Conference on Everything

Saturday,
May 5th, 2012
13:00—19:00 PM
Wolfson Hall,
Churchill College
Abstracts

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1. **How do immune cells seek and destroy bacteria**

   By Si Ming Man

   Our immune system consists of a large network of cells and proteins which protect us from bad microbes that have the potential to cause infections and make us ill. But how do immune cells identify and kill bad microbes? I investigated the interaction between immune cells and the bacterium called *Salmonella*. *Salmonella* is a type of disease-causing bacteria that is one of the leading causes of food poisoning worldwide. Immune cells have receptors which act like sensors that detect unique patterns found on bacteria. Two receptors found inside the immune cell have been identified to be key in detecting *Salmonella* during infection. Recognition of *Salmonella* by the immune cell initiates a series of striking cellular events that leads to the production of chemicals which can inhibit the growth of these bacteria and initiate warning to other cells about potential threats. Understanding how immune cells recognise *Salmonella* is important because it could provide a new avenue for the development of novel treatment and vaccination strategies in response to these human pathogens.

2. **Testing alternative theories of gravity**

   By Christopher Berry

   General relativity (GR) is our best theory of gravitation. It has so far passed every experimental test; however, it is still to be tested in regions of extremely strong gravity. The coming decade will see new precision measurements, in particular gravitational wave observations, that could highlight deviations from GR. We will look at f(R)-gravity, one of the simplest extensions of GR. There are several observable modifications to gravity in f(R) theory. Current laboratory measurements already place extremely tight constrains on deviations from GR. These effectively rule out any astrophysically interesting effects of f(R)-gravity.

3. Building trees and digging tunnels: understanding the evolution of talpid moles

By Richard S. Thompson

The 17 extant genera of true moles (family Talpidae) exhibit some of the most pronounced specialisations amongst living mammals. Although best known for their tunnelling habit, a number of genera exhibit semiaquatic adaptations (*Desmana, Galemys, Condylura*) or possess a more generalized body plan (*Urotrichus, Neurotrichus, Uropsilus* and *Dymecodon*). In order to understand the evolution of these unique specialisations, it is crucial to study both the morphology and DNA of this diverse mammalian group. Here, an existing detailed morphological study of the Talpidae is supplemented with new morphological characters and an eight locus molecular alignment in order to produce the most robust talpid phylogeny to date. A number of extinct taxa are added to this extant dataset, including the oldest confirmed talpid, *Eotalpa*, which lived on the Isle of Wight roughly 34 million years ago. Both parsimony and model-based methods are used to produce phylogenetic hypotheses for the Talpidae, allowing both the timing and evolution of talpid locomotor habits to be assessed. The data suggests convergent evolution of extreme fossoriality in North America and Eurasia, a model of evolution that conflicts with the morphological data when analysed alone. The integration of molecular phylogenetic data with traditional morphological approaches is key to the future study of systematics; allowing fossil taxa to influence large combined topologies should improve the positioning of such taxa for studies of both dating and phenotypic evolution.

4. Physics of ultra-cold gases

By Kayvan Sadegzadeh

In this talk, I would like to discuss my research on the theory of ultracold atomic gases. In particular, I will be considering a gas of lithium at a billionth of a degree above absolute zero. This exotic state of matter exhibits a number of remarkable properties. I will introduce the concepts of superconductivity and superfluidity, before focusing on a region of interest between these two phenomena. Here, the 'quasiparticle' description of such matter gives rise to a new particle called the 'Fermi polaron'.

5. Silicate, carbonate co-substituted hydroxyapatite for bone grafting applications

By Robert J. Friedrichs

The assortment of ions present in native bone mineral has driven research in creating ionic substitutions in synthetic calcium phosphate (CaP) bone grafting ceramics, namely hydroxyapatite (HA). For example, silicon substituted HA (SiHA) and carbonate substituted HA (CHA) have been shown to enhance bone formation. Co-substituting silicate and carbonate anions may encourage faster bone regeneration and remodelling given its constituent ionic substitutions have both clinically shown promise as synthetic bone grafting materials. Silicon carbonate HA (SiCHA) was synthesised via a wet precipitation methods and heat-treated up to 1200° C in a wet CO_2 atmosphere. The resulting product was characterised using physicochemical techniques.

X-ray diffraction showed that the HA phase was stable up to 1200° C. X-ray fluorescence along with C-analysis revealed that silicon substituted at 0.65 wt % and carbonate substituted at 4.35 wt %. Fourier transform infrared spectroscopy (FTIR) showed that carbonate ions substituted for both the A-hydroxyl site and B-phosphate site in HA. A sintering study indicated that SiCHA discs densified at a similar temperature to SiHA (~1200° C) rather than CHA (900° C). This may be due to stonger Si or Ca interactions with OH groups coupled with a lower amount of OH groups present due to A type carbonate substitution. *In vitro* biological experiments using bone related cells will investigate the potential of SiCHA for use in bone grafting applications.

