Major Research Plan

Following the principle of definite objective, stable support, integration and refinement and leap- forward development", Major Research Plan focuses on key basic scientific issues with strategic importance to the nation and major frontier areas and give high priority identified on the basis of the capability and advantages of the country. Rather than individual project, Major Research Plan is designed to be a program cluster which contains a number of projects with relatively identical objectives for innovative research resources integrity in order to explore the possible break-through in the identified areas.

Applicants should meet the following eligibility criteria:
(1) Having experience of undertaking basic research projects;
(2) Bearing a senior academic position.

Post-docs in station and graduate students are not eligible to apply.

A Major Research Plan is framed with three types of programs, namely, the Fostering Program, Key Program and Integrated Program, of which each one is open to application. Proposals shall be prepared in accordance with the requirement for Major Research Plan and outlines for proposal preparation, featuring interdisciplinary research, emphasizing on the contributions to solving key scientific issues and fulfilling the overall goals of the Major Research Plan. Applicants should select “Major Research Plan” for the column of the funding type in the form of proposal, and Fostering Program, Key Program, or Integrated Program for the column of sub-type in the form of proposal, and the titles of the Major Research Plan in the annotation. Proposal is not accepted in case of incorrect selections or without any selections.

Funding for Fostering Program project, Key Program project of the Major Research Plan is equivalent to the average level of General Program and Key Program respectively. Generally, duration of funding for Fostering Program project is 3 years, for Key Program project 4 years, and that for Integrated Program project is determined by the steering committee of each Major Research Plan according to the actual need. For Fostering Program project and Key Program project, the collaborative organizations involved

may not exceed 2 in number. The Integrated Program project will not be counted in limitations of total number of projects applied and undertaken for senior academic title holder, and the collaborative organizations involved may not exceed 5, and main participants must be the actual contributor to the Integrated Program project, and total number of main participants may not exceed 9.

Integrated Research on the Eco-Hydrological Process in Heihe Basin

By choosing the Heihe Basin as a typical study area, this Major Research Plan aims to systematically explore the processes and mechanism of interaction between ecosystem and hydrological system in inland watersheds by establishing a research platform for scientific observation and experiment, data collection and modeling simulation in China; to improve the research capabilities on analysis and prediction about the inland watershed's hydrological, ecological and economic system evolution by setting up the eco-hydrological process model and decision making system for water resource management. The expected achievement will serve as the fundamental theories and S&T support for water and ecological security as well as sustainable development of the economy in inland watersheds.

I. Key scientific issues

(1) Plant water use efficiency in arid environment and its adaptive mechanism to water stress. The research is to recognize the plant's unique water use pattern formed in long-term adaptation to arid climates, understand the characteristics of the hydrological cycle at different spatial scales, and analyze the water use processes of plant individual, population, community, ecosystem and the plant's adaptive mechanism to water stress.

(2) Mechanism of interactions between surface water and groundwater and the eco-hydrological effects. The research is to investigate the circulation nature, exchange processes and water quality evolution between surface water and groundwater, and recognize the basic characteristics of the hydrology, water resources and water environment in arid zones and their impacts on regional ecological processes.

(3) Mechanism of eco-hydrological processes at different scales and scaling methodologies. The research is to study on the interactions between spatial patterns of hydrology and vegetation in arid inland watersheds,

investigate the interaction mechanism of eco-hydrological processes at different scales, and develop and improve the scaling technologies and methodologies.

(4) Response mechanism of watershed eco-hydrological processes to climate change and human activities. The goal is to understand the historical evolution of human activities, spatial mode of action and intensity, develop the methodology of converting human elements into spatial parameters, and establish the watershed ecology, hydrology and economy coupled models.

(5) Methodological and technological synthesis of experimental observation and data simulation. The research focuses on establishing the research platform that integrate observation, experiment, and data simulation at basin scale, improving field observation and research network based on the overall concept of watershed, and establishing the scientific issue oriented research platform that takes watershed as a unique system and aims at the simulation of eco-hydrological processes.

II. Scientific targets

Through the establishment of the "integrated and water-centered eco-hydrological research platform", which integrates observation, experiment, simulation, scenario analysis and decision making, the research plan aims to reveal the interaction of eco-hydrological processes at different scales such as plant individual, community, ecosystem, landscape and watershed, characterize the response mechanism of eco-hydrological processes to climate change and human activities in inland watersheds, develop the scaling methodologies of different eco-hydrological processes, establish the integrated models of coupling watershed ecology, hydrology and social economy, improve the understanding of water resources formation and transformation mechanism in inland watersheds, and improve the regulatory ability of sustainability, so as to promote the research level of the watershed eco-hydrology in China.

III. Overall arrangement

The duration of the research plan is 8 years with a total budget of 150 million yuan. The projects were initiated in 2010, and carried out in the first 5 years. Fostering Program projects, Key Program projects and Integrated Program projects will be funded in 2013:

1. Fostering Program Project

The funding is targeted at the proposals of basic research with innovative

ideas on the advanced ecological, hydrological and human dimension issues specific to the Heihe basin. The project will be funded with no less than 500,000 yuan per projectfor 3-year.

2. Key Program Project

(1) The funding is targeted at the proposals with significant innovative ideas on the basin's ecological, hydrological and economical processes and their interactions.

(2) The aerial remote sensing research on data collection and environmental parameter inversion that can support the integrated study of eco-hydrology in the Heihe basin.

(3) Research on the design and development of the integrated models, data assimilation of watershed land surface and spatial decision making systems for watershed resource management in the basin.

The project will be funded with no less than 2,000,000 yuan per project for 4-year.

3. Integrated Program Project

Based on the results from previously supported Fostering Program projects and Key Program projects, the research directions, which will contribute to the overall objectives of the Major Research Plan dominantly, should be applied as "a group of projects" for the integrated study and will be funded for 4 years in the form of "Integrated Program projects".

