CHINESE ACADEMY OF SCIENCES ANNUAL REPORT 2012

中国科学院

The Chinese Academy of Sciences (CAS) was founded on November 1, 1949, in Beijing. As a leading national academic institution, a premier advisory body in science and technology, and the largest research and development organization in natural sciences and high technologies in China, CAS consists of three parts: research institutes, educational institutions, and the Academic Membership Divisions. The academy is a 'national team' embodying the country's highest ideals in science and technology (S&T), a 'locomotive' driving national innovation in S&T, a 'pioneer' in supporting nationwide S&T reform and transparency, a 'think tank' offering consulting services for S&T development, and a 'big school' cultivating S&T research talent.

中国科学院
CHINESE ACADEMY OF SCIENCES

Message from the President

2011 has started with the whole nation immersed in the celebration of the progress we have made in the past year and with full anticipation of another fruitful and productive new year.

In 2011, CAS has concentrated on formulating scientific development plans for the next 10 years based on previous accomplishments, and on analyzing the needs and the future needs of the country with the hope to contribute more to accelerating the transformation of the country's economic development mode with science and technology. This plan is called *Innovation 2020*, the aim of which is to bring CAS into a new phase of development.

Focused on the formulation of long-term development plans and strategic deployments, CAS has concentrated its efforts on the following areas:

- *Further improve CAS's development strategy and strategic mission based on the analysis of new challenges and opportunities. We have emphasized our strategy as running CAS with democracy, flourishing it with openness and boasting it with talent.*
- *Request CAS institutes to further define their strategic positioning on the basis of their current research competencies, of the global trends in science and technology, and of an overall analysis of both the domestic and international situations they face. The idea is to make CAS institutes position themselves in the right niche in the scientific community compared with their counterpart institutes both at home and abroad.*
- *Urgently commit efforts to take care of the common concerns and needs of our scientists, so that they can devote*

more time and efforts to research work.

In the past year, CAS has continuously made a series of scientific accomplishments such as the following:

- *Provided strong assistance to the successful docking between Tiangong-1(space lab) and Shenzhou-8 (manned spacecraft) with the completion of a series of on-orbit payload experiments, including experiments in materials science, space environment, physical measurement, and Sino-German life sciences cooperative research.*
- *Contributed to the control and communication systems in Jiaolong submersible, including the realization of automatic near-seabed cruise and of hovering positioning and the high-speed digital acoustic communication reaching the advanced international standard.*
- *Developed and pilot-tested the world's first high-Tc superconducting power station.*

CAS has also been credited with 36 national science and technology awards out of the national total in 2011. Of which, CAS Member Professor Xie Jialin, the Institute of High Energy Physics, took away the top award. As principal implementing units, CAS won 13 Second Prizes for Natural Sciences, 6 Second Prizes for Technological Inventions and 12 Second Prizes for S&T Progress.

The past year has also seen strong efforts from CAS in further upgrading and improving its innovation capacity, innovation eco-system and culture, talent-recruitment & training and partnership & collaboration. We have recruited 63 top-level scientists through the National Thousand-talent Program and 203 researchers through the CAS Hundred-talent Program. A total of 63 CAS young scientists were awarded with the National Outstanding Youth Funds. We have also created a Youth Society for the Promotion of Innovation with the initial selection of 690 members. Among the 50,000 enrollments in CAS higher education, 11,000 of them have graduated with Masters or PhDs. 51 new Members and 9 new Foreign Members have been elected into the CAS Membership system. The strategic studies and proposals we finished have played a significant role on the decision-makings. Efforts have also been made by CAS in further strengthening the integration of S&T with economy, education and culture, international partnerships and collaboration and internal management.

2012 will be a year of critical importance to the country and the people including CAS. It will be a year that we start our implementation of the 12th Five-year Plan and a year that CAS's *Innovation 2020* enters into full implementation.

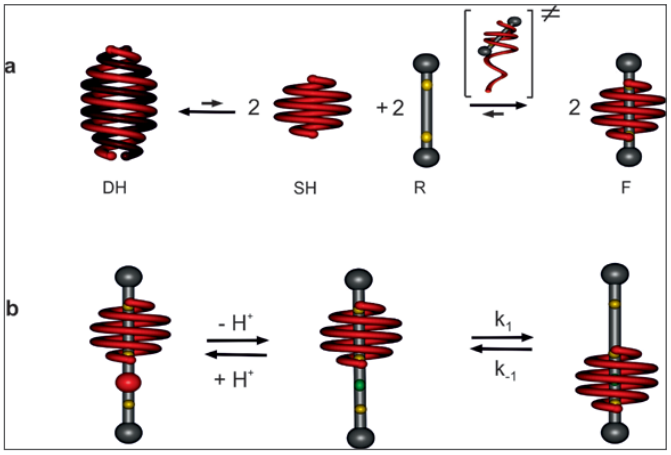
In the new year, through our efforts on the three major issues above-mentioned, we will work hard to generate and produce *quality science and*

Scientific Research Development

Basic Research

Foldaxanes – A new family of molecular machines

Prof. Jiang Hua at the CAS Institute of Chemistry and Prof. Ivan Huc at French University of Bordeaux led their team to create a novel family of molecular shuttles wherein a single helix wraps itself around a dumbbell- shaped molecule and is capable to shuttle up and down around the rod similar to that found in bistable rotaxanes. The assembly and disassembly of such helix-rod host-guest complexes are much slower than the shuttling process. The dynamic behavior of this kind of machine is reminiscent of that of biological molecular machines but contrasted with conventional, mechanically interlocked molecules. It was published in *Science* (2011, 331, 1172-1175).



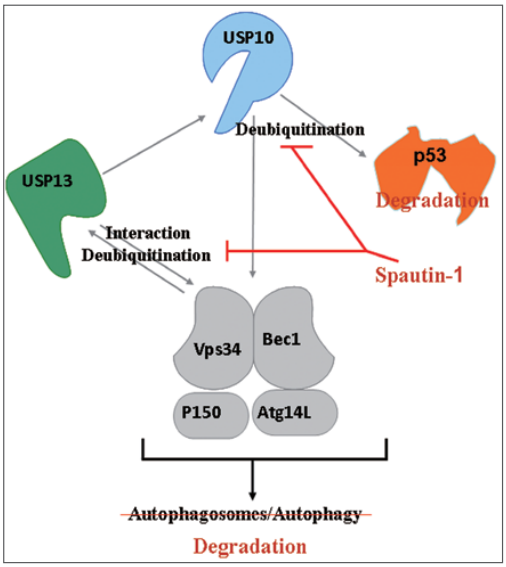
The assembly (a) and the dynamic behavior (b) of helix-rod host-guest complexes

Team leaders: Prof. Jiang Hua, hjiang@iccas.ac.cn
Prof. Ivan Huc, i.huc@iecb.u-bordeaux.fr

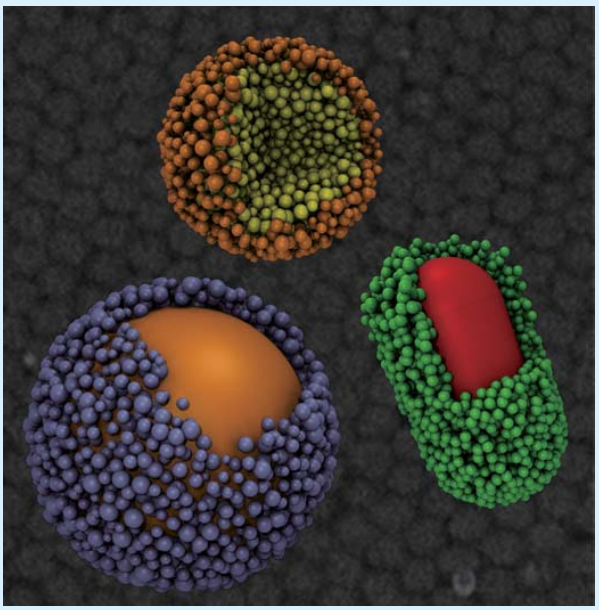
Selective autophagy inhibitor and its application in revealing the relationship between p53 and Beclin1

A team led by Prof. Ma Dawei from the CAS Shanghai institute of Organic Chemistry and Prof. Yuan Junying of Harvard Medical School has identified a new autophagy inhibitor, named "spautin". Using this molecular tool they revealed a molecular mechanism involving protein deubiquitination that connects two important tumor suppressors, p53 and Beclin1. Consequently, this work provides a convenient chemical tool to explore the potential of specific down-regulation of p53 and autophagy as therapies for human diseases. It was published in *Cell* (2011, 147, 223-234).

Team Leaders: Prof. Ma Dawei, madw@sioc.ac.cn
Prof. Yuan Junying, junying_yuan@hms.harvard.edu



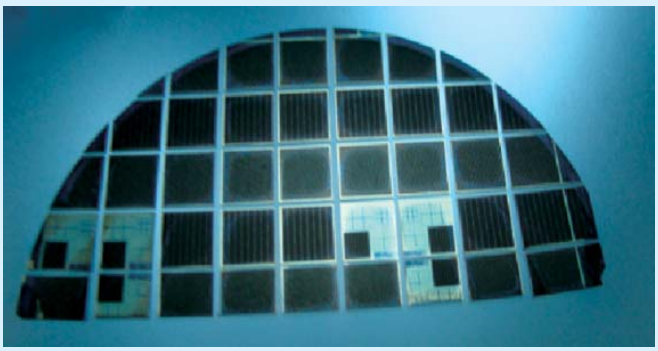
Dispersed super nanoparticles



Controllable self-assembly of inorganic nanoparticles is the most effective way to achieve its macroscopic application. Prof. Tang Zhiyong and his group at the CAS National Center for Nanoscience and Technology have achieved this based on previous research with scientists at the University of Michigan. Both experiment and simulation results reveal that polydisperse (20-30%) nanoparticles can spontaneously assemble into self-limiting, monodisperse (7-9%) supraparticles with the morphologies of loose cores and tight shells, which is governed by the balance between Coulomb repulsion and Van der Waals attraction of nanoparticles themselves. This self-limiting assembly strategy can be used not only for controllable assembly of various semiconductor materials, but for construction of isotropic or anisotropic gold/semiconductor core/shell nanostructures. It was published in *Nature Nanotechnology* (2011, 6, 580-587).

GaAs solar cell achieved high efficiency

Research team headed by Prof. Yang Hui at the CAS Suzhou Institute of Nano-tech and Nano-bonics achieved a conversion efficiency of 43.1% under AM1.5 and 200 suns by building optically integrated GaInP/GaAs/InGaAsP/InGaAs four-junction solar cells. They used GaInP/GaAs dual junction cell to absorb the short-wavelength portion and InGaAsP/InGaAs to convert the long-wavelength portion of the solar spectrum. This achievement not only led the solar cell efficiency to a new level, but pushed the development of multi-junction solar cells. Attracted by this, Sony decided to set up a joint research lab in the institute, realizing a conversion efficiency of 26% for GaAs single junction solar cells within half a year. It was published in *Nanoscale Research Letters* (2011, 6:576)



GaAs solar cell achieved high efficiency

New functional basis of NLO materials

At present the traditional design thinking of the exploration of new NLO materials is enhancing the polarity of single polyanion group. Researchers headed by Prof. Guo Guocong (FJIRSM, CAS) firstly put forward that good NLO materials could be got by designing both complicated ploycation and polyanion with large molecular polarizability as functional components. They successfully synthesized two inorganic supramolecular compounds $(Hg_6P_3)(In_2Cl_9)$ and $(Hg_8As_4)(Bi_3Cl_{13})$. They both have large SHG efficiencies compared to $AgGaS_2$, and type-I phase-match. Theoretical studies of NLO properties for the two compounds show that both the host framework and anionic guest make comparable contribution to the NLO properties. The work is new design thinking for exploration of new NLO materials. It was published in *J. Am. Chem. Soc.* (2011, 133, 3410-3418).

