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The Institute of Advanced Studies (IAS) is at the confluence of multi-disciplinary studies in the physical and biological sciences, mathematics, engineering and information technology, etc. The mission of the IAS is to advance the state of knowledge of fundamental science, to cultivate the next generation of research talent, and to give NTU’s science and technology initiatives the “Nobel boost”. The institute regularly hosts international conferences, workshops, public lectures and outreach programs on wide-ranging topics by world-renowned scientists. It serves as a research hub for Nobel Laureates and distinguished scientists to share ideas, stimulate collaborations across disciplines and inspire new innovations in Singapore.
In July 2005, in conjunction with the 50th Anniversary of the Nanyang Technological University, we decided to form the Institute of Advanced Studies (IAS, NTU) to promote and advance the state of knowledge of fundamental science and to cultivate the next generation of active scientists and engineers at the university. With the support of the President of the university, Dr Su Guaning, we formed a local committee which is advised and guided by an International Advisory Board comprising of many world-renowned scientists, including Nobel Laureates and Fields Medalists.

Over the last five years, the IAS has organized numerous activities to promote and enhance multi-disciplinary research ranging from the Physical and Mathematical Sciences and Biological Sciences to Engineering and IT at Nanyang Technological University. These activities included many international conferences, workshops and symposia, as well as schools and courses. We have also reached out to Junior Colleges and high schools in Singapore through Science forums and public talks.

The principal activities of IAS essentially revolves around a concept in which the Institute constantly invites top-class renowned scientists and Nobel Laureates to Singapore for conferences, workshops, public lectures, interactions and collaborations with academics, researchers, and students from Singapore. The IAS also identifies certain niche research areas to enhance research focus of the University.

Many of our events have been specially structured to promote and improve research collaborations between Singapore and overseas scientists, with the goal of complementing and augmenting the ongoing research strengths at NTU. Through these events, the IAS hopes to enhance the research environment at NTU (as well as Singapore) through the interaction and exposure with heavyweight scientists from multidisciplinary fields.

In the next five years, IAS will consolidate its existing strengths and seek for more inter-disciplinary collaborations and research. With the establishment of the Imperial College-NTU medical school, IAS hopes to provide greater synergy between medical science and engineering research.

Prof Phua Kok Khoo
Director, Institute of Advanced Studies
Nanyang Technological University
Management Team, Advisory Committee and Fellows

- Institute Directors

From left: Prof Kwek Leong Chuan (Deputy Director, Physical Sciences), Prof Phua Kok Khoo (Director), and Prof Hew Choy Sin (Deputy Director, Life Sciences)
Director –
Phua Kok Khoo

Prof Phua is the Founding Director of the Institute of Advanced Studies (IAS) at Nanyang Technological University (NTU). He is an Adjunct Professor at the National University of Singapore (NUS) and Drexel University, USA. He is also a consultant to many government bodies and committees, as well as chairman and board member of various junior colleges and secondary schools in Singapore. He has contributed extensively to numerous organizations in Singapore including the Lee Foundation, the Tan Kah Kee Foundation, the National Library Board, the CDAC, the CRISP and the Institute for Mathematical Sciences at NUS as well as overseas organizations like the Mathematical Sciences Research Institute, University of California at Berkeley, USA. In addition, he is also the Honorary Professor in various universities in China. For his many contributions, he was awarded the first President Award by the Institute of Physics, Singapore in 2006. He is also an elected Fellow of the American Physical Society. Prof Phua’s interests include Phenomenology in High Energy Physics and Science Education.

Deputy Director (Life Sciences) –
Hew Choy Sin

Prof Hew is an Adjunct Professor at IAS, NTU and specializes in Orchid Physiology. He has been a consultant to many regional and local floricultural companies and societies, and has served in several government bodies including the National Institute of Education, NSTB and PSC. He is also an advisor to the Guangzhou Scientific Technology Exchange Centre, China on horticultural production and is the Advisor and Visiting Professor of the Research Centre for Chinese Orchids, South China Normal University. In 1997, the NSTB awarded Prof Hew with the National Science Award, for his outstanding contribution to the orchid research.

Deputy Director (Physical Sciences) –
Kwek Leong Chuan

Prof Kwek is an Associate Professor of Physics at the National Institute of Education (NIE), NTU and a Principal Investigator at the Centre for Quantum Technologies (CQT) at NUS where he leads a group working on distributed quantum computing and simulation of many-body problems. He was the Fujitsu Visiting Professor at the University of Cambridge in 2004. He is also an elected Fellow of the American Association for the Advancement of Science (AAAS), a recipient (team) of the National Science Award in 2006 and the President of the Institute of Physics, Singapore.
International Panel of Advisors

Prof David Baltimore
(Nobel Laureate in Physiology or Medicine, 1975)
President
California Institute of Technology, USA

Prof Shu Chien
Department of Bioengineering and Medicine and Institute of Engineering in Medicine
University of California, San Diego

Prof Paul Chu
President
The Hong Kong University of Science and Technology

Prof Aaron Ciechanover
(Nobel Laureate in Chemistry, 2004)
Faculty of Medicine
Technion-Israel Institute of Technology, Israel

Prof Peter Goddard
Director
Institute for Advanced Study
Princeton, USA

Prof Gerard’t Hooft
(Nobel Laureate in Physics, 1999)
Institute for Theoretical Physics
Utrecht University, Netherlands

Prof Masatoshi Koshiba
(Nobel Laureate in Physics, 2002)
International Center for Elementary Particle Physics
University of Tokyo, Japan

Prof Lee Yuan Tseh
(Nobel Laureate in Chemistry, 1986)
President
Academia Sinica, Taiwan

Prof Anthony J Leggett
(Nobel Laureate in Physics, 2003)
Department of Physics
University of Illinois at Urbana-Champaign, USA

Prof Leung Ping Chung
Chairman
The Management Committee of the Institute of Chinese Medicine
The Chinese University of Hong Kong
International Panel of Advisors

Prof Pierre-Louis Lions  
(Fields Medalist, 1994)  
Prof au College de France et a l’Ecole Polytechnique  
College de France

Prof Rudolph A. Marcus  
(Nobel Laureate in Chemistry, 1992)  
Division of Chemistry and Chemical Engineering  
California Institute of Technology, USA

Prof Douglas Osheroff  
(Nobel Laureate in Physics, 1996)  
Department of Physics  
Stanford University, USA

Prof Mary A Ritter  
Pro-Rector for Postgraduate and International Affairs  
Imperial College London, United Kingdom

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Department of Mathematics  
Harvard University  
Cambridge, USA

Prof Gang Tian  
Department of Mathematics  
Massachusetts Institute of Technology  
Cambridge, USA

Prof Samuel Ting Chao Chung  
(Nobel Laureate in Physics, 1976)  
Department of Physics  
Massachusetts Institute of Technology  
Cambridge, USA

Prof Yang Chen Ning  
(Nobel Laureate in Physics, 1957)  
Honorary Director  
Center for Advanced Study  
Tsinghua University, China

ProfAhmed Zewail  
(Nobel Laureate in Chemistry, 1999)  
Arthur Amos Noyes Laboratory of Chemical Physics  
California Institute of Technology, USA
Prof Pierre–Gilles de Gennes was born in Paris, France and was home-schooled to the age of 12. Thereafter, he studied at the École Normale Supérieure. After leaving the École in 1955, he became a research engineer at the Saclay Center of Commissariat à l’Énergie Atomique, working mainly on neutron scattering and magnetism. In 1971, he became Professor at the Collège de France, and participated in STRASACOL (a joint action of Strasbourg, Saclay and Collège de France) on polymer physics. From 1980 onwards, he became interested in interfacial problems: the dynamics of wetting and adhesion.

He was awarded the Lorentz Medal and Wolf Prize in 1989. In 1991, he received the Nobel Prize in Physics for discovering “methods developed for studying order phenomena in simple systems can be generalized to more complex forms of matter, in particular to liquid crystals and polymers”. He was then Director of the École Supérieure de Physique et de Chimie Industrielles de la Ville de Paris (ESPCI), a post which he held from 1976 until his retirement in 2002.
IAAS Local Committee

**Chairman**

Prof Phua Kok Khoo
Director, Institute of Advanced Studies

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Prof Lam Khin Yong
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School of Physical and Mathematical Sciences

Prof Alfred Huan
Head, Physics and Applied Physics, School of Physical and Mathematical Sciences

Prof Chang Ngee Pong
City College of New York

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Tony Mayer (Senior Science Officer) (2007 – 2009)

James Tham (School of Biological Sciences) (2005 – 2007)
IAS Fellows

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Chang Ngee Pong (City College of New York)
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Kerson Huang (Massachusetts Institute of Technology)
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Ling San (Nanyang Technological University)
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Chen Ken Shiung (Nanyang Technological University)
Klaus Heese (Nanyang Technological University)
Low Hwee Boon (Nanyang Technological University)
Christos Panagopoulos (Nanyang Technological University)
Jean, Yong Wan Hong (National Institute of Education)
IAS Lee Kong Chian Distinguished Professorship

Special thanks to Lee Foundation for the strong support and donations towards IAS programmes and activities.

About Lee Kong Chian

A philanthropist and prominent businessman, the late Lee Kong Chian was the son of an immigrant from Fujian who made the journey to Singapore in 1903 with his father. His intelligence and talents attracted tycoons Cheng Hee Chuan and Tan Kah Kee who were responsible for his early start in business. Lee made his enterprises in rubber planting and later expanded into pineapple, coconut oil and sawmills among others. Lee also invested large capitals in big enterprises. The last fifteen years of his life was devoted to charity work under the Lee Foundation. The Lee Foundation bears the mark of Lee Kong Chian’s progressive outlook on charity. Though a corporate magnate, Lee led a simple life and was known to be humble. His legacy continues to live on, with landmark institutions named after him, including the Lee Kong Chian Reference Library (National Library Board), Lee Kong Chian Art Museum (National University of Singapore), etc.

IAS Lee Kong Chian Distinguished Professorship

The IAS Lee Kong Chian Endowment Fund was set up with a pledge commitment by the Lee Foundation, Singapore, to support the Nobel Laureates program of IAS. The Lee Kong Chian Endowment Fund is used to support the work and outreach of Nobel Laureates so as to inspire and raise the insights of our students, faculty and Singapore, at Nobel Laureates level. The Nobel Laureates and other distinguished visitors of similar standing who visited IAS are appointed as “Lee Kong Chian Distinguished Professor”.

With Permission from the Lee Foundation and National University of Singapore
Prof Martin Perl is a Professor with Stanford University and the Stanford Linear Accelerator Center (SLAC) and was awarded the 1995 Nobel Prize in Physics for his work in the discovery of tau lepton.

He presented his plenary lecture at the Conference on Particle Physics, Astrophysics, and Quantum Field Theory: 75 Years since Solvay on 27 to 29 November 2008 that opened the question of whether it was possible to directly detect dark energy through the presence of dark energy density. He also gave another talk titled “Lessons in Teaching Physics from My Life in Teaching” at the Physics Education Workshop held in conjunction with the conference.

Prof Gerard’t Hooft is currently a Professor of theoretical physics at the Spinoza Institute of Utrecht University. His plenary lecture at the Conference on Particle Physics, Astrophysics, and Quantum Field Theory: 75 Years since Solvay was a discussion about crystalline gravity, the space-time interaction of matter with gravity. He also presented another talk titled “Education in the Netherlands and the Nobel Prizes” at the Physics Education Workshop. Prof Gerard’t Hooft shared his 1999 Nobel Prize in Physics with Martinus J. G. Veltman for “elucidating the quantum structure of electroweak interactions in physics”.

Prof Richard Ernst, an Honorary Doctor of the Technical University of Munich and University of Zurich, was awarded the 1991 Nobel Prize in Chemistry for his contributions towards the development of the methodology of high resolution Nuclear Magnetic Resonance spectroscopy. At the SPMS Conference which was held from 20 to 22 July 2009, he presented three public lectures titled “Academic responsibility and our future”, “Fascinating insights in Chemistry, Biology and Medicine by Nuclear Magnetic Resonance and Magnetic Resonance Imaging” as well as “Arts and Sciences — A personal perspective of Tibetan painting”. He shared with the participants, perspectives like relations between arts and sciences, how to become a successful scientist and scientist’s responsibilities.

Prof Rudolph Marcus presented a lecture titled “From ‘On Water’ and Enzyme Catalysis to Single Molecules and Quantum Dots, Theory and Experiment” at the SPMS Conference. Marcus theory, named after him, provides a thermodynamic and kinetic framework for describing one electron outer-sphere electron transfer and reveals information on such common phenomenon as photosynthesis and corrosion. He received the 1992 Nobel Prize in Chemistry for his contributions to the theory of electron transfer reactions in chemical system. He is an active Professor at Caltech and a member of the International Academy of Quantum Molecular Science.
Prof Anthony Leggett gave a lecture on “Some thoughts on the prospects for topological quantum computation” at the SPMS Conference which enthused many students and lecturers. He is widely recognized as a world leader in the theory of low-temperature physics, and his pioneering work on super fluidity was recognized by the 2003 Nobel Prize in Physics. He was knighted (Knight Commander) by Queen Elizabeth II in 2004 for “services to physics”.

Prof Jean-Pierre Serre delivered a lecture on “Modular forms: old questions and recent results” at the SPMS Conference. He is a French mathematician in the fields of algebraic geometry, number theory and topology. Prof Serre, at twenty-seven in 1954, is the youngest ever to be awarded the Fields Medal. He was also the first recipient of the Abel Prize in 2003.

Prof Pierre-Louis Lions received the 1994 Fields Medal for his mathematical work on the studies of nonlinear partial differential equations. He was the first to give a complete solution to the Boltzmann equation with proof. At the SPMS conference, he delivered a lecture titled “On Mean Field Games”. The participants were presented with Mean Field Games, a new class of mathematical models and problems introduced and studied in collaboration with Jean-Michel Lasry. The lecture infused a lot of thought to the current research model of Partial Differential Equations at NTU.

Prof Yang Chen Ning gave a plenary talk titled “Some Problems in Cold Atom Research” during the Conference In Honour Of Murray Gell-Mann’s 80th Birthday which was held from 24 to 26 February 2010. In 1957, at the age of 35, Prof Yang Chen Ning and Prof Lee Tsung-Dao received the Nobel Prize in Physics for their theory that the law of conservation of parity (mirror-reflection) does not apply to the weak force interactions between elementary particles. Prof Yang is also well known for his collaboration with Prof Robert Mills in developing a gauge theory of a new class.
Prof Murray Gell-Mann received the 1969 Nobel Prize in Physics for his work on the theory of elementary particles. His contributions span the entire history of particle physics, from the early days of the particle zoo to the modern day QCD. Along the way, even as he proposed new quantum numbers to bring order into the zoo, he had fun in naming them.

An interesting talk titled “Some Lessons from 60 Years of Theorizing” was presented by Prof Gell-Mann at the Conference In Honour Of Murray Gell-Mann’s 80th Birthday.

Prof Kenneth Geddes Wilson gave a plenary talk titled “Could the Testing of the Laws of Physics Ever Be Complete?” at the Conference In Honour Of Murray Gell-Mann’s 80th Birthday. He also held a dialogue session at the Physics Education parallel session with science teachers from local secondary schools and junior colleges.

He was awarded the 1982 Nobel Prize in Physics for his seminal approach, combining quantum field theory and the statistical theory of critical phenomena of second-order phase transitions i.e. for his constructive theory of the renormalization group.

Prof Gerard’t Hooft shared the 1999 Nobel Prize in Physics with Martinus J. G. Veltman for “elucidating the quantum structure of electroweak interactions in physics”. He has written a constitution for its future inhabitants and was awarded the Lorentz Medal in 1986 and the Spinozapremie in 1995. Prof Gerard’t Hooft delivered a lecture titled “Classical Cellular Automata and Quantum Field Theory” at the Conference In Honour Of Murray Gell-Mann’s 80th Birthday.
Research Highlights
**Biophysics**

Theoretical Biophysics emphasizes on the elucidation of the fundamental physical principles that govern the realm of protein science. Proteins are important biological macromolecules present in all organisms. Chemically they are simply polymers of amino acids, molecules that contain an amine group, a carboxyl acid group and a side chain that varies from one amino acid to another. To perform biological functions, proteins fold into one or more specific spatial conformations, driven by a number of non-covalent interactions. At NTU, these studies are embodied in an IAS Biophysics project, which employs coarse-grained models and simple force fields to capture the main physics behind the protein folding process. This project is led by Kerson Huang (IAS Senior Fellow and Nanyang Professor, Emeritus Professor of Physics, Massachusetts Institute of Technology), jointly with Chew Lock Yue of the School of Physical and Mathematical Sciences (SPMS, NTU).

Protein structures can be organized into four distinct levels: primary, secondary, tertiary and quaternary. Primary structures are the sequences of amino acids. Secondary structure refers to the highly regular local sub-structures. There are two main types of secondary structure: alpha helix and the beta sheet (β-sheet), first suggested by Linus Pauling in 1951. By enhancing the Conditioned Self-Avoiding Walk (CSAW) model, a model first proposed by Huang, the researchers in NTU and the Zhou Pei-Yuan Centre for Applied Mathematics in Tsinghua University, have made significant progress in the analysis of the formation of β-sheet.

In a recent article (Phys. Rev. E 82 (2010) 011915), the research group further developed a Hamiltonian approach to investigate the normal modes of protein secondary structures and the mechanism of α-β phase transition theoretically. The occurrence of the α-β transition within protein structures is known to be the source of prion disease. The team is currently investigating the dynamics of α-β phase transition by means of the CSAW model, and enhancing their theoretical model through the inclusion of stochastic dynamics.
Orchid Herbs Research

The Orchid Herbs Research is led by Hew Choy Sin (IAS, NTU), together with Chen Ken Shiung and Klaus Heese of the School of Biological Sciences (SBS, NTU), as well as Tan Swee Ngin of the National Institute of Education. Steven Schachter (Harvard Medical School) and Leung Ping Chung (Chinese University of Hong Kong) are the project group advisors. Steven Schachter is one of the world’s leading authorities on epilepsy whilst Leung Ping Chung is a TCM expert. Other collaborators for the project include Zhou Jun and Hu Jiangmiao from the Kunming Institute of Botany, Chinese Academy of Sciences.

The scope of the Orchid Herbs research project has widened, going beyond the isolation of useful compounds, and entering into the testing of putative compounds using different biological testing systems. In particular, the Group is studying the pharmacological effects of Tienma and Gouteng for the treatment of Alzheimer’s disease. Tienma is the dried tuber of the plant Gastrodia elata, and has been commonly used in Traditional Chinese Medicine (TCM) to treat headaches, epilepsy and infantile convulsions, etc. Gouteng is a herbal medicine also for the treatment of neurological diseases.

There have been several interesting findings, and some of these have been published in the international journals. The others have been presented during the Conference on the Recent Development in Chinese Herbal Medicine which was held in January 2010 at the Institute of Advanced Studies (IAS, NTU).
Research Highlights

Theoretical High Energy Physics and Cosmology

Cosmology and General Relativity

Asymptotic freedom in physics refers to the property that the interactions between particles become arbitrarily weak at short distances. This project, led by Kerson Huang (IAS Senior Fellow and Nanyang Professor, Emeritus Professor of Physics, Massachusetts Institute of Technology), involves the study of asymptotically free scalar potentials to construct a self-contained and self-consistent model to simulate the cosmological inflation, big bang, and solve the dark energy problem.

In a self-consistent treatment, the scalar potential should grow from zero at the big bang to something finite later. That is, it should vanish at small length scales — a feature known as “asymptotic freedom” (as mentioned earlier). The inflationary universe scenario postulates that at the very beginning of the universe, extremely rapid (superluminal) expansion occurred. The hot big bang scenario would then take over after the inflationary era.

The latest scientific finding in last decade is the discovery that the universe is not only expanding, but it is also accelerating in its expansion: under the influence of a mysterious dark energy.
Particle Physics

Particle physics is the study of fundamental constituents of matter and the forces of nature. Historically, much of our current understanding of modern physics is steadfastly anchored in particle physics. The completion of the Large Hadron Collider (LHC) in 2008 and its commencement of data readings in late 2009 will hopefully push the frontiers of particle physics further. The LHC, with an investment of more than $9 billion, is the world's biggest and also the most expensive science machine to date. Around 8,000 scientists work together on this long term project that demanded their full commitment in order to ensure that everything goes as planned.

Singapore has been leading many South-East Asian Nations in scientific research. It is important for the country to position itself so that the local scientists can benefit from the data coming out from the LHC and also contribute to the understanding of fundamental questions of nature. The theme of the theoretical particle physics project is "Phenomenology of Multi-Particle Production", with Yang Chen Ning (Nobel Laureate in Physics, 1957) and Gerard 't Hooft (Nobel Laureate in Physics, 1999) as the project group advisors. Emmanuel Tsesmelis (CERN) has also shown significant interest in the program.

