NUI Galway
OÉ Gaillimh

School of Mathematics, Statistics and Applied Mathematics Research Day
26th April 2012

Contents

Programme

9.30-10.00	Tea and Coffee	
10.00-10.15	Ray Ryan	Opening Remarks
10.15-10.45	Graham Ellis	Measuring Shape
10.45-11.15	Ashley Piggins	An Introduction to Social Choice Theory
11.15-11.45	Tea and Coffee	
11.45-12.15	Johnny Burns	The Topology of Homogeneous Spaces
12.15-12.45	Milovan Krnjajic	Bayesian Modelling and Inverse Problems
12.45-2.00	Lunch and Poster Session in Arts Millennium Building	
2.00-2.30	Niall Madden	Postprocessing of Finite Element Solutions to One-Dimensional Convection-Diffusion Problems
2.30-3.45	Blitz Session	
3.50-5.00	Poster Session in Arts Millennium Building	
5.00	Reception and Presentation of Poster Prizes in Staff Club, Quadrangle	

1 Introduction

Welcome to the annual Research Day of the School of Mathematics, Statistics and Applied Mathematics. Research in the School covers a broad range of areas in pure and applied mathematics, statistics, biostatistics and bioinformatics. There are close to 30 PhD students in the School, spread across all these areas. Among the funded research activities in the School are the De Brún Centre for Computational Algebra and the Galway wing of the BIO-SI centre for bioinformatics and biostatistics, both supported by SFI under the Mathematics Initiative. The latter is a collaboration with the School of Mathematics and Statistics in the University of Limerick. There are several other collaborative activities with UL in mathematical modelling and in statistics.

During the past year, a new interdisciplinary activity was formally initiated. CORE, The Complex Systems Research Centre is a collaboration between Physical, Mathematical, Biological, Computational and Social Scientists with the common aim to understand the most challenging and complex problems faced by science and society. The centre was launched with a three day conference in October 2011, with the theme Self-Organization, Emergence and Nonlinearity in Physical, Natural and Social Systems. CORE has run a regular research seminar with local and invited speakers and a workshop is planned for June in collaboration with COST, the intergovernmental framework for European Cooperation in Science and Technology

Recent activities in statistics, biostatistics and bioinformatics include CASI 2011, the 31st Conference on Applied Statistics in Ireland, held in NUI Galway, the ninth annual RECOMB Satellite Workshop on Comparative Genomics and the 2nd International BIO-SO Workshop on Statistical Modelling. The annual Groups in Galway conference, now in its 34th year, continues to attract leading researchers and has established Galway as an acknowledged centre of excellence in algebra.

In 2011 the de Brún Centre for Computational Algebra hosted a week-long de Brún Workshop on groups, combinatorics and computing, the annual two-day Groups in Galway meeting and the annual two-day Irish Geometry Conference. The centre welcomed a number of visitors including Professor Arny Feldman of Franklin & Marshall College who visited for 12 months.

The work of the School continues to attract funding in a difficult environment. Successes in SFI, IRCSET and Hardiman Scholarships led to a record intake of 12 new research postgraduates into the School.

The School continues to develop its research activities into new areas, including computational algebra, geometry and topology, group theory and design theory, numerical analysis, quantum computing and computer algebra, biostatistics and bioinformatics, mathematical physics, mathematical modelling and biomechanics. The lectures given today give a sample of some of these and the poster session showcases some of the work being done by our research students.

Graham Ellis was appointed Established Professor of Mathematics during the past year and Tim Downing has taken up a post as Contract Lecturer in Bioinformatics. Donal O'Regan's outstanding record of research was honoured by his election to membership of the Royal Irish Academy.

We would particularly wish to note with sadness the passing of a valued and respected colleague. Jim Flavin served as Professor of Mathematical Physics for 39 years. He retired in 2002 but carried on his research work in the years since then. He contributed to the life and work of the University in many ways, as a teacher, scholar, scientist and governor. He will be greatly missed.

Ray Ryan
Head of School

2 Presentations

Measuring Shape

Graham Ellis
School of Mathematics, Statistics and Applied Mathematics

To illustrate the potential uses of computational topology software I will describe a method of MacPherson and Schweinhart for measuring the shape of complicated geometric structures such as branched polymers.

An Introduction to Social Choice Theory

Ashley Piggins
Economics

Mathematical methods can be applied to the social sciences. These methods have been particularly fruitful in economics. Social choice theory is concerned with aggregating individual preferences or judgements into a collective or social preference or judgement. The talk will explore the early history of the subject and present Arrows impossibility theorem (which marks the beginning of the modern period of social choice theory). The talk will conclude by describing some recent work in the area.

The Topology of Homogeneous Spaces

Johnny Burns
School of Mathematics, Statistics and Applied Mathematics

We will look at some examples of Homogeneous Spaces. We will consider how and why one might compute their Betti Numbers and discuss a formula involving these numbers.

Bayesian Modelling and Inverse Problems

Milovan Krnjajic
School of Mathematics, Statistics and Applied Mathematics

Bayesian modelling is a modern approach to statistical analysis which provides a fully probabilistic framework for inference by merging rigorous statistical theory with results of computer based simulations. Going beyond finite-dimensional parametric model specifications, Bayesian non-parametric methods specify prior distributions on function spaces and yield flexible statistical models capable of quantifying all aspects of uncertainty present in the problem. Bayesian models are especially suitable for analysis of inverse problems, which involve ”inverting” the output of computer codes running (deterministic) forward physical models to obtain distributions of unknown forward model inputs of interest. Applications include studying the flow of liquids (e.g. in oil reservoirs), atmospheric event reconstruction, tomography, analysis of seismic data, and other engineering or scientific problems.

Postprocessing of finite element solutions to one-dimensional convection-diffusion problems

Niall Madden
School of Mathematics, Statistics and Applied Mathematics

Consider the harmless-looking differential equation

$$-\varepsilon u'' + au' + bu = f \quad \text{on } (0,1), \qquad u(0) = u(1) = 0,$$

where ε is a small positive parameter. It is well-known that standard finite element and finite difference methods will yield numerical approximations to this problem that appear quantitatively and qualitatively useless: they oscillate wildly, and are extremely inaccurate. One can attempt various forms of post-processing to recover some useful approximation – much like methods in signal processing are applied to recover information from noisy data. For the purposes of this talk, a particularly interesting approach is that of Song, Yin and Zhang (*Int. J. Numer. Anal. Model.* 4: 127–140, 2007). Here we present a simple, intuitive and more general version of their analysis.

This is joint work with Prof. Martin Stynes, UCC.

"Blitz" of 7-minute presentations

- Alexander Rahm, *Invariants of infinite discrete groups of isometries*
- John Newell, *Estimating mean residual life in right censored studies*
- Ray Ryan, *Finite difference calculus for polynomials on vector spaces*
- Pádraig Ó Catháin, *Thoughts on research*
- Michael Tuite, *What is a vertex operator algebra?*
- Guranda Tevdoradze, *Overview of research work in mathematics (1982–2012)*
- Petri Piiroinen, *Quantifying decision making*

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3 Poster Session

Probing the DNA methylation and genetic expression patterns of IBD patients

Alan Barnicle
Supervisors: Cathal Seoighe, Laurence Egan

Patients with Inflammatory bowel disease (IBD) have an elevated risk of colon cancer but the molecular mechanisms underlying the risks have not been fully elucidated. It is known that the epigenetic factors such as DNA methylation are associated with the development of colon cancer. A subset of IBD called Ulcerative Colitis (UC) is an inflammatory disorder specific to the colon. The pathology of UC involves inflammation of crypt architecture i.e. the epithelial lining of the colon. Recently, interest has risen to isolate populations of intestinal epithelial cells, for investigations of human colonic adenocarcinoma which originates from colonic epithelia. The objective of this study is to utilize the genomic and epigenomic information of a subset of patients to discover what role methylation plays in IBD-associated Colon Cancer.The data generated from this study should provide an important contribution to the understanding of inflammation-associated carcinogenesis, and provide potentially valuable biomarkers for the diagnosis of this condition

Supported by IRCSET

Survival trees based on node re-sampling

Alberto Alvarez-Iglesias
Supervisors: John Newell and John Hinde

Tree based methods applied to survival analysis (commonly called survival trees) are a popular non parametric alternative to the Cox proportional hazard model. One of the reasons for the popularity of these methods is that the results of the statistical analysis can be displayed in a tree fashion. This feature facilitates the interpretation of the model and makes the model particularly attractive for clinicians and physicians. It has been shown in the literature that trees that are generated using the recursive partitioning algorithm are affected by the variable selection bias (White and Liu 1994; Shih 2004). Methods for growing survival trees based on conditional inference procedures (Hothorn et al. 2006) were developed to eliminate this problem. However, such methods are problematic for

different reasons. The main drawback of this approach is the incapability of detecting interaction effects in the model. In this work, a new method for growing survival trees is presented which aims to overcome all these difficulties. The new method will be applied to a cohort of women with breast cancer from the West of Ireland.

[1] Hothorn, T., Hornik, K. and Zeileis, A. (2006). Unbiased Recursive Partitioning: A Conditional Inference Framework. *Journal of Computational and Graphical Statistics*, 15(3):651-674.

