides, Listeria infection or LLO stimulation can cause intracellularmultimerization of NLRX1, thereby promoting the binding of its LIR domain to LC3 and mediates mitophagy.

Further knockout mice and cells with mitochondrial autophagy inhibitor Mdivi-1 and NLRX1 genes showed that inhibition of mitochondrial autophagy pathway would lead to accumulation of intracellular mitochondrial reactive oxygen species, thus inhibiting the survival of Listeria.

This study for the first time reported the hijacking of mitochondrial autophagy by intracellular pathogens in host immune cells and the discovery of a novel mitochondrial autophagy receptor NLRX1 (Fig. 3-1-60), which deepened our understanding of the physiological function of mitochondrial autophagy and provided a new molecular target and therapeutic idea for anti-infection therapy. The research results were published in *Nature Immunology*.

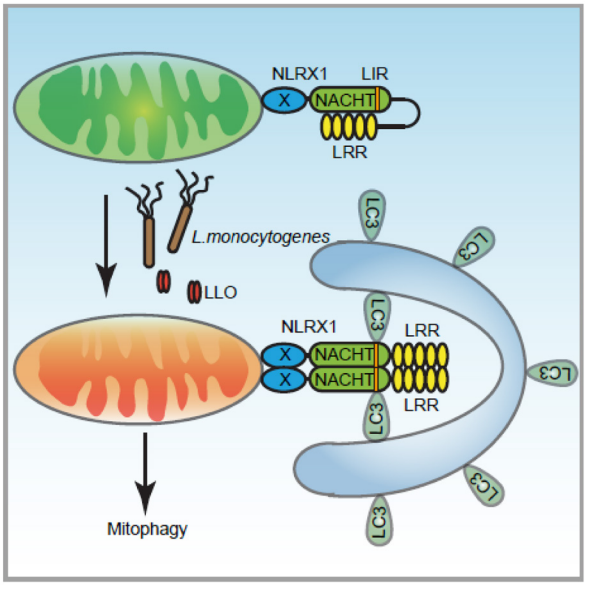


Fig. 3-1-60 A working model forListeriahijacking host cell mitophagyfor immune escape

Research on viral pneumonia and novel emerging respiratory infectious diseases provides scientific support for fighting against epidemics

Virus is a common pathogen of lower respiratory tract infection. Novel emerging viruses, such as the H1N1 virus and SARS-CoV-2, pose a serious threat to human health and public safety. However, there is still lack of rapid and accurate test tools, early warning methods and effective antiviral treatments. With the support of NSFC (national science fund for distinguished young scholars 81425001) and other founds, Professor Cao Bin's team established the national research platform for influenza, viral pneumonia and emerging infectious diseases (CAP-China).For the first time, they clarified that influenza virus, adenovirus and respiratory syncytial virus are the common pathogens of adult community acquired pneumonia (CAP) in China. They not only established the rapid molecular detection platform of new pathogens, but also led a number of randomized controlled trials on treatment of respiratory virus infection. The research results were adopted by the latest Chinese influenza and CAP guideline. Details are as follows.

(1) They identified the common pathogens of adult viral pneumonia in China, and revealed the importance of non-influenza virus pneumonia for the first time, which changed the stereotype that non-influenza viruses mainly affect children and immunosuppressed people. The research results have been adopted by the latest *Guideline for Diagnosis and Treatment of Adult CAP in China* (2016 Edition), and *Influenza Diagnosis and Treatment* (2018, 2019 and 2020 Edition) (Fig. 3-1-61.

(2) The clinical features of COVID-19 patients were first depicted, including lymphopenia, coagulation disorders, and cytokine storm, diffuse pulmonary ground glass opacity, respiratory failure and extra pulmonary organ damage. Based on their findings, the team warned of a global pandemic and argued that the potential risk factors of older age, high SOFA score, and d-dimer greater than 1 μg/mL could help clinicians to identify patients with poor prognosis at an early stage. They found that the longest observed duration of viral shedding in survivors was 37 days. The research results were adopted by the COVID-19 guidelines of China and WHO.

(3) The team conducted the first Lopinavir-Ritonavir trial for COVID-19, which set a precedent for scientific and standardized clinical research in the outbreak of a pandemic.

(4) The team revealed the immune pathogenesis of influenza and put forward the novel concept of "viral sepsis". They found that high-dose corticosteroid therapy could not reduce the mortality of patients with severe H7N9 pneumonia, while low-dose corticosteroid therapy could reduce the death risk of influenza pneumonia. They suggested low-dose (80mg/d), and short-period (10 days) corticosteroid therapy can be used for the treatment of severe and critically ill COVID-19 patients.

The related results were published in *Lancet* (4 papers), *New England Journal of Medicine* (1 paper) and *European Respiratory Journal*(1 paper), and two of them were listed as highly cited papers of ESI.

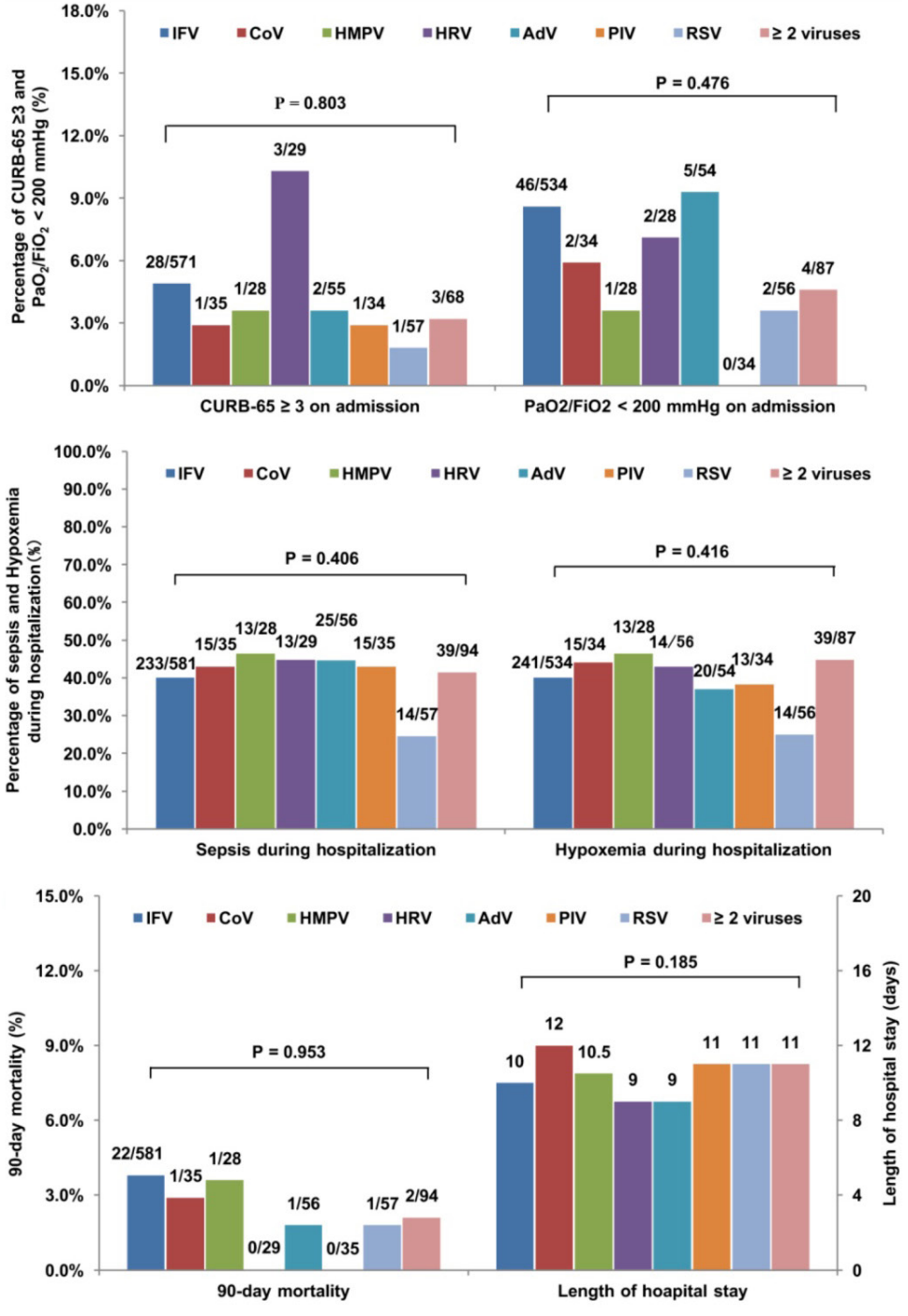


Fig. 3-1-61 Comparison of severity at admission, complication rate and prognosis of influenza and non-influenza virus pneumonia

The Pathogenesis of Diabetic Kidney Disease

Diabetic kidney disease (DKD) is one of the most serious complications of diabetes mellitus.Although there is compelling evidence that podocyte injury is a key mediator in the pathogenesis of diabetic kidney disease, cell-specific therapy is not clinically available. Recent studies have shown that hyperglycemia may not a primary underlying cause of the development of DKD. However, emerging evidence suggests that lipid metabolism disorders are associated with renal dysfunction, as well as other pathological features of DKD. Notably, podocytes are particularly sensitive to lipid accumulation, which can lead to insulin resistance and cell death. Considering the importance of podocyte lipid metabolism in DKD, it is clinically significant to identify potential therapeutic targets that may be beneficial for podocyte lipid metabolism. With the support of the National Natural Science Foundation of China (National Science Fund for Distinguished Young Scholars,Grant No.: 81525005, Major Research Plan,Grant No: 91642204, 91949202), Professor Fan Yi and his team from Shandong University have revealed a novel mechanism of topodocytes lipid dysmetabolism in DKD. The important results are as follows:

(1) JAML(junctional adhesion molecule-like protein) is identified as a novel mediator contributing to proteinuric kidney disease progression and play an important role in regulating lipid metabolism in podocytes.Junctional adhesion molecules (JAMs), including JAM-A(JAM-1), JAM-B (JAM-2), JAM-C (JAM-3), JAM-4 and JAML are members of animmunoglobulin subfamily play crucial roles in the regulation of cell polarity, epithelial barrier formation and leukocytesmigration. Recently, the role of JAM-family membersin lipid metabolism and dysregulation-associated diseases has attracted attention.The study demonstrated that JAML, a novel member of the JAM family,was significantly inducedin podocytes treated with sera obtainedfrom patients with DKD. Additionally,JAML expression was found increasedin the glomeruli of experimental modelsof DKD, and in glomeruli and sera of patientswith DKD or other proteinuric kidney disease. More importantly, JAML expressioncorrelated with lipid accumulation andthe estimatedglomerular filtration rate in patients with DKD, suggesting JAML mayrepresent an attractive therapeutic target for DKD or other proteinurickidney diseases (Fig.3-1-62).