The project aims to harness data from the LHC and test the signatures from typical seesaw mechanism for neutrino physics. It seeks to explore and understand multi-particle processes at LHC, plugging into the local National Grid Program and train students interested in particle physics on the analysis of data from LHC, as well as collaboration with Santa Fe Institute on related interdisciplinary issues involving particle physics.

A simulated event at CMS particle detector of the LHC of the European Particle Physics Institute, the CERN
Neutrino physics

In particle physics and cosmology, the origin of masses of both bright and dark matter is expected to be well understood at the tera-electron-volt (TeV) energy frontier that is being explored by the Large Hadron Collider (LHC). Based on TeV seesaw models, it is expected that we could interpret why neutrino masses are very small but yet their flavor mixing angles are very large. Going beyond a possible link between neutrino physics and collider physics, one may even speculate further a grand picture to establish a dynamical relationship between the cosmological matter-antimatter asymmetry and neutrino oscillations (see the figure).

Motivated in part by the testability of TeV seesaw mechanisms at the LHC, Phil Chan (IAS Associate Fellow and NUS), Low Hwee Boon (IAS Associate Fellow) and Xing Zhi Zhong (Institute of High Energy Physics, Chinese Academy of Sciences) have suggested a viable seesaw model of neutrino masses, in which the flavor structure is partly fixed with a novel flavor symmetry proposed by the Nobel Laureate Lee Tsung Dao and his collaborator, R. Friedberg in 2006. This work, entitled “Friedberg-Lee symmetry and tribimaximal neutrino mixing in the inverse seesaw mechanism”, was published in Phys. Rev. D 80 (2009) 073006. More research activities on neutrino physics are underway to reveal the underlying properties of elusive neutrinos and gain a deeper insight into their irreplaceable roles in astronomy and cosmology.
Quantum Information Science

Quantum information science is an emerging interdisciplinary area that involves the study of information theory at the microscopic (atomic) level. Already, many mathematicians, computer scientists, physicists, biologists, chemists and engineers are working side by side to probe the feasibility of information processing at the molecular and atomic level. In Singapore, this area has become one of the niche research focuses of the National Research Foundation and the Ministry of Education, resulting in the establishment of a Centre for Quantum Technology at the National University of Singapore (NUS).

The Institute of Advanced Studies (IAS, NTU) and the Centre of Quantum Technology (CQT, NUS) have been in partnerships for several years (since 2007). The organisation of the Asia Pacific Conference on Quantum Information Sciences and the Les Houches School of Physics were some examples of the joint efforts between CQT and IAS. The joint invitations of research scientists and visiting professors, like Anthony Leggett, Jorge Tredicce and Jean-Marie Francois, were also part of the CQT-IAS partnership.

In research, together with several European groups, the team has constructed entanglement witness for many-body problems using structure factors, and has shown several results concerning coupled cavities. Together with Li Da Fa at Tsinghua University, the IAS and CQT have also formulated a new quantum uncertainty principle, based on Wigner-Araki-Yanase-Dyson measure of entropy. The collaboration with Tsinghua University is part of an ongoing project between Tsinghua and NTU. The project is linked to the research group of Rainer Dumke at the School of Physical and Mathematical Sciences (SPMS, NTU). In theoretical computer science, Hartmut Kluack (SPMS, NTU) has recently joined the group of principal investigators at CQT to study quantum complexity theory, specifically in the area of communication complexity, space-time trade-off and approximation algorithms.
Research Highlights

a) The superconducting chip mounted on a cryostat. The chip consists of microstructures which allow efficient trapping and manipulation of ultra cold atoms. 
b) The atoms are trapped in magnetic fields generated by the vortices on the superconducting chip. c) As shown on the absorption image the atoms can be stored efficiently and manipulated in this novel trap.
Nanoscience

The nanoscience research topics cover the synthesis, properties and device applications of semiconductor nanowires, heterostructures and nanocarbons such as carbon nanotubes (CNT), graphene and carbon cones which are all currently under worldwide research focus.

Selected achievements include CNT-based biosensors, ZnO nanowire light-emitting diodes, Si nanowire photo-voltaics, and fundamental understanding and hydrogen storage application of graphene materials.

A Nanoscience Workshop was jointly organised by the Institute of Advanced Studies (IAS, NTU) and the Tsinghua University, from 26 to 28 February 2009, at the Physics Department of Tsinghua University. The purpose of the workshop was to initiate scientific collaborations as well as other possible formal cooperative activities between Tsinghua University and Nanyang Technological University. Twelve faculties from NTU and NIE participated in the workshop. In addition, the NTU team also visited Tsinghua Surface Sciences Lab and the Tsinghua-Foxcom Nanotechnology Research Center. The next workshop will be held in November 2010 at NTU.

As a support to the promotion of international nanoscience joint research, the IAS provided sponsorship for Fan Hong-Jin (SPMS, NTU) to attend and co-organize the Materials Research Society Spring Meeting in San Francisco from 5 to 9 April 2010.
Multiscale Analysis

Multiscale Analysis, Modeling and Simulation is an emerging research area which has made significant impact in many scientific disciplines, including Biology, Chemistry, Environmental Science, Fluid Dynamics, Geophysics, Information Science and Materials Science.

Despite considerable progress in a wide range of the sciences and a growing awareness of the importance of Multiscale approaches, currently there is fragmentation in Multiscale Methodology in analysis and applications. It is important to integrate these isolated efforts and diverse developments, and provide a unique opportunity to make significant advances.

An International Conference on Sparse Representation of Multiscale Data and Images was held on 14-17 December 2009 at the Institute of Advanced Studies (IAS, NTU).

This conference was organised by Thomas Hou (Caltech, USA) and Tai Xue Cheng of the School of Physical and Mathematical Sciences, NTU.
History of Science

The Institute of Advanced Studies (IAS, NTU) is expanding its activities to include initiatives with a stronger emphasis on humanities and social sciences. This is done in close collaboration with NTU’s College of Humanities, Arts and Social Sciences. One such initiative is the History of Science. The IAS will also draw on initiatives and collaborations with the National University of Singapore and the Institute for Southeast Asian Studies. Two joint conferences organized to-date are the International Conference “The Bright Dark Ages: Rethinking Needham’s Grand Question” (May 2010) and “Asia-Europe Dialogue and the Making of Modern Science” (May 2009).

Further collaboration is foreseen with the Needham Research Institute (Cambridge, UK) to develop this area further. The International Institute of Asian Studies (Leiden, the Netherlands) will also be involved. Ho Peng-Yoke (Director Emeritus of the Needham Research Institute) is a Senior Fellow of IAS. The IAS can play a significant role in further linking the scientific communities from Europe and Asia in the research on History of Sciences including wider areas such as science, technology and (Chinese traditional) medicine.

As the scientific community in this research area is more fragmented and less ‘institutionalized’ in Asia, such an initiative is particularly needed for further capacity building and networking, among the Asian and European scholars.
Conferences
The 100 Years of Physics Symposium in Singapore was jointly organized by the Institute of Advanced Studies (IAS, NTU) and the School of Physical and Mathematical Sciences (SPMS, NTU). As part of the World Year of Physics 2005, the Symposium was a unique outreach to a wider non-physics community and the next generation of scientists and engineers.

The Symposium’s Opening Ceremony was held at the Nanyang Executive Centre (NEC, NTU) on 10 August 2005 and was graced by Mr Tharman Shanmugaratnam (current Minister of Finance, Singapore). The keynote speakers included Prof Robert Laughlin (Nobel Laureate in Physics, 1998), Prof Alex Pines (Wolf Prize Winner, 1991), Dr Akira Tonomura (Imperial Prize Winner, 1991) and Prof Paul Davies (Templeton Prize Winner, 1995).
As part of the objective to reach out to a wider non-physics community and future researchers and scientists, the organisers of the symposium had also maintained an e-proceedings on its website www.100yearsofphysics.org.

An educational forum and a regional cooperation panel discussion were tied up during the symposium and had paved the way for future cooperation between institutions from different countries.

Welcome address by Dr Su Guaning

Mr Tharman Shanmugaratnam had a cordial conversation with Prof Tan Eng Chye and Prof Lee Soo Ying
Conferences

Conference in Honour of CN Yang’s 85th Birthday: Statistical Physics, High Energy, Condensed Matter and Mathematical Physics  | 31 October to 3 November 2007

As a tribute to Prof Yang Chen Ning on the occasion of his 85th Birthday and to celebrate his pioneering contributions to physics, a conference was held on 31 October to 3 November 2007 at the Swissotel Merchant Court. It was attended by distinguished scientists from around the world including several Nobel Laureates.

Over many years, Prof Yang has been a supporter of Nanyang Technological University (NTU) in education and research. In 1967, he attended an International Conference at Nantah’s Department of Physics (“Nantah” is the Chinese abbreviation of the former NTU). In 1971, Prof Yang was appointed as External Examiner for the Department of Physics, NTU. Prof Yang also accepted the Institute of Advanced Studies’ (IAS, NTU) invitation to be a member of the International Advisory Committee in 2005. When NTU organized the 37th International Physics Olympiad in July 2006, Prof Yang delivered two inspiring lectures to students and staff at NTU. During the event, he also launched the NTU’s CN Yang Scholars Programme designed for exceptional students with a deep passion in Science, Technology, Engineering, Mathematics and Research.

In conjunction with this unique conference, a series of events were held. These included CN Yang room dedication, signing of Memorandum of Understanding between NTU and Tsinghua University, Science Education Symposium, Asia-Pacific Meeting on Frontiers in Plasma Physics as well as Public Lecture by renowned Chinese artist Prof Fan Zeng and Prof Yang Chen Ning.

The Opening Ceremony of the conference was graced by Mr Tharman Shanmugaratnam (current Minister of Finance, Singapore) on 31 November 2007. The three-and-a-half day programme included three Public Lectures by Nobel Laureates, presentations by more than 60 invited eminent speakers and contributed talks by local and overseas researchers. The Nobel Laureates were Prof Walter Kohn (Chemistry, 1998), Prof Martin Perl (Physics, 1995) and Prof Claude Cohen-Tannoudji (Physics, 1997).
A room at the IAS was also dedicated to Prof Yang to mark the joyous celebration of his 85th Birthday on 30 October 2007. The Room-Naming Ceremony, held at Nanyang Executive Centre (NEC, NTU) was attended by Dr Su Guaning (President of NTU), Prof Bertil Andersson (Provost of NTU), Mr Anthony Teo (Secretary to the University), IAS committee members and many other VIPs. Prof Yang, accompanied by Mrs Yang, unveiled the plaque outside the room. Located on the fourth floor of the NEC, the room was styled with an interior design of a Balinese theme.

The conference banquet was held on 1 November 2007 at the Ballroom of Swissotel Merchant. President SR Nathan, President of the Republic of Singapore, was the Guest-of-Honour for the evening. The guests were entertained by a variety of performances including a Chinese instrumental duet, a Beijing opera and a mask changing show.

To commemorate the occasion, a special stamp with artwork specially drawn by Prof Fan Zeng, a book titled “Prof Yang Chen Ning at Nantah” and a gold-framed copy of the stamp were presented to Prof Yang at the Conference.
Proceedings of the Conference in Honour of CN Yang’s 85th Birthday

Special book titled “Professor Chen-Ning Yang at Nantah” presented to Prof Yang at the Conference
Prof Yang exchanged views with young students during a visit to Nantah in 1976

Prof Yang had a cordial conversation with students in the “Physics Seminar” held at Nantah in March 1976
Prof Yang held a cordial talk with Mr Lee Hsien Loong (current Prime Minister of Singapore) at the “25th International Conference on High Energy Physics” in August 1990. On the left is Prof Phua Kok Khoo, Chairman of the Organizing Committee for the Conference.
Prof Yang and his mother, Mrs Yang Meng Hua visited Singapore in February 1987. On the right is Prof Phua Kok Khoo.
A Science Education Symposium was held at the Hwa Chong Institution Auditorium on 2 November 2007. This event, sponsored by the Ministry of Education (MOE), was jointly organized by the Institute of Advanced Studies (IAS, NTU) and National Institute of Education (NIE, NTU). It was attended by more than 200 participants, including science teachers and students from 14 schools, NIE staff, MOE officials and overseas delegates. This symposium provided a rare opportunity for teachers and students to listen to leading scientists who shared their knowledge and experiences at school level.

Prof Leo Tan (Former Director of NIE) officiated the opening and chaired the first session of the Symposium. Prof Lee Sing Kong (Director of NIE), chaired the subsequent session of the Symposium.

The keynote speaker was Prof Walter Kohn, (Nobel Laureate in Chemistry, 1998). His talk featured excerpts from a new documentary on solar electricity titled “Power of the Sun” produced by Prof Kohn and Park Alan Heeger and narrated by John Cleese. This was followed by a presentation by Prof Michael Fisher, University of Maryland, on “Pictures, Models, Approximations & Reality: Phase Transitions and our understanding of the physical world”.

Prof Kerson Huang (Emeritus Professor of Physics, Massachusetts Institute of Technology and also IAS Senior Fellow), gave a lecture titled “Frontiers of Science in the 21st Century”, namely Quantum Engineering, Life Science and Cosmology. The final talk was delivered by Prof Igor Bray (Curtin University, Australia) on “Matter-Antimatter Interactions and their Applications”.

Prof Walter Kohn, Nobel Laureate in Chemistry, 1998
Conference on Particle Physics, Astrophysics and Quantum Field Theory: 75 Years since Solvay | 27 to 29 November 2008

The three-day High Energy Physics (HEP) Conference was held on the beautiful and scenic campus ground of Nanyang Technological University (NTU) with state-of-the-art facilities at the Institute of Advanced Studies (IAS, NTU).

Since the 1970s, Singapore was home to a strong group of particle physics enthusiasts. In 1990, Singapore hosted the 25th Rochester Conference (in conjunction with Singapore’s silver anniversary, the 25th National Day). The Opening Ceremony was graced by Mr Lee Hsien Loong (current Prime Minister of Singapore). And subsequently, the education and economic landscapes of Singapore have grown rapidly with focus placed on science and technology in the education system. At the Opening Ceremony of the Particle Physics Conference held on 27 November 2008, the Guest-of-Honour Mr Lui Tuck Yew (Acting Minister for Information, Communications and the Arts) also emphasized the important role that physics and engineering related sectors played in the economic development of the island state.

Having crossed the millennium, high energy particle physics continues to flourish once again well into the next decade. With numerous anticipated new data and results from the international collaborative experiments at CERN’s Large Hadron Collider, these events
will likely take us to a new level of fundamental knowledge — a physics realm beyond the present Standard Model.

Around 190 participants from 17 countries and 48 institutions congregated at this meeting of the great minds. The program featured three plenary talks by Prof Gerard’t Hooft (who presented *Crystalline Gravity*), Prof Martin Perl (who presented *Can the existence of dark energy be directly detected?*) and Prof Harald Fritzsch (who addressed the issue of flavor mixing, neutrino masses and neutrino mixing angles). Prof Gerard’t Hooft and Prof Martin Perl were both invited as Lee Kong Chian Distinguished Professors. There were a total of 23 specially invited HEP presentations, 33 parallel talks and 12 poster displays. There was a good mix of Theoretical and Experimental Talks. Updates on Fermilab (Fermi National Accelerator Laboratory), LHC (Large Hadron Collider), RHIC (Relativistic Heavy Ion Collider) were presented by Prof Dan Green, Prof Tatsuya Nakada and Prof Jim Thomas respectively. Dr Yasaman Farzan (Institute for Research in Fundamental Science, Tehran, Iran), winner of the first International Union of Pure and Applied Physics’s young theorist price in Particle Physics, delivered an impressive talk on CP violation. Physicists from Singapore also presented 9 parallel talks covering Neutrino Physics, Particle Phenomenology, Blackholes and Quantum Field Theory.

Running concurrently with the conference on the second day was a workshop dedicated to discussions about physics education in Singapore. There were interesting lessons learned from our Nobel Laureate speakers, Prof Gerard’t Hooft and Prof Martin Perl who spoke passionately on “Education in the Netherlands and the Nobel Prizes” and “Lessons in teaching Physics from my life in Teaching” respectively. The objective of the education
workshop was to discuss and explore possible actions to counter the trend of declining students’ interest in physics and other “hard core” disciplines in science and engineering. The workshop received overwhelming response and was well-attended by close to 100 school teachers and National Institute of Education trainees.

The conference banquet was held at the Raffles Hotel, Singapore’s prestigious landmark established since 1887. Amidst a lavish spread of Asian culinary delights and Chinese musical performances, Prof Chang Nggee Pong (City College of New York) gave a light-hearted speech on the title of the conference, with particular reference to “75 years since Solvay”. He mentioned that the conference signified an opportunity to reminisce the fundamental achievements of HEP physics since Solvay 1933.

The participants enjoyed the sightseeing tour of Singapore on 30 November 2008, which included places of interest such as Mount Faber, ViVo City, Marina Barrage and the Esplanade (“The Durian”). They were each given two bottles of “NEWater” which left them wondering if that was a new type of wine! Looking to the future, we are confident that there will be a steady increase in HEP activities in Singapore and South-East Asia.
The SPMS Conference 2009 was jointly organized by the Institute of Advanced Studies (IAS, NTU) and the School of Physical & Mathematical Sciences (SPMS, NTU). The three-day conference featured the following five Lee Kong Chian Distinguished Professors who shared their latest findings with the participants.

Prof Richard Ernst presented three public lectures titled “Academic responsibility and our future”, “Fascinating insights in Chemistry, Biology and Medicine by Nuclear Magnetic Resonance and Magnetic Resonance Imaging” as well as “Arts and Sciences — A personal perspective of Tibetan painting”.

Prof Rudolph Marcus presented his lecture titled “From ‘On Water’ and Enzyme Catalysis to Single Molecules and Quantum Dots, Theory and Experiment”.

Prof Anthony Leggett gave a lecture on “Some thoughts on the prospects for topological quantum computation” which enthused many students and lecturers.

Prof Jean-Pierre Serre delivered a lecture on “Modular forms: old questions and recent results”.

Prof Pierre-Louis Lions’s lecture titled “On Mean Field Games” infused a lot of thought to the current research model of Partial Differential Equations at NTU.
The International Conference on Sparse Representation of Multiscale Data and Images was held at the Nanyang Executive Centre (NEC, NTU) from 14 to 17 December 2009. This conference was jointly hosted by the Institute of Advanced Studies (IAS, NTU) and the School of Physical and Mathematical Sciences (SPMS, NTU). Prof Tom Hou (Charles Lee Powell Professor of Applied and Computational Mathematics from Caltech) and Prof Tai Xue Cheng (NTU) co-chaired this conference, which brought together experts in images, vision and scientific computing to exchange ideas and identify new research areas.

In recent years, there has been an explosive growth in the development of new efficient algorithms to represent multiscale signals, images and general data by exploiting the sparsity of these signals or images. At the same time, another exciting area called
adaptive data analysis emerges. Renowned speakers including Prof Bjorn Engquist, Prof Tom Hou, Prof Alfred M. Bruckstein, Prof Ron Kimmel, Prof Norden E. Huang, Prof Raymond Chan, Prof Chen Zhi Ming, Prof Patrick Flandrin, Prof Christoph Schnoerr and Prof Fadil Santosa from USA, Europe and Asia shared their recent works with the participants at the conference. Given that information technology and media innovation are one of the important research areas of NTU, the local community had a great time interacting with these leading international experts.

The conference also provided a forum for intellectual interaction with academic experts, and generated a greater awareness about the importance of reliable knowledge, a global mindset, diverse interests and deep passion in the pursuit of scientific excellence. An attractive feature of this interdisciplinary conference was the deep integration achieved within the topic during this four-day conference.

Apart from the formal event, some of the participants visited the Division of Mathematical Sciences at SPMS, as well as places like Marina Barrage and Chinese Heritage Centre.

Associate Prof Tai Xue-Cheng  
SPMS, NTU
In recent years, there has been an increasing trend of Chinese herbal medicine research being conducted in Research Institutions, Universities and Hospitals in Singapore. Therefore the Institute of Advanced Studies (IAS, NTU) had organized a two-day conference on the recent developments in Chinese herbal medicine, which served as a platform for local and overseas scientists to share and exchange their ideas and findings. The conference was held at the Nanyang Executive Centre (NEC, NTU) on 25 and 26 January 2010. It was jointly organized by the Consortium for Globalization of Chinese Medicine (CGCM), a non-profit global organization with the mission of advancing the field of Chinese herbal medicine to benefit humankind.

