EXCELLENCE IN SCIENCE

THE ROYAL SOCIETY

THEO MURPHY INTERNATIONAL SCIENTIFIC MEETING ON

Quantum-Coherent Energy Transfer: implications for biology and new energy technologies

Wednesday 27 – Thursday 28 April 2011
The Kavli Royal Society International Centre

Organised by Dr Alexandra Olaya-Castro, Dr Ahsan Nazir and Professor Graham Fleming FRS

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DAY 1

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12.45	Discussion	**18.00**	CLOSE
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DAY 2

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10.15	**Yoshitaka Tanimura** Theory of energy transfer beyond perturbative treatments	**14.45**	**Dongho Kim** The role of electronic couplings in excitation energy transfer processes of various molecular assemblies
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11.00	Coffee	**15.30**	Tea
11.30	**Markus Tiersch** Transport and entanglement in model systems of photosynthesis	**16.00**	**Greg Scholes** Lessons from nature about solar light-harvesting
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Quantum-Coherent Energy Transfer: implications for biology and new energy technologies

Organised by Dr Alexandra Olaya-Castro, Dr Ahsan Nazir and Professor Graham Fleming FRS

Wednesday 27 – Thursday 28 April 2011

Evidence that photosynthetic systems are capable of supporting quantum-coherent energy transport at high temperatures has generated controversy over the implications of such phenomena for biology and applications. This meeting will bring together leading scientists from photosynthesis, quantum information, and organic-polymer based research to discuss far-reaching consequences of these quantum effects in the design of novel, robust and efficient energy technologies.

Day 1 - Wednesday 27 April 2011

Session 1 – Excitation energy transfer: setting the scene
Chair – Professor Rienk van Grondelle, VU Universiteit, The Netherlands

09.00 Royal Society Welcome by
Professor Sir Peter Knight, Principal, Kavli Royal Society International Centre

09.15 Welcome by
Dr Alexandra Olaya-Castro, Organiser

09.30 Coherence effects in photosynthetic light harvesting
Professor Graham Fleming FRS, University of California Berkeley, USA

Recent developments in multidimensional ultrafast nonlinear spectroscopy led to observation of long lived electronic coherence in photosynthetic light harvesting complexes, including the most important light harvesting protein of plants LHCII. The initial experiments we carried out at 77K, but recent studies by Scholes and coworkers and Engel and coworkers have shown that the long lived coherence persists at physiological temperatures. In this talk, I will survey the experimental data and the current understanding of such experiments, which involve observations of ensemble coherence. I will then turn to a discussion of what advantages and potential new functions coherence may bring so as to elucidate design principles utilized in nature. Finally, I will briefly discuss the influence, if any, of electronic coherence in photosynthetic charge separation.

10.00 Discussion

10.15 Charge generation from excitons in molecular semiconductors
Professor Sir Richard Friend, University of Cambridge, UK

Excitons in molecular semiconductors generally show high Coulomb binding energies, of order 0.5 eV, because dielectric screening is low. They also show comparable values for the exchange energy between spin-singlet and spin-triplet configurations. These both present challenges and opportunities for the use of such materials in solar cells. I will illustrate this with examples from the Cambridge group:

Current designs for organic photovoltaic diodes depend on the ionisation of photogenerated excitons at the heterointerface between electron-accepting and hole-accepting semiconductors. It is very well established that photoinduced electron transfer across the heterointerface can be very rapid and very efficient. However, these excitations can stabilise as coulombically-bound charge-transfer excitons that are not easily separated to fully-separated charge carriers. I will present evidence for some polymer-polymer heterojunctions (formed between F8BT and PFB) that the coulombic binding between electron and hole in the charge transfer state is of order 0.2 eV. This can be determined from the magnetic field dependence of photocurrent and from long-lived luminescence.

Large exchange energies allow scope for multiple exciton generation for materials for which the triplet exciton energy is less than one half of the singlet exciton energy, since this favours energetically the fission of a photogenerated singlet to a pair of triplet excitons. We have shown that this process is effective in pentacene and that the resultant triplets can be ionised against a heterojunction formed with fullerene.

