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Singapore, 20 July 2009

School of Physical and Mathematical Sciences Conference 2009

– Spotlight on speakers

Details on presentation topics of highlighted Nobel Laureates and Fields medallists, and information about the speakers:

Some thoughts on the prospects for topological quantum computation
Monday 20 July 2009, 2.00 pm – 2.45 pm, SPMS LT 2

Sir Anthony J. LEGGETT
University of Illinois at Urbana-Champaign
Nobel Laureate (2003) and Lee Kong Chian Distinguished Professor

Sir Leggett will review the basic idea of topologically protected quantum computation using nonabelian anyons, and introduce some of the condensed-matter systems (nu=5/2 and 12/5 quantum Hall systems*,(p+ip) Fermi superfluids,Josephson junction arrays....) which have been proposed for its implementation.

He will also discuss the experimental situation regarding the existence of nonabelian anyons in these systems, and some of the practical difficulties which need to be overcome in each case.

About Sir Anthony J. LEGGETT
Sir Anthony J. Leggett, the John D. and Catherine T. MacArthur Professor and Center for Advanced Study Professor of Physics, has been a faculty member at Illinois since 1983. He is widely recognised as a world leader in the theory of low temperature physics, and his pioneering work on superfluidity was recognised by the 2003 Nobel Prize in Physics. He is a member of the National Academy of Sciences, the American Philosophical Society, the American Academy of Arts and Sciences, the Russian Academy of Sciences (foreign member), and is a Fellow of the Royal Society (U.K.), the American Physical Society, and the American Institute of Physics. He is an Honorary Fellow of the Institute of Physics (U.K.). He was knighted (KBE) by Queen Elizabeth II in 2004 "for services to physics".

Fascinating Insights in Chemistry, Biology and Medicine by NMR and MRI
Monday 20 July 2009, 1.30 pm – 2.20 pm, SPMS LT 1

Richard R. ERNST
Laboratory of Physical Chemistry, ETH Zurich, Switzerland
Nobel Laureate (1991)and Lee Kong Chian Distinguished Professor

In the course of the past fifty years, the usage of nuclear spins as reporters have become a major source of information on the inner workings of nature. Nuclear spins are capable of sensing local magnetic fields which themselves are influenced by the chemical environment.

Thus, they are capable of reporting on the local structure in molecules and in organisms. In addition, they interact, and allow one to measure inter-nuclear distances that can be related to molecular geometries. They are sensitive to dynamic processes and permit one to explore molecular dynamics and physiological processes. In this way, NMR has become a major tool of investigation in chemistry, in molecular biology, and finally also in medicine.

Today, magnetic resonance imaging (MRI) is indispensable in clinical medicine for monitoring a large number of possible diseases in humans. Perhaps the most fascinating application is the exploration of brain function which provides a marvellous tool for quantitatively measuring mental activity and linking psychology to physiology.

About Richard R. ERNST

Born at Winterthur in Switzerland, Ernst was educated at the Federal Institute of Technology Zurich (ETH), where he obtained his PhD in 1962. He worked as a research chemist for Varian Associates, Palo Alto, California, from 1963 until 1968, before returning to the Federal Institute where he was appointed professor of physical chemistry in 1976.

The technique of nuclear magnetic resonance (NMR) described by I. I. Rabi in 1944, and developed by Felix Bloch and Edward Purcell in the late 1940s, quickly became a recognised tool for the exploration of atomic nuclei. As nuclei possess a magnetic moment they will tend to align themselves with any strong magnetic field. If, however, nuclei are subjected to radio waves of the appropriate frequency, they will be raised to a higher energy level, and align themselves in a different direction with respect to the field. With the removal of the radio signal, the nuclei will revert to their original energy state by emitting radiation of a characteristic frequency. The frequency of the radiation emitted allows nuclei to be identified, and the structure of certain molecules determined.

But, the process was time-consuming because, in order to find which radio frequency a sample responded to, it was necessary to sweep the applied frequency through a range of frequencies. Ernst developed a technique in which the sample was subjected to a single high-energy radio pulse. In this way numerous nuclei would respond and emit an apparently jumbled signal. But Ernst showed that, with the aid of Fourier analysis and a computer, the signal could be unravelled into its separate components. Ernst's procedure considerably increased the sensitivity of NMR.

In 1970, Ernst made a further advance. He found that if he subjected his samples to a sequence of high-energy pulses instead of to a single pulse, it enabled him to use NMR techniques to study much larger molecules. Ernst's ‘two-dimensional analysis’, as it became known, opened the way to investigate complex biological molecules such as proteins. His work also laid the foundation for the development by Peter Mansfield and others of MRI (magnetic resonance imaging).

<u>From 'On Water' and Enzyme Catalysis to Single Molecules and Quantum Dots, Theory and Experiment</u>

Tuesday 21 July 2009, 1.30 – 2.20pm, SPMS LT 1

Rudolph A. MARCUS
Division of Chemistry and Chemical Engineering, Caltech, USA
Nobel Laureate (1992) and Lee Kong Chian Distinguished Professor

Much of theoretical chemistry has involved equations and their application to experiments, Debye, Debye-Hueckel, Transition State Theory, Kramers, LCAO, RRKM, among others. In fortunate circumstances one can, as in a theory of electron transfer reactions, relate different experiments to each other without adjustable parameters, and indeed make predictions without computations.