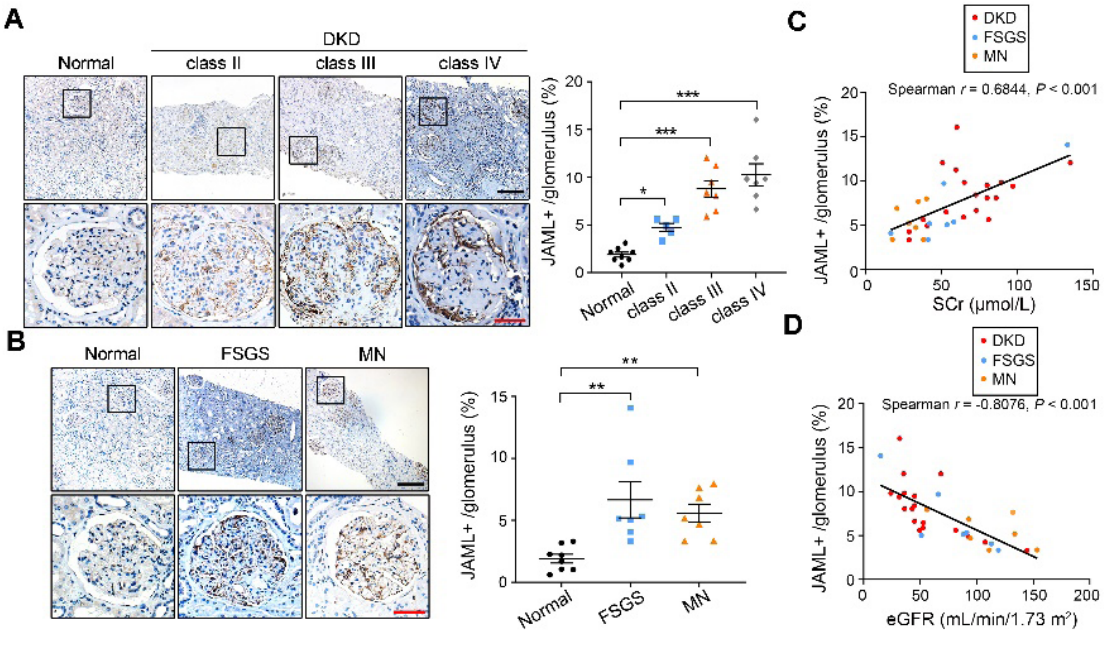


Fig.3-1-62 Theexpression of JAML in renal biopsysamples from subjects with DKD and other proteinurickidney diseases.

(2) The important role of JAML is further confirmed functionally and mechanistically.Podocyte-specific genetic JAMLdeletion markedly alleviated renal injury and podocyte lipid accumulation in two different diabetic mouse models of DKD. Finally, it was further revealed that JAML mediated podocyte lipid metabolism by regulating sterol regulatory element-binding protein 1(SREBP1) and its target genes involved in fatty acids and cholesterol synthesis. AndSIRT1, an epigenetic regulator ,was identified as a key mediator linking JAML to SREBP1signaling(Fig.3-1-63).

This study is the first time to show that JAML is an important mediator in podocyte lipid metabolism disorder. The pharmacological targeting of JAML may provide a new approach for the treatment of DKD and other proteinuric kidney diseases. The research article entitled *Elevation of JAML promotes diabetic kidney disease by modulating podocyte lipid metabolism* was published in *Cell Metabolism* as a cover article with an accompanying review.

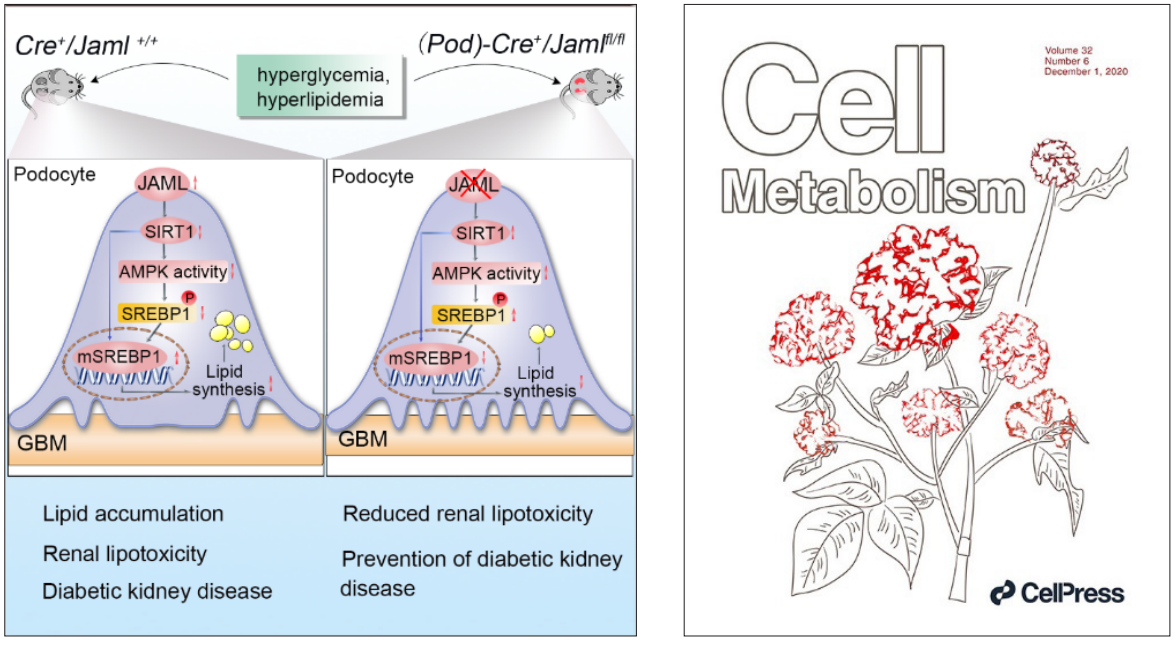


Fig.3-1-63 The molecular mechanisms by which JAML regulates podocyte lipid metabolism and the cover of "Cell metabolism"journal. (On the cover, the immunofluorescence images of synaptopodin (a podocyte marker, red) in glomeruli look like flowers. The well-bloomed flowers represent normal glomeruli and the withered flowers represent damaged glomeruli under diabetic conditions)

Part 4

International (Regional) Cooperation and Exchange

NSFC

2020 ANNUAL REPORT

In 2020, NSFC conductedthe international (regional) cooperation work following General Secretary Xi Jinping's important directive guidance on scientific and technological innovation.According to the overall strategy of the NSFC's international cooperation, multiple reform tasks have been effectively promoted. In parallel, the international cooperation work of the NSFC have been systematically developed. Comprehensively and synergistically,we enriched and optimized the cooperation mechanisms between scientific foundation organizations, expanded the international cooperation network, strengthened the cooperation with overseas funding agencies. In particular, we had schemedsustainable development international cooperation scientific plan (project) within the framework of "the Silk Road Economic Belt and the 21st-Century Maritime Silk Road" (or "the Belt and Road") initiative.We also focused on boosting thedomestic and internationalcommunication/cooperation among young scientist community.

I. SystematicalPromotion of International Cooperation

In the past year, we strengthened the dialogue mechanisms, promoted strategic cooperation, and deepened partnerships. Dialogue mechanisms for regular high-level policy discussions with the German Research Federation, the Russian Foundation for Basic Research, and the Swiss National Science Foundation have been set up. The fourth biennial strategy meeting was held on-line with the National Agency for Research and Innovation of the United Kingdom. Video conferences with the Director-General of the European Union Research Directorate and the Vice-President of the Royal Society have been implemented. By strengthening communication, enhancing mutual trust, and promoting project cooperation and policy docking, we have promoted long-term, stable and in-depth partnerships. We also completed joint project collection and funding work with the National Science Foundation, and discussed project management policies and practices with the National Institutes of Health. Stable and harmonic cooperation mechanisms with the American civil foundations have been consolidated. The open attitude and the implementation of cooperation with Europe for the Science Foundation have played a role as a ballast stone. In 2020, more than maintaining joint funding with Germany, the United Kingdom, the Netherlands, Sweden, Norway, the European Union and other countries and regions, we witnessed a significant improvement in the strategic dialogue and policy negotiation with Russia.A diversified, multi-level and wide-ranging cooperation pattern with Russia has been initially established. Academician Panchenko, the Chairman of the Russian Basic Research Foundation, was recommended by the NSFC and the Chinese Embassy in Russiaand received the "2019 Inter-Republic of China Science and Technology Cooperation Award" in China.In parallel, substantive cooperation with Japan, South Korea, Israel and other advanced Asian countries have continued to deepen through which the cornerstone of scientific and technological cooperation with these countries has been consolidated. Wide-scale cooperative research and communications with Japan Society for the Promotion of Science, Japan Science and Technology Agency, National Research Foundation of Korea, and Israel Science Foundation were continuously implemented for jointly funding research.The dual (or multiple) cooperation mechanism is mature and stable.

Through the internationalplatforms China's leading voice and influence have been enhanced, and cooperation in field of scientific installations with international organizationshas been improved. Director Li Jinghaihad participated in 6 online meetings of the Global Research Council Management Committee, conducted dialogues and discussions on topics including task-oriented research, public participation, scientific and technological cooperationof post-new coronavirus pandemic, and RCC evaluation followed by offering NSFC solutions.Director Li Jinghaihad also participated in spring and autumn conferences by International Institute for Applied Systems Analysis (IIASA) and participation committee meetings (online), and recommended 4 Chinese experts to the post-epidemic era virtual research plan jointly initiated by the International Science Council and IIASA. We participated in the Belmont annual conference and joint research project discussions for seeking new interdisciplinary cooperation plan.We organized and completed the funding work of the two aspects: CERN particle physics and CMS detector upgrade.In the

meantime, we actively participated in its annual resource assessment management meeting to profile the installation'sconstruction progress, China's contribution and the development of the relevant discipline.

We were committed to serving the national strategyand steadily advance the SDG plans of "Belt and Road" international cooperation. According to the NSFC's"Belt and Road"SDGplan, the inter-organization cooperative research projects have been promoted in fields of sustainable development and COVID-19 investigation.

By fully utilizing the cooperation network,the scientific funding work has beenrhythmicallyboosted. Under the sophisticated international situation, the NSFC has actively and steadily developed the network of international scientific and technological cooperation. During the epidemic, a cooperation agreement was signed with the Russian Science Foundation in the form of letter. By the end of December 2020, NSFC has established cooperative relationships with 98 scientific research funding agencies or international organizations in 51 countries (regions), and the cooperation network covers five continents in the world. In 2020, NSFC has funded 818 international (regional) cooperation ormobility projects, with a scale of 975 million RMB. These funding includes: 102 key international (regional) cooperative research projects withfunding of 250 million RMB; 266 inter-organization cooperative research projects with funding of 576 million RMB; 234 inter-organization cooperation and mobility projects with funding of 94 million RMB; 70 double (or multi-)side conference projects with funding of 10 million RMB; 146 foreign scholars research fund projects with funding of 45 million RMB.