Representation theory of classical groups: the proof of multiplicity one conjectures

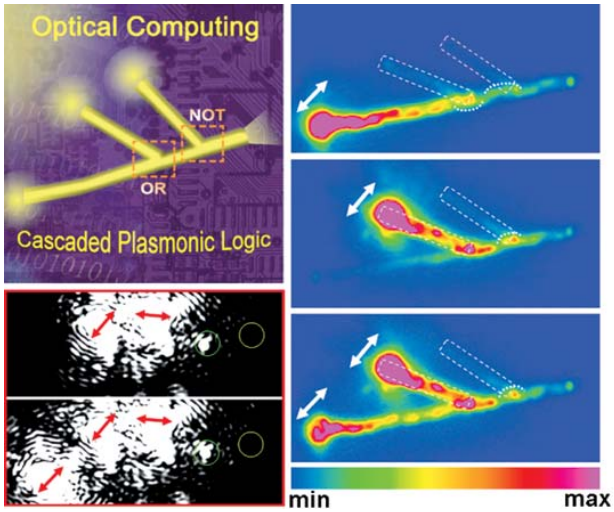
Langlands program predicates that various mathematical subjects, such as number theory, algebraic geometry and representation theory, are very deeply related to each other. This is one of the most important problems for the 21st century mathematics. L-functions are the key objects in Langlands program, and multiplicity one theorems are basic to the theory of L-functions. Based on some previous works, Prof. Sun Binyong of the CAS Academy of Mathematics and Systems Science and his collaborators prove the multiplicity one conjecture for classical groups, as well as the multiplicity one conjecture for theta correspondences. The results were published in two top mathematical

journals: Annals of Mathematics and Inventions mathematicae, and were cited by quite a few famous mathematicians.

Cascaded logic gates in nanophotonic plasmon networks

The manipulation of light at the nanometer scale is important for both fundamental research and its applications. Surface plasmon resonances in metal nanostructures provide the possibility for the light manipulation at the nanometer scale and can potentially be applied in many fields. Prof. Xu Hongxing and his team in the CAS Institute of Physics investigated the possibility to cascade plasmonic logic gates. They demonstrated that a plasmonic binary NOR gate, a 'universal logic gate', can be realized through cascaded OR and NOT gates in four-terminal plasmonic nanowire networks by controlling the surface plasmon interference. The mechanism was revealed by using quantum-dot based fluorescence imaging technique. This finding provides a path for the development of novel nanophotonic on-chip processor architectures for future optical computing technologies. The results are published in *Nature Communications*.

Team leader: Prof. Xu Hongxing, hxxu@iphy.ac.cn



Logic gate NOR based on surface plasmon interference

China's first optical frequency standard

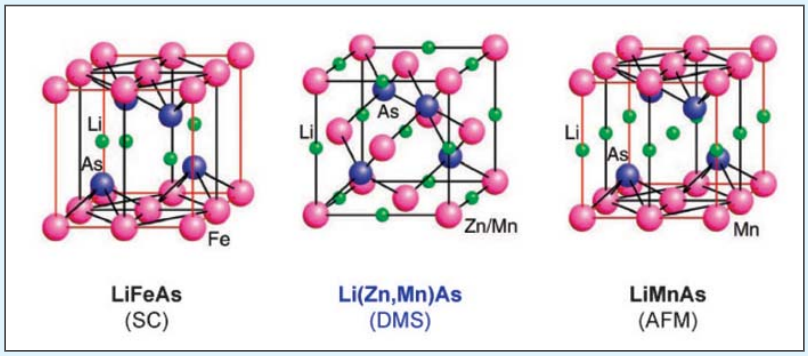
The optical frequency standards based on cold atoms represent the best performance on the international high-precision frequency and time technologies. Research group led by Prof. Gao Kelin in the CAS Wuhan Institute of Physics and Mathematics has realized the first optical frequency standard based on a single trapped calcium ion in China. In the measurement, the optical frequency comb referenced to a Hydrogen maser, which was calibrated to the SI second through GPS. Two rounds of measurements were taken in May and June 2011 respectively. The frequency was measured to be 411 042 129 776 393.0(1.6) Hz with a fractional uncertainty of 3.9×10^{-15} in a total averaging time of $> 2\times10^{6}$ s within 32 days. The systematic uncertainty has been evaluated to be at 10^{-16} level,an international advanced level.

Team leader: Prof. Gao Kelin
klgao@wipm.ac.cn

A new type diluted ferromagnet based on I–II–V semiconductor

Research group head by Prof. Jin Changqing from the Institute of Physics and Prof. Uemura from Colombia University discovered a new generation dilute magnetic semiconductor (DMS) Li (Zn,Mn) As. Comparing with the isostructural classical (Ga,Mn) As DMS, Li (Zn,Mn) As can be individually tuned carriers & spin concentration that would be promising to optimize the interplay of multiple quantum natures of electron. This is an extended work on the "111" type iron pnictide superconductors what they discovered in 2008 during iron superconductor fever. Semiconducting ferromagnetic Li (Zn,Mn) As, superconducting LiFeAs, and antiferromagnetic LiMnAs systems share compatible square lattice, which may enable development of novel junction devices in the future. The paper was published recently in *Nature Communications* 2:422 (2011).

Team Leader : Prof. Jin Changqin Jin@iphy.ac.cn



Progress of quantum information science

Researchers at the University of Science and Technology of China accomplished a series of pioneering achievements in the frontier of quantum information science as follows: verification of the new form of Heisenberg uncertain principle firstly, laying the ground for quantitative research of Non-Markov processes in experiments by controlling the open quantum systems; preparation of the eight-photon entangled state by high brightness two-photon entangled state sources which is prepared by some special-cut nonlinear crystals, extending the dynamical decoupling method to the protection of two-qubit entangled states in experiment; and experimentally demonstration of the probabilistic quantum cloner, realizing the quantum simulation of chemical reaction dynamics, solving the ground-state problem in a two-qubit Heisenberg system,and demonstrating in experiment the preparation and storage of frequency-uncorrelated entangled photons from cavity-enhanced spontaneous parametric downconversion. These results were published in *Nature, Nature Physics, Nature Photonics,* and *Physical Review Letters*, etc.

Hypersonic Flight Conditions Duplicating Shock Tunnel

Development of hypersonic flight conditions duplicating shock tunnel

Prof. Jiang Zonglin and CAS Member Yu Hongru from the CAS Institute of Mechanics, together with their team, developed a long test duration detonation-driven shock tunnel. This most advanced facility in the world hypersonic research area consists of a series of the innovative techniques for creating a long test duration shock tunnel based on the detonation-driven method developed in China. It is about 278m in length with a nozzle exit diameter of 2.5m, being capable of reproducing air flows of 100ms test duration for Mach 5~9 at 30~40km altitude to meet the requirements from testing integrated hypersonic vehicles of full scale and investigating into fundamental physical issues in hypersonic and high temperature gas dynamics.

Discovery of the heaviest anti-matter nucleus (anti-Helium4) from the RHIC

High-energy nuclear collision experiments have been performed at the STAR detector on the Relativistic Heavy-Ion Collider (RHIC) at the Brookhaven National Laboratory for exploring the matter created at the microseconds after the Big Bang. Scientists from the Shanghai Institute of Applied Physics, the Institute of Modern Physics and other RHIC-STAR institutions observed the signal of anti-helium4, the heaviest observed antinucleus to date by analyzing one billion events of the Au+Au collisions. In total, 18 anti-helium-4 counts were detected based on the Time of Flight detector which was constructed by the STAR-China group together with Time Project Chamber detector. The yield provides a benchmark for possible future observations of anti-helium-4 in cosmic radiation by the AMS-II detector which was lunched in International Space Station in 2011. The paper was published in *Nature* 473, 353 (2011).

Contact: Prof. Ma Yugang ygma@sinap.ac.cn

Time keeping of the national time service center reaches international advanced level

In 2011, the National Time Service Center (NTSC) obtained significant progress in time keeping, and all the technical indicators were much better than most timekeeping laboratories. In 2011, the difference between UTC (NTSC) and UTC is controlled within 30ns, that is |UTC-UTC (NTSC)|<30ns, which is far superior to the ITU requirements of 100ns. The middle and long term stability of the independent atomic time TA (NTSC) ranked in the top 3-4 of all the timekeeping laboratories in the international atomic time (TAI) network, and in TAI calculation, 7.4% of the weight was contributed by NTSC, ranked in the third of the timekeeping laboratories all over the world. NTSC has become one of the world's most important institutes in the field of time research.

NTSC primary time comparison and measurement system

Confirmation of the Copernican principle with the kinetic Sunyaev Zel'dovich background

The Copernican principle,e.g., we human beings do not live in a special region of the Universe, is a cornerstone of modern cosmology and one of the necessary conditions required to derive the cosmic acceleration from type Ia supernova observation. However, it remains largely unproven, in particular at the Gpc radial scale and above. Here will show that violations of this type will inevitably cause a first order anisotropic kinetic Sunyaev-Zel'dovich effect. If large scale radial inhomogeneities have amplitude large enough to explain the "dark energy" phenomena, the induced kinetic Sunyaev-Zel'dovich power spectrum will be much larger than the Atacama Cosmology Telescope and/or South Pole Telescope upper limit. This single test confirms the Copernican principle, rules out the adiabatic void model as a viable alternative to dark energy and hence consolidates the cosmic acceleration. It was published and highlighted in *Physical Review Letters* 107, 041301 (2011).

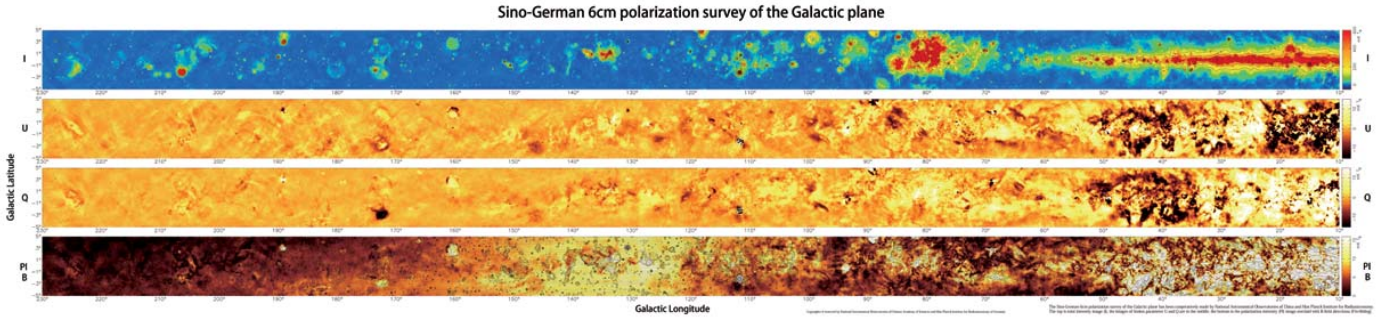
Team leader: Prof. Zhang Pengjie pjzhang@shao.ac.cn

Precise mass measurement for proton drip-line nuclide ^{65}As

Rapid proton capture process (rp process) is one of nuclear reactions for heavy element synthesis in the universe. Precise measurements of masses, half-lives, and reaction rates for some short-lived nuclides are important and needed for modeling the process. ^{65}As is a key isotope located at the reaction path of the rp process. Recently direct mass measurement of short-lived ^{65}As and other three neighboring nuclides have been measured, for the first time, in the newly-built HIRFL-CSR acceleration complex in IMP. The relative mass precision up to 10^{-6} has been reached. The precise mass ^{65}As is used in the theoretical calculations of the nuclear astrophysics, and important conclusion has been made, i.e. the ^{64}Ge is not a significant waiting point nuclide in the rp process of Type I x-ray burst. Over 40 scientists from China, France, Germany, Japan, and United States have been involved in this research project. The results were published in *Physical Review Letters*, 106, 112501 (2011)