10.45 Discussion

11.00 Coffee

11.30 Fundamental aspects of electronic energy transfer
Professor Robert Silbey, MIT, USA

Excitation energy transfer in molecular aggregates has been studied theoretically from the fundamental work of Forster and Davydov to the present day. In this talk, recent advances will be discussed in the context of these earlier ideas to illustrate the fundamental issues that are relevant to understand recent experiments.

12.00 Discussion

12.15 Quantum Information science meets Biology
Professor Martin Plenio, Ulm University, Germany

In this lecture I will speak about various aspects of quantum dynamics and quantum information that have been developed over the last decade or so. I will then explore which of these concepts might be useful in studying the excitation transport in bio-molecular systems and which once may need to be applied with care.

12.45 Discussion

13.00 Lunch

Session 2 – Energy transfer in biomaterials
Chair – Professor Graham Fleming FRS, University of California Berkeley, USA

14.00 Understanding excited state dynamics using quantum control tools
Professor Valeria Kleiman, University of Florida, USA

Treating light-matter interactions quantum mechanically provides new schemes to quantum control photo-initiated reactions. Still, elucidation of the mechanism to achieve control has not been straightforward. In this talk we present a series of experiments with arbitrarily shaped femtosecond laser pulses to control the emission quantum yield and energy transfer of chromophores in solution. We use the combination from open-loop and close-loop experiments to isolate the dominant elements underlying the control mechanism and to unravel the role that the electric field spectral phase plays in the excited state dynamics.

14.30 Discussion

14.45 Coherent multidimensional optical spectroscopy of excitons with classical fields and entangled photons
Professor Shaul Mukamel, University of California Irvine, USA

Energy- transfer and charge-separation pathways in the reaction center of photosystem II may be revealed by coherent two-dimensional optical spectroscopy. The excited state dynamics and relaxation of electrons and holes are simulated using a two-band tight-binding model. The dissipative exciton and charge carrier motions are calculated using a transport theory, which includes a strong coupling to a harmonic bath with experimentally determined spectral density, and reduces to the Redfield, the Förster, and the Marcus expressions in the proper parameter regimes. The simulated third order two-dimensional signals, generated in the directions −k1+k2+k3, k1−k2+k3, and k1+ k2−k3, clearly reveal the exciton migration and the charge-separation processes. Novel 2Dsignals that make use of entangled photons will be presented and the observation of quasiparticle entanglement in multidimensional nonlinear optical spectroscopy of aggregates will be discussed.

15.15 Discussion

15.30 Tea

16.00 Photosynthesis and how to convert solar energy into fuels
Professor Richard Cogdell FRS, University of Glasgow, UK

One of the great challenges facing mankind is how to provide for our energy needs as oil and gas start to run out. Solar energy has the capacity, in principle, to provide this energy. For example enough solar energy hits the surface of the earth each hour to provide for man's current annual energy needs. Solar cells already have the capability to convert solar energy into electricity at efficiencies of close to 20%. The problem however is to produce fuels. In particular dense, portable fuels that can be used for transport needs such as flying and shipping. There is one major chemical process on our planet that does convert huge amounts of solar energy into fuel each year. That is photosynthesis.

In this presentation the key reactions in photosynthesis will be highlighted together with strategies of how to use them as a blueprint to devise novel ways to produce solar fuels. The basic reactions of photosynthesis can be broken down into four partial reactions. These are; 1) Light harvesting, 2) Charge separation, 3) Use of the positive charges to remove electrons from water, and 4) Use of the negative charges to do reductive chemistry (production of the fuel).

In Glasgow we are concentrating on steps 1-3. Ours is a dual approach. We are using working biological modules (light harvesting complexes and reaction centres) to learn the design principles of how to array them on surfaces and to answer the question as to what precise supra-molecular architectures are required for efficient light harvesting and charge separation. At the same time chemical systems capable of carrying out reactions 1-3 are being synthesised and tested. Progress in both these approaches will be described, together with some ideas about how to tackle reaction 4.