IV. Key research directions in 2013

The year of 2013 is the fourth year for this Major Research Plan to call for proposals. According to the previous funding arrangement and overall plan as well as the decision made by the steering committee for this plan, Fostering Program projects and Key Program projects with close relations to integrated research directions will be accepted in 2013 in order to serve for the overall integrity in the final stage of the research plan. Projects without close relations to integrated research directions will not be accepted.

In 2013, aimed at the overall design objectives of the Major Research Plan and the key process mechanisms, vital parameters and environment variable data urgently needed in the implementation of the Integrated Program projects, following directions will be funded with a total budget of 35 million yuan.

1. **Study on groundwater processes and the effects in permafrost region of the upper reaches**

The research is to understand the spatial-temporal principles of the soil freeze-thaw cycles on the upper reaches, to proclaim the eco-hydrological functions of water retention and water release of the frozen soil, and to investigate the source and receptor relationships between soil water, groundwater and base flow in the soil freeze-thaw cycles. Based on freezing and thawing mechanisms and underground hydrological processes, the establishment of surface water -soil water -groundwater transformation model in permafrost region should be included.

2. **Study on spatial distribution of watershed snow cover related to blowing snow processes**

By introducing the influence of blowing snow processes on snow cover, the research is to establish a snow-melting model based on dynamic processes. Combined with data from blowing snow observation stations and satellite remote sensing data, delineation of the area distribution of watershed snow cover should be included.

3. **Study on spatial distribution patterns of the watershed eco-hydrological parameters and multi-source data assimilation**

The research is to quantitatively analyze the spatial-temporal features and the uncertainties of the key eco-hydrological parameters and determine the optimal spatial-temporal resolution of the remote sensing data. In order to support targeted spatial distribution data for scale-effect investigation of eco-hydrological processes and validation of watershed eco-hydrological models, the establishment of multi-source data assimilation system and the generation of consecutive and long time-series data about the spatial distribution of watershed eco-hydrological parameters such as monthly precipitation, evapotranspiration and soil water content should be included.

4. **Spatial interpolation and dynamic analysis and simulation of eco-hydrological parameters**

The research is to quantitatively analyze the spatial nonstationarity of the eco-hydrological parameters obtained by observation, monitor and survey and realize the classification of the eco-hydrological parameters data as spatial non-stationary and spatial stationary data. The establishment of the analysis method for spatial interpolation and spatial simulation and the generation of spatial dataset of the eco-hydrological parameters in the Heihe river basin should be included.

5. Decision-making support system for integrated watershed management

Taking watershed social-economic water consumption model and water resource allocation as major objectives, the research is to address watershed hydrological processes model and ecological effects evaluation model and establish synthetic decision making support system on medium and long-term water resource optimized management in the Heihe river basin. Effects of different system constraints such as water rights institution, industry and urbanization development, land use change, oasis scale change and climate change, on the operation of system and benefits should be included.

V. Selection criteria

Proposals for the research plan should meet the following requirements:

(1) Emphasis on fundamental and innovative researches focusing on eco-hydrological and related issues in the Heihe basin.

(2) Emphasis on systematic and interdisciplinary researches focusing on the overall objectives of the research plan.

(3) Substantial international cooperation.

Single Quantum State Detection and Its Interactions

Quantum mechanics strengthened not only the understanding of the laws in the micro cosmos, but also promoted greatly the development of modern science and technology. Up to now, it is still far from completely understanding on the single particle level all quantum characteristics of multi particle system in complex environment with internal interactions, in particular, research on the precision measurement of single quantum state and its interactions is still at initial stage, which not only affects substantial development of contemporary physics with quantum mechanics as its central part, and other disciplines concerned as well. In recent years, along with the development of the experimental precision and control technology, some of new single quantum state system and complex quantum structures could be established and the quantum characteristics could be directly detected. Therefore, great breakthrough may be fostered in the research concerning single quantum state and its interdisciplinary development with information, material, energy and chemistry.

Single quantum state refers to quantum state of single particle systems, such as single photon, single electron, single atom, single molecule and sub particles in condensed matter, etc., and macro quantum state formed by multi-particles gathering at the same micro state (such as Bose-Einstein condensed state, super conductivity or super fluid quantum state). This Major Research Plan aims at developing relevant materials and systems by physical and chemical means, constructing such single particle quantum state and macro quantum state and detecting directly its rich quantum effects. The objectives of this research plan is to understand the property of quantum state and basic laws of quantum coherent process, develop new techniques of constructing quantum devices and means of quantum detection, explore potential applications in information and energy technology, promote the development of basic research in the fields of physics, chemistry and information technology in China, and solve some basic science and key technology issues with national strategic significance.

I. Scientific targets

To develop physical and chemical methods and technologies for relevant materials and systems, construct high quality quantum structures as well as new precision detection methods for understanding the mechanism of relevant phenomena and processes at single quantum state, and to discover several novel quantum effects through the measurement of single quantum state and study of interaction between quantum states;

To provide solid physical basis for the application of quantum effect in the studies on major scientific issues in information technology, energy and environment, and farsighted knowledge for substantial and sustained development of national economy and security;

To form gradually the Chinese school with international reputation and foster a high level research team, especially a number of outstanding young scholars engaging at experimental science for promoting the competitiveness and position of experimental science in China.

II. Key scientific problems

1. Physical and chemical preparation of relevant materials and the construction of single quantum system
2. Property and precision detection of single quantum state system
3. Quantum state and environment, and interaction between quantum states
4. Modeling and numerical computation of quantum state interaction

III. Application and funding in 2012

In 2012, 33 applications were received, among them, 14 were for Key Program project, 13 for Fostering Program project (one application declined), and 6 for Integrated Program project. After expert review, we funded 6 Key Program projects, 5 Fostering Program projects and 4 Integrated Program projects. Total funding was 40 million yuan. The 4 Integrated Program projects were in areas of single photon, superconductivity, topological insulator and gaseous state single molecule, respectively.

