Ultra-fast Energy Transfer from Monomer to Dimer within a Trimeric Molecule

Using artificial system to model the photosynthetic process has been attracting intense research interests. Natural photosynthetic apparatus use very limited kinds of pigments to harvest the solar energy. To harvest more solar energy in a broader spectral region under the limited condition, nature adopts the strategy of pigment aggregation, for the aggregated pigments having a varied absorption spectrum depending on the aggregated pigment number, hence of the extended spectral region. The peripheral light-harvesting complex LH2 in the photosynthetic bacteria is a good example of illustrating such a strategy. Within the LH2 protein frame, there are two concentric bacterio chlorophyll (BChl) rings, one composed of monomeric BChl molecules absorbing at 800 nm, another of dimeric BChl molecules absorbing at 850 nm. Solar energy is transferred from the monomeric ring to the dimeric ring, i.e., from the monomer to the dimer.

Dr. Li Xiyou's group in the Department of Chemistry, Shandong University, has designed a trimeric perylenetetracarboxylic diimide (PDI) molecule, with three PDI molecules covalently connected by a melamine. By molecular simulation, it was found that two of the three PDI molecules can assume a face-to-face conformation capable of forming a dimeric structure, while the third one appended acts as a monomer, which partially resembles the structural block in the LH2 complex. The existence of dimeric and monomeric structures within the trimer was further supported by the absorption spectroscopic and NMR evidences, while fluorescence measured revealed a possibility of energy transfer from the monomer to the dimer.

Dr. Weng Yuxiang's group in Beijing National Laboratory of Condensed Matter Physics, Institute of Physics of CAS investigated the energy transfer from the monomer to the dimer within the trimeric perylenetetracarboxylic diimide (PDI) molecule by using the femto-second time-resolved transient absorption spectroscopy, in cooperation with the former group. Based on the fact that the UV-visible absorption spectra for the monomer and dimer are overlapped, they proposed a monomer/dimer co-exciation model. By using the single value decomposition method, they resolved the individual absorption spectra of the transient species, and the decay dynamics were obtained by global fitting. Finally, they obtained a monomer to dimer energy transfer time constant of 0.8 ps, very close to a similar process within the LH2 complex (0.8-0,9ps). This work was published in J. Am. Chem. Soc. 2009, 131(1) pp 30-31.

This work was supported by NSFC, Ministry of Education and CAS.

New Progress in Heterogeneous Catalysis Research

A significant progress in the research on nano-scale catalysis morphological effect conducted by Prof. Shen Wenjie and his collaborators from Dalian Institute of Chemical Physics, Chinese Academy of Sciences was published in the April 9th issue of *Nature* (2009, 458, 746-749). By manipulating the size and morphology of metal oxide nano-particles, the group successfully cracked the tough problem of low-temperature catalytic oxidation of carbon monoxide by taking advantages of non-noble metals, marking a significant progress in basic research on nano-scale catalysis, reduction of vehicle exhaust emission and air pollution. The research work was also given a thorough account by the April 13th issue of C&E News, sponsored by the American Chemistry Society.

Catalytic oxidation is currently the most effective method for removing CO, one of the main pollutants in vehicle exhaust emission and the utilization of fossil fuels. Traditional catalysts, Hopcalite (a mixture of Mn and Cu oxides) for instance, can get rid of CO in low-temperature condition, but they are not active in normal temperature and quickly become inactive with the existence of a trace of water vapor. Noble metals can be used for catalytically oxidizing CO under the circumstance of small amount of water vapor, but on the condition that the temperature is above 100 degree Celsius. Gold nano-particles carried by transition metal oxides are found in recent research to display excellent catalytic activity and stability both in low-temperature condition and with the existence of small amount of water vapor. However, it has always been a challenging task in heterogeneous catalysis research to build a system of non-noble metal catalysts that can be utilized in the high-efficiency oxidization of CO under the condition of low temperature with the existence of water vapor.

By taking advantages of the morphology effects of nano-scale catalytic materials, Shen's group succeeded in sufficiently exposing the highly active crystal face of metal oxides, so as to effectively exhibit their excellent property for oxidizing CO. Through precise control of the preparation conditions, structurally regular Co_3O_4 nanorods are successfully obtained, with the activity (110) crystal plane accounting for more than 40% of the surface. Since there are more Co_{3+} active sites for the oxidization of CO, the complete transformation of CO can be achieved with the existence of water vapor even when the temperature is as low as minus 77 degrees Celsius. The reaction rate is more than 10 times that of nano-scale cobaltosic oxide particles. Under the condition of near cold start of the automobile engine (with a large quantity of water vapor and carbon dioxide), the Co_3O_4 nanorods show outstanding activeness and stability in oxidizing CO. In this way, the CO of the vehicle exhaust emission and hydrocarbon compounds can be oxidized into H_2O and CO_2 by using Co_3O_4 nanorods that display no structural changes. The preparation methods in which the highly active crystal planes are exposed by precise morphological control can also be applied to other metal oxides. In the meantime, the research result sheds light on the basic research on nano-scale catalysis and the development of next generation of high-efficiency metal oxide catalysts.

Prof. Shen's research was supported by the NSFC General Project in 2004 (Grant No.: 20473087) and 2007 (Grant No.: 20773119) respectively.

Key Progress in Research on Terrestrial Carbon Cycle in China

The academic article "The carbon balance of terrestrial ecosystems in China" coauthored by Prof. Piao Shilong and Prof. Fang Jingyun from the College of Urban and Environmental Sciences of Peking University was published in April 23rd issue of *Nature*, giving an account of the latest progress in the research on the terrestrial carbon sink in China.

The reason that the dynamic change of global and regional carbon cycle and carbon budget has become one of the hot topics in climate change research lies in the fact that it not only bears much on the salient fluctuation of CO_2 density in the air so as to impact the stability of the global climate, but also is closely related to the Kyoto Protocol (an international convention setting caps on the use of fossil fuels in different countries). As one of the largest industrial sources of CO_2 release, China is now the cynosure of all eyes in that the question whether the terrestrial ecosystem in China plays a "carbon sink" or a "carbon source" role is regarded as a major environmental issue by Chinese scientists and the international community as well.

Based on existing land use and resource inventory data, observational data of the CO_2 density in the air, remote sensing data and meteorological data, the research team of the College of Urban and Environmental Sciences of Peking University conducted a comprehensive study on the spatial-temporal pattern and related mechanism of the terrestrial carbon sink/source by taking advantages of such advanced technologies as remote sensing and GIS, together with the research models such as the atmospheric inversion model and the process-based model of carbon cycle in the ecosystem. It is estimated in the research that China's terrestrial ecosystem maintained a net carbon sink in the range of 0.19-0.26 Pg carbon (PgC) per year in the 1980s and 1990s, accounting for approximately 28-37% of the total industrial release of CO_2 during the period in question, much larger than that of the European countries (7-12%) and comparable to that of the US (20-40%). The carbon sink in China's terrestrial ecosystem is mainly attributed to the regional climate change, tree planting, CO_2 fertilization and shrub recovery in particular. Besides, such agricultural management practices as "returning more crop stalks into the farmland" also contributed a great deal to the accumulation of carbon sink in China's farmland ecosystem.

