PART Ⅱ
Project Review

2.1

Breakthrough in the Research on "Coronal Heating" through International Collaboration

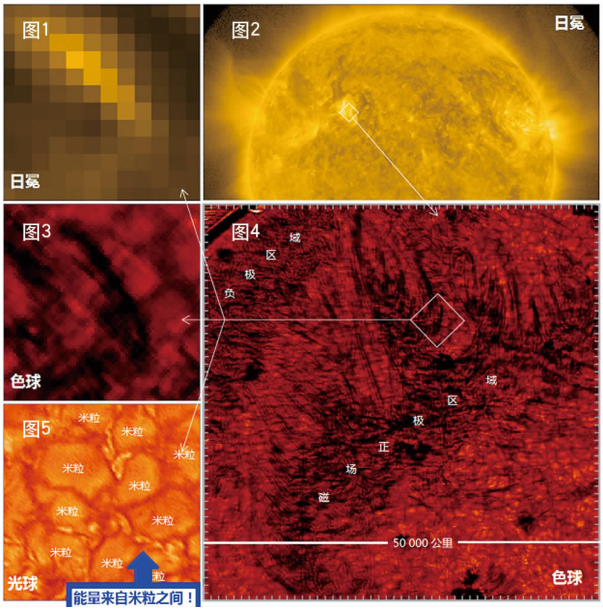
Since the Sun's radiation energy comes from ongoing nuclear reaction in its core region, it is expected that the temperature should ever drop down from its center to outside. However, the temperature in the solar outer atmosphere has an abnormal distribution, that is, the temperature slowly increases form 4,600 K above the photosphere to about 20,000 K at the chromosphere and then abruptly increases to million degrees in the corona. How to make up for the radiation energy in the corona to maintain high temperature is the so–called "corona heating" problem. Along with the problems of dark matter and dark energy, corona heating is listed as one of eight mysteries in astrophysics by *Science* magazine. Corona heating is also a primary targeted scientific aim of major international observing facilities, like Hinode (Japan, 2006) and SDO satellite (NASA, 2010).

Through collaboration with Associate Prof. Wenda Cao and Prof. Philips Goode from the Big Bear Solar Observatory (BBSO), Research Prof. Haisheng Ji from the Purple Mountain Observatory firstly carried out high resolution imaging observation at He I 1083 nm to an active region (boxed region in Figure (a)) on the Sun with the 1.6 meter aperture New Solar Telescope (NST), the largest solar optical telescope in the world, and a narrow–band 1083 nm filter made in China. He I 1083 nm has a high excitation level and is optically thin, thus high resolution imaging at this wavelength gives us a natural link between the photosphere and corona. Figure (b) gives a snapshot of their observations (a 1083 nm filtergram), in which ultrafine dark magnetic channels in absorption with the cross section of about 100 km were unexpectedly revealed. These relatively cool channels are indeed cousins of overlying hot coronal loops, which link positive and negative magnetic polarity regions. The background of the filtergram is the photosphere, which shines in due to the optically thin nature of He I 1083 nm.

Figure (d) gives an enlarged region of the 1083 nm filtergram. By comparing simultaneous observation of corona made by SDO (Figure (c)) and photosphere made by NST (Figure (e)), they show that injection absorption material is accompanied by corona heating and that the energy actually comes from an intergranular lane area. Since similar events are ubiquitous, the observation answers the question of where the energy heating the corona comes from. The physics is that convection in granules pushingmagnetic field toward the lane area and causingmagnetic energy release there. The energy release caused upward matter and energy injection.

The work was published *in Astrophysical Journal Letters*. NASA gave a news release on its web after an interviewing with Prof. Goode.

The work was supported by NSFC.



(a) Million degree corona as observed by SDO satellite. (b) Highest resolution images of chromosphere at He I 1083 nm. We can see numerious ultrafine channels in absorption. (c–d) A single heating event as observed in corona, chromosphere and photoshpere. We can see that the matter and energy come from an intergranular lane area.

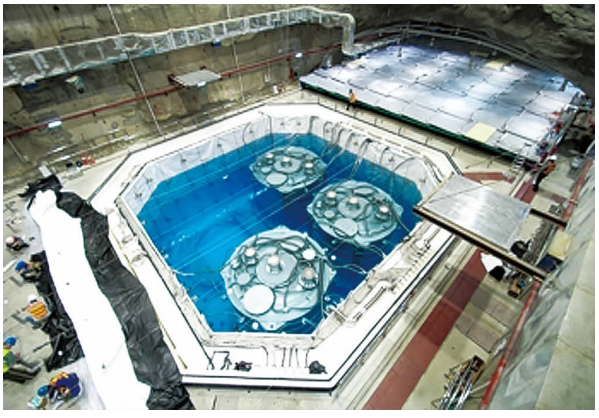
2.2

A New Type of Neutrino Oscillation Discovered at Daya Bay Experiment

On March 8, 2012, the international collaboration of the Daya Bay Reactor Neutrino Experiment announced that a new type of neutrino oscillation (corresponding to the neutrino mixing angle θ_{13}) is discovered using antineutrinos detected by six detectors running for 55 days. The oscillation amplitude was measured to be 9.2% with an uncertainty of 1.7%, corresponding to a non-oscillation probability of one out of ten-million. This result leads to a better understanding of the elemental properties of neutrinos and opens the door towards the study the "mystery of antimatter disappearance". Upon the release, the experimental result is received significant responses from the international high energy physics community, and is regarded as "a milestone in the neutrino physics". The paper, with a title of "Observation of Electron-Antineutrino Disappearance at Daya Bay", was published in *Physical Review Letters* on April 27, 2012.

Neutrinos are a kind of elemental particles constituting the material world. Classified into three types, neutrinos have no electric charge but with extremely small mass. Different types of neutrinos may convert into each other in flight, called "neutrino oscillation". The neutrino mixing angle θ_{13} is one of the six elemental parameters describing the neutrino oscillation and its value determines the future direction of the neutrino physics. It is also related to the "mystery of antimatter disappearance" in the Universe and is a hot topic of the neutrino physics in the international community. Since 2003, there had been seven countries who proposed eight experiments, but only three proposals finally were implemented. The Daya Bay team, led by Yifang Wang from the Institute of High Energy Physics, Chinese Academy of Sciences, proposed an experimental plan to measure the neutrino mixing angle θ_{13} using the reactors of Daya Bay Nuclear Power Plant. This proposal utilized a number of new methods to reduce systematic errors and improve the precision of θ_{13} measurement, such as multi-module detectors at each site to detect antineutrinos and multi-coincidence veto detectors to precisely determine the efficiency of cosmic muons. The designed precision of the experiment can improve the measurement precision by an order of magnitude over that of the previous experiments.

The Daya Bay international collaboration was started in 2005. The experiment was officially approved in 2006, and the tunnel construction started in 2007. Over the course of the experiment, the collaboration overcame a lot of technical difficulties, completed the detector prototyping, the engineering design and the construction. A number of achievements are actually the best in the world. Eight identical high precision detectors were constructed and their relative uncertainty reached a rare precision of 0.2%.

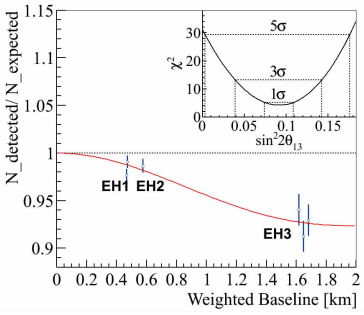


Top view of the far experimental hall: three antineutrino detectors are placed in the water pool as the Cherenkov detector; the resistive plate chambers are visible at the far end of the hall.

The Daya Bay Experiment used detectors at the two near sites to measure the reactor antineutrino flux to predict the number of antineutrinos in detectors at far site. After careful data analysis and effective background rejection, it was proved that 6% antineutrinos disappeared in the far site detectors. More accarate x^2 analysis found that the amplitude of the neutrino oscillation is:

$\sin^2 2\theta_{13}$= 0.092 ± 0.016 (stat.) ± 0.005 (syst.). The non–zero probability of $\sin^2 2\theta_{13}$ is determined with a statistical significance of 5.2 standard deviation.

The Daya Bay Reactor Neutrino Experiment is a starting point of China's neutrino physics program. Through nine–year persistent effort, the experimental neutrino physics study in China moved to the frontiers of the research field. This project is supported by various funding programs of the National Natural Science Foundation of China, including the National Science Fund for Distinguished Young Scholars, General Program, Key Program and Major Program.



Ratio of measured versus expected number of antineutrinos of six detectors at three experimental halls. The x axis is the travel distance of antineutrinos. The y axis is the ratio and it is 1 if no oscillation. The red line is the best fit curve of neutrino oscillation. The figure of $\chi 2$ versus $\sin^2 2\theta_{13}$ is shown in the right top inset.