II. Exploration of the Advantages of Talent Funding

In 2020, recipients of NSFC Research Fund for International Young Scientists were from 42 countries, of which Pakistan, India, the United States, Germany and the United Kingdom ranked in the top five. In order to increase the attractiveness of the research fund for foreign young scholars, the Bureau of International Cooperation and the Department of Foreign Experts Affairs of the Ministry of Science and Technology have worked together to leverage their respective advantages and integrate resources. On April 17, 2020, the Bureau of International Cooperation and the Ministry of Science and Technology Foreign Experts signedmemorandum on the joint development of the foreign young scholar research fund project. The NSFC continued to provide scientific research funding to the project leader, while the Foreign Experts Department subsidized salary subsidies and living expenses. This measure will provide more perfect conditions for foreign outstanding young researchers to come to China for scientific research.

On the basis of the steady implementation of the foreign young scholars research fund project, through inter-organizational channels, NSFC worked with overseaspartners from top to bottom and leveraged the project as a carrier to attract talents, select talents, and recommended talents.The "China-UK Talents" and "China-Europe Talents" projects jointly funded by the Royal Society, the British Academy of Medical Sciences and the European Research Council supported the establishment of long-term cooperative relationships between outstanding Chinese scientific researchers and high-level European research teams. The "PostSino-German Bilateral Symposium Young Scholars Academic Visit" and the "German Outstanding Young Scholars Fund" projects promoted by the Sino-German Science Center were officially launched in 2020. Thereafter, foundations for Germanapplicants including doctoral candidates, outstanding young scholars and senior outstanding young scholars have been initially formed.

III. Special International Cooperation towards COVID-19 Crisis

Since the outbreak of the coronavirus pandemic, NSFC has actively strengthened communication and cooperation with scientific funding agencies of various countries, and promoted the international scientific community for jointly coordinating and mobilizing global scientific resources to carry out research on COVID-19.

NSFC, the German Research Federation and the British National Agency for Research and Innovation timely issued a joint statement to call for the scientific community to jointly respond to the COVID-19 epidemic. During the emergency period, NSFC consolidated and strengthened cooperation with the Russian Foundation for Basic Research, the French National Scientific Research Center, the Japanese Society for the Promotion of Science, the Korean National Research Foundation and other multinational scientific funding agencies. We encouragedand supported the global academic community through letters, telephone calls and video conferences to work against the epidemic.The Bill and Melinda Gates Foundation of the United States became the first partner institution of NSFC to support international cooperation in the battle against the COVID-19. The Gates Foundationadditionally provided1.0 million USD for the groups that funded byNSFC*via*the project of "Fundamental Research on the Traceability, Pathogenesis, and Prevention of Novel Coronaviruses". Through the "Global Research Collaboration for Infectious Disease Preparedness" (GloPID-R) website and the edition of the "Novel Coronaviruses Cooperation Research Plan" on the Chinese and English homepage of NSFC, special guidelines for the epidemic weretimely released to global researchers. Dual (or multiple) funding for joint research on COVID-19 have been carried out based on the cooperation with the German Research Federation, the Korean National Research Foundation, the Swedish Research Council, the Turkish Science and Technology Research Council, the New Zealand Health Research Institute, the Melinda Gates Foundation and the BRIC and Eastern European countries (Belarus, Bulgaria) and other relevant funding agencies.

NSFC continuously advocated and vigorously promoted the mobilityprogramsand contacts between Chinese and foreign COVID-19 researchers to form a cooperation network.The "Special International Webinaron COVID-19 Research" was jointly held with scientific funding agencies from the European Union, Japan, Singapore, Australia, Egypt and Morocco. "China-Korea Novel Coronary Pneumonia Epidemic Prevention Seminar"was co-organized with the National Research Foundation of Korea. Furthermore, NSFC held the second China-U.S. Global Health Symposium with the Bill and Melinda Gates Foundation of the United States on the theme of "Global Health Innovation Cooperation in the Post COVID-19 Era".By this means, future research funding plans were discussed in the scenario of currentregularepidemics.

IV. Wide-scaleCooperation with Hong Kong, Macao and Taiwan

In 2020, joint funding collaborationswith the Hong Kong Research Grants Council, the Macao Science and Technology Development Fund and the Li Kwoh-ting Science and Technology Development Foundation have been implemented. 55.89 million RMB in totalwas funded for cooperation and mobility projects in Hong Kong, Macao and Taiwan.Delivered from the Macao Science and Technology Development Fund, 5 batches of 80 projects were reviewed. The correspondence reviews were from 284 mainland experts.

NSFC and the Hong Kong Research Grants Council jointly organized forum for young scholars from the two places to further enhance mutual understanding. Cooperative relations were cultivated and established through the communication which will be helpful for setting up more solidscientific cooperationbetween the two places. Academic seminars on cutting-edge disciplines were also jointly held by NSFC and the Beijing-Hong Kong Academic Exchange Center with an emphasis on human health and national network security. Through a combination of online and offline meeting, NSFC and Li Kwoh-ting Science and Technology Development Foundation organized cross-strait academic seminars. Mid-term inspections of research projects and summary on completed projects had been implemented during the seminars.

V. Comprehensive Cooperation with Germany

In accordance with the requirements and development planby the Joint Committee of the Sino-

German Center, NSFC continued to vigorously promote the reform of the project funding system, especially upgradethe talent projects. Afunding pattern that balances "send out" and "bring in" has been successfully formed. The Sino-German Center investigated the needs of the domestic scientific community in the early stage of the epidemic, assisted the leaders of the two institutions to communicate and negotiate through letters and sharednew discoveries. Therein, Sino-German scientific collaborationsfor the epidemic study were promoted, and special emergency project has been issued.The 2020 LindauProgrammeinterview and selection work was at the initial high incidence stage of the epidemic. The Sino-German Center overcame the difficulties and launched anonline review meeting to evaluate the 121 LindauProgramme applicants of whom 60 candidates were selected. Then, online communications were organized in June. The National Science and Technology Evaluation Center of MOST was entrusted to systematically sort out and evaluate the work of the Sino-German Center in the past 20 years. Thereafter, the "Sino-German Science Center Funding Performance Evaluation Report" has been completed.

VI. Typical results

(i) A series of breakthroughs have been made in the study of the evolution of the earth system during the Proterozoic to Phanerozoic transition period

Focusing on the frontiers of earth system evolution during the critical transition period, Zhu and his team from Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences and Graham, University College London, UK, supported by the key international cooperation project "Severe Fluctuations of the Proterozoic to Phanerozoic Transition Period Earth System and Biosphere Resilience (41661134048)" Following a series of breakthroughs in 2019, such as the discovery of clues to the origin of animal embryonic development patterns 610 million years ago (Current Biology,2019), and the discovery that the origin and rapid evolution of animals are directly controlled by the oxygen content in the atmosphere and ocean (Nature) Geoscience, 2019a) and proposed an oxidation model of the Precambrian long-term anoxic ocean (NatureGeoscience, 2019B), etc. A new breakthrough was made in 2020: (1) Based on the study of the developmental process and morphological structure characteristics of helicforaminifera 610 million years ago, it is believed that helicforaminifera belongs to the general kingdom of animals, which provides important clues to reveal the origin of animals (Science Advances, 2020)(Fig. 4-7-1). (2) It was revealed that the low atmospheric oxygen level of the Earth during this period was maintained by the insufficient Marine nutrition of 1 billion ~ 800 million years ago, which was one of the key factors leading to the delay of animal origin (NatureGeoscience, 2020)(Fig. 4-7-2).

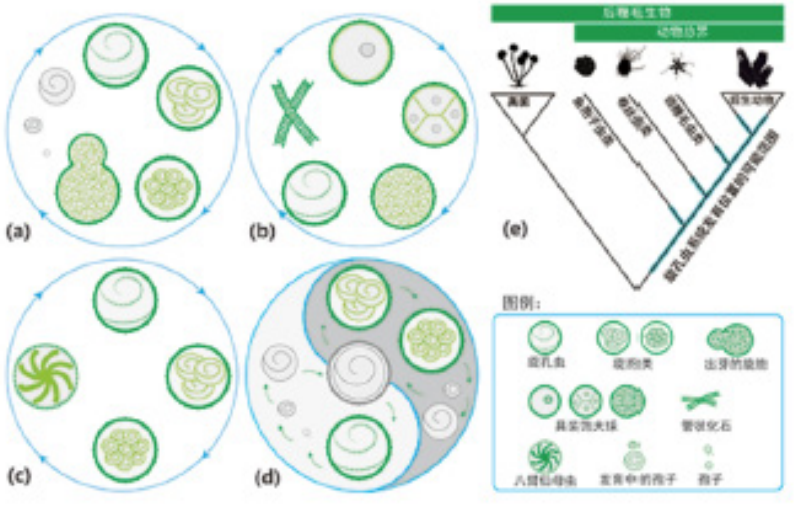


Fig.4-7-1 Development and life cycle of Trichinomonas and their position in biological systems (Science Advances, 2020

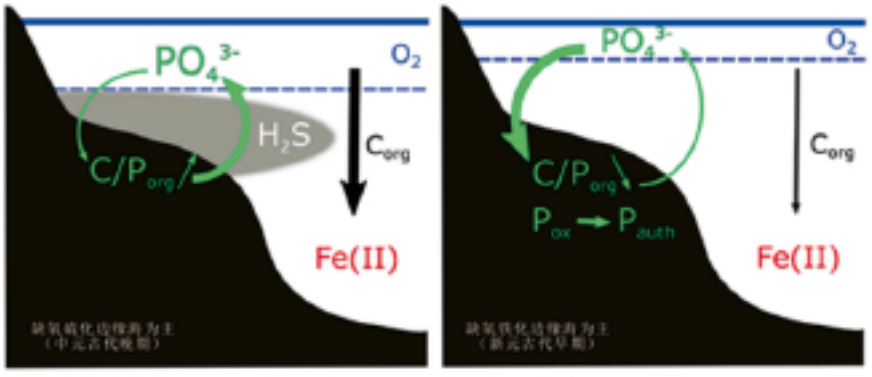


Fig.4-7-2 Model of Marine biogeochemical cycle evolution around 900 million years (Nature Geoscience, 2020)

(ii) Urbanization and endemism: A systematic study on the endemism model of cities and towns along the Yellow River and the Rhine River

The Collaboration Group is the most heavily funded project of the Sino-German Science Center, which supports scientists to collaborate with each other in well-defined thematic areas (which can be interdisciplinary) and builds a foundation for collaboration. The project focuses on the Yellow River and Caiin River, features international mutual learning, and works proactively around the Yellow River basin to serve the major national strategy of "ecological protection and high-quality development of the Yellow River Basin". The project leaders are Professor Wang Fang of Peking University and Martin of Hanover University Professor Prominski set up including planning and design, history, archaeology, ecological environment, cross-functional teams in the field of hydrology and water resources, and mathematical statistics, through multiple valley joint survey, bilateral workshop, youth in the form of personnel training and exchange, from the population flow, land use and ecological response, cultural associations, long sequence, multi-scale to explore human and nature" The local evolution rules and development strategies of watershed towns in the "Life Community" and urban-rural synergy system are aimed at promoting the inheritance of local cultural values and the sustainable development of urban and rural synergy. As the first accomplisher, Professor Wang Fang won the first prize of the 8th Institute of Higher Education Scientific Research Outstanding Achievement Award (Humanities and Social Sciences) by the Ministry of Education, and the first prize of the Huaxia Construction Science and Technology Award by the Ministry of Housing and Urban-Rural Development.