[2] Shih, Y-S. (2004). A Note on Split Selection Bias in Classification Trees. *Computational Statistics and Data Analysis*, 45: 457-466.

[3] White, A.P. and Liu, W.Z. (1994). Bias in Information-Based Measures in Decision Tree Induction. *Machine Learning*, 15, 321-329.

Supported by IRCSET

Algorithm for computing cohomology of $SL(2,\mathbb{Z}[\frac{1}{m}])$

Bui Anh Tuan
Supervisors: Graham Ellis

1995, Alejandro Adem and Nadim Naffah published a paper named *On the cohomology of* $SL(2,\mathbb{Z}[\frac{1}{p}])$ where p is any prime. Now, we would like to calculate the more general case, $SL(2,\mathbb{Z}[\frac{1}{m}])$, where m is any positive integer. We know that, $SL(2,\mathbb{Z}[\frac{1}{p.n}]) = SL(2,\mathbb{Z}[\frac{1}{n}]) *_{\Gamma_0(p)} SL(2,\mathbb{Z}[\frac{1}{n}])$ then by using some techniques in trees and groups acting on trees we found a algorithm to compute cohomology of $SL(2,\mathbb{Z}[\frac{1}{m}])$. The algorithm was implemented in GAP with packages HAP and "congruence".

[1] Graham Ellis and Gerald Williams. On the cohomology og generalized triangle groups. In Comment. Math. Helv. 80 (2005).

[2] Jean-Pierre Serre. Trees. In Springer-Verlag Berlin Heidelberg 1980.

[3] Keith Conrad. $SL(2,\mathbb{Z})$.

Supported by School of Mathematics,Statistics and Applied Mathematics - National University of Ireland, Galway

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Elastic Instability

Artur Gower
Supervisor: Michel Destrade

If you compress an elastic solid enough, such as a biological tissue, there will be a point at which wrinkles will appear, i.e. a bifurcation solution will be possible. This is well described by calculating the linearized equations on top of a full non-linear deformation. I am also working on surface waves, specifically Rayleigh waves, in layered media, again using the approach of incremental elasticity. And I am interested in the constitutive theory, that is the theory that characterize a specific material as being elastic, fluid, plastic etc.. Further more I'm fond of Conservation methods in numerical analysis and Hamiltonian formulation of non-linear elasticity.

Supported by NUIG - Hardiman Scholarship

Negative energy balance alters hepatic miRna expression in postpartum dairy cattle

Attia Fatima
Supervisors: Cathal Seoighe, Dermot Morris

Negative energy balance is a metabolic disorder of dairy cows. In this study 11 miRNAs were differentially expressed in liver tissues of dairy cattle under severe negative energy balance, two weeks postpartum. These miRNAs have been implicated in liver diseases. These miRNAs appear to regulate a set of hepatic genes that have been previously reported to have significantly altered expression in the same set of animals[1]. Identification of SNPs in either the miRNA seed or the 3-UTR regions of targets affected by SNEB could lead to identify animals susceptible to negative energy balance.

[1] McCarthy, S., Waters, S., Kenny, D., Diskin, M., Fitzpatrick, R., Patton, J., Wathes, D. and Morris, D. (2010). Negative energy balance and hepatic gene expression patterns in high-yielding dairy cows during the early postpartum period: a global approach. Physiol Genomics.42A (3): 188199

Conjugacy Classes of Subgroups of a Direct Product.

Brendan Masterson
Supervisor: Götz Pfeiffer

The purpose of this research is to describe a way of computing the conjugacy classes of subgroups of a direct product, $G_1 \times G_2$, using knowledge of the conjugacy classes of subgroups of G_1 and G_2. As a basis we have *Goursat's lemma*, which describes the bijective correspondence between subgroups of a direct product and quintuples which contain subgroups of each factor group and an isomorphism between their quotients. We implement a program in GAP which performs this procedure in an efficient manner.

[1] K. Bauer, D. Sen, P. Zvengrowski. A Generalized Goursat Lemma, 2011.

Propensity Scores in Observational Studies

Cara Dooley
Supervisors: John Hinde, John Newell

The propensity score was originally suggested by Rosenbaum and Rubin in 1983 for use in observational studies, the propensity score can be used to balance over observed covariates when the control group and group of interest have heterogeneity in the observed covariates. We will discuss some of the uses of propensity scores in observational studies and issues in the calculation of propensity scores, with illustrated examples.

[1] David Firth. Bias reduction of maximum likelihood estimates. *Biometrika*, 80, 27-38, 1993.

[2] Paul R. Rosenbaum and Donald B. Rubin. The central role of the propensity score in observational studies for causal effects. *Biometrika*, 70, 41-55, 1983.

Supported by SFI grant 07/MI/012

Identifying Underlying Structure in Classification and Regression Trees using Surrogate Splits

Deirdre Wall
Supervisor: John Newell

Tree based models are useful for classification and prediction problems, where a graphical representation of the underlying structure is presented. Random Forests have been shown to provide improved prediction. The advantage of random forests is a reduction in prediction error however no information relating to the underlying structure of the variables is available. Surrogate splits are typically used for handling missing data in trees but alternatively they can be used to identify potential candidate trees with comparable prediction power. An example fitted to breast cancer data where conflicting results in previous research can be consolidated by examining surrogate splits.

[1] Breiman, L.: `Classification and Regression Trees`, (1984)

Supported by NBCRI

Multiple Imputation in a Cluster Randomised Trial setting - a case study

Eoghan O'Brien
Supervisors: John Hinde, John Newell

Multiple Imputation is an increasingly popular method of dealing with missing data problems. Properly implemented, it can reduce bias and increase power. However, there are problems with doing this in a naive way. Many statistical software packages now offer multiple imputation routines and there are several different methods available. In this poster we will discuss missing data and show how to deal with it using some of these different approaches. We will use a case study on patients with dementia for illustration.

Computational Homology of Cubical and Permutahedral Complexes

Fintan Hegarty
Supervisor: Prof. Graham Ellis

Homology is the study of connectivity and "holes " in spaces. This thesis is aimed at the homological study of subsets of $\mathbb{R}^n$ arising from experimental data. We develop a mathematical machinery for efficiently computing the homology of cellular spaces with a view to applications

in image analysis. We discuss and implement in GAP a cubical approach to homology computations, and then introduce and implement a new approach based on permutahedral complexes.

Supported by Science Foundation Ireland

Carlsson's algorithm for persistent homology calculation used in the system GAP

Guranda Tevdoradze
Supervisors: Graham Ellis

The algorithm for computation of the persistent homology of filtered simplicial complexes in arbitrary dimension over any field written by its authors in language C and implemented using the GNU Multiple Precision Arithmetic Library [1], was later interpreted in order to calculate the persistent homology of filtered cubical complexes for two- and partially three-dimensional cases with Z2 coefficients [2]. The interpretation has been implemented within MAPLE system. The presented work in progress tries to implement the persistent homology computing algorithm in its cubical d-dimensional version in the GAP system, namely in its package HAP, for Homological Algebra Programming [3].

[1] Carlsson G., Zomorodian A., Computing Persistent Homology, http://comptop.stanford.edu/u/preprints/persistence1.pdf .

[2] Stroembom, D., Persistent Homology in the Cubical Setting: Theory, implementations and applications, 2007, http://epubl.luth.se/1402-1617/2007/124/LTU-EX-07124-SE.pdf .

[3] Ellis, G., GAP package HAP - Homological Algebra Programming, http://www.gap-system.org/Packages/hap.html .

Supported by Hardiman Research Scholarship.

Vertex Operator Superalgebra

Hoang Dinh Van

Supervisors: Dr. Michael P. Tuite

Let V be a vertex operator superalgebra of CFT-type. We define the Casimir vectors $\mu^{(n)}$ constructed from the basis $\{u\}$ and its dual basis $\{\bar{u}\}$ of $V^{(1/2)}$. We consider the 2-point correlation of $Z((u,x),(\bar{u},y);\tau)$ and assume the symmetry constraint on the vectors of level 2. By applying the Zhu recursion formula which is extended by (G. Mason, MP Tuite and A. Zuevsky) we obtained a first-order differential equation of $Z(\tau)$. Solving this equation allows us to compute explicitly the character function $Z(\tau)$ of V. Moreover, we also prove that V is the tensor product of rank 1 FermionicVertex Operator Superalgebra.

[1] Goeffrey Mason and Michael Tuite, *Vertex Operators and Modular Forms*, "A Window Into Zeta and Modular Physics", MSRI Publications Volume **57** (2010).

[2] Tuite MP., *The Virasoro Algebra and Some Exceptional Lie and Finite Groups*. SIGMA **3** 2007.

[3] Zhu Y., *Modular Invariant of Character of Vertex Operator Algerbas*. J. Am. Math. Soc. **9** 1996.

[4] Goeffrey Mason and Michael Tuite, *Torus n-point Funtions for Vertex Operator Superalgebras and Continous Fermion Orbifolds*, Comm. Math. Phys. **283** (2008).