The conference comprised of two concurrent sessions: the main session in English (two-day) and a parallel session in Mandarin (half-day). IAS invited various prominent speakers including Prof Joseph M. Betz (National Institutes of Health, USA), Prof Leung Ping Chung (Chinese University of Hong Kong), Prof Steven Schachter (Harvard Medical School), Prof Tommy Cheng (Yale University and Chairman of the Board of Directors of CGCM) and Prof Zhou Jun (Kunming Institute of Botany, Chinese Academy of Sciences). Scholars and researchers from the USA, Korea, Japan, China, Canada, Hong Kong, Macao, Malaysia and local TCM students also took part in the conference.

The main session of the conference was further divided into four consecutive subsections, namely Policy/Challenges; Clinical Studies; Biological Activities/Mechanism; and Approach/Biological Activities/Mechanism. The conference covered a wide range of topics such as review of the problems encountered by the National Institutes of Health in approving research funding, characterization of botanical products, research design, constraints and development of herbal medicine in the region, debate over the scientific nature of Chinese medicine and approaches to the globalization of Chinese herbs. Recent clinical trials and the study of biological effect/mechanism of various herbs were also described and reviewed. The conference had included both Western and traditional views on the sciences of Chinese medicine. Through discussion and exchange of views, it was hoped that the gap between Chinese herbal medicine and Western medicine would be narrowed.

There were about 50 poster presentations featured at the conference, providing young graduate students and prospective researchers with a platform to showcase their latest findings and receive comments from celebrated senior scientists, TCM practitioners and Prof.
The conference speakers and participants are leading experts in the field of Chinese herbal medicine.
“The conference was excellent and it was an honour to participate.”

Prof Joseph M. Betz,  
National Institutes of Health, USA

“I was very happy to meet a lot of colleagues and to have an opportunity in sharing ideas with each other. I think the Symposium was one of the excellent meetings to know the state-of-the art on Chinese Medicine.”

Prof Kim Yeong-Shik,  
Seoul National University, Korea
The Conference in Honour of Murray Gell-Mann’s 80th Birthday was no ordinary conference. It was held from 24 to 26 February 2010 at the idyllic and beautiful premises of the Nanyang Executive Centre (NEC, NTU). The conference was graced by four Nobel Laureates and several renowned scientists across the globe who celebrated Prof Murray Gell-Mann’s 80th Birthday and his contributions to fundamental sciences.

The conference, chaired by Prof Harald Fritzsch and co-chaired by Prof Phua Kok Khoo, attracted around 250 participants from 33 countries, including the United States, Australia, Britain, China, France, Germany, India, Israel, Indonesia, Malaysia and Singapore. The four Nobel Laureates present at the conference were: Prof Yang Chen Ning (Physics, 1957), Prof Kenneth Geddes Wilson (Physics, 1982), Prof Gerard’t Hooft (Physics, 1999) and Prof Murray Gell-Mann (Physics, 1969). Prof Harald Fritzsch and
Prof Murray Gell-Mann delivering his speech

Prof George Zweig both shared a light-hearted account of their encounters with Prof Gell-Mann, with their lectures titled “Murray Gell-Mann — A Scientific Biography” and “Memories of Murray and the Quark Model” respectively.

Another highlight of the conference took place on the second day when all the participants were treated to a sumptuous banquet dinner at the Regent Hotel. The Guest-of-Honour, Mr Lim Chuan Poh (Chairman, Agency for Science, Technology and Research) paid tribute to Prof Gell-Mann for his efforts in deepening our understanding of the laws of Nature. Prof Kenneth Young (CUHK, Hong Kong), who was also Prof Gell-Mann’s student, spoke affectionately about his former PhD mentor.

In celebration of Prof Gell-Mann’s birthday, students from the Hwa Chong Institution put up a fine display of Wushu performance, an elegant fan dance and a captivating fusion of Eastern-Western music. The exotic music ensemble by the Hwa Chong’s Chinese Orchestra,

Talking about Singapore’s various research initiatives, from left: Dr Francis Yeoh (National Research Foundation, Singapore), Mr Lim Chuan Poh (Agency for Science, Technology and Research, Singapore), Professor Bertil Andersson (NTU Provost).

Prof Harald Fritzsch and Prof Phua Kok Khoo delivering their speeches
A toast to Prof Gell-Mann on the Banquet night
Hwa Chong Institution’s Chinese Orchestra culminating in the “Happy Birthday” song

highly commended by Prof Chang Ngee Pong (City College of New York), culminated in a “Happy Birthday” song. Everyone sang, clapped and cheered for Prof Gell-Mann who was visibly moved; he told us that he was very touched by the gesture of the audience at the banquet.

The last day of the conference ended with parallel sessions on Particle Physics, Quantum Mechanics and Complexity. In addition, more than 80 teachers attended a Physics Education Workshop which was held in conjunction with the conference. Most of the teachers who attended the workshop thoroughly enjoyed the captivating talks and hands-on activities at the workshop. The parallel sessions on Quantum Mechanics and Complexity began with two invited talks by Prof Kerson Huang (Emeritus Professor of Physics, Massachusetts Institute of Technology, and also IAS Senior Fellow and Nanyang Professor) and Dr Gunnar Pruessner (Department of Mathematics, Imperial College London). Prof Huang presented the idea of Conditioned Self-Avoiding Walk (CSAW) as a model of protein folding. Dr Pruessner gave an overview on the current development of Self-Organized Criticality (SOC). The special talks were followed by talks from researchers from Australia, Japan, the Netherlands, Indonesia, France, Russia, Brunei, Turkey and Singapore. The topics presented were wide-ranging, spanning from quantum entanglement to the complexity theory of business, social and biophysical systems.
Workshops

International Workshop on Spintronics | 8 to 12 May 2006

The Institute of Advanced Studies (IAS, NTU) successfully kicked off its first Workshop series from 8 to 12 May 2006 at the School of Biological Sciences. This first workshop focused on an emerging technology that promises to provide new devices that are faster and has lower energy consumption: Spintronics. Indeed, this new technology is expected to provide impetus for the microelectronics industry which is comparable to the development of transistor fifty years ago.

The Guest-of-Honour for the opening of the workshop was Dr Su Guaning (President of NTU). In his welcome speech, Dr Su remarked that “such pursuit and sharing of new knowledge is one of the goals of this Institute, and the Institute will be organizing many more such workshops to bring researchers together.” There were more than 130 participants hailing from 12 countries who attended the five-day workshop. Eminent speakers invited to the workshop include Prof David Awschalom (UCSB, USA), Prof Tomasz Dietl (Warsaw, Poland), Prof Sergei Ganichev (Regensburg, Germany), Prof Allan Macdonald (Texas, USA), Prof Lauren W. Molenkamps (Wuersburg, Germany), Prof Naoto Nagaosa (Tokyo, Japan), Prof Iunsaku Nitta (Tohoku, Japan), Prof Stuart Parkin (IBM, USA) and Prof Seigo Tarucha (Tokyo, Japan). They spoke on a range of pedagogical and research topics which ranged from theoretical topics on Quantum Spin Hall effect to experimental topics on magnetic race track as a novel storage class spintronics memory as well as the use of quantum dots for quantum computing.

The International Organizing Committee comprised of Prof Hideo Ohno (Tohoku), Prof Zhang Fu Chun (Hong Kong) and Prof Zhang Shou Cheng (Stanford) who also delivered keynote talks at the workshop. The participants interacted actively with the invited speakers throughout the workshop and enjoyed social programs such as the barbecue dinner at Marina South and a Banquet Cruise onboard the Imperial Cheng Ho III which cruised past the Sentosa and Western Anchorage.
The International Organizing Committee comprises Professors Hideo Ohno, Takao Nakamura, and Junji Noda, who also delivered keynote talks at the workshop. The participants interacted actively with the invited speakers throughout the workshop and enjoyed a full program with a banquet dinner at Marco Polo and a farewell dinner at the Imperial Hotel, which hosted the reception and Western Anchorage.

The workshops were a great success, with a high turnout of participants from around the world. The workshop started with an opening ceremony, where the organizers welcomed all attendees and introduced the invited speakers.

The workshops were divided into several sessions, each focused on different aspects of spintronics. The attendees had the opportunity to discuss the latest research and developments in the field, share ideas, and network with colleagues from around the world.

The workshops concluded with a closing ceremony, where the organizers thanked all attendees for their participation and contributions. The workshop was highly successful, and the attendees expressed their satisfaction with the program and the organization.

Participants of the International Workshop on Spintronics
Workshops

International Workshop on Multiscale Analysis and Applications
18 to 22 December 2006

The International Workshop on Multiscale Analysis and Applications, jointly organized by the Institute of Advanced Studies (IAS, NTU) and the School of Physical and Mathematical Sciences (SPMS, NTU) was successfully held at the Nanyang Executive Centre (NEC, NTU) from 18 to 22 December 2006. It was officially opened by Dr Su Guaning (President of NTU).

Multiscale phenomena abound in numerous areas of applications, such as Biology, Chemistry, Environmental Science and Engineering, Fluid Dynamics, Geophysics, Information Science, Materials Science and Engineering as well as Physical Science. Mathematical analysis has played an important role in developing multiscale modeling and computational techniques to study these multiscale problems. The interplay between mathematical analysis and developments of new multiscale methodologies has proved to be fascinating and challenging, which has resulted in tremendous growth of activities in this field. The objectives of this workshop were to identify some of the fundamental issues in this emerging area and, by bringing together experts from different areas, it was hoped that new insight may be found to the fundamental ways of modeling and predicting multiscale phenomena.

Co-chaired by Prof Tom Hou (Charles Lee Powell Professor of Applied and Computational Mathematics from Caltech) and Prof Ling San (SPMS, NTU), the workshop brought together about 40 researchers in the field, including many of the leading experts from all over the world. The programme featured many interesting talks where recent exciting developments were presented and in turn led to a very lively and stimulating discussion amongst the participants.

Apart from the high quality scientific programme, the participants also enjoyed an interesting social programme, which included the workshop banquet in the Hua Song Museum where it showcased the stories of Chinese communities from all over the world. There was also a half-day tour of the historical parts of Singapore for them to experience the multi-cultural aspects of the country, culminating in a boat ride along the Singapore River.
Speakers and Participants of the Workshop
Workshops

International Workshop on New Trends in Biomolecular Modeling: From Protein Folding to DNA Compaction | 15 to 16 March 2007

Prof Kerson Huang (Emeritus Professor of Physics, Massachusetts Institute of Technology and also IAS Senior Fellow) conducted a workshop titled “New Trends in Biomolecular Modeling: From Protein Folding to DNA Compaction” on 15 and 16 March 2007 at the Nanyang Executive Centre (NEC, NTU). Several other researchers working in related fields from China and Singapore were also invited to speak at the workshop. The invited speakers were Prof Ouyang Zhong Can (Chinese Academy of Science, Institute of Theoretical Physics, China), Prof Lai Pik Yin (National Central University, Taiwan), Prof Lei Jin Zhi and Prof Sun Wei Tao (Tsinghua University, China), Dr Chew Lock Yue (SPMS, NTU), Dr Mu Yu Guang (SBS, NTU), Prof Lars Nordenskiold (SBS, NTU), Prof Jagath C. Rajapakse (SCE, NTU), Prof Feng Yuan Ping (NUS), Prof Liu Xiang Yang (NUS), Prof Song Jian Xing (NUS), and Prof Neil Clarke (Genome Institute of Singapore).

There were energetic discussions on a wide range of recent developments in protein folding and DNA properties, such as dynamics of protein folding, DNA compaction, and objective assessment of protein structure prediction. A roundtable discussion was held at the end of the workshop, where regional collaborations between China, Taiwan, Singapore and other countries were proposed. Topics on encouraging physics and engineering students into biophysics research were also discussed. The workshop received more than 40 registrations, mainly from NTU and NUS, including a large proportion of graduate students.
International Workshop on Plasma Applications in Nanofabrication and Photovoltaic Solar Cells | 5 to 6 July 2007

A two-day International Workshop on “Plasma Applications in Nanofabrication and Photovoltaic Solar Cells” was held at the Nanyang Executive Centre (NEC, NTU) on 5 and 6 July 2007.

The workshop was jointly organized by the Institute of Advanced Studies (IAS, NTU), the National Institute of Education (NIE, NTU) and the University of Sydney, Australia. About 60 local and overseas researchers and academics attended this workshop. The guest speaker of the workshop was Prof Claude Cohen-Tannoudji (Nobel Laureate in Physics, 1997). He delivered a talk on “Measuring Time — Atomic Clocks and Ultracold Atoms”.

The Workshop focused on the major aspects of plasma applications in nanofabrication. In particular, the physics and applications of plasma systems for the fabrication and processing of nanostructured materials and high efficiency thin-film photovoltaic solar cells were discussed. This workshop was an effort to demonstrate the major advance in plasma applications in the area of renewable photovoltaic energy generation. It described the current methods used and the plasma-based tools that are used to achieve the as-yet-elusive goal of deterministic nanoassembly in nanoscale manufacturing.

The keynote lecture for this event was delivered by Prof A. Aberle (School of Photovoltaic and Renewable Energy Engineering University of New South Wales, Australia). Prof A. Aberle is also a renowned expert in thin film solar cell. The workshop was concluded with a special roundtable discussion involving distinguished speakers, academics and staff from NUS, NTU, NIE, A*STAR and the Economic Development Board.
Fourth Asia Pacific Workshop and Third Asia Pacific Conference on Quantum Information Science  | 30 July to 2 August 2007

A four-day International Workshop titled “Fourth Asia Pacific Workshop and Third Asia Pacific Conference on Quantum Information Science” (APWCQIS 2007) was held at the Nanyang Executive Centre (NEC, NTU) from 30 July to 2 August 2007. This was jointly organized by the Institute of Advanced Studies (IAS, NTU) and the Department of Physics, National University of Singapore (NUS). About 130 local and overseas researchers and academics attended this workshop.

The keynote speaker of the workshop was Sir Anthony J. Leggett (Nobel Laureate in Physics, 2003). He delivered three talks on “Review of some physical systems of possible interest for topological quantum computing” (Parts I and II) and “Failure of ‘local realism’ in EPR-Bell experiments: Is it locality or realism which is at fault?”
Since its conceptualization by Alan Turing, theoretical computer science has become one of the most prominent research areas. This covers a wide range of topics including algorithms, computational complexity, probabilistic and quantum computation, information theory, cryptography, coding theory, computational number theory and algebra. Most protocols rely on discrete mathematical structures such as finite fields, graph theory, set theory, combinatorics and discrete probability theory.

The objective of the workshop was to provide a forum about current problems and future developments of discrete mathematics and theoretical computer science with a particular focus on Coding Theory and Cryptography. There were 8 speakers from Singapore (6 from NTU, 1 from DSO National Laboratories and 1 from the Institute for Infocomm Research) and 7 from Tsinghua University (4 from the Department of Mathematical Sciences, 1 from the Centre for Advanced Study and 2 from the Institute for Theoretical Computer Science). In addition, 4 eminent plenary speakers namely Prof Yvo Desmedt (University College London, UK), Prof Piotr Indyk (MIT, USA), Prof Moni Naor (Weizmann Institute of Science, Israel) and Prof Andrew Odlyzko (University of Minnesota, USA) also delivered talks during the workshop. Many students of the Division of Mathematical Sciences, NTU attended the workshop as well. One of them presented his recent research outcomes as one of the six representatives from NTU. Apart from the formal event, all participants gathered during the banquet and the tour of Singapore in a friendly atmosphere, facilitating socialization.
NTU-Tsinghua Joint Workshop on Discrete Mathematics and Theoretical Computer Science held at NEC
**NTU-University of Tokyo Joint Symposium**  | 20 February 2009

The NTU-University of Tokyo Joint symposium 2009 was jointly organized by the Institute of Advanced Studies (IAS, NTU) and the Division of Physics and Applied Physics of the School of Physical and Mathematical Sciences (SPMS, NTU) on 20 February 2009. This symposium provided a platform for exchange of ideas, interaction and further collaboration. Topics covered at the symposium included Ultra Cold Atoms, Superconductivity, Correlated Systems, Photoemission and Optical Properties.

**Tsinghua-NTU Joint Workshop on Nanoscience**  | 26 to 28 February 2009

Following the signing of the Memorandum of Understanding by the Institute of Advanced Studies (IAS, NTU) and Tsinghua University in 2007, the Tsinghua-NTU Workshop on Nanoscience 2009 was the second series of joint workshops organized by the two Universities aimed at promoting synergy between the two Institutions.

This workshop was held at Tsinghua University from 26 to 28 February 2009. A total of 18 presentations were delivered during the three-day event with 10 presentations from NTU, namely Dr Yu Ting, Dr Fan Hong Jun, Dr Sun Han Dong, Prof Shen Ze Xiang, Dr Wu Tao, Associate Prof Sun Xiao Wei, Associate Prof Zhang Qing, Dr Yu Hong Yu, Associate Prof Rajdeep Singh Rawat and Prof Xu Shu Yan. The delegates toured the Tsinghua-Foxcomm Nanotechnology Center as well as the Tsinghua Department of Physics.

**Inaugural Institute of Physics Singapore March 2009 Meeting**  | 6 to 7 March 2009

The inaugural Institute of Physics Singapore (IPS) March 2009 Meeting sponsored by the Institute of Advanced Studies (IAS, NTU) was held from 6 to 7 March 2009 at the Nanyang Executive Centre (NEC, NTU). The meeting gathered physicists and engineers working in the Industry, Universities and Schools together for a genuine interaction on physics issues and matters.
The NTU delegates visited the School of Medicine, Tsinghua University from 15 to 17 May 2010. During the visit, there was a one-day joint workshop on Life Science Research organized by Prof Wang Zhao (Tsinghua) and Dr Klaus Hesse (NTU). The workshop marked another joint effort between Tsinghua University and NTU, aimed primarily to forge stronger research collaborations and exchanges between the two Institutions.

Prof Sun Fang Lin (Assistant Dean and Director of Academic Committee at the School of Medicine, Tsinghua University) gave the opening remarks at the beginning of the workshop in which he provided an excellent overview of the history and structure of the School of Medicine, Tsinghua University. Speaking on behalf of Prof Phua Kok Khoo (Director of IAS), Prof Kwek Leong Chuan thanked the local organizers for their hard work in this joint venture.

There were two plenary lectures: from the Tsinghua side, the plenary lecture was delivered by Prof Chang Jie Liang who elaborated on how the carboxyl terminus protein (CHIP) promote Runx, an essential transactivator for osteoblast differentiation; from the NTU side, Prof Richard J. Sugrue who talked about the interaction of the respiratory syncytial virus with host cells.

There were a total of 17 interesting talks covering a wide range of topics in the Life Sciences. Tsinghua faculty members delivered 10 talks and NTU faculty members gave 7 talks.

At the end of the workshop, Prof Hong Bo (Vice Dean of the School of Medicine, Tsinghua University, Beijing) gave the closing speech and commented on the interesting findings from the various speakers from Tsinghua and NTU. He hoped that the faculty members would be able to forge greater collaborations after the workshop.

The NTU delegates also visited several laboratories in the new Medical Science Building of Tsinghua University. They were very impressed with the organization, support, resources and research at the Tsinghua School of Medicine. The informal interaction and discussion with Tsinghua delegates were also beneficial.
Participants of the Tsinghua-NTU Joint Workshop on Life Sciences
COURSES AND SCHOOLS
**Prof Tom Hou**  
“**Computational Methods for Fluid Dynamics**”  
| 18 to 26 March 2006 and 5 to 10 May 2008  

As part of the IAS distinguished lecture series, Prof Tom Hou (Charles Lee Powell Professor of Applied and Computational Mathematics from Caltech), visited the Institute of Advanced Studies (IAS, NTU) from 18 to 26 March 2006. He conducted a well attended one-week intensive graduate course on “Computational Methods for Fluid Dynamics”.

In addition, he presented a seminar on his recent research activities. Many faculty members also met up with him to discuss potential mutual research interests and possible future collaborations.

The second series of the graduate course was conducted by Prof Tom Hou from 5 to 10 May 2008.

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**Prof Kerson Huang**  
“**Statistical Mechanics for Protein Folding**”  
| 4 to 28 April 2006  

Under the invitation by the Institute of Advanced Studies (IAS, NTU), Prof Kerson Huang (Emeritus Professor of Physics, Massachusetts Institute of Technology and also IAS Senior Fellow), conducted a graduate course on “Statistical Mechanics for Protein Folding”. This course was jointly organized by the IAS, Graduate Studies Office and the Division of Physics and Applied Physics (PAP, NTU). It was conducted from 4 to 28 April 2006 and the topics were based upon his recent book titled “Lectures on Statistical Physics and Protein Folding”.
Prof Chang Ngee Pong
“Frontiers of Modern Physics”
| 31 July to 25 August 2006 and 30 June to 25 July 2008 |

Prof Chang Ngee Pong (City College of New York, and also IAS Senior Fellow and Nanyang Professor) conducted a graduate module titled “Frontiers of Modern Physics” from 31 July to 25 August 2006. It was jointly organised under the auspices of Institute of Advanced Studies (IAS, NTU), Graduate Studies Office and the Division of Physics and Applied Physics (PAP, NTU). Prof Chang also interacted with the staff and students of PAP and gave them advice on physics, research and strategies for student recruitment.