The research adopted, for the first time, both the top-down atmospheric inversion model and the bottom-up process-based research model for the analysis of ground data, presenting a systematical account of the scale and mechanism of carbon sink in China's terrestrial ecosystem, which sheds light on further understanding the role assumed by the terrestrial ecosystem in the global carbon cycle and proves that the volume of CO_2 absorbed by the terrestrial ecosystem partly offsets the industrial release of CO_2 in China, providing reference for policy making of CO_2 release and offering China more edge in the negotiation under the United Nations Framework Convention on Climate Change.

The same issue of *Nature* carried a comment by Dr. Gurney, a renowned specialist on carbon cycle research, on the significance of the research. The editor of *Nature* stated, "The publication of a comprehensive assessment of China's terrestrial carbon budget fills a major gap in the geographical spread of carbon balance data". "This is an impressive paper." expressed by Dr. Marland, a climate researcher, in the column This week's news of *Nature*.

The research work has been continuously funded by the National Natural Science Fund.

A New Progress in Research on the Mechanism of Bio-Invasion

Reallocation of nitrogen (N) to the photosynthetic apparatus is likely to play a crucial role in any growth increase; however, no study has been conducted to explore potential evolutionary changes in N allocation to photosynthesis versus defenses in alien invasive plant species. In a common garden experiment with *Ageratina adenophora*, a globally noxious invasive weed throughout the subtropics, researchers from Xishuangbanna Tropical Botanical Garden (XTBG) of Chinese Academy of Sciences, the University of Montana, the National Autonomous University of Mexico, and the University of Delhi compared the differences in N allocation to the photosynthetic apparatus versus cell walls between plants from invasive (China and India) and native (Mexico) populations, and discussed the ecological and physiological causes and consequences of the differences found. This research was jointly supported by the General Program and Key Program of the National Natural Science Fund, Major Project of the Chinese Academy of Sciences and Applied Basic Program of Yunnan Province. The research results were published in *Proceedings of the National Academy of Sciences* of the United States of America (*PNAS*) on February 10, 2009.

Prof. Yu-Long Feng of XTBG and his colleagues found in their cooperative research that area-based leaf N contents were not significantly different between plants from invasive and native populations of *A. adenophora*. However, the proportions of leaf N allocated to the cell walls were reduced and higher proportions of leaf N were allocated to the photosynthetic apparatus in plants from invasive populations. There were tradeoffs for N allocation to photosynthesis versus cell walls, which were mediated by leaf mass per area. With increasing leaf mass per area, the proportion of leaf N in photosynthesis decreased while proportion of leaf N in cell walls increased. Plants from invasive populations had lower defense ability against natural enemies, as indicated by lower leaf mass per area, N contents in cell walls and leaf density but larger leaf size, which may be the results of evolutionary responses to the lack of natural enemies especially specialists in introduced ranges. The higher proportions of leaf N in photosynthesis for plants from invasive populations contributed

directly to higher photosynthetic rates and N-use efficiencies, and therefore to higher growth rates, facilitating successful invasions.

In the paper, “resource” is specified as N rather than “biomass” as generally referred to in previous studies, and where “resource” is allocated are also explicitly designated, i.e. the photosynthetic apparatus (growth), and cell walls and N-based defense chemicals (defenses). It also helps to understand the different effects of specialist and generalist enemies on evolution of introduced plant species. Furthermore, the paper elucidates for the first time how the reallocation of “resource” from defenses to growth contributes to invasiveness of alien plant species, i.e. via increasing resource-capture ability and -use efficiency. This research provides the first potential mechanism behind the commonly observed and genetically based increase in plant growth and vigor when they are introduced to new ranges, taking the investigation of mechanistic causes for invasiveness to a new level.

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New findings in anti-viral infection and control of inflammation

Based on previous studies on phosphotase SHP-1-mediated promotion of interferon and pro-inflammatory cytokine production in immune cells such as dendritic cells and subsequent elimination of invading virus and other pathogens published in *Nature Immunology* in May, 2008, Academician Cao Xuetao’s group from the National Key Laboratory of Medical Immunology and Institute of Immunology in Shanghai had another new story in *Nature Immunology* recently. After almost 10 years’ investigation on the molecular mechanism underlying the initiation and regulation of anti-viral immunity and control of inflammation, the group independently identified a new E3 Ub ligase, Nrdp1, which can preferentially induce the production of type I interferon but inhibit the production of pro-inflammatory cytokines in macrophages and dendritic cells once stimulated by pathogen components or infected by virus, leading to the elimination of invading pathogens and attenuation of the inflammatory responses. This is the fourth time for Prof. Cao and his group to present their research findings in Nature Immunology in the past 4 years.

Supported by NSFC (projects No. 30572122, 30721091, 30771118), Prof. Cao and his group have cloned new molecules from human dendritic cell cDNA library since 1998. They firstly cloned a new molecule that can make the tumor cells resistant to death induction once the new gene was transfected into the tumor cells, so the new molecule was designated as death-resistant protein (DRP). The mouse homolog of this human molecule reported by foreign scientists 3 years later proved and identified the regulation of tumor cells apoptosis and carcinogenesis, which was named as Nrdp1 etc.

The finding indicates that Nrdp1 may prevent viral infection by promoting interferon production, which has provided new insight into the molecular mechanisms for the immune recognition and regulation, and also will contribute to the possible drug design to selectively activate Nrdp1 to induce antiviral immunity and control the pathogenesis of inflammatory diseases.

Major Headway in Avian Origin Research

Editor's Note: The issue of avian digital homologies in avian origin research has long been puzzling paleontologists, and it is also one of the most controversial issues in evolutionary biology research. An international research team led by Prof. Xu Xing, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences and winner of the National Science Fund for Distinguished Young Scholars, proposed a new hypothesis for this study published in *Nature* on June 18. Meanwhile, National Science Foundation of the United States also announced this result in the front page of its official website and accepted relevant interviews. Dr. H. Richard Lane, program director in the Division of Earth Sciences of NSFC commented on this research on dinosaurs saying that it provides a whole new perspective on the evolution of bird manual digits. It is expected that this research will remove contradictions in avian digital homologies between paleontological and modern developmental data.

Scientists have discovered a unique beaked, plant-eating dinosaur in China. The finding, they say, demonstrates that theropod, or bird-footed, dinosaurs were more ecologically diverse in the Jurassic period than previously thought, and offers important evidence about how the three-fingered hand of birds evolved from the hand of dinosaurs. The discovery is reported in a paper published in this week's edition of the journal *Nature*.