6. Turbulent buoyant convection from a maintained source of buoyancy in a narrow vertical tank

By Daan Van Sommeren

This work focuses on understanding the mixing produced by an ideal source of buoyancy with zero volume flux released into a long vertical enclosure of small crosssectional area. This is relevant for flows in chemical reaction columns, magma flows in confined geophysical geometries, and heat or gas flows in mine shafts.

Experiments are performed to examine the buoyancy-induced mixing which results from the injection of a small constant volume flux of fluid of density ρ_s at the top of a long narrow vertical tank with square cross-section that is filled with fluid of density $\rho_0 < \rho_s$.

The injected fluid vigorously mixes with the less dense fluid that initially occupies the tank, such that a dense mixed region of turbulent fluid propagates downwards. The density at any height within this mixed region increases with time. For an ideal point source of constant buoyancy flux B_s, we show that the height of the mixed region grows as $h \sim B_s^{1/6} d^{1/3} t^{1/2}$ and that the reduced gravity $g' = g(\rho - \rho_0) / \rho_0$ at the top of the tank increases as $g'(0) \sim B_s^{5/6} d^{-7/3} t^{1/2}$, with d the width of the tank. Once the mixed region reaches the bottom of the tank, the turbulent mixing continues, and we demonstrate that the reduced gravity at each height increases approximately linearly with time. Our results are consistent with Prandtl's mixing length theory, which suggest that the local turbulent flux is given by $J = \lambda d^2 (\delta g' \mid \delta z)^{3/2}$, with λ an O(1) constant. We solve the corresponding nonlinear turbulent diffusion equation, and show a good agreement with experimental profiles obtained with a dye attenuation technique. We elucidate our model and experimental results by considering the problem of a methane leakage in a mine shaft.

7. How to build lightning-fast computers? Jump into the quantum world (at your own risk)!

By Frederik Floether

In this talk, I will discuss the work I have been doing as part of the collaboration between the Semiconductor Physics group and Toshiba Research Europe in Cambridge. In particular, I will show how the use of quantum bits, instead of classical bits, could revolutionise the future of high-speed computing.

Our group is trying to use the counterintuitive laws of quantum physics in order to dramatically speed up information processing. Unlike classical objects which seemingly always have well-defined properties (e.g. a cat is alive or dead but not both simultaneously!), quantum objects may have several mutually exclusive properties at once. The upshot is that doing computational operations with such quantum objects (qubits) allows, for certain tasks, the calculations to be exponentially sped up in comparison with classical computing. Accordingly, the holy grail of photonic quantum information processing is a fully integrated chip where qubits, in the form of photons, can be generated, manipulated, and measured. Such a scalable system would allow the processing of a large number of qubits and make quantum computers a reality. As is the habit of holy grails, they are not the easiest goals to achieve and one has to proceed in many small steps. So far, I have focused on the manipulation stage of the chip. I have measured the properties of different types of waveguide couplers — directional and X-couplers — which will help us to design future waveguides with the desired properties. In order to implement accurate quantum logic gates, the properties of the waveguides must be known and controlled very precisely.

8. Automated model optimization to study spike shape modulation in Layer 2/3 cortical pyramidal neurons

By Mike Vella

It has been proposed that, contrary to the "classical" view in which cortical action potentials are encoded as purely digital, all-or-none events, action potential (AP) shape may be used by the brain for representing and processing information. Cortical pyramidal neurons of Layer 2/3 show prominent variations in AP waveform during sustained depolarizing responses, which may lead to different levels of synaptic output at proximal axonal synaptic terminals, and different patterns of invasion of the dendrites by back-propagating APs. A range of membrane ionic channels probably plays an important part in this phenomenon. We carried out electrical recording during conductance injection, combined with morphological reconstruction and multicompartmental modelling of Layer II/III pyramidal neurons in rat and mouse cortical slices, to investigate the mechanism of AP waveform modulation. Evolutionary optimization techniques were implemented and a computational cluster architecture was designed for searching the parameter space of ion channel distributions and properties efficiently in parallel, to fit models to experimental data. As a test of the fitting process, we assessed its ability to detect point voltage-dependent conductances of different types, introduced at the soma by conductance injection (dynamic clamp). Using the available evidence, we describe how the inactivation kinetics of voltage-dependent potassium channels appears to play a particularly important role in the modulation of action potential waveform of these neurons.