Supported by Science Foundation Ireland

Linear and Affine Spaces of Matrices with Special Properties

James McTigue
Supervisors: Dr Rachel Quinlan

The rank of a matrix is a concept of fundamental importance in linear algebra, and in any mathematical area where one has occasion to consider linear functions, or matrix encoding of data.

Despite the generally haphazard behaviour of rank with respect to matrix addition in the space $M_{m\times n}(\mathbb{F})$ ($m \times n$ matrices with entries in a field $\mathbb{F}$), one can inquire into the existence of $\mathbb{F}$-subspaces of $M_{m\times n}(\mathbb{F})$ in which rank does behave in a controlled manner. This may mean that within

the subspace all non-zero elements have the same rank, or that the non-zero ranks occurring in the subspace have a particular upper or lower bound. Investigations of such properties can involve:

- Construction of large subspaces having the property - such objects are elusive and cannot normally be found by inspection;
- Determination of (bounds on) the maximum possible dimension of a subspace having the property;
- Construction and classification of those subspaces in which this maximum is attained.

[1] R. Brualdi, Z. Huang, X. Zhan, *Singular, nonsingular and bounded rank completions of ACI-matrices*, Linear Algebra Appl. (volume 433, pages 1452-1462, 2010).

[2] R. Quinlan, *Spaces of matrices without non-zero eigenvalues in their field of definition, and a question of Szechtman*, Linear Algebra Appl. (volume 434, pages 1580-1587, 2011).

[3] J. McTigue, R. Quinlan, *Partial matrices whose completions have ranks bounded below*, Linear Algebra Appl. (volume 435, pages 1956-1967, 2011).

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Adaptive coevolutionary networks

John Donohue
Supervisor: Dr. Petri Piiroinen

Until recently, studies of networks were usually pursued via two independent strands [1]. The ”dynamics on networks” approach employs a model comprised of dynamic nodes arranged into a static topology whereas the ”dynamics of networks” approach considers the topology of the network itself as a dynamical system. We aim to analyse models which draw on both these two distinct strands of research, i.e. networks whose links change adaptively with respect to their states [2]. Here we look at an example of such interplay between the states of a network and its topology using an extension of the classical Lotka-Volterra predator-prey model.

[1] T. Gross and B. Blasius, Adaptive coevolutionary networks: a review. In J.R.Soc Interface, pp. 259-271, 5, October 2007.

[2] T. Gross and H. Sayama, Adaptive Networks: Theory, Models and Applications (Understanding Complex Systems), 1st Edition, 2009, Springer.

Supported by IRCSET

A Mathematical Model of CENP-A Incorporation in Human Centromeres

Kevin Doherty
Supervisors: Dr. Martin Meere, Dr. Petri Piiroinen

DNA is found in cells wrapped around nucleosomes comprised of eight histones. This is further packaged in a number of steps to form chromosomes. A region of the chromosome called the centromere is needed for kinetochore formation and subsequent spindle microtubule attachment, thereby allowing one copy each of the DNA to be faithfully segregated into two daughter cells during mitosis. A large number of proteins are involved in different stages of this complex process. A histone H3 variant, Centromere Protein A (CENP-A) has been shown to be required for kinetochore formation and accurate chromosome segregation [1]. We developed a mathematical model of CENP-A incorporation and maintenance, which we analysed using a dynamical systems approach.

[1] Van Hooser, A. A., Ouspenski, I. I., Gregson, H. C., Starr, D. A., Yen, T. J., Goldberg, M. L., Yokomori, K., Earnshaw, W. C., Sullivan, K. F. and Brinkley, B. R. Specifcation of kinetochore-forming chromatin by the histone H3 variant CENP-A. *Journal of Cell Science* 114, 3529-3542, 2001.

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An Introduction to Discontinuity Geometry

Neil Humphries
Supervisors: Petri Piiroinen

Dynamical system with impacts can present many analytical challenges as most of the techniques and results that have been developed for use with (smooth) dynamical systems are calculus-based and so are built on an assumption of the continuity of both the function and its derivatives - which is not the case for a system with impacts. Discontinuity geometry is a relatively new geometric analytical technique applicable to one class of such systems - *periodically-forced impact oscillators* (PFIOs) - with the basic premise that the dynamics of a PFIO can be fully ascertained from the specific details of a geometric object that is defined by the oscillator component of the model running in the absence of impacts [1]. In this poster we will present a brief outline of both the general basics of this framework and a specific method that has been developed within it to establish the existence of periodic orbits of a PFIO under parameter variation. A far fuller description of all this material, and more, can be found in [2]

[1] Chillingworth D.R.J., Discontinuity Geometry for an Impact Oscillator, *Dynamical Systems*, (4)2002, pp. 389-420.

[2] Humphries N. and Piiroinen P.T., A discontinuity-geometry view of the relationship between saddle-node and grazing bifurcations, *Physica D*, D.O.I. 10.1016/j.physd.2011.05.003

Supported by IRCSET

Iterative Solvers for Singularly Perturbed Problems

Nhan Anh Thai
Supervisors: Niall Madden

Singularly perturbed problems are differential equations (ordinary or partial) which are characterised by a small positive perturbation parameter multiplying the highest derivative, leading to the presence of boundary layers. These problems occur in a wide range of mathematical models, from fluid flow to computational finance. Over the past 20 years, there has been a great interest in developing new parameter robust schemes which yield accurate solutions, independent of the width of the layers. These robust schemes lead to linear systems that we must solve numerically. However, very few studies have considered the issue of solving the linear systems with efficiency that is robust with respect to the layer width. My PhD project is to do just that.

[1] Demmel, James W., Applied numerical linear algebra,Society for Industrial and Applied Mathematics (SIAM),Philadelphia, PA,1997,

[2] Linss, T., Layer-adapted meshes for reaction-convection-diffusion problems,Lecture Notes in Mathematics, Vol 1985

Supported by IRCSET

Evidence for intron length conservation in a set of mammalian genes associated with embryonic development

Paul K. Korir
Supervisor: Prof. Cathal Seoighe

We carried out an analysis of intron length conservation across a diverse group of nineteen mammalian species in light of recent research suggesting a role for time delays associated with intron transcription in gene expression oscillations required for early embryonic patterning. Gene sets annotated as being involved in pattern specification in the early embryo or containing the homeobox DNA-binding domain were significantly enriched among genes with highly conserved intron content. We used ancestral sequences reconstructed with probabilistic models that account for insertion and deletion mutations to distinguish insertion and deletion events on lineages leading to human and mouse from their last common ancestor. Using a randomization procedure, we showed that genes containing the homeobox domain show less change in intron content than expected, given the number of insertion and deletion events within their introns. Our results suggest selection for gene expression precision or the existence of additional development-associated genes for which transcriptional delay is functionally significant.

[1] Seoighe, C and Korir, PK *Evidence for intron length conservation in a set of mammalian genes associated with embryonic development*, BMC Bioinformatics, 12(Suppl 9):S16, 2011.

[2] Takashima Y, Ohtsuka T, González A, Miyachi H, Kageyama R *Intronic delay is essential for oscillatory expression in the segmentation clock*, *PNAS*, 108(8):3300–3305, 2011.

[3] Swinburne I, Silver P *Intron delays and transcriptional timing during development*, *Dev. cell*, 14(3):324–330, 2008.Supported by National University of Ireland, Galway and Science Foundation Ireland.

The Autoimmune Potential of Transcriptional Noise

Peter Keane
Supervisors: Cathal Seoighe, Rhodri Ceredig

The mammalian adaptive immune system is mediated by populations of B and T cells which express a surface receptor capable of recognising and binding to foreign antigens. The stochastic manner of generating these receptors opens up the possibility that a receptor may recognise the body's own proteins, generating an autoimmune response. Self-reactive T cells are purged from the repertoire by a process of selection in the thymus, however it remains unclear how this is achieved. An in-depth analysis of the transcriptome of the thymus would yield a greater insight into this process and whether a break down of this system results in autoimmunity.

Supported by PRTLI Cycle 5

Dynamic Asymmetric Networks

Richard, Burke, Petri, Piiroinen

In this study we are investigating nonlinear dynamical systems, represented as complex networks. We have built robust mathematical models of interacting nodes of integrators, chaotic oscillators and flocking agents. We are drawing heavily on a technique called *Edge Snapping* to create networks that evolve (themselves) naturally to a static steady state. The hope is to analyse the emergent topologies of these networks using appropriate graph-theoretic metrics. We also aim to understand the influence of key parameters and initial conditions on the network evolutions. Finally, we want to undertake a rigorous investigation of the stability of the dynamic networks.

[1] P.DeLellis, M. diBernardo, F. Garofalo and M. Porfiri, "Evolution of Complex Networks via Edge Snapping", IEEE Transactions on circuits and systems-1: regular papers, vol. 57, 2010, pp.∼ 2132-2143.

[2] L.M. Pecora and T.L. Carroll, "Master Stability Functions for Synchronized Coupled Systems", Phys. Rev. Lett., vol. 80, 1998, pp.∼ 2109-2112.

[3] M. E. J. Newman, "The structure and function of complex networks", SIAM Rev.45, 25 March 2003, pp.∼ 167-256.