2.3

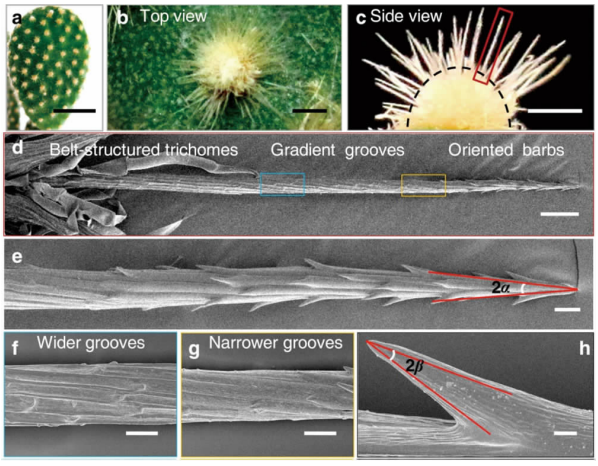
Breakthrough in the Research on the Efficient and Continuous Fog Collection System

After discovering the directional water collection ability of spider silk for the first time in the world (*Nature* 463: 640–643), researchers from the Institute of Chemistry, Chinese Academy of Sciences and Beijing University of Aeronautics and Astronautics have obtained new breakthrough in the continuous and efficient fog collection. Recently, inspired by the cactus in the most drought desert, they probed into the relationship of the structure–function of cactus (Opuntia microdasys) and found that the cactus had evolved a multi–structural and multi–functional integrated continuous fog collection system, which is superior to that found on the spider silk and can collect water more efficiently. This work has been published recently in *Nature Communications* in Article format (*Nat. Commun.* 3:1247 doi: 10.1038/ncomms2253 (2012)). The in situ image of fog collection in a cluster of cactus spines has been chosen to highlight as the "Featured Image" of the magazine in the current issue and aroused wide interest from global peers. Discovery of this continuous and efficient fog collection system supplies new ideas of designing and fabricating artificial freshwater collectors. It also paves an avenue to solve the global water crisis and is of great significance to the development of the global agriculture, industry, etc.

The traditional desalination and secondary recovery of waste water both require complex equipment and are of high cost. Fog collection, a method to translate the latent water (water drops with diameters ranging from 5 to 40 micrometers) into the dominant, available water, is simple and low cost and is expected to solve the water crisis. However, the existing fog collectors such as the Standard Fog Collectors with polypropylene, Raschel mesh and two dimensional fog collectors with planar nylon mesh rely heavily on the gravity to transport water drops collected, which hinders the rapid transfers of the water drop hence the continuity of the fog collection, but also rises the risk of water drop re–evaporation. Then, is there any method to transport the water drops collected directionally and rapidly to a specific place without aids from the gravity?

Professor Jiang and his team studied the drought–tolerant cactus Opuntia microdays originating from the Chihuahua desert systematically. They found that the cac-

tus had evolved unique structural features: the plump and succulent stems of it are covered evenly with clusters of spines and trichomes. A single conical spine can be divided into three parts with different subtle structures: the tip with oriented conical barbs; the middle with gradient grooves; the base with belt structured trichomes (Figure 1).



Morphology of the cactus (Opuntia microdasys) and the structures of a single spine of it.

The integration of the structures gives rise to the integration of the multiple functions. Specifically, when the fog flows to the spine, tiny water drops deposited on the tip of it are collected through frequent coalescence, and then are transported via the grooves with width gradient in the middle part, finally absorbed as soon as they contact with the trichomes at the base. Meanwhile, the new born fresh surface starts next cycle for water drop deposition –collection –transportation –absorption. The quick transport and depart of the water drops collected grantees the continuous fog collection. Compared with the discontinuous fog collectors found on spider silks, this continuous fog collection system can collect water more efficiently. The discovery of this unique fog collection system is the first time in the world. Further analysis of the mechanism underlying show that the gradient of Laplace pressure arising from the conical shape of the spines and barbs and the gradient of surface free energy arising from the gradient of the grooves along the spines cooperatively drive the water drops to move towards base of the spine with high speed (Figure 2). Additionally, the water drops are transported away when they are still in micro–size (far smaller than the capillary length of water ~2.73mm), so influence from the gravity can nearly be neglected.

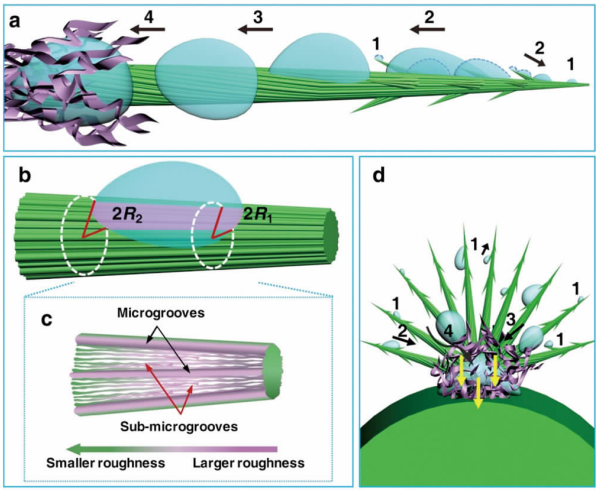


Illustration of the continuous fog collection and the mechanism underlying.

Investigation on the unique surviving ability of cactus, i. e. the relationship between structures and functions, provides new idea of designing and fabricating continuous and efficient fog collectors. It also offers a new approach to relieve the global water crisis and benefits to the development of the global agriculture, industry and so on.

This work has been supported by National Natural Science Foundation of China.

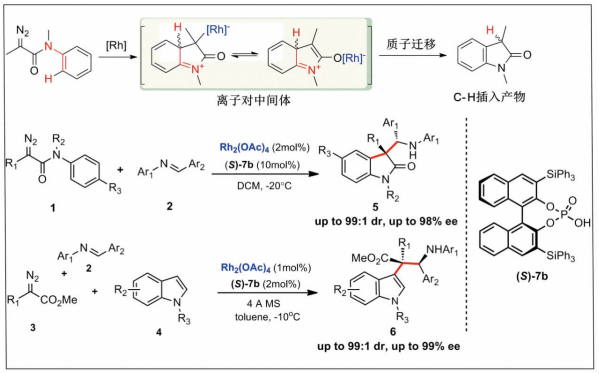
2.4

New Progress in the Research on Polyfunctional Chiral Molecules

Significant progress has recently been made in discovering novel multi–component reactions for rapid construction of polyfunctional chiral molecules. Professor Wenhao Hu and his team in the Shanghai Research Engineering Center of Molecular Therapeutic and New Drug Development, East China Normal University have published their research achievement entitled "Highly Enantioselective Trapping of Zwitterionic Intermediates by Imines" in *Nature Chemistry,* 2012, 4, 733–739, and this publication was immediately highlighted by *Synfacts* (2012, 8, 1231).

Supported by NSFC, Prof. Hu's research group has been focusing its researches on novel multi–component reactions and enantioselective catalysis. Based on its previous research experience in active oniumylide trapping process, they discovered another active zwitterionic intermediate that can be trapped by an electrophile. Zwitterionic intermediate generated from a rhodium carbenoid and an enamine has been proposed to proceed with a fast proton shift, producing a C–H insertion product (please see the scheme below). Hu's research group found that, under a combined catalytic system of dirhodium acetate and a Bronsted acid catalyst, this active intermediate can be trapped by an imine, affording polyfunctionalindole derivatives in good yield with excellent stereoselective control. Both intramolecularly and intermolecularly formed zwitterionic intermediates can be rapidly trapped to efficiently generate multi bonds in one step.

It is highly desirable to have structurally diversified new chemical entity (NCE) for biological screening in modern drug discovery. One of the bottle–neck in drug discovery is lack of highly efficient synthetic technology to build sufficient NCE in a timely fashion. The current



Highly enantioselective synthesis of indole derivatives via active zwitterionic intermediate trapping process

synthetic method reported by Hu and his co–workers provides an efficient entry to rapidly construct chiral polyfunctionalindole derivatives with highly stereoselective control. Since the indole motif is widely present in pharmaceuticalrelated compounds, this synthetic technology can be potentially applied in drug discovery. Preliminary studies have shown promising anti–cancer activity of the indole derivatives, and additional research is in progress in the laboratory.

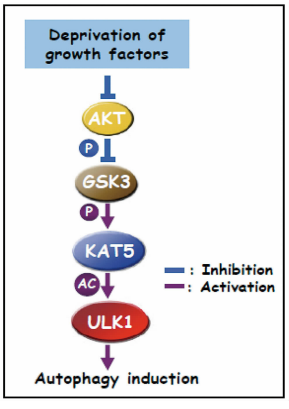
This research has been supported by National Natural Science Foundation of China, including the National Science Fund for Distinguished Young Scholars and Key Program respectively.

2.5

Breakthrough in Autophagy Research

A team of Xiamen University, led by Professor Lin Shengcai, has delineated a signaling pathway that mediates autophagy induced by deprivation of growth factors in metazoan cells. This represents a major breakthrough in the field of autophagy as it provides answers to how growth factor deprivation leads to the initiation of autophagy. Professor Lin´s team has received grant awards from the National Natural Science Foundation of China, and National Basic Research Program of the Ministry of Science and Technology. The work was published in *Science* on April 27, 2012.

Autophagy is a self–recycling catabolic process. Research on the mechanism of autophagy dates back to the 90s of the last century, and has mainly relied on the unicellular organism yeast as a model system. At present, we have learned a great deal of the key components of the core machinery involved in the autophagy processes. However, a stark contrast between unicellular eukaryotes and metazoans (multicellular organisms) is that cells in metazoans depend on extracellular stimuli for the uptake of nutrients to sustain energy homeostasis. Thus, during growth factor deprivation, cells have to undergo autophagy by recycling intracellular cytosolic components and even organelles to maintain energy supply. It is well established that growth factors bind to their cognate receptors, and activate the AKT kinase, which in turn phosphorylates and subsequently inhibits the downstream protein kinase GSK3. When growth factors are lacking, GSK3 becomes de–inhibited, able to phosphorylate substrates. Professor Lin and colleagues found that in the absence of growth factors the active GSK3 phosphorylates an acetyltransferase known as TIP60–K(lysine)–transferase 5 or KAT5, leading to activation of the acetyltransferase.



Simplified model depicting how growth factor deprivation leads to the activation of ULK1 and to the induction of autophagy

The activated TIP60 acetylates ULK1 (ATG1 in yeast) that is a critical kinase for initiation of autophagy, thereby linking growth factor deprivation to the machinery of autophagy. This pathway has thus revealed the signaling route for growth factor deprivation to cause autophagy in multicellular organisms. Importantly, this GSK3 –ULK1 autophagy pathway differs from the one taken by glucose starvation that depends on the activation of AMPK to activate ULK1.