IV. Key funding research areas in 2013

In 2013, this Major Research Plan has been implemented its 5th year of implementation. In the last 4 years, 47 Fostering Program projects, 24 Key Program projects, and 4 Integrated Program projects were funded. Total funding reached 131.5 million yuan, accounting for 87.7% of the total budget. According to the overall planning and the need of development, this Major Research Plan will enter the stage of integrated innovation, so the Integrated Program project will come from the selected excellent projects from previously funded Fostering Program projects and Key Program projects. In 2013, our focus of project integration will be at: 1) photoelectric effect of single molecule and photon state and electron state of single molecule, 2) precise measurement and control of single self spin quantum state, and 3) preparation and construction of single quantum system.

New project may be proposed for research on new principles, new method and new technology in precise measurement of single quantum state.

The budget for 2013 will be 30 million yuan.

V. Principles of project selection

(1) New concepts and methods of material preparation and measurement focusing on single Quantum state system based on experiments.
(2) Theory and simulation that can greatly promote the development of experimental work in China.
(3) Reasonable technical route with creative academic ideas.
(4) Good background and working accumulation related to research.
(5) Important roles in accelerating the overall development of the Major Research Plan and understanding of keyscientific concerns.

Fuel Proliferation and Transmutation in Advanced Nuclear Fission Energy

Energy and environment are indispensable to the existence and development of human society. Up to now, nuclear energy has seen about 16% of the total electricity for the whole world. Although Fukushima Nuclear Power Station in Japan had accident in March 2011, the IAEA pointed out in its recently released report that “atomic energy still has great prospects”, because the primary driving force for nuclear energy remains unchanged. China has also made its own policy of efficiently developing nuclear power with safety as preconditions. Rapid development of nuclear power in China has presented opportunities as well as challenges to relevant basic science disciplines. Generally, China is still weak in the scientific foundations for nuclear energy and relevant technology, which could not meet the needs for developing nuclear energy on the basis of making independent innovation. In addition, the Fukushima nuclear accident indicated tougher but critical requirements on nuclear safety. Within the funding scope of NSFC, with science as the basis and objectives as the guidance, giving more support on basic research in major fundamental scientific issues in nuclear energy areas has important strategic significance, hence this Major Research Plan.

I. Scientific targets

Overall scientific targets

To conduct innovative research in areas of nuclear fuel proliferation and transmutation for making major breakthroughs by focusing on major national needs, research status home and broad, and national medium and long term plan for energy development, following the principle of "definite objectives, stable support, integration and refinement and leap-forward development".

To explore and develop new mechanisms, new methods, new technologies and new materials in the advanced nuclear fission energy system, foster and expand high level research teams for achieving world leading results.

To support the third generation of nuclear power development with better safety and make the research on the fourth generation of nuclear power in China among the leading position in the world, and provide scientific basis and technology accumulation and talents resources for the development of Chinese nuclear industry with creative and proprietary technologies.

Specific scientific targets

1. New phenomena, mechanisms, methods and technologies in nuclear fuel proliferation and transmutation

(1) Deeply understand the physical, chemical and nuclear properties of actinides, especially complex properties caused by 5f electron structure, and develop new reaction channel and mechanism related to nuclear fission.

(2) Explore new methods of nuclear fission proliferation and transmutation, develop new mechanisms, new schemes of long lifetime, high radiation waste transmutation, and optimize means of nuclear fission proliferation and transmutation.

(3) Develop mechanism and method of separation of uranium-thorium-plutonium and sub actinide and important fission products.

2. Basis research on nuclear energy application

(1) Develop basic methods of new types of recycle for nuclear fuel and key technologies and methods for ADS design.

(2) Develop relatively complete data bases and computational methods for nuclear fuel proliferation and transmutation.

(3) Develop new separation technologies for nuclear fuel proliferation and transmutation system.

(4) Develop new types of nuclear fuel, functional materials and materials for separation.

II. Key scientific issues

According to the stresses on fundamental, strategic and pioneering themes, the research should be concentrated on the nuclear fuel proliferation and transmutation in advanced nuclear fission energy system, strengthen experimental studies and the combination of theory and practice, develop new mechanisms, and coordinate closely with the national medium and long term plan for nuclear energy development. The following are the three key scientific issues of the Plan:

1. Nuclear fuel and its nuclear process in advanced nuclear fission energy system

Key studies focus on the neutronics and neutron economy in nuclear fuel system, proliferation process of U-233 etc., its relevant nuclear reaction parameters and mechanisms, and preparation, characterization and mechanisms of new types of nuclear fuel. Key issues also include complex

physical chemical behaviors of actinides with 5f electron structure.

2. Basic behavior of nuclear fuel in combustion process in advanced reactors and its proliferation and transmutation

Key studies focus on the reactor coupling of ADS and relevant reactor physics and thermo engineering; physical basis and key technologies for strong beam proton acceleration; reactor physics, the reactor thermo engineering and coupling of fast reactor and thorium reactors; new mechanisms and theoretical simulation of advanced nuclear fuel proliferation and transmutation; new technologies for nuclear detection; design, preparation and characterization of new nuclear structural functional materials.

3. New method and new mechanism of post treatment of spent fuel

Key studies focus on the physical and chemical behavior of key long lifetime radioactive nuclides and sub actinides; new types of separation material; new method of post treatment of spent fuel; and basic scientific problems of dry post treatment.

III. Implementation

This Major Research Plan supports researches in the form of the Fostering Program project and Key Program project. These two types of projects have different funding intensities and research targets. Proposals with innovative ideas and research merit at the initial stage but with need of further investigation can be supported with Fostering Program project. Proposals with innovative ideas and research merit and good research foundation and accumulation, and possible majorcontributions to the overall target of this Major Research Plan can be supported with Key Program project. According to the progress and the investigation results, the Plan may be adjusted on the funding amount of the projects (terminate the project or give additional funding).