Automorphism groups of the Sylvester Hadamard matrices

Ronan Egan
Supervisor: Dane Flannery

A *Hadamard* matrix of order n is an $n \times n$ matrix H with entries in $\{\pm 1\}$ such that $HH^\top = I_n$. These matrices can only exist when $n = 1, 2$ or a multiple of 4, and the famous Hadamard conjecture is that Hadamard matrices of order $4t$ exist for all $t \geq 1$. The *Sylvester* Hadamard matrix H_n of order 2^n is $\otimes^n \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$, where $\otimes$ denotes the Kronecker product. We investigate the automorphism groups of the Sylvester matrices, and other Hadamard matrices and their associated expanded designs. In particular we examine the regular subgroups. These determine whether the matrix is group-developed or cocyclic.

[1] Warwick de Launey and Dane Flannery, *Algebraic design theory*, Mathematical Surveys and Monographs, vol. 175, American Mathematical Society, Providence, RI, 2011.

[2] J. F. Dillon, *Some REALLY beautiful Hadamard matrices*, Cryptogr. Commun. **2** (2010), no. 2, 271-292.

[3] William M. Kantor, *Symplectic groups, symmetric designs and line ovals*, Journal of Algebra **33**, 43-58, 1975.

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Impacting Systems with friction

Shane Burns
Supervisors: Petri Piiroinen

Impact Mechanics is concerned with the reaction forces and impulses which develop during a collision and the governing dynamics which ensue [1]. One special case occuring in impacts with friction is that of the *Painléve paradox*. The *Painléve paradox* is the phenomenon whereby a large increase in negative acceleration occurs from an initial period of sliding. This motion can occur in the pin-on-disc braking mechanism in a car whereby the pin periodically jumps from the disc, resulting in a screeching noise[2]. There are however many inconsistencies with the current impact models in existence due to discontinuities in the impact laws. The aim of this project is to analyze these discontinuities and in particular the *Painléve paradox*.

1 W.J.Stronge, *Impact Mechanics*, Cambridge University Press, 2000.

2 R.I. Leine, B. Brogliato and H. Nijmeijer, *Periodic motion and bifurcations induced by the Painlev paradox*, European Journal of Mechanics A/Solids 21, pp. 869–896, 2002.

Sparse Grids for High Dimensional Partial Differential Equations

Stephen Russell
Supervisor: Dr. Niall Madden

The "Curse of Dimensionality" is one of the greatest challenges in scientific computing and refers to the fact that the computational cost associated with solving a problem grows exponentially with the number of dimensions. In recent years, Sparse Grid methods have been developed to address this issue. These methods have the possibility of producing solutions at a cost that is independent of dimensions. The two-scale combination sparse grid method reduces the number of unknowns from N^2 to $N^{3/2}$ and, as a result, is much more efficient.

In this presentation I describe both approaches, and give a comparison of their results for a test case.

I then describe a more general interpretation that involves projections between finite element subspaces. This gives the same numerical results as the two-scale method, but is easier to apply to different numerical schemes (such as finite difference methods), and to generate recursive algorithms.

[1] Susanne C. Brenner and Ridgway Scott. *The mathematical theory of finite element methods. 3rd ed.* Texts in Applied Mathematics15. New York, NY: Springer. xvii,397 p., 2008

[2] Mark S. Gockenbach. *Understanding and implementing the finite element method.* Philadelphia, PA: Society for Industrial and Applied Mathematics(SIAM). xvi, 363 p., 2006.

[3] Fang Liu, Niall Madden, Martin Stynes and Aihui Zhou. *A two-scale sparse grid method for a singularly perturbed reaction-diffusion problem in two dimensions.* IMA J. Numer.Anal., 29(4):986-1007, 2009.

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Topics in Geometric Topology

Thomas Shanahan
Supervisors: Dr. James Cruickshank and Dr. Javier Aramayona

This is a fascinating area of research. It combines such areas as Algebraic Topology, Group Theory and Geometry. I am interested in mapping class groups and geometric structures on surfaces which naturally lead to Teichmüller space [1, chapter 10].

Here I would like to quote a lovely Theorem. (**Cartan Hadamard**) Let X be a connected surface equipped with a hyperbolic structure, and suppose that the natural pathmetric on X is complete. Then X is isometric to $\mathbb{H}^2/\Gamma$, where Γ is a discrete subgroup of $PSL(2,\mathbb{R})$ acting freely on $\mathbb{H}^2$.

Corollary: The universal cover $\tilde{X}$ of X above is isometric to $\mathbb{H}^2$. [2,pg 12-15]

[1] Benson Farb and Dan Margalit *A primer on Mapping Class Groups, version 5.0* http://www.math.uchicago.edu/ margalit/mcg/mcgv50.pdf

[2] Javier Aramayona, Hyperbolic Structures on Surfaces, 2011 http://www.maths.nuigalway.ie/ javier/hypstr.pdf

Supported by NUIG, College of Science

Genomic analysis of distal junction of nucleolar organizer regions on the human acrocentric chromosomes

Thong Nguyen, Cathal Seoighe, and Brian McStay

The human genome includes around 300 copies of rDNA repeat tandemly clustered in nucleolar organizer regions (NORs) on acrocentric chromosomes. While it is known how individual rDNA repeats within an active NOR can toggle between active and silent states, the selection mechanism operating at the level of whole NORs is not understood. One possibility is that rDNA-adjacent sequences on acrocentric short arms regulate whole NOR activity. We established a 400kb contig distal to the rDNA repeats; we refer to this contig as the distal junction (DJ). To identify functional regions in this region, we have carried out an analysis of chromatin structure and transcription profile of the DJ using ChIP-seq, RNA-seq, FAIRE-seq, DNase-seq, and MNase-seq data. Interestingly, there is strong evidence of regions of open chromatin consistent among different cell types and evidence of mRNA transcripts originating from the DJ. These results were validated experimentally. Our findings suggested that the DJ is actively transcribed by RNA polymerase II and contains potential NOR-regulating elements.

Higher Genus Aspects of Vertex Operator Algebras

Thomas Gilroy
Supervisors: Michael Tuite

This year I have been working on the development of a recursion theory for the genus 2 correlation functions of Vertex Operator Algebras. The approach has been to build genus 2 correlation functions from genus 1 functions and sewing procedures on toriand then using Zhu's recursion formulae for genus 1 functions on each of the sewn tori. There is a deep connection between the algebraic and geometric aspects of the recursion which will be studied when the recursion has been finalised.

[1] Yongchang Zhu, *Vertex Operator Algebras, Elliptic Functions, and Modular Forms,* Ph.D thesis, Yale University (1990), appeared as: *Modular Invariance of Characters of Vertex Operator Algebras* J. Amer. Maths. Soc **9** (1996)

[2] Geoffrey Mason and Michael P. Tuite, *On Genus Two Riemann Surfaces Formed from Sewn Tori*, Commun. Math. Phys. **270** (2007), 587–634.

[3] Geoffrey Mason and Michael P. Tuite, *Free Bosonic Vertex Operator Algebras on Genus Two Riemann Surfaces I*, Commun. Math. Phys. **300** (2010), 673–713.

Supported by IRCSET

Minimizing Passive Release Of Growth Factors From A Heparin-Based Delivery System

Tuoi VO Thi Ngoc
Supervisors: Martin Meere

A mathematical model that describes the leakage of heparin-binding growth factors from an affinity-based delivery system is considered. In the delivery system, heparin binds to a peptide which has been covalently cross-linked to a fibrin matrix. Growth factor in turn binds to the heparin, and growth factor release is governed by both binding and diffusion mechanisms, the purpose of the binding being to slow growth factor release. The governing mathematical model, which in its original formulation consists of six partial differential equations, is reduced to a system of just two equations. It is usually desirable that there be no passive release of growth factor from a device, with all of the growth factor being held in place via binding until such time as it is actively released by invading cells. However, there will inevitably be some passive release, and so it is of interest to identify conditions that will make this release as slow as possible. In this poster, we identify a parameter regime that ensures that at least a fraction of the growth factor will release slowly. It is found that slow release is assured if the matrix is prepared with the concentration of peptide greatly exceeding the dissociation constant of heparin from the peptide, and with the concentration of heparin greatly exceeding the dissociation constant of the growth factor from heparin. Also, for the first time, in vitro experimental release data is directly compared with theoretical release profiles generated by the model and a satisfactory agreement has been found.

[1] S.E. Sakiyama-Elbert, J.A. Hubbell, *Development of fibrin derivatives for controlled release of*

heparin-binding growth factors, Journal of Controlled Release, **65**, 2000, 389-402.

[2] S.J. Taylor, J.W. McDonald III, S.E. Sakiyama-Elbert, *Controlled release of neurotrophin-3 from fibrin gels for spinal cord injury*, Journal of Controlled Release, **98**, 2004, 281-294.

[3] M. D. Wood and S. E. Sakiyama-Elbert, *Release rate controls biological activity of nerve growth factor released from fibrin matrices containing affinity-based delivery systems*, Journal of Biomedical Materials Research Part A, **84A**, 2007, 300-312.