Professor Lin and colleagues have been focusing on the research of signaling pathways related to cell growth/death, autophagy and metabolic control. Over the recent years, he has published articles in internationally top journals including *Science, Nature Cell Biology, Nature Chemical Biology, and Developmental Cell*. The discovery made on the mechanism of growth factor deprivation–induced autophagy was inspired from his earlier work showing that the activation of the tumor suppressor p53 by genotoxic agents requires an assembly of a complex containing TIP60 and the scaffold protein Axin (*Nature Cell Biology, 2009*). They observed that TIP60 displays multiple bands when separated on the PAGE gel. Through several molecular biology approaches coupled to mass spectrometry, they found that the multiple bands of TIP60 in fact represent differently phosphorylated forms, revealing that TIP60 can be phosphorylated at the amino acid residues of Ser86 and Ser90, singly or both. Soon after that did they realize that Ser86 is phosphorylated by GSK3, connecting GSK3 activation to the autophagy core machinery after induction by growth factor deprivation.

Autophagy has been implicated in the control of energy homeostasis, clearance of damaged organelles or aggregated proteins, and hence in the development of cancer and neurodegenerative diseases. In particular, cancer cells may utilize autophagy for survival by evading starvation. The delineation of signaling pathways and the key components involved therein is vital to our understanding on how relevant diseases may occur. That is to say, the important finding made by Professor Lin´s group may provide novel therapeutic targets for treating diseases such as cancer and neurodegenerative diseases.

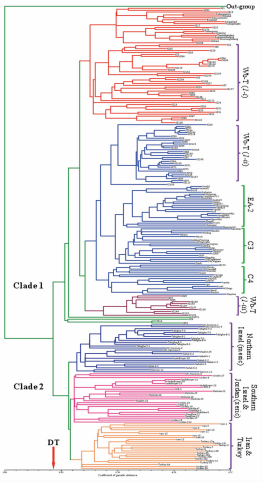
2.6

The Tibetan Plateau and its Vicinity–One of the Centers of Domestication of Cultivated Barley.

Professor Guoping Zhang and his group in Zhejiang University, cooperated with their colleagues from Israel, the United Kingdom and Australia, proved with convincing molecular evidences that the Tibetan Plateau and its vicinity is one of the centers of domestication of cultivated barley. The findings will end the long–term controversy about the existence of Tibetan wild barley, and demonstrate widely genetic diversity of the wild barley in the area, which may provide elite and special genetic resource for barley and other cereal crop improvement in abiotic stress tolerance. This work was published in *Proceedings of the National Academy of Sciences of the United States of America (PNAS)* in last October.

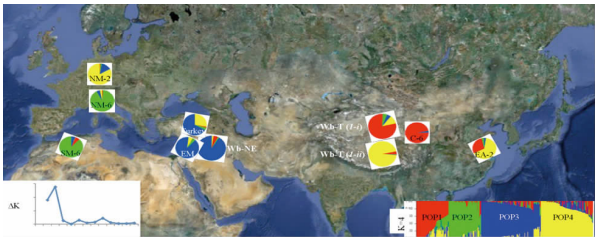
Barley (*Hordeum vulgare L.*) is the fourth most important cereal crop in the world, with diverse use and wide adaption. For a long time, the Near East Fertile Crescent has been recognized as a center of origin and domestication of barley. Although wild barley was discovered by a Swedish named Aberg in Daofu, Sichuan as early as 1930s, the contribution of the Chinese wild barley to cultivated barley has been not highly recognized. Since 1960s, some Chinese scientists have collected a large number of wild barley accessions from the Tibetan Plateau and its vicinity, and proved that the Tibetan wild barley differed from those from the Near East according to the results obtained by morphological and cytological studies. Moreover, the viewpoint that Tibet area could be a center of domestication of cultivated barley was once proposed, but it did not convince the international colleagues due to deficiency of strong evidences.

Professor Zhang and his group had a systemic analysis of wild barley, including 75 accessions from the Near East and 95 accessions from Tibet, and some representative cultivated barley from the different areas of the world, using whole genome–wide coverage of markers (1309 DArT markers). Cluster analysis revealed that Tibetan wild and some cultivated barleys (Clade 1) could be distinctly separated from the Near East wild barleys (Clade 2), indicating that the split between the wild barleys in the Near East and those in Tibet occurred around 2.76 million years ago, with bulbous barley acting as out–group. The results obtained from molecular genetics methodology fully proved the existence of the Tibetan wild barley. However, the relationship between wild barleys from the Near East and Tibet is still unclear.



Phylogenetic tree (Neighbor–joining) of 238 barley accessions. Clade 1:the Tibetan wild barley + cultivated barley, Clade 2: the Near East wild barley.

Meanwhile, they also employed some novel methodologies, such as STRUCTURE, to study the genetic relationship between cultivated barleys from East Asia and Mediterranean basin, and wild barleys from the Near East and Tibet. The results indicated that Qingke (a naked barley), which has been widely planted in the Tibetan Plateau and its vicinity, showed much closer genetic relationship with the Tibetan wild barley than both cultivated and wild barleys from the Near East. Thus, they deduced that Chinese six–rowed hulless barley (Qingke) may originate from the Tibetan wild barley.



The geographic distribution of wild and cultivated barley.

This work, supported by National Natural Science Foundation of China, greatly enhanced the academic position of Chinese barley science in the world, and will promote the exploration and utilization of the China–unique elite plant germplasm, as well as the development of barley genetics and breeding.

2.7

Important Progress in Modeling Study on the Climate Variability over the Last Millennium

Projection of rainfall change in the coming decades is a great challenge. It has profound effects on international and domestic agriculture, water resources, ecosystems, food security, drought and flood disasters, and sustainable economic development. Constrained by the short period of observed data and the coarse spatial resolution of proxy data, knowledge of precipitation variation on decadal –to –centennial time scale, as well as its causes and mechanisms remain quite limited. Climate modeling over the last millennium may provide an effective way for the issue. However, based on the millennium climate modeling results, previous researches mainly focused on global and regional temperature changes, precipitation changes were rarely reported.

Prof. Liu Jian and her colleagues from the School of Geography, Nanjing Normal University made a modeling study on global rainfall and East Asian monsoon precipitation changes over the last 1000 years. The variability of the global mean precipitation, global monsoon precipitation and the East Asian summer monsoon precipitation on decadal–to–centennial time scale, as well as its response to natural (Solar and Volcanic, SV) forcing and anthropogenic (Greenhouse Gases, GHG) forcing were investigated.

They found that global rainfall changes (amount and pattern) induced by SV forcing (Solar and Volcanic Heating) are different from the changes induced by GHG forcing (Greenhouse Gas Emission). The total of global precipitation increase for a given temperature increase due to SV forcing is 2.1% per °C, but only about 1.2% to 1.3% per °C due to GHG forcing. This difference is consistent with the global tropospheric energy budget, which requires a balance between the latent heat released in precipitation and radiative flux divergence. The radiative flux divergence is less for increased greenhouse gases. They also found that the spatial patterns of global precipitation and sea surface temperature (SST) induced by SV forcing is different from that induced by GHG forcing (Figure): Under SV forcing the ocean dynamical thermostat mechanism dominates. It means the solar heating at the surface warms SST in the west tropical Pacific more because in the east tropical Pacific the heating is countered by upwelling of cold waters from below, thus causing a stronger SST gradient. The increased SST gradient gives rise to an enhanced pressure gradient and hence stronger easterly winds and a stronger Walker circulation. Along with the stronger Walker circulation, moisture convergence is concentrated in the tropical monsoon and Indo –Pacific warm pool regions. The wet regions get wetter, augmenting global precipitation. While under GHG forcing the global rainfall increased less because the increase in atmospheric

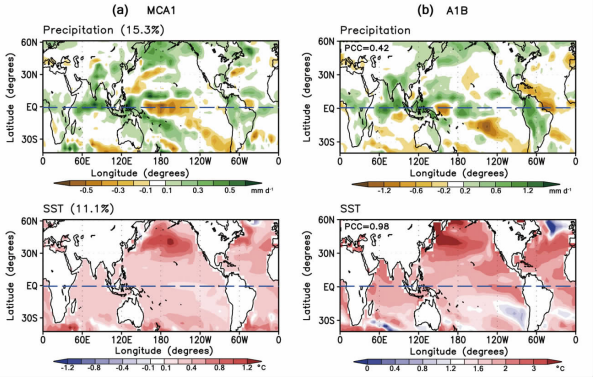


Figure Spatial patterns of global precipitation and SST simulated by ECHO–G model. a, The precipitation (mm d–1, upper left) and SST (o C, lower left) patterns of the leading maximum covariance analysis (MCA) mode in the forced millennium run for the period 1000–1850. It represents the SV mode, showing increased rainfall in the tropical monsoon and Indo –Pacific warm pool regions. The SST increased more in the western equatorial Pacific than that in the eastern equatorial Pacific, causing a stronger SST gradient. b, The precipitation (mm d–1, upper right) and SST (o C, lower right) patterns simulated in the A1B run forced only by GHG change for the period 2070–2099 relative to the period 1990–2019. It represents the GHG mode, showing that for the same global surface temperature increase it produces less rainfall than SV mode. The SST increased more in the eastern equatorial Pacific than that in the western equatorial Pacific, causing a weaker SST gradient.

static stability is noticeably greater, the increased atmospheric stability favors a weaker Walker circulation and the accompanying weaker SST gradient, causing much less moisture convergence in the tropical monsoon and Indo–Pacific warm pool regions. This is called atmospheric static stabilization mechanism.