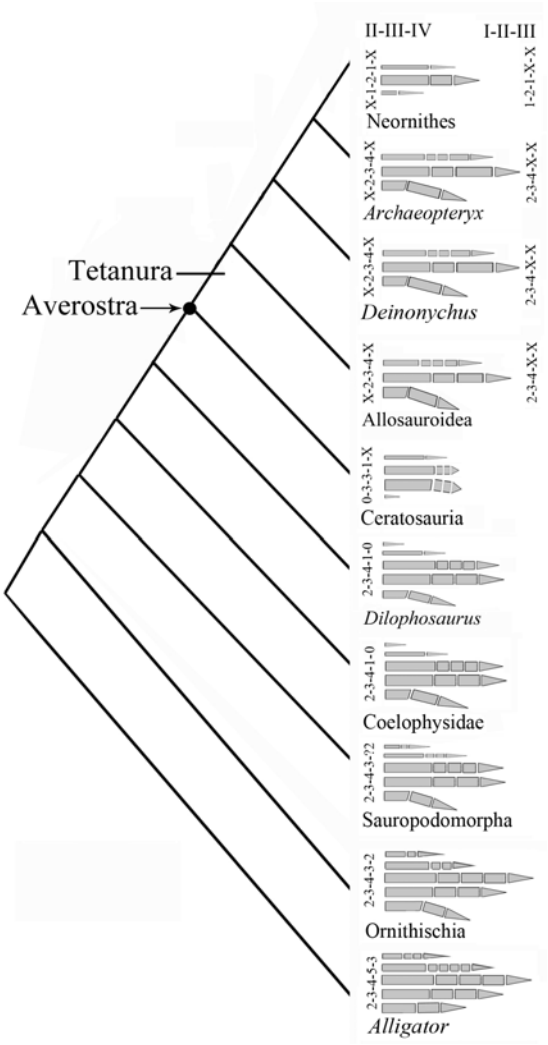
"This new animal is fascinating, and when placed into an evolutionary context it offers intriguing evidence about how the hand of birds evolved," said scientist James Clark of George Washington University.

Clark, along with Xu Xing of the Chinese Academy of Science's Institute of Vertebrate Paleontology and Paleoanthropology in Beijing, made the discovery. Clark's graduate student, Jonah Choiniere, also was involved in analyzing the new animal.

"This finding is truly exciting, as it changes what we thought we knew about the dinosaur hand," said Xu. "It also brings conciliation between the data from million-year-old bones and molecules of living birds."

Limusaurus inextricabilis ("mire lizard who could not escape") was found in 159 million-year-old deposits located in the Junggar Basin of Xinjiang, northwestern China. The dinosaur earned its name from the way its skeletons were preserved, stacked on top of each other in fossilized mire pits.

A close examination of the fossil shows that its upper and lower jaws were toothless, demonstrating that the dinosaur possessed a fully developed beak. Its lack of teeth, short arms without sharp claws and possession of gizzard stones suggest that it was a plant-eater, though it is related to carnivorous dinosaurs.



The newly discovered dinosaur's hand is unusual and provides surprising new insights into a long-standing controversy over which fingers are present in living birds, which are theropod dinosaur descendants. The hands of theropod dinosaurs suggest that the outer two fingers were lost during the course of evolution and the inner three remained.

Conversely, embryos of living birds suggest that birds have lost one finger from the outside and one from the inside of the hand. Unlike all other theropods, the hand of Limusaurus strongly reduced the first finger and increased the size of the second. Clark and Xu argue that Limusaurus' hand represents a transitional condition in which the inner finger was lost and the other fingers took on the shape of the fingers next to them.

The three fingers of most advanced theropods are the second, third and fourth fingers-the same ones indicated by bird embryos-contrary to the traditional interpretation that they were the first, second and third.

Limusaurus is the first ceratosaur known from East Asia and one of the most primitive members of the group. Ceratosaurs are a diverse group of theropods that often bear crests or horns on their heads, and many have unusual, knobby fingers lacking sharp claws.

The fossil beds in China that produced *Limusaurus* have previously yielded skeletons of a variety of dinosaurs and contemporary animals described by Clark and Xu.

These include the oldest tyrannosaur, *Guanlong wucaii*; the oldest horned dinosaur, *Yinlong downsi*; a new stegosaur, *Jiangjunosaurus junggarensis*; and the running crocodile relative, *Junggarsuchus sloani*.

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New Progress in Gold-Nanoparticle-Based Biochips

A significant progress in the research on the application of gold nanoparticles in biochips has recently been obtained by the research team led by Prof. Wang Zhenxin at Changchun Institute of Applied Chemistry, Chinese Academy of Sciences. The research findings have been published in such top academic journals as *Analytical Chemistry* and *Biosensors and Bioelectronics*.

As a high-flux analytical technique coming into being in the 1990s, biochip technology has been widely applied to genomics research as DNA biochips gained unprecedented development, and, as a result, enormous success has been achieved in genetic sequencing research. Compared with the human genome project, research on proteomics and glycomics are facing much severer challenges, therefore, it has become one of the urgent tasks for analytical chemistry in life sciences to develop high-speed, low-cost and high-flux biochip-based proteomic analytical techniques.

By labeling biochips with biomolecule-modified gold nanoparticles, Prof. Wang and his research team succeeded in obtaining the expected new-type biochips via the application of surface enhanced Raman spectrum and resonant light scattering detection methods, realizing the precise detection of polypeptide, protein and carbohydrate on the one hand and making it possible to investigate into the interaction between zymolyte, enzyme, protein and antibodies on the other.

The research has been supported by the National Natural Science Fund, the Hundred Talents Program of the Chinese Academy of Sciences, the Fund of Chinese Academy of Sciences for Key Topics in Knowledge Innovation Project, and the Bayer Group of Germany respectively.

Topological Insulator Research Made Important Progress

According to different structure of electronic states, materials are divided traditionally into two types, namely, “metals” and “insulators”. Topological insulators, however, are new states of quantum matter. It is very different from traditionally defined “metals” and “insulators”. The electronic state of its body is an insulator with energy cap, and its surface is metal state without energy gap. This surface metal state without energy gap is also very different from the surface state in the general sense in that is it due to unsaturated bind on the surface or due to surface reconstruction. The surface state of topological insulator is completely determined by the topological structure of body electron state of the material. It is determined by symmetry, and independent from specific structure of the surface. Just because the surface metal state is determined by symmetry, it is very stable, almost not affected by impurity and disordering in the material. In addition, the basic property of topological insulator is the combined result of “quantum mechanics” and “the theory of relativity”. Due to coupling effect of self-spinning orbit, there will form a surface electronic state of no energy gap, self-spin identified protected by temporal reverse symmetry on the surface. This surface state forms a kind of 2-D electronic gas without effective mass (which is different from 2-D electronic gas of approximate effective mass, such as the widely used 2-D electronic gas in field effect semiconductors), which needs to be described by Dirac equation, not Schrödinger equation. These charming and important properties provide topological insulator with great possibilities of important applications in electronic technology in the future. Searching for strong topological insulator materials with sufficiently large body energy gap and stable chemical properties thus become important focus and difficulties in current research.