Supported by the Mathematics Applications Consortium for Science and Industry (MACSI) and Science Foundation Ireland (SFI)(06/MI/005)

Computational homology of n-types

Van Luyen Le
Supervisor: Graham Ellis

An *n-type* X is a connected CW-space with homotopy groups $\pi_i(X) = 0$ for all $i > n$. Up to homotopy equivalence such a space can be specified algebraically by means of a simplicial group G_* whose Moore complex is trivial in degrees greater than or equal to n and there is the equivalence of categories

$$Ho(\text{simplicial group } G_*) \xrightarrow{\simeq} Ho(n-\text{type } X)$$

We describe an algorithm for computing the integral homology of a simplicial group and illustrate an implementation on simplicial groups arising as the nerve of a category object in the category of groups.

[1] G. Ellis, "Homology of 2-types", *J*. London Math. Soc. (2) 46 (1992), no. 1, 1–27.

[2] M.Crainic, "On the perturbation lemma, and deformations", arXiv:math/0403266v1 (2004), pp 13.

[3] G. Ellis and L.V. Luyen, "Computational homology of n-types", to appear in *J. Symbolic Computation*.

Supported by the NUI Galway, College of Science, PhD fellowship

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4 Abstracts of PhD Theses

Derivative Estimation for Noisy Data; an Additive Penalty P-Spline Approach

Simpkin, Andrew
Supervisor: Dr. John Newell

In many situations it is of primary interest to estimate the rate of change of the relationship between response and explanatory variables. In this thesis derivative estimation using spline smoothing is explored. A review of derivative estimates found as a by product of several popular spline smoothing techniques is provided. Concerns with these estimates are raised and an additive penalty method utilising the attractive properties of P-Splines is introduced. This approach is shown to improve on semi-parametric and P-Spline derivative estimates in simulated smoothing scenarios. Variability bands for derivative estimates are developed for the additive penalty and P-Spline methods with these tested for coverage and precision in further simulations. Motivating examples in environmental, biomedical and astronomical applications are revisited throughout the thesis.

[1] Eilers,P.H.C., and Marx,B. Flexible smoothing with B-splines and penalties. Statistical Science 11,2(1996),89-121.

[2] deBoor,C. A Practical Guide to Splines. Springer, New York,1978.

Virasoro Correlation Functions for Vertex Operator Algebras

Hurley, Donny
Supervisor: Dr. Michael Tuite

This thesis considers Virasoro correlation functions in the theory of Vertex Operator Algebras on Riemann surfaces of genus zero and one, and considers the degeneration limit to one torus of a general genus two partition function. Virasoro correlation functions on Riemann surfaces of genus zero and one are necessarily symmetric but the Zhu reduction formula does not present them in a manifestly symmetric way. We show that these correlation functions can be expressed as the symmetric sum of weights of particular graphs at each genus. Furthermore, we can express

the correlation functions at genus zero and one in terms of derangements and permutations respectively. We discuss modular forms and elliptic functions, which naturally arise at genus one, including a general formula for the modular derivative of Eisenstein series and a particular non-linear differential equation obeyed by Weierstrass functions. We also consider the 1-point function for a Virasoro descendent of the vacuum on a genus one Riemann surface. Using this result we solve the problem of the degeneration limit for the partition function of a general Vertex Operator Algebra on a genus two Riemann surface formed by sewing two tori in the limit where one of the tori pinches down to a Riemann sphere.

Features and purposes of mathematical proofs in the view of novice students: observations from proof validation and evaluation performances

Pfeiffer, Kirsten
Supervisor: Dr. Rachel Quinlan

This thesis describes a comprehensive exploratory study of the approaches taken by novice students to the validation and evaluation of mathematical proofs. A theoretical framework based on sociocultural learning theories was considered suitable as a basis to develop a new terminology and schema for observations and interpretations of proof validations and evaluations. In this theoretical framework learning is seen as accessing and participating in the practice of an expert community. The theoretical considerations of this thesis build on Hemmi's conception of proofs as artifacts in the community of practice. Philosophical theories about the evaluation of artifacts are specialized to the case of mathematical proof. A result of these considerations is a schema that extends Hemmi's model of proofs as artifacts, and provides both a theoretical basis and an analytic tool for consideration of the practice of proof evaluation and for interpretation of specific instances of proof evaluation. The study is based on a series of tests and interviews with first year honours mathematics students at the National University of Ireland, Galway. The students were asked to evaluate and criticize numerous proposed (correct and incorrect) proofs of mathematical statements. The participants' written comments and the interview discussions on different and partly incorrect proofs give insights into their criteria for valuing a mathematical proof, their habits when performing proof validations and evaluations and their knowledge about features and purposes of mathematical proofs. This thesis describes the theoretical framework as well as the design, observations and findings of the written and oral exercises. It also includes a discussion about advantages and shortcomings of the schema that has been developed and used for the interpretation of evaluations of mathematical proofs and a discussion about possibilities for further research.

Algorithms for nilpotent linear groups

Rossmann, Tobias
Supervisors: Dr Alla Detinko, Dr Dane Flannery

The thesis presents algorithms for testing irreducibility and primitivity of nilpotent linear groups over infinite fields. Extensive structural results for finite primitive nilpotent groups are also given.

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5 Abstracts of Masters Theses

Mathematical modelling of glucose homeostatsis in the human body

O'Callaghan, Liam
Supervisor: Dr. Petri T. Piiroinen

Glycemic Regulation, or the control of a person's blood sugar level, is an important aspect of patient care in a hospital's intensive care unit. Patients who have been injured or have just undergone an operation require constant monitoring to ensure that the level of glucose in their blood remains within its normal range. The body has a highly complex system by which blood sugar is regulated, but it is often the case that, in critically ill patients, this system fails or becomes inadequate, and must be augmented by other means. The mechanisms by which blood sugar is regulated (by a complex process involving many hormones, including insulin and glucagon) are quite well understood. The dynamics of the system, however, are not. Essentially, a practitioner administering insulin would have an idea of the chain of events that, following the drug's administration, result in lowering a patient's blood sugar level. However, the magnitude of such an effect can at present not be predicted with a significant level of accuracy. We present an analysis of a "minimal model" which was recently developed for glycemic control in the critically ill. A minimal model is essentially the smallest possible model that expresses the features that are required. The analysis consists of looking for blood glucose values to which the model will move towards, or move away from, and also the nature of this motion. Whether or not the predictions made by this model are realistic is obviously of critical importance. The prospects for future advancement and the development of a full-scale description of the glucose regulatory system will also be presented. In particular, the binding process between insulin and its corresponding receptors needs to be effectively modelled, and the subsequent signalling which results in the lowering of blood glucose explained, if the effect of insulin is to be properly quantified.

[1] T Van Herpe, B Pluymers, M Espinoza, G Van den Berghe, and B De Moor., A minimal model for glycemia control in critically ill patients., In *Proc. of the 28th IEEE EMBS Annual International Conference (EMBC 06)*, pp. 54325435, 2006.

[2] R Hovorka, LJ Chassin, M Ellmerer, J Plank, and ME Wilinska., A simulation model of glucose regulation in the critically ill., *Physiological Measurement*, 29:959, 2008.

Numerical Solutions of Models for Glucose and Insulin Levels in Critically Ill Patients

Nhan, Anh Thai
Supervisor: Dr Niall Madden

This thesis is concerned with the numerical solution of mathematical models for glucose and insulin levels in critically ill patients. These models present several difficulties that make computing accurate solutions efficiently a nontrivial challenge. These difficulties include that the differential equations are stiff, have discontinuous data, and have highly non-uniform dynamics. The numerical methods we use are all examples of classical one-step Runge-Kutta methods. We show how to choose from these methods the ones that are most suited to problems with discontinuous data. We then show how so-called implicit methods can be implemented to generate stable solutions to stiff problems. Finally, in the context of using a Dynamic Bayesian Network to simulate glucose and insulin levels in Intensive Care Unit patients where the glucoregulatory system are very fast and unpredictable, we propose a time stepping control algorithm that allows the stepsize to adapt to changes in the model dynamics.

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6 Research Activity from 1 Jan 2011 to 31 Dec 2011

Permanent and Contract Staff

Aramayona, Javier

Current Research Interests

Mapping class groups, Teichmüller spaces and their various combinatorial models. Spaces of nonpositive curvature and their isometry groups.

Publications

Most significant publications

[1] Automorphisms of the graph of free splittings, with J. Souto, Michigan Math Journal, 60 (2011), vol. 3.

[2] Hyperbolic structures on surfaces. To appear in *Geometry, Topology and Dynamics of Character Varieties*, IMS Lecture Notes Series Volume.

Research Activities

One preprint (Convexity of strata in diagonal pants of surfaces, submitted); three papers in their final stages of preparation.
Co-organiser of Groups in Galway 2012; co-organiser of the William Rowan Hamilton Geometry and Topology Workshop (Dublin, September 2012).
Invited speaker at *British Topology Meeting* 2011 (Edinburgh, September 2011), *Surface groups in Paris* (Paris, March 2012), *Group actions and applications in geometry, topology and analysis* (Kunming, China, July 2012).
Research visits to institut Henri Poincaré (1 week), Universidad Autónoma de Barcelona (1 week), University of British Columbia (2 weeks).
Three papers refereed.