The results showed that the global monsoon precipitation (GMP) sees more during warm period but less during cold period. The simulated GMP was strong during the Medieval Warm Period (1050–1250) but weak during the Little Ice Age (1450–1850). The prominent upward GMP trend occurred in the 20th century. Although the GMP was strong in both the Medieval Warm Period and the Present Warm Period, the spatial patterns are different apparently. The results also showed that the centennial–millennial response of the East Asian summer monsoon precipitation to external forcing depends on latitude. The extratropical (36–50° N, 105–125° E) precipitation responds to effective solar radiation most significantly than the subtropical (21–35° N, 105–125° E) precipitation. The tropical (6–20° N, 105–125° E) precipitation is insensitive to the effective solar radiation.

The above mentioned results have been published on *Nature, Journal of Climate, and Climate Dynamics*. It is of great significance to reconcile a series of academic dispute on climate change.

This research was supported by the General Program from the National Natural Science Foundation of China.

2.8

Important Progresses on the Mechanism of the Earth's Ring Current Decay

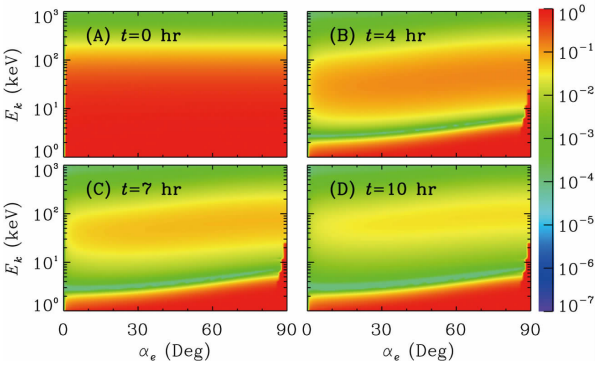
The Earth's ring current is a key factor to influence the near Earth's geomagnetic storms and space weather. During storms, strong convective electric fields accelerate and inject ions in the plasma sheet into the inner magnetosphere, hence the generation of ring current. Ring current decay is produced via charge exchange between ring current ions and neutral atoms and Coulomb collision processes. Recent researches have shown that ring current decay driven by wave–particle interaction perhaps plays an important role. However, since the region for wave–particle interaction tends to occur locally, whether the global effect on ring current decay is comparable with that of Coulomb collision processes or charge exchange still remains unknown.

By introducing relativistic distribution function for describing characteristics of energetic particles, Prof. Fuliang Xiao and his team in the Institute of Space Plasma, Changsha University of Science and Technology, have made some progresses on the mechanism of ring current decay. Firstly, they have analyzed instability of electromagnetic waves in the relativistic space plasma and found that the amplitude and frequency for wave growth are different from those in the non–relativistic space plasma, more consistent with observation.Secondly, they have developed a 3D ray tracing code for electromagnetic waves. Using a global density model they have simulated trajectories of electromagnetic waves and demonstrated that propagation of different wave modes is primarily determined by the spatial background distribution characteristics.Whistler –mode chorus wave is often present beyond the plasma pause (the trough region), meanwhile, electromagnetic ion cyclotron wave primarily occurs in the duskside plasma plume.Such ray tracing code is helpful for better understanding propagation and spatial distribution of electromagnetic waves and further understanding the global effect of wave–particle interaction on ring current decay. Thirdly, the team improved their hybrid finite difference method and extended it to a 3D diffusion model including the wave–particle interaction and radial diffusion. Fourthly, they have calculated pitch angle scattering of ring current particles by electromagnetic ion cyclotron waves and found that the precipitation time approached tens of minutes.The timescale and amplitude for the precipitation are comparable to the observation. Finally,

they have performed multi–satellite correlated data analysis and a 3D numerical simulation by incorporating numerous loss and acceleration processes. The modeling results have successfully reproduced the observed storm–time evolution of ring current and radiation belt particles. Such data analysis and numerical modeling provide a new observational support for wave–driven stochastic acceleration and pitch angle scattering of radiation belt and ring current particles.

Based on this research project, Prof. Fuliang Xiao and his team have published twenty one papers in leading journals such as *Journal of Geophysical Research*、*Geophysical Research Letters*、*Plasma Physics and Controlled Fusion*、*Journal of Atmospheric and Solar–Terrestrial Physics*. Those important progresses above-mentioned are helpful for further understanding the formulation, growth and decay of the Eeath's ring current during storms, and developing a dynamic model of ring current particles driven by wave–particle interaction, as well as providing the theoretical basis and simulation method for improving research and forecasting ability on space hazardous weather.

This project was supported by the National Natural Science Foundation of China.



Numerical simulation on time evolution of ring current induced by electromagnetic ion cyclotron waves. Clearly, the distribution function of ring current particles with energies 1–100keV drops rapidly within a few hours.

2.9

Microscopic Model of Hardness and Novel Metastable Phase Design

How to build the links between macroscopic mechanical properties and microscopic electronic structures remains one of the foremost challenges of computational materials science. Hardness is an important macroscopic mechanical property of a material. How to scientifically define and understand hardness of materials has been an important but difficult problem puzzling scientists for over a century. Hardness cannot be directly evaluated from quantum mechanics, and there is currently no quantitative theory that even relates it to anything that can be calculated from first–principles.

Granted by National Natural Science Foundation of China, focusing on chemical bond, Prof. Tian Yongjun of the Yanshan University and Prof. Wang Tianhui of the Nanjing University established a microscopic model of hardness together with a new scaling of population ionicity, which allows the quantitative prediction of hardness for polar covalent crystals. The results successfully solved the theoretical problem linking hardness to microscopic electronic structures. Based on the theoretical model, they innovatively designed a series of novel metastable phases, among which some have been successfully synthesized. The establishment of the model leads the exploration of novel superhard materials to a "quantitatively" designable stage from "qualitatively", and promotes the development of computational materials science.

Physical Review Focus of American Physical Society published a highlight story titled "Chipping away at Hardness", and more than 10 academic societies and websites such as American Materials Research Society published highlights or news, and indicated "Predicting the hardness of materials based on their atomic structure has often been like trying to scratch diamond with

chalk", "now, Chinese scientists present a theoretical expression. This realized the expecting desire in the field of materials for a long time, which links electronic properties to macroscopic property hardness", "and aid in the hunt for new superhard compounds", "Prof. Gerbrand Ceder of MIT said 'the authors unified several insights in a fairly elegant way. Every time you can make a connection between a microscopic property and calculatable things, it's a step forward'", and "Prof. Julien Haines of the Montpellier University of Science and Technology in France said 'it appears to be a powerful and useful technique'". More than 100 institutions in 23 countries and regions used the microscopic model in their following and developing studies, such as the group headed by the members of the US National Academy of Sciences Prof. Marvin L. Cohen and Prof. Steven G. Louie in University of California at Berkeley, and the groups from Oak Ridge National Laboratory, CNRS of France, the University of Heidelberg of Germany, Osaka University of Japan and others.

The microscopic model of hardness has become a practical tool in materials design, and was extended to the related research fields such as nanocrystalline materials, solid defects and thin films. The related achievements received national excellent Ph.D. Thesis at 2004 and 2007, and won the first class prize of Natural Science Award from the Ministry of Education in 2008 and the second class prize of the National Natural Science Award by the Ministry of Science and Technology of China in 2011. The achievements are leading the exploration of novel superhard materials to a "quantitatively" designable stage from "qualitatively".

The formed indentation when a pyramid–shaped diamond indenter is pressed into material surface in measuring the hardness of a material.

2.10

First Scientist from China Won 2011 Tribology Gold Medal

According to the unanimous voting of the Awards Committee of International Tribology Council, the 2011 Tribology Gold Medal, the world's highest award in tribology, was bestowed on Professor Qunji Xue, member of Chinese Academy of Engineering and director of the Academic Committee of the Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences. One Gold Medal is awarded to each year for outstanding and supreme achievement in the field of Tribology, first scientist from china ever received the world's highest honour in tribology since established in 1972. The Gold Medal and Parchment were presented at the Embassy in Beijing by Britain´s Ambassador to China, Lord Sebastian Wood, on February 27, 2012. Relevant department leaders from the Ministry of Science and Technology, Chinese Academy of Sciences, Chinese Academy of Engineering, National Natural Science Foundation of China and Tribology Institute of Chinese Mechanical Engineering Society, attended the award ceremony.

Under his leadership with the fund of the Science Fund for Creative Research Groups by National Natural Science foundation of China, Prof. Xue and his group, which include one member of the Chinese Academy of Sciences, three Winners of awards from the National Science Fund for Distinguished Young Scholars, and

two awardees from the 100 Talents Program of CAS, firstly proposed the model of TZP ceramic phase transformation during wear process, and pioneered the use of nanotechnology for preparing self–lubricating ceramic materials. Prof. Xue firstly applied organic LB film to solve the lubricating problems of space devices, and prepared nanoparticles functionalized by organic groups which he discovered and proved this kind of materials displaying a continuous lubricating effect from room temperature to high temperature, and the "molecular bearing model" was so presented. He firstly performed the research work on nano materials as lubricant additive, and developed series of nano–particles lubricant additives.