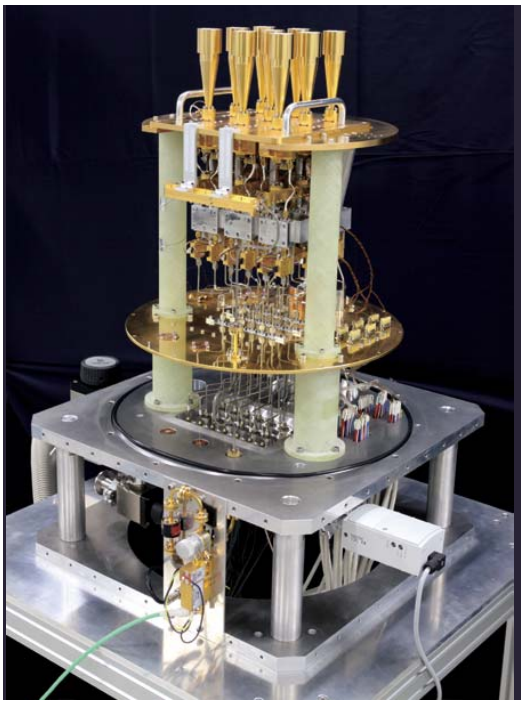
Polarized radio emission of the Milky Way measured, new Supernova Remnants found

The 10-year Sino-German polarization survey of the Galactic plane at 6 cm wavelength was finished, by using the Urumqi 25-m telescope of the Xinjiang Astronomical Observatory. Large-scale diffuse polarized emission was observed for about 4500 hours in order to study the magnetic field of the Milky Way. The survey covered the northern band of the Milky Way with Galactic longitude between 10 and 230 degrees, and Galactic latitude between -5 and 5 degrees, an area of 2200 square degrees. This survey is the highest frequency polarization survey ever made with earth-based instruments. Several large discrete objects were investigated, and two new supernova remnants (SNRs) were discovered from the Urumqi Galactic plane survey. There have been 24 publications since the project started in 2002, mostly in *Astronomy & Astrophysics*. Two of which were even highlighted.



Superconducting spectroscopic array receiver

Superconducting millimeter multibeam receiving technology that enables large sky coverage, high spectrum resolution and high sensitivity are exclusively required in modern astronomy and astrophysics. Along



with making major breakthroughs in this area, researchers in the CAS Purple Mountain Observatory have finished developing Superconducting Spectroscopic Array Receiver (SSAR), a 3x3 multi-beam receiver for Delingha millimeter telescope, the major open facility for millimeter-wave radio observation in China. It is not only the first multibeam receiver developed for radio observation in China, but also the first one based on the sideband-separation technique. SSAR has been successfully put into observation since the end of 2010. Rich observation results of supernova remnants, interstellar molecular clouds and star-forming regions have been obtained. The expected high sensitivity of SSAR and its considerable enhancement of mapping speed have been proved.

Team leader: Prof. Yang Ji, jiyang@pmo.ac.cn

The superconducting frontend

BEPCII: collision luminosity keeps going up

The luminosity of the upgraded Beijing Electron Positron Collider (BEPCII) keeps going up. On the early morning of April 8, 2011, the collision luminosity of the BEPCII reached a new record $6.492\times10^{32}cm^{-2}\ s^{-1}$, which was 65 times higher than that of the BEPC. In addition, due to the stable run of all the accelerator sub-systems, the integrated luminosity of the Beijing Spectrometer (BESIII) reached its highest 14.95pb-1 based on shift and 29.35pb-1 based on day. The running efficiency got a new high, which shows its excellent performance, laying a solid foundation for further upgrading its collision luminosity, improving data acquisition efficiency and making even greater scientific achievements.

First ITER product to be delivered

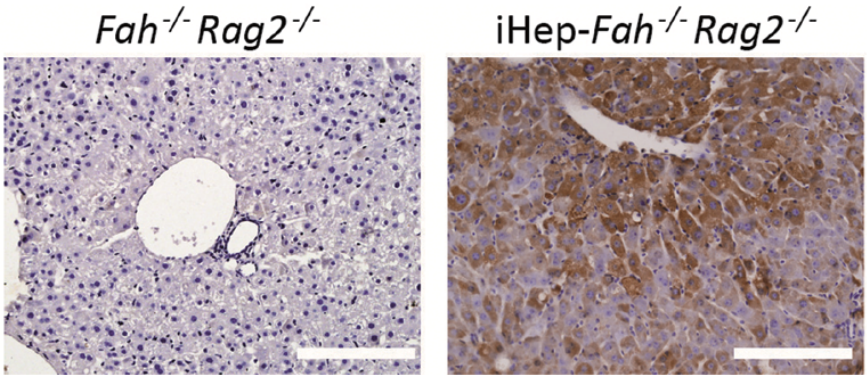
The delivery ceremony of first made-in-China product for ITER Project, ITER Toroidal Field (TF) superconductive conductor was held on December 12, 2011. This 780-meter-long conductor, the first-ever ITER product made by seven ITER parties, will be shipped to Japan. The conductor is 100% made domestically, and China is the second ITER members capable of producing this after Japan. Moreover, China is the only country among the six ITER conductor task undertaking parties that its all samples have passed strict international tests the first time and with excellent quality. ITER Director General Prof Osamu Motojima highly applauded the achievement, commending that China is "the leading country of ITER project".

中國科學院
CHINESE ACADEMY OF SCIENCES

Life Sciences and Biotechnology Research

Induction of functional hepatocyte-like cells from mouse fibroblasts by defined factors

Dr. Hui Lijian's team, from the Shanghai Institute of Biochemistry and Cell Biology, the Shanghai Institutes for Biological Sciences, demonstrateed the direct conversion of adult fibroblasts into functional hepatocyte-like (iHep) cells for the first time. iHep cells show typical epithelial morphology, express hepatic genes and acquire hepatocyte functions. Notably, transplanted iHep cells repopulate the liver of fumarylacetoacetate-hydrolase deficient ($Fah^{-/-}$) mice and rescue almost half of recipients from death by restoring liver functions. The study provides a new strategy to generate functional iHep cells for the purpose of liver engineering and regenerative medicine. It was published in *Nature* 475:386-389.



Repopulation of iHep cells in $Fah^{-/-}Rag2^{-/-}$ livers determined by Fah immunostaining

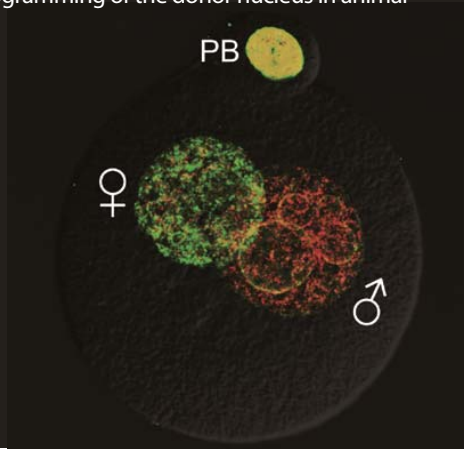
Team leader : Dr. Hui Lijian ljhui@sibs.ac.cn

Important role of Tet3 dioxygenase in oocyte epigenetic reprogramming

In early mammalian embryos, silent genes are activated to gain developmental potential and establish distinct lineages. One important process for gene activation is DNA demethylation, i.e. the removal of methylated cytosines. The biochemical mechanism and its exact biological significance are unknown. A team led by Drs. Xu Guoliang and Li Jinsong, from the Shanghai Institute of Biochemistry and Cell Biology, the Shanghai Institutes for Biological Sciences, discovered that a maternal factor, Tet3 dioxygenase, is responsible for the oxidation of the paternal genomic DNA in the early mouse embryo. The oxidation of the paternal DNA is required for its demethylation and activation of pluripotency genes such as Oct4 and Nanog. Moreover, it was demonstrated

that Tet3-mediated DNA oxidation was involved in the reprogramming of the donor nucleus in animal cloning. It was published in *Nature* 477:606-610.

Team leaders : Dr. Xu Guoliang glxu@sibs.ac.cn
Dr. Li Jinsong jsli@sibs.ac.cn

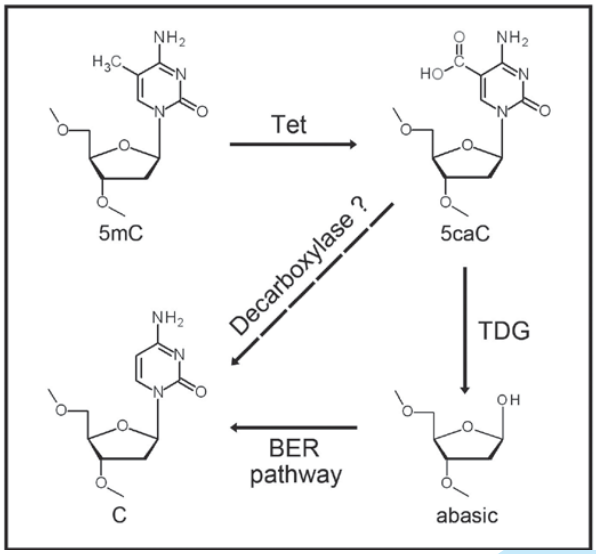


DNA oxidation in mouse zygotes. 5mC is green (female pronucleus) and 5hmC is red (male pronucleus).

New insight into DNA demethylation: the 7th base

The prevalent DNA modification in higher organisms is the methylation of cytosine to 5-methylcytosine (5mC), which is partially converted to 5-hydroxymethylcytosine (5hmC) by the Tet family of dioxygenases. Despite their significance in epigenetic regulation, it is unclear how these cytosine modifications are reversed. A team of researchers, led by Dr. Xu Guoliang, from the Shanghai Institute of Biochemistry and Cell Biology, the Shanghai Institutes for Biological Sciences, provide direct evidences that 5mC (the 5th base) and 5hmC (the 6th base) in DNA are oxidized to 5-carboxylcytosine (5caC, the 7th base) by Tet dioxygenases. 5caC is specifically recognized and excised by thymine-DNA glycosylase (TDG). Their data suggest that oxidation of 5mC by Tet proteins followed by TDG-mediated base excision of 5caC constitutes a pathway for active DNA demethylation. It was published in *Science* 333:1303-07.

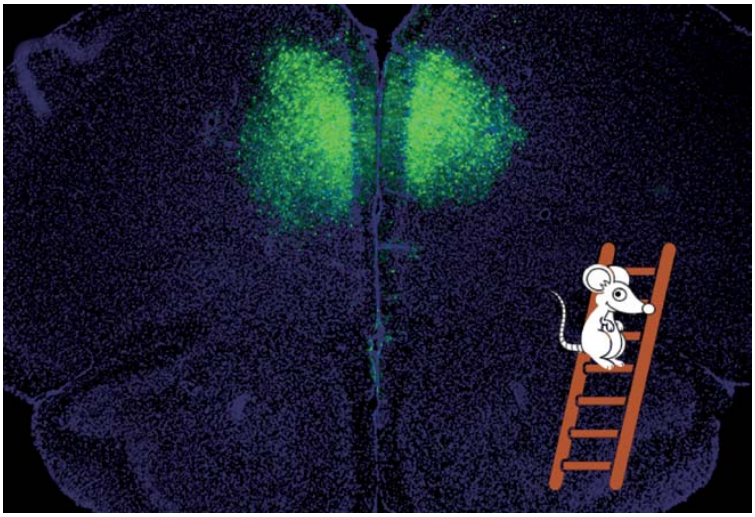
Team Leader: Dr. Xu Guoliang,glxu@sibs.ac.cn



Pathway of active DNA demethylation.