More recently a major focus in theoretical chemistry has been on computations for individual systems, on the specific rather than on the generic, and not on equations relating data in different fields. In practice, both approaches are complementary. We consider several examples where analytical insights, sometimes complemented by computation, have been used to treat novel phenomena. They are drawn from our recent work on the catalysis of organic ‘on-water’ reactions in emulsions, several aspects of enzyme catalysis, including the temperature independence of the H/D kinetic isotope effect for some enzymes operating under their natural conditions, an abnormal change in the Arrhenius pre-exponential factor for a thermophilic enzyme operating below its break-point temperature (an analogy to a glass transition), and predictions relating single molecule enzyme catalysis to other single molecule properties.

We interpret intermittent fluorescence of semiconductor nanoparticles in terms of an electron transfer, structural diffusion, and trap surface states theory. The studies in this lecture were inspired by puzzles in the experimental results.

About Rudolph A. Marcus
Rudolph A. Marcus was born on 21 July 1923, in Montreal, Quebec, Canada. He earned a B.Sc. in 1943 and a Ph.D. in 1946 from McGill University. In 1949, he worked on post doctoral research at the University of North Carolina at Chapel Hill.

From 1951 to 1964, Marcus worked at the Polytechnic Institute of Brooklyn. In 1951 and 1952, he published RRKM theory papers (Rice-Ramsperger-Kassel-Marcus), utilising statistical ideas of the original RRK theory with the transition state theory of the 1930s to explain solution reaction rates. In 1955, Marcus began his research on electron transfers utilizing his knowledge in electrostatics.

Marcus explored the function of enfolding solvent molecules in solution to resolve the speed of reactions. He concluded that because slight adjustments occur in the molecular structure of the reactants and molecules, it is more difficult for electrons to move about. Furthermore, Marcus determined that the parabola depicts the correlation between the electron-transfer reaction and the reaction rate.

In 1968, he joined the faculty at the University of Illinois. From 1976 until 1977, Marcus travelled to Europe where he was first a Visiting Professor at the University of Oxford, then a Humboldt Awardee at the Technical University of Munich. It was in Munich that Marcus became fascinated by photosynthesis and electron transfers. In 1978, Marcus moved to the California Institute of Technology as the Arthur Amos Noyes Professor of Chemistry. Marcus received the Nobel Prize for Chemistry in 1992 for advancing the theory of electron-transfer reactions in chemical systems. The Marcus theory revealed information on such common phenomenon as photosynthesis and corrosion.

Modular Forms: Old Questions and Recent Results
Monday 20 July 2009, 1.30 pm – 2.30 pm, SPMS LT 3

Jean-Pierre SERRE
Collège de France
Fields Medallist (1954) and Lee Kong Chian Distinguished Professor

Modular forms are an old topic, starting with Euler’s work on partitions, and continuing with Gauss, Jacobi, Ramanujan, Hecke, etc. They are of interest to combinatorists, analysts, algebraic geometers and number theorists alike. Why? This is what the lecture will be about.

About Jean-Pierre SERRE
One of the best known mathematicians who has made many important contributions to number theory, algebraic geometry and algebraic topology, Professor Serre is the youngest person ever to have been awarded the Fields Medal. He won it in 1954 at the age of 27, three years after receiving his doctorate degree as a student of Henri Cartan. The numerous other awards he has received include: the Wolf Prize in Mathematics in 2000, and the first Abel Prize in 2003. He is also the recipient of no fewer than 10 honorary doctorate degrees, including from Cambridge, Oxford and Harvard.

Besides being a member of the French Academy of Sciences, he is also a foreign member of the Royal Society in the UK, the National Academy of Sciences in the US, as well as several other academies. Professor Serre held the Chair in Algebra and Geometry at the College de France from 1956 to 1994.

<u>On Mean Field Games</u>
Wednesday 22 July 2009, 8.40 am – 9.40 am, SPMS LT 3

Pierre-Louis LIONS
Paris-Dauphine University, Collège de France
Fields Medallist (1994) and Lee Kong Chian Distinguished Professor

This talk will be a general presentation of Mean Field Games (MFG in short), a new class of mathematical models and problems introduced and studied in collaboration with Jean-Michel Lasry.

Roughly speaking, MFG are mathematical models that aim to describe the behaviour of a very large number of “agents” who optimise their decisions while taking into account and interacting with the other agents. The derivation of MFG, which can be justified rigorously from Nash equilibria for N players games, letting N go to infinity, leads to new non-linear systems involving ordinary differential equations or partial differential equations.

Many classical systems are particular cases of MFG, like, for example, compressible Euler equations, Hartree equations, porous media equations, semi-linear elliptic equations, Hamilton-Jacobi-Bellman equations, Vlasov-Boltzmann models etc. In this talk we shall explain in a very simple example how MFG models are derived and present some overview of the theory, its connections with many other fields and its applications.

About Pierre-Louis LIONS
Pierre-Louis Lions, born on 11 August 1956, is a French mathematician. He received his doctorate from the University of Pierre and Marie Curie in 1979. He studies the theory of non-linear partial differential equations, and received the Fields Medal for his mathematical work in 1994 while working at the University of Paris-Dauphine. Lions was the first to give a complete solution to the Boltzmann equation with proof. Other awards Lions received include the IBM Prize in 1987 and the Philip Morris Prize in 1991.

He is a doctor honoris causa of Heriot-Watt University (Edinburgh) and of the City University of Hong-Kong. Currently, he holds the position of Professor of Partial differential equations and their applications at the prestigious College de France in Paris as well as a position at Ecole Polytechnique.

In the paper "Viscosity solutions of Hamilton-Jacobi equations" (1983), written with Michael Crandall, he introduced the notion of viscosity solutions. This has had a great effect on the theory of partial differential equations.

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Media contact:

Patricia Yap, Assistant Manager, Corporate Communications Office
Tel: 6790 5417; Mobile: 9846 6716; Email: patriciayapwl@ntu.edu.sg