In the area of diamond–like carbon (DLC) based solid lubrication film with low friction and long service life, Prof. Xue's group solved the technological problems of highly residual stress and low film–to–substrate adhesion for DLC, successfully developed series of high performance DLC based solid lubrication films desirable for water environment as well as automotive engine environment, revealed the cause of low coefficient of friction for DLC based films, and established the failure model of DLC highly environmental sensitivity as well as the system theory of DLC lifetime extension. These relevant research works have gained much praise and recognitions by domestic and foreign peers. Prof. Xue was actively and passionately involved in the education of the next generation of tribologists, and awarded with the Outstanding Supervisor of Chinese Academy of Science for 4 times. Over 50 PhD students have successfully finished their research work under his supervision, many of whom are now quite active in key positions in universities or research institutes, or in prominent companies in China and the rest of the world. Prof Xue has made significant contributions which helped to raise the global standards of tribology on a wider global scale. Many outstanding research results were granted by the General Program, Key Program and the Science Fund for Creative Research Groups of National Natural Science Foundation of China.

Britain´s Ambassador to China, Lord Sebstian Wood, presents the medal to Prof. Xue Qunji.

2.11

New Theory Finds Its Role in Shaping Eco–system for Paddy Fields

Funded by the National Natural Science Foundation of China, Professor Peng Shizhang and his team obtained key breakthrough on the rice water–saving irrigation and its environmental effects. The research achievement has been widely applied in the national needs such as the saving water and increasing production operation in the four northeastern provinces of China.

The research revealed that the response mechanisms of rice on soil water regulation from differentangles such as the stomatal regulation and morphological adaptation of function leaves, the establishment of reasonable population structure, the optimization of canopy structure and the enhancement of light interception performance, adaptation and compensation effects of root morphology and function. Professor Peng put forward the theory of rice controlled irrigation, and defined the lower limits of soil moisture of root layer soil in different growth periods, and formed a practical mode of controlled irrigation technology. The team put forward the integrated mode of water–saving irrigation for different types of rice irrigation districts based on the combination of the above

original theory, efficient water and fertilizer management modes and advance agricultural technologies. The application of the controlled irrigation technology in China has achieved remarkable economic and social benefits.

The main innovations of the research are outlined as follow:

1. Improved model of rice water requirement was established, in which the influences of water regulation in paddy fields on the crop coefficient, soil moisture correction factor were considered. The model is in high accuracy and applicability for rice under water–saving irrigation.

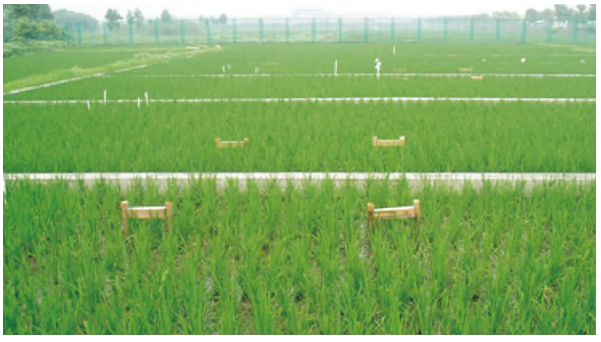
2. Physiological and growth responses of rice to soil moisture regulation and its mechanisms with different water and nitrogen managements were calcified. Water regulation threshold of controlled irrigation was put forward based on the above mechanisms. And the Water regulation threshold is more reasonable than that promoted relying solely on comparative test.

3. Physiological and growth model of rice under water–saving irrigation was created, which is more adaptable to the synthesized simulation of stomatal conductance–photosynthesis rate –transpiration rate and the simulation of root function–structure. The model reflects the compensation effect of water and nitrogen managements on rice growth and the responses of the rice root on rhizosphere moisture environment. The improvements bring some make–ups for the theoretical defects of the existing simulation model.

4. Effects of water–saving irrigation on nitrogen and phosphorus losses and greenhouse gas emissions from paddy fields were calcified in this research. The irrigation technology indicators and the coupling mode of water–saving irrigation and controlled drainage for paddy fields were proposed. And the mode can be an effective measure to control non –point pollution from paddy fields.

Accumulated application area of the innovation has reached to 75,000 ha. Grain yield has been increased by 40 million kilograms, 230 million cubic meters of irrigation water has been saved and accumulative benefit by improving yield and saving water has been increased by about 100 million RMB due to the spread of the technology. In addition, the global warming potential of methane and nitrous oxide emissions from paddy fields under controlled irrigation was reduced by 33% compared to traditional irrigation, and the non–point pollution caused by nitrogen and phosphorus losses from paddy fields was decreased by more than 65%.

Based on the results of this research, Professor Peng Shizhang and his team have published more than 80 academic papers. 40 scientific papers were retrieved by Science Citation Index and Engineering Index. Three monographs have been published about these achievements. Three first class prizes of the provincial and ministerial level of scientific and technological award received by the team due to their innovations. Professor Peng was honored with ICID Wat Save Technology Award 2012



Kunshan irrigation and drainage experiment station

2.12

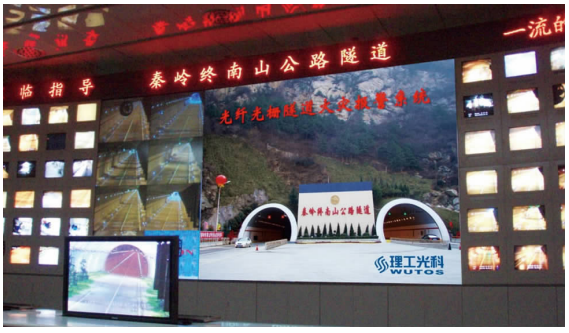
Fiber Bragg Grating As Sensor in Fire Alarm

The traditional temperature sensing fire alarm method based on electric induction principle cannot work in some harsh environments including flammable and explosive condition. Long-distance transmission, and strong electromagnetic interference, also there are special requirements in some applications such as public security and firefighting. Optical fiber sensing technology has attracted great attention due to its unique characteristic including non-electric transmission, intrinsically safe. Developed by foreign company, Raman-based optical fiber fire alarm system using time-division multiplexing technology has dominated the domestic market for more than two decades. However, due to its restraint between response speed and detecting precision, this technology is difficult to spread with large scales in domestic petrochemical industry. While in these particular industries, fire safety monitoring systems are legislatively enforced in China, the development of fire alarm systems with intrinsic safety is a must, and urgently required.

Supported by the Key Program, In the title of optical fiber sensitive materials and micro-processing technology, under the National Natural Science Foundation of China (NSFC), Prof. Desheng Jiang and his group in the National Engineering Laboratory for Fiber Optic Sensing Technology in Wuhan University of Technology has successfully developed the Fiber Bragg Grating (FBG) temperature sensing fire alarm systems based on wavelength-division multiplexing (WDM) technology. With fundamental innovation and key technology breakthrough, the limitation of large capacity multi-point Fiber Bragg Grating wavelength-division sensing technology has been overcome, and the multiplexed sensing probes have been increased from 20-30 to more than 400. Through the technological innovation of fiber micro-processing, core components for wavelength demodulation with rotary filters have been invented and developed. High speed detection and demodulation of fire alarm system has been developed with the proposed Fiber Bragg Grating multi-channel parallel and synchronous analysis techniques. Fire alarm monitoring problems in long-distance and large-scale engineering such as tunnels and underground facilities have been successfully solved by the proposed FBG-based infrastructure with multi-region WDM technology instead of multi-point. The 20 km repeat-less fire alarm system for tunnel application has been realized for the first time worldwide. These works are the integrated innovations in many disciplines including mechanics, materials, engineering and information science. Many concrete engineering problems have been resolved by adopting the leading and advanced technologies, meanwhile the related interdisciplinary integration and development is pushed and promoted. Prof. Desheng Jiang and his group also have integrated these technological innovations into a new generation fire alarm system with key technical parameters better than that of other products. It has greatly enhanced the fire alarm technology level in field of public security and firefighting, and solved many fire alarm technical problems long-existing in numerous particular industries such as petrifaction, reserve oil depots, tunnels, electric power and so on.

The technologies developed by Prof. Desheng Jiang and his group have been granted intellectual property rights, and demonstrated their advantages against fiber products from other company in the international bidding of fire alarm monitoring system for some key projects in China. The related technology and system have been rewarded for the second class prize of the National Technological Invention Award. The products have been successfully used in the vast majority of national petrochemical oil depots, more than 3000 km highway tunnels (groups), cross-river tunnels and under-sea tunnels. The systems have also successfully warned of major fire precautions of oil depots and tunnels in a timely manner, which have avoided enormous disasters of life and property. These fiber optic fire alarm systems have been greatly appreciated and recognized by industrial colleagues and firefighting units.

Fiber Bragg Grating temperature sensing fire alarm system in one of the oil reserve bases



The Fiber Bragg Grating temperature sensing fire alarm system in the Zhongnanshan tunnel

2.13

New Progresses in the Design of Control Systems with Actuator Saturations and Delays

Any practical control system is inevitably subject to actuation saturation constraints. Control signals computed theoretically cannot be applied on the plant accurately in the presence of actuator saturations, which can lead to performance degradation and even instability of the closed–loop system. Hence the controller designing by taking the actuator saturations into consideration has extremely important significance in engineering and is very challenging in theory.

With the funding support of the National Natural Science Foundation of China (Grant No. 60904007), the principle investigator, Dr. Bin Zhou, and his collaborators systematically developed a new parametric Lyapunov approach to deal with a series of control problems for systems subject to actuator saturation nonlinearity in a unified framework based upon an in–depth study on previous works of others. The main achievements and innovations include:

1. A parametric Lyapunov approach is proposed for the robust low gain controller design for polynomially unstable linear systems subject to actuator saturations.

2. A parametric Lyapunov approach is proposed for the design of global and semi–global stabilizing controllers for control systems subject to both actuator saturations and time–delays.

3. A parametric Lyapunov approach is established for the design of global stabilizing and restricted tracking nonlinear controllers for polynomially unstable systems and double integrators with actuator saturations and time–delays.

4. A parametric Lyapunov approach is developed for the design of feedback controllers to spacecraft rendezvous control systems subject to actuator saturations and time–delays.