The neural circuit mechanism of bi-directional control of social hierarchy

Research group led by Dr. Hu Hailan from the Institute of Neuroscience, the Shanghai Institutes for Biological Sciences, found bi-directional control of social hierarchy by synaptic efficacy in medial prefrontal cortex (mPFC). They found social hierarchical status of mice correlated with the synaptic strength in mPFC neurons - the higher the rank status, the stronger the synapses (cellular junctions where neurons communicate with each other) in the mPFC. Using viral vectors and molecular tools, the authors manipulated the hierarchical status of mice by tweaking the strength of synapses in mPFC. Strikingly, subordinate mice moved up the hierarchy ladder when researchers increased their mPFC synaptic strength; conversely, dominant mice became subordinate when their mPFC synaptic strength was decreased. It established simple and robust behavioral paradigms for the study of social hierarchy. It opens the opportunity to a better understanding of the whole dominant circuitry. It was published in *Science*.



This picture depicts the viral expression of a gene called GluR4 in the medial prefrontal cortex of a subordinate mouse, which resulted in its upward shift on the social ladder.

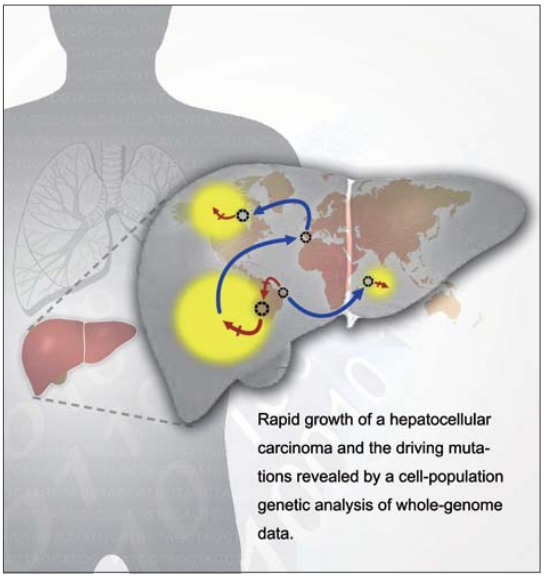
Team leader: Dr. Hu Hailan, hailan@ion.ac.cn

miRNAs protect the heart

Prof. Li Peifeng and his group at the Institute of Zoology have made important discovery on the study of miRNA in heart research. They discovered that miR-499 protects against myocardial infarction by inhibiting cardiomyocytes apoptosis and reducing myocardial infarct size. They further revealed its molecular mechanism. The data provided a new way of thinking in elucidating the pathogenesis and provide a new approach for the prevention and diagnosis of myocardial infarction, especially played an important guiding significance in developing of miRNAs as therapeutic drugs of apoptosis-related heart diseases. It was published in *Nature Medicine* 2011;17(1),71-78.

Rapid growth of a hepatocellular carcinoma and the driving mutations revealed by cell-population genetic analysis of whole-genome data

Research team led by Prof. Wu Chung-I at the Beijing Institute of Genomics reported the analysis of the evolution of tumors in a case of hepatocellular carcinoma. In this study, selected tumor sections were subjected to exon as well as whole-genome sequencing. Putative somatic mutations were individually validated across all nine tumor and seven nontumor sections. By using a cell-population genetic definition, this approach identified three coding changes (CCNG1, P62, and an indel/fusion gene) as tumor driver mutations. These three mutations, affecting cell cycle control and apoptosis, are functionally distinct from mutations that accumulated earlier, many of which are involved in inflammation/immunity or cell anchoring. This case is particularly informative about cancer growth dynamics and the underlying driving mutations. It was published online in *PNAS* on July 5.2011.

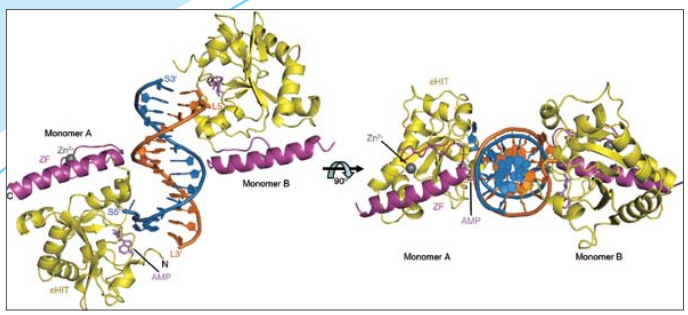


Schematic model of miRNA-499's role in regulating cardiomyocytes survival.

Team leader: Prof. Li Peifeng, peifli@ioz.ac.cn

Crystal structure of S. pombe aprataxin Hnt3 sheds light on its role in the repair of abortive DNA ligation

APTX is a neurodegenerative disease-related protein whose dysfunction causes ataxia with oculomotor apraxia 1 (AOA1), a relatively rare condition that is characterized by progressive problems with movement. It is now known that APTX has a direct role in catalyzing the nucleophilic release of adenylate groups from 5′-AMP-termini at DNA nicks or breaks during the repair of abortive DNA ligation. In a recent paper published in *Nature Structural & Molecular Biology* (18, 1297–1299, 2011), Profs. Wang Dacheng and Jiang Tao's teams at the Institute of Biophysics, report the crystal structures of the yeast Aprataxin ortholog apo Hnt3, and Hnt3-DNA and Hnt3-DNA-AMP complexes, in which Hnt3 recognizes and processes 5′ adenylated DNA in a structure-specific manner. The structures provided a distinct molecular platform for DNA recognition and processing to reveal the structural mechanism for the functional performance of APTX protein. They also identified some key amino acid residues involved in Hnt3 function through mutational and interaction studies, which showed the structural basis for different Aprataxin mutations inducing AOA1.



Ribbon diagram of Hnt3 in complex with dsDNA and AMP. eHIT, yellow; ZF, magenta; short strand of the dsDNA, blue; long strand, orange.

Team leader: Prof. Wang Dacheng,dcwang@ibp.ac.cn
Prof. Jiang Tao,tjiang@ibp.ac.cn

REF6 demethylates Histone H3 Lysine 27 tri-methylation to release gene repression

Scientists in the Institute of Genetics and Developmental Biology demonstrated that REF6/JMJ12 (RELATIVE OF EARLY FLOWERING 6/Jumonji domain-containing protein 12) is the long-sought-after H3K27me3/2 demethylase. REF6/JMJ12 is similar in sequence to animal H3K9me2/3 and H3K36me2/3 demethylases. In animals, H3K9me3 recruits HETEROCHROMATIN PROTEIN 1 (HP1) in animals. In contrast Arabidopsis homolog of HP1, LIKE HETEROCHROMATIN PROTEIN 1 (LHP1), binds to H3K27me3 at euchromatin to repress gene expression. Therefore, REF6/JMJ12 along with LHP1 might have acquired the novel function of acting in H3K27me3-mediated gene silencing during evolution. This is the first case of convergent evolution towards demethylation by recruiting distinct biochemical pathways in plants and animals. It was published in *Nature Genetics*.

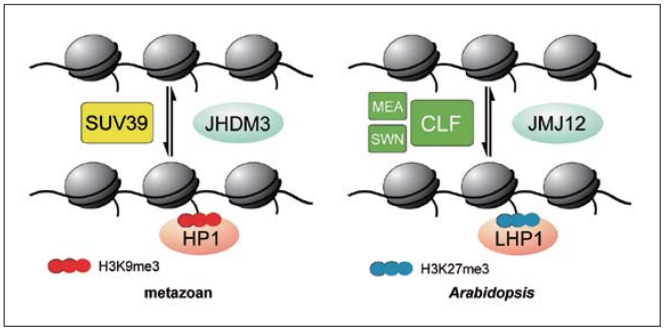


Diagram of comparison of biochemical roles of HP1 and KDM4 in metazoan (left) with LHP1 and REF6 in Arabidopsis (right)

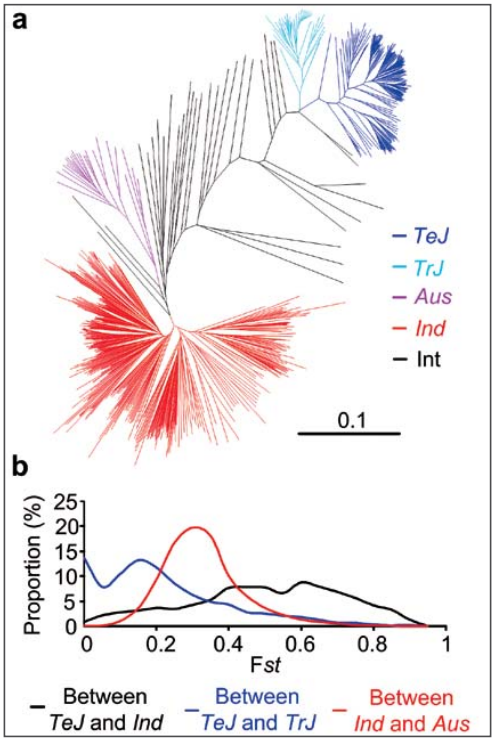
Team leader: Prof. Cao Xiaofeng, xfcao@genetics.ac.cn

Team leader: Prof. Cao Xiaofeng, xfcao@genetics.ac.cn

New breakthrough in genome-wide association study of rice complex traits and genetic variation surveys of cultivated rice

A high-density haplotype map has enabled a genome-wide association study (GWAS) in a population of indica subspecies of Chinese rice landraces. Here we extend this methodology to a larger and more diverse sample of 950 world-wide rice varieties including Oryza sativa indica and japonica subspecies to perform GWAS. We identified a total of 32 new loci associated with flowering time and ten grain-related traits, indicating that the larger sample increased the

power to detect trait-associated variants using GWAS. To characterize various gene alleles and complex genetic variation, we developed an analytical framework for haplotype-based de novo assembly of the low-coverage sequencing data in rice. Candidate genes were identified for 18 associated loci through detailed annotation, expression profiling and identification of putative causal mutations. This study demonstrates that the integrated approach of sequence-based GWAS and functional genome annotation has the potential to resolve complex traits to their causal polymorphisms in rice.



Genetic structure and population differentiation of 950 rice accessions.

Deep resequencing of cultivated and wild rice sheds light on domestication of Asian rice and yields markers for identifying agronomically important genes

As one of the most important crops in the world, rice is primary food source for over one third of the world's population. Its domestication began approximately 10,000 years ago and changed significantly in various agronomic traits. Led by Prof. Wang Wen in the Kunming Institute of Zoology, an international team used the next-generation sequencing technology to draw the first high-quality genome variation maps for 40 representative cultivated and 10 wild rice by deep sequencing. They obtained 6.5 million high-quality single nucleotide polymorphisms (SNPs), 808,000 small indels and 94,700 structure variations. Using the information, it was clarified the complex evolutionary history of Asian cultivated rice and supported the independent origination of the two rice subspecies *(japonica and indica)*. Furthermore, they also identified thousands of genes which could be selected during rice domestication process and are valuable resource for future rice breeding. It was published in *Nature Biotechnology*.