Burns, John

Current Research Interests

My current research interests are Algebra (Lie algebras, Lie groups, Weyl groups) and Differential Geometry (Homogeneous manifolds, Symmetric spaces). The concept of exponents of a Lie algebra can be generalised to a B-stable ideal (for B a Borel subalgebra) and they arise naturally in the study of certain projective subvarieties of flag varieties (Hessenberg varieties). Research (with R. Suter) in this area is ongoing. Also Goetz (Pfeiffer) and I have been studying the geometry of maximal Abelian subgroups of Coxeter groups with applications to branching rules for the restrictions of Lie algebra representations to subalgebras. //

Publications

Nothing appeared in 2011

Research Activities

Journal submissions: Power sums of Coxeter exponents (with R. Suter, arXiv:1101.5082v1). Submitted to Adv. Math. // Invited talks: 1 talk (King's College London). Refereeing: 1 paper. Conferences and workshops: The Irish geometry conference (co-organiser), Groups in Galway, 5th De Brn workshop. Postgraduate supervision: 1 Ph.D. student. Thesis Examination: 2 (internal) Ph.d theses

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Cruickshank, James

Current Research Interests

I have two main interests at the moment.

- Topology: I am interested in moduli spaces and realisation spaces of objects that have some geometric structure. I particular, I have an interest in frameworks and linkages. There are many interesting questions relating to the spaces of flexes of these objects. More recently, I have also become interested in surfaces and geometric structures on surfaces and I have started working with Javier Aramayona and Tom Shanahan in this area
- Linear algebra: I have also been thinking about some problems related to linear spaces of nilpotent matrices.

Publication (appeared in 2011)

- *Series Parallel Linkages*, with Jonathan McLaughlin. Publ. Mat. Vol 55. No 2, p359–378

Destrade, Michel

Current Research Interests

I am currently mostly interested in applying the principles of Continuum Mechanics to the modelling of soft matter, including biological tissues and gels. The equations of motion can be written down to take into account all physical characteristics of these materials, including coupling with other fields such as electromagnetism or fluid dynamics. However great care must be taken when large deformations are envisaged, especially in the elaboration of adequate boundary conditions, with crucial repercussions in the correct formulation of numerical simulations.

Keywords: Stability of soft solids; Acousto-elasticity with application to soft tissues; Mechanical modelling of Human Skin and of Brain Tissue.

Publications

Numbers of publications appearing in calendar year 2011: 6

Four significant publications

[1] M. Shams, M. Destrade, R.W. Ogden. Initial stresses in elastic solids: Constitutive laws and acoustoelasticity, Wave Motion, 48 (2011) 552-567.

[2] M. Destrade, R.W. Ogden. On magnetoacoustic waves in finitely deformed elastic solids, Mathematics and Mechanics of Solids, Special Issue in Honour of M.M. Carroll [invited contribution], 16 (2011) 594-604.

[3] R. De Pascalis, M. Destrade, A. Goriely. Nonlinear correction to the Euler buckling formula for compressed cylinders with guided-guided end conditions, Journal of Elasticity, 102 (2011) 191-200.

[4] M. Destrade, A. Goriely, G. Saccomandi. Scalar evolution equations for shear waves in incompressible solids: A simple derivation of the Z, ZK, KZK, and KP equations, Proceedings of the Royal Society A 467 (2011) 1823-1834.

Research Activities

Research grants: NUI and Ile-de-France Mobility Grants for A. Ni Annaidh (co-I), 2 Postgraduate IRCSET Fellowships (co-I), NUI Galway start-up grant, NUI Galway Hardiman Scholarship, Erasmus Staff Training Programme, Italian Institute of Higher Mathematics Visiting Professor Programme, Royal Society International Joint Project; Numbers of graduate students: 4; Conferences/Seminars: 5; Outreach talks: 8; Guest Visits: 3; Host Visits: 3; Papers/Grants refereed: 29; Editorships: Quarterly Journal of Mechanics and Applied Mathematics, International Journal of Applied Mechanics, International Journal of Non-Linear Mechanics; Memberships: Acoustical Society of America, Society for Industrial and Applied Mathematics, International Society for the Interaction of Mechanics and Mathematics; External posts: Adjunct Professor of Mechanical Engineering, University College Dublin; Directeur de Recherche, Institut d'Alembert, CNRS, Paris, France (on leave).

Detinko, Alla

Current Research Interests

Computational group theory; linear groups, permutation groups, algebraic groups.

Publications: in calendar year 2011

Four significant publications

[1] A. Detinko, B. Eick, D. Flannery, 'Computing with matrix groups over infinite fields', LMS Lecture Note Series 387 (2011), 256–270.

[2] A. Detinko, D. Flannery, E. O'Brien, 'Algorithms for the Tits alternative and related problems, Journal of Algebra 344 (2011), 397–406.

[3] A. Detinko, D. Flannery, E. O'Brien, 'Recognition of finite matrix groups over infinite fields, Journal of Symbolic Computation, accepted for publication.

[4] A. Detinko, D. Flannery, 'Computing with matrix groups over infinite fields', Mathematisches Forschungsinstitut Oberwolfach, Report No. 37/2011.

Research Activities

[1] Research grants: SFI STTF grant (PI).

[2] Conferences:

(i) Co-organizer of 'The 5th de Brún Workshop: Groups, Combinatorics, Computing' NUI Galway, 11–16 April, 2011.

(ii) Invited speaker at Computational Group Theory, Mathematisches Forschungsinstitut Oberwolfach, Germany, August 2011.

[3] PhD students: one PhD degree awarded in 2011.

[4] Reviewing: 5 reviews for Mathematical Reviews.

[5] Membership: member of the American Mathematical Society.

Downing, Tim

Studying the evolution of drug-resistance and immune response evasion in human pathogens offers insights into the genetic diversity of virulence factors and mechanisms of treatment tolerance. I am examining the genomes of parasites to identify mutations associated with sporadic epidemic outbreaks of disease and endemic backgroupd infection. Relating phenotypic variation to pathogen genotypes within populations and across a global scale can inform on the origins and dispersal of infectious diseases. I am working with partners in the Wellcome Trust Sanger Institute to understand how sampling parasites taken recently from patients, coupled with others from distinct continental locations with a selection experimentally subjected to acute drug pressure in vitro to deliver a clinically relevant profile of the genomic steps towards treatment and drug therapy failure that can be applied to other infectious agents.

Current Research Interests

My prinicipal interests lie in the genetic epidemiology in closely related samples; adaptive evolution and diversification in sympatric populations; and in the co-evolution of pathogen virulence and host immune genetic repetoires.

Publications

Most significant publications

[1] Genome-wide SNP and microsatellite variation illuminate population-level epidemiology in the Leishmania donovani species complex. Downing T, et al. Infection, genetics and evolution. 2012 12(1):149-169. PUBMEDD: 22119748.

[2] The battle of the SNPs. Downing T. Nature reviews microbiology. 2012 10(1):6. PUBMED: 22138960.

[3] Whole genome sequencing of multiple Leishmania donovani clinical isolates provides insights into population structure and mechanisms of drug resistance. Downing T, Imamura H et al. Genome research 2011. 21(12)2143-56. PUBMED: 22038251.

[4] The differential evolutionary dynamics of avian cytokine and TLR gene classes. Downing T, Lloyd AT, O'Farrelly C, Bradley DG. Journal of immunology 2010. 184(12)6993-7000. PUBMED: 20483729.

Research Activities

I moved to NUI Galway in March 2012 and have continued active collaborations with the Wellcome Trust Sanger Institute (Cambridge), the Institute of Tropical Medicine (Antwerp), Strathclyde University (Glasgow), Charite University (Berlin) and the Natural History Museum (Paris). I referee for a variety of journals (eg Molecular Biology and Evolution).

Ellis, Graham

Current Research Interests

My research interests lie in *homotopical algebra*, particularly nonabelian algebra related to low-dimensional integral homotopy types of spaces. Much of my recent research activity has focused on developing practical algorithms for computing algebraic homotopy invariants of spaces. The algorithms are being implemented as part of an officially refereed, and ever growing, *Homological Algebra Package (HAP)* for the computer algebra system GAP. The algorithms were initially aimed at spaces arising theoretically as classifying spaces of algebraic objects such as groups, Lie algebras and crossed modules. Recently my focus has broadened to include spaces modelling real-life data from medical images, bioinformatics and dynamical systems.

Publications

4 publications appeared in 2011

Most significant publications

[1] Dutour Sikirić, Mathieu; Ellis, Graham; Schrmann, Achill On the integral homology of $PSL_4(\mathbb{Z})$ and other arithmetic groups. J. Number Theory 131 (2011), no. 12, 23682375.

[2] Ellis, Graham; King, Simon Persistent homology of groups. J. Group Theory 14 (2011), no. 4, 575587.

[3] King, Simon A.; Green, David J.; Ellis, Graham The mod-2 cohomology ring of the third Conway group is Cohen-Macaulay. Algebr. Geom. Topol. 11 (2011), no. 2, 719734.