With the support of the funding, as the first author, Dr. Zhou has published 30 SCI papers.

By now the achievements have been recognized by the international academic community. In particular, the parametric Lyapunov equation based low gain design and the nonlinear global stabilizing control laws for polynomially unstable systems subject to actuator saturations have been cited as basic technical lemmas and approaches by some other investigators (see, for example, [Yuan and Qu, *EJC, 2011, 17(2): 172–179*], [Wang and Saberi et al, *IJRNC, DOI: 10.1002/rnc.1767*], [Wang and Saberi et al, *Automatica*, 48:2633 –2639], and [Shakev et al, *JIRS*, 65(1–4): 389–408]). The Dr. Zhou'

s thesis "Parametric Lyapunov Approach to the Design of Control Systems with Saturation Nonlinearity and Its Applications" has received the "National Excellent Doctoral Dissertation Award" in 2012 from the Academic Degrees Committee of the State Council and the Ministry of Education of China. For his excellent work, Dr. Zhou was selected as the "New Century Excellent Talents in University" from the Ministry of Education in 2011.

Based upon the achievement of this funding, Dr Bin Zhou and his collaborators have further established a truncated predictor approach to the control and constraint control of time–delay systems, which has been funded by another project from the National Natural Science Foundation of China (Grant No. 61273028) in 2012. Up to now, some related results have been published on *Automatica* as a regular paper.

2.14

Breakthrough *Achieved* in the Research on Digital PET

As with the better known ultrasonography (US), computed tomography (CT) and magnetic resonance imaging (MRI), positron emission tomography (PET) is a critical medical imaging technology that has enormous clinical and research applications. It is well accepted that PET has become one of important early detections of many serious diseases such as cancer and brain disorders.

A major limitation of the PET technology has been its inadequate spatial resolution. In the early days, the technology is also limited to imaging only human beings and large animals. There are continual efforts to improving the spatial resolution and other performance properties of the PET imaging technology. In 2006, Siemens launched its Inveon ® micro PET system that boasts a 1.56 mm spatial resolution and a 7.20% sensitivity. It arguably represents the state of the art PET imaging technology available commercially. Human PET systems at matched resolutions and sensitivity are however not available because of the high cost.

It takes the traditional PET with analog–digital hybrid electronics about 30 years to reach the current performance level. To push further, we believe that the PET electronics needs to be re–invented in order to significantly lower the cost and improve the robustness and stability of the resulting, increasingly complicated systems. Supported by the NSFC project "Research and development of application–adaptive small animal PET scanners" and MOST project "Research on the key components of the state of the art PET/MRI dual modality medication imaging equipment", Prof Qingguo Xie from the Biomedical Engineering Department of Huazhong University of Science and Technology, has advanced the concept of all–digital and transformable PET system and developed the first such system for scientific research, called Trans–PET ®. Trans–PET ® has a spatial resolution as high as 0.87 mm. Its sensitivity ranges from 5% to 26%, adjustable for different applications.

The traditional PET system uses custom–made electronics, fixed geometric structure and closed system architecture, which cause bottlenecks to many practically important system–level issues, such as accurate calibration, and ultimately lead to considerable degradations in the imaging performance. With the advent of digital technologies, it is natural to convert PET electronics to fully digital to leverage inexpensive, powerful, and open–architecture digital electronics that are nowadays widely available. However, the scintillation signal in PET is an ultra–fast pulse signal, consisting of a leading edge with a 1 ns rising time and an exponential tail with a 40~50 ns decay time constant. Digitizing such a signal using the conventional ADC would require a sampling rate of 4 GSps or higher, which is currently infeasible at an acceptable cost. Until the beginning of the 21st century, after years of exploration PET scientists could only digitize the scintillation pulse signal at tens of MSps after slowing the pulse down with certain techniques. Directly digitization of the PET signal at the front–end of the data acquisition system, without any other pre–processing, is a tremendous scientific challenge.

To circumvent this critical challenge, Prof. Xie et al. first

proposed a method named Multi–Voltage Thresholds (MVT) Sampling in 2003 that laid the ground work for accurately digitizing of fast scintillation pulse signals. When the idea was published on the *IEEE Transactions on Nuclear Science* – the most prestigious journal for the field of nuclear imaging, one of the reviewers commented that it is "an extremely novel concept for electronics for processing PET singles events" and would have great potentials in PET related engineering applications. Supported by NSFC projects of "Research on μPET DAQ system and image reconstruction method with multiple constraints" and "Characterization modeling of PET scintillation pulses", Prof. Xie´s group keeps pushing forward their research on MVT and has accomplished a series of breakthroughs in the theories, methods and techniques for digitalization of PET scintillation pulses and processing of the resulting digital samples. In 2009, they successfully developed all–digital PET detector module. In 2011, they obtained the first image from the Trans PET ®. To date, the group has published a number of high–quality papers in top journals of nuclear science and instrumentation (*IEEE TNS, vol.59, no.3, pp.498–506, 2012; JINST, 7 T04001, 2012; IEEE TNS, vol.56, no.5, pp. 2607–2613, 2009; IEEE TNS, vol.56, no.5, pp.2678–2688, 2009; NIM–A, vol.602, no.2, pp.618–621, 2009; IEEE TNS, vol.52, no. 4, pp.988–995, 2005*). In addition, more than 30 patents are filed, issued and granted in China, US, German, Japan and other countries.

Meanwhile, Prof. Xie´s team has been collaborating with many domestic and oversea research institutes on PET–related fields including electronics, image reconstruction, system design, biomedical research and pharmacy development. They are gradually forming into an " international consortium for innovations" on digital PET.

For instance, an important collaboration is on fulfilling the MVT in integrated circuitry (IC). This work will further decrease the system complexity, and will result in better performance–to–cost ratio. Furthermore, the size of the detector module can be greatly reduced, giving more structural flexibility to the system design. From 2010, Prof. Zhen Ji´s team from Shenzhen University has been developing the PET scintillation pulse digital processing IC based on the MVT method using the CMOS technology. The chip designed by them has been taped out in September of 2012.

The digital PET developed by Prof. Xie´s team has eliminated the bottleneck caused by analog electronics. The resulting digital data acquisition circuit for ultrahigh–speed pulses is characterized by high reliability, high stability and high flexibility. It is capable of auto–correcting the system calibration parameters. The digital PET employs the standard all–purpose digital electronic components that can be frequently and conveniently upgraded. If the single IC based MVT solution is adopted, the system will be even more convenient to integrate and minimize, while the hundreds of thousands detection channels of a PET system can have uniform performance properties. The modular architecture of digital PET will endow great application adaptability to the system structure.

Supported by the NSFC, Prof. Xie´s team has covered the distance between proposing the digital PET concept to realizing the technology with an actual, working system. They have gone through the whole research procedure, beginning from key hardware, firmware and software components development, to system design, integration, validation and testing, and finally obtaining successful demonstration and practically relevant evaluations with animal imaging experiments. The team has built up unique expertise and technology repository for the transition of traditional PET to a digital era.

The digital Trans–PET ® and the NaF imaging of a mice.

2.15

Innovation and Progress in Methodology and Practical Applications in Supply Chain

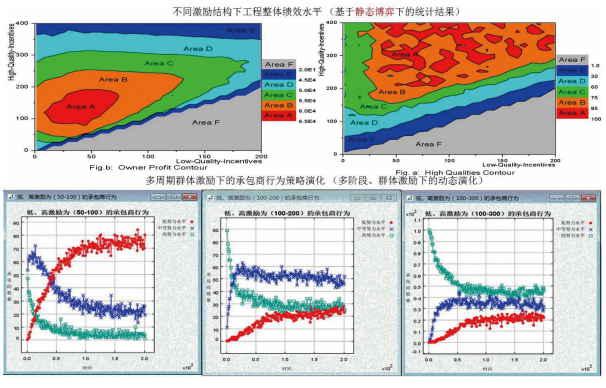
Under the support of NSFC Key Program project, Professor Sheng Zhaohan in the School of Management and Engineering at Nanjing University broke through traditional methods such as structured mathematical model in the research of supply chain, and has made great progress in the supply chain management theory, experimental platform building, engineering applications and so on, introducing a concept that the supply chain is composed of multiple autonomous agents, and constitutes a complex adaptive system, integrating Quantitative and Qualitative methods with Computational Experiments.

The team used computer technology to simulate a variety of scenarios of supply chain system, proposed a new methodology which is the combination of quantitative method and qualitative method and computational experiments. This innovative methodology is significant in analyzing complex phenomena in the supply chain and revealing the evolution of the supply chain. By means of this methodology, the team found that the dominate enterprises would exploit other firms to protect themselves when product price gets decreased. This prevalent phenomenon in the supply chain enterprises reflects certain rules and quantitative characteristics, and canbe treated as a new index to observe the enterprises' capability. Moreover, the team found that software companies's trategies by means of technical schemes to protect their software from being pirated are dissatisfactory, which indicates that firms should not pursuit excessive governance when protecting intellectual property.

The team developed an optional, renewable and extendible computational experiment software system named Supply Chain Computing Experimental Platform, which can be used to research on typical problems of supply chain management. This platform can offer software and program to supply chain researchers to study on some typical problems (Multi–party negotiations in supply chain, coordination with contracts, risk management and Bullwhip effect and reduction strategies and so on). The system can be renewed and extended and can greatly help the researchers use computational experiment study on the supply chain.

Combining computational experiments techniques in supply chain management with field management practices of major projects in China, Prof. Sheng and his team have been working on the issues of field management, such as the selection of business outsourcing mode in strategic resources supply chain of large projects, the evaluation of strategic resources suppliers and integrated management. A series of important management recommendations were adopted by "Project Management Implementation Rules" in first time.