Team leader: Prof. Wang Wen,wwang@mail.kiz.ac.cn

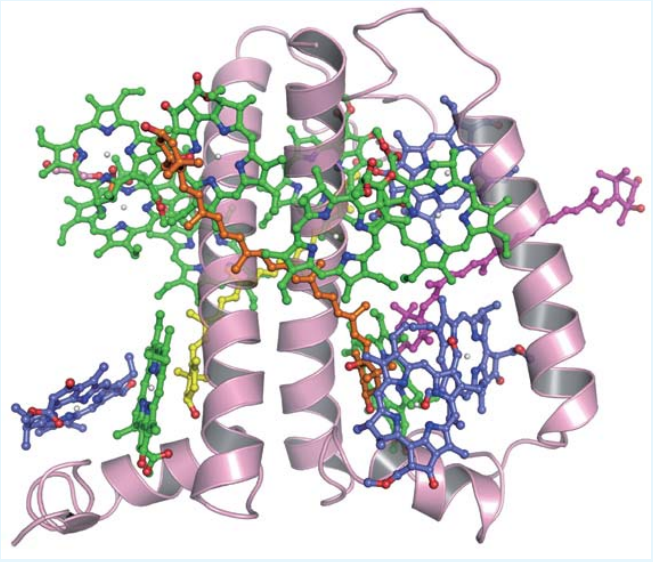
Modern sustainable agricultural pilot project

Modern sustainable agricultural pilot project was initiated in 2009, aiming to increase production with green agricultural technologies. Two pilot projects were implemented in central Henan Province and northeast Shenyang city. The Henan project aims at improving crop yield while the Shenyang project is characterized

Heavy-duty Agricultural Machinery

Team leader: Prof. Sun Jianghua, sunjh@ioz.ac.cn

by of heavy-duty agricultural machinery on large area land farming. In 2011, 3,333 ha of medium and low yield farmland was transformed into high yield one in Henan. Wheat yield reached 8700kg/ha comparing to the average 7815kg/ha. The Shenyang project applied a series of CAS agricultural technologies including high yield corn breeding, molecular breeding of japonica rice and soybean, virus-free seed potato breeding system, ecological crops cultivation system, and precision agricultural construction and testing. The experimental 133 ha of corn land got a yield of 2175kg/ha with a revenue increase of over 400,000 RMB. Yield of virus-free potato increased by 20%, a net income of 2,000,000 RMB.



Overall structure of CP29 viewed parallel with the membrane plane. The apoprotein is shown as a pink ribbon, and pigments are shown as ball-and-stick models.

Team leader: Prof. Chang Wenrui, wrchang@sun5.ibp.ac.cn

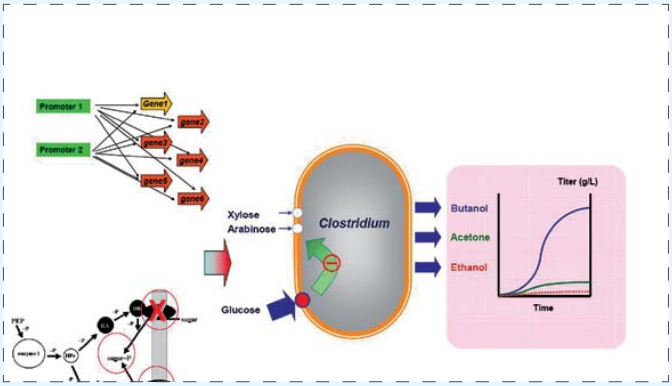
Crystal structure of minor light-harvesting complex CP29 from spinach

CP29, one of the photosynthesis membrane proteins, is a minor light-harvesting complex of higher-plant photosystem II, functioning in absorbing and transferring solar energy for photosynthesis and also playing important role in photo-protection. Prof. Chang Wenrui's group at the Institute of Biophysics has successfully determined the crystal structure of CP29 at 2.8 Å resolution, which is the first report of minor light-harvesting complex structure. CP29 apoprotein has three long transmembrane α-helices and two short helices. Each CP29 monomer

contains 13 chlorophyll and 3 carotenoid molecules. Based on the present X-ray structure, an integrated pigment network in CP29 is constructed. Two special pigment clusters have been identified and might function as potential energy-quenching centers and as the exit or entrance in energy-transfer pathways. It was published in *Nature Structural & Molecular Biology* (2011, 18: 309-315).

New breakthrough in butanol production from lignocellulosic materials

Research group led by Prof. Yang Sheng and Prof. Jiang Weihong, at the Institute of Plant Physiology and Ecology, Shanghai Institutes for Biological Sciences, achieved new progress in anaerobic fermentation of butanol from pentose sugars. A new engineering strategy was applied on Clostridium acetobutylicum by attenuating glucose phosphoenolpyruvate-dependent phosphotransferase system (PTS) and overexpressing the xylose pathway enzymes, making the strain capable of efficiently co-fermenting the mixture of glucose, xylose and arabinose, and thus overcoming a technical bottleneck in lignocellulose-based butanol production. A related Chinese patent has been applied, which is expected to benefit the bioconversion of corn stover, bagasse, sweet sorghum stalk, and corncob. Currently, the research group is cooperating with domestic biobutanol-producing enterprises as well as other related institutes to perform the strain assessment and the further industrialization.



Attenuation of glucose phosphoenolpyruvate-dependent phosphotransferase system (PTS) and overexpression of the xylose pathway enzymes in Clostridium acetobutylicum for efficient utilization of mixed sugars.

Production of L-alanine by microbial fermentation

L-alanine is an important pharmaceutical intermediate, which has a global market of 30,000 tons per year. L-alanine is currently produced from petroleum-based feedstock, and large amount of carbon dioxide emmission occurs during the production process. Dr. Zhang Xueli and his colleagues from the Tianjin Institute of Industrial Biotechnology have developed a fermentation technology for L-alanine production. Cell factories were developed by metabolic engineering of Escherichia coli strains, which can produce 115 g/L L-alanine with a yield of 0.95 g/g glucose. The whole production process has no carbon dioxide emmission. This

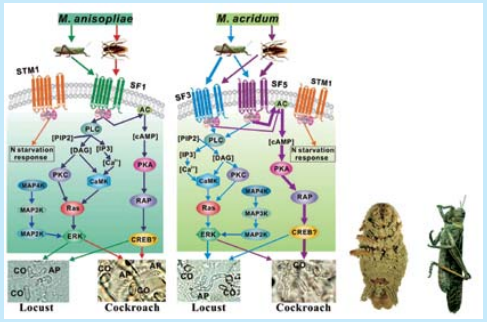
technology was licensed to a local company. Pilot-scale fermentation was successfully completed in a 100m^3 fermentor, and the production cost decreased 40% compared to current technology. Manufacturing facilities for production of 7,000 tons L-alanine per year have been constructed, and the annual sale is estimated to be 160 million Yuan.

Team leader: Dr. Zhang Xueli,zhang_xl@tib.cas.cn

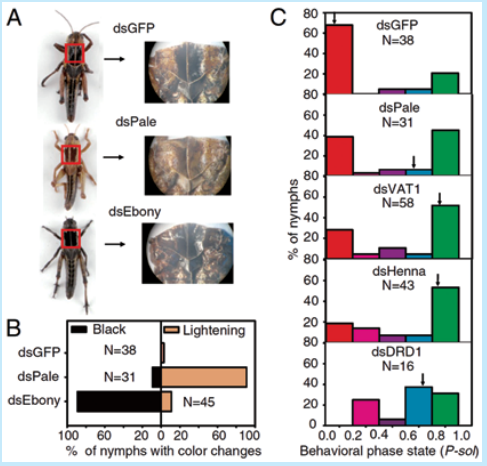
Progress of biological disaster prevention and control

CAS biologists made some progress in biological disaster prevention and control to decrease their damages to agricultural production. Microarray, RNA interference and pharmacological intervention analysis revealed that signals from the head are integrated to initiate locust phase change by CSP and takeout genes or maintain phase state by catecholamine metabolic pathway. These results first elucidated the molecular genetic mechanism of locust phase change. Phylogenomic and omparative genomic analyses revealed that the genus Metarhizium may have evolved from plant endophytes and both species have a strikingly larger proportion of genes encoding secreted proteases and chitinases than other fungi to target insect cuticles. Transcriptional analysis of both fungi during early infection processes provided insights into the receptors and pathways involved in fungal infectivity and specificity. Study on Chinese historical records revealed that precipitation showed nonlinear effects on occurrences of human plague in China during 1850-1964; both precipitation and temperature showed negative effect on locust occurrences .

Virus-free Potato Seedling Rapid Propagation



Differentially regulated signaling pathways employed by M. anisopliae and M. acridum infecting locust and cockroach.



Catecholamine metabolic pathway genes modulate the body color and behavioral phase state in locusts.

Industrialization of a new hyperthermostable SOD

Researchers headed by Prof Dong Zhiyang in the Institute of Microbiolog obtained a novel hyperthermophilic superoxide dismutase (SOD) gene in metagenomic library constructed from hot spring sample. The modified SOD retains activity in 100℃ and shows striking stability across a pH spanning from 4.0 to 11.0. The specific activity of SOD is up to 2,000 U/mg, the protein expression level of SOD is up to 5g/L and the activity reaches 10,000U/mL.

The thermostable SOD is obtained from microbial fermentation and is safer than the traditional SOD product extracted from animal blood. It can be conserved at room temperature for more than two years in normal state. The production line of pure SOD with 1000kg/year capacity was built up in August, 2011 and the annual output will reach 200 million yuan.

Team leader: Prof. Dong Zhiyang, dongzy@im.ac.cn

Study of biodiversity and adaptive evolution of indigenous animals in Sino-Himalayas

Many indigenous animals have survived in the Tibetan Plateau. Focusing on the biodiversity of indigenous animals here, scientists from the Kunming Institute of Zoology carried out research on the genetic basis of their adaption. It was found that Tibetan Antelope lived in the harsh environment based on its genome data, and so did other highland animals. Thus, these mechanisms may be essential for high altitude adaption. Meanwhile, in study of the genetic basis of adaption of energy metabolism and food digestion, it was revealed that the genetic mechanism of their adaption to harsh environment essential for the following study and utilization of their gene resources, especially utilization of high altitude adaption genes. These findings were published in journals such as *Science, PNAS, Genome Res., Mol. Biol. Evol., PLoS Genet*.

Research progress on animal biodiversity conservation

Research group led by Prof. Wei Fuwen (weifw@ioz.ac.cn) at the Institute of Zoology (IOZ) made a breakthrough in understanding how the giant panda digests cellulose and hemicellulose in its bamboo diet. Dr. Du Weiguo (duweiguo@ioz.ac.cn) of IOZ demonstrated at the first time that turtle (Pelodiscus sinensis) embryos moved within the egg to exploit small-scale spatial thermal heterogeneity. Mitochondrial gene in the molecular clock research done by scientists from the Chengdu Institute of Zoology (Prof. Zeng Xiaomao, zengxm@cib.ac.cn)pointed out the limitations of mtDNA genes of hynobiid in using the molecular clock. Scientists from IOZ (Dr. Sun Jianghua, sunjh@ioz.ac.cn) examined the population genetics and behavior of the fungus, vectored by a highly invasive bark beetle, and discovered that the fungus was introduced by the beetle from the US to China and the fungal novel genotypes facilitated the invasion of the beetle/fungal complex in China.

A hynobiid salamander, *Onychodactylus fischeri*

Research progress on plant biodiversity conservation

Comprehensive analysis of the dataset, involving 6,286 individuals representing 1,757 species in 141 genera of 75 families of seed plants, was made to assess the universality, sequence quality and discriminatory power of the four candidate barcodes (i.e. rbcL, matK, trnH-psbA and ITS). The results indicated that the three chloroplast markers showed higher level of universality, while ITS provided the highest discriminatory power among the four markers (Prof. Li Dezhu, DZL@mail.kib.ac.cn). Using common-garden plants of Ficus, functional traits were compared for seven hemiepiphytic species and seven non-hemiepiphytic species. It was indicated that the conservative hydraulic conductivity and drought tolerance traits might be one

basis for the hyper-diversification of hemiepiphytic Ficus species in tropical rain forests(Prof. Cao Kunfang, caokf@xtbg.ac.cn).A study was conducted to describe a new mode of pollination-by-deceit that may ultimately represent a "bridge" between generalist food mimesis and mimicry of mushrooms (Prof. Wang Hong, wanghong@mail.kib.ac.cn).