16.30 Discussion

16.50 Poster session

18.00 End of Day 1

Day 2 - Thursday 28 April 2011

Session 3 – Quantum features of energy transport
Chair – Dr Alexandra Olaya-Castro, University College London, UK and Dr Ahsan Nazir, Imperial College London, UK

09.30 Quantum coherence and quantum transport in photosynthetic antenna complexes
Professor Greg Engel, University of Chicago, USA

Long-lived quantum coherence in photosynthetic antenna complexes persists to physiological temperature and has been suggested to impact energy transport efficiency. We will present new 2D electronic spectra indicating that manifestly quantum transport dynamics appear in photosynthetic complexes. These dynamics arise from system bath coupling that mixes excitonic populations and coherences. From this mixing, excitonic populations take on oscillatory character and coherences "borrow" lifetime from the populations. The interpretation and origin of these terms of the relaxation superoperator will be discussed in detail.

10.00 Discussion

10.15 Theory of energy transfer beyond perturbative treatments
Professor Yoshitaka Tanimura, Kyoto University, Japan

A complete treatment of the entanglement of quantum systems, which evolves through the contact with thermal bath, must include the fact that the system and the bath are not fully separable. Therefore, quantum coherent superpositions of system and bath states, which are rarely included in theoretical models, are invariably present when an entangled state is prepared experimentally. We demonstrate their importance for the time evolution of the entanglement based on nonlinear optical measurement. We analytically derive an expression for the non-Markovianity in the time evolution of a two-level system in dissipative environment, and find a close connection with the directly observable nonlinear optical response. The result indicates that memory in the bath induced fluctuations rather than in the dissipation causes non-Markovianity. Initial correlations between states of the system and the bath are shown to be essential for a correct understanding of the non-Markovianity. Based on reduced hierarchy equation of motion approach, the differences between the correlated (entangled) and factorized dynamics are illustrated by multi-dimensional spectra.

10.45 Discussion

11.00 Coffee

11.30 Transport and entanglement in model systems of photosynthesis
Dr Markus Tiersch, University of Innsbruck, Austria

Recent experimental evidence suggests that in the early step of photosynthesis, where light is absorbed and excitation energy is transported through a network of molecular complexes of chlorophyll units, the energy transfer happens quantum coherently, even at room temperature. Stimulated by these findings, theoretical models of the excitation transfer process have linked the transport properties of light-harvesting complexes to entanglement. In this talk, we shall critically revisit the theoretical modeling of transfer scenarios in light-harvesting complexes and discuss the notion and role of entanglement in this context.

12.00 Discussion

12.15 The quantum Goldilocks principle
Professor Seth Lloyd, MIT, USA

The Goldilocks principle for the design of complex systems states that there is a level of complexity that is `just right' - less complexity compromises functionality, and greater complexity compromises robustness. This talk proposes a quantum Goldilocks principle for biomolecular complexes. As natural selection acts on quantum biological processes such as photosynthesis, time and energy scales are tuned to allow these quantum processes to function to efficiently and robustly.

12.45 Discussion

13.00 Lunch

Session 4 – Next generation of materials for energy technologies
Chair – Professor Jenny Nelson, Imperial College London, UK

14.00 Excitation dynamics in polymers
Dr Laura Herz, University of Oxford, UK

Conjugated polymers and molecules are increasingly used as cheap artificial light-harvesting materials in photovoltaic devices. Primary photoexcitations in conjugated molecular material are now generally believed to be correlated electron-hole pairs (excitons) with binding energy of up to a few hundred meV. However, the extent of their initial wavefunction delocalization and the following localization dynamics are still a matter of controversy. This talk will show how such wavefunction delocalization

dynamics are affected by relaxations of the conjugated backbone conformation and by the molecular arrangement in the condensed phase. Excitonic delocalization is demonstrated to occur along an individual conjugated backbone but also for certain conditions across several distinct molecular subunits of the material, both of which affect the rate of energy transfer in the organic material.
For materials designed for use in photovoltaic applications, typically a blend of at least two materials is used who form a type-II heterojunction at their interface, thus making charge separation energetically favourable. Electronic wavefunction delocalization near or across the interface has a pronounced effect on the efficiency of such charge generation as will be shown for the example of a molecular heterojunction formed between a conjugated polymer wrapped around a single carbon nanotube.