9. **Towards a greater understanding of the "killer" shrimp *Dikerogammarus villosus*: impacts, control, and projections for future spread**

By Allison Truhlar

September 2010, *Dikerogammarus villosus*, a shrimp native to Eastern Europe, was found in Grafham Water, Cambridgeshire, United Kingdom. The species, which is more commonly known as the "killer" shrimp, has caused dramatic ecological change in its invaded range across Europe, and is now considered a national research priority for the Great Britain Non-Native Species Secretariat, Natural England and the Environment Agency. To help address the *D. villosus* problem, I devised a three-pronged research course: 1 – further quantify the ecological impact of *D. villosus*, 2 - evaluate methods of control and eradication, and 3 - identify areas at high-risk for future invasion. I will present my results to date and explain how they contribute to our understanding of *D. villosus* invasions.

10. **Building a robot friend that will *probably* speak to you**

By Matt Henderson

This talk is an introduction to dialogue systems, machines that humans can converse with using natural language, and in particular how probability theory is unreasonably useful in dealing with real spoken language. Probability theory is used to model uncertainty both in the system's observations of the user, and also in what the system believes the current state of the dialogue to be. It is shown that although grammars and rules may seem like natural models of language, real language is better modelled using statistical means which allow for ungrammatical language and robustness when faced with bad speech recognition. A new method for statistical spoken language understanding developed by the speaker is presented, along with results from an experimental evaluation with real human users recruited using Amazon's Mechanical Turk. The talk will include demonstrations of talking to a dialogue system, which will *probably* work.

Conference on Everything - Poster session

18:15 PM
SCR Lobby,
Churchill College
Abstracts

1. **The effect of unsteady hydrodynamic loads on tidal stream turbines**

   By Carl Sequeira

   Prototype tidal turbines have experienced oscillating loads with magnitudes much higher than design predictions. This has been attributed to high levels of unsteadiness in the marine environment. The consequence of high amplitude oscillating loads is that turbines may fail long before their design life due to fatigue. It took the wind turbine industry over 15 years to come to terms with this fatigue problem, but the operating environment of a tidal turbine presents a problem several orders of magnitude greater. If tidal turbines are to be realised as a reliable source of renewable energy over the next few decades, we need to be able to predict unsteady blade loads accurately during the turbine design stage. This poster demonstrates how we are applying unsteady computational fluid mechanics techniques to build low fidelity, rapid tools that can address this problem for industry.

2. **Quantum information and cryptography**

   By Oliver Snowdon

   The universe holds secrets from us all the time. Some of these are potential discoveries waiting to be made, but others are things which we could, even in principle, never find out. In this talk we will see how, using computer simulations, we can obtain a "God's eye view" of a "model universe", and explain how our lack of knowledge leads to dissipative phenomena such as friction and resistance. We will also explore how we can send secret messages of our own using quantum cryptography, and with any luck, see a working demonstration of a do-it-yourself quantum
   cryptography setup.

3. On the Impact of Social Norms on Energy Use in Churchill College

By Aaron Gillich

The role of behaviour in domestic energy use has long been a subject of much academic study. Recent work has examined the applications of behavioural science to energy efficiency and shown the potential for principles such as social norms to influence domestic energy use. This paper presents results from a study of electricity use in student accommodation at Churchill College. Students were given different feedback on their energy use throughout the term. Some were told only their own energy use, while others had their energy use compared to that of their neighbours. The results show that providing students with feedback can help curb their energy use, and that the use of social norms can increase this effect. This suggests the potential for relatively cost effective energy savings to be realised in student accommodations through behavioural 'nudges'.

4. The capillary interaction between granular objects

By Himantha Cooray

Particles floating at the surface of a liquid generally deform the liquid surface. Minimizing the energetic cost of these deformations results in an inter-particle force, which is usually attractive and causes floating particles to aggregate and form surface clusters. We present a numerical method for determining the three-dimensional meniscus around pairs of vertical circular cylinders and floating spheres. This involves the numerical solution of the fully nonlinear Laplace–Young equation using a mesh-free finite difference method. Inter-particle force-separation curves for pairs of particles are then calculated for different radii, contact angles and densities. These results are compared with previously published asymptotic and experimental results. For large inter-particle separations and conditions such that the meniscus slope remains small everywhere, good agreement is found between all three approaches (numerical, asymptotic and experimental). This is as expected since the asymptotic results were derived using the linearized Laplace–Young equation. For steeper menisci and smaller inter-particle separations, however, the numerical simulation resolves discrepancies between existing asymptotic and experimental results, demonstrating that this discrepancy was due to the nonlinearity of the Laplace–Young equation.