Wildlife resources utilization obtain a series of progress

Oricinoside, the first category of natural antidepressant new drug has been developed and in phase I, II, III clinical trials from a traditional Chinese medicinal herb. *Indole alkaloids* from *A. scholaris* has been approved for clinical trial to treat respiratory diseases by SFDA. Elite variety of Plukenetia volubilis, a healthy edible oil-seed bearing plant, has been approved and registered in Yunnan. Four varieties of orchids that are the most important ornamental flower in the world were registered internationally. A novel functional fruit - Lycium barbarum, Zhongke Lvchuan No.1 was registered. Study on "Utilization of Yunnan's Endemic Rhododendron Germplasm Resources and Application of Key Industrialization Technology" won a local S&T award. The *Dendrobium officinale*, Zhongke No.1 and the *Curcuma alismatifolia*, Hongguanyin were certified by the local government. The biodiesel plant *Jatropha curcas* was commercially planted.

Resource and Environment Research

Glacial-interglacial Indian summer monsoon dynamics

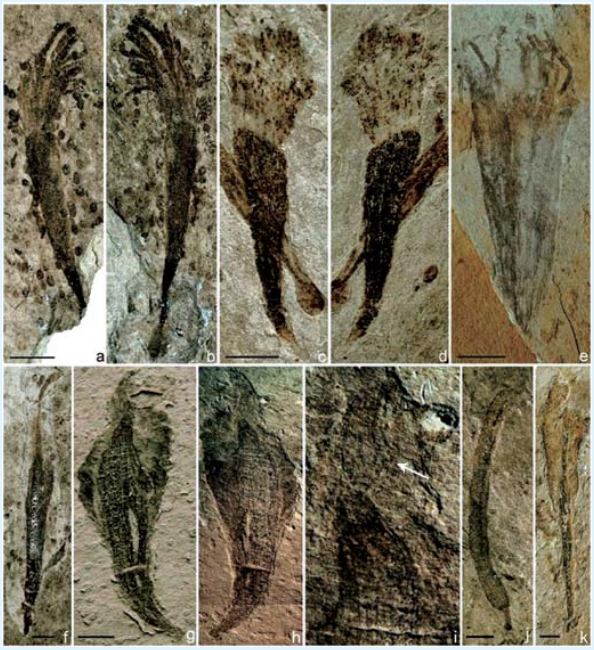
Using a 666-m long sediment core retrieved from Heqing Basin by the Chinese Environmental Scientific Drilling Program, the research group led by Prof. An Zhisheng from the Institute of Earth Environment presented a new insight into glacial-interglacial Indian summer monsoon (ISM) dynamics. They revealed that glacial-interglacial ISM variation is driven by changes of cross-equatorial pressure gradient (XEPG) modulated by both Southern and Northern Hemisphere ice volume and temperature. Interglacial ISM maxima are dominated by an enhanced Indian low associated with global ice volume minima. In contrast, the glacial ISM reaches a minimum, and actually begins to increase, before global ice volume reaches a maximum. This early

strengthening is attributed to an increased XEPG derived from Southern Hemisphere high-latitude cooling. This work was published in *Science* on August 5, 2011.

Team leader: Prof. An Zhisheng, anzs@loess.llqg.ac.cn

Six hundred million years old fossils of large seaweeds and possible animals discovered in South China

Professor Yuan Xunlai and his colleagues from the Nanjing Institute of Geology and Palaeontology, in collaboration with other scientists from China and USA, report the discovery of a diverse assemblage of fossilized seaweeds and possible animals from approximately 600 million-year-old rocks in Nature. The fossils, recovered from the early Ediacaran Lantian Formation in Xiuning of Anhui Province, South China, indicate that morphological diversification of macroscopic eukaryotes may have occurred only tens of millions of years after the snowball earth event that ended 635 million years ago, just before the Ediacaran Period. And their presence in the highly organic-rich black shale suggests that, despite the overall oxygen-free conditions, brief oxygenation of the oceans existed and were opportunistically utilized by the Lantian organisms.



Photomicrographs of Lantian macrofossils of probably algal

The 10th GSSP defined in China

The International Union of Geological Sciences (IUGS) has approved the Global boundary Stratotype Section and Point (GSSP, commonly known as the "Golden Spike") for the base of Cambrian Stage 9 being named as Jiangshanian Stage after Jiangshan county, Zhejiang Province.

The GSSP is the 10th "Golden Spike" set up in China, now having the world's largest number of GSSPs. The Jiangshanian GSSP is the 3rd GSSP defined by Prof. Peng Shanchi's research group from the Nanjing Intstitute of Geology and Palaeontology, Chinese Academy of Sciences (NIGPAS) and is the 7th one defined by NIGPAS as well .

Out of Tibet: Ancestral woolly rhino suggests high-plateau origin of Ice Age megaherbivores

Prof. Deng Tao's team from the Institute of Vertebrate Paleontology and Paleoanthropology reported a new middle Pliocene (~3.7 million years ago) woolly rhino from the high-altitude Zanda Basin in western Himalaya. The new species occupies the most basal position of the woolly rhino lineage and is the earliest representative of this rhino group. As the Ice Age began about 2.8 million years ago, the Tibetan woolly rhino descended, through intermediate forms, to low altitude,

Origin, distribution, and dispersal of woolly rhinos in Eurasia

Team leader: Prof. Deng Tao, dengtao@ivpp.ac.cn

high latitude regions in northern Eurasia, and became part of the emerging woolly mammoth-woolly rhino fauna in the middle to late Pleistocene. The new Tibetan fossils suggest that some megaherbivores first evolved in Tibet before the beginning of the Ice Age. The cold winters in high Tibet served as a habituation ground for the megaherbivores, which pre-adapted to the Ice Age and then successfully expanded to the Eurasian mammoth steppe. This research was published in *Science*.

Key technologies in utilizing functional peptides of tropic marine mollusks and their industrialization

In collaboration with 4 companies, the South China Sea Institute of Oceanology has invented a series of new technologies to improve the efficiency of the preparations of functional peptides extracted from tropic mollusks. These new technologies are based on a new class of enzyme preparations produced by new microbial species collected from the deep-sea of South China Sea. The higher efficiency of the preparations is attributed to the property of catalyzing the hydrolysis of the glycosaminoglycan side chain of tropic mollusk binding proteins before polypeptide chains cleavages.

The commercial application of new tropic marine mollusks peptides technologies

Long-term paleoceanographic records from Kuroshio Source Area and evolution of mainstream of Kuroshio Current

Research group led by Prof. Li Tiegang from the Institute of Oceanology established an age-depth model covering the past 2.36 Ma based on oxygen isotope and biostratigraphic data, which fills in the blanks of paleoceanographic study of the Western Philippine Sea. Their time-series data demonstrates the existence of mid-Pleistocene transition (MPT) and reveals a long-term cyclicity of the ocean carbon reservoir. The group also reconstructed the evolution pattern of warm current system in the East China Sea and the Yellow Sea since the last deglaciation. The results lay the foundation for better understanding the crucial environmental problems in this region and also contribute to the comprehension of the role of tropical oceans in global climatic change.

Team leader: Prof. Li Tiegang, tgli@qdio.ac.cn

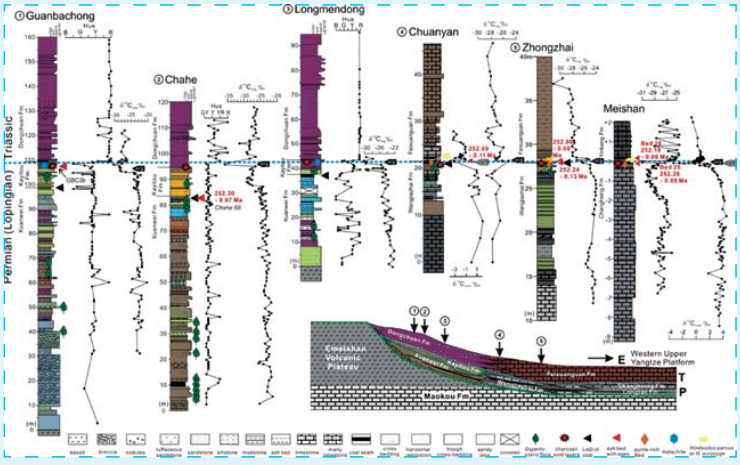
Breakthrough in technology of ocean bottom seismometer

The research group led by Hao Tianyao from the Institute of Geology and Geophysics developed 40 single-sphere 7-channel broadband OBSs, including a number of key devices such as the acoustic transponder, low-power acquisition system, and attitude controlling gimbal device. The instrument array has been used in marine tests for 154 set-times and participated in the joint sea-land seismic observation in Bohai

Sea and South China Sea, where the instrument recovery rate exceeded 98% and the data completeness exceeded 90%. In the first half of 2012 a comparative test involving 200 sets of the instrument will be carried out in the shallow waters of Shengli Oilfield.

Biggest mass extinction sweeps life from land and sea within 200,000 years

The Late Palaeozoic Research Group led by Professor Shen Shuzhong from the Nanjing Institute of Geology and Palaeontology, in collaboration with the scientists from USA and Canada,studied a suite of geochronologic, isotopic, and biostratigraphic data and established a database based on tens of well-preserved Permian-Triassic sections in South China and Tibet. High-resolution biostratigraphical framework, high-precision U-Pb dating and composite biodiversity pattern reveal that the extinction peak occurred just before 252.28±0.08 million years ago, and coincided with a d13C excursion of –5‰ that is estimated to last for no more than 20,000 years, which saw widespread oceanic anoxia and frequent wildfires due to rapid climatic drying. The extinction interval was less than 200,000 years. The rapid global warming derived from a massive release of thermogenic carbon dioxide and/or methane by large-scale volcanic activities which caused the catastrophic collapse of both terrestrial and marine ecosystems.



Meters above and below PTB of measured Meishan section

New sensors for rapid on-site monitoring of environmental pollutants in coastal zone

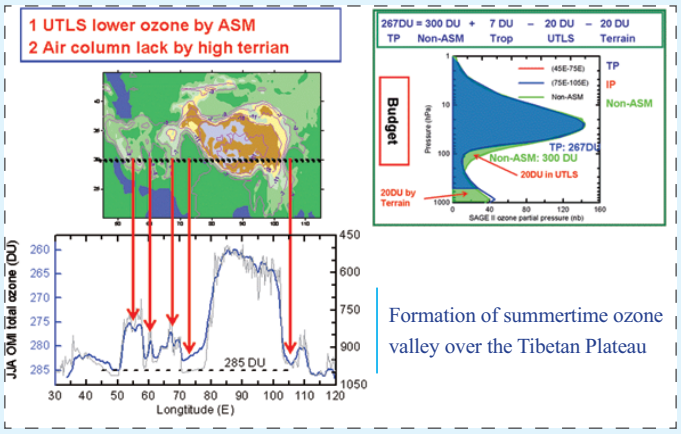
Research group led by Prof. Qin Wei and Prof. Chen Lingxin from the Institute of Coastal Zone Research has developed high sensitive and selective novel polymeric membrane ion-selective electrodes for detecting potentiometric of heavy metals in seawater, which led to various chemical sensors for rapid on-site monitoring of marine pollution. A novel optical method based on noble metal nanomaterials was then constructed, which is a breakthrough in the detection of ultra-trace heavy metals in complicated matrix. On this basis, an instrument integrated with sample pretreatment and measurement for the on-site determination of heavy metals in seawater was fabricated. Related results were published in *Chem. Soc. Rev.*, *Angew. Chem.* and *JACS*.