(iii) Quantitative calculation method of dynamic traffic network predictability

Supported by the China-Israel International Cooperation Project (61961146005) "Optimal Regulation of Urban Integrated Transportation Network", Prof. Cao Xianbin of Beihang University, Prof. Yan Gang of Tongji University, and Shlomo of Bar-Ilan University, Israel Together with Professor Havlin, he proposes a Predictability analysis method for dynamic Networks that can be quantified. His paper "Predictability of Real Temporal Networks "is published in National ScienceReviewE. How to quantitatively characterize the predictable limits of complex dynamic traffic networks is a very challenging scientific problem. The research innovation to a variety of applications in the field of actual dynamic network mapping for topology - temporal two-dimensional matrix, applies only to the square of drop rate calculation method is extended to arbitrary matrix, thus calculated through the topology - temporal interaction of the two arbitrary dynamic network can predict the limit, the urban comprehensive transportation network traffic prediction and dynamic regulation is of great significance (Figure 4-7-3).

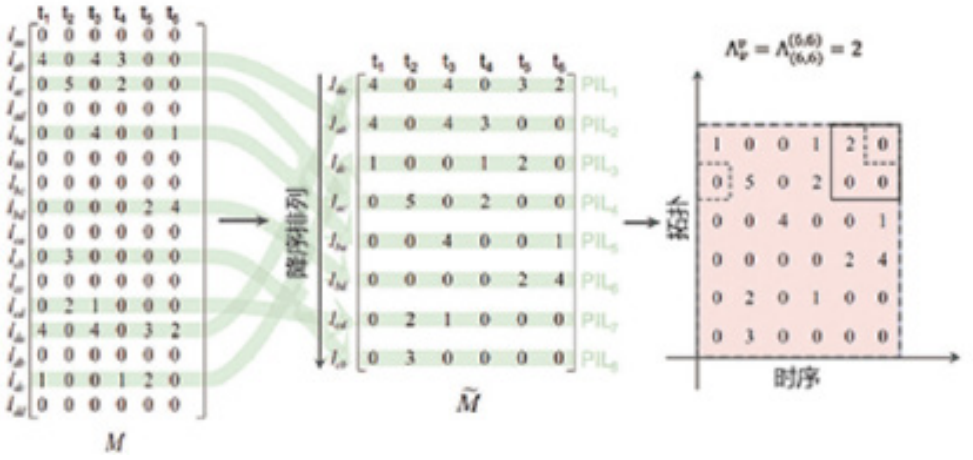


Fig.4-7-3 Mapping from dynamic Network to topology-temporal two-dimensional matrix and calculating method of random field roast rate

(iv) Sino-Canada-Paleocognitive Aging International Joint study

Funded by the International (Regional) Cooperation and Exchange Project (81861128001) "Sino-Canada-PaleoCognitive Aging International Joint Research", the team of Professor Yao De of the University of Electronic Science and Technology of China, Professor Alan Evans of Mcgill University, Canada, and Mitchell Antonio Valdes of the Cuban Neuroscience Center Professor Sosa has carried out close cooperation and developed WeBrain, an international cloud brain platform that can integrate multiple data, tools and computing power. Based on this cooperation, we have studied the effects of early malnutrition on brain cognition. The structural basis of intelligence; The mechanism of Brain aging has been published in NeuroImage, Human Brain Mapping and other professional journals. Project as "- plus - ancient brain science partnership (CCC)" the specific content, in the process of cooperation also promoted international exchanges and cooperation between China and Cuba and Canada, contributed to the university of electronic science and technology and Mcgill university jointly organized "biomedical engineering and neuroscience" double master's project (approved by the Ministry of Education began to recruit students) (Fig. 4-7-4).

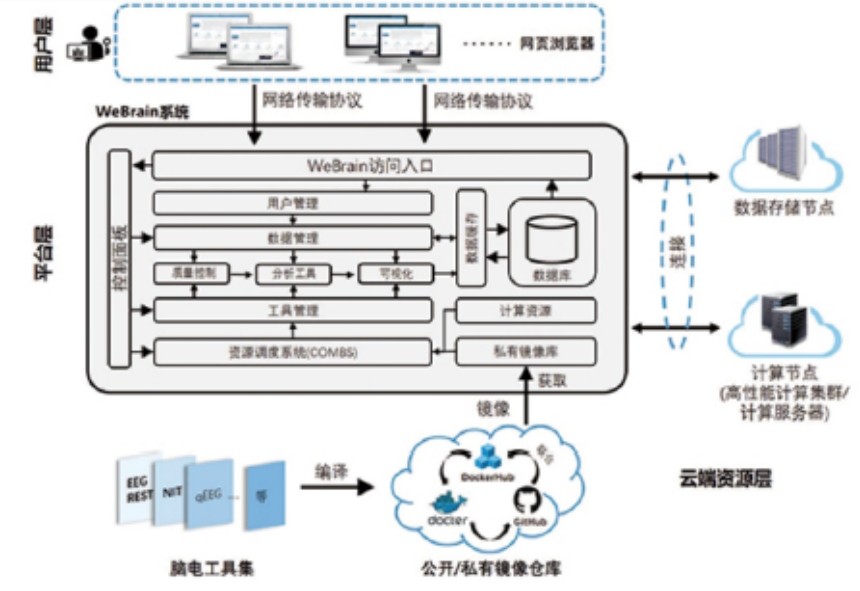


Fig.4-7-4 Based on the cloud-native cloud brain science platform WeBrain, it can realize the integration of tools, data and computing Nodes in the cloud, so as to promote multidisciplinary international cooperative research

Part 5

Research Integrity

NSFC

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I. Implement Academic Atmosphere Construction Action Plan Based on Principles of Education, Motivation, Regulation, Supervision and Punishment

Through resolute implementation of General Secretary Xi Jinping's important instructions on academic atmosphere construction, as well as earnest implementation of the "Opinions on Further Strengthening the Construction of Research Integrity" and "Opinions on Further Promoting the Spirit of Scientists and Strengthening the Construction of Work Style and Academic Atmosphere" jointly released by the General Office of the CPC Central Committee and the General Office of the State Council, NSFC released the Implementation Plan for advancing the Academic Atmosphere Construction Action Initiative to urge responsible conducts of research, review and management among four parties (referring to applicants, applicants' home institutions, review experts and NSFC staff), construct and improve NSFC research integrity system based on principles of education, motivation, regulation, supervision and punishment, actively nurture clean scientific research environment and healthy scientific research ecology, so as to form a social atmosphere that reveres knowledge, advocates innovation, respects talents, cherishes science, and devotes to science, and lay a solid foundation for the high-quality development of basic research in China and building China into an innovative country.

II. Consolidate the institutional foundation of academic atmosphere and research integrity with regulations

Firstly, the revision and release of the Charter of NSFC Supervision Committee was completed to appropriately reform the operating mechanism of the Supervision Committee, energize the Supervisory Committee, increase its staff, establish additional biomedical professional committees and comprehensive professional committees, and improve the effectiveness of handling research misconduct allegations. Secondly, is to revision and release of the Measures for the Investigation and Handling of Research Misconducts of NSFC Funded Projects was completed under the guidance of the Legislative Affairs Committee of the Standing Committee of the National People's Congress concerning relevant issues on the investigation and handling of research misconducts encountered in the revision process. Thirdly, the Measures for the Supervision and Inspection of NSFC Awarded Funds was formulated to better supervise the legal and compliant management and use of NSFC project funds, and further strengthen the supervision and inspection of NSFC project funds. Fourthly, the Notice on Earnest Performance by National Science and Technology Plans (Special Projects, Funds, etc.) Undertaking Institutions of Research Integrity Responsibilities is jointly released by NSFC and the Ministry of Science and Technology to further hold the undertaking institutions accountable.

III. Build a solid ideological foundation for research integrity construction through education and popularization

Active measures were taken to promote the education and popularization of academic style and research integrity by full implementation of the Opinions on Further Promoting the Spirit of Scientists and Strengthening the Construction of Work Style and Academic Atmosphere and active advocation of responsible conducts of research, academic review and scientific research management. Firstly, special program guide was released to attract outstanding think tanks to carry out relevant special research, with a view to enriching the popularization and education of research integrity. Research was carried out on typical cases of research misconducts and warning education, a database of typical cases was set up

based on the handled cases of research misconducts, and systematic visual warning education materials were formed. Special research was conducted on compiling and publishing a systematic, readable, and interesting primer on NSFC research integrity, tailored for universities, research institutes and other institutions to carry out research integrity education and training. Secondly, in order to vigorously promote the spirit of scientists, and guide teachers, students and scientific and technological workers to inherit the excellent style of research and adhere to academic integrity, the 2020 Scientific Ethics and Academic Norms Popularization and Education Conference and Propaganda Month Launch Ceremony was jointly held by China Association for Science and Technology, Ministry of Education, Ministry of Science and Technology, Chinese Academy of Sciences, Chinese Academy of Social Sciences, and Chinese Academy of Engineering. NSFC representatives attended the activities. Thirdly, results of spot checks conducted in 2018 and 2019 of NSFC awarded project funds were announced, and two batches of typical cases of research misconducts investigated and adjudicated in 2020 were published, which played a role in warning and education. Fourthly, under the normalized mechanism of popularization, full advantage of varied training meetings, network meeting, research integrity construction related meetings was taken to publicize NSFC's new practice and measures in promoting research integrity, as well as typical cases of research misconducts and problems found in supervision and inspections of project funds, with a total audience of upwards of 3000 participants.