14.30 Discussion

14.45 The role of electronic couplings in excitation energy transfer processes of various molecular assemblies

Professor Dongho Kim, Yonsei University, Korea

Various synthetic strategies have been developed to devise a variety of covalently linked and self-assembled porphyrin arrays in molecular photonics because of their similarities in architecture and subunit structures to the natural photosynthetic light-harvesting complexes. For the porphyrin arrays to be efficient molecular devices, they should have very regular pigment arrangements which allow a facile light energy or charge flow along the array but do not result in the alteration of individual properties of the constituent pigments leading to the formation of so-called energy or charge sink. In these respects, understanding of photophysical properties of these macromolecular architectures, particularly the excitation energy migration processes occurring on ultrafast timescale, is essential for the rational design of molecular devices for photonic, electronic, or optoelectronic applications.
In the present study, we discuss the excitation energy migration processes of directly coupled linear porphyrin arrays (orthogonal and fused) and cyclic porphyrin arrays (1,3-phenylene bridged and directly linked) that have been investigated both at the ensemble and single-molecule levels by ultrafast spectroscopic technique and single molecule fluorescence spectroscopy. We have revealed that the ultrafast excitation energy migration processes in porphyrin arrays are strongly influenced by the electronic couplings among the constituent porphyrins as well as the structural rigidity of overall architectures. Our results on these spectroscopic observations allow for a better understanding of how the light-signal transmission occurs in these sorts of molecular assemblies and provide insight into the relationship between electronic coupling/structural rigidity and the excitation energy migration efficiency.

15.15 Discussion

15.30 Tea

16.00 Lessons from nature about solar light-harvesting

Professor Greg Scholes, University of Toronto, Canada

The aim of this presentation is to summarize what has been learned from studies of photosynthetic light-harvesting and energy transfer into a few important ‘lessons’ that will aid the design of optimal synthetic light-harvesting systems. Some of these design principles are not easily mimicked, yet they are fascinating and still under study. An example is the role that the protein plays in optimizing light harvesting. Other phenomena challenge our understanding of chemical dynamics. Recently, for example, it has been discovered that quantum-mechanical coherence is involved in the transport of the solar energy captured by pigment molecules in the light-harvesting proteins. This has stimulated immense excitement because evidence suggests that this biological process employs intrinsically quantum-mechanical phenomena—not too dissimilar from those studied in quantum information science. It is the realization that biology, normally understood to occur in a classical, thermodynamic limit, is able to utilize quantum-mechanical superposition states and interferences that is most tantalizing. These and other concepts that could be employed by nanoscale systems for light harvesting will be described.

16.30 Discussion

16.45 Overview

18.00 Close of meeting

Organiser, speaker and chair biographies

Professor Richard Cogdell FRS, University of Glasgow, UK (Speaker)
Richard Cogdell is the Hooker Professor of Botany at Glasgow University. He obtained his PhD from the University of Bristol in 1973. Then after a Post-Doctoral period in the US at Cornell University and the University of Washington he returned to an academic position at Glasgow in 1975. He has been an active researcher in the area of the primary reactions of purple bacterial photosynthesis for more than 40 years. At Glasgow the main focus of his research has been to determine the structure and function of the purple bacterial light harvesting complexes. More recently he has been trying to use photosynthesis as a model to devise robust artificial systems capable of using solar energy to make fuels.