In the theoretical research, the team has published some academic monographs, such as "Theory and Application of Computational Experiments in Social Science", "Computational Experiment Platform for Supply Chain Management", "Research of Construction Supply Chain based on Computational Experiment". In addition, 33 papers were published in international journals, 25 of them are SCI and 19 SSCI papers. These academic achievements well reflect the National Natural Science Fund's aims that NSFC project should closely combine national strategic needs with academic frontier research.



The computational experimental analysis of the effects of different motivational strategies that project owner used to motivate suppliers.

2.16

New Progress in the Research on Emergency Medical Rescue Management

A group woking on evidence–based decision–making research, led by Professor Lulu Zhang, the director of Institute of Military Health Management at the Second Military Medical University, has been focusing its research direction of health resources allocation and evidence–based health policy –making for more than 10 years. This group studies on the complex mechanism of emergency medical rescue system on the basis of large numbers of on–site investigation and empirical research in the event of Wenchuan earthquake emergency medical rescue in 2008. In the sponsor of National Natural Science Foundation of China and collaboration with Emergency Office of the Ministry of Health, West China Hospital of Sichuan University, et., they obtained distribution characteristics of earthquake casualties, multilateral coordination mechanism, local management system, allocation efficiency of supportive medical forces, as well as complex system structure and evolution discipline of the integration of "evacuation", "treating" and "prevention". They systematically compare the results with that from international disaster rescue practice and put forward policy advice which can improve the overall performance of the catastrophic emergency medical rescue system.

The thesis "Emergency medical rescue efforts after a major earthquake: lessons from the 2008 Wenchuan earthquake" based on the research findings was published on the top medical journal *The lancet* (*the lancet*, Vol.379, No.9818, P853–861, 3/March/2012, referring to http://www.thelancet.com/journals/lancet/article/PIIS0140–6736 (11)61876–X/fulltext). The editorial written by the editor has mentioned that "While China is learning from other countries in health–care delivery and research, it has much to share for reciprocal benefit. Lulu Zhang and colleagues share China's emergency medical rescue experiences from the earthquake."

This article is not only an achievement of medical emergency management empirical research which was independently completed by Chinese scholars and published in the internationally renowned medical journal, but also another breakthrough of the academic team led by Prof. Lulu Zhang in the process of internationalization after her election of chairwoman of Technology Commission on Medico–military Administration and Logistics (first in Asia) in International Committee of Military Medicine (ICMM).

2.17

New Progress in the Researech on the Molecular Mechanism of Cardiomyocyte Apoptosis

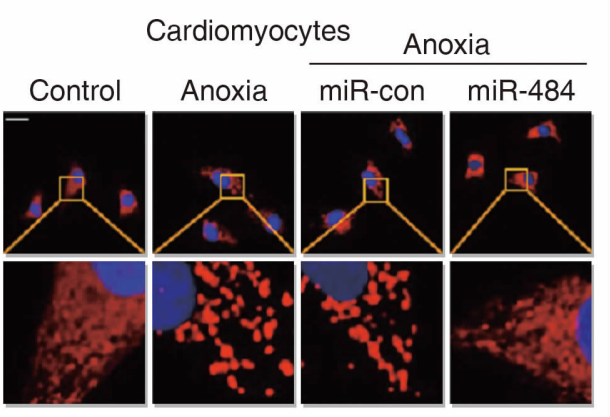
Cardiovascular disease is a leading cause of mortality worldwide. Cardiomyocyte apoptosis plays an important role in the development and progression of heart disease. To search for key regulators in controlling apoptosis and to clarify its molecular mechanism have great significance in preventing and treating of cardiovascular disease and in discovering new drug targets. With continuous support of Key Program, General Program and other programs from National Natural Science Foundation of China (NSFC), the research team led by Research Professor Li Peifeng from the Institute of Zoology, Chinese Academy of Sciences made great achievements in the field, holds an important space in the international arena. The main achievements areas followings:

1. Systematically investigated the molecular mecha-

nism of miR–23a in regulating cardiac hypertrophy. They produced miR–23a transgenic mice, and found that these mice exhibited exaggerated cardiac hypertrophy in response to the stimulation with phenylephrine or pressure overload by transverse aortic banding. They also found that knockdown of endogenous mir–23a with its specific antagomir could reduce cardiac hypertrophy in response to hypertrophic stimuli. Their study first reveals that miR–23a can mediate the hypertrophic signal through regulating Foxo3a. The results they obtained provide theoretical basis to develop miR–23a into drug or target in treating heart disease.

2. They have made important progress and breakthroughs in the field of miRNAs regulating of mitochondrial dynamics and cardiomyocyte apoptosis. They first discovered that cardiac specific miR–499 could inhibit mitochondrial fission, apoptosis of cardiomyocytes in vitro and myocardial ischemia injury in vivo. The team revealed that both the calcineurin catalytic subunits are direct targets of miR–499 and that miR–499 inhibits cardiomyocyte apoptosis through its suppression of calcineurin–mediated dephosphorylation of dynamin–related protein–1 (Drp1), thereby decreasing Drp1 accumulation in mitochondria and Drp1–mediated activation of the mitochondrial fission program. They also found that miR–484 could inhibit mitochondrial fission, apoptosis and myocardial ischemic injury and identified that miR–484 protects cardiomyocyte against apoptosis through targeting fis1 and regulating mitochondrial fission. miRNA is a class of small non–coding RNA. Study of miRNA on cardiac function raised widespread interest in recent years. To develop miRNA into target of preventing and treating heart disease has a promising prospect.

The findings provide a new approach to clarifying mechanism of cardiomyocyte apopsosis, pathogenesis of myocardial infarction and the prevention and diagnosis of myocardial infarction. In particular, the findings have guiding significance in developing miRNAs into drugs of treating apoptosis–related heart disease. The research group published their research findings in international mainstream journals including *Nature Medicine, Nature Communication JBC*, et al. and obtained widely recognition from domestic and international counterparts. *Nature China*、*Nature Reviews Drug Discovery* spoke very highly of some of their research findings.



Anoxia led cardiomyocytes to undergo mitochondrial fission. Overexpression of miR–484 could inhibit anoxia induced mitochondrial fission.

2.18

Breakthrough in the Clinical Immunology during Hepatitis B Virus Infection

It has been demonstrated that the interactions between HBV infection and host immunity determines the development and outcome of HBV–associated diseases. However, there are several key questions need to be answered. Firstly, the mechanisms underlying the immune system to eliminate the viruses remain to be poorly understood. Secondly, how does HBV escape from the immune surveillance, thus leading to viral persistence. Thirdly, it is urgently needed to develop novel and effective immune therapeutic strategies for patients undergoing antiviral therapy. The resolution of the questions will undoubtedly change the clinical practice in the future.

Targeting these questions, Professor Wang Fusheng

and his team in Beijing 302 Hospital performed a comprehensive research in a large cohort of HBV–infected patients. They have demonstrated the pathogeneic mechanisms of immune–induced liver damage. Most importantly, based on some preclinical studies, they preferentially used cytokine–induced killer (CIK) cells for HBV–infected patients in clinic. Through their long–term investigation and clinical study, they have published more than 30 papers in international journal, including some top journals in the field of liver diseases such as *Gastroenterology, Hepatology, and Journal of Hepatolgoy.* The total impact factors of these SCI papers are more than 150. Furthermore, two national patents were granted, two first class prizes of the Military Medical Research Award and the China Medical Science and Technology Award were received in 2010 respectively as well as one second class prize of the National Science and Technology Progress Award was received in 2011.

The main innovations of the research are as follows:

1. They demonstrated for the first time that the dynamic expression of PD–1 is closely associated with the outcome of acute and chronic HBV infection. Following HBV infection, PD–1 expression is generally upregulated on expanded HBV–specific CD8 T cells in the acute phase of clinical onset. This early transitory upregulation of PD–1 may efficiently attenuate overaggressive liver damage through restraining excessive immune responses of T cells. In this phase, the PD–1 expression is closely correlated with ALT level (Figure 1A). If PD–1 upregulation in effector T cells was delayed for two weeks, antiviral CD8 T–cell responses were not properly restrained and considerable liver damage will be occurred in acute phase (Figure 1B). By contrast, If PD–1 is persistently highly expressed, the effector CD8 T cells will be exhausted, thus correlating with chronic hepatitis B (Figure 1C).

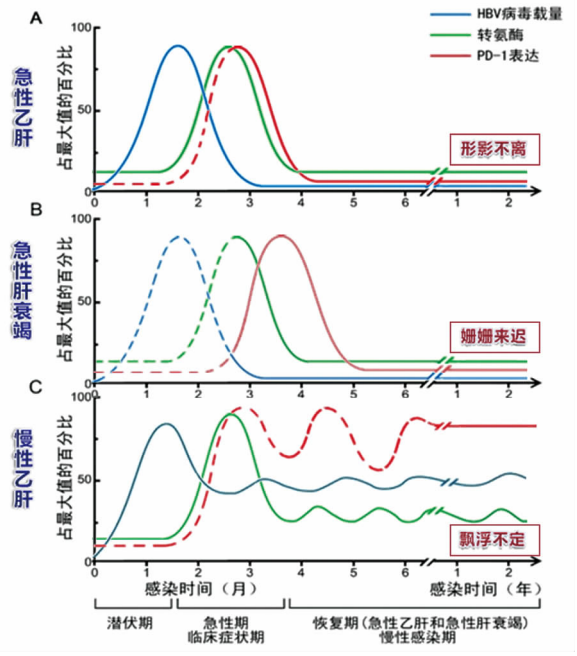


Figure 1 Dynamic of PD–1 may predict the outcome of acute HBV infection

2. They found that chronic hepatitis B (CHB) is usually characterized by persistent viral replication and fluctuation of liver function. The research demonstrated that the dysfunction of DC subsets, high levels of PD–1/PD–L1 expression and the increased Treg cells are responsible for the impairment of HBV–specific CD8 T cells and HBV persistence. They also found that non–specific inflammatory infiltration into the liver was responsible for hepatic damage in these patients.