Due to the good response, Prof Chang conducted the second series of the graduate course from 30 June to 25 July 2008.

“The Course was very well organized. Prof Chang was very knowledgeable and created an atmosphere of learning and curiosity for us. He was also very helpful and attentive to the needs of the class and taught us well. On the whole, I am extremely pleased and grateful for the course. Thanks to the Institute for organizing the successful graduate course.”

Cheng Yu Hua
MSE, NTU

“I appreciate the course by Prof Chang. He is really a respectable teacher with his solid physics profession, insight view, kind personality and pretty nice pronunciation.

I believe all the students who attended his lectures enjoy his course as I did. The only drawback, if there is any, is that we can only attend this course for one month.

If there are more lectures or courses like this, please let us know.”

Fan Zhong Cheng
SPMS, NTU

Prof Chang Ngee Pong
“Frontiers of Modern Physics”
Prof Mark Ainsworth
“Introduction to Finite Element Method”
13 to 17 November 2006

The Institute of Advanced Studies (IAS, NTU) and the School of Physical and Mathematical Sciences (SPMS, NTU) jointly organized a course on “Introduction to Finite Element Method” (FEM) from 13 to 17 November 2006 at the Nanyang Technological University (NTU).

The course was delivered by Prof Mark Ainsworth from the University of Strathclyde. He was awarded the Leslie Fox Prize at the age of 24 and he was a recipient of the prestigious Whitehead Prize awarded by the London Mathematical Society. The concepts of FEM were introduced gently through many Engineering application problems, together with fundamental Mathematical interpretations.

More than 200 postgraduates and faculty members from the different Engineering departments and the College of Science attended the course. The students gained a deeper understanding of the fundamentals of FEM, and also a broader appreciation of its applications which were useful for future research. The faculty members also benefited immensely through discussions and interactions with Prof Ainsworth to further strengthen the research in FEM within NTU.

In addition, Prof Ainsworth gave very interesting and informative talks to the CN Yang scholars on Numerical Simulations and Scientific Computing.

Prof Chang Ngee Pong
“EE9902 Quantum Physics in Modern Technology”
6 to 22 August 2007 and 29 June to 3 July 2009

Prof Chang Ngee Pong (City College of New York, and also IAS Senior Fellow and Nanyang Professor) conducted a special course titled “EE9902 Quantum Physics in Modern Technology” from 6 to 22 August 2007. It was a 3-AUs credit course for graduate students mainly from the School of Electrical and Electronic Engineering and the School of Mechanical and Aerospace Engineering.

Prof Chang introduced basic concepts behind quantum physics with the aim to inspire the Engineering students to understand and apply the principles used in modern technology. Applications of these principles to selected areas in nanotechnology were discussed. The enrollment was overwhelming and there were 61 students formally registered in this course.

The second series of the graduate course was conducted by Prof Chang from 29 June to 3 July 2009.
**Graduate Lecture Series by Invited Speakers: Prof Anthony Leggett, Prof Kerson Huang and Prof Chang Ngee Pong** | 28 to 30 July 2008

A three-day Graduate Lecture Series was held at the Nanyang Executive Centre (NEC, NTU) from 28 to 30 July 2008. Speakers for the series included Prof Anthony Leggett (Nobel Laureate in Physics, 2003), Prof Kerson Huang (Emeritus Professor of Physics, Massachusetts Institute of Technology and IAS Senior Fellow) and Prof Chang Ngee Pong (City College of New York, and also IAS Senior Fellow and Nanyang Professor). A variety of topics were covered, ranging from the wonders of Pure Mathematics and Quantum Physics, to the workings of Superconducting Qubits.

**Prof Karl Kimon Berggren “Introduction to Nanostructure Fabrication”** | 10 to 13 Mar 2009

The four-day course titled “Introduction to Nanostructure Fabrication” was conducted by Prof Karl Kimon Berggren from Massachusetts Institute of Technology at the School of Electrical and Electronic Engineering from 10 to 13 March 2009. A total of 40 staff and students participated in the course. It gave an overview of nanostructure fabrication, Optical Microscopy and Lithography.

The processing techniques for Thin-Film Deposition, Patterning, as well as practical tips and methods were also surveyed. The course was designed for engineers, students and scientists who were engaged in the research and development of Nanostructures and Nanoscale devices.
The Institute of Advanced Studies (IAS, NTU) organized the first “Les Houches” Session in Asia. The one-month Summer School held at the Nanyang Executive Centre (NEC, NTU) was organized by the Institute of Advanced Studies (IAS, NTU) in collaboration with the Les Houches School of Physics in France and the Centre for Quantum Technology (CQT, NUS). This was the first time that the Les Houches School of Physics, well-known as one of the premier summer and winter schools around the world, was held outside of France since its establishment in 1951.

The Opening Ceremony of the Summer School was held on 29 June 2009 with the French Ambassador, His Excellency, Mr Pierre Buhler as the Guest-of-Honour. Dr Su Guaning (President of NTU) and Prof Phua Kok Khoo (Director of IAS), addressed the guests...
and participants during the welcome speeches. Prof Leticia Cugliandolo (Director of École de Physique des Les Houches) gave a nice overview presentation on the Les Houches School of Physics in France.

The Les Houches School of Physics in Singapore aimed to attract young graduate students and researchers into these very active fields of research frontier. It offered an overview of the latest developments and allowed the participants to share the excitements and challenges of the community with experts in the fields of Ultracold Gases and Quantum Information.

“I’m really enjoying this school! You guys have done an amazing job putting all this together and I am really grateful to be here. Thanks.”

Katanya Kuntz
University of New South Wales Canberra, Australia

“Thank you very much for taking care of us during our stay throughout the period of the school. I personally am very much indebted. I have enjoyed the school greatly and certainly have learnt much from it. The hospitality was great. In fact far exceeding whatever expectations I had. Thank you again. Please accept the assurance of my highest regards.”

Jesni Shamsul
International Islamic University Malaysia, Pahang, Malaysia
Special Report of the Les Houches School of Physics in Singapore

To many physicists around the world, the “Ecole des Houches” is a brand name that is almost synonymous with the best Advanced Physics Education that a young physicist could ever get in his graduate years. Since its establishment in 1951 by Cécile DeWitt-Morette, the “Ecole des Houches” has maintained one of the highest standard and rigor in the organization of Physics Summer Schools. The school combines in-depth courses in the most advanced fields with appropriate pedagogy so that the materials covered in the school are accessible to beginners in the field. The school has trained generations of high-level scientific students, some of whom have since become Nobel Prize winners after their stint at the Les Houches Summer Schools either as a student or a lecturer.

The idea for the school was first mooted over coffee break sometime in 2007 by a group of French and local scientists namely, Prof Martial Dulcoy, Prof Berge Englert, Prof Benoit Grémaud, Prof Kwek Leong Chuan and Prof Christian Miniatura. It was felt then that Singapore was a good choice for a “Les Houches session” outside France for many reasons: her central location in Asia, the huge investments made by the Singapore Government in higher education as well as in Sciences and Technology research, the long collaboration history between Singapore and France (in particular between the Centre for Quantum Technologies (CQT, NUS) and the Centre National de la Recherche Scientifique (CNRS)).

The Nanyang Technological University (NTU) was selected as a suitable location within Singapore for its good facilities and infrastructures and also its relatively “remote” location in this tiny island of Singapore. The consent from the French Committee finally gave the whole venture a moral boost and made the Singapore session as the 91st Session of the long Les Houches Summer School history.

Primary Objective

One of the principal objectives of the Les Houches session in Singapore is to provide the best students within the Asia-Pacific region an opportunity to attend top-level courses typically provided by the Les Houches Advanced School in Europe. Indeed, it is a documented fact that few Asian students attend the sessions in France due to the long journey and funding issue.

Prof Leticia Cugliandolo (Director of Ecole de Physique des Houches) elaborated on the launch of the Summer School session in Singapore: “The idea of organizing a similar Summer School in Singapore is to “export” this sort of structure to East Asia and gather physics students from the neighbouring countries. France has an interest in strengthening Scientific and Academic links with the region and this appears as an excellent occasion to achieving this goal.”
For this first School which was held outside Europe, the topic chosen was decided as “Ultracold Gases and Quantum Information”. This topic was specially selected as it is an important and active area of research in physics in Singapore and the topic lies at the heart of an ongoing collaboration between CNRS and CQT. Moreover, NTU has also recently embarked on some Cold Atoms research, so the organization of the School could benefit NTU as well.

The organization of the summer course would help to enhance closer scientific and technological cooperation between Asian and European research centres. The Asian students would be keener to consider European and French Universities and Laboratories for their future studies.

Demographics
More than 110 postdoctoral fellows and graduate students applied for the School with more than half of the candidates coming from Asian countries. Nearly 67 participants were eventually admitted to the school, with approximately one third (19) being female students. Most of the selected students were graduate students rather than post-doctoral fellows (around 5). In terms of demographics, there were 21 different nationalities at the school. These participants came from the Universities and colleges of 16 different countries, with more than half of the participants (35) coming from Asian countries. 18 of the participants came from Singapore (NTU and NUS). Part of the reason for the strong representation from Singapore is due to the intensive research in cold atoms and quantum information in the country. Note that amongst the 18 participants from Singapore, there were about 6 different nationalities, reflecting the cosmopolitan nature of Singapore education system. There were also 23 participants from Europe with the majority (8) from France.
Scientific Direction

The Scientific Directors for the School were Prof Leticia Cugliandolo (Director of Les Houches, France), Prof Phua Kok Khoo (Director of IAS, NTU) and Prof Artur Ekert (Director of CQT, NUS).

The session itself was originally proposed and organized by Prof Kwek Leong Chuan (IAS, NTU, Singaporean Principal Organizer), Prof Berthold-Georg Englert (CQT, NUS), Prof Christian Miniatura (CNRS, INLN, Nice, French Principal Organizer), Prof Benoît Grémaud (CNRS, LKB, Paris) and Prof Martial Ducloy (CNRS, LPL, Villetaneuse).

Lecturers

To ensure a high level of pedagogical lectures, the lecturers for the School were specially selected for their expertise and ability to deliver clear and succinct lectures at graduate level. A total of 86 hours of lectures were delivered over the four weeks, excluding the special sessions by invited guests like Prof Anthony Leggett (Nobel Laureate in Physics, 2003), Prof Frédéric Chevy (LKB, Paris) and Prof Xing Zhi Zhong (IHEP, China). Originally, 96 hours were planned but one of the lecturers, Prof Daniel Estève could not attend due to health problems.

The lecturers for the fundamental courses were:

- Prof Valerio Scarani (CQT, NUS)
- Prof Dagmar Bruss (Düsseldorf, Germany)
- Prof Chiara Macchiavello (Pavia, Italy)
- Prof David Guery-Odelin (LCAR, Toulouse, France)
- Prof Patrizio Vignolo (INLN, Valbonne, France)

There were also topical courses:

- Quantum Cryptography by Prof Nobert Lütkenhaus (Waterloo, Canada)
- Quantum Optical Devices by Prof Christian Kurtsiefer (CQT, NUS) and Prof Antia Lamas- Linares (CQT, NUS),
- Ions And Atomic Devices by Prof Jürgen Eschner (ICFO, Barcelona, Spain)
- Disorder And Localization Phenomena by Prof Dominique Delande (LKB, Paris, France) and Prof Cord Müller (Bayreuth, Germany)
- Quantum Phase Transitions by Prof George Batrouni (INLN, Valbonne, France)
- Quantum Hall Effects by Prof Mark Oliver Goerbig (LPS, Orsay, France) and Prof Fermi Lüttinger liquids by Prof Thierry Giamarchi (Geneva, Switzerland)

Most participants felt that the lectures were excellent and pitched at the appropriate level. There were also good scientific interactions between the participants, lecturers and guest lecturers throughout the sessions.
Entertainment and social events

The official opening for the School on 29 June 2009 was graced by the French Ambassador to Singapore, His Excellency, Pierre Buhler. One of the enjoyable moments during the school was a celebration of the French National Day with wine and cheese during dinner on 14 July, the French National Day.

The celebration of the French National Day was indeed a memorable event for many Asian participants who have never seen the buffet of French wine and cheese. It was also a cultural event in which the participants were exposed to some French music (including the French national Anthem which the French lecturers and participants sang with gusto).

The group also celebrated five birthdays – for people at the school who were born in the month of July during the celebration (Prof Martial Ducloy, Bess Fang, Christopher Gaul, Huo Ming Xia and Zahra Shadman).

Participants at the School had access to many sports facilities including the swimming pool nearby at NTU and enjoyed several sports events like basketball and football matches during the School. There were also other special “outings”, including a visit to CQT which provided substantial funding for the school. Tours were also conducted to the research laboratories at the School of Physical and Mathematical Sciences at NTU. It was also not all work and no play. Special activities, like trips to Sungei Buloh and Pulaau Ubin were organized every Saturday for all participants.

More adventurous students at the school visited neighboring countries like Malaysia, Indonesia and Thailand during the weekends when they were free to arrange their own activities. The students, especially those coming from Europe, were deeply impressed with what they saw during these getaways and shared their adventures with other participants at the School. It was a unique experience that the participants would not forget and was surely an attractive flavor of the Singapore session.

Prof Phua Kok Khoo (Director of IAS) commented: “One of the key success factors of Les Houches in France is the stringent selection criteria and the insistence on good lectures and a high level of rigour, supplemented with good pedagogy in these courses. IAS will continue to collaborate with strategic partners such as Les Houches School of Physics, to develop similar programs so that NTU, NUS, and eventually Singapore and Asia, will benefit from these programs in the long term.”

The organizers would like to thank the Les Houches Scientific Advisory Board for their support and advice and also appreciate the support from staff at the French Embassy in Singapore, particularly Mr Antoine Mynard, Mr Olivier Guyonvarch, Mr Marc Piton and Mr Walid Benzarti.

Moreover, the school would not have been possible without the generous financial support of the Merlion Program, CNRS (PICS) and University of Nice Sophia. Some of the social events would not have been possible without the support of French companies like Carrefour.
Participants enjoying discussions with Prof Anthony Leggett (Nobel Laureate in Physics, 2003)
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Courses and Schools

Colloquia
23 February 2007 | Prof Salk Sung Ho
“Spin-charge coupling in High Tc Superconductivity; 2-D systems of strongly correlated electrons”

Prof Salk is a Professor of Physics at the Korea Institute for Advanced Study (KIAS) and Vice President of the Korean Academy of Science and Technology. Prof Salk is a well known theoretician who specializes in many areas of Physics, including Classical and Quantum Phase Transitions in High Tc Superconductivity, Strongly Correlated Electron Systems, Gauge Theory and Quantum Field Theory, Low Dimensional Physics, Nanoscience and Chemical Physics. He has more than 500 publications in leading international journals.

Prof Steven Schachter
22 October 2008 | “Overview of Epilepsy”
23 October 2008 | “Neurotechnology and Epilepsy”
5 November 2008 | “TCM and Epilepsy”

Prof Schachter (Director of Research, Department of Neurology, Beth Israel Deaconess Medical Center, Harvard Medical School) was invited to NTU as Tan Kah Kee Professor from 18 October to 8 November 2008.

He gave three lectures to the School of Biological Sciences (SBS) double degree students majoring in Biomedical Sciences and Chinese Medicine. He felt that the double degree program was unique and provided intensive training for students who study Life Sciences and Traditional Chinese Medicine (TCM). The degree program also prepared them to work on herb-related medicine research, an area which he felt was gaining attention in recent years.

Through his inspiring lectures and visits, Prof Schachter had provided the students with the latest updates on the treatment of epilepsy using TCM. He also offered an invaluable insight into the Harvard Plant Products Program with information on how to relate TCM to modern medical treatment. In addition, he shared how the study of the artworks of contemporary artists suffering from epileptic condition could shed light onto the world that the epilepsy patients were living in.

Prof Schachter also had discussions with the SBS staff who were actively involved in Neurobiology research, as well as with the Medicinal Chemistry group at the School of Physical and Mathematical Sciences.

7 and 8 January 2009 | Prof Leung Ping Chung
“Understanding Medicine” and “Research on Chinese Medicine”

Prof Leung Ping Chung (Chairman of the Institute of Chinese Medicine, Chinese University of Hong Kong) presented two lectures on “Understanding Medicine” and “Research on Chinese Medicine” to the Biomedical Sciences students at the School of Biological Sciences on 7 and 8 January 2009 respectively.
11 January 2010 | **Prof Emmanuel Tsesmelis**

**“CERN and its Particle Physics Programme”**

Prof Emmanuel Tsesmelis from CERN delivered a wonderful speech to the NTU students on “CERN and its Particle Physics Programme” at the School of Physical and Mathematical Sciences on 11 January 2010. He discussed about CERN Laboratory’s primary aims and the basic ingredients of the LHC programme - The Superconducting Accelerator, The High-Precision Particle Detectors and The High-Performance Computing.

11 February 2010 | **Prof Amnon Aharony**

**“Writing and Reading Spin Information on Mobile Electronic Qubits”**

and | **Prof Ora Entin-Wohlman**

**“New Clues in the Mystery of Persistent Currents”**

Prof Amnon Aharony and Prof Ora Entin-Wohlman from Ben Gurion University, Israel delivered talks on “Writing and Reading Spin Information on Mobile Electronic Qubits” and “New Clues in the Mystery of Persistent Currents” respectively at the School of Physical and Mathematical Sciences on 11 February 2010. Prof Amnon Aharony’s lecture focused on mobile electrons, which moved through Mesoscopic Quantum Networks (made of quantum wires or of arrays of quantum dots). Prof Ora Entin-Wohlman talked about her findings on the Superconducting Transition of Measured Persistent Currents in Copper and Gold.

27 February 2010 | **Prof Yang Chen Ning**

**“An Interesting Parlor Game and Its Meaning”**

Prof Yang Chen Ning (Nobel Laureate in Physics, 1957) gave a special lecture titled “An Interesting Parlor Game and Its Meaning” to the NTU and NUS students on 27 February 2010. It was held at the Lee Kong Chian Lecture Theatre, NTU. He illustrated Dirac’s game with simple algebra and then went on to talk about the Mathematics of knot theory, including the introduction of Alexander Polynomial and Jones Polynomial. He showed how these Mathematics were connected to the study of many-body interactions phenomena in Physics and others. Dr Su Guaning (President of NTU), chaired the lecture which was well attended by close to 900 students.

16 April 2010 | **Prof Marvin Weinstein**

**“Strange Bedfellows: Quantum Mechanics and Data Mining”**

Prof Marvin Weinstein from Stanford Linear Accelerator Centre, Stanford University delivered a wonderful speech to the NTU students on “Strange Bedfellows: Quantum Mechanics and Data Mining” at the School of Physical and Mathematical Sciences on 16 March 2010. He discussed about the basic problem of data clustering, reviewed the basics of clustering approaches and explained how Dynamic Quantum Clustering work. He also presented an interesting demonstration of the computation for a simple data set.

4 May 2010 | **Prof Li Zheng Cao**

**“Materials Issues in Ageing Management and Maintenance of Nuclear Power Plants”**

Prof Li Zheng Cao from the Department of Materials and Science Engineering, Tsinghua University visited NTU and delivered a speech to the NTU faculty and students on “Materials Issues in Ageing Management and Maintenance of Nuclear Power Plants (NPPs)”. It was held on 4 May 2010 at the School of Electrical and Electronic Engineering, NTU. Prof Li gave an overview on the NPPs development status in China, and discussed about the maintenance problems of the NPPs.
Outreach
37th International Physics Olympiad

8 to 17 July 2006

The 37th International Physics Olympiad (IPHO), the most prestigious Physics competition for Pre-University students, was held at the National Institute of Education (NIE, NTU) from 8 to 17 July 2006.

IAS was the co-organizer of the 37th IPHO, together with the Ministry of Education (MOE), National Institute of Education, Nanyang technological University, National University of Singapore and the Institute of Physics Singapore. Professor Xu Shuyan was the Chairman and Professor Kwek Leong Chuan together with Professor Tang Sing Hai of NUS were the Vice-Chairmen of the 37th IPHO. Many world renowned scientists were invited to this special event, including 4 Nobel Laureates, a Templeton Laureate and about 800 competitors, leaders and officials from 86 countries. The event was extensively covered worldwide by leading International TV crews, news agencies and mass media.
Special talks for CN Yang Scholars

Prof Low Boon Chye on “Science and Scientific Methods as I have come to know”

21 March 2007

Prof Low Boon Chye (Senior Scientist from the National Centre for Atmospheric Research Boulder, Colorado USA) gave an inspiring seminar on 21 March 2007 to more than 30 CN Yang Scholars. The seminar was held at the Nanyang Executive Centre (NEC, NTU).