Dr. Zhang Haijun. Research Professor Dai Xi and Research Professor Fang Zhong and their research group T03 at the State Lab of Condensed Matter Physics in the Institute of Physics of CAS made important progress recently in this research. In collaboration with Professor Zhang Shousheng of Stanford University in the US, they predicted a new type of strong topological insulator material system (Bi2Se3, Bi2Te3 and Sb2Te3). They made systematic studies by theoretical and computational methods on the physical mechanism of these materials becoming strong topological insulators, found the KP Hamilton value describing the Dirac point, and calculated quasi APRES electronic spectra. This type of topological insulator has special advantageous properties. First, the material has pure chemical phase. It is very stable and easy to synthesize. Second, there is only one Dirac point in the surface state. It is the simplest strong topological insulator. This simplicity is a good platform for studying the theoretical model. Third, and a very attractive point is that the body energy gap of the material is very large, especially Bi2Se3, which is about 0,3 eV (equivalent to 3,600K), much larger than room temperature energy scale. This also means that it is possible to make self-pinning electronic device at room temperature energy consumption. Their work has been published in Nature Physics 5, 438 - 442 (2009), and has been supported by the Chinese Academy of Sciences, NSFC, and national key programs of basic research development and international S&T programs.

While publishing theoretical work, relevant experimental studies have also made important progress, and verified theory. The first case is that Professors M. Z. Hasan and R. J. Cava of Princeton University of the US reported observation of Dirac point of surface state in Bi2Se3 (Nature Physics，5，398(2009)). The second case is that the research group of Fang Zhong and Dai Xi in collaboration with Z. X. Shen of Stanford University observed single Dirac point on the surface in Bi2Te3 material using ARPES (Science(2009), received).

Major Progress in Biodiversity Achieved

In cooperation with Prof. James Brown of the New Mexico University, USA, a research team led by Prof. Fang Jingyun of the City and Environment College of Peking University published their latest research results on the mechanisms of biodiversity in the Proceedings of the National Academy of Sciences,(PNAS), US.

The increase of biodiversity (or species diversity) from poles to equator is one of the most pervasive features of the eco-system on earth. The study on its transformation and mechanism can be traced back to Darwin in the nineteenth century. In the last 20 years, research has become a focal point in bionomics, environmental sciences and conservation biology, along with the increasing attention to biodiversity by the international community.

The team led by Prof. Fang has been dedicated to the research on China's species diversity and its mechanisms for years. In cooperation with botanists all round the country, they have built up the database of Chinese tree distributions which includes about 11,000 samples, after investigating the plant diversity in about 60 major mountain areas in China. Moreover, they compare it with the database of North America to investigate the effectiveness of metabolic theory of ecology proposed by the research team led by James Brown, to explain the mechanisms of species diversity. The essence of the theory is that the environmental energy controls the metabolic speed and individual size of species, and thereby controls the magnitude of species. The team led by Fang discovered that the magnitude of species in China and North America does depend on the environmental energy, as predicted by the metabolic theory. However, the dimension of the space greatly affects the relationship between energy and species diversity, i.e. the metabolic theory has strong spatial dependence. The team also discovered that the relationship between species richness and energy is much steeper in eastern Asia than in North America. This leads to an important conclusion that, there exist more species in the warm southern East Asia than in southern North America with the similar climate, but in cold climates at high latitudes, there are more tree species in North America. The conclusion, also supported by field survey and investigations, changed the long held concept that the species diversity in East Asia is richer than that in North America.

The findings revealed the mechanisms of biodiversity in East Asia and North America, developed the metabolic theory and therefore are considered an important step towards the mechanical explanation of biodiversity.

This work is sponsored by NSFC projects numbered 40638039, 90711002 and 30721140306.

New Developments of Direct Methods in Protein Crystallography

Professor Hai-fu Fan and colleagues at the Institute of Physics have been long engaged in the study of direct methods in crystallography. Recent progresses were made in the iterative dual-space direct-method SAD (Single Anomalous Diffraction) phasing proposed in 2004 [1] and the iterative dual-space direct-method MR (Molecular Replacement) model completion proposed in 2006 [2]. These significantly improved conventional SAD phasing and MR-model completion (see Figures 1 and 2 respectively).

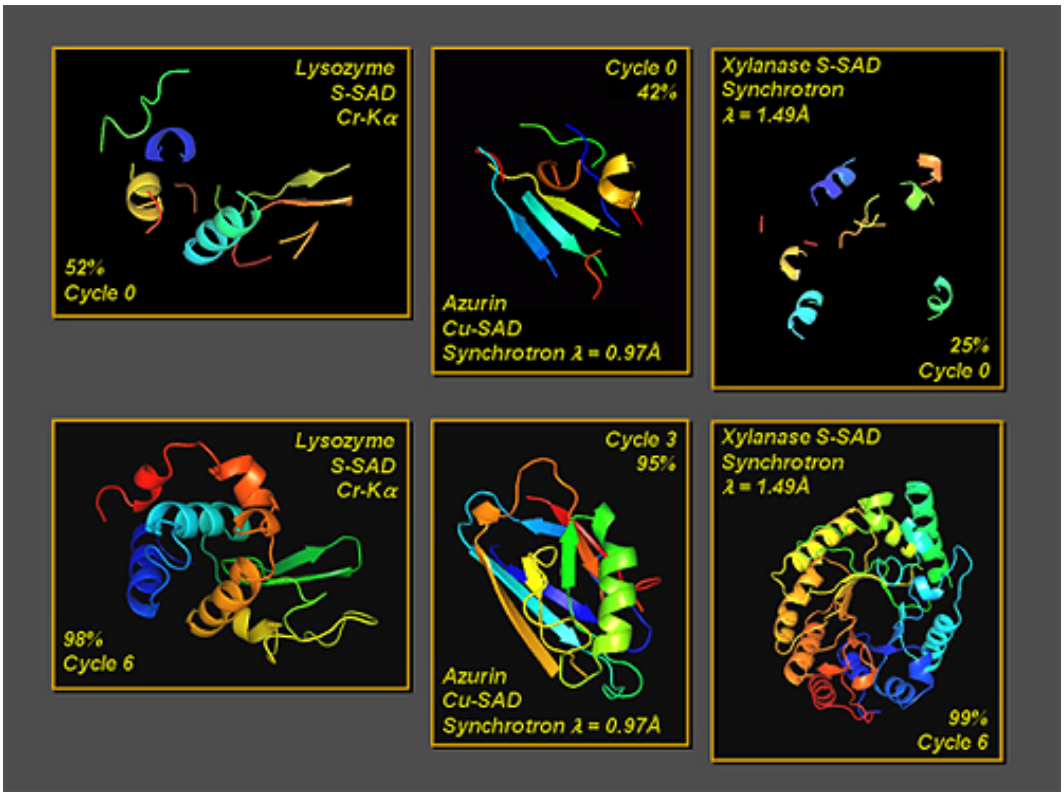

***Figure 1**. Iterative dual-space direct-method SAD phasing and fragment extension Comparison of results from OASIS-2000 (upper row, without dual-space iteration) and that from OASIS-2004 (lower row, with dual-space iteration). Samples from left to right are lysozyme, azurin and xylanase.*

Solving the crystal structure of proteins forms an indispensable part of the experimental basic for understanding the relationship between structure and function of biological macromolecules. MR method is most frequently used in solving protein structures when there is a previously solved protein which is homologous to the structure to be solved; SAD method is the first choice in solving de novo protein structures. In recent years, about 80% protein structures newly deposited in the Protein Data Bank (http://www.rcsb.org) were solved by either MR or SAD method.