IV. Guarantee NSFC academic atmosphere construction with a complete supervision system

Whole-process supervision was carried out on research activities such as project preparation, application, review, implementation, conclusion and application of results in NSFC funded activities. Such measures as project similarity checking and on-site supervision of panel review meetings were adopted to ensure accountability of key application and review procedures. Firstly, NSFC's Open Letter on All Parties Seriously Performing Their Compliance Assurance and Creating a Clean and Positive Review Environment was released, requiring review experts to carry out their review work independently, objectively and impartially, and resolutely resist any form of requesting the reviewers to give favored ratings. All NSFC staffers were required to perform their duties objectively and impartially, be honest and self-disciplined, strictly implement the confidentiality and avoidance regulations of the review process, and strictly abide by the relevant regulations on conflicts of interest. Secondly, in order to resolutely maintain a clean scientific research environment and guard the fairness and impartiality of NSFC review system, a special statement was released to raise the science community's awareness of unidentified people or organizations claiming to offer "paid assistance" for project applications, putting an end to all kinds of misconducts that interfere with the review work, such as asking for favor, putting a word for other applicants, disclosing confidential review information, etc. The statement was also intended to remind applicants to be vigilant and guard against deceits. Thirdly, on-site supervision was carried on during panel review meetings. it is clearly stated in "Opinions on the Evaluation of NSFC Proposals in 2020" that "mobile communication equipment such as mobile phones shall be centrally deposited during panel review meetings, meanwhile technical shielding measures shall be used at the review meeting site to ensure that the meeting review process is not disturbed. Various reminders such as banners were set up at the meeting registration office or panel review rooms to remind review experts, applicants and NSFC staff to earnestly fulfill their commitments, abide by rules and disciplines, and perform their duties with due diligence. Alternative Plan for panel review were formulated for the inability to organize on-site panel review meetings due to the requirements for the prevention and control of COVID-19, requiring review experts to participate in video review meetings in an independent environment, and the on-site environment be subject to the supervision by on-site supervision teams, which ensured that on-site supervision of panel review meetings was carried out in a standardized

and orderly manner.

V. Safeguard academic atmosphere and research integrity with rigorous investigation and punishment of research misconducts

In 2020, NSFC accepted a total of 525 allegations and clues of research misconducts and took the initiative to investigate and adjudicate them. On June 11, October 13-14, and December 15, 2020, the 6th, 7th, and 8th plenary sessions of the Fifth NSFC Supervision Committee were held deliberate cases and form recommended adjudication suggestions regarding a total of 165 respondents and 8 awardee institutions (Figure 5-5-1).

A special review was jointly conducted by NSFC Supervision Committee and NSFC science departments on improper signatures of papers listed in NSFC proposals.

Figure 5-5-1 The 7th plenary session of the 5th NSFC Supervision Committee held in Beijing

VI. Continue to do a good job in the supervision and inspection of the funds of the science funded projects

Firstly, NSFC completed random inspection tasks in Shandong province, Shanghai, and Guangxi province. In accordance with inspection reports by accounting firms, comprehensive analysis of related projects and financial information and data was conducted, and related awardee institutions were required to address and rectify existing problems in management and use of NSFC project funds. Secondly, NSFC completed random inspection of 948 projects, with a total funding of 756 million yuan, from 52 awardee institutions in Zhejiang, Hainan and Yunnan provinces. On October 23-25, and November 3-6, preparatory meetings for inspection of NSFC project funds were held in Hangzhou, Haikou and Kunming respectively (Figure 5-6-1), to assign inspection tasks in Zhejiang, Hainan, and Yunnan provinces, and, in accordance with relevant requirements, publicize the new keynotes and requirements of NSFC reform in the new era, and conduct systematic research on the new situations and new problems encountered by awardee institutions in the implementation of streamlining administration and delegating power, improving regulation, and upgrading services in the field of science and technology. Thirdly, earnest investigations were conducted on allegations of misuse of NSFC project funds.

Part 6

Organizational Structureof NSFC

NSFC

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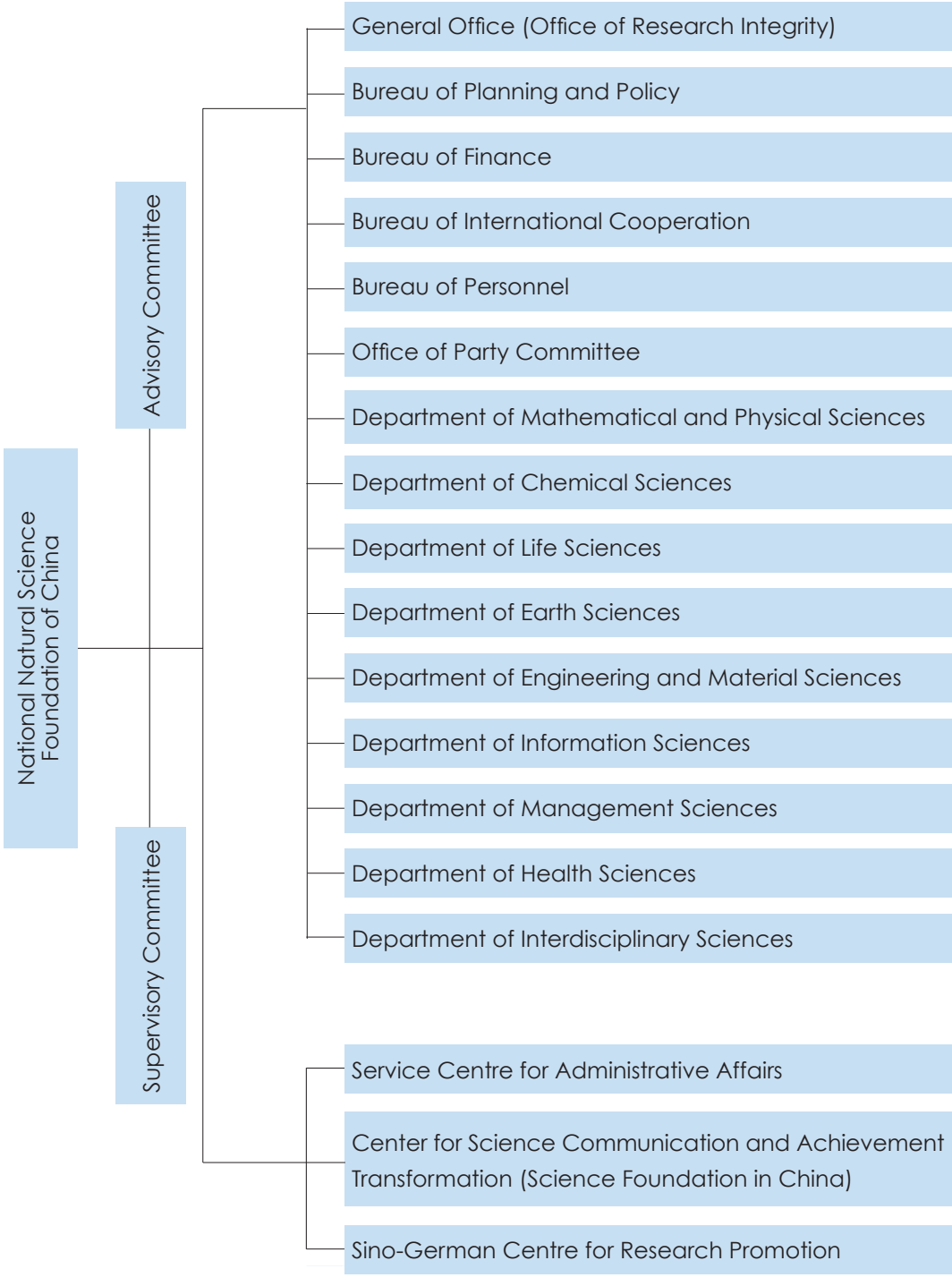
1. Organizational Chart



2 Members of The 8th Council of theNational Natural Science Foundation of China (NSFC)

President: Li Jinghai
Vice Presidents: Gao Fu, XieXincheng, Hou Zengqian, Gao Ruiping, Wang Chengwen, Lu Jianhua
Secretary-General: Han Yu
Members: Wang Hongyang, Wang Enge, Zhu Rixiang, Wu Hao, Liu Changsheng, Sun Changpu, Yan Chunhua, Song Jun, Zhang Guangjun, Zhang Xi, Chen Zuoning, Chen Xiaohong, Zhao Xiaozhe, Zhong Denghua, Kang Le, Tong Aiping, Pan Aihua

3 Members of the 5th Supervisory Committee of theNational Natural Science Foundation of China (NSFC)

Director: Chen Yiyu
Deputy Director: Zhu Zuoyan, He Minghong
Members: Wang Yizheng, Wang Hongyan, Wang Jiancheng, Wang Yuefei, Zhu Bangfen, Zhu Weitong, Liu Zhihua,Liuming, Yan Shouke, Yan Jinghua, SuXianyue, Li Zhaohu, Li Zhenzhen, Shao Feng, Zhou Xingshe, Zheng Yongfei, Yao Zhujun, Gao Xiang, Huang Haijun, Cui Xiang, Jiao Nianzhi

4 NSFC Staff

(1)Permanent staff

The staff quotaat NSFC is 249. By December 31, 2020, NSFC has 214permanent staff, of whom 128aremales and 86 females;and 199 are professional and technical personnel. The average age of the permanent staff is 46.