The seminar literally opened with a bang, as a short video on solar flares was screened. Through interesting and mind-stimulating questions about the fundamental concept of nature, Prof Low proceeded to share his personal views on the Philosophy of Science. Drawing examples from the historic milestones of Physics, Biology and Mathematics, he gave fresh and alternative perspectives to the basis for Science and Scientific research. He also shared with the audience his personal experience of being an aspiring researcher in his younger days. In doing so, he stressed the beauty and importance of language in the scientific arena.

The engaging and interactive style of the seminar captivated the audience and refueled their passion for research. The seminar was so exciting that the Professors from NTU also took the opportunity to join in the sharing of research experiences. Each viewpoint raised by the students and Professors was unique, and every experience shared was valuable.

The seminar was indeed a fruitful one. The mind-stimulating perspectives on the Philosophy of Science have broadened the horizons for the young audience. The real-life research experiences shared will continue to inspire them and boost their passion for Science.

Wan Chee Yuen
Chemical and Biomolecular Engineering
CN Yang Scholars Program

“Prof Low’s talk was a real eye-opener and it gave us useful insight into the life of a researcher.”

Ms Cheryl Seow
A first-year student majoring in Physics

“He (Prof Low) did not just talk about developments in science, but he went into the very fundamentals that can be applied across all scientific disciplines.”

Ms Jillian Pakiam
A first-year student majoring in Biological Sciences
Outreach

Interactive Sessions with CN Yang Scholars

Prof Chang Lay Nam | 13 July 2007

Prof Chang Lay Nam (Dean of the College of Science at Virginia Tech) was invited by the Institute of Advanced Studies (IAS, NTU) to give a special talk to the CN Yang Scholars. Prof Chang had been working in the Physics faculty at the University of Pennsylvania for seven years before joining the Virginia Tech in 1978. An outstanding educator and scientist, he had conducted research at Massachusetts Institute of Technology and the University of Chicago and had been Visiting Professor of various Institutions of higher learning around the world.

Beginning with the comment that it is an exciting time to be a scientist, Prof Chang cited sequencing of the human genome and new forms of therapies as evidence that the discoveries of today were what scientists in his time could only talked about. The fact that more than 70 percent of Gross Domestic Product (GDP) today was predicated upon findings of the past decade, demonstrated the rapid rate of scientific advancements. Boundaries are blurring, not just between Pure and Applied Sciences, but also across many aspects of human life. Prof Chang emphasized the importance of teamwork in research by leveraging upon each member’s strength so that more can be accomplished in the quest for knowledge.

Prof Chang went on to share his insights on the requirements of being a successful scientist. The most notable of which is to have a healthy sense of curiosity and willingness to question and ponder over things that may seem obvious or silly. This quality of being inquisitive, when used in moderation and in appropriateness, is essential in breaking new grounds.

A significant portion of the talk was devoted to the discussion on the fatal shootings at Virginia Tech in April 2007. The mention of mental illnesses being a stigma in America and how the shooting incident called for more research, help and therapy in this area was touched upon. In addition, issues regarding the complicated nature of stereotypes and prejudices were raised.

The audience benefited greatly from Prof Chang’s talk. His sincerity touched the hearts of the participants and left them inspired to ponder about his final words of daring to question, to buck the trends and to be different.

Ang Gim Yean
Chemical and Biomolecular Engineering
CN Yang Scholars Program

Prof Yang Chen Ning | 3 March 2010

Named in honour of Prof Yang Chen Ning, one of the greatest Scientists of the era, the CN Yang Scholars Programme is one of the premier undergraduate programmes at Nanyang Technological University (NTU) for Science and Engineering students. To many of the students under the programme, Prof Yang Chen Ning is a model Scientist par excellence. It was therefore a great honour for many of them when they were given the chance to interact with Prof Yang at a special dialogue session for the students. During the dialogue session, many students were keen to find out Prof Yang’s perspectives and opinions regarding the future directions of Physics, Mathematics and Engineering research. They also wanted to know how they could do better in research as students and how they should cultivate their interest in Science and Engineering.
An inspiring dialogue session with Prof Yang Chen Ning (7th from left)
Prof Kerson Huang (Emeritus Professor of Physics, Massachusetts Institute of Technology and IAS Senior Fellow), delivered a seminar on Science and Culture to NTU students. All who attended the interactive seminar were captivated as Prof Huang’s presentation shed light on the cultural thinking of the Westerner and the Chinese, how they were different, and how this led to the technological gap between these two civilizations.

His interesting insights, no doubt gleaned from his experiences in mainland China and in the United States, piqued much interest from his avid listeners as he richly coloured his presentation with examples. For instance, he highlighted the story of Zheng He’s worldly travels, and how he returned only with gifts from the lands he explored. In comparison, Western trips such as that of Christopher Columbus resulted in discoveries and expansion into new lands. The Chinese interest in spreading their cultural influence and learning about other cultures contrasts starkly with the Western interest in colonization and conquering of newly discovered lands.

Prof Huang went on to elaborate how the Chinese, invaded by various foreign powers after her unification, managed to continually integrate their thinking and practices into its own culture, and hence felt no urgent need for technological development. In contrast, Western history was rife with lots of conflict and civil fighting, spurred by intolerance for alternative ways of thinking. This created a continual need for more power and hence, better technology in order to suppress opposition. This need, together with the influence of the Renaissance age, spurred rapid scientific and technological development in the West.

Prof Huang also compared Chinese and Western ways of thinking; while the Chinese explained observed occurrences with mythology and tales, the Westerners sought scientific and factual explanations to these occurrences, thus spurring the development of science and technology. This was summed up with a tongue-in-cheek example: the Chinese dragon is always seen with its feet and claws hidden in clouds; its mode of flight is unknown. The Western dragon, on the other hand, is always pictured with wings as an attempt to explain its flight.

The seminar had been very interesting and thought-provoking, and all who had attended walked away with a greater awareness of how a civilization’s culture and thinking affected its pursuit and advancement of science.
Leveraging on the Institute of Advanced Studies (IAS, NTU) excellent international linkages in the academic world, three Nobel Laureates and other eminent scientists were invited to share their life experiences and impart their passions in Science at the inaugural International Science Youth Forum (ISYF). The Nobel Laureates were Prof Sir Anthony Leggett (Physics, 2003), Prof Douglas Osheroff (Physics, 1996) and Prof Kurt Wüthrich (Chemistry, 2002).

The five-day forum, jointly organized by IAS, NTU and the Hwa Chong Institution (HCI), was held from 19 to 23 January 2009 in conjunction with HCI’s 90th anniversary celebrations. The event was sponsored by Temasek Foundation and co-sponsored by BASF, with support from the Ministry of Education (MOE).

“The International Science Youth Forum provides a useful platform for budding scientists to develop a sense of community in the creation of knowledge and innovation” commented by Agency for Science, Technology and Research (A*STAR) Chairman, Mr Lim Chuan Poh, at the closing ceremony. “This greatly enhances the global body of scientific knowledge and accelerates scientific breakthroughs.”

The forum, congregating in its inaugural event 82 outstanding science students and 28 science educators from 25 secondary schools and junior colleges in China, Hong Kong (SAR), Indonesia, Malaysia, Philippines, Taiwan, Thailand, Vietnam, and Singapore, was the first of its kind for high school and Pre-University students in Asia which created a high-profile platform for science students from Asia to network with their counterparts. It also provided an avenue for intellectual dialogue and engagement with Nobel Laureates and eminent scientists, thus generating greater awareness about the importance of broad-based knowledge, diverse interests, deep passion, tenacity and a global mindset in the pursuit of scientific excellence.
Quotes from Student and Teacher Delegates:

“The inaugural ISYF 2009 has been an enriching and enjoyable experience for the entire student and teacher delegate. The overwhelming success of the ISYF would not have been possible without the active participation of our student delegates, and their passions for Science and knowledge.”

Tay Jian Hua
Chairperson
Student Organizing Committee
Hwa Chong Institution, Singapore

“The Nobel Laureates shared how their research produced unexpected results only when they refused to quit. This courage to take the road less travelled and to persevere in one’s beliefs is both an inspiration and an encouragement to us as young Science researchers.”

Fang Ewe Jiunn
Chung Ling High School, Malaysia

“This student-led Forum has impressed many of the educators present at the ISYF. Interacting first-hand with the Nobel Laureates has also proven to be an eye-opening experience for our students and we hope that they will go back to share the insights they have gleaned with their peers so that more will be enthused about Science and research.”

Ms Wang Pei Dong
Principal
The High School of Xi’an Jiaotong University, China
2nd International Science Youth Forum @ Singapore with Nobel Laureates for High School Students | 19 to 22 January 2010

The Institute of Advanced Studies (IAS, NTU) organized the 2nd International Science Youth Forum (ISYF) from 18 to 22 January 2010 at the Hwa Chong Institution. IAS invited five Nobel Laureates, namely Prof Jerome I. Friedman (Physics, 1990), Prof David J. Gross (Physics, 2004), Prof Leland H. Hartwell (Physiology or Medicine, 2001), Prof Douglas D. Osheroff (Physics, 1996) and Sir Richard J. Roberts (Physiology or Medicine, 1993), and Emeritus Professor David Phillips (President-elect of the Royal Society of Chemistry, UK) to the Forum. The ISYF 2010 brought together 93 outstanding Science students and 29 Science educators from 26 secondary schools and junior colleges from Brunei Darussalam, China, Hong Kong SAR, Indonesia, Japan, Malaysia, the Philippines, South Korea, Taiwan, Thailand, Vietnam, and Singapore.
Inaugural Lecture of the Raffles Laureate Series | 6 August 2009

The Raffles Institution, in partnership with the Institute of Advanced Studies (IAS, NTU), organized the Inaugural Lecture of the Raffles Laureate Series by Prof Anthony Leggett (Nobel Laureate in Physics, 2003) on 6 August 2009. With the Raffles Laureate Series, the school is setting its sights on higher ground, to produce even more future global leaders in Science and the Humanities, including Singapore’s first Nobel Prize winner.

“As the top educational Institution in Singapore, RI is the logical choice for these Nobel Laureate lectures to take place. It was hoped that by giving students such privileged access to these great minds, the students will be inspired to achieve the highest aspirations in their pursuit of the frontiers of knowledge, as represented by the Nobel Prizes, the pinnacle of recognition.” said Prof Phua Kok Khoo (Director of IAS, NTU).

Prof Leggett’s lecture topic was “An Unusual Route to the Nobel Prize and the Possibility of Moving Backwards in Time” in which he shared his inspiration and experiences driving his lifelong career as an explorer and experimenter, in particular the lessons he had gleaned from winning a Nobel Prize. There was also a Q & A segment, chaired by Dr Su Guaning (President of NTU).

2nd Lecture of the Raffles Laureate Series | 21 January 2010

The second lecture of the Raffles Laureate Series was delivered by another Nobel Laureate, Prof Douglas D. Osheroff (Nobel Laureate in Physics, 1996). In his lecture titled “My Story of Discovery”, he talked about his life in high school, how a teacher influenced the way he looked at science, and also his undergraduate and graduate life. He inspired the students to go into experimental Science, and also shared with them about his scientific discoveries.
Public Lectures
20 September 2005 | **Prof Douglas Osheroff**  
“Global Warming and Energy Policy for the 21st Century”

Prof Douglas Osheroff (Nobel Laureate in Physics, 1996) gave a public lecture on “Global Warming and Energy Policy for the 21st Century” on 20 September 2005 at NTU. On the same day, he had an interactive session with the undergraduate students from the School of Physical and Mathematical Sciences in which he shared his experiences and journey in obtaining the Nobel Prize.

7 April 2006 | **Prof Kerson Huang**  
“The Story of Quantum Theory”

In the excerpt from his book “Fundamental Forces of Nature” (refer the Special Articles section), Prof Kerson Huang (Emeritus Professor of Physics, Massachusetts Institute of Technology and also IAS Senior Fellow) noted that “in that magnificent edifice that was classical physics, the atom appeared merely as a convenient metaphor. There was no hard evidence for its existence, and there were prestigious voices against it….When we finally acquired the ability to really “listen” to the atoms, however, we were not prepared for what we heard.” In the excerpt, Prof Huang was talking about the heroic struggle for Quantum Theory. His talk on 7 April 2006 traced the development of Quantum Theory from spectroscopic data to Bohr’s atom to the Heisenberg uncertainty principle.

11 October 2005 | **Prof Leung Ping Chung**  
“The Challenge of Research on Chinese Medicine, Some Clinical Trials Using Chinese Medicine – Methodology and Difficulties”

Prof Leung (Chairman of the Management Committee of the Institute of Chinese Medicine, Chinese University of Hong Kong) gave a talk titled “The Challenge of Research on Chinese Medicine, Some Clinical Trials Using Chinese Medicine – Methodology and Difficulties.” He shared with the audience his experience on evidence based clinical trials for the Chinese medicine, from preparations of the herbal compounds to the interpretations of results.
10 May 2006 | **Prof David D. Awschalom**
“*Beyond Electronics: Spintronics and Quantum Computers*”

The Institute of Advanced Studies (IAS, NTU) jointly organized a public lecture titled “Beyond Electronics: Spintronics and Quantum Computers” with the Hwa Chong Institution and Tan Kah Kee International Society on 10 May 2006 at the Hwa Chong Institution Auditorium. The invited speaker was Prof David D. Awschalom from the University of California, Santa Barbara. He is also the Director of the Centre for Spintronics and Quantum Computation and Associate Director of the California Nanosystems Institute.

Prof Awschalom began his lecture by giving a brief insight into the current semiconductor technology and its limitations. He then went on to explain to the audience an insight into the significance of various current research projects and findings on Spintronics.

The lecture was well attended by about 200 teachers and students. Among the audience were scholars from the Agency for Science, Technology and Research (A*STAR). Throughout the lecture, Prof Awschalom engaged the audience by posting questions and encouraging students to ask questions. His clear and engaging delivery obviously generated interest on the prospect of Spintronics among the students. The lecture not only allowed the students and teachers to learn from Prof Awschalom, it also motivated them to forge ahead with their research interests.

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11 April 2006 | **Prof Lee Yuan Tseh**
“*My Experience of Becoming a Scientist*”

Prof Lee Yuan Tseh (Nobel Laureate in Chemistry, 1986) delivered a public lecture on 11 April 2006 at NTU. Titled “*My Experience of Becoming a Scientist*”, Prof Lee’s lecture was filled with interesting insights on his self-development and achievements as a scientist. And contrary to the common belief that a scientist is rational, cruel and even weird, Prof Lee explained that the life of a scientist can also be fun, beautiful and full of aspiration.
9 July 2006 | **Prof Yang Chen Ning - “My Life”**

Prof Yang (Nobel Laureate in Physics, 1957) shared his life experience by giving a talk titled “My Life” on 9 July 2006, as part of the launching of the CN Yang Scholars Program. He also gave another talk on “Symmetry & Physics” as part of the 37th International Physics Olympaid on 10 July 2006.

9 July 2006 | **Prof Aaron Ciechanover**

“The Ubiquitin Proteolytic System: From Basic Mechanisms through Human Disease and onto Drug Targeting”

Prof Aaron Ciechanover (Nobel Laureate in Chemistry, 2004) delivered a public lecture titled “The Ubiquitin Proteolytic System: From Basic Mechanisms through Human Disease and onto Drug Targeting” on 9 July 2006 at NTU and many students attended his lecture.

8 September 2006 | **Prof Low Boon Chye**

“The Inconstant Sun”

Prof Low Boon Chye (Senior Scientist from National Centre for Atmospheric Research Boulder, Colorado USA and Tan Kah Kee Professor) gave a public lecture titled “The Inconstant Sun” on 8 September 2006 at NTU. The lecture was attended by a number of astrophysics enthusiasts from schools and polytechnics. The study of the Sun and its influence on our atmosphere and space environment is a part of his research area. Prof Low investigates the physics of the solar atmosphere and has regular publications in Astrophysics and Plasma Physics.
**16 November 2006 | Prof Gerard ‘t Hooft**

**“Theoretical Physics and Science Fiction”**

Prof Gerard ‘t Hooft (Nobel Laureate in Physics, 1999), delivered an interesting lecture titled “Theoretical Physics and Science Fiction” on 16 November 2006. The lecture was held as part of the Nobel Laureate Lecture Series jointly organized by the Institute of Advanced Studies (IAS, NTU) and the School of Physical and Mathematical Sciences (SPMS, NTU).

There are many constraints when mankind wishes to travel elsewhere in the solar system, for example, the need for oxygen, the need to overcome low temperature, gravity, and the different atmospheric pressure, cosmic radiation, toxic dust, and so forth. Even if current or future technology allows mankind to travel and colonize the moon, it is still not clear how the travel to other parts of the solar system can be accomplished given the huge distances. However, robots could be sent to overcome some of these constraints. They can then beam the images or information back to people on Earth.

Prof Gerard ‘t Hooft said that it was important for the establishment of a self-sustaining enterprise to provide the people on Earth with “entertaining” information so that these people were willing to pay for the huge expenses involved in these expeditions.

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**1 February 2007 | Prof Robert Howard Grubbs**

**“Applications of Olefin Metathesis Catalysis: Fundamental Research to Commercial Products”**

Prof Robert Howard Grubbs (Nobel Laureate in Chemistry, 2005) gave a public lecture titled “Applications of Olefin Metathesis Catalysis: Fundamental Research to Commercial Products” at the School of Biological Sciences, NTU on 1 February 2007.

Metathesis is a scientific jargon for “changing places”. In Olefin Metathesis, the “catalyst pair” (a dancing pair consisting of metals) and the “alkene pair” (a dancing pair consisting of two alkylides) dance around each other and change partner with one another. The catalyst pair hold hands and when they meet the “alkene pair”, the two pairs unite in a ring dance. After sometime, they let go and leave their former partners and dance with their new ones. This fascinating mechanism is now known as the Chauvin’s mechanism.

With strong experimental support from investigations by Prof Robert H Grubbs, Prof Thomas J. Katz and Prof Richard R. Schrock, it was discovered that metathesis could be very important for organic synthesis if suitable, reliable and effective catalysts could be found.
Other than being stable and well-defined, the catalysts are required to have reactivity that could be adjusted depending on the purpose. In addition, they had to be selective, react with double bonds and leave other parts of the molecules intact. Moreover, Chauvin showed how metal alkylidenes could act as catalysts in Olefin Metathesis.

In the early 70's, Prof Richard Schrock started researching on new alkylidene complexes. He showed that molybdenum and tungsten were suitable metals as catalyst, with the discovery of a group of very active molybdenum catalyst in the 90's. In 1992, Prof Robert H Grubbs and his team discovered that the metal ruthenium could act as catalyst in Olefin Metathesis. Ruthenium had higher selectivity than molybdenum and it was stable in air. The new catalyst also had the ability to initiate metathesis in the presence of alcohols, water and carboxyl acids. Prof Grubbs' catalysts eventually became the benchmark for laboratory preparation of new catalysts.

In the final part of his talk, Prof Grubbs spoke on the commercial potential of metathesis in Pharmaceuticals, Biotechnical and Food Industry. One intriguing application is the synthesis of insect pheromones. Metathesis is also an important tool for the search of new pharmaceuticals products for the treatment of Bacterial Infections, Hepatitis C, Cancer, Alzheimer's disease and other diseases.

5 February 2007 | Prof Aaron Ciechanover

“Why Our Proteins Have to Die So We Shall Live: An Overview of the Ubiquitin Proteolytic System”

Prof Aaron Ciechanover (Nobel Laureate in Chemistry, 2004) delivered a public lecture titled “Why Our Proteins Have to Die So We Shall Live: An Overview of the Ubiquitin Proteolytic System” at NTU on 5 February 2007. Translation of the genetic code to proteins was a main focus of biological research before the 1980s. With the discovery of the lysosome, it was suggested that cellular proteins were degraded within this organelle. Yet, a growing body of experimental evidence had strongly suggested that intracellular proteolysis was largely non-lysosomal. However, the mechanisms involved had remained obscure. The discovery of the modification of protein substrates by ubiquitin as a degradation signal by Prof Ciechanover, Prof Hershko and Prof Rose had resolved the enigma. It led to the important understanding that regulated proteolysis was a major pathway involved in controlling a broad array of cellular processes such as cell cycle and division, apoptosis, transcription, antigen presentation, signal transduction, receptor-mediated endocytosis, quality control and modulation of diverse metabolic pathways. This development transformed intracellular proteolysis from a neglected process and research area into a major player in modern Biology.
The scope of the ubiquitin system had since been broadened beyond proteolysis, and we now know that modification by ubiquitin and ubiquitin-like proteins served many non-proteolytic functions as well.