IV. Basic selection criteria

To achieve the overall objectives, this Major Research Plan encourages:

(1) Exploratory studies with original creative ideas and special features.
(2) Studies on key technologies closely related to the overall objectives.
(3) Interdisciplinary research between mathematics and physics, chemistry and materials.
(4) Collaboration with outstanding overseas scientists.
(5) Systematic research and improvement with clear scientific target.

V. Key funding areas and research projects in 2013

Status and Problems during the implementation of this Major Research Plan:
(1) Not enough number of applications on the research of development and characterization of new types of nuclear fuel;
(2) Key topics were not focused though many applications on reactor thermo engineering, structure and surface materials;
(3) Research related to ADS has been preliminaryformed group of projects for Key Program plus Fostering Program;
(4) Not enough of researches on the post treatment of spent fuel;
(5) Lack of experimental research on thermo state, and simulation research were mainly based on generic software only.

In 2013, funding will be focused on the basic research related to fuel proliferation and transmutation, and researches needed for technology and safety issues related to advanced reactor types for making systematic arrangement in important research directions.

Applicants may select 1 or several areas according to directions for Key Program project and Fostering Program project. There is no need to cover all areas for the Key Program project and Fostering Program project. Applicants can make their own decision on the project name, scientific targets and specify and give detailed targets for Key Program project, technical scheme and budget.

1. Nuclear fuel in advanced nuclear fission energy system and its nuclear process

Research area for Key Program project

Studies on design, preparation, structure, characterization, property and mechanism of new nuclear fuel

Main research contents will be included the composition, preparation, structure and characterization of new types of nuclear fuel with better security and economics, and relevance between nuclear microstructure and its property.

Expected targets are to obtain a number of creative results on the preparation, structure, performance and mechanism of new types of nuclear fuel. The application should give clear targets to be achieved.

Research areas for Fostering Program projects

(1) New mechanisms and theoretical models of advanced nuclear fuel proliferation and transmutation.
(2) Development of simulation research software for important scientific problems in nuclear energy system, and development of nuclide data base related to studies on nuclear parameter and neutronics related to thorium uranium fuel cycling.
(3) New methods of efficient extract and purification of nuclear fuel, and basic problems in super high temperature properties of nuclear fuel and energy conversion of burn-up fuel.

Basic behavior of combustion in nuclear fuel reactor and its proliferation/ transmutation

Research area for Key Program project

Reactor physics and reactor thermo engineering of thorium based fuel molten salt reactor

Main research contents will be included the theory and experiment of thermo physical characteristics and nuclear characteristics of fluoride molten salt; the coupling method and computational method of reactor physics and reactor thermo engineering of molten slat reactors; the scheme and safety evaluation of new types of high efficiency thorium based molten salt proliferation reactor with high nuclear fuel proliferation ratio; and studies on reactor physics and thermo engineering; scientific problems in closed cycling of fluid state nuclear fuel in molten slat reactors.

Expected research targets should be included a number of innovative research results on coupling method and computational method of reactor physics and reactor thermo engineering of molten slat reactors, and develop reliable parameters and standard for safety evaluation of molten salt reactorson the basis of the results. The application should give clear targets to be achieved.

Research areas for Fostering Program projects

(1) Non homogenous dual physical model and computation method for neutron transport in carbon reactor core containing covered fuel particles in molten salt environment.
(2) Differentiation of fission products of various types of nuclear fuel in reactor combustion process and its mechanism, basic process of long lifetime nuclide ADS proliferation.
(3) Design, synthesis and corrosion resistant and radioactive resistant

properties of new types of nuclear structure materials.

New methods and new mechanisms of post treatment of burn-up fuel

Research area for Key Program project

Applied basic research on the post treatment of spent fuel

Main research contents will be included to develop new types of functional separation materials for the post treatment system of burn-up fuel, and make necessary verifications by thermo experiments, and explore new method and new mechanism of post treatment of spent fuel.

Expected targets should be included to achieve a number of results on separation behavior or solid physical chemical behavior and mechanism in the application of new types of functional separation materials in post treatment of burned up fuel, so as to provide scientific basis for major national need such as development of new technologies for burn-up fuel treatment in China. The application should give clear targets to be achieved.

Research areas for Fostering Program project

(1) Important theoretical basis and key technology problems in dry post treatment process of burn-up fuel;
(2) Studies on chemical types, migration behaviors and mechanisms of key radioactive nuclides in post treatment of burn-up fuel.
(3) New method of detection method and mechanism related to nuclear accidents and nuclear contamination.

VI. Funding plan for 2013

In 2013, NSFC is planning to fund 12 Fostering Program projects with average funding not less than 700,000 yuan per project for 3 years and 3 Key Program projects with funding about 3 to 6 million yuan per project for 4 years. The total budget for 2013 is about 30 million yuan.

Deep Sea Process and Evolutionin the South China Sea

The deep sea process is the breakthrough in today's ocean science and Earth system science frontiers. The South China Sea is the largest marginal sea in

the Western Pacific and also in low latitudes. Combining the modern deep sea process with its geological evolution of the South China Sea, the Plan aims to reveal the evolution patterns of marginal seas and their effects on submarine resource and macro-environment development by thoroughly studying this particular case.

I. Scientific objectives

The overall scientific objectives are to explore the deep sea basin of the South China Sea by utilizing a series of new techniques, to reveal the deep sea process and evolution, and to reconstruct its "life history". Thereby a systematic research model for studies of the evolution of marginal seas can be established. Specific objectives include:

(1) Rediscover the seafloor spreading history of the South China Sea and its pre- and post-spreading evolution by re-measuring magnetic anomaly lineation at higher resolutions and dating, seismic imaging, and studying volcanic seamount chains.