Professor Greg Engel, University of Chicago, USA (Speaker)
Greg Engel received his undergraduate degree from Princeton University in 1999 and completed his doctoral work at Harvard University in 2004. At Harvard, he studied atmospheric chemistry with Professor Jim Anderson. In 2005, he moved to UC Berkeley at a Miller Postdoctoral Fellow and worked with Graham Fleming's group to study ultrafast dynamics of photosynthetic energy transport. In collaboration with the Fleming group, Engel worked on the initial experiments demonstrating quantum coherence in photosynthetic systems. In 2007, Engel moved to the University of Chicago as an Assistant Professor where his group studies the dynamics and control of excited state reactivity.

Professor Graham Fleming FRS, University of California Berkeley, USA (Organiser, Chair and Speaker)
Graham Fleming currently serves as UC Berkeley’s Vice Chancellor for Research, a position which he assumed in April 2009. Fleming served as the Deputy Director of Lawrence Berkeley National Laboratory from 2005 through 2007. Through joint appointments as Melvin Calvin Distinguished Professor of Chemistry at UC Berkeley, and Founding Director of both the Berkeley Lab's Physical Biosciences Division and UC Berkeley’s California Institute for Quantitative Biosciences (QB3), he has re-shaped the intersection of physical and biological sciences, while maintaining his own investigations into ultrafast chemical and biological processes, in particular, the primary steps of photosynthesis. Throughout his administrative career, Fleming has remained a highly active scientific researcher. He has authored or co-authored more than 400 publications, and is widely considered to be one of the world's foremost authorities on ultrafast processes. In addition to his many other activities, Fleming has given numerous talks around the world on the inter-relation and inter-complexity of energy, climate and photosynthesis. In 2007, Fleming led the effort (with co-chair Mark Ratner) to define Grand Challenges in Basic Energy Science for DOE/BES, resulting in “Directing Matter and Energy: Five Challenges for Science and the Imagination.”

Professor Sir Richard Friend FRS, University of Cambridge, UK (Speaker)
Richard Friend is the Cavendish Professor of Physics in the University of Cambridge, since 1980. He has pioneered the study of organic polymers as semiconductors, and his research group has demonstrated that these materials can be used in wide range of semiconductor devices, including light-emitting diodes and transistors. He co-founded Cambridge Display Technology Ltd in 1992 to develop light-emitting diode displays and Plastic Logic Ltd in 2000, to develop polymer transistor circuits that are now being developed as flexible active-matrix backplanes for e-paper displays. He is currently working on organic thin-film solar cells.

Dr Laura Herz, University of Oxford, UK (Speaker)
Laura Herz is a Reader in Physics at the University of Oxford and a Tutorial Fellow at Brasenose College. She received her PhD in Physics from the University of Cambridge in 2002 and was a Research Fellow at St John's College Cambridge from 2001 - 2003 after which she moved to Oxford. Her research interests lie in the area of organic and organic/inorganic hybrid semiconductors including aspects such as self-assembly, nano-scale effects, energy-transfer and light-harvesting for solar energy conversion.

Professor Dongho Kim, Yonsei University, Korea (Speaker)
Dongho Kim received his B.S. (1980) from Seoul National University and PhD. (1984) from Washington University. After postdoctoral research at Princeton University, he joined the Korea Research Institute of Standards and Science (1986). In 2000, he moved to Yonsei University as a Professor of Chemistry. He received the Scientist of the Month Award (1999), the Sigma-Aldrich Award (2005), the Korea Science Award in Chemistry (2006), and the Star Faculty Award (2006) and was selected as the Underwood Professor at Yonsei University (2007). Since 2002, he has been a fellow of The Korea Academy of Science and Technology. Currently, he is leading the Center for Smart Nano-Conjugates through the World Class University Program. His research activity is focused on the experimental investigation of pi-conjugated molecular systems such as porphyrin, pyrene, perylenebisimide, thiophene, and their assemblies with particular interest in excitation dynamics both in ensemble and at single-molecule level. He has co-authored more than 300 articles and about 15 reviews in journals and book publication.