Ubiquitination is a highly complex, temporally controlled, and tightly regulated process that targets numerous cellular proteins in a specific manner. It is carried out by a modular cascade of enzymes with high specificity towards defined structural motifs in the target proteins. Further understanding of the mechanisms of ubiquitination and degradation is important for the development of highly specific mechanism-based drugs.

31 October 2007 | Prof Walter Kohn
“Nearsightedness of Electronic Matter”

In the opening remarks of his lecture during the Conference in honour of Prof CN Yang’s 85th Birthday, Prof Walter Kohn cited 1953 as a very exciting year for him. That year, he was invited to the Institute of Advanced Study in Princeton where he worked closely with Prof Res Jost. Around the same period, Prof Yang Chen Ning, in collaboration with Prof Lee Tsung Dao, proposed his great work on the symmetry of nature, which won them the Nobel Prize in Physics.

Prof Kohn related a phone call he received from Prof Niels Bohr while working with Prof Res Jost at the famous Copenhagen Institute. In the conversation, Prof Niels Bohr expressed his surprise at the fuss people made over superconductivity. He felt that he could easily understand superconductivity, but not normal conductivity, since the electrons orbit non-stop about the nucleus in an atom. The mechanism behind superconductivity remained an elusive topic. The mechanism behind low temperature superconductivity differed drastically from that for high temperature superconductivity. However, in honour of Prof Yang’s monumental contribution to Physics, Prof Kohn highlighted an important paper published in 1962 in which Prof Yang essentially unified both aspects of superconductivity through an analysis of off-diagonal long range order.

In the absence of long range ionic interactions, large molecules or material system can be studied by considering only neighborhoods of a point in question, without the necessity of studying the entire system. This principle is called the principle of “Nearsightedness of Electronic Matter” (NEM).

In particular, this technique underlines the computational principle of “divide and conquer” first proposed by Prof Yang Wei-Tao of Duke University. In such computation, one can divide the total volume into little segments with overlapping buffer zones. The principle of nearsightedness of matter then dictates the thickness of the buffer region beyond the walls of the partition.

According to Prof Kohn, the NEM principle had been inspired in part by Prof Yang Chen Ning’s incessant search for fundamental principle.
profmartinperl

“Innovation and Speculation in Engineering and Science: An Example from the Search for Massive Elementary Particles”

31 October 2007 | Prof Martin Perl

Prof Martin Perl (Nobel Laureate in Physics, 1995) gave a talk titled “Innovation and Speculation in Engineering and Science: An Example from the Search for Massive Elementary Particles” on 31 October 2007. Prof Perl did not entirely talk about the search for a massive elementary particle. It was a talk that dealt with how scientists should go about doing scientific research, the qualities that one should develop and nurture for more creative explorations, and how one should speculate judiciously in Engineering and Science.

Speculations must also conform to the practicality and feasibility constraints. In the fifties, there were some work done on nuclear powered airplane and the engineering designs. For example, the nuclear reactor was placed in the front and the crew was located at the rear. However, these designs were extremely dangerous. Not only could the crew be exposed to all sorts of radiation, the nuclear reactor might not be able to contain the excessive chained reactions. According to Prof Perl, such research goes nowhere. Therefore, however original, imaginative and creative, all research must fit into the realities of the physical world, including obeying the fundamental physical laws.

To be able to propose something speculative, creative and imaginative, several new skills are required, like competency in mathematics, ability to visualize, ability to apply appropriate physical constraints and practicality, acquisition of good laboratory skills, awareness of personality traits and temperament of oneself and collaborators. In research, it is always necessary to develop good ideas. However, for every successful idea, one may need to overcome many incorrect and useless ideas. A successful researcher needs to reduce the frequency of bad ideas through a good understanding of the physical laws and mastering the appropriate technology quickly.
Prof Claude Cohen-Tannoudji (Nobel Laureate in Physics, 1997) delivered a public lecture in which he talked at length about how one could trap and cool down the atoms and use them for various applications. If we apply to an atom at rest, two laser beams propagating in opposite direction with the same frequency and intensity, the net force acting on the atom is zero. However, if the atom is moving, the apparent frequencies of the two oppositely directed beams are no longer the same and so the atom will experience a force opposite to the velocity of the atom, slowing the atom down. We observe this phenomenon whenever a racing car or a plane passes us. The frequency increases when the source (of the sound in this case) is approaching us and decreases when it is moving away from us. This phenomenon is also known as the “Doppler effect”. For this reason, we call such cooling technique as Doppler cooling.

Interestingly, there are limits to the temperature that one can lower using Doppler cooling alone. However, atoms can have two degenerate ground states associated with two optical potential that are out of phase with each other. Under suitable conditions, the atom can jump preferentially using optical pumping from one ground state to the other. As such, an atom can be made to “move uphill” through one optical potential, losing energy in the process. Before the atom regains the lost kinetic energy, it jumps to the other “ground state”, which is incidentally at its minimum potential, or analogously at “the bottom of the hill”. The atom is then made to climb up the “hill” again losing more energy. The process is similar to the Greek Mythology in which King Sisyphus was punished to roll a huge boulder up a mountain, only to see it roll down the mountain as soon as it reached the top. This cooling process was amusingly coined as “Sisyphus cooling” by Prof Jean Dalibard and Prof Claude Cohen-Tannoudji several years ago.

In fact, further cooling can be achieved, just as one could blow over the surface of a cup of coffee to cool it down, one could release some of the atoms from a body of atoms and allow the remaining to come to some lowered equilibrium temperature. So what could one do with these ultracold atoms? Researchers in this field are able to control and manipulate these cooled atoms for atomic clocks, observation of many body phenomena like Superfluid-Mott Insulator transition, Bose-Einstein Condensation-Bardeen Cooper Schreifer (BEC-BCS) crossover and so forth, atom tweezers, high temperature superconductors and optical lattices. The latter has found useful applications in quantum information theory.
The celebrations in honour of Prof CN Yang’s 85th Birthday ended with a public lecture on the interpretations of “Beauty” by renowned artist Prof Fan Zeng and Prof Yang Chen Ning on 3 November 2007. The lecture chaired by Dr Su Guaning (President of NTU), was delivered in Mandarin and had attracted an overwhelming audience of more than 1800 participants.
23 June 2009 | Prof Tommy Cheng Yung Chi “Chinese Medicine, the Modern Approach”

Prof Tommy Cheng (Professor of Pharmacology, Yale University and the Chairman of the Consortium for Globalisation of Chinese Medicine) delivered a lecture titled “Chinese Medicine, the Modern Approach”. He discussed about the new paradigm for future medicine, the principles of combined usage of herbs and his basic studies of herbal medicine. The lecture was jointly organized by the Institute of Advanced Studies (IAS, NTU), the Tan Kah Kee International Society and the Singapore-China Business Association.

18 July 2009 | Prof Feng Da Hsuan “Global Talent Migration: An Asian Perspective”

Prof Feng Da Hsuan (Senior Executive Vice President, National Cheng Kung University) delivered a public lecture on “Global Talent Migration: An Asian Perspective” on 18 July 2009 at the Hwa Chong Institution High School Auditorium. His lecture examined the transition of higher education in the 20th century and its challenges and developmental opportunities in the 21st century.

6 October 2009 | Dr Henry Lee “Unveil Crime Mysteries”

Dr Henry Lee, one of the world’s foremost forensic scientists, delivered a public lecture on “Unveil Crime Mysteries” in which he shared with the audience his interesting experience in crime investigations, his life in Taiwan and USA, and the current trend in forensic science. The lecture was jointly organised by Institute of Advanced Studies (IAS, NTU), the Tan Kah Kee Foundation and Tan Kah Kee International Society.
Public Lectures

Prof Kerson Huang
9 January 2010 | “中国文明的根源” (Lecture in Mandarin)
6 February 2010 | “The Roots of Chinese Civilisation” (Lecture in English)

Prof Kerson Huang (Emeritus Professor of Physics, Massachusetts Institute of Technology, and also IAS Senior Fellow and Nanyang Professor), delivered a public lecture titled “The Roots of Chinese Civilisation” on 9 January 2010 (in Mandarin) and 6 February 2010 (in English) at the Singapore Management University’s Ngee Ann Kongsi Auditorium and the Hwa Chong Institution High School Auditorium respectively. His talk on inspiring experiences of Chinese Civilization had attracted more than 600 participants for both sessions.
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4 March 2010 | Prof Yang Chen Ning
“Reflections on Returning to My Roots: Six Years after moving to Tsinghua”

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归根反思
——记杨振宁在南大高等研究所的演讲

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上周四，诺贝尔奖得主杨振宁教授为南洋理工大学高等研究所进行公开演讲：《归根反思——定根清华园六十年的一些感想》。演讲在南洋大礼堂举行，协办机构包括杨振宁国际学会、新加坡中华总商会、新加坡中国友好协会以及新加坡华人俱乐部。

分享成长经历
演讲第一部分，杨教授讲述了他在合肥出生，之后到了厦门、北平和昆明的成长经历和学习体验。从1345年，他到芝加哥后，接着在普林斯顿大学研究生院求学。1966年，他被美国加州大学工程研究生院录取，1969年才离开。演讲中，杨教授分享了他在美国的经历，以及他对中国文化所作出的一些贡献。

2003年以后
演讲中，杨教授分享了他对于“归根”这一概念的思考。他认为，人在成长过程中，往往会遇到一些困难和挑战，但是这些困难和挑战也是我们成长的必经之路。杨教授分享了他在中国和美国的求学和工作经历，以及他对科学和教育的热爱。

千人计划
此外，杨教授特别提及中国政府为吸引全球顶尖人才而实施的“千人计划”。杨教授说，千人计划是政府为吸引全球顶尖人才而实施的一项重要计划。他希望，更多的中国科学家能够回到祖国，为中国的发展贡献力量。

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Collaborations with Other Institutions
Collaborations with Other Institutions

MOU Signing Ceremony between the Institute of Advanced Studies and College of Science of NTU and Tsinghua University, China | 30 October 2007

The MOU signing ceremony between the Institute of Advanced Studies and College of Science of NTU and Tsinghua University, China, was held on the morning of 30 October 2007.

The MOU aims to foster closer ties with Tsinghua University and to promote direct contact, faculty and student exchange as well as research collaboration between the two Universities.

Signatories for the MOU:
Prof Phua Kok Khoo, Director of IAS, NTU (seated left), Prof Zhu Bang Fen, Tsinghua University, (seated middle), Prof Lee Soo Ying, Dean of College of Science, NTU (seated right), witnessed by Prof Yang Chen Ning (standing left) and Dr Su Guaning, President of NTU (standing right)
Collaboration with the Institute for Mathematical Sciences, Imperial College, UK | March 2010

The Institute of Advanced Studies (IAS, NTU) and the School of Physical & Mathematical Sciences (SPMS, NTU) have been in discussion with the Institute for Mathematical Sciences (IMS), Imperial College London, UK, to explore on further collaboration.

During a visit by Prof Ling San and Prof Chee Yeow Meng to the IMS in March 2010, two common areas of interest, namely Multiscale Problems and Complexity were identified. A joint workshop on these topics will be held at the Imperial College in July 2011 to kick-start the collaboration.
Collaborations with Other Institutions

Collaboration with the Korea Institute for Advanced Study | 17 to 20 April 2010

Prof Kwek Leong Chuan visited the Korea Institute for Advanced Study (KIAS) from 17 to 20 April 2010 and he also gave a talk on Entanglement Witness during his visit. Similar to the IAS at NTU, KIAS was modeled after the Princeton Institute of Advanced Study. KIAS comprised of three schools, namely Mathematics, Physics and Computational Sciences. It has more than 70 full-time research fellows, about 36 faculty members and 16 visiting scholars. During the short visit, Prof Kwek met the Acting President of KIAS, Prof Kim Jaewan who expressed interest to foster closer ties between KIAS and IAS, NTU.

With the full support of the Korean government, KIAS was established in October 1996. It is located on a 30-acre site in Hongneung, within the Seoul campus of the Korea Advanced Institute of Science and Technology (KAIST).

Currently, the KIAS has several programs in Mathematics (Algebra, Geometry, Topology, Analysis, and Applied Mathematics), Theoretical Physics (Particle Physics, Cosmology, Condensed-Matter, Astrophysics, Nuclear Physics, and Statistical Physics), and Computational Sciences (Bio-and Nano-Sciences, Protein Folding, and Cryptography). Like many Institutes of Advanced Study worldwide, the KIAS regularly hosts many visiting researchers and scholars as well as organized many conferences and workshops. The Institute has several renowned scholars who stayed for several weeks to several months each year at the campus, and the list includes scientists like Prof Leonard Susskind, Prof John Kosterlits, Prof Efim Zelmanov and Prof Kim Chung Wook. Moreover, many KIAS research fellows subsequently went on to take up key positions at local Universities and international research Institutes elsewhere.

MOU Signing Ceremony between Institute of Advanced Studies of NTU and Korea Institute for Advanced Study (KIAS) | 11 June 2010

The MOU signing ceremony between IAS and KIAS was held on 11 June 2010 at the Nanyang Executive Centre (NEC, NTU). Desirous of promoting and developing cooperation in the field of basic Sciences, the MOU aims to foster closer ties between the two Institutions and to promote cooperative activities including exchange of scientific information, publications, organization of joint workshops, seminars and conferences.
Collaborations with Other Institutions

Signatories for the MOU:
Prof Kim Jaewan, Vice President of KIAS / Acting President (seated left),
Prof Hew Choy Sin, Deputy Director of IAS, NTU (seated right)
Collaborations with Other Institutions

Collaborations between the Institute of Advanced Studies at NTU and Universities in Vietnam

Special Report on Vietnam Trip by IAS

An IAS delegate led by Prof Phua Kok Khoo, together with Prof Hew Choy Sin and Prof Kwek Leong Chuan, visited Ho Chi Minh and Hanoi from 15 to 17 January 2008. The visit to Vietnam was hosted by Prof Jean Tran Thanh Van (Orsay) who hoped that Singapore, particularly NTU, could establish some form of long term collaborative program with Universities in Vietnam.

The purpose of the visit was two-fold:

- To ascertain the organizational structure and gauge the standards of educational system and research at the Universities in Vietnam
- To establish long-term close collaborations between Universities in Vietnam and the Institute of Advanced Studies at Nanyang Technological University

Vietnam is a large country with a population of 82 million people and due to the fact that it has been developing rapidly in the last few years, Vietnamese students are now been regarded very highly in terms of their learning capabilities and knowledge.

The visits were summarized as follows:

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Faculty of Electrical and Electronics Engineering at Ho Chi Minh City University of Technology (HCMUT)

Vietnamese Academy of Science and Technology in Hanoi
Day 1

15 January: Visit to Vietnam National University, Ho Chi Minh City (VNU-HCM), hosted by Prof Dat Huynh Thanh (Vice President of VNU-HCM), Prof Hong Tran Thi (Director of International Relations) and several other high ranking officials.

VNU-HCM was set up to train the necessary manpower needs for the related Industry. It is located near a Science park and it has a high school for the gifted students (Grade 10-12). There are about 700-800 students at the High School and many of them are subsequently accepted into Universities elsewhere, including Nanyang Technological University (NTU) and National University of Singapore (NUS). Furthermore, they have exchange programs with the Faculty of Computer Science at NUS.

Day 2

16 January: Visit to Ho Chi Minh City University of Technology (HCMUT) hosted by Prof Tuan Phan Dinh, Vice Rector (Research and Development and External Relations).

HCMUT has a separate college that provides training for Bachelor degree (3 years), equivalent to our polytechnic diploma. The University provides Engineering (4.5 years), Master (2 years) and PhD (4 years) Programs. Students who do well at Bachelor degree and wish to continue studying will need to do the full 4.5 years of Engineering program. In total, there are 48 Undergraduate programs, 37 Master programs, and 38 Doctoral programs. According to Prof Van who accompanied the delegates, several students from HCMUT had subsequently passed the entrance examination to Ecole Polytechnique, a premier University in Paris, France.
Collaborations with Other Institutions

HCMUT also has other centres like the Centre for Information Technology and the Centre for Construction Technology. Besides the University Centres, there are another two national key laboratories in HCMUT, namely Polymer and Composite Laboratory and the Digital, Cybernetics and System Engineering Laboratory where both were established with US$4.3 million. There are about 20 key laboratories nationwide, including these 2 laboratories which are dedicated to the Life Sciences research in Hanoi.

Moreover, the partnership has extended to training programs for talented Engineers, where it is managed by the Ministry of Education and Training under the PFIEV program (le Programme de Formation d’Ingénieur d’Excellence au Vietnam). The Asean University Network (AUN-SEED Net) is supported by the Japanese government under a sponsorship of US$20 million. This funding supports 19 Universities from 10 countries. HCMUT and Hanoi University of Science and Technology (HUST) in Hanoi are the only two Universities from Vietnam which are under this program.

Day 3

17 January: Visit to the Institute of Materials Science (Vietnamese Academy of Science and Technology) hosted by Prof Hieu Nguyen Van.

Prof Hieu was the President of the Vietnamese Academy of Science and Technology from 1983 to 2003 and he is the current Honorary President. The delegate also met Prof Phuc Nguyen-Xuan and Prof Liem Nguyen-Quang, the Director and Vice Director of the Institute respectively.

The Institute of Materials Science of the Vietnam Academy of Science and Technology is well equipped with cutting edge equipment. Prof Hieu hoped to arrange meeting between the NTU delegate and the Minister of Education and Training in a separate visit. Prof Phua Kok-Khoo also reiterated the need for NTU to sign an MOU with the new University to be set up under the Academy.

The Red Sea Group (Hung Hai) from Taiwan has invested US$2 billion in Information and Telecommunication research. Therefore, the Vietnamese Academy is devoted to its mission to train manpower skilled in high-end technology. Prof Hieu emphasized that research is an integral part of education and many efforts have been made to develop a more vibrant educational system. With regard to this, he had tried to convince the government to establish a new University named Hanoi University under the supervision of the Academy which aims to set education and training at the highest international standards.

The first intake of students in October 2008 catered to both graduate and undergraduate study. There are 6 Departments, namely Mathematics, Physics, Chemistry, Biotechnology, Information Technology, Material Science and Engineering.

He noted that in Vietnam, only 20 percent of the faculty members hold a PhD degree. He proposed that the new University be equipped with a faculty where all members had good doctoral degree and significant scientific publications in International Journals. He noted that 15 years ago, the government tried to improve the structure of 2 existing Universities and increase the number of PhD among teaching staff but was unsuccessful.
It was difficult to implement the policy as it was not easy to terminate the contracts of staff without PhD degrees. He expected the new University to have a lecturer-student ratio of 1:10 as compared to 1:25 in existing Universities and the medium of teaching to be in English.

The University hopes to take in only the top 2 percent of the annual cohort. Students are expected to do projects in the research labs during their training period at the University. He also noted the possibility of offering scholarships to selected students under government funding to go abroad for higher degrees. The University will start with an initial intake of 200 students, eventually with a target of enrolling 400 students annually.

The delegate also visited the Hanoi University of Science and Technology (HUST). They were welcomed by Prof Luong Pham-Hoang (Vice President and Dean of the University). Other faculty members include Prof Chien Nguyen Duc (Director of the Institute of Engineering), Prof Hoa Ta Phuaong (Vice Director of International Cooperation), and Prof Huy Pham Thanh (Vice Director of the International Training Institute for Materials Science). HUST is one of the key Technological Universities in Vietnam and has trained over 100,000 Engineers in Vietnam.

The University has a newly established Hanoi Advanced School of Science and Technology, 6 Institutes, 17 Research Centres and 14 faculties. HUST will be expanding its area to accommodate a second campus.

Summary

The delegate was very impressed with the knowledge of the researchers, the availability of good research equipment and facilities (particularly in Hanoi) in Vietnam. There were some recommendations following the visit:

- IAS, NTU should consider partnership with the Vietnamese counterpart on niche areas of research relevant to IAS. Some of the possible areas are Quantum Information Science and Spintronics, Plasma Processing and Herbal Medicine.
- IAS, NTU should establish collaborations with the National Key Laboratories at HCMUT and HUST.
- For undergraduate student recruitment, NTU could focus on high schools and colleges affiliated to the various Vietnam Universities.
- For events organized by the IAS, NTU, the delegate should try and encourage more Vietnamese to participate in these events. Some forms of financial support may be necessary to help the Vietnamese researchers to visit Singapore.
- Vietnamese staff and students should be invited to attend short courses conducted in Singapore. Similarly, NTU fellows and faculty members should be encouraged to travel to Vietnam to deliver short courses and lectures.