Team Leader: Prof. Qin Wei, wqin@yic.ac.cn
Prof. Chen Lingxin, lxchen@yic.ac.cn

中國科學院
CHINESE ACADEMY OF SCIENCES

Stratospheric processes and their roles in climate and weather in East Asia

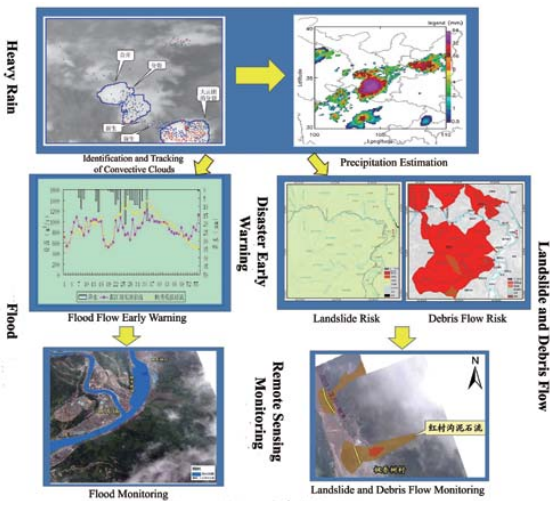
Institute of Atmospheric Physics has accomplished the integrated field campaign on stratosphere-troposphere exchange process of two important and typical weather systems, the cut-off low in northeast China and the Asian summer monsoon over Tibet, and gathered some important unknown facts about atmospheric composition and vertical structure. It was revealed that the region controlled by South Asian High is enhanced by tropospheric tracers and dehanced by stratospheric tracers, and that the summertime ozone valley over the Tibetan Plateau is caused by both the lower ozone concentration in the UTLS and the lack of air-mass due to huge and high terrain of TP. It's also revealed that the generation and upward propagation of gravity waves and Rossby waves have great impacts on stratospheric circulation, and that the major unusual signals in stratospheric circulation is a significant harbinger for the tropospheric severe weather and climate.



Formation of summertime ozone valley over the Tibetan Plateau

Integrated monitoring and early-warning techniques on catastrophic chains

The research team from the Institute of Remote Sensing Applications has developed quantitative retrieval methods on the key disaster-causing parameters in the catastrophic chains of "Heavy Rain – Flood - Landslide And Debris Flow" with the identification accuracy of strong convective clouds higher than 85%, the accuracy of precipitation estimation higher than 80%, the extraction accuracy of flood water area higher than 85% and the recognition accuracy of the landslide from the debris

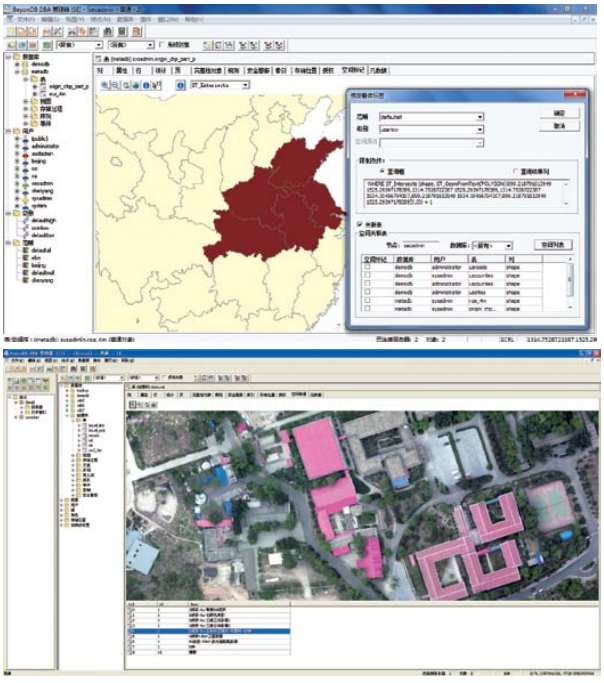


The Losses-driven and Active Monitoring Techniques

flow higher than 95%. The scientists have also developed the comprehensive assessment techniques on the catastrophic chains, which can quickly assess the losses of the urban residential area, arable land, roads and population caused by natural disasters of the catastrophic chains with an accuracy of over 70%.

High-security spatial database management system and its application

The Institute of Geographic Sciences and Natural Resources Research (IGSNRR) has developed a new spatial database management system, BeyonDB, which was highlighted for its cross-platform and high-security. BeyonDB not only have common functionalities of relational database, but also specialize in spatial data management. Now it has been fully integrated with MapGIS and partly integrated with ArcGIS and SuperMap as well. Those products have been applied in a national space data infrastructure application system.



BeyonDB establishes a kind of multi-granularity spatial access control technique based on layer-region-elements. The upper shows how to label security level for a feature BeyonDB supports integrated management of query of massive image data based on database and file system

Climate changes and their impacts during past dynasties

Research group led by Prof. Ge Quansheng from the Institute of Geographic Sciences and Natural Resources Research (IGSNRR) has completed a monograph on climate changes and their impacts by dynasty. The study indicates that the average temperature of Central East China during the 20th century is not the highest in the past 2000 years; the precipitation variability of the 20th century doesn't exceed the natural range over the last 1500 years; the climate developing trend of the 20th century is similar to that of the Sui-Tang Dynasties. They found that the boom periods are mostly associated with warm climate, while the bad periods patch with cold weather. Climate conditions, especially the extreme climate events, give notable impetus to social development, but it is greatly attached to other factors such as politics and culture.

Monitoring tower in Ürümqi Glacier No. 1

Cryosphere change in western China and its impacts

A research group of CAREERI has established the regional cryosphere monitoring network with the most comprehensive monitoring elements, finishing the second Glacier Inventory. The inventory found that most of the glaciers in Western China have a tendency towards extent decreasing and thickness reducing in the past 50 years. The work observed the background information such as temperature, thickness, ground ice reserve volume in permafrost regions in Tibetan Plateau, and defined the relationship between the characteristics of permafrost and the climate, elevation, landform, surface vegetation cover. Through systemic analysis on the observational data for Ürümqi Glacier No. 1, the work revealed the response mechanism of the continental glacier to climate change, and thus established the glacier dynamic models to demonstrate the glacier change and its impacts on hydrology and water resources.

Lake Eutrophication process monitoring and cyanobacteria bloom forecast technology research and system integration

It is a selected scheme to build a cyanobacteria bloom forecast system to avoid water quality crisis and ensure the safety of the drinking water from eutrophic lakes and its ecology. The Nanjing Institute of Geography and Limnology has put forward a series of sensitive indexes of the cyanobacteria bloom overwintering, recruiting, bloom formatting and its risk for an ecological disaster to design a comprehensive index monitoring system that well indicates the whole process of cyanobacteria development from occurrence to triggering off a disaster. On this basis, an on-line water quality monitoring platform is set up, which consists of 18 automatic monitoring stations covering the whole north area of Lake Taihu Moreover, the work has developed a 3-in-1 cyanobacteria bloom warning model and forecast system based on the remote sensing image monitoring, on-line ground monitoring and manual monitoring.

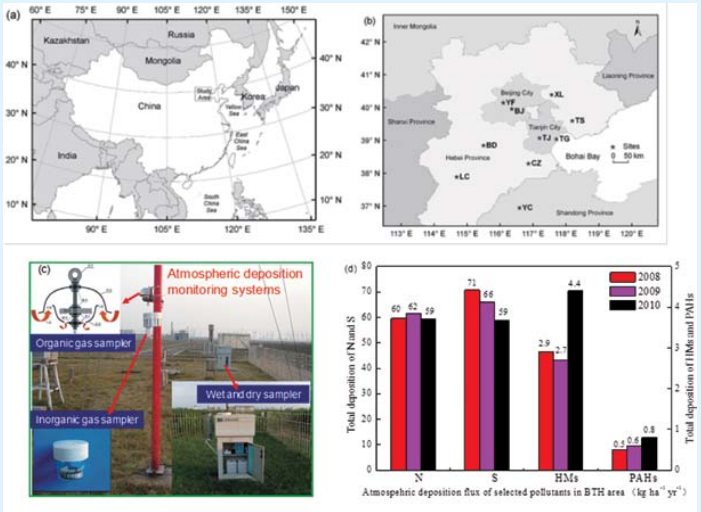
Ecological function of soil microbes involved in nitrogen cycle

Research group led by Prof. He Jizheng from the Research Center for Eco-Environmental Sciences (RCEES) carried out studies on ammonia oxidizing archaea (AOA) and ammonia oxidation bacteria (AOB). By using culture-independent molecular methods and stable isotope probing techniques, they demonstrated that nitrification in low nitrogen input soil and strongly acidic soil are mainly driven by archaea, not bacteria. These studies provided direct evidence that archaeal autotrophic activity is directly linked to ammonia oxidation and demonstrated the more important role of AOA than AOB in strongly acidic soil. Results were published in *PNAS, Nature Geoscience* etc.

Team Leader : Prof. He Jizheng, jzhe@rcees.ac.cn

Research on wet and dry depositions of atmospheric contaminants in BTH area (Beijing,Tianjin and Hebei)

There is an increasing concern of the regional and complex environmental pollution exhibited in Beijing-Tianjin-Tangshan area, especially for the atmospheric pollution in the BTH urban agglomeration. Research on the point-line-surface integrative and three-dimensional monitoring technology and equipment were carried out. Several technologies and equipment with independent intellectual property rights for online-monitoring of the atmospheric pollution were developed, such as the multi axis differential optical absorption spectroscopy (MAX-DOAS). Based on the ground-based radar observation, remote sensing data monitoring and ground measurements, a ten-site atmospheric wet and dry deposition fluxes monitoring network was established, which covered 250 thousands km^2 area in the BTH area and various ecological types. During the past 3 years, the spatial and temporal variations of wet and dry deposition chemistry of nutrients, PAHs, heavy metal and other air pollutants was simultaneously quantified, which is lack in China. The primary results suggested direction of controlling the regional atmospheric pollution in BTH area.



Observation net of wet and dry depositions of atmospheric contaminants in the BTH area

中國科學院
CHINESE ACADEMY OF SCIENCES

Inhibiting technique for dioxin emission from waste incineration

Research group led by Prof. Zheng Minghui from the Research Center for Eco-Environmental Sciences (RCEES) has made progress in dioxin emission reduction for municipal solid waste incineration. Calcium-based inhibitor was prepared and applied to the cooling stage of flue gas during waste incineration. Significant inhibiting efficiency for dioxin formation has been achieved due to the suppressing effect on both pathways of de novo synthesis and precursor formation of dioxins. The developed calcium-based inhibitor has been applied to the waste incinerator built in Taian, Shandong Province. By the joint application of multiple techniques comprising the calcium-based inhibitor, activated carbon adsorption and high efficient dust abatement, the dioxin emission reduced for about 80%. The concentration of dioxins in stack gas could meet the European Union emission limit of 0.1 ng TEQ/Nm^3.

Electrochemical water treatment technology by multielectrode-induction

Research group led by Prof. Qu Jiuhui from the Research Center for Eco-Environmental Sciences (RCEES), has invented electrochemical water treatment technology by using multielectrode-induction, which combines the multiple functions of oxidation, coagulation, flotation and reduction. The mechanisms of •OH generation and Al_{13} species formation during the electrochemical process were clarified. A series of electrode materials and electrochemical reactors have been fabricated and developed according to water quality and technical requirements, and have been turned into mass production. The electrochemical techniques can purify water with high efficiency and low cost, and has been successfully implemented in mobile and stationary treatment facilities for drinking water, municipal water and industrial wastewater.

Pilot experiments of the waste incineration plant

High-technology

Completion of TG-1 and SZ-8 rendezvous and docking mission

As the leading organization of the utility system of the Chinese Manned Engineering Program, CAS burdens in this mission to carry out scientific experiments and related research on the space platforms of TG-1 and SZ-8.