(2) Reveal the patterns of bottom circulation and the deep sea response to sea level change in the evolution history of the South China Sea by observing the modern deep sea process and analyzing deep sea sediments.

(3) Discover the deep biogeochemical process and evolution in the South China Sea by deploying submarine hydrological observation and analysis.

(4) Investigate resource and environment effects of the deep sea process evolution of the South China Sea based on integrated research approaches.

II. Key scientific issues

Research themes include deep sea processes on three time-scales with a focus on the northern South China Sea:

(1) The deep sea process of the basin formation (~10^6 year scale): to investigate the pre-, co-, and post-spreading processes, with an emphasis on the "duration of the seafloor spreading".

(2) The deep sea process during sea-level change (~10^4 year scale): to reconstruct the environmental evolution history of the marginal sea during glacial-interglacial cycles by scrutinizing the sensitivity of semi-closed sea basin of the South China Sea to the sea level change.

(3) The deep sea process from modern observation (~10^0 year scale): the basis to understand the geological scale variation, including deep water circulation, bottom sediment transport, and submarine biogeochemistry

observations.

The following key scientific issues will be included:

1. Age and process of seafloor spreading
2. Time and cause of the volcanic seamount chain activities
3. Response of the deep sea sedimentation process to sea basin evolution
4. Variation of bottom current and sediment transport mechanism
5. Development and effect of carbonate platforms
6. Distribution and effect of submarine overflows and down-hole fluids
7. Deep sea carbon cycle and the function of microorganism
8. Biogeochemical background of deep sea energy resource formation

III. Key funding areas and research projects in 2013

Based on the granted projects in previous years, the Plan will continue to focus on key scientific problems with the similar funding level. Combined by deep diving voyage in 2013 and scheduled ocean drilling leg in 2014, the Plan is expected to expand its research scope, to introduce new and high technology, and to establish field investigation and indoor research projects. At the same time, integrated research will be taken into consideration. The support will be mainly going to “Key Program”. “Integration Program” will be launched this year. Some of Fostering Program projectwill be still encouraged to support exploratory studies with creative ideas and research values but in need of further investigations.

Following priorities will be given in 2013:

1. Apply deep diving or deepwater observation technologies to study deep processes in the South China Sea.
2. Investigate geological records of continents and islands in surrounding countries to study the evolution history of the South China Sea.
3. South China Sea evolution during the rifting stage: processes in late Mesozoic and early Cenozoic.
4. Carbonate platforms and sedimentation: modern process and geological evolution.
5. New perspectives of carbon reservoir change in the South China Sea: deep sea carbon cycling and microbial processes.
6. Interaction of upper-ocean and deep processes in the South China Sea.
7. Studies in favor of integration but non-repetitive to granted projects.
8. Other studies with creative scientific ideas.

Neuronal Circuits of Emotion and Memory

Emotion and memory form the core of cognitive functions, and memory is the basis for cognition. Emotions affect almost all cognitive functions, and are essential for organisms to survive and adapt to the environment. The formation, modification and maintenance of the neural circuits for emotion and memory and their regulation are one of the most active directions of neuroscience research, since they are the key to understanding higher brain functions.

Neuronal circuits are the biological basis of emotions and memories, and impairments of emotion and memory are associated with abnormal anatomy and dysfunction of neural circuits. Analysis of emotions and memories related to abnormal structures and dysfunctions of neural circuits in neurological and psychiatric diseases will provide a scientific basis and new ideas for a new generation of technical methods of diagnosis and treatment. In recent years, the rapid development of newly-emerging technologies in molecular biology, physics, and chemistry and computer science provides new opportunities for in-depth study of the neuronal circuits driving emotion and memory.

This major research plan takes emotion and memory as its main object, making the best use of cutting-edge aspects of medicalscience, life science and information science, along with the philosophy of systematic study, such as connectional groups andfunctional groups, in combination with the clinical features of emotion and memory disorders, to work out the basic structure and function of the neural circuitry for emotion and memory. It is an important scientific problem to understand the integrative mechanisms of the neuralcircuits and the pathological processes that lead to neurological and psychiatric diseases, in order to improve clinical diagnosis and promote patient rehabilitation.

In 2012,a total of 87 applications including 22 “Key Program project”" and 65 “Foresting Program project” were received. However, some points of insufficiencies could be observed in the application in 2012, such as: few of applications for research on neural circuit by truly new technologies and newmethods; few number of genetic study on the emotion and memory neural circuit; very few studies carried out with non-human primate model; lack of projects on emotion and memory under multimodal level at the same time. Moreover, among the variety of applications concerning emotion and

memory related to neural circuits in neurological and psychiatric diseases, someof them were lack of innovation. Cooperation between clinicians and basic researchers and interdisciplinary studies should be strengthened in the future.

Ⅰ. Scientific objectives

This major research program is aimed to take the neuralcircuits for emotion and memory as the main objective, search for key circuit nodes related to emotion and memory at multiple levels, reveal the relationships between phenotypes and abnormal neural circuits, to study circuits driving pathological processes in mental disorders, develop an in-depth understanding the mechanisms of neural and psychic diseases, find new means of prevention, diagnosis and treatment, and provide a scientific basis for improving people's psychological health .

Ⅱ. Core scientific issues

The core issue of the Plan is to investigate the neural circuits for emotion and memories, the mechanism of interaction between them, and adjustment of genetic and environmental factors on the neural circuits at multiple levels. Following 4 aspects will be included:

(1) The structural and functional basis of the circuitry for emotion and memory and their relationships.
(2) The interactions between the circuits for emotion and memory and their mechanisms.
(3) The neural circuitry underlying emotion and memory-related neurological and psychiatric diseases.
(4) The mechanisms through which the neural circuits for emotion and memory are regulated by genetic and environmental factors.

Ⅲ. Key research directions and projects in 2013

This major research plan will be implemented around the above-mentioned important scientific issues by taking five research directions.