[4] Ellis, Graham; Smith, Paul Computing group cohomology rings from the Lyndon-Hochschild-Serre spectral sequence. J. Symbolic Comput. 46 (2011), no. 4, 360370.

Research Activities

I supervised four PhD students and one postdoctoral researcher. I was on the editorial boards of three journals: Homology, Homotopy and Applications; Journal of homotopy and related structures; Applicable Algebra in Engineering, Communications and Computing. A gave an innvited lecture at the SIAM conference on Applied Algebraic Geometry in Raleigh, North Carolina. I attended an Oberwolfach meeting on computational group theory.

Flannery, Dane

Current Research Interests

Linear groups, computational group theory, algebraic design theory.

Publications: in calendar year 2011

Four significant publications

[1] W. de Launey and D. L. Flannery, *Algebraic Design Theory*, Mathematical Surveys and Monographs, vol. 175, American Mathematical Society, 2011.

[2] A. S. Detinko, B. Eick, and D. L. Flannery, 'Computing with matrix groups over infinite fields', LMS Lecture Note Series 387 (2011), 256–270.

[3] A. S. Detinko, D. L. Flannery, and E. A. OBrien, 'Algorithms for the Tits alternative and related problems', Journal of Algebra 344 (2011), 397–406.

[4] A. S. Detinko, D. L. Flannery, and E. A. O'Brien, 'Recognition of finite matrix groups over infinite fields', Journal of Symbolic Computation, accepted.

Research Activities

[1] Research grants: one SFI Research Frontiers Programme award (PI); one NUI Galway Hardiman Scholarship (Supervisor).

[2] Conferences:

(i) Co-organizer of 'The 5th de Brún Workshop: Groups, Combinatorics, Computing' NUI Galway, 11–16 April, 2011.

(ii) Invited speaker at

- Computational Group Theory, Mathematisches Forschungsinstitut Oberwolfach, Germany, August 2011.
- International Workshop on Hadamard Matrices and their Applications, RMIT University, Australia, November 2011.

[3] PhD students: one PhD student conferred in 2011.

[4] Reviewing: 2 reviews for Mathematical Reviews.

Hayes, Michael

Research Interests

Up to 2006 my research interests were in fluid mechanics mainly using lubrication and perturbation techniques. These techniques were applied to the governing (Navier Stokes and conservation) equations. The resulting partial differential equations were solved to establish the fluid and subsequent solute thickness in the phosphor coating of TV screens.

My current/ future research interests are in the analysis of stochastic differential equations.

Publications

Below are listed a number of publications including a publication in the Physics of Fluids journal.

1. The fluid profile of a gravity driven film over any small two dimensional object, M.A. Hayes, S.B.G. O'Brien & J.H. Lammers, (1999), in Advances in coating and drying of thin films, (Ed. F. Durst, H. Raszillier), Shaker Verlag, 253-258.
2. Models for flows over non-flat substrates, S.B.G O'Brien, M. Hayes, J. Lammers, (2000), in Trends in the application of mathematics to mechanics, 147-155, Elsevier (ISBN 2842992458).
3. Green's function for flow over a small two dimensional topography, M.Hayes, S.B.G. O'Brien, J. Lammers, (2000), Phys. Fluids, 12, 2845-2861.
4. Evaporative and topographical effects in coating flows, S.B.G. O'Brien, M. Hayes, (2001), Mathematics in industry 2001.
5. A model for dip-coating of a two liquid mixture, M. Hayes, S.B.G. O'Brien, (2002), Int. J. Math. Math. Sci., 29, 313-325.
6. M.A. Hayes, S.B.G.O 'Brien. 2004. Spin-coating over a small sinusoidal topography,. Int. J. Math. Math. Sci. 43, 2279-2298.
7. S.B.G. O'Brien, M. A. Hayes. 2005. A model for gravity driven flow of a thin liquid solid suspension with evaporation effects. Z. angew. Math. Phys. 56, 1-22.

Current Activities

From 2007, I have been passing the Institute and Faculty of Actuaries examinations. In 2008 I was awarded an interim qualification.

Hinde, John

Current Research Interests

Statistical modelling, particularly generalized linear models and random effects models; statistical computing and statistical software; likelihood theory and inference; applications of statistics in biological, medical and social sciences.

Publications

Most significant publications

[1] Papageorgio, G, and Hinde, John (2012) Multivariate Generalized Linear Models with Semi- and Smooth Nonparametric Random Effects. *Statistics and Computing*, **22**, 1, pp 79-92.

[2] Coffey, Norma and Hinde, John (2011) Analyzing Time-Course Microarray Data Using Functional Data Analysis - A Review, *Statistical Applications in Genetics and Molecular Biology*, **10**: Iss. 1, Article 23. DOI: 10.2202/1544-6115.1671, (`www.bepress.com/sagmb/vol10/iss1/art23`)

[3] Urbano, Mariana Ragassi, Hinde, John, and Demétrio, Clarice (2011) Bioassay models with natural mortality and random effects. In *Proceedings of the 26th International Workshop on Statistical Modelling, Valencia*, pp 616-621.

[4] Hinde, John (2011) Teaching Styles Revisited - Teaching Statistical Modelling in R. In *Proceedings of ISI 2011*, Dublin, ref CPS022-04, 6 pages.

Research Activities

Current research grants:

SFI Mathematics Initiative - Bio-statistics and Informatics (BIO-SI) with Prof. Mackenzie, University of Limerick (€500,000)

Graduate students: 3; Postdoctoral Researchers: 1.

Journal submissions: 1 accepted, 2 under review

Conferences: Co-organised 1; attended 6.

Invited talks: *Overdispersion, glms and Random Effects* — João Branco Meeting, IST, Lisbon, Portugal, May 2011.

Mixtures and Random Effects — Italian Biometric Society, Gargnano, Italy, July 2011.

The Diversity of Biometry, Invited Discussant — 58th Congress International Statistical Institute, Dublin, August 2011.

Editorships: Statistics and Computing (Associate); Computational Statistics and Data Analysis (Associate); Statistical Modelling (Advisory Board).

Referee: International Journal of Biostatistics; Journal

of Classification; Statistics in Medicine; Statistical Modelling; Biometrics.

President of the British and Irish Region of the International Biometric Society (2010-2012); Council Member, International Biometric Society.

Holian, Emma

Current Research Interests

Mixture modelling to cluster longitudinal data profiles and to model the group features via generalized linear mixed models and penalized smoothing models, leading to the formulation of the Regression Cluster Model (RCM). Analysis into capability of the RCM to handle missing data within profiles or profiles measured at variable time-points. Extension of the RCM to longitudinal profiles measured on discrete or categorical scales. Applications in microarray analysis.

Publications

Recent publications pending review

[1] E.L. HOLIAN, N. COFFEY, J.P. Hinde. Regression Cluster Model with penalised spline smoothing, Pending review.

[2] M.J. MARTINEZ, E.L. HOLIAN. An alternative estimation approach for the heterogeneity linear mixed model, Pending review.

[3] N. COFFEY, E.L. HOLIAN, J.P. Hinde. Comparion of Weighted Regression Analysis in nlme and lmer Packages, Pending review.

Research Activities

Memberships: Irish Statistical Association - Executive committee member.
Collaborative work with Marie-José Martinez, Team MISTIS, INRIA Rhône-Alpes & Laboratoire Jean Kuntzmann, and University of Grenoble II, FRANCE, on an alternative estimation approach for the heterogeneity linear mixed model and cluster analysis of discrete and categorical response profiles - supported by NUIG Millenium Fund for travel.

Jennings, Kevin

Current Research Interests

Algebra, finite fields, difference sets.

Research Activities

Attended F_q10 Finite fields conference, June 2011, Ghent, Belgium.

Krnjajić, Milovan

Current Research Interests

Bayesian model specification, Bayesian non-parametric modelling, Inverse problems. Applications in engineering, science, medicine.

Publications

[1] Krnjajić, Milovan (2011), Book review: ”Bayesian Nonparametrics” by N. L. Hjort, C. Holmes, P. Mueller, and S. Walker (eds.) *Journal of the American Statistical Association* Dec. 2011, Vol. 106, No. 496, Book Reviews

Research Activities

Presented research work at two conferences. Served as a reviewer for several statistical journals and scientific funding agencies (NSF (USA), JASA, JRSS/B, CSDA).

Madden, Niall

Current Research Interests

My area of research is numerical analysis, covering the design of novel algorithms for computing accurate numerical solutions to differential equations and the mathematical analysis of those methods. I am especially interested in fitted finite difference and finite element methods for boundary value problems. Such techniques generate very large systems of linear equations that must be solved efficiently, so I am also interested in aspects of numerical linear algebra.

While the numerical methods for differential equations present many interesting mathematical challenges, they are also ubiquitous in the modelling of physical processes. I'm involved in collaborative projects with the Marine Modelling (Ryan Institute) and Machine Learning/Data Mining (Information Technology) groups.

Publications

[1] N. Madden and K.K. Mondal. Improved mathematical and numerical modelling of dispersion of a solute from a continuous source. *Lect. Notes Comput. Sci. Eng.*, 81:177–185. Springer, 2011.