The delegate was indeed impressed with the standard of research and the dedication of researchers in Vietnam. Moreover, some of the key laboratories in Vietnam are equipped with advanced facilities for research. It would be mutually beneficial if IAS, NTU, could work closely with the Vietnamese in many aspects of research as well as organization of workshops and other events.
Snapshots of Activities
Snapshots of Activities

Banner of 100 Years of Physics Symposium in Singapore (10 to 12 August 2005)

Banner of International Workshop on Multiscale Analysis and Applications (18 to 22 December 2006)

Banner of International Workshop on Spintronics (8 to 12 May 2006)
Snapshots of Activities

Banner of NTU-Tsinghua Joint Workshop on Discrete Mathematics and Theoretical Computer Science (12 to 14 December 2008)

Banner of Les Houches School of Physics Summer Session in Singapore (29 June to 24 July 2009)

Banner of Inaugural Institute of Physics Singapore March 2009 Meeting (6 to 7 March 2009)
Snapshots of Activities

Proceedings of Conference in Honour of CN Yang’s 85th Birthday: Statistical Physics, High Energy, Condensed Matter and Mathematical Physics (31 October to 3 November 2007)

Poster of Conference in Honour of CN Yang’s 85th Birthday: Statistical Physics, High Energy, Condensed Matter and Mathematical Physics (31 October to 3 November 2007)

Proceedings of Conference on Particle Physics, Astrophysics and Quantum Field Theory: 75 Years since Solvay (27 to 29 November 2008)

Poster of Conference on Particle Physics, Astrophysics and Quantum Field Theory: 75 Years since Solvay (27 to 29 November 2008)
Snapshots of Activities

Poster of Conference in Celebration of the Official Opening of the School of Physical and Mathematical Sciences Building (20 to 22 July 2009)

Poster on Conference on Sparse Representation of Multiscale Data and Images (14 to 17 December 2009)

Poster of Conference on Recent Development in Chinese Herbal Medicine (25 to 26 January 2010)

Poster of 1st Raffles Laureate Series (6 August 2009)
Poster of Conference in Honour of Murray Gell-Mann's 80th Birthday; Quantum Mechanics, Elementary Particles, Quantum Cosmology and Complexity (24 to 26 February 2010)
“Global Warming & Energy Policy For the 21st Century”

Biography of The Speaker

Douglas Osheroff

Nobel Laureate, Physics, 1996; Professor of Physics and Applied Physics, School of Humanities and Sciences, Stanford University

Douglas Osheroff is a Nobel Laureate in Physics, the J.G. Jackson and C.J. Wood Professor of Physics and the Gerhard Casper University Fellow for Undergraduate Education at Stanford University. His Ph.D. thesis work resulted in the discovery of three superfluid phases of liquid $^3$He.

Osheroff worked in the physical research division at Bell Laboratories for 15 years where he became head of the Low Temperature and Solid State Research Department. There, he worked in collaboration on these newly discovered superfluid phases of liquid $^3$He, as well as studied the nature of nuclear spin order in solid $^3$He and made the first observations of weak localization in thin disordered metallic films. Osheroff’s research still focuses on the properties of condensed matter near absolute zero. He was a member of the Columbia Accident Investigation Board, which determined the causes of the accident that destroyed Columbia on re-entry.

Osheroff has received numerous honors, among them, the Sir Francis Simon Memorial Award, Oliver E. Buckley Condensed Matter Physics Prize, MacArthur Prize Fellowship Award, and the 1996 Nobel Prize for Physics. Stanford University gave him their Walter J. Gores Award for Excellence in Teaching. He is a member of the American Academy of Arts and Sciences and the National Academy of Sciences. Osheroff earned his bachelor’s in physics at Caltech and his Ph.D. at Cornell University.

Abstract:

Based on the analysis of trapped gas in ice cores from Greenland and Antarctica, it is clear that the CO2 levels in our atmosphere now exceed the levels seen in the previous 400,000 years.

The level has risen sharply over the past 100 years, and correlates strongly with the burning of fossil fuels and destruction of our forests. At the same time, average ocean temperatures have risen about 1 degree Celsius, and there is growing evidence that this is having a profound impact on our environment, including the melting of much of the Antarctic ice shelf, ground water percolation through the Greenland ice cap, the melting of glaciers around the world at an accelerating rate, and the wide destruction of coral colonies.

In the next 50 years, largely due to development in India and China, we expect that the CO2 level in our atmosphere will again double, unless a concerted effort world wide is undertaken to limit our production of CO2 through conservation and a shift to alternate energy sources. While it is not easy to predict through the highly non-linear models the consequences of such high levels of CO2, it is clear that the time required to remove the gas from our atmosphere is long, and that whatever changes occur, they will not be easily reversed.

Probable changes include a rise in ocean levels as a result of the melting of fossil ice, shifts in climate, and stress and possible extinction of native species unable to adapt to the rapid changes. It is essential that we begin to confront this technological and economic challenge now.
Snapshots of Activities

Advertisement of Public lecture titled “My Life” by Professor Yang Chen Ning (9 July 2006)

Advertisement of Public lecture titled “The Inconstant Sun” by Professor Low Boon Chye Low (8 September 2006)

Advertisement of Public lecture titled “Theoretical Physics and Science Fiction” by Professor Gerard’t Hooft (16 November 2006)
Advertisement of Public lecture titled “Global Talent Migration: An Asian Perspective” by Professor Feng Da Hsuan - (18 July 2009)

Advertisement of Public lecture titled “The Roots of Chinese Civilisation” by Professor Kerson Huang (6 February 2010)
Advertisement of Public lecture titled “Reflections on Returning to My Roots: Six Years after moving to Tsinghua” by Professor Yang Chen Ning (4 March 2010)
Snapshots of Activities

Advertisement of Public lecture titled “Chinese Medicine, the Modern Approach” by Professor Tommy Cheng Yung Chi (23 June 2009)

Advertisement of Public lecture titled “Chinese Medicine, the Modern Approach” by Professor Tommy Cheng Yung Chi (23 June 2009)

Advertisement of Public lecture titled “Chinese Medicine, the Modern Approach” by Professor Tommy Cheng Yung Chi (23 June 2009)
Snapshots of Activities

IAAS Colloquium (8) – CERN and its Particle Physics Programme

Professor Emmanuel Tsesmelis
Senior Physicist, CERN (Directorate Office of Condensed Matter, Department of Physics, University of Oxford)

Title: CERN and its Particle Physics Programme

CERN is the European laboratory for particle physics, the world's largest particle physics research centre. Founded in 1954, the laboratory is one of Europe's most visible and successful institutions, having discovered the Higgs boson and produced the LHC. The LHC is the highest-energy particle accelerator ever built, and is expected to make major discoveries in the field of particle physics.

Advertisement of IAS Lecture titled “An Interesting Parlor Game and Its Meaning” by Professor Yang Chen Ning (27 February 2010)

Speaker: Prof Yang Chen Ning
Affiliation: Professor, Institute of Physics, National Taiwan Normal University

Chairman: Sung Hsing, President, National Taiwan University

Venue: Lee Kong Chian Lecture Theatre, South Spine, 553-1-20, National University of Singapore

Time: 4:00 pm, February 27th, 2010 (Sat)

Biography of Prof Yang Chen Ning

Yang Chen Ning received his B.S. degree in physics from National Taiwan University in 1981 and his Ph.D. in physics from the University of California at Berkeley in 1987. He returned to the National Taiwan University in 1989 as a research professor. He was appointed Associate Professor in the Department of Physics at the National Taiwan University in 1990. In 1992, he was appointed Professor of Physics at National Taiwan University.

He has been the Director of the Institute of Physics, National Taiwan University, since 1998. His research interests include the study of the fundamental properties of matter, particularly the properties of elementary particles, and the search for clues to the origin of the universe.

Admission is free.

Please register online at: http://www.ntu.edu.tw/
Snapshots of Activities

Advertisement of Colloquium titled “Writing and Reading Spin Information on Mobile Electronic Qubits” by Professor Amnon Aharony and “New Clues in the Mystery of Persistent Currents” by Professor Ora Entin-Wohlman (11 February 2010)

Advertisement of Colloquium titled “Strange Bedfellows: Quantum Mechanics and Data Mining” by Professor Marvin Weinstein (16 April 2010)

Advertisement of Colloquium titled “Materials Issues in Ageing Management and Maintenance of Nuclear Power Plants” by Professor Li Zheng Cao (4 May 2010)
Visiting Professors / Visitors
The objective of the Lee Kuan Yew Distinguished Visitors programme is to invite internationally eminent and outstanding academics and scholars to Singapore as Lee Kuan Yew Distinguished Visitors to make high-level contributions to NUS, NTU and to Singapore in general. It is funded by the Lee Kuan Yew Endowment Fund which was established in 1983 by friends and well-wishers of Singapore’s former Prime Minister, Mr Lee Kuan Yew, on the occasion of his 60th birthday.

*Nanyang Visiting Professorship is for renowned overseas professors who have established eminence in the strategic areas of development identified by the University, to join the University as faculty members working on part-time basis.

Lee Kuan Yew Distinguished Professors#

Shu Chien
27 to 29 November 2008
*Bioengineering and Medicine* • University of California, San Diego • IAS International Advisor

Aaron Ciechanover
23 March 2010
*Biology and Medicine* • Nobel Laureate in Chemistry, 2004 • Technion-Israel Institute of Technology • IAS International Advisor

Nanyang Professors*

Chang Ngee Pong
28 Dec 2004 to 27 Dec 2006 and 10 July 2007 to 9 July 2009
*Physics* • City College of CUNY

Kerson Huang
3 November 2009 to 2 November 2011
*Physics* • Massachusetts Institute of Technology
Tan Kah Kee Professors*

Low Boon Chye
7 to 29 September 2006
*Astrophysics and Plasma Physics • National Center for Atmospheric Research

Steven Schachter
18 October to 8 November 2008
*Neurology • Harvard Medical School

Chang Ngee Pong
10 July to 2 August 2009
*Physics • City College of New York

*The Tan Kah Kee Professorship was launched in honour of the late Mr Tan Kah Kee and to pay tribute to his exceptional and wide-ranging contributions. The Professorship will contribute to the advancement of NTU as an institution of academic excellence and fulfill one of Mr Tan Kah Kee’s legacies, namely, his model of modernization through the promotion of education as well as industrial and technological development.

IAS Visiting Professors

Hou Yi Zhao, Thomas
18 to 26 March 2006 and 5 to 10 May 2008
*Applied and Computational Mathematics • California Institute of Technology

David D. Awschalom
10 May 2006
*Physics • University of California, Santa Barbara

Mark Ainsworth
13 to 17 November 2006
*Mathematics and Statistics • University of Strathclyde

Salk, Sung-Ho Suck
23 February 2007
*Physics • Korea Institute for Advanced Study • Korean Academy of Science and Technology

Karl Kimon Berggren
10 to 13 Mar 2009
*Engineering • Massachusetts Institute of Technology

Xing Zhi Zhong
1 July to 15 August 2009
*Physics • Institute of High Energy Physics, Chinese Academy of Sciences
Visiting Professors / Visitors

Feng Da Hsuan
1 to 4 April 2007 and 16 to 19 July 2009
Physics • National Cheng Kung University

Philip Hall
24 to 25 April 2007 and 3 to 8 September 2008
Applied Mathematics • Imperial College London

Chang Lay Nam
25 July 2007
Physics • Virginia Tech

David Kiang
16 October 2007
Physics • Chinese University of Hong Kong

Jean-Francois Roch
4 November 2008
Physics • École normale supérieure de Cachan

IAS Visitors / Scholars

Henry Lee
6 October 2009
Forensic Science • University of New Haven • Chief Emeritus of the Connecticut State Police

Ho Peng Yoke
31 October 2009 to 6 November 2009
History of Science • Needham Research Institute, Cambridge

Lei Jin Zhi
1 to 28 February 2010
Mathematics • Tsinghua University

Li Zheng Cao
30 April to 5 May 2010
Materials Science and Engineering • Tsinghua University
Jorge Treddice
17 to 22 November 2008
*Physics* • Institute for Nonlinear Sciences in Nice

Khoo Iam Choon
12 December 2008
*Electrical Engineering* • Pennsylvania State University

Chen Hong Hwa and Tsai Wen Chieh
3 to 7 February 2009
*Molecular Biology* • National Cheng Kung University

Tommy Cheng Yung Chi
21 to 24 June 2009
*Pharmacology* • Yale University • Consortium for Globalization of Chinese Medicine

Leung Ping Chung
11 October 2005, 6 to 11 January 2009, and 21 to 24 June 2009
*Medicine* • Chinese University of Hong Kong

Constantino Tsallis
16 to 20 Nov 2009
*Statistics and Mathematical Sciences* • Brazilian Centre for Physics Research

Emmanuel Tsesmelis
11 January 2010
*Physics* • CERN

Amnon Aharony
10 to 15 February 2010
*Physics* • Ben Gurion University

Ora Entin-Wohlman
10 to 15 February 2010
*Physics* • Ben Gurion University

Marvin Weinstein
14 to 19 April 2010
*Physics* • SLAC National Accelerator Laboratory
Awards and Fellowships

Prof Phua Kok Khoo
Elected as American Physical Society (APS) Fellow in 2009
2006 President’s Medal
Institute of Physics Singapore (IPS)

Prof Kwek Leong Chuan
Elected as American Association for the Advancement of Science (AAAS) Fellow in 2009
Elected as Institute of Physics (UK) Fellow in 2008
2006 National Science Award (Team)
The Agency for Science, Technology and Research (A*STAR)
2006 Premier Science Award
Institute of Physics Singapore (IPS)
**Prof Lim Hock**

2007 President's Medal  
Institute of Physics Singapore (IPS)

**Prof Xu Shuyan**

The Cadi Scientific Medal and Prize:  
The Public Awareness of Physics  
Award 2008  
Institute of Physics Singapore (IPS)

**Prof Loh Teck Peng**

2010 GSK-SNIC Award in Organic Chemistry  
Elected as Academy of Sciences Malaysia Fellow in 2009
Special Articles
This section features special articles on some IAS Eminent Visiting Professors. It includes a CERN Courier article on Professor Gell-Mann, an interview report on Professor Kerson Huang, and transcript of Prof Martin Perl’s lecture for your reading pleasure.

CERN Courier, May 2010

Gell-Mann: quantum mechanics to complexity

Extracted from an article that first appeared in the May 2010 Issue of CERN Courier

A conference in Singapore held at the Institute of Advanced Studies, Nanyang Technological University, gathered former students and collaborators of Murray Gell-Mann to celebrate his 80th birthday with a retrospective of his achievements in various fields.

To celebrate Murray Gell-Mann’s many contributions in physics in his 80th year, the Institute of Advanced Studies at Nanyang Technological University and the Santa Fe Institute jointly organized the Conference in Honour of Murray Gell-Mann, which took place in Singapore on 24-26 February. Aptly entitled “Quantum Mechanics, Elementary Particles, Quantum Cosmology and Complexity” to focus on Gell-Mann’s achievements in these fields, the three-day conference was a festival of lectures and discussions that attracted more than 150 participants from 22 countries. Those in attendance included many of Gell-Mann’s former students and collaborators. For a select few this was their second visit to Singapore, having attended the 25th Rochester Conference held there 20 years ago.

The meeting began with a brief scientific biography of Gell-Mann presented by his close collaborator Harald Fritzsch of Ludwig-Maximilians University, who highlighted his main achievements. During the 1950s Gell-Mann worked with Francis Low on the renormalization group and with Richard Feynman on the V-A theory of weak interaction.
The application of the SU(3) symmetry group to classify hadrons led Gell-Mann to predict the existence of the Ω- particle in 1961; its subsequent discovery in 1964 paved the way to his receiving the Nobel Prize in Physics in 1969. Gell-Mann and George Zweig independently proposed quarks as the constituents of hadrons in 1964.

Gell-Mann studied the current algebra of hadrons together with various co-workers. In 1971 he introduced light-cone algebra together with Fritzsch, as well as the colour quantum number for quarks. A year later they proposed the theory of QCD for the strong interaction. In 1978 Gell-Mann, Pierre Ramond and Richard Siansky proposed the seesaw mechanism to explain the tiny neutrino masses. Then, in around 1980, Gell-Mann switched his interest towards the foundations of quantum mechanics, quantum cosmology and string theory.

**Multifaceted**

Gell-Mann’s interests extend beyond physics - he loves words, history and nature. He has moved between disciplines that include historical linguistics, archaeology, natural history and the psychology of creative thinking, as well as other subjects connected with biological and cultural evolution and with learning. He currently spearheads the Evolution of Human Languages Program at the Santa Fe Institute, which he co-founded.

The subsequent talks by Nicholas Samios of Brookhaven National Laboratory and George Zweig of Massachusetts Institute of Technology (MIT) were very entertaining. They touched on the historical background that led to the discovery of the Ω- — predicted by Gell-Mann’s Eightfold Way — and to the quark model of hadrons, and were accompanied by interesting anecdotes and photographs. Zweig related the origin of the terminology “quark” and how the battle between “aces” and quarks unfolded.

There were several talks on recent advances in various theoretical and experimental aspects of QCD as well as on the Higgs boson. CERN’s John Ellis discussed the Higgs particle and prospects for new physics at the LHC. Nobel laureate CN Yang of Tsinghua University gave a talk on his recent work on the ground-state energy of a large one-dimensional spin-1/2 fermion system in a harmonic trap with a repulsive delta-function interaction, based on the Thomas Fermi method. Gerard ’t Hooft of Utrecht University – another Nobel laureate -presented a possible mathematical relationship between cellular automata and quantum-field theories. This may provide a new way to interpret the origin of quantum mechanics, and hence a new approach to the gravitational force.

Gell-Mann himself ended the first day’s sessions with interesting personal recollections and reflections on “Some Lessons from 60 Years of Theorizing”. His main observations can be summarized as follows. First, every once in a while, it is necessary to challenge some widely conceived idea, typically a prohibition of thinking in a particular way -a prohibition that turns out to have no real justification but holds up progress in understanding. It is important to identify such roadblocks and get round them. Second, it is sometimes necessary to distinguish ideas that are relevant for today’s problems from ones that pertain to deeper problems of the future. Trying to bring the latter into today’s work can cause difficulties. Finally, doubts, hesitation and messiness seem to be inevitable in the course of theoretical work (and experiments too, sometimes). Perhaps it is best to embrace this tendency rather than organizing over and around it, for example, by publishing alternative contradictory ideas together with their consequences, and leaving the choice between them until a later time.

The following day and a half covered a variety of topics. Rabindra Mohapatra of the University of Maryland discussed neutrino masses and the grand unification of flavour. Further talks focused on the origins of neutrino mixing and oscillations, as well as on what the LHC might reveal about the origin of neutrino mass.

John Schwarz of Caltech gave an interesting review of the recent progress in the correspondence between anti-de Sitter space and conformal field theory, which is one
of the most active areas of modern research in string theory. He focused mainly on the
testing and understanding of the duality and the construction and exploration of the
string theory duals of QCD. Other talks reported on string phenomenology and string
corrections in QCD at LHC. Itzhak Bars of the University of Southern California described
a gauge symmetry in phase space and the consequences for physics and space-time.

The sessions on quantum cosmology covered topics on black holes, dark matter, dark
energy and the cosmological constant. These included a talk by Georgi Dvali of New York
University, who discussed the physics of micro black holes.

The main sessions of the conference ended with a talk by Nobel
laureate Kenneth Wilson of Ohio State University, a former
student of Gell-Mann. He touched on a fundamental problem:
could the testing of physics ever be complete? According to
Wilson, in the real world no law about continuum quantities
such as time, distance and energy can be established to be exact
through experimental tests. Such tests cannot be carried out
today, and cannot be done in the foreseeable future -although
estimates of uncertainties can be improved in future. Wilson
also took part in a discussion session with school teachers and
students in a Physics Education Meeting held in conjunction with
the conference.

The parallel sessions on particle physics, cosmology and general
relativity attracted presentations by more than 30 speakers, many
of whom were young physicists from Asia (China, China (Taiwan),
India, Indonesia, Iran, Japan, Malaysia and Singapore). There
was also a special session on quantum mechanics and complexity

- To mark the occasion of Gell-Mann’s 80th birthday, the publication of Murray Gell-
Mann: Selected Papers, edited by Harald Fritzsch (World Scientific 2010), was launched
during the conference. For the full list of speakers and more information about the
conference, see www.ntu.edu.sgiasjupcomingeventsjGM80Conference. The proceedings
will be published by World Scientific Publishing Company, Singapore.
Participants gathered at the foyer of Nanyang Executive Centre in Nanyang Technological University (NTU) with Gell-Mann (front row, seventh from the left). (Courtesy Institute of Advanced Studies, NTU)
Wake! For the Sun, who scatter’d into flight
The Stars before him from the Field of Night,
Drives Night along with them from Heav’n, and strikes
The Sultan’s turret with a Shaft of Light.