3. They identified, for the first time, the reference values on lymphocyte and DC subsets in a large cohort of HBV–infected patients. In addition, the restoration of DC function can predict the antiviral efficacy in patients who underwent IFN–α treatment. Indeed, immune parameters have been identified to serve as the indicators of disease progression of CHB, however, it is still lack of a large database on the immunological parameters. As such, through 10 year's investigation, Prof. Wang and his team have characterized the reference values on lymphocyte and DC subsets in patients with acute hepatitis, chronic hepatitis B and liver failure, and further analyzed the clinical significance of these data. These findings will provide some important insight into prediction of the disease progression for chronic hepatitis B patients; in particular, they found that the recovery of peripheral pDC numbers and functions may accurately predict the antiviral efficacy in CHB patients with IFN–alpha treatment.

4. They first put forward the "climbing slope hypothesis" on antiviral treatment in CHB patients. The im-

munomodulatory therapy has become a helpful perfection for antiviral treatment regimen (Figure 2). Based on these findings, they put forward a novel "climbing slope hypothesis". To obtain the status like healthy individuals, the CHB patients absolutely need to overcome the aforementioned obstacles. In general, when the patients who set down in a "wheelchair" undergo antiviral therapy with nucleotide analogs (Figure 2A), a majority of patients may completely suppress viral replication and likely establish an "initial slope" upwards for top, who are called the partial responders. Some of them will exhibit HBeAg seroconversion, thus prolonging the upward "climbing slope" again, but there is still a big gap between the ascending slope and the peak (Figure 2B). At this stage, the antiviral therapy appears not enough to help patients arrive at the top because they in general are in lack of full recovery of the host's antiviral immune responses against HBV. Here, the combination of antiviral treatment with immunomodulatory therapy may efficiently clear the cccDNA, virions and HBV-infected cells, and finally lead to HBsAg seroconversion (Figure 2C). The hypothesis will help hepatologists to systemically evaluate antiviral efficacy and design more reasonable treatment protocols though the hypothesis remains to be further validated in the future clinical investigation.

5. They first developed the cytokine-induced killer (CIK) cell therapy in CHB patients, and found that CIK may significantly boost antiviral immune responses of the host. Since 1999, they have identified the optimal clinical protocol for CHB patients, and acquired approval in the treatment of HCC and CHB. In the approval of informed consent, they have finished CIK treatment for 125 patients with CHB. This research project was funded by the National Science Fund for Distinguished Young Scholars and the Key Program from National Natural Science Foundation of China.

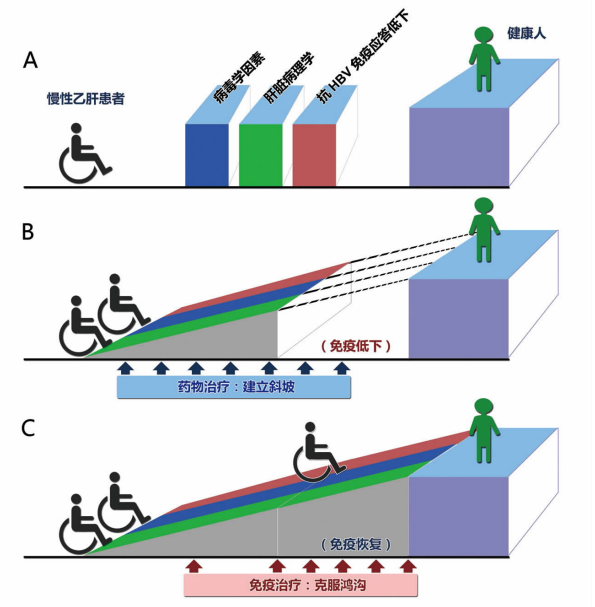


Figure 2 Antiviral therapy for CHB patients: the Climbing Slope Hypothesis

2.19

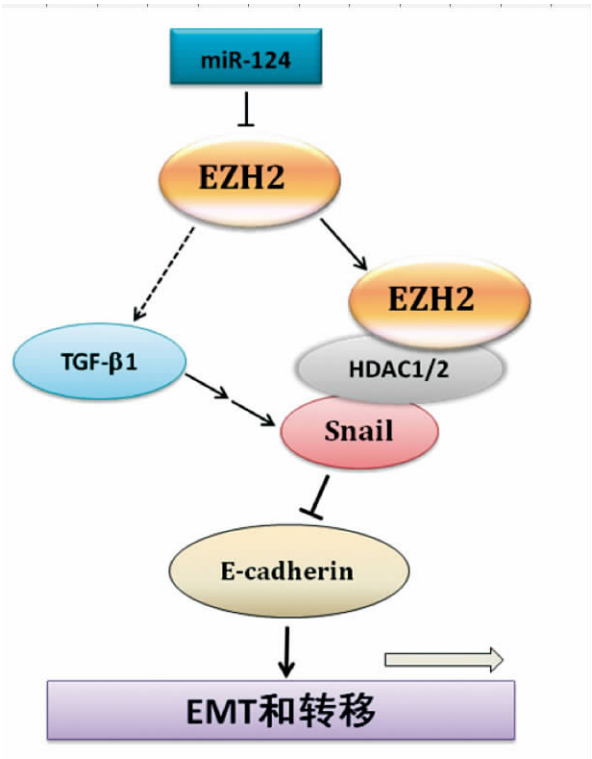
Systemic Study of the Oncogenic Role of EZH2 and Underlying Mechanisms in the Metastasis of Human Cancers

It is known that metastasis is one of the leading causes of cancer-related death. The development and progression of human malignancies is a complicated process that involves multiple molecular abnormalities, including the activation of a series of oncogenes and/or inactivation of numerous tumor suppressor genes. Enhancer of zeste homolog 2 (EZH2), the catalytic subunit of polycomb repressive complex 2 (PRC2), has been identified as the sole histone methyltransferase that methylates histone H3 lysine 27 (H3K27) and mediates transcriptional silencing. Previous studies has identified that the gene EZH2 is an important oncogene to promote cancer cell growth and/or proliferation. However, 5 years ago, the potential functions and underling mechanisms of EZH2 in the metastatic process of human cancers was not clear, and moreover, whether or not EZH2 could be served as a molecular marker in the diagnosis and/or treatment of human cancers remained obscure.

During the past 5 years, withseveral projects supported by the National Nature Science Foundation of China, Professor Xie Dan and his team in the State Key Laboratory of Oncology in South China, Sun Yat-Sen University Cancer Center, has been focusing their studies on the critical scientific issue, cancer metastasis. His team systemically investigated the oncogenic role of EZH2 and precise mechanisms in the metastatic process of human cancers. They first found that EZH2 is not only a promising immunomarker for the early detection of hepatocellular carcinoma (HCC) in liver needle biopsies, but also can serve as a novel biomarker for the prediction of HCCs distant metastasis and/or poor prognosis (*Gut, 2011*). In addition, over expression of H3K27me3, a molecule, H3K27 trimethylated by EZH2, could predict HCCs vascular invasion (*Mol Med, 2011*). Furthermore, in several types of other human cancer, such as esophageal squamous cell carcinoma (ESCC), pancreatic and breast cancers, Professor Xie's team evaluated that (1) the levels of EZH2 predicts tumor response to chemoradiotherapy and prognosis for ESCC patients (*Int J Cancer, 2010*), (2)knock down of EZH2 by specific siRNA can dramatically inhibit pancreatic cancer cells metastasis to the liver of mouse (*Cancer Lett, 2010*), and (3)EZH2 is a key downstream target of the MAPK pathway, contributing to the anti-proliferative effects of curcumin against breast cancer (*Eur J Pharmacol, 2010*).

In study of the function and molecular mechanisms of EZH2 in human cancers, the team demonstrated that EZH2 plays a crucial role in the metastasis of HCC both in vitro and in vivo. With the result, they clarified that a specific microRMA, miR-124, can target and down-regulate EZH2 expression in HCC, and thus inhibits epithelial-mesenchymal transfer (EMT) activities and ultimately suppresses HCC cell invasiveness and metastasis, suggesting that miR-124 can be employed as an effective therapeutic target for HCC(*Gut, 2012*). In ovarian cancer, they further found that the 2 genes,TGF-β1 and E-cadherin, are important downstream targets of EZH2, by which EZH2 regulates cancer cell EMT and invasiveness (*Carcinogenesis, 2010*). Furthermore, Professor Xie's team provided evidence, for the first time, that in cancer cells, EZH2 interacted with HDAC1/HDAC2/Snail to form a repressive complex; these components interact in a linear fashion, in which HDAC1 or HDAC2 bridge the interaction between EZH2 and Snail; and the EZH2/HDAC1/2/Snail complex could closely bind to the E-cadherin promoter by Snail to repress E-cadherin and thus promoting cancer EMT and metastasis (*Oncogene, 2012*).

In the above systemic studies, Professor Xie's team clarified the oncogenic role and underlying mechanisms of the important oncogene EZH2 in the progression and/or metastatic process of human cancers. The results provide a basis for the concept that up-regulated expression of EZH2 inhuman cancers may be important in the acquisition of an aggressive/poor prognostic phenotype. Furthermore, their studies a highlight an important role of EZH2 in the regulation of invasion and metastasis in the molecular etiology of human cancers, and implicate the potential application of EZH2 as an ideal molecular target in cancer therapy.



A proposed molecular mechanism in which EZH2 promotes cancer metastasis