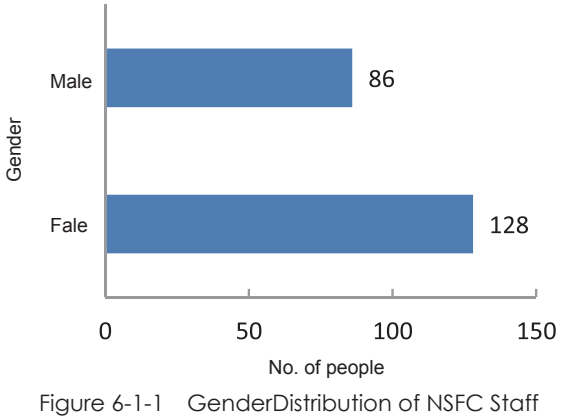


Figure 6-1-1 GenderDistribution of NSFC Staff

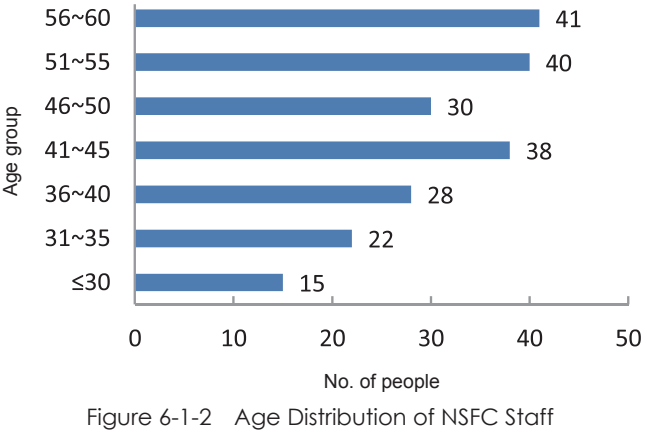


Figure 6-1-2 Age Distribution of NSFC Staff

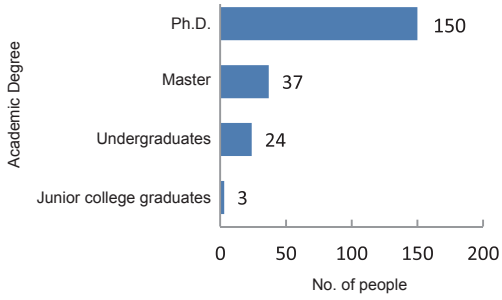


Figure 6-1-3 Academic Degree of NSFC Staff

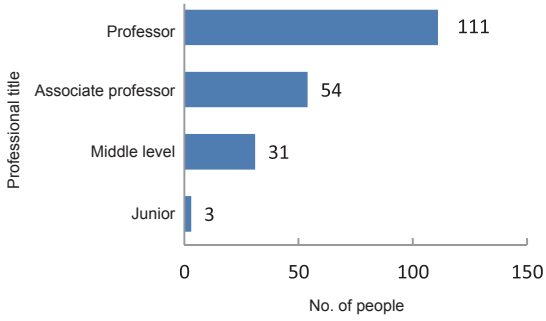


Figure 6-1-4 Professional Title of NSFC Staff

(2) Rotational Program Directors

By December 31, 2020, there are 122Rotational Program Directors on duty at NSFC, and119of them have a Ph.D. degree. Among the Rotational Program Directors, 99 are males and 23females; 41are professors or research fellows and 80 are associate professors.

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

Leaders of NSFC's Bureaus and Departments (by December 31, 2020)

Units	Leaders
General Office (Office of Research Integrity)	Han Zhiyong, Guo Jianquan, He Jie, LvShumei(F), Zhang Yongtao, Jing Yaxing, Liu Ke(Director of Information Center)
Bureau of Planning and Policy	Wang Changrui, Che Chenwei, Wang Yan(F), Yao Yupeng
Bureau of Finance	Zhang Xiangping(F), Gao Suqing(F)
Bureau of International Cooperation	Zhou Liyao, Fan Yingjie(F)
Bureau of Personnel	Zhou Yanze, Wang Cuixia(F), Liu Ning(Director of Office of Retirement Affairs)
Office of Party Committee	Zhu Weitong (F), Fang Yudong
Department of Mathematical and Physical Sciences	Jiang Song(concurrently), Dong Guoxuan, Meng Qingguo
Department of Chemical Sciences	Yang Xueming(concurrently), Yang Junlin
Department of Life Sciences	Li Peng(F, concurrently), Feng Xuelian(F), Gu Ruisheng
Department of Earth Sciences	Guo Zhengtang(concurrently), Yu Sheng
Department of Engineering and Material Sciences	Qu Jiuhui(concurrently), Wang Qidong, Wang Guobiao
Department of Information Sciences	Hao Yue(concurrently), Zhang Zhaotian
Department of Management Sciences	Ding Lieyun(concurrently), Yang Liexun, Liu Zuoyi
Department of Health Sciences	Zhang Xuemin(concurrently), Sun Ruijuan(F), Xu Yanying(F)
Department of Interdisciplinary Sciences	Chen Yongjun

Leaders of NSFC's Subordinate Units (by December 31, 2020)

Units	Leaders
Service Centre for Administrative Affairs	Feng Wenan, Yang Tao, Shi Xinghe
Center for Science Communication and Achievement Transformation (*Science Foundation in China*)	Li Jianjun, Tang Longhua, Peng Jie(F)
Sino-German Centre for Research Promotion	Fan Yingjie(F, concurrently)

Appendix

NSFC

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I. Important Activities of NSFC in 2020

January

On January 3, the Second Inspection Team of the Central Committee reported the inspection results to the Party Group of NSFC. Wu Yuliang, Vice Minister of the Central Organization Department, Xue Li, Leader of the Second Inspection Team of the Central Committee, Li Jinghai, Party Secretary and President of the National Natural Science Foundation of China, Deputy Leader and other members of the Second Inspection Team of the Central Committee, members of the Office of the Central Inspection Work Leading Group, Central Commission for Discipline Inspection and the Central Organization Department, members of the Disciplinary Inspection and Supervision Group of the National Supervisory Committee in MoST, members of the leading Party Group of NSFC attended the meeting. Directors at division level or higher of NSFC and its affiliated units attended the meeting too.

On January 8, Director Cui Zhenlong and Deputy Director Cui Ming of the Department of Education, Science, Culture and Health of the National Audit Office attended the 2019 Annual Budget Implementation Audit Progress Meeting of NSFC. Li Jinghai, Secretary General and President of NSFC, Wang Chengwen, Party Group Member and Vice President of NSFC, and Han Yu, Party Group Member and Secretariat, attended the meeting. Gao Ruiping, Member and Vice President, chaired the meeting.

On January 10, Party Secretary and President Li Jinghai met with Professor Nils Christian Stenseth of the University of Oslo, Norway, who came to China to receive the "2019 International Science and Technology Cooperation Award".

On January 13, Xie Xincheng, Vice President and Hou Zengqian, Party Group Member and Vice President, presided over Workshop on the Sustainable Development of International Cooperation along the "Belt and Road" Countries.

On January 14, Party Secretary and President Li Jinghai attended the Global Research Council (GRC) Governing Board meeting.

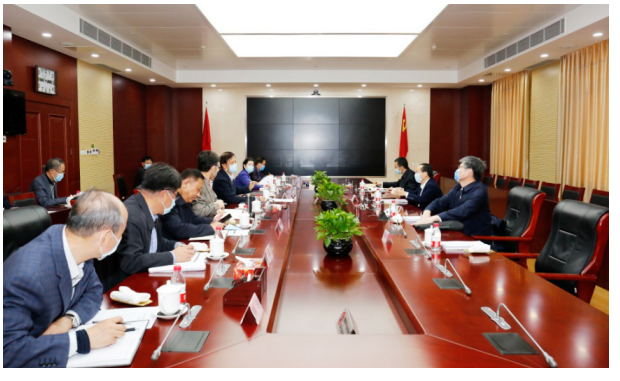
February

On February 14th, Party Secretary and President Li Jinghai held a telephone conference with Andrew

Thompson, the international champion of UK Research and Innovation (UKRI).

On February 14, Wang Chengwen, Party Group Member and Vice President, and Han Yu, Party Group Member and Secretariat inspected the prevention and control of COVID-19, visiting the employees who were fighting on the front line against the COVID-19. During the investigation, Vice President Wang Chengwen emphasized the need to resolutely implement the important instructions of Xi Jinping on the prevention and control of COVID-19, resolutely implement the decisions and deployments of the Party Central Committee and the State Council, and in accordance with the deployment requirements of the Committee and Party Group, make every effort to provide security services for epidemic prevention and control.

March



On March 25th, party group secretary and director Li Jinghai, party group members and deputy directors Gao Ruiping and Wang Chengwen held work talks with visiting director Zhang Kejian and deputy director Wu Yanhua of the State Administration of Defense Technology Industry.

On March 31, Gong Tanghua, the leader of the Inspection and Supervision Team of the State Supervision Commission in the MoST and Party Group Member of MoST visited NSFC. The purpose of the visit was to implement the spirit of the Fourth Plenary Session of the 19th Central Commission for Discipline Inspection, carry out in-depth exchanges on the comprehensive and strict governance. Party Secretary and President Li Jinghai presided over the seminar. Members of the Inspection and Supervision Team and members of the leading group of the Natural Science Foundation of China attended the meeting.

April

On April 16, Li Meng, Party Group Member and Vice President the Party Leadership Group of the Ministry of Science and Technology, Secretary of the Party of MoST's directly affiliated organ, visited NSFC. The purpose of the visit was to supervise the implementation of the inspection and rectification tasks. Li Jinghai, secretary

general and president of NSFC, attended the meeting and delivered a speech. Wang Chengwen, member of the Party Group, Vice President and Secretary of the Party Committee, presided over the meeting. Members of the MoST's General Office, Department of Resource Allocation and Management, Department of Supervision and Scientific Integrity, Department of Basic Research, Department of Personnel and Affiliated Agencies, members of NSFC's CPC committee and Office of Discipline Inspection Committee attended the meeting.

On April 22, Party Group Secretary and President Li Jinghai, Party Group Members and Vice Presidents Gao Ruiping and Wang Chengwen attended the 2020 NSFC's Fund Review Deployment Meeting and delivered speeches. Party group members and Vice Presidents Gao Fu, Hou Zengqian, Lu Jianhua, and Vice President Xie Xincheng attended the meeting. Party member and secretariat Han Yu presided over the meeting.

On April 22, the Central Disciplinary Inspection and Supervision Group in MoST and the CPC Group of NSFC held the first meeting on Strict Party Governance in 2020. In the meeting, discussion was held on conducting communication and consultation on implementing the spirit of the Fourth Plenary Session of the 19th Central Commission for Discipline Inspection was held. Li Jinghai, Secretary General and President of NSFC, attended and presided over the meeting. Gong Tanghua, leader of the discipline inspection and supervision group, and member of the party group of the MoST, attended the meeting and delivered speeches. Xu Minzhen, deputy director of the Third Division of the Second Supervision and Inspection Office of the Central Commission for Discipline Inspection, and Xuan Hongyun, deputy head of the Discipline Inspection and Supervision Group of the Central Commission for Discipline Inspection in MoST attended the meeting. All members of NSFC's party group and leadership team attended the meeting. Members from the Office of NSFC, CPC committee and Office of Discipline Inspection Committee attended the meeting.

May

On May 20, NSFC held the 2020 Meeting on Strict party governance, party conduct and clean government building, and anti-corruption work. Gong Tanghua, leader of the Disciplinary Inspection and Supervision Team of the Ministry of Science and Technology and member of the Party Group of the Ministry of Science

and Technology of the State Supervision Commission of the Central Commission for Discipline Inspection, attended the on-site meeting and delivered a speech. The meeting summarized the situation of strict party governance, party conduct and clean government building, and anti-corruption work, and made arrangements for the work in 2020.

On May 26, Gong Tanghua, leader of the Disciplinary Inspection and Supervision Team of the Ministry of Science and Technology of the Central Commission for Discipline Inspection and member of the Party Group of the MoST, went to the Natural Science Foundation of China to investigate the review of the 2020 Science Fund, and supervised and guided the central inspection and rectification work. Gao Ruiping, member of the party group and Vice President, presided over the research symposium, and Han Yu, member of the party group and secretary-general, attended the meeting.