– Rubaiyat, Verse 1

醒醒游仙夢裡人，
残星几点已西沉。
羲和骏馬鬃如火，
红到苏丹塔上云。

鲁拜集, 第一诗

The Physicist-Poet

BY JEAN LOO QINGWEN

Driven by curiosity, IAS Senior Fellow, Prof Kerson Huang is inspired to share new discoveries in science and literature.
The Physicist-Poet: Prof Kerson Huang

Extracted from an interview article that first appeared in @NTU (Jan/Feb 2010), published by the Corporate Communications Office, NTU.

Most people would probably regard physics and Chinese literature as parallel fields with little in common, but for Prof Kerson Huang, a leading authority in physics who has authored two translations of classic literary works, it is readily apparent what unifies them. “For me, it is quite natural to see what they have in common – their sense of beauty,” he explains.

SEEKING THE TRUTH

Prof Huang’s life has been dedicated to explicating and sharing the truths of science and literature. The Chinese-American physicist-poet holds the post of Prof of Physics Emeritus at the Massachusetts Institute of Technology (MIT), where he has been a faculty member since 1957. In November 2009, he accepted an appointment as Nanyang Prof for two years, and is currently a visiting Prof at NTU’s Institute of Advanced Studies (IAS).

Over the course of his five-month sojourn at IAS, Prof Huang’s engagements have included advising a number of projects related to biophysics, high energy physics and statistical mechanics; discussing the establishment of a new Centre for the History of Science; and speaking at the International Science Youth Forum 2010. Earlier this year, he also delivered an IAS Public Lecture on “The Roots of Chinese Civilisation” in both English and Chinese.

“I’m enjoying my time here,” he says. “It’s interesting to be in a country that is developing a culture of pure research, which will be very important in the long run.”

AN EARLY LOVE OF SCIENCE

Prof Huang was born in Nanning, China, in 1928. As a child, he did not take an easy path to discovering his passion for learning; growing up in Manila, the Philippines, during the Japanese Occupation, he was unable to go to school, and so turned to studying physics at home with the guidance of a tutor.

“Physics is absorbing and beautiful because in one equation, it can explain to us how the whole universe works,” he says. “An equation may be simple in its statement, but complicated enough to describe the way of the world, when we study its details.”

Following the end of the war, Prof Huang enrolled in MIT and dove headlong into the challenges of higher academia. After completing his PhD at MIT in 1953, he joined the Institute for Advanced Study at Princeton University before returning to his alma mater in 1957 as a member of its Department of Physics.

Much of Prof Huang’s teaching and research career has been devoted to high-energy theory and statistical mechanics, subjects he has explored in a series of textbooks that have become foundational texts in the field. “The nature of physics is beautiful,” he recalls of his years as an educator, “and what I’ve always tried to do is to present its truths to students in an exciting way.”

THE PROBLEM OF FOLDS

In 1999, Prof Huang retired from teaching and has since chosen to devote himself to the complexities of biophysics. He is currently working on a long-term project with a team that includes Dr Chew Lock Yue from NTU’s School of Physical & Mathematical Sciences and researchers from the Centre for Applied Mathematics at Beijing’s Tsinghua University.
This collaboration began in 2006 and takes a novel approach to the study of protein folding, regarded as one of the most intriguing questions in biophysics. A protein is a sequence of molecules or amino acids; when it is put into water, this sequence will fold into a specific shape that allows it to fit with other molecules, so as to perform certain biological functions.

The team is employing a novel computer-driven model known as Conditioned Self-Avoiding Walk (CSAW) in its investigations. “What we are trying to understand via CSAW is how a protein folds into a shape, what determines that shape, and whether we can engineer it,” he explains. “We hope this statistical approach will lead to a better understanding of protein folding, and so open the door to more refined applications in drug design.”

THE WRITTEN WORD
Come, fill the Cup, and in the Fire of Spring
Your winter-garment of Repentance fling:
The Bird of Time has but a little way
To flutter – and the Bird is on the Wing.
– Rubaiyat, Verse 7

Besides science, Prof Huang’s other consuming passion has been for the written word. An avid reader of literature, he has penned his own verses since he was a youth. As a postgraduate student at MIT, Prof Huang adapted Edward FitzGerald’s Rubaiyat of Omar Khayyam into qijue (七绝), a classical Chinese verse form with four lines of seven characters each.

Written originally in Persian, Rubaiyat is a selection of 1,000 poems that was translated by FitzGerald into English in 1859. “This work is made up of very beautiful verses with imagery and phraseology in the best Victorian tradition,” explains Prof Huang. “I loved FitzGerald’s translation very much, and so it was natural for me to want to translate it into Chinese.”

Published in 1953, Prof Huang’s adaptation is known for its elegance and emotion. In 1986, the book, long out of print, was republished in Taiwan, and has since won over a new generation of admirers.

DRIVEN BY CURIOSITY
In 1984, Prof Huang embarked on another feat of literary translation. With the help of his wife, Rosemary, he rendered the I Ching (易经) into English. Known as the Book of Changes, it dates to the third century BC and comprises a divination system based on traditional philosophy and literature. Having first read the book as a youth, Prof Huang was eager to make its merits more readily available.

And this is precisely what he has been busy doing at NTU – sharing his knowledge and ideas with others. From discussions of scientific theory with colleagues to meeting students on the university’s premier CN Yang Scholars Programme, Prof Huang has been making the most of his time on campus, always with keenness and curiosity.

In words that might apply equally to his love of science and literature, he explains: “Our sense of curiosity is driven by the challenges we are exposed to… There are interesting elements in every question, and if we can find the answer, important implications may arise from our discovery.”
Developing Creativity and Innovation in Engineering and Science

MARTIN L. PERL

Stanford Linear Accelerator Center, Stanford University,
2575 Sand Hill Road Menlo Park, CA 94025, USA

Transcript of Prof Martin Perl’s keynote lecture at the Conference in Honour of CN Yang’s 85th Birthday

In this talk I discuss a range of topics on developing creativity and innovation in engineering and science: the constraints on creativity and innovation such as the necessity of a fitting into the realities of the physical world; necessary personal qualities; getting a good idea in engineering and science; the art of obsession; the technology you use; and the technology of the future.

1. Creativity and Innovation in Engineering and Science

1.1. Creativity

Creativity is sought everywhere: in the arts, entertainment, business, mathematics, engineering, medicine, the social sciences, and the physical sciences. Common elements of creativity are originality and imagination. Creativity is intertwined with the freedom to design, to invent and to dream. In engineering and science, however, creativity is useful only if it fits into the realities of the physical world.

1.2. Examples of Constraints on Creativity and Innovation

A creative idea in science or engineering must conform to the law of conservation of energy (including the mass energy $mc^2$). An inventor that thinks that she or he knows how to violate the conservation of energy will have to disprove a vast amount of laboratory measurements and accepted theory.

Figure 1 shows a traditional design for a perpetual motion machine, a rotating wheel with moving weights that seem to always give the wheel a non-zero torque. A direct dynamical analysis of the forces is tedious, therefore physicists and engineers simply use conservation of energy to negate the scheme, but this does not convince perpetual motion zealots who vary the design. At present many perpetual motion seekers are thinking about obtaining energy from the quantum mechanical fluctuations of the...
Fig. 2 All objects are made of the ordinary matter outlined here. There are other known types of matter such as unstable quarks and leptons, force carrying particles such as the Z0, and dark matter. But we do not know how to make objects of these particles.

Vacuum. This is a sophisticated proposal and negating it is complicated, perhaps at some deeper level the proposal has validity, but a radical change in our physics theory and new experiments are required before one should talk about building a machine to extract energy from the vacuum.

A creative idea in science or engineering must conform to our present knowledge of the nature of matter as shown in Fig. 2, unless we invent or find a new form of matter. Of course we have created new structures out of the known forms of matter such as nanotubes and layered materials.

1.3. Observations and Rules of Thumb

If your idea is in an area where the basic science or mathematics is not known, begin by paying attention to the known observations and rules of thumb in that area. Keep in mind, however, that observations and rules of thumb may be wrong. Remember when doctors thought that stomach ulcers were caused by stress or spicy food, now it is known that most ulcers are caused by bacterial infection.

1.4. Practicality and Feasibility Constraints

Creativity in science, engineering and computer science is constrained by feasibility and practicality. Consider the work in the US on a nuclear reactor powered airplane in the 1950's. Before the development of intercontinental missiles there was a desire to build a bomber that could fly around the world and perhaps even keep circling [1]. There were three severe problems faced by the designers: the weight of the reactor and the shielding, the shielding of the crew from the reactor radiation, and the contamination of an area if the plane crashes. Tests went as far as connecting a nuclear reactor to an engine. But the plane was never built. This idea violated the constraint of feasibility.

Since the maturation of automobile technology and powered aircraft technology, inventors have dreamed of a flying car, a vehicle used by the public that could be driven
on the road or flown. The vehicle would have easy convertibility between the two modes, Fig. 4. There have been a few temporary successes but the concept does not meet the constraint of practicality. How is the airspace to be regulated? Where are the wings when the vehicle is used as an automobile? What is the cost of purchase and maintenance?

2. Necessary Personal Qualities for Creativity in Engineering and Science

2.1. Be Competent in Mathematics

You don’t have to be a mathematical genius. While there are positions in scientific and technical fields that don’t require much mathematics, you should be competent in mathematics so that you can understand new developments.

2.2. Visualization
In engineering and scientific work it is crucial to be able to visualize how the work can be accomplished. The intended work might be the invention of a mechanical or electronic device, the synthesis of a complicated molecule, the design of an experiment to evaluate the efficacy of a new drug, or the full modeling of how proteins fold and unfold.

Different kinds of work require different kinds of visualization. Spread sheets or flow charts may work best in some cases. Drawings might be more suitable in others. Whatever the project, the value of visualization is in finding the best way to proceed while avoiding mistakes and perhaps even finding alternative solutions or good related ideas. Do not go into engineering or science if you do not have a basic ability to visualize. Visualization is crucial for creativity in engineering and science!

2.3. **Imagination**

Imagination is another crucial ability required to be creative in engineering and science — imagination with respect for the constraints I have talked about: known physical laws, correct observation and experimentation, feasibility, practicality. Begin with the far reaches of your imagination at the science fiction level, then gradually apply these constraints. Figure 5 shows the change from Jules Verne’s science fiction space vehicle to the space shuttle.

2.4. **Evaluate Your Laboratory Skills**

Evaluate the extent of your hands-on skills and laboratory skills. Are you good at working with tools, at building equipment, at running equipment — electronics, microscopes, telescopes...? This is my strength. I am an experimenter in physics because I like to work on equipment, am mechanically handy and get great pleasure when an experiment works. But hands-on skills do not have to be your strength. Isadore Rabi, my doctoral research supervisor at Columbia University in the 1950’s, had no laboratory skills. Yet Rabi won a Nobel Prize for advancing experimental atomic physics. When choosing what to work on in engineering and science, honestly evaluate the extent of your hands-on and laboratory skills.

3. Getting a Good Idea in Engineering and Science

3.1. **Personality and Temperament**

You must take into account your personality and temperament when choosing a technical field, or particular field of science. Be yourself. Creative scientists and engineers have many different types of personalities.

3.2. **It is Much Easier to Get Bad Ideas than Good Ideas**

In science and engineering for every good idea expect five or ten or twenty wrong ideas, or useless ideas, or obsolete ideas. Consider some of the following obsolete, bad ideas:

- The phlogiston model of combustion.
- Lamarckian evolution.
• A physical electromagnetic ether.
• Steam powered automobiles that can be competitive with internal combustion automobiles.

There are other ideas that appear to be wrong but are still pursued:
• Cold fusion.
• Using zero point energy from fluctuations of the vacuum.
• Telepathy.

3.3. Great Engineers and Scientists Have Bad Ideas as well as Good Ideas
Nikola Tesla was a pioneer and inventor in electrical technology. He was one of the first to understand alternating current phenomena and its use. He was one of the first to demonstrate the feasibility of long distance wireless, indeed in this field he is the equal of Marconi. But he also thought he could use the same wireless transmitting tower, Fig. 6, to transmit efficiently, large amounts of low frequency power to an antenna very far away. At the radio frequencies used by Tesla this was not possible because the power spreads out rapidly. Of course, substantial amounts of power can be transmitted at high frequencies using microwave beams. I don’t understand how Tesla, who understood radio theory so well and could visualize alternating current phase diagrams in his head, could be confused here.

3.4. Reduce the Frequency of Bad Ideas
There are several rules for reducing the frequency of your bad ideas. Make sure that you understand the physical laws and the neighboring technology relevant to your new idea. Colleagues, the literature, and the Web can be of help. Sometimes you have to keep going until you are the expert on the idea and you discover the show-stopper! Try to avoid the “dam the torpedoes, full speed ahead” state of mind. Several times I have rushed into a project even though it didn’t feel quite right, just hoping that it would work out in the end. It never did work out.

3.5. Sorting Out Good and Bad Ideas
On the other hand you may turn a bad idea into a good idea — don’t kill the bad idea prematurely. A bad idea can evolve into a good idea. This evolution into a good idea can be a short process, like turning a bug into a feature, to quote my colleague Eric Lee. Or
the evolution from bad to good can be long with many intermediary steps. It is rare for the complete development of a good idea to occur quickly. Be prepared for a winding road of research, development and prototyping or for a maze with many wrong turns.

3.6. Can Creativity and Innovation Skills in Engineering and Science Be Taught in the Classroom?
I believe the pressure of reality is important — a product must be improved or an experiment must work or a more efficient computer algorithm is needed. I don’t think these skills can be taught in the classroom. For a contrary view see Ref. 2.

3.7. Helpful Hints
Keep your eyes and ears open by scanning the literature, usually through the internet these days. Also eat lunch with colleagues, don’t eat at your desk. Avoid the “not invented here” prejudice. If you find an available technology that is superior to your own, use it!

You can learn from many people with different talents and different technical specialties. Five years ago we wanted to make a colloidal solution of powdered meteorite, my academic friends in colloid science were of little help, they knew a great deal about the theory and behavior of colloidal solutions of pure substances. But our meteoritic material consisted of a mixture of minerals such as silicates plus small metallic nodules. We learned how to make a colloidal solution of powdered meteorite from an engineer who was a specialist in the lubrication of automobile engines. One of the functions of engine oil is to suspend small particles that come from engine wear and incomplete combustion.

3.8. Limit Your Working Hours
These days there is pressure in engineering and science to work very long hours, a “24/7” work-week. But creativity and innovation require relaxation time and non-technical activities.

3.9. Luck
The importance of Good Luck is overrated for discovery and innovation in engineering. For a contrary view see Ref. 3. But it is important to avoid Bad Luck. The basic avoidance principle is the same as being careful when crossing a freeway. In engineering and science most bad luck is caused by mistakes in calculations, design, measurements, or experiments.

4. Colleagues
In the modern world the highly productive solitary engineer or scientist is rare. Find colleagues who are smarter than you and know more. I always look for such colleagues. The obvious advantage is that she or he may be able to solve the problem that has produced a dead end in your work. But more importantly, smart and knowledgeable
colleagues can save you a lot of time!

You don't have to be a fast thinker or a fast talker. In fact, it is best to avoid having such people as colleagues.

5. Obsession

5.1. **Obsession is Important When You Have a Good Computing, Engineering, or Scientific Idea**

When you are imagining and visualizing an idea that you expect to be fruitful it is important to be obsessed with the idea. Think about the idea as much as possible — perhaps even to the extent of neglecting boyfriends, girlfriends, children or spouses. Obsession, immersing yourself in the problem, will enable you to focus and thoroughly explore all the aspects of the idea: what has been done on related ideas, compatibility with physical laws and mathematics and logic, feasibility, practicality, extensions, and variations.

Obsession involving an entire field often leads to great new technology. Serious efforts to build a powered, heavier-than-air airplane occupied decades before the Wright brothers flew in 1903, Fig. 7. They were the first to make a controlled flight using design principles that are the foundation of present airplane design.

5.2. **Ending Obsession**

But, if in the course of the work you find that you run out of money, or someone else has a better idea, or your idea has a serious flaw — give up the obsession and move on!

An entire field can also be involved in a hopeless obsession. A good example is the concept of using a rigid, lighter-than-air dirigible to compete with airplanes. This was exciting technology in the early decades of the twentieth century. But almost all dirigibles, whether commercial or military, crashed or were dismantled within a decade of their construction. The building of commercial or large military dirigibles ended in 1938 when the Hindenburg zeppelin exploded and crashed in New Jersey, Fig. 8. The obsession was over.

5.3. **Ambiguous Obsession — Power from Controlled Fusion**

Since the 1950's a substantial scientific and engineering community has been working on using controlled nuclear fusion to produce power. The physics and engineering is understood in outline. There is no violation of any known laws of nature. There are several reasons for the long gestation period. The plasma physics is very complicated and details may not yet be understood, even prototype apparatus are enormous and expensive. There are severe engineering materials problems to be solved.

Yet the controlled fusion scientific and engineering community believes that it is feasible...
to build such a power plant. The question is practicality. How much will it cost to build and operate a fusion power plant? I think the fusion powder community is obsessed. It may be a good obsession that will lead to final success, or it may be an obsession that should be ended.

6. The Technology You Use
You must be interested in — perhaps even enchanted by — some of the technology, software, or mathematics you use. Then the bad days when the project or the research is stalled or moves backwards are not so bad, at least you have enjoyed the technology.

My 1955 Ph.D. thesis [4] made use of the atomic beam resonance apparatus of Fig. 9 for measuring the nuclear quadrupole moment of sodium.

The apparatus was beautiful — a shining brass vacuum vessel with a glass McLeod vacuum gauge filled with mercury. The current for the beam deflecting magnets came from surplus submarine batteries that were recharged every night from an ac-dc motor generator set. The sodium beam was produced by a pinhole oven that could produce a beam for about eight hours. I loved the technology and had myself built the smaller parts. But if the oven clogged I had to stop the experiment, clean and refill the oven, recharge the submarine batteries, that was a bad day.

Another advantage of being enchanted by the technology, programming, or mathematics that you work with is that you will be more likely to think of improvements and variations.

You should be fond of the technology, mathematics, or programs that you use, but not so much in love that you are blind to the possibility that there may be a better way.

7. The Technology of the Future — Replacement of Technologies
It is often impossible to predict the future of a technology. Some technologies are replaced again and again by new technologies serving the same function. An example is sound reproduction.

- Invented in 1890’s: Gramophone and phonograph mechanical inscription of a physical trace of sound on a disc or a cylinder with mechanical reproduction.
- Introduced in 1920’s: Electrical amplification used for mechanical inscription and sound reproduction. Gradually replaced purely mechanical system. Cylinders no longer in general use.
- Introduced in 1950’s: Long playing records.
- Introduced in 1960’s: Radical change in technology by recording on magnetic tape, cassette format dominant.
- Introduced in 1980’s: Another radical change in technology — development of the Compact Disc with digital recording. Until then all widely used systems for sound reproduction were analog.
- Present: Prevalent use of digital sound recording on magnetic hard drives and flash memories.
8. The Technology of the Future — Incremental Improvements

Some technologies persist through incremental improvements. A good example is the reciprocating internal gasoline engine, developed in practical form largely in Germany in the last few decades of the nineteenth century. Many efforts have been made to replace the use of internal gasoline engines in automobiles and small trucks; for example the Wankle rotary engine has been tried commercially. But the reciprocating internal gasoline engine is continually improved with the use of new auxiliary technologies such as computer control, Fig. 10.

9. The Technology of the Future — Some Promising Technologies Go Nowhere

Early in my technical career I learned that some promising technologies go nowhere. In 1950 I was a chemical engineer working in a radio tube factory of the U.S. General Electric Company. My boss had a special interest in developing very small radio tubes for use in portable radios and hearing aids. The smaller filaments used to heat the cathode would take less power allowing a longer lasting battery. Other tube companies had the same interest. My boss also pointed out that very small vacuum tubes would be an advantage in home radio sets because the time between turning on the set and hearing the sound would be shorter since the filament would heat up faster.

While we and other companies worked developing smaller vacuum tubes, the transistor was invented at Bell Laboratories in 1949 by John Bardeen, Walter Brattain, and William Shockley. The transistor age had arrived and the small vacuum tube was relegated to a few special uses, Fig. 11.

Acknowledgments

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References

1. See: Review of Manned Aircraft Nuclear Propulsion Program
Selected Research Publications

Year 2010

K. Huang, H. B. Low and R. S. Tung, Cosmology of an asymptotically free scalar field with spontaneous symmetry breaking, Preprint (2010)


Year 2009


**Year 2008**


**Year 2007**


### At a glance – IAS activities

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### At a glance – Visiting Professors & Visitors (2005 – 2010)

![Pie chart showing the distribution of visiting professors and visitors.](chart.png)
At a glance – Research Publications By Fellows

![Bar chart showing research publications by fellows from 2006 to 2010](image-url)