The study of combining direct methods with SAD/SIR (Single Isomorphous Replacement) data was started in the Institute of Physics in the first half of 1960's. During the early 1980's to the late 1990's similar

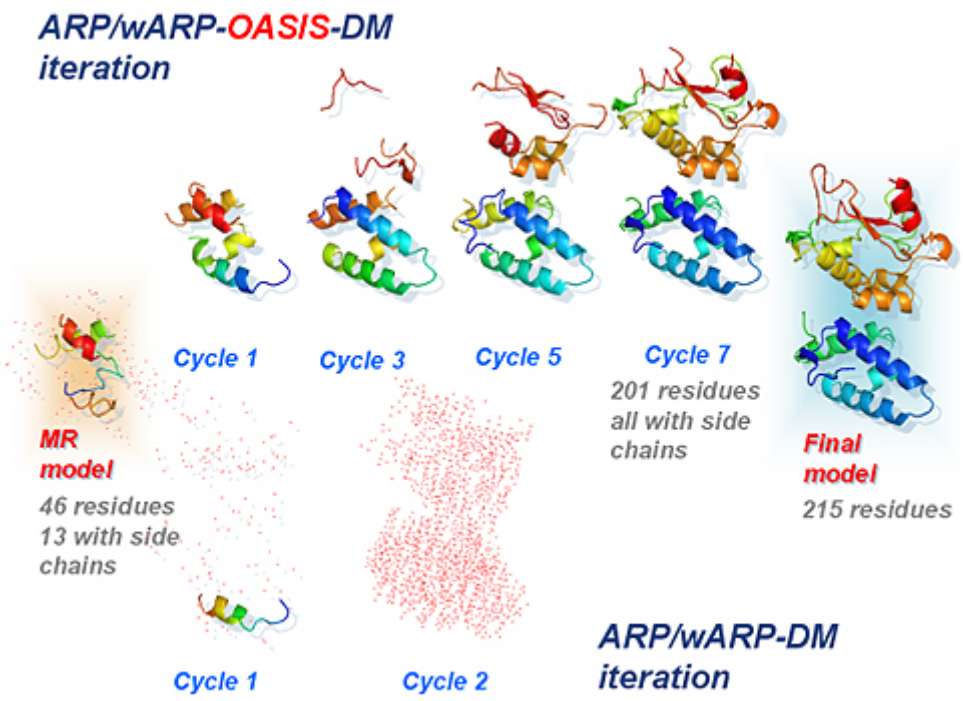

***Figure 2**. Iterative dual-space direct-method MR-model completion Comparison of results from the program combination of ARP/wARP-OASIS-DM (upper row) and that of ARP/wARP-DM (lower row) with the starting and the final model shown on the left and right respective*

investigation had been the focus of most direct-methods centers around the world. The method proposed by Fan in 1965 [3, 4] was significantly improved in 1984 [5] and 1985 [6] by the research group on Methods of Solving Crystal Structures (http://cryst.iphy.ac.cn) at the Institute of Physics. Since then, their work becomes an important part of direct-methods research in the world crystallographic community.

At the moment, applications of direct methods in protein crystallography can be divided into three categories:

1. Locating heavy atoms in protein structures;
2. Ab initio determination of protein structures;
3. Resolving the phase ambiguity intrinsic to some traditional protein crystallographic techniques.

Methods of the first category do not solve the entire structure of proteins; methods of the second category require diffraction data at resolution higher than ~1.2Å and, only ~5% of the protein diffraction data that have been deposited in the Protein Data Bank satisfy this requirement; in contrast, methods of the third category are applicable in most cases. Direct methods developed in the Institute of Physics belong to the third category. The program OASIS written by Fan et al. based on their own methods is the most important program for the implementation of direct methods of the third category. The first edition of OASIS was the only program that was included in the CCP4 (http://www.ccp4.ac.uk) suite during 2000 to 2008 for breaking SAD/SIR phase ambiguities by direct methods. The latest edition of OASIS released in 2006 incorporates methods proposed by Fan and colleagues in 2004 and 2006 and has been included in the latest version of CCP4 in 2008. Besides, OASIS-2006 has also been incorporated since 2006 into the EMBL-HH Automated Crystal Structure Determination Platform (http://www.embl-hamburg.de/Auto-Rickshaw) enabling iterative dual-space phasing and model completion. OASIS has been applied by researchers in the world community of protein

crystallography for solving protein structures with SAD data that were difficult in phasing with other methods (see Figure 3). A new and significantly improved version of OASIS will be released in 2009.

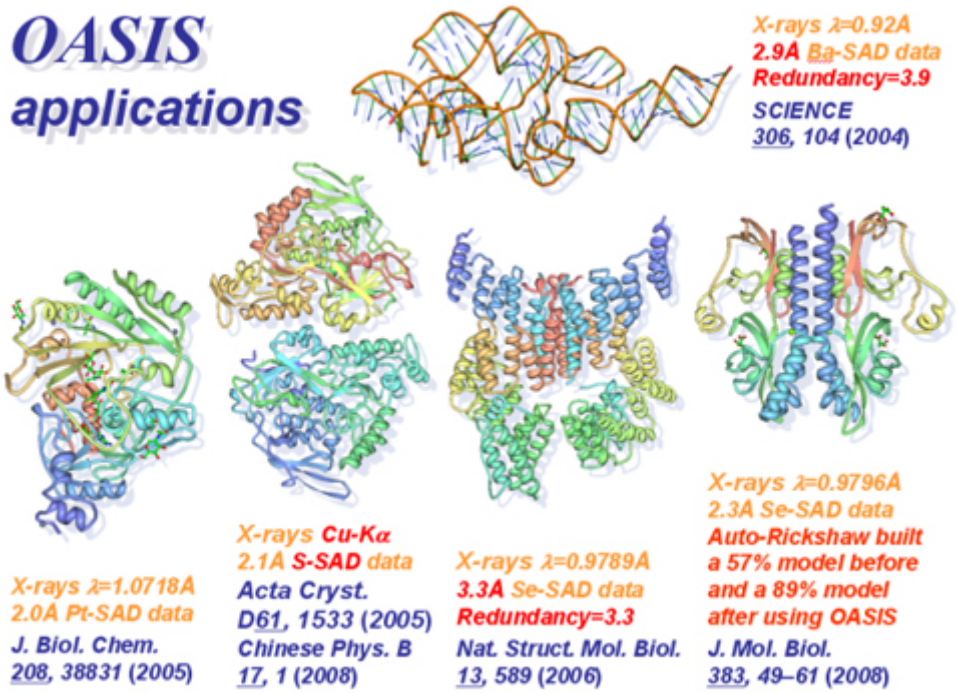

Figure3.**Applications of OASIS**

References

[1] Acta Cryst. (2004). D60, 1991–1996.

[2] Acta Cryst. (2007). D63, 793–799.

[3] Acta Phys. Sin. (1965). 21, 1114-1118 (in Chinese).

[4] English translation of [3]: Chinese Phys. (1965) 1429-1435.

[5] Acta Cryst. (1984). A40, 489-495.

[6] Acta Cryst. (1985). A41, 280-284.