On May 29th, the Natural Science Foundation of China held a "two sessions" spirit transmission meeting to in-depth study and implement the spirit of the Third Session of the 13th National People's Congress and the Third Session of the 13th National Committee of the Chinese People's Political Consultative Conference. The leading group of the Natural Science Foundation of China and members at the deputy bureau level and above participated in the on-site meeting, and those at the division level and below participated in the form of live webcast.

June

On June 8, Party Secretary and President Li Jinghai, Party Member and Deputy Director Gao Ruiping and Vice Governor of Shanxi Province Wang Yixin held a working meeting in Beijing. Natural Science Foundation Planning Bureau Director Wang Changrui, Director of Shanxi Provincial General Office Zhao Guoguang, Shanxi Provincial Science and Technology Director Zhang Xinwei accompanied the meeting.

On June 11, the third meeting of the Eighth Committee of Natural Science Foundation of China was held. The meeting reviewed and approved the work report of the whole committee made by the Party Secretary and President Li Jinghai, the work report of the supervisory committee made by Chen Yiyu, the director of the supervisory committee, and the "National Natural Science Foundation Deepening Reform Plan" and the "2019 Science The implementation of the fund budget and funding plan and the report on the 2020 budget and funding plan. At the meeting, Wang Chengwen, member of the party group and Vice President, announced the Central Second Inspection Group's feedback on the inspection of the Party Group of the Natural Science Foundation of China and the implementation of rectification. Members of the 8th Natural Science Foundation of China Committee, the Central Organization Department and the relevant responsible comrades of the Disciplinary Inspection and Supervision Group of the National Supervisory Committee of the Central Commission for Discipline Inspection in the Ministry of Science and Technology attended the meeting; consultant of the Natural Science Foundation of China, member of the 5th Supervisory Committee, and directors of various science departments (part-time) attended the meeting as non-voting delegates with members at the deputy bureau level (inclusive) and above of various departments; members and staff below the department level (including rotating program directors and part-time staff) watched the opening ceremony via live webcast. The meeting was chaired by Gao Fu, member of the party group and Vice President.

On June 30, the China-Korea COVID-19 research webcast seminar was held. Party Secretary and President Li Jinghai and Director of the National Research Foundation of Korea (NRF) Jung-hae Roh delivered speeches via video.

July

On July 1, Party Secretary and President Li Jinghai delivered a lecture on the theme of "Study and Implement Xi Jinping's Thoughts on the Overall Strict Governance of the Party, Strengthen the Political Awareness, Strengthen the Political Construction of the Party, Conscientiously Fulfill the Political Responsibility and Mission" for all party members and active applicants as part of the "July 1" special Party Class. Party Group members, Vice Presidents Gao Fu, Hou Zenqian, Gao Ruiping, Lu Jianhua, Party members, Secretariat Han Yu attended, Party group member, Vice President and CPC Committee secretary Wang Chengwen presided over the Party class.

On July 14, O Wenhan, a delegation led by Party Group Member of the Ministry of Finance and Assistant Minister visited the Natural Science Foundation of China to conduct research. Li Jinghai, Secretary General and President of NSFC presided over the research meeting. Party Group members and Vice Presidents Gao Ruiping and Wang Chengwen, and Party members and secretariat Han Yu attended the meeting.

On July 22, 24, and 25, Gao Ruiping, party group member and Vice President, attended the 2020 Seismological Science Joint Fund, NSFC-Shandong Joint Fund, Smart Grid Joint Fund, NSFC-Guangdong Joint Fund, NSFC-Shenzhen Robot Basic Research Center Project , Nuclear Technology Innovation Joint Fund, NSFC-Henan Joint Fund, NSFC-Yunnan Joint Fund, NSFC-Xinjiang Joint Fund, Joint Fund for Promoting Cross-Strait Science and Technology Cooperation, and Joint Fund for Scientific Research of Yangtze River Water and other 11 joint fund joint working meetings.

August

On August 19, a delegation led by Li Xueyong, chairman of the Education, Science, Culture, and Health Committee visited the Natural Science Foundation of China for research. Party Secretary and President Li

Jinghai presided over the research seminar and made a work report. All members of the leadership team attended the research meeting.

From August 20 to 21, Party Secretary and President Li Jinghai, Party Member and Secretariat Han Yu led a team to Naiman Banner, Tongliao City, Inner Mongolia to conduct research and supervision on targeted poverty alleviation, presided over a symposium on targeted poverty alleviation, and visited the villagers's first secretary, and organized a laptop donation ceremony, and check the situation of the Naiman Banner Youth Science Education Base of the Natural Science Foundation of China. Party Secretary and President Li Jinghai fully affirmed Naiman Banner's achievements in poverty alleviation work, and emphasized that the Natural Science Foundation of China, Naiman Banner Committee and the government should unify their thinking, conduct investigations and research seriously, and thoroughly implement the rural revitalization and development strategy. To promote poverty alleviation and achieve practical results, and strive to make a "Naiman plan" that effectively connects poverty alleviation and rural revitalization.

On August 28, the first plenary meeting of the Advisory Committee of the Natural Science Foundation of China in 2020 was held in Beijing. The meeting was chaired by Yang Wei, Director of the Advisory Committee, Li Jinghai, Party Secretary and President, Gao Ruiping and Wang Chengwen, Party Leaders and Deputy Directors, and Han Yu, Party Member and Secretary-General, attended the meeting. The main members of various departments attended the meeting as nonvoting delegates.

September

On September 7, Party Secretary and President Li Jinghai, and Deputy Director Xie Xincheng met with visiting UAE Ambassador to China Ali Obaid Al Dhaheri and his entourage.

On September 28, Vice President Xie Xincheng met with the Science and Technology Counselor of the US Embassy in China.

On September 28-30, the "Second Global Health Symposium" was successfully held in Shanghai. Party member and Vice President Gao Fu, and Vice President Xie Xincheng attended the meeting and delivered speeches and keynote speeches at the opening ceremony.

October

On October 16, Party member and secretary-general Han Yu attended and delivered a speech at the disciplinary development strategy research project exchange meeting jointly supported by the Natural Science Foundation of China and the Chinese Academy of Sciences.

On October 21, the 2020 National Science Fund for Distinguished Young Scientists Review Committee meeting was held in Beijing. A total of 54 participants, consisting of members of the Ninth National Science Fund for Distinguished Young Scholars attended the meeting. The meeting was presided over by Li Shushen and Guo Zhengtang, deputy directors of the evaluation committee. Gao Ruiping, member of the party group and Vice President, attended the meeting and delivered a speech.

On October 23, Wang Chengwen, member of the party group and Vice President, attended the Hangzhou preparatory meeting for the supervision and inspection of funds for some of the projects funded by the National Natural Science Foundation of China in Zhejiang Province.

On October 30, Party Secretary and President Li Jinghai, Vice President Xie Xincheng, Party Leadership Member and Secretary-General Han Yu invited experts from the scientific and technological circles and representatives of Xinhua News Agency to hold a special symposium on the theme of "Attracting global scientific and technological resources to participate in my country's scientific and technological innovation and basic research" meeting.

November

From November 4th to 5th, the Natural Science Foundation of China held the 2020 Party Group (Expanded) Meeting to convey and learn the spirit of the Fifth Plenary Session of the 19th Central Committee of the Party, and systematically plan the development plan for the 14th Five-Year Plan of the Science Foundation and the mid- to long-term period from 2021 to 2035, Development plan, in-depth discussion of the science fund to further deepen the reform direction. Members of the leading group of the Natural Science Foundation of China, leaders of the Disciplinary Inspection and Supervision Group of the National Supervisory Committee of the Central Commission for

Discipline Inspection in the Ministry of Science and Technology, directors of various science departments and all bureau-level officials attended the meeting.

On November 17-18, the 23rd Joint Committee Video Meeting of the Sino-German Center for Scientific Promotion was held. Party Secretary and President Li Jinghai and German Research Federation (DFG) Chairman Katja Becker attended the opening ceremony and delivered speeches. Vice President and Chinese Chairman of the Joint Committee Xie Xincheng and DFG's Vice Chairman Axel Brakhage co-chaired the meeting. Party Member and secretariat Han Yu, President of Jilin University Zhang Xi, Dean of the Institute of Surface Earth System Science of Tianjin University Liu Congqiang, and the German members of the Joint Committee attended the meeting.

On November 18th, the naming ceremony of "Tang Aoqing" Asteroid co-sponsored by the Natural Science Foundation of China, the He Liang He Li Foundation, the Purple Mountain Observatory of the Chinese Academy of Sciences and Jilin University was held in Beijing. Zhu Lilan, Chairman of the Trust Committee of the He Liang Heli Fund, Duan Ruichun, Secretary-General, Li Jinghai, Secretary of the Party Group and President of the Natural Science Foundation of China, and members of the leadership team, Zhang Xi, President of Jilin University, Zheng Weitao, Vice President, Chang Jin, Director of the Purple Mountain Observatory, Chinese Academy of Sciences, Near-Earth Objects The group chief scientist Zhao Haibin and the family of Mr. Tang Aoqing attended the naming ceremony. Members of various departments of the Natural Science Foundation of China and members of Jilin University attended the ceremony. The naming ceremony was presided over by Han Yu, member and Secretary-General of the Party Group of the Natural Science Foundation of China.

On November 19-20, the 4th Biennial Strategic Meeting between the Natural Science Foundation of China and the UK Agency for Research and Innovation (UKRI) was held via the video conference. Party Secretary and President Li Jinghai and Andrew Thompson, UKRI's international champion, attended the meeting and exchanged views. Deputy Director Xie Xincheng and UKRI Director of International Cooperation Bureau Tim Wheeler co-chaired the meeting.

From November 19th to 20th, the Natural Science Foundation of China's Party Member Capacity Building Training Course was held on the Fu Jen campus of Beijing Normal University. Tu Qingyun, Vice President of Beijing Normal University, delivered an opening speech, and Wang Chengwen, Party Group member and Vice President, and secretary of the CPC committee of NSFC also delivered a speech. The training class invited Cui Yuting, Executive Deputy Secretary of the Party Committee of MoST, and experts from the Central Party School, Tsinghua University, Beijing Normal University, and the Social Science Development Research Center of Higher Education from the Ministry of Education to give lectures.

On November 20th, Wang Chengwen, member of the party group and Vice President, attended the 2020 National Science Ethics and Style of Study Promotion and Education Report and the Launching Ceremony of Publicity Month.

From November 20 to 21, the Outstanding Achievement Matchmaking Event co-sponsored by the National Natural Science Foundation of China and Guangdong Province was successfully held in Guangdong Province. Gao Ruiping, member of the party group and Vice President, Wang Xi, deputy governor of Guangdong Province, and other relevant leaders attended the event. More than 70 outstanding domestic scientists were invited to come to Guangdong to carry out the docking of achievements. At the meeting, there were 6 achievement transformation projects that were successfully signed.