1. The structural and functional basis of the circuits for emotion and memory and their relationships

(1) It is to analyze the relationships between the structure and function of neural circuits for emotion and memory with animal models and human subjects, interdisciplinary cooperation, and a combination of molecular detection and imaging technology,.

(2) It is to develop an in-depth understanding of emotion and memory functions and the mechanisms of related diseases, accumulate critical data, and build a systematic framework by taking advantage of the animal resources for non-human primates in China and in vivo electrophysiology, behavioral observation, and optical imaging. The funding priority will be given to this direction in 2013.
(3) It is to analyze the effect of genetic background on the structure and function of emotion and memory in the human brain by us of multimodal imaging technologies.

2. Interactions of the neural circuits for emotion and memory and their mechanisms

(1) It is to study specific and general foundations and their interactions in the neural circuits of emotion and memory through selective manipulation of the excitability of the neural circuits of emotion and memory, and study the circuit mechanisms of the information encoding, storage, storage, consolidation, extraction, transmission and information integration in the neural circuits of emotion and memory.
(2) It is to reveal the key pathways of neural circuit interactions between emotion and memory and the modulation involved, and study changes in the adaptability of the neural circuits for emotion and memory and their interactions, including active feedback control structures the remodeling functional loops.

3. Mechanisms underlying the regulation of the neural circuits for emotion and memory by genetic and environmental factors.

(1) It is to study the roles of chromatin remodeling, DNA methylation and hydroxylmethylation, as well as non-coding RNA in the coding, storage, retrieval and processing of information on emotion and memory at the epigenetic level.
(2) It is to explore the impact of environmental factors such as stress on the formation of the neural circuits for emotion and memory and the underlying mechanisms.
(3) It is to determine the effects of genetic and environmental factors on the plasticity of these circuits and their roles in neurological and psychiatric diseases.

4. Neural circuit mechanisms underlying emotion and memory-related neurological and psychiatric diseases

It is to investigate the neural circuit mechanisms underlying the impairment of emotion and memory caused by common major neuropsychiatric

disorders such as mild cognitive impairment, Alzheimer disease, major depressive disorder, bipolar disorder, post-traumatic stress disorder, schizophrenia, and autism.

5. Development of new methods and new technologies for studying the neural circuits for emotion and memory

(1) It is to establish new methods for tagging and tracing the neural circuits for emotions and memories, including specific molecular markers, methods for sampling and detecting bioactive molecules, and minimally invasive tracing methods in human subjects. Projects proposed in this field will be supported with high priority in 2013.

(2) It is to develop new technologies for studying the connectomics of the neural circuits for emotion and memory, including whole-brain connectomic reconstruction of the neural circuits for emotion and memory in wild-type animals and in animal models of emotion and memory, to build a complete database with high-precision of their structures and functions.

(3) It is to develop new imaging technologies for research on the neural circuits for emotion and memory as well as automatic image recognition, segmentation and visualization technologies.

(4) It is to develop new technologies for the processing and coding of emotion and memory information to be able to quantitatively describe the dynamics of the neural circuits and the relation between their function and behavior.

(5) It is to develop and utilize transsynaptic-labeled new marker to track neuronal circuit, such as GFP Reconstitution across Synaptic Partners (GRASP) and other chimeric protein markers.

Basic Algorithms for High Performance Scientific Computation and Computable Modeling

Scientific computation is one of the important S&T progress in the 20th century, and, with the invention of electronic computer, it was developed very fast and have been widely used. Scientific computation has become the third method in scientific research along with theoretical studies and experimental research, and an important means of promoting major scientific discoveries and S&T progress. Nowadays, scientific computation has been seen as an important indicator for a nation's S&T competitiveness and key factor in S&T innovation and development. Solution to many

scientific problems in major national needs requires basic algorithm of scientific computation and computable modeling. The launch of this Major Research Plan is, within the funding scope of the National Natural Science Fund, to strengthen research on important and basic scientific issues in scientific computation, design efficient basic algorithm and develop computable model with practical demand on precision so as to reduce computation complexity and task, improve significantly the capability of using computer to solve scientific and engineering problems and meet the increasing demand from applications.

The Plan will provide further support for scientific research on scientific computation in frontier areas and major needs, promote coordinated development of hardware and software for scientific computation, leverage intercrossing and merging of mathematics with other disciplines, foster number of high level talents in scientific computation, and achieve leapfrog development of scientific computation as well as scientific and technological development.

I. Scientific targets

Focusing basic algorithm and computable modeling, conduct researches on common efficient algorithm of scientific computation, computational modeling based on mechanism and data, and evaluation of problem driven high performance computation and algorithm, promote the development of high performance scientific computation in China, and provide key support of numerical simulation technology and method for solving bottle neck problems in scientific frontiers and national needs.

(1) Make innovative and systematic achievements in common efficient algorithm research, and, in particular, breakthroughs in construction, basic theory and parallel realization technology of high fidelity and high efficiency discrete method, nonlinear eigen value algorithm and optimization method of complex targets of partial differential equations.
(2) In areas of computable modeling and high performance computation, focusing on solving problems of modeling related to multi process coupling, data driven and model-data integration, develop practical computable model, and achieve large scale numerical simulation by efficient use of several hundred thousand processor cores.
(3) In promotion of disciplines and talent fostering, gather and foster large number of innovative talents of scientific computation with versatility on international frontier, develop a number of high level interdisciplinary

research teams, and make leap frog development of scientific computation in China.