Professor Valeria Kleiman, University of Florida, USA (Speaker)
Professor Kleiman was born in Buenos Aires, Argentina. She was raised and educated in Argentina and Uruguay, attending the School of Exact and Natural Sciences at the University of Buenos Aires, where she studied Chemistry and Physics. In 1990 she graduated with a major in Physical Chemistry and moved to the U.S. to pursue her graduate education. Her PhD. thesis work "The Use of Quantum Mechanical Interference to Control Photochemical Reactions" involved some of the first experiments in quantum control. After graduation in 1996 she went to the National Institute of Standards and Technology and then the Naval Research Laboratory where she continued her postdoctoral work on coherent control and started investigations on light harvesting in conjugated dendrimers. Since 2001 she is at the University of Florida, currently holding the title of Associate Professor in Chemistry. She has received several awards, including the Ralph E. Powe Junior Faculty Enhancement Award, the CAREER Award from the National Science Foundation and the Research Innovation Award. Professor Kleiman is currently a visiting professor at the Institute for Photonic Sciences (ICFO) in Cataluña, Spain.

Professor Seth Lloyd, MIT, USA (Speaker)
Seth Lloyd was the first person to develop a realizable model for quantum computation and is working with a variety of groups to construct and operate quantum computers and quantum communication systems. Dr Lloyd's interests include the application of information theory to physical systems, quantum coherence in photosynthesis, and the characterization of complex systems. He is the author of over a hundred scientific papers, and of `Programming the Universe,' (Knopf, 2004). Dr Lloyd is a professor of Mechanical Engineering at MIT, and an adjunct faculty member at the Santa Fe Institute. He is currently the director of the W.M. Keck Center for Extreme Quantum Information Theory (xQIT) at MIT.

Professor Shaul Mukamel, University of California Irvine, USA (Speaker)
Shaul Mukamel, currently the Chancellor Professor of Chemistry at the University of California, Irvine, received his PhD. in 1976 from Tel Aviv University. Following postdoctoral appointments at MIT and the University of California, Berkeley, he has held faculty positions at Rice University, the Weizmann Institute, and the University of Rochester. He is the recipient of the Sloan, Dreyfus, Guggenheim, and Alexander von

Humboldt Senior Scientist award, the OSA Lippincort Award and the APS Plyler Award for Molecular Spectroscopy. He is a fellow of the American Physical Society and the Optical Society of America. His interests focus on developing computational techniques for the design of novel ultrafast laser pulse sequences for probing electronic and vibrational dynamics in molecules. Biophysical applications include folding and dynamical fluctuations in proteins, hydrogen bonding, long-range electron and energy transfer in photosynthetic complexes, and signatures of chirality. Other areas are attosecond x-ray spectroscopy, excitons in semiconductor nanostructures, many-body effects in quantum optics. He is the author of over 650 publications in scientific journals and the textbook, Principles of Nonlinear Optical Spectroscopy (Oxford University Press, 1995).

Dr Ahsan Nazir, Imperial College London, UK (Organiser and Chair)
Ahsan Nazir is an Imperial College Junior Research Fellow in the Quantum Information Theory Group at Imperial College London. His primary research interests are based around understanding the delicate interplay of quantum coherence and noise in open quantum systems. In particular, he has developed and applied open system models in a number of areas, including both solid-state quantum information processing and quantum biology. He received his D.Phil in 2004 from the University of Oxford, for theoretical work on schemes for quantum information processing in semiconductor nanostructures. He then held Research Fellowships at Griffith University, Brisbane, and University College London, before joining Imperial College in January 2011.

Professor Jenny Nelson, Imperial College London, UK (Chair)
Jenny Nelson has 20 years' experience of research into novel nanostructured and molecular photovoltaic materials. Her current research is focused on the fundamental electrical, spectroscopic and structural characterization of pi-conjugated molecular electronic materials, the multi-scale modelling of optoelectronic properties of such materials, and their application to photovoltaic energy conversion. She has published over 150 articles in peer reviewed journals, several book chapters and a book on the physics of solar cells.

