

# Institute of Mathematics and Physics, Aberystwyth University, Seminar Programme, Spring 2011

September 26, 2011

- Thursday 20th January, 3pm, Room 319
- Prof. Hans Maassen  
Department of Mathematics  
Radboud University, Nijmegen
- Introduction to Quantum Probability  
and Quantum Information

We argue that for the mathematical treatment of quantum mechanics an extended, non-commutative version of probability theory is needed. This theory is based on projection operators and operator algebras on the Hilbert space that is the daily tool of physicists. Argument for the necessity of this extension is the violation of Bell's inequality. We show that this violation permits a certain simple card game to be won, that could not be won if classical probability would hold. The 'no cloning theorem' and Heisenberg's principle of 'no information without perturbation' become basic theorems in non-commutative probability.

- Thursday 10th February, 4pm, Room 321
- Mr Sebastian Wildfeuer  
IMAPS
- Title: The  $H^\infty$ -Control Problem

This will be an introductory talk on the  $H^\infty$ - control problem for classical linear systems. We discuss solutions for the control problem via Linear Matrix Inequalities and Riccati Equations and related topics such as dissipative systems.

- Thursday 17th February, 3pm, Room 321
- Prof. P.I.C. Teixeira  
Instituto Superior de Engenharia de Lisboa  
Rua Conselheiro Emdio Navarro 1,  
P-1950-062 Lisbon, Portugal
- Title: More surprises in patchy colloids

Simple models of hard spherical particles with bonding sites are relevant to understanding a range of systems, including patchy colloids (super atoms with controlled functionality on the scale of microns) and biopolymers. The anisotropic interactions promote aggregation (self-assembly) of the particles, which may form what is known as network fluids. In this talk I shall discuss some new results for the model with two patches of type A and a variable number of patches of type B, which are responsible, respectively, for chaining and branching of the networks. In particular we find that we are able to obtain an unconventional pinched, or re-entrant, phase diagram, similar to that predicted by Tlusty and Safran [T. Tlusty and S. A. Safran, *Science* 290, 1328 (2000)] using a more coarse-grained theory. We further show how our model may shed some light on the criticality of the dipolar Yukawa hard-sphere fluid and its limiting case, the dipolar hard-sphere fluid.

- Wednesday 23rd March, 1pm, Llandinam B20
- Richard Taylor  
Professor of Physics, Psychology, and Art  
Department of Physics, University of Oregon
- Title:  
Stress, Seeing and Semiconductors: Using the Physics of  
Fractals to Cross Disciplines

Fractals are patterns that repeat at many magnifications. These intricate patterns are found throughout nature, ranging from clouds, rivers and lightning through to our brains, blood vessels and lungs. Due to their prevalence in nature and their growing impact on technology, fractals have assumed a rapidly expanding role across the sciences and arts. In this talk, I will explore some of the intriguing properties of fractals by taking a scientific journey through the research fields I have worked in. These include nano-electronic circuits, artificial retinas, solar cells, collapsing Antarctic ice-shelves, neural brain structure and the stress-reducing properties of artworks. I hope to show a common theme - that quantification of their underlying fractal geometry provides an enhanced understanding well beyond the traditional qualitative views of these diverse systems.

- Thursday 14th April, 3pm, Room 321
- Dr Andrew Kraynik  
University of Manchester
- Title:  
Foam structure and rheology: the shape and feel of  
random soap froth

- Thursday 12th May, 3pm, Room 321
- Dr. Michael H. Denton  
Department of Physics, Lancaster University
- Title: Source, acceleration, and loss of electrons in the outer radiation belt

The outer radiation belt, dominated by electrons with energies  $> 500$  keV, is a dynamic region of geospace. It responds to changes in the solar wind such that the measured electron flux in the region may change by five orders of magnitude in less than 24 hours. Due to their high energies electrons in the radiation belt damage spacecraft systems, reducing satellite lifetimes, or even causing the loss of entire assets.