On November 25-27, the Natural Science Foundation of China held a special training course on "Learning and Implementing the Spirit of the Fifth Plenary Session of the 19th Central Committee of the Communist Party of China". Shi Zongkai, Deputy Director of the School Affairs Committee of Tsinghua University, delivered a speech, and Li Jinghai, Secretary of the Party Leadership Group and President of NSFC, made a speech. Peng Zongchao, Secretary of the Party Committee of the School of Public Administration of Tsinghua University, Wang Chengwen, member of the Party Group and Vice President of NSFC, and Secretary of the CPC Committee, and Han Yu, member of the Party Group and Secretariat, attended the meeting. Bureau-level members of NSFC participated in the on-site meeting, and divisioin-level members participated in the training in the form of webcast.

On November 29, the Natural Science Foundation of China's Interdisciplinary Science High-end Academic Forum and the inauguration ceremony of the Department of Interdisciplinary Sciences was held in Beijing. Han Qide, Vice Chairman of the 12th CPPCC National Committee and Honorary Chairman of China Association for Science and Technology, Chen Jia'er, Former Director of the Natural Science Foundation of China, Li Jinghai, Secretary of the Party Group and President of the Natural Science Foundation of China, Discipline Inspection and Supervision Group in MoST, National Development and Reform Relevant responsible members and experts in related fields of the Commission, the Ministry of Education, the Chinese Academy of Sciences, the Chinese Academy of Engineering, the Science and Technology Commission of the Central Military Commission, and the Chinese Association for Science and Technology, as well as members of the leading group of the Natural Science Foundation of China, attended the opening ceremony and inauguration ceremony of the forum. The members of various departments of NSFC participated in the opening ceremony and inauguration ceremony. The opening ceremony and inauguration ceremony of the forum were presided over by Lu Jianhua, member of the Party Leadership Group and Vice President of the Natural Science Foundation of China.

December

On December 4th, Party Secretary and President Li Jinghai held a meeting with Katja Becker, Chairman of the German Research Foundation (DFG) via video conference.

On December 8, the Central Disciplinary Inspection and Supervision Group in MoST and the Party Group of NSFC held the second meeting in 2020 on the topic of Comprehensive and Strict Party Governance. Gong Tanghua, leader of the Discipline Inspection and Supervision Team and member of the Party Leadership Group of MoST, and Li Jinghai, Secretary General of the Party Leadership Group and President of the Natural Science Foundation of China, attended the meeting and delivered speeches. Xuan Hongyun, deputy head of the Discipline Inspection and Supervision Group of the National Supervision Commission of the Central Commission for Discipline Inspection in the MoST, and all members of the Party Group and the leading group of the Natural Science Foundation of China attended the meeting. Other members of the Discipline Inspection and Supervision Group and relevant departments of NSFC attended the meeting. The meeting was chaired by Li Jinghai.

On December 14, members of the leadership team of NSFC went to the Chinese Academy of Engineering Sciences and the Chinese Academy of Sciences for special consultations on the reform of the science fund, and listened to the opinions and suggestions of the leaders of the Chinese Academy of Engineering Sciences and the Chinese Academy of Sciences and the directors of the standing committees of various academic departments.

On December 16, the 2020 National Natural Science Foundation Management Work Conference was held in Beijing. Party Secretary and President Li Jinghai, Party Leadership Members and Vice President Gao Ruiping and Wang Chengwen attended the meeting. Representatives from the Leading Groups and some supporting units from 36 networks across the country, and relevant memebers from various bureaus (offices), the Ministry of Science and directly affiliated units attended the meeting. Party member and secretary-general Han Yu presided over the opening ceremony.

II. Shuangqing Forum

"Shuangqing Forum" are academic seminars set up by the National Natural Science Foundation of China, based on the funding of the Science Fund, in order to carry out strategic research on discipline development, promote interdisciplinary and integration, promote the transformation of scientific research paradigm, improve the scientific fund system and management operation mechanism, and improve the excellent management of the science fund. It mainly discusses forward-looking, comprehensive and cross-cutting scientific issues facing the frontiers of science in the world and major national needs, as well as major policy issues in the management of science fund funding, helping to build a new era science fund system with advanced concepts, standardized systems, fairness and efficiency.

In 2020, through the "Shuangqing Forum" NSFC fully implemented the spirit of General Secretary Xi Jinping's important instructions on scientific and technological innovation, implementing the requirements of the "National Natural Science Foundation of China's Upgraded Reform Framework and Division of Labor Plan", and implementing the "encourage exploration, highlight originality, focus on cutting-edge, and create innovative ways, demand-driven, breakthrough bottlenecks, common-oriented, cross-financing" funding orientation of the new era science fund, strengthen the function of academic exchange platform and strategic research mechanism, and focus on the mid-term and long-term planning of the science fund and the formulation of the "14th Five-Year Plan". A total of 26 Shuangqing Forums were held throughout the year (No. 252-277, Attached Table 2-1), with 956 participants. Among them, the Science Departments hosted 24 sessions, and the Bureau (Office) hosted 2 sessions. It mainly involves 12 issues of basic science issues at the forefront of science, 9 issues related to deep scientific issues oriented to the needs of national development strategies, and 5 issues related to major policy and management issues related to the development and improvement of the science fund system. In addition, Technology Poverty Alleviation Lecture, first phase, was held.

Figure 2-1 Novel coronavirus infection and immune defense

Attached Figure 2-2 Positioning of basic engineering science research and its scientific problem condensing mechanism

Figure 2-3 Electrochemical energy beyond the traditional system

Attached Table 2-1 2020 "Shuangqing Forum" Subject Directory

Issue 252: Fundamental Research on Intelligent Group System for Social Governance (May 20, 2020)	Issue 265: Panoramic Intelligent Sensing and Smart Grid (October 31-November 1, 2020)
Issue 253: Key scientific issues of novel coronavirus infection and immune defense (June 8, 2020)	Issue 266: Frontier Theory and Methods of Intelligent Building and Infrastructure Life Cycle (November 6-7, 2020)
Issue 254: New theories and new paradigms of organization and management under the digital economy (August 10, 2020)	Issue 267: Opportunities and Challenges of Artificial Intelligence to Mathematics (November 10-11, 2020)
Issue No. 255: Coastal Zone-Offshore Multi-Interface Transsphere Interaction and Sustainable Healthy Ocean (September 10-11, 2020)	No. 268: Deep Earth Frontier Physics Symposium (November 12-13, 2020)
Issue 256: Innovation and Reform and Cultivation of New Kinetic Energy in Northeast China (September 17-18, 2020)	Issue 269: Frontiers and Challenges of Neuromodulation (November 14, 2020)
Issue 257: China's economic development laws and key scientific issues in theoretical research (September 21-22, 2020)	Issue 270: Challenging scientific issues and disruptive technologies for deep oil and gas geophysical exploration (November 16-17, 2020)
Issue 258: Planetary Habitability and Evolution (September 23-24, 2020)	Issue 271: Blockchain basic theories and key technologies (November 18-19, 2020)
Issue 259: Leverage the unique advantages of the Science Foundation to help international cooperation in the new era (September 24-25, 2020)	Issue 272: Blood Ecology and Major Diseases (November 26-27, 2020)
Issue 260: Policy Informatics and Policy Intelligence (October 19-20, 2020)	Issue 273: Cognition and Utilization of Electromagnetic Space Information Resources (December 7-8, 2020)
Issue 261: Positioning of basic engineering science research and its scientific problem condensing mechanism (October 22-23, 2020)	Issue 274: Ecological Protection and Sustainable Development of the Yellow River Basin (December 9-10, 2020)
Issue 262: Electrochemical energy beyond the traditional system (October 26-27, 2020)	Issue 275: Key scientific issues in the prevention and control of major livestock and poultry diseases (December 14-15, 2020)
Issue 263: From molecule to factory-molecular chemical engineering theory and transformative technology (October 29-30, 2020)	Issue 276: Major Issues in AI Empowering Education (December 16-17, 2020)
Issue 264: Basic research strategy for innovative drugs (October 30-31, 2020)	Issue 277: Opportunities and Challenges of Biotechnology (December 29-30, 2020)

III. NSFC Policy Files

Administrative Normative Document System of NSFC

Organization and Management

- National Natural Science Foundation of China Regulations
- Regulations of the Supervisory Committee of NSFC
- Regulations of the Advisory Committee of NSFC
- Management Measures for NSFC
- Working Methods of the Expert Advisory Committee of Scientific Departments in NSFC
- Management Measures for Evaluation Experts of NSFC
- Rules for the Management and Implementation of the Regional Liaison Network of NSFC
- Rules for the Implementation of the Registration Administration of Dependent Units of NSFC

Procedure Management

- Management Measures for General Program of NSFC
- Management Measures for Key Program of NSFC
- Management Measures for Major Program of NSFC
- Management Measures for International (Regional) Cooperative Research Program of NSFC
- Management Measures for Tianyuan Fund for Mathematics of NSFC
- Management Measures for Young Scientists Fund of NSFC
- Management Measures for Excellent Young Scientists Fund of NSFC
- Management Measures for National Science Fund for Distinguished Young Scientists of NSFC
- Management Measures for Fund for Less Developed Regions of NSFC
- Management Measures for Science Fund for Creative Research Groups of NSFC
- Management Measures for the Research Fund for International Young Scientists of NSFC
- Management of Overseas Young Scholars Cooperative Research Fund
- Management of the Hong Kong and Macao Young Scholars Collaborative Research Fund
- Management Measures for Special Fund for Research on National Major Research Instruments of NSFC
- Management Measures for International (Regional) Exchange Program of NSFC
- Management Measures for Major Research Plan of NSFC
- Management Measures for Joint Funds of NSFC
- Management Measures for Special Projects of NSFC
- Procedures for the Change Management of NSFC Projects (for Trial Implementation)

Fund Management

- Measures for Fund Management of NSFC
- Supplementary Notice of Minister of Finance on Issues Relevant to Fund Management of NSFC Funded Projects
- Notice of the Ministry of Finances to NSFC on Further Improving Science Fund Projects and Fund Management

Supervision and Guarantee

- Measures for Evasion and Confidentiality Management in Project Evaluation of NSFC
- Code of Conduct for Project Evaluation Experts of NSFC
- Rules for the Implementation of the Supervisory Work of NSFC Subsidized Projects Assessment Meeting
- Measures for Project Review Management of NSFC
- Measures for the Management of Research Achievements of NSFC Funded Projects
- Measures for Investigation and Handling of Scientific Research Misconduct of NSFC Funded Projects
- Management Measures for Information Disclosure of NSFC
- Complaint Rules of the NSFC
- Interim Measures for the Audit Work of NSFC
- Measures for the Supervision and Inspection of NSFC Funded Projects