Dr Alexandra Olaya-Castro, University College London, UK (Organiser and Chair)
Dr Alexandra Olaya-Castro is an EPSRC Career Acceleration Research Fellow based in the Department of Physics and Astronomy of University College London (UCL). Her research aims at the theoretical understanding of possible roles of quantum phenomena in biological environments. She is currently investigating quantum dynamics in photosynthetic light-harvesting systems and the variations of these quantum properties when spectral and structural adaptations occur. She finished her doctorate in Physics at the University of Oxford in 2005 and moved to UCL in 2008 after holding a Junior Research Fellowship at Trinity College, Oxford.

Professor Martin Plenio, Ulm University, Germany (Speaker)
Martin Plenio received his Diploma and Doctorate from the University Göttingen in 1992 and 1994 respectively. From 1995 to 1997 he held a Feodor-Lynen fellowship at Imperial College where he joined the academic staff in 1998 as a Lecturer. In 2003 he became Professor of Quantum Physics. Following the award of an Alexander von Humboldt Professorship he joined Ulm University as Director of the Institute for Theoretical Physics in 2009 but remains part-time Professor at Imperial College London. In his scientific work Plenio has made important contributions to entanglement theory, the implementation of quantum information processing and quantum simulation with atoms, ions and photons, noise assisted quantum processes and more recently also the exploration of quantum effects in biology. Plenio has published 160 articles in refereed journals which have received more than 8000 citations. For his work he was awarded the Maxwell Medal and Prize of the IOP for 2004, a Royal Society Wolfson Research Merit Award in 2005 and the Royal Society Clifford Paterson Lecture for 2008 and an Alexander von Humboldt Professorship in 2009.

Professor Gregory Scholes, University of Toronto, Canada (Speaker)
Greg Scholes is a Full Professor at the University of Toronto in the Department of Chemistry. He undertook his PhD studies at the University of Melbourne, then spent time at Imperial College London as a Ramsay Memorial research fellow (Professor David Phillips), then pursued further postdoctoral work at the University of California, Berkeley (Professor Graham Fleming FRS). His present research concerns the study of light-initiated energy and electron transfer processes in systems ranging from semiconductor nanocrystals to conjugated polymers to photosynthetic light-harvesting proteins. Recent awards include election to the Academy of Science, Royal Society of Canada in 2009. Dr Scholes serves as a Senior Editor for the Journal of Physical Chemistry.

Professor Robert Silbey, MIT, USA (Speaker)
Bob Silbey is the Class of '42 Professor of Chemistry at MIT, where he has taught and done research for the past 44 years. He did his PhD. research at the University of Chicago, a postdoctoral year at the University of Wisconsin before joining the MIT faculty. Silbey's theoretical research has been concerned with problems having to do with electronic energy transport in solids: exciton energy levels, transport, spectral lineshapes, and phonon scattering. In the past decade, he has also been interested in the description of both single molecule spectroscopy and ultra-fast spectroscopy. He is a member of the US National Academy of Sciences and a Fellow of the American Academy of Arts and Sciences as well as the Royal Society of Chemistry. For recreation, he sails his 34' sailboat in the waters off Cape Cod in Massachusetts.

Professor Yoshitaka Tanimura, Kyoto University, Japan (Speaker)
Yoshitaka Tanimura received his PhD. under the guidance of Professor Ryogo Kubo at Department of Physics from Keio University in 1989. He was at the University of Illinois and the University of Rochester as a postdoctoral fellow of Professor Peter G Wolynes and Professor Shaul Mukamel, respectively. Then he spent nine years as associate professor at the Institute for Molecular Science before joining the faculty at Kyoto University in 2003. Research in his group is broadly concerned with the dynamic theory of processes of chemical interest in condensed matter. He developed theoretical descriptions and simulation methods based on the reduced hierarchy equations of motion and path integral formulation to investigate tunnelling phenomena, electron transfer reactions, and ultrafast nonlinear optical spectroscopy of molecular system in condensed-phase and biological systems. Based upon one of his expressions, he proposed high order multidimensional vibrational spectroscopy in 1993. This spectroscopy gives direct information on the anharmonic motions of molecules and provides a unique probe of quantum dynamics in condensed phase. This work stimulated an entirely new field of spectroscopy.