On TG-1, earth environment monitoring devices, space material science facilities and space environment monitors were arranged. A high spectral and spatial resolution hyper-spectral imager data is used for geological survey, resource exploration, land desertification assessment etc. And a colloidal crystal growth experiment was done, adopting a remote image data transmitting approach for the first time in China. In the recovery capsule of SZ-8, the Sino-German cooperation in space life sciences experiments were conducted with 17 experiments, including 10 Chinese, six German and one joint experiments. The academy was also committed to supporting the mission with 30 key tasks of illumination, optical imaging, and laser guidance.

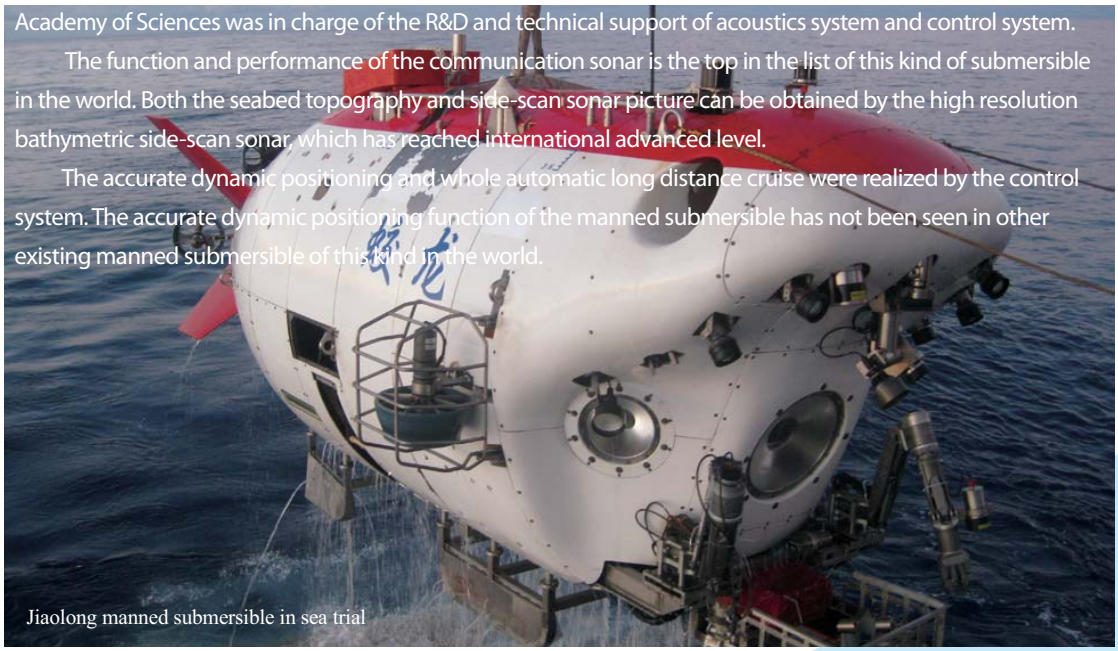
China's first manned submersible finishes 5,000 meters sea trial

China's first manned submersible Jiaolong successfully finished its 5,000 meters sea trial in July, 2011. Its maximum depth of 5,188 meters created another record for manned submersible in China.

Being one of the major developer of the Jiaolong 7000-Hmeter manned submersible, the Chinese Academy of Sciences was in charge of the R&D and technical support of acoustics system and control system.

The function and performance of the communication sonar is the top in the list of this kind of submersible in the world. Both the seabed topography and side-scan sonar picture can be obtained by the high resolution bathymetric side-scan sonar, which has reached international advanced level.

The accurate dynamic positioning and whole automatic long distance cruise were realized by the control system. The accurate dynamic positioning function of the manned submersible has not been seen in other existing manned submersible of this kind in the world.



Jiaolong manned submersible in sea trial

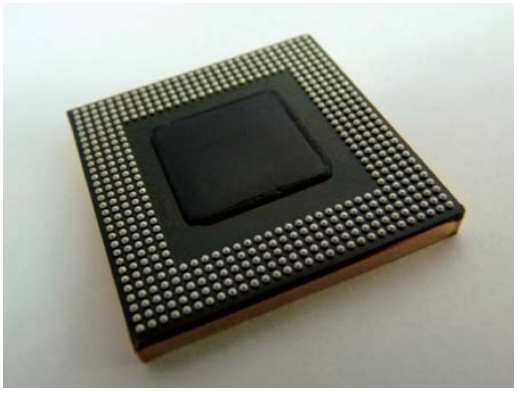
Chang'e-2 lunar exploration mission and extended tests completed

In June, 2011, Chang'e-2 completed its lunar exploration mission. On August 25th, it entered into Lagrangian2 point orbit to carry out the extended tests and outer space environment exploration. On September 15th, it sent back the first batch of scientific data from 1,720,000 km away successfully. In mid-November, full coverage of moon maps and images with seven-meter resolution were processed, which were validated by experts and were shown to reaching the highest international standard; the quality of data and image processing was controlled effectively; its resolution, image quality, data consistency and integrity, mosaic precision and other aspects were better than similar international full moon digital maps. CAS scientists played an important role in the mission and extended tests, scientific exploration data receiving and processing, VLBI navigation production of high resolution images and other landmark scientific achievements.

High-density three-dimensional system-level packaging technology made new breakthrough

Scientist in the Institute of Microelectronics developed a high-density packaging technology for the first homemade Loongson CPU products. The Loongson CPU package adopts a new Cavity-down WB-BGA platform with over 800 bonding wires which are 50% beyond the common sensed limit of only 60um pad pitch. The clock frequency of the CPU reaches 800MHz. The technology is effective to fill the domestic blank, and reaches advanced standards. Cooperated with a local company, the Loongson series CPU realized its million order of magnitude mass production.

Micrograph of multi-layer wire-bondings in the CPU package



First domestically packaged CPU

WIA-PA approved as IEC international standard for wireless network in process automation

The industrial wireless network technology standard – WIA-PA (Wireless network for Industrial

Automation – Process Automation) proposal, was approved as an international standard IEC 62601 by International Electrotechnical Commission (IEC) on October 14, 2011. It is another IEC international standard after WirelessHART.

WIA-PA is an open and interoperable wireless network standard designed to address the needs of industrial process measurement and control applications for reliable, real-time and secure wireless communication, which was developed by WIA working group led by the Shenyang Institute of Automation. As an IEC standard, WIA-PA provides users with larger scale and lower cost network framework, more interoperability, and greater product and service quality, which can reduce the risks in production and consumption process.

First 8 Mbit phase change random access memory (PCRAM) test chip

Scientists from the Shanghai Institute of Microsystem and Information Technology developed an 8 Mbit phase change random access memory (PCRAM) test chip. The bit yield of the chip cell is more than 99%, based on an audio demonstration has confirmed that the chips can realize all the storage functions including read, write and erase. Upon the chip, there established a state-of-the-art PCRAM platform on 40nm technology mode. Over 300 patents were applied and 80 of them authorized, covering the aspects of materials innovation, nano-processing and integration, chip design and testing method. The first Chinese PCRAM test chip indicates that China has entered advanced ranks in the nonvolatile memory research and development areas.

Virtual process Engineering (VPE) platform

VPE mainly consists of an experiment & measurement subsystem, a control & data acquisition subsystem, a high performance modeling subsystem, a software subsystem, and a visualization subsystem. Based on both the multi-scale high performance computer integrating GPUs with CPUs and the multi-scale high-speed and high-accuracy EMMS computational mode of first global calculation, then regional modeling, and finally detailed evolution, VPE is to realize so-called virtual reality for process engineering by simulating, measuring, and controlling complex industrial processes

Virtual Process Engineering (VPE) platform

with high-accuracy and in real time, on-line comparing and interchanging simulation and experimental data, and dynamic visualizing relevant results in three-dimensional manner, in order to provide both basic design guidelines for industrial process development and efficient measure for on-line operation optimization, accident prediction and analysis, and new staff training at much lower cost in time and money.

World's first High-Tc superconducting power substation put into operation in power grid

The world's first High-Tc superconducting power substation, developed by the Institute of Electrical Engineering, was put into operation officially in the power grid in Baiyin, Gansu. The substation with voltage

Indoor appearance

level of 10.5 kV integrates a 1 MJ/0.5 MVA high temperature superconducting (HTS) magnetic energy storage devices (SMES), a 3-phase 1.5 kA high-Tc superconducting fault current limiters (SFCL), a 630 kVA HTS transformer, and a 75m long/1.5 kA 3-phase AC HTS transmission cable. These new-type superconducting power devices can enhance the stability and reliability of the grid, improve the power quality, decrease the system losses and reduce the occupation area of substation. Till now, it is the only distribution-level High-Tc superconducting substation in the world. It integrates the latest and the most advanced research results of superconducting power technology of recent 10 years in China.

Demonstration project of 100t/d integrated drying and incineration of sewage sludge in circulating fluidized bed

With the technique of the Institute of Engineering Thermophysics, demonstration project of 100t/d sewage sludge integrated incineration in circulating fluidized bed in Hangzhou Qige Sewage Treatment Plant passed 72 hours' trial operation examination. It means a great leap forward of the Chinese sewage sludge incineration disposal technique. It is the first process system in the world that successfully integrates the drying and incineration of sewage sludge in one single device. Compared with the separated disposal technique

drying sewage sludge first and then incinerating it, the integrated technique has the advantages of simple system, compact structure, and low investment cost. In addition, the operation energy consumption decreases significantly, reducing the cost of sewage sludge disposal to a level that is suitable to widely utilize the technique in China. This technique provides a feasible solution to the sewage sludge disposal with reduction, stabilization and harmlessness in China.

0.5MW dye-sensitized solar cell pilot production line built

Collaborating with a local company, the Institute of Plasma Physics, has finished the commissioning and test running of its 0.5MW pilot production line of Dye-sensitized Solar Cell (DSC) in Tongling, Anhui. This pilot line can produce 300cm2-large DSC solar cells with efficiency about 6% at a finished-product rate more than 90%. This is China's first DSC pilot production line of independent innovation, indicating that China DSC R&D has entered a new stage.

Novel catalyst and its matching process technology for mixed alcohol synthesis via syngas

The Institute of Coal Chemistry developed a novel catalyst and its matching process technology for mixed alcohol synthesis via syngas. At the mild reaction conditions of 240-260℃, 4.0-6.0MPa and 2000-4000h-1, the pilot test has been stably run for more than 1200 hrs. The catalytic performance of the novel CuFe-based

catalyst used in this process displayed the leading level in China with CO conversion>80%, C2+selectivity>50% and space time yield of alcohol>0.23kg/kg.h. Cooperating with company partners, the R&D team excluded the traditionally rigorous reaction conditions with high temperature/pressure and noble metal, developed the mild technical route for highly value-added chemical alcohols and alternative alcohol fuel additive synthesis via syngas. Under the mild reactions of lower reaction pressure and temperature, the technology obtained the highly efficient low-carbon conversion of syngas with higher total alcohol yield and C2+ alcohol selectivity, exhibiting the industrial application potential to replace conventional methanol synthesis.

Demonstration of solar power electric vehicle charging station with flow battery energy storage device

A power supply system integrating 50kW solar power with 60kW/600kWh vanadium flow battery has been successfully used in the electric vehicle (EV) charging station at Youyi Street, Dalian. This system was jointly designed and developed by the Dalian Institute of Chemical Physics. Introducing green solar power into EV charging station will reduce the power dependency on the grid, and achieve diversification of energy sources. By using the vanadium flow battery energy storage system, the direct impact to the grid, resulting from electric vehicle charging with a strong current, can be avoided. The energy storage system can also serve as a backup station and achieve peak shaving. Such a system, featuring integrated solar power and flow battery device, will become a new mode for the future electric vehicle charging station.

60kW/600kWh vanadium flow battery energy storage system for solar power electric vehicle charging station in Dalian

View of solar power electric vehicle charging station in Dalian