Major Progress in China-UK Collaboration on the Causal Relationship between Volcanic Activity and Biological Distinction

Science carried a report recently on the collaborative results between research teams led by Prof. Paul Wignall of Leeds University and Prof. Lai Xulong of China University of Geosciences.

The research for the first time reveals that the 260-million-year-old Emeishan volcanic province of southwest China overlies and is interbedded with Middle Permian carbonates that contain a record of the Guadalupian mass extinction. Sections in the region thus provide an opportunity to monitor directly the relative timing of extinction and volcanism within the same locations. These show that the onset of volcanism was marked by both large phreatomagmatic eruptions and extinctions amongst fusulinacean foraminifers and calcareous algae. The temporal coincidence of these two phenomena supports the idea of a cause-and-effect relationship. The crisis predates the onset of a major negative carbon isotope excursion that points to subsequent severe disturbance of the ocean-atmosphere carbon cycle.

The research started in the year 2005 and has been long supported by the National Natural Science Foundation of China.

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• News in brief •

NSFC set up “Research Fund for Young Foreign Scholars”

Recently, forty young foreign scholars from US, Britain, Germany, France and Japan obtained funding from the newly-set-up Research Fund for Young Foreign Scholars. The amount of funding was 7.4 million yuan RMB. These young scholars are from various scientific disciplines such as mathematics and physics, chemistry, life sciences, earth sciences, and engineering and material science. They will conduct research in 27 Chinese universities and 12 institutes of the Chinese academy of Sciences for six to 12 months.

Setting up of this fund is an important symbol of Chinese basic research system going international. Along with economic development, basic research conditions in China are continuously improving, and now capable of hosting foreign scholars doing research in China for long period of time.

Setting up of this fund is also a strategic measure for the future. It aims at attracting outstanding young foreign scholars to do basic research in China, building a bridge and a linkage of academic communications for younger generations in an increasingly opening up environment of basic research. This has great importance in fostering main force of international researchers doing scientific cooperation with China in the future.

How often does human DNA mutate?

Yali Xue

(The Wellcome Trust Sanger Institute, Hinxton, Cambridge, CB10 1SA, UK)

Editor's comments: The human mutation rate – how often new changes appear in the DNA – is fundamental to understanding many aspects of medical genetics and human evolutionary genetics. But it is low, and has therefore been difficult to measure. In the past, scientists could only estimate it approximately, either by observing how often mutant phenotypes appeared, or by comparison of humans and closely related species, such as chimpanzee, where many mutations could accumulate but the time period was uncertain. Now, a new study supported by the NSFC in China and The Royal Society in the UK reports the first direct measurement of the human mutation rate at the individual letters (nucleotides or bases) of DNA. This was possible because new (next)-generation sequencing technology is much more powerful than the methods available previously. The work was published in the leading journal *Current Biology* on 15th September 2009. The results were reported in the news by Nature, Science and the BBC, as well as in more than 20 Chinese newspapers and radio stations after the work first appeared online on 27th August. It was also one of the research highlights in Nature on 3rd September, which commented "This direct measurement of the human mutation rate should help researchers to refine evolutionary dating and better understand the source of genetic disease". From the work, researchers could estimate that everyone has around 200 new mutations in their genome; as the authors said, "we are all mutants". The ability to reliably measure rates of DNA mutation means we can begin to ask how mutation rates vary between different regions of the genome and perhaps also between different individuals.

Key words: Mutation rate, deep-rooting pedigree, next-generation sequencing, human Y chromosome

Mutation is an inevitable and fundamental property of DNA: changes occur by chance when DNA is replicated and passed on to the next generation, and this process can be affected by factors in the environment. Fortunately, most changes have no effect whatever. A tiny fraction are harmful and can lead to cancer or genetic disease, and an even smaller proportion are actually beneficial, and provide the raw material for evolution. We therefore want to understand how often mutations do occur, so we can have a better understanding of both their bad and good effects.

In the past, it was just impossible to measure this important parameter directly because it was so low. Scientists only could estimate it approximately, and developed two ways of doing this. In one, they looked for new cases a specific medical phenotype in a family, such as the blood disease haemophilia. If they detected all the cases, and could determine what proportion were due to new mutations and also knew how big the gene was, they could calculate a rate. Alternatively, they could compare the DNA between human and closely related species, such as chimpanzee. Here, if they knew how many years or generations separated the species, they could again calculate a rate. But there were a lot of uncertainties involved.

Now, with the new generation of sequencing technology with its lower cost and higher throughput, it has become possible to measure the rate directly for the first time. We therefore designed a study to do this as part of an international joint project supported by the National Natural Science Foundation, China and The Royal

Society, UK. Our work has just been published in the 15th September issue of Current Biology[1], and we describe the results here. But even with the benefit of the latest technology, we had to design the project carefully.

We used the Y chromosome because it has several unique features which worked to our advantage. Most of it (almost 60,000,000 nucleotides) is transmitted simply from father to son each generation. This means that the son has exactly the same Y chromosome, apart from any mutations that have occurred. So does the son's son, although again apart from mutations that have occurred in the two generations, and so on for further generations. This would not be true of other parts of the genome, because they mix each generation.

In our study, we chose two men who were male-line relatives, but were separated by 13 generations. This meant that we would pick up mutations that had occurred in all these generations. We were particularly interested one particular family because it carries a Y-linked hearing impairment mutation[2], but this condition turned out to be irrelevant to our study. We began by purifying the Y chromosomes from the two men by flow sorting them. We then sequenced them by next-generation sequencing (in this case using the Illumina Genome Analyzer) to find the differences between the two Y chromosomes. Although the next-generation sequencing made this study possible, the high error rate of the technology gave us an enormous numbers of false positives (more than 30,000), far more than the number of real mutations we expected which was less than 10. But by using the known "gold standard" positions on the chromosome whose sequence was predicted from previous studies[3], we excluded the vast majority of these false positives and ended up with 23 candidate differences. This number was small enough to then use traditional Sanger sequencing to test all of them. In this way, we confirmed that 12 of the 23 were real differences.

But this was not the end. The chromosomes we sequenced came from cell lines and the 12 differences could have arisen in the family (real mutations) or in the cell lines (somatic mutations). Fortunately, we could distinguish between these possibilities by sequencing blood DNAs from the two men as well as from other individuals in the family. In the end, we found that eight of the differences were somatic mutations, and only four were real mutations that happened during transmission in the family. For technical reasons, we restricted the analysis to around 10 million bases from the two chromosomes, but this was enough to calculate the rate for the whole genome. Four mutations in 10 million bases of DNA over 13 generations gave us about one mutation in every 30 million nucleotides per generation. In the six billion nucleotides in the complete genome, everyone has about 200 mutations.

The mutation rates are thought to vary in different parts of the genome, and this kind of variation can be followed up in future studies. Our study, for the first time ever, has shown that one can use next-generation sequencing technology to measure the very low mutation rate of human nuclear DNA reliably. Reassuringly, the mutation rate we observed is consistent with that inferred from evolutionary comparisons but can potentially be measured more precisely and provide new insights into human mutation processes.