5. Temporary accommodation after disaster

By Elizabeth Wagemann

The frequency of natural disasters has increased in the last five decades, and the cost in human lives, homelessness, and economic disruption has gone up with it. After a disaster, housing is one of the main factors that can help to re-establish normalcy in such a chaotic situation.

The relief after disaster is usually organized in four phases distinguishing: emergency shelter, temporary shelter, temporary housing and permanent housing. This research is centered on the temporary accommodation (shelter and housing), because it is a key phase in the disaster recovery process: the solution between immediate relief and permanent housing. Designers, engineers and architects have projected ingenious relief shelters, such as prefabs, inflatables, geodesic domes, igloos and cardboard tubes, among others. These proposals have been published through journals, but many of them are not adequate solutions because they tend to develop universal solutions of shelter whereas the needs are local. In practice, prototype solutions have been generally more expensive and frequently rejected by users because they do not suit local conditions (cultural and climatic). Usually shelters given are adapted without regulation or design, and other transitional solutions are developed by people, following the particular criteria of the users. Therefore, it is usual that solutions given do not fit with the needs while the informal construction and the adaptation of shelters increase the risk from future disaster events. Why is there a mismatch between the designs developed and the real needs of temporary accommodation after disasters? It is argued in this research that most designs have been focused on shelter as a product, more than on the problem of giving accommodation to a population which needs to re-build their lives. Usually, designers attempt to produce fixed and ideal solutions where flexibility must be adopted. For example, prefabricated systems (as containers) are welcomed for their quickness to solve the problem in an emergency, but when their use is longer than planned, design problems arise because emergency solutions are not designed to last. Finally, after a disaster several requirements must be met, and one of the major conflicts identified is the gap between short-term necessities and long-term requirements. The main research objective is to describe and analyse the gap between designs developed to temporary accommodations after disasters and real necessities.

6. Deconstructing Binary Oppositions: An Exploration of Public/Private, City/Rural, Rich/Poor, Eastern/Western and Mother Tongue/Foreign Language Dichotomies in the English Education of Bangladesh

By Manzoorul Abedin

English is loved and loathed at the same time in Bangladesh. While there is a general attitude toward **English** as non-threatening to the national language or culture, at the same time, English is an increasing source of socioeconomic divisions. Languages are sensitive and sentimental issues in Bangladesh, which has a near-unique history of sacrificing lives for protecting its national language, **Bangla** (Bengali). English, which came to Bangladesh in the wake of the British colonial rule (1757-1947), thus relates to Bengali in a complex, yet controversial way. Historically, government intervention has been characterised by a Bengali-English dichotomy in the **public** sector and a *laissez faire* attitude in the **private** sector. In recent years, private spending (in the form of private tuition, for instance) has become higher than the total contribution of public expenditure per student at the secondary level placing enormous strains on curricula, family resources, parents, and school learners. A rather disturbing equity issue arises from the fact that private English medium schools, colleges and universities in Bangladesh, almost entirely based in **cities**, are in general expensive, and much better resourced than their public counterparts. Essentially the private institutions provide a globalised curriculum imported from/modelled after **western** curriculum. In effect, the **rich** elite receive a "western" education whereas the mass can only aspire to the national curriculum and a nationally ordered matriculation with less global cachet. Yet another consistent finding is that students who fail in English in national exams are mostly from **rural** areas which constitute the majority of the country. The poster, a pictorial contrastive analysis, synthesises references and statistics to provide insights on these complex dynamics that mediate students' English proficiency achievement in Bangladesh. By doing so, I shall attempt to sketch a broad outline of the problematic language policy and planning that has occurred in the country to justify the need to take an *emic* perspective (i.e. to consider the socioeconomic and cultural dimensions) in policy-making.

7. 3D electron microscopy of solar cells—towards more efficient nanomaterials

By Giorgio Divitini

World economical growth demands for an ever-increasing, sustainable energy production. The sun is one of the most promising energy sources; however, harnessing its power has proven a difficult task, because commonly available, traditional silicon-based solar cells are still relatively expensive. In the past twenty years new technologies have emerged, mostly based on nanostructured materials. Dye-sensitised and polymer heterojunction thin film solar cells, for example, have a great potential for two main reasons: their production can be scaled up easily to cheap mass-production, and they can provide an interesting cost/efficiency ratio. Moreover, unlike conventional solar cells, they are still effective in non-ideal illumination conditions (very common in the UK).

The design and synthesis of nanostructured thin film cells, however, requires extensive research and optimisation. Whereas traditional investigation systems (electron microscopy) are limited to bi-dimensional information, in this work we show how more complete, 3D information can be obtained by performing electron tomography on a solar cell cross-section. The extracted information gives valuable feedback on the synthesis process, as well as shedding light on the basic working principles of the photoelectrical process.