II. Key scientific issues

Based on the scientific computation trend and national needs, following the principle of "what to do and what not ", and meeting the requirement of proposing key scientific problems focusing on features of fundamental, farsighted and interdisciplinary, this Major Research Plan give emphasis on basic algorithm and computable modeling related to high performance scientific computation. The key scientific issues are follows:

High efficiency common algorithm of numerical computation

One of the major problems in high performance computation is how to develop high efficiency and high precision algorithm, so as to make full use of high performance computers and meet the requirements on precision of simulation and confidence level in large scale computation of practical problems. Main research contents are:

1. Construction and analysis of high efficiency high precision schemes for differential equations

High precision, high efficiency discrete method and theory of nonlinear applied partial differential equations; high fidelity method and theory of stochastic differential equations, algorithm and analysis of nonlinear eigen value problems, and large scale scalable new algorithms, etc.

2. Fast method for complex data processing

Mathematical theory and fast algorithm for compressed cognition, high efficiency integrated algorithm of high flux different source data, small sampling data based high dimensional system reconfiguration theory and algorithm, method and algorithm of multilevel bio network, algorithm of high resolution 3-D image reconstruction using 2-D projective image, etc.

3. Optimizing method for uncertain and complex object functions

Addressing the optimization problems in research such as data assimilation in aircraft design, weather and climate forecast and bio-molecular network, develop high efficiency optimal algorithm for complex object function, stochastic object function, non computable precision object function and object-less function.

Mechanism and data based computable modeling

Study computable modeling for problems with characteristics such as multi temporal spatial scale, multi field coupling, anisotropic, non equilibrium, super high dimensional and uncertainty, Main research contents are:

1. Coupling and analysis of typical physical models

For multi physical scale coupling model (such as diffusion and transport coupling model in particle transportation, multi scale coupling model for dislocation and cracks in materials), according to the requirement on precision and stability of algorithm, study mutual representation and transformation relationship between different variables with same contents, principle of determination of coupling region or interface, and connecting conditions complying with physical conservation laws and easy to compute.

2. Sparse representation of super high dimensional data

Study central manifold hidden in high dimensional or massive data, main characteristics of using low dimensional variable or sparse representation to characterize high dimensional data, focus on studying low dimensional nonlinear approaching model for high dimensional linear problems, transform high dimensional linear problem to low dimensional nonlinear problem, and develop new method of lowing the dimension of super high dimensional data.

3. Mixed modeling of mechanism and data

Many problems in complex physical and biological phenomena require studies by combining mechanism and data, such as sparse radar imaging, data assimilation in atmospheric and marine sciences, and construction of bio-molecular network, etc. based on known mechanism, combining typical characteristics of sensitive factors subtracted in data, explore and develop mixed computable models. Focus on studying matching of mechanism based model and typical data characteristics, and related data demand analysis.

Problem-driven high performance computation and algorithm evaluation

Focusing on important issues coming from major national need and scientific frontier but with solid scientific computational basis, develop high performance computation and analyze, evaluate the effectiveness of algorithm and modeling. Main research contents are:

1. Numerical simulation and algorithm evaluation in multi physical process coupling conditions

Continued and simultaneous multiple physical processes are common in physics and materials, such as inertia confined fusion process related to particle transport and fluid instability, material dislocation and crack related to elasticity and plasticity and crystal bond break, etc. Using developed computable model and basic algorithm, study high efficient algorithm of numerical simulations of specific physical processes, and evaluate the effectiveness of the models and algorithm. Focus on algorithm of diffusion and transportation coupling and internal explosion and compressible turbulent flow coupling, and large scale numerical simulation of inertia confined fusion process by making effective use of ten thousand processors; make large scale high efficiency coupling computation of material dislocation and crack using multi scale models, and strengthen understanding of material damage failure mechanism.

2. Computation and algorithm evaluation based on data extraction and analysis

Inference and predictions using mathematical models based on data extraction and related analysis are of much importance to study many complex problems, such as cell adaptive control network, signal switch control network, high flux or low flux filtering control network in bio regulation network. By means of sparse representation model, study fast algorithm for specific super high dimensional and multi source data for computation. Focus on characteristics extraction and network characterization method for massive bio data, develop high efficiency regulation network inference algorithm, and realize large scale and high efficiency computation of system in parametric space for related dynamical equations. Through scientific computation, understand the relationship between topological structure and dynamic parameters of bio network, and explore the relationship between structure and function.

3. Computation and algorithm evaluation by model and data complementation

Not all scientific problems can be resented only with modeling or with data description. For example, information assimilation that is very important in atmospheric and marine research, understanding of mechanism affecting weather and climate changes, but numerical models are not perfect, data is not complete, information from different sources are not in good coordination. Problems like this require complementing and merging of models and data, and introducing developed numerical model and massive

data to conduct information assimilation method and technology. It is better to select one or two problems, such as information assimilation problem in weather and climate forecast, all band transmission simulation of elastic wave field in complex media, to conduct research on high performance computation of model and data complementation.

III. Key funding direction and research project in 2013

This Major Research Plan supports projects in the form of the "Fostering Program project" and "Key Program project" in the five-year period. These two types of projects have different funding intensities and research targets. The priority funding will be given to research areas which are well discussed and new research directions could be initiated after discussion. For those important directions with good research basis, definite and urgently needed in the area of computable modeling and algorithm, it could be supported in the form of "Key Program project". For those directions that need to be encouraged, it could be supported in the form of the "Fostering Program project".

In 2013, it is planning to fund 15-20 "Fostering Program projects" with funding of 600,000 to 900,000 yuan per project for 3 years, and about 8 "Key Program projects" with 3 to 5 million yuan per project for 4 years. The total budget for 2013 is about 40 million yuan.

In 2013, NSFC is planning to fund "Fostering Program project" and "Key Program project" in the areas listed below. Applicants may choose one or several areas for their proposals. It is not necessary to cover all areas for the application of Fostering Program project and Key Program project. Applicants could make their own decision on project name, scientific targets, and detailed targets for Key Program project, technical scheme and related budget.