In addition to demonstrating the power of the technology and paving the way for future mutation studies, this study also highlighted the potential advantages of using SNPs in forensic genetics in the future[4]. Currently, forensic scientists use markers called Y-STRs when they need to distinguish between different Y chromosomes. However, as we have seen, sons carry the same Y chromosome as their fathers, and these cannot be distinguished unless a mutation has occurred. In practice, male line relatives less than 20 generations apart are likely to carry the same Y-STR type, so are not distinguished by current methods. This was the case for the two men tested in our study: they showed exactly the same pattern with Y-STRs[5]. But they have four Y-SNP differences, so this means that SNPs are better than STRs at telling Y chromosomes apart. Indeed, if more of the Y chromosome was used, almost every Y chromosome could be distinguished. Some technical advances and cost reductions are needed before this can come into practice, but the possibility illustrates the surprising

ways in which science advances.

Selected related links (comments on the work):

http://www.sanger.ac.uk/Info/Press/2009/090827.shtml

http://www.nature.com/nature/journal/v461/n7260/full/461015b.html

http://www.nature.com/news/2009/090827/full/news.2009.864.html

http://esciencenews.com/articles/2009/08/27/we.are.all.mutants

http://news.xinhuanet.com/tech/2009-08/29/content_11962256.htm

References:

[1] Xue, Y. *et al*., Human Y chromosome base-substitution mutation rate measured by direct sequencing in a deep-rooting pedigree. *Current Biology* (in press) (2009).

[2] Wang, Q. J. *et al*., Y-linked inheritance of non-syndromic hearing impairment in a large Chinese family. *Journal of Medical Genetics* **41**, e80 (2004).

[3] Karafet, T. M. *et al*., New binary polymorphisms reshape and increase resolution of the human Y chromosomal haplogroup tree. *Genome Res*earch **18**, 830-838 (2008).

[4] Xue, Y. and Tyler-Smith, C. The hare and the tortoise: one small step for four SNPs, one giant leap for SNP-kind. *Forensic Science International: Genetics* (in press) (2009).

[5] Vermeulen, M. *et al*., Improving global and regional resolution of male lineage differentiation by simple single-copy Y-chromosomal short tandem repeat polymorphisms. *Forensic Science International: Genetics* **3**, 205-213 (2009).

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Research progress on colossal anisotropic magnetoresistive effect

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Perovskite manganites show exotic functionalities due to the coupling between spin, charge, orbital and lattice, such as metal-insulator transition, colossal magnetoresistance (CMR), charge-orbital order and phase separation. Recently, an extraordinary anisotropic magnetoresistance (AMR) has been observed in perovskite manganite single crystals. The AMR value is about 2 orders larger than that of the conventional 3*d* transition metals and alloys, which is attributed to tunable metal-insulator transition temperature modulated by the magnetic field. This result provides a new route for exploring novel AMR materials and their applications.

Key words perovskite manganite, metal-insulator transition, AMR

The correlated electron materials show many interesting physical properties due to the coupling between spin, charge, orbital and lattice. In doped perovskite manganite $Ln_{1-x}A_xMnO_3$ where Ln and A are rare- and

alkaline-earth cations, respectively, prominent change of the physical properties can be got due to the subtle variation of the coupling between spin, charge, orbital and lattice by doping, strain effect and external field, etc. Recently, Run-Wei Li's group in Ningbo Institute of Materials Technology and Engineering, Chinese Academy of Sciences, has found colossal Anisotropic Mametoresistance (AMR) in the $La_{0.69}Ca_{0.31}MnO_3$ single crystals, which has been published on Proceedings of the National Academy of Sciences (PNAS). 106, 142224(2009).[1]

In 1857, W. Thomson found AMR effect, i.e. the resistivity changing with the orientation of the external magnetic field. AMR effect is found universally in 3*d* magnetic materials and has been applied in various magnetic read-out heads and magnetic sensors. The AMR value in the conventional 3*d* magnetic materials is usually very small compared to giant magnetoresistance (GMR), tunneling magnetoresistance (TMR) and colossal magnetoresistance (CMR). For example, the AMR value in the permalloy, the most widely used AMR material, is only about 1-2% at the room temperature. Due to the lower sensitivity of the AMR devices compared to the GMR and TMR devices, the AMR devices are being replaced gradually by the GMR and TMR devices. However, the research results in Li's group indicate that even a weak crystalline anisotropy can induce a colossal AMR effect in perovskite manganites, the AMR value can even be larger than GMR and TMR.

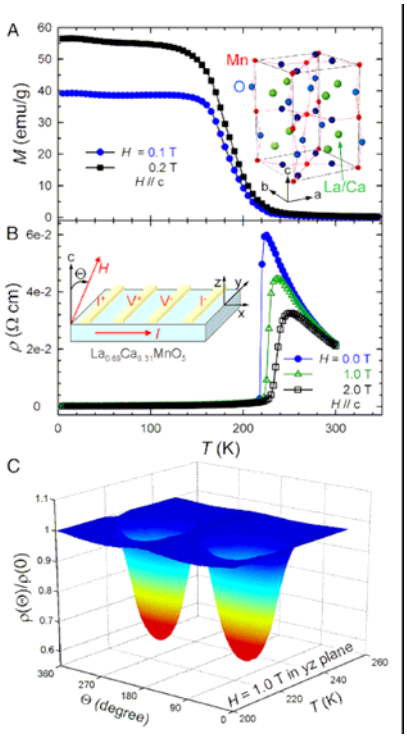

Fig.1 M(T) and ρ(T, θ) of $La_{0.69}Ca_{0.31}MnO_3$ single crustal

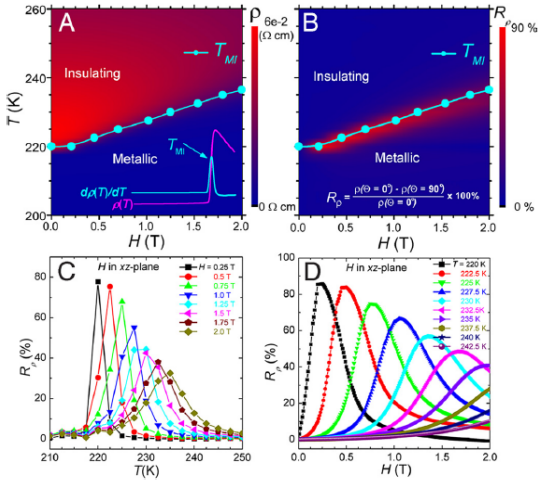

Fig.2 The dependence of AMR on T and H

$La_{0.69}Ca_{0.31}MnO_3$ single crystals are orthorhombic, deviating from the cubic perovskite structure via two dissimilar Jahn-Teller (*J*–*T*) distortions—in-plane (i.e., in *ab*-plane) rotation and out-of-plane (***c***-axis) tilt of the MnO_6 octahedron. The metal-insulator transition coincides with a ferromagnetic-to-paramagnetic transition at $T_{MI} \approx 220$ K, characterized by the *T*-dependence of magnetization $M(T)$ and the resistivity $\rho(T)$ shown in Fig. 1 *A* and *B*, respectively. The measured $\rho(T)$ vs. ***H*** curve demonstrates a typical negative magnetoresistance behavior. However, the observed MR shows a strong dependence on the field orientation, leading to a remarkable AMR effect.