Our understanding of physical processes within the radiation belt remains incomplete. We do not know the source of the electrons and we do not know the dominant loss mechanisms, although candidates for each have been proposed. The NASA Radiation Belt Storm Probes (RBSP) mission, due to be launched in 2012, aims to resolve some of these issues.

We present a description of current knowledge of radiation belt dynamics, outline recent observations and progress in this field, and briefly summarise the RBSP mission and its goals.

- Monday 16th May, 14:00, Room 321
- Prof. Alexander M. Linkov  
Institute for Problems of Mechanical Engineering of  
Russian Academy of Sciences  
(presently Rzeszow University of Technology)
- Title: Speed Equation in Problems of Hydraulic  
Fracturing: Theory and Applications
- Abstract. The talk concerns with hydraulic fracture, the technique used extensively for various engineering purposes. They include stimulation of oil and gas reservoir recovery, increasing heat production of geothermal reservoirs, measurement of in-situ stresses, control of caving in the roof of coal and ore excavations, enhancing efficiency of  $CO_2$  sequestration and isolation of toxic substances in rocks.  
In contrast with many publications, which employed the global form of the mass balance to trace liquid front propagation in time, the local speed equation is written explicitly and used. The author shows that employing the speed equation extends options of numerical simulation. Its using also discloses the crucial feature of the problem: at the points of the liquid front we have prescribed two rather than one boundary conditions.

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This indicates that the problem will appear ill-posed when solved numerically for a fixed front at a time step. Consequently the problem requires proper regularization to have accurate and stable numerical results.

The author suggests a method of regularization employing the very source of the difficulty to overcome it. Numerical examples illustrate the exposition and demonstrate the efficiency of -regularization for numerical simulation of hydraulic fractures.

- Wednesday 13th July, 2pm, Room 319
- Prof. Santanu Dey  
Department of Mathematics,  
Indian Institute of Technology Bombay
- Title: Generalized Interaction Model and Transfer  
Functions

Using a construction involving lifting of row contractions we generalize the toy model of repeated interactions between quantum systems presented by Gohm. For this model there is an outgoing Cuntz scattering system involving two wandering subspaces. We associate an input/output linear system which leads to a transfer function. This transfer function is a multi-analytic operator, and we show that it becomes inner if we assume that the system is observable.

- Thursday 14th July, 3pm, Room 321
- Dr. Kristin Høydalsvik  
Norwegian University of Science and Technology (NTNU)
- Title: In situ X-ray imaging of catalyst nanoparticles by using ptychographic coherent diffractive imaging

Ptychographical coherent diffractive imaging is a technique for obtaining real-space images of high resolution without the use of lenses. The method consists of measuring oversampled small-angle scattering patterns of an object by using coherent X-rays. High resolution real-space images are obtained by using an iterative phase retrieval procedure, with resolution better than  $\sim 40\text{nm}$ . The reaction  $\text{Li}_2\text{ZrO}_3 + \text{CO}_2 \rightarrow \text{Li}_2\text{CO}_3 + \text{ZrO}_2$  (temperatures  $> 600^\circ\text{C}$ ) is highly relevant for  $\text{CO}_2$  storage.  $\text{Li}_2\text{ZrO}_3$  particles were deposited onto  $\text{Si}_3\text{N}_4$  membranes, mounted at the beamline, and heated to  $620^\circ\text{C}$ . The particles were imaged, using ptychographical coherent diffractive imaging, both for low- and high  $\text{CO}_2$  partial pressure. Another important application for X-rays is structural determination of buried layers. In the last part of the talk, I will present the preliminary results of X-ray studies of a sample consisting of a  $\text{SiC}$ -substrate and an interlayer capped by graphene\*. For example, by using X-ray reflectivity, the film thickness of the interlayer has been found to be approximately  $26\text{nm}$ . In order to gain knowledge about the crystal structure of this interlayer, we have also performed measurements using grazing-incidence wide-angle X-ray scattering (GIWAXS) in the home laboratory at NTNU.

(\*) Prepared in collaboration with Aberystwyth University.