Research areas for Key Program projects

1. **Computation method for nonlinear eigen value problems of partial differential equations**

In regard to nonlinear eigen value problems of partial differential equations simulating microstructure of matters, it is to develop high effective and practical method of nonlinear iteration, grid self adaptive method and scalable computation method for discrete problems, study relevant mathematical theory, and achieve effective numerical simulation of over 10

thousand core processors.

2. **Basic algorithm for high order nonlinear partial differential equations**

For strong nonlinear, small parameter and higher order partial differential equations in scientific and engineering problems (such as imaging processing and phase filed modeling), it is study large time step, spatial temporal self adaptive algorithm, nonlinear iteration method and initial value selection method, develop relevant fast algorithm and theory of relevant algorithms.

3. **Self adaptive non-structural grid method for multi phase coupling dynamical problems in high temperature and high pressure conditions**

For national major engineering, study computable modeling, self adaptive non-structural grid method with high precision and high efficiency in explosion and high speed chemical reactions, it is to study the self-adaptive non-structural grid method for interactions between composition, interface instability and mixing phenomena, complex phase interface, phase change mass transfer, thermo chemical non equilibrium and turbulent combustion, develop relevant scalable parallel algorithm featuring high efficiency, and realize numerical simulations of large scale engineering problems using 10,000 core processors.

4. **New computation method for transport problems in different spatial temporal scales**

Focusing on gas dynamic problems for high speed aircrafts in large spatial and temporal scales, based on Boltzmann equation and macro fluid dynamic equations, it is to develop computable models crossing free molecule, transition and continuum regions, develop high efficiency computational method describing transition from meso to macro scales, and verify the validity of the model and algorithm in the transition region through real problems.

5. **Key mathematical theory and fast algorithm for optimizing complex shapes**

Shape optimization (including generalized shape optimizing problems, i.e., topological problems) appears in many practical problems, such as design of aircraft shapes, design of large loading structure configurations, integrated design of material and structures, etc. Due to features of large number of design variables and confining functions, multidisciplinary and multi target

coupling nature and complex relations between multi scale and multi level structures, optimization design of complex shapes used in numerical simulations has become hot spot in relevant research areas. Applications are advised to focus on optimization problems of aircraft structure topology and aerodynamic and aero elastic problems in aircraft design, develop key mathematical theory and computable numerical optimization models for large scale optimization problems (over 100,000 variables), propose high performance fast algorithm with original ideas based on solid mathematical basis (we do not suggest simple modifications on existing commercial software), and complete verification through significant applications.

6. Studies on mathematical method in information assimilation

For initial value problems in climate prediction, propose reasonable information assimilation scheme and relevant new mathematical optimization method, break the bottle neck of high dimension and large amount of computation in existing information assimilation schemes, reduce the effect of low estimation of covariance in background error and some key mathematical problems related to flow dependence, so as to make high efficiency assimilated multi source data observation, and verify through major application of climate prediction using new assimilation scheme.

7. Mixed modeling and high efficiency computation method for information processing

Focusing on major national need on identification and tracking of targets in space and terminal guidance, it is to study key information processing problems such as image processing, week signal identification, machine learning and target reduction from incomplete information, propose principles and method for effective mixing modeling, develop high efficiency computation method based on continuous, discrete data mixing modeling, and solve basic algorithm problems of relevant information processing and verify through practical applications.

8. Sparse representation and dimension reduction modeling for large complex data set and system

For super large complex data set and system appearing in modern applications (such as in the design of large IC), starting from physical mechanism and differential equations, study basic theory of error problems in complex random sampling and new regular algorithm for complex differential systems for input and out sampling, develop mathematical theory and effective method for reduced dimension modeling for large scale differential system models.

9. Theory and algorithm of discovering characteristics of complex bio

system based on high flux data and its applications

For complex bio problems in biomedical science, it is to study dimension reduction, characteristics selection, statistics and analysis of small sampling high flux data and network construction, and develop theory and algorithm of discovering characteristics of high order bio system using small sampling and multi source data integration. Based on small sampling, high flux (genome, transcriptome, epigenetic group and image) data, it is to investigate the reconstruction method of bio molecular network model between different molecules (gene, non coding RNA, etc.), explore laws of dynamic change of molecular bio network in disease occurrence and development process and between different molecular levels, and analyze pathogenesis of major disease.

10. **Computation model and performance optimization algorithm for E-class computer system**

Based on PetaFlops high performance computer system made in China, meeting the challenges of E-class (ExaFlops) computer in concurrence, local, recoverable and energy consumption, it is to study scalable computation model and performance optimization algorithm for E-class computer, and develop high efficiency and good scalable common concurrent parallel algorithm base (such as large algebraic equation solving) and practical program base that may support 1 or 2 application fields, as well as to verify on P-class high performance computers made in China and install on the hundred PFlops high performance computer that are to appear.

Research areas for "Fostering Program projects"

1. Probability algorithm for matrix recovery and computation
2. Temporal concurrent and self adaptive method for differential equations
3. Mathematical theory and computation method for fractional order differential equations
4. High efficiency algorithm for unsteady magneto hydrodynamic equations
5. Computation and algorithm of atmospheric and oceanic model and data complementation
6. Large scale hetero parallel scalable algorithm for magnetic confined fusion simulation test program
7. Computation to the limit of parallel computation scale and performance
8. Important algorithm problems in mass medical image data analysis and applications in clinical diagnosis
9. Dynamic modeling and control mechanism for bio-molecular system
10. Quantification of uncertainty of numerical simulation of real complex system
11. Computable modeling and algorithm explorations for hard to compute real problems

IV. Basic selection criteria

To achieve the overall objectives of this Major Research Plan, it is required that researchers in different areas form research team for application (research team formed with members in the areas of algorithm, problem and software is encouraged), and give priorities to applications with the following features:

(1) Exploratory studies with innovative ideas and special features.

(2) Studies merging modeling, algorithm and numerical simulation.

(3) Practice of mathematics in interdisciplinary research and difference from existing methods.