In conventional 3*d* transition metals or alloys, AMR depends monotonically on temperature or magnetic field and saturate at the high field, but in the perovskite manganite, the situation is different. The temperature- and field dependence of AMR and their correlation with the field dependent metal-insulator transition were

systematically investigated. The results are shown in Fig. 2. T_{MI} increases almost linearly with field (see Fig. 2*A*). A key discovery here is that the measured R_ρ peak follows almost exactly the field dependence of T_{MI}, as shown in Fig. 2*B*. Large AMR emerges only near T_{MI} (Fig. 2*C*), whereas no prominent AMR appears in either the pure ferromagnetic-metallic state at $T \leqslant T_{MI}$ or the pure paramagnetic-insulating state at $T \geqslant T_{MI}$. We can define the value of AMR as $R_\rho = \frac{R_{0^o} - R_{90^o}}{R_{0^o}}$ or $R_\rho = \frac{R_{0^o} - R_{90^o}}{R_{90^o}}$, where R_{0^o} and R_{90^o} is corresponding to the resistance when H//$\boldsymbol{c}$ axis and $H \perp \boldsymbol{c}$ axis respectively. The nonmonotonic field-dependence of R_ρ at a given T close to T_{MI} is evident in Fig. 2*D*, such that R_ρ(H and T) exhibits very similar line shapes for varying field or temperature. Under 220 K and 0.2 T, if adopting the former definition of R_ρ, $R_\rho$reaches 90%, and if the latter definition is adopted, R_ρ can be over 600%. This result breaks undoubtedly the conventional impression that the AMR value is smaller than that of GMR and TMR.

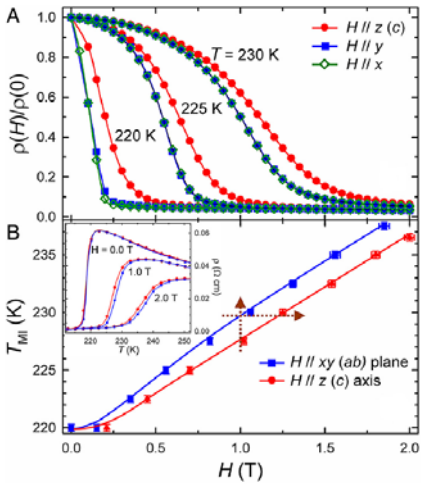

Fig.3 The dependence of resistivity and T_{MI} on the direction of magnetic field

In order to study the mechanism of the anomalous AMR effect, the dependence of the resistivity and T_{MI} on the magnetic field was investigated in detail. Fig. 3 presents the measured field-dependence of both the normalized resistivity and T_{MI} for the field along three different sample orientations. The measured ρ(***H***) has similar values for the ***H***//x and ***H***//y directions but quite different values for the ***H***//z direction (see Fig. 3*A*). A small difference in ρ(***H***) between the ***H***//x and ***H***//y directions can mainly be attributed to the Lorentzian MR, whereas the large difference between the ***H***//z and ***H***//x(y) directions gives rise to the observed giant AMR. Also shown in the *Inset* of Fig. 3*B*, a small but clear shift of ρ(T) is evident by orienting ***H***//z- from ***H***//x(y)-direction, thus indicating an anisotropic field-dependent metal-insulator transition. As presented in Fig. 3*B*, the T_{MI} (***H***) curve for the ***H***//z direction deviates from that for the ***H***//x(y) direction. The crystalline ***c***-axis (i.e., the z direction), which is perpendicular to the sample plane, is the hard axis for the field-dependent metal-insulator transition. The correlation between AMR and metal-insulator transition displayed in Fig. 2 and Fig. 3, especially the gap of the two T_{MI} (***H***) curves shown in Fig. 3*B*, provide a crucial key for understanding the anisotropic magneto-transport properties. The difference in T_{MI} due to field orientations (***H***//***c***- or ***H_c***-axis) leads to the observed unusual AMR effect. At a given field strength (vertical cut and between the two T_{MI} curves in Fig. 3*B*), the sample becomes insulating when ***H***//***c***-axis while remaining metallic when ***H_c***-axis—creating the R_ρ peak as shown in Fig. 2*C*. On the other hand, at a given T (horizontal cut in Fig. 3*B*), the sample becomes metallic as ***H_c***-axis but remains insulating as ***H***//***c***-axis, thus resulting in the R_ρ peak as shown in Fig. 2*D*. When the system is far away from the gap region of the two T_{MI} (***H***) curves, only conventional AMR with small amplitude should exist.

Jahn-Teller distortions and double-exchange (DE) interactions, which are intimately coupled in this class of doped perovskite oxides, play vital roles in both the transport and the magnetic properties. Simply speaking, Jahn–Teller (J-T) distortions tend to promote insulating phase to the system whereas DE interaction endorses ferromagnetic-metallic state, although the strength of DE interaction depends on the degrees of J-T distortions thus making a close coupling between them. Bending the Mn-O-Mn bond by enhancing J-T distortion reduces DE interaction so as bandwidth. The subtle competition between them causes the metal-insulator transition in these doped manganites. However, external field tends to disturb such a competition by facilitating the metallic state, evident by appearing *negative* CMR near the T_{MI} and tuning the metal-insulator transition. Owning to the strong correlation character in these materials, lattice also has its response to applied magnetic field by alter J-T distortions, depending on the detailed lattice structure and applied field orientation. Indeed, the giant AMR observed in $La_{0.69}Ca_{0.31}MnO_3$ reflects exactly the different lattice response to the external field, depending on the field direction.

If, in a cubic peroviskite structure, lattice should have identical response to external field in all high-symmetry crystalline directions, thus no AMR is generated by magneto-elastic coupling. However, in orthorhombic $La_{0.69}Ca_{0.31}MnO_3$, the structure has lower symmetry by bearing two distinct J-T distortions from a cubic perovskite. The lattice has larger response when the field is perpendicular to ***c***-axis than parallel to ***c***-axis, thus creating instinct effects on the transport properties including metal-insulator transition through different couplings with the DE interaction. This different response exactly makes ***c***-axis as the hard axis for the field-dependent metal-insulator transition, having a small but crucial anisotropy as clearly shown in the two field-dependent T_{MI} curves (see Fig. 3*B*). Consequently, the system exhibits a giant AMR effect near the metal-insulator transition region that is stimulated by the distinct lattice response to external field because of the asymmetric J-T distortions. Based upon the above scenario for the nature of intrinsic AMR, we are able to qualitatively explain the dissimilar magnitude of AMR effects observed in different manganite systems. Of course, in the imperfect crystal, the twinning effect can not be ignored.

The finding of the colossal AMR effect in perovskite manganite provides an alternative route for exploring novel AMR materials, and stimulates researchers to re-investigate the mechanism of the AMR effect. From the viewpoint of applications, the colossal AMR effect has applications in magnetic read-out heads, direction/angular sensors, etc.

This research is being supported by National Natural Science Foundation of China (10874192).

References：

[1] Run-Wei Li et al. *PNAS*. 106, 142224(2009)