Dr Markus Tiersch, University of Innsbruck, Austria (Speaker)
Markus Tiersch is a postdoctoral researcher in the quantum information and quantum computation group at the University of Innsbruck, Austria, and at the Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences. After graduating from the Dresden University of Technology, Germany, where he worked on decoherence in adiabatic quantum computation, he held a research appointment at the Max Planck Institute for the Physics of Complex Systems.

In 2009, he completed his doctorate at the University of Freiburg, Germany, where he developed methods for benchmarking entanglement dynamics in open and high-dimensional quantum systems. His current research interests are centered around the interface of quantum information science, and the dynamics of molecular systems of biology and spin chemistry. There, he investigates quantum information methods and notions, as well as the treatment of non-classical effects in the context of energy transport in photosynthesis and the radical-pair model of spin chemistry.

Professor Rienk van Grondelle, VU Universiteit, The Netherlands (Chair)
Rienk van Grondelle studies the primary processes in photosynthesis. He has developed important new experimental tools such as multi-pulse, visible-pump-midIR-probe, stark and time-resolved single molecule emission spectroscopy. He has made major discoveries leading to our current understanding of photosynthetic light-harvesting and charge separation. On the basis of these achievements they were able to identify the major component in the process of energy dissipation in photosynthesis.

He has published a total of about 440 scientific papers in peer-reviewed scientific journals, including Nature, Proc. Natl. Acad. Sci USA, Biophys. J, J. Phys. Chem, Biochemistry, PCCP etc. His work attracted more than 16000 citations.

In 2001, he was elected as a member of the Royal Netherlands Academy of Arts and Sciences. In 2005 he received an honorary doctorate from Lund University. In 2006, he was elected as a foreign member of the Lithuanian Academy of Sciences. In 2007, he was selected for the Chaire Blaise Pascal, Ile de France. In 2009 he was appointed as Academy Professor by the Royal Netherlands Academy of Arts and Sciences. In 2010 he received the prestigious ERC Advanced Researcher grant.

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Poster numbers and titles

1	Alex Chin	Efficient simulation of strong system-environment interactions
2	Dmitrii Shalashilin	Multiconfigurational Ehrenfest method for quantum nonadiabatic dynamics in molecules
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4	Francesca Fassioli	Quantum coherent energy transfer in the antenna protein of photosynthetic cryptophyte algae
5	Hendrik Ulbricht	Coherent control of the motion of complex molecules and the coupling to internal state dynamics
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9	Brendon Lovett	Phonon induced dephasing and renormalization of optically driven quantum dots
10	Dara McCutcheon	Master equation approaches to coherent and incoherent dynamics in energy transfer processes
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Participant List

Correct as of 11 April 2011

Title	Forename	Surname	Organisation
Dr	Javier	Almeida	Ulm University, Germany
Dr	Janet	Anders	University College London, UK
Dr	Paul	Barker	Univeristy of Cambridge, uK
Miss	Katie	Barr	University of Leeds, UK
Dr	Jochen	Blumberger	University College London, UK
Dr	Steve	Brierley	University of Bristol, UK
Dr	Dan	Browne	University College London, UK
Mr	Dirk	Bruyland	
Dr	Alex	Chin	Ulm University, Germany
Dr	Jenny	Clark	Univeristy of Cambridge, UK
Professor	Richard	Cogdell FRS	University of Glasgow, UK
Dr	Animesh	Datta	University of Oxford, UK
Mr.	Nike	Dattani	University of Oxford, UK
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