[2] N. M. Chadha and N. Madden. A two-weight scheme for a time-dependent advection-diffusion problem. *Lect. Notes Comput. Sci. Eng.*, 81:99–108. Springer, 2011.

[3] C. G. Enright, M. G. Madden, N. Madden, and J. G. Laffey. Clinical time series data analysis using mathematical models and DBNs. *Lecture Notes in Computer Science*, 6747:159–168. Springer, 2011.

Research Activities

I was fortunate to be on sabbatical during the academic year 2010/2011, spending most of Semester 1 at the Institute for Mathematics and its Applications at the University of Minnesota, and most of Semester 2 at the University of Auckland. I also had shorter visits to the University of Alberta, Edmonton; the Chinese Academy of Sciences, Beijing; Universität Duisburg-Essen; and Tufts University, MA.

During 2011 I submitted two papers to journals: one on an optimal time-stepping algorithm, co-authored with Naresh Chadha (still under review), and one a post-processing of finite element solutions co-authored with Martin Stynes (accepted).

I refereed papers for various journals, including IMA J. Numer. Anal., Appl. Math Comput., and Appl. Numer. Math.

I presented at international conferences in Vancouver (2), and Dresden, and gave invited seminars at Auckland, Beijing and Duisburg-Essen.

Nhan Anh Thai, working under my supervision, was a awarded a Masters in Mathematics for this thesis titled *Numerical Solutions of Models for Glucose and Insulin Levels in Critically Ill Patients*.

I currently had two graduate students: Nhan Anh Thai (Ph.D.) working on linear solvers for singularly perturbed problems, and Stephen Russell (M.Sc.) who is studying sparse grids.

McCluskey, Aisling

Current Research Interests

My research interests reside primarily within analytic topology, with a particular fascination in how order theoretic structures mesh with topology. An example of one such question which has held my attention and that of collaborators for some time concerns the order that naturally arises amongst the (homeomorphism classes of) subspaces of the real line.If A and B are subspaces of $\mathbb{R}$ and $[A]$ and $[B]$ are the respective homeomorphism classes, we say that $[A] \leq [B]$ if and only if A embeds into B. This order lacks antisymmetry but nonetheless the ensuing order-theoretic structure of $\mathscr{P}(\mathbb{R})$ has the potential to represent partially-ordered sets of cardinality at most $2^{\mathfrak{c}}$. But which ones? This question has engaged the attention of several eminent international collaborators with all of whom successful research exchange positions have been awarded. Such fusion between order and topology continues to fuel my research interests on the following question: for a non-empty set X, the collection $Top(X)$ of all topologies on X sits inside the Boolean lattice $\mathscr{P}(\mathscr{P}(X))$ (when ordered by set-theoretic inclusion) which in turn can be naturally identified with the Stone space $2^{\mathscr{P}}(X)$. Via this identification then, $Top(X)$ naturally inherits the subspace topology from $2^{\mathscr{P}}(X)$. This suggests the possibility of applying lattice-theoretic methods in pursuit of fundamental topological questions, not least of which is just how complex a set $Top(X)$ is in terms of the Borel hierarchy. I also have a research interest in continua theory in the context of both a natural associated order and also dynamical systems.

My research platform has recently (since 2008) expanded to include a new research direction within Mathematics Education. My particular interest is in facilitating development in and aptitude for advanced mathematical thinking in undergraduate mathematics education.

Publications

Three publications appearing in 2011.

Most significant publications

[1] A.E. McCluskey, T.B.M. McMaster and W.S. Watson, "Representing set-inclusion by embeddability (among the subspaces of the real line)", Topology Appl. 96 (1) (1999), 89-92.

[2] A.E. McCluskey and T.B.M. McMaster, "An elementary counterexample on dense normality", Top. Appl. 130 (1) (2003), 87-90.

[3] A.E. McCluskey, D.W. McIntyre and W.S. Watson, "The propositional theory of closure", Experimental Mathematics 16 (4) (2007), 501- 512.

[4] A.E. McCluskey and R.W. Knight, "A consistent counterexample in P(R)", Topology Appl. 156 (11) (2009), 1943 - 1945.

Research Activities

I maintain active links with 'local'like-minded researchers via the Galway Topology Colloquia series, founded at NUI Galway in 1997 and running annually between centres of research at Oxford, Birmingham, Belfast and Galway. A key focus for the establishment of this event was to foster a productive and enabling environment for postgraduate students in the area. Since 2009, Ircset-funded postgraduate Mr. Jorge Bruno has joined me at NUI Galway and contributes significantly to our forum as he pursues his PhD. A joint paper on $Top(X)$ was accepted in December 2011 for publication in *Topology and its Applications*. In 2011, I refereed articles for the journals *Topology and its Applications*and *International Journal of Mathematical Education in Science and Technology*. I completed a Masters degree in Academic Practice at NUI Galway (in the subject area of mathematics education) in May 2011. I was a keynote speaker at the Women in Mathematics Day in UL in April 2011. I hosted a mathematics research visitor, Professor Ivan Reilly (University of Auckland) in July 2011 with whom I collaborate. I presented at conferences in New York (Summer Topology Conference) in July 2011, in Prague (Topology Symposium) in August 2011 and in Belfast (Galway Topology Colloquium) in August 2011. I was co-organiser for the latter event. I also presented at mathematics education conferences in St. Patrick's Drumcondra (MEI4) in September 2011 and at the Delta conference in Rotorua, New Zealand (Teaching and Learning of undergraduate mathematics and statistics) in November 2011. I published two single-author papers in respect of the research presented at the last two conferences. I was also part of a collaborative and ongoing project in mathematics education, whose research has been presented at British Society for Research into Learning Mathematics (BSRLM) in Oxford in November 2011 and published in its proceedings. A second (and distinct) collaborative paper (with Eaton and O'Reilly) concerning a cross-border research initiative was presented at the international conference on Initial Teacher Education in St. Patrick's Drumcondra in June 2011. I was granted sabbatical leave for September 2011 - August 2012 and put arrangements in place to spend November 2011 - May 2012 at the University of Auckland, New Zealand.

Mc Gettrick, Michael

Current Research Interests

My current research interests are mainly in the area of Quantum Computation (an interdisciplinary research area involving mathematics, physics and computer science). In particular, I work mostly on studying properties of Quantum Random Walks (QRW) (which have been proven useful as a methodology for designing Quantum algorithms - such as the Grover search algorithm - that outperform Classical algorithms). My work is concerned with rigorous proof of properties of QRWs (e.g. amymptotics, localization,...), qualitative aspects, simulations, and sometimes consideration of necessary physical resources for their implementation.

Within Quantum Computation I also have a strong interest in Quantum (Evolutionary) Game Theory. Other interests are in Computer Algebra and using mathematics and computational techniques to analyze and compose music.

Publications

2 publications in 2011
Most significant publications

[1] "Mimicking the Probability Distribution of a Two-Dimensional Grover Walk with a Single-Qubit Coin", Di Franco, C., Mc Gettrick, M., Busch, Th. **Physical Review Letters** Volume: 106 Issue: 8 (2011)

[2] "Alternate two-dimensional quantum walk with a single-qubit coin", Di Franco, C., Mc Gettrick, M., Machida, T., Busch, Th. **Physical Review A** Volume: 84 Issue: 4 (2011)

Research Activities

I participated in two conferences in 2011:

- In July I attended a Workshop on Reversible Computation in Gent, at which there were some very interesting talks comparing classical to quantum reversible computation.
- In December I was invited to give a talk at a School on Quantum Information at the Department of Atomic Energy in Bhubaneswar (India). This established research contacts with Dr. Indranil Chakrabarti, who has since applied for an IRCSET postdoc position to come and work with me in Galway.

In the Summer of 2011, a 3rd. year theoretical physics student (Shane Duane) worked with me as an intern. He developed some very interesting and useful software for visualizing online various quantum random walks (try it at http://hop.to/quantum/). Other research visitors that came to Galway to collaborate were Dr. Chandrasekhar Madaiah from UCC (August 2011) and Dr. Carlo Di Franco from UCC (September 2011). An application to IRCSET for postdoctoral funding for Dr. Colin Wilmott proved unsuccessful. But once again this has led to us starting a collaboration together on measuring the entanglement and discord generated in quantum random walks.

Meere, Martin

Current Research Interests

Drug release modelling. A number of problems are being considered, including modelling leakage from affinity based drug release systems, and modelling drug release from thermoresponsive polymers.
Centromere modelling. The aim of this project is to build a model to quantitatively describe how human centromere identity is faithfully propagated from one generation to the next.
Modelling diffusion in crystals. This is ongoing work with colleagues at the University of Nottingham.
Modelling wave/structure interactions. This work is in collaboration with colleagues in the department of Civil Engineering at NUI Galway.

Publications

[1] Rongbing Yang, Tuoi Vo T. N., Alexander V. Gorelov, Fawaz Aldabbagh, William M. Carroll, Martin G. Meere, Yury Rochev, A mathematical model for pulsatile release: controlled release of rhodamine B from UV-crosslinked thermoresponsive thin films, *International Journal of Pharmaceutics*, 427:320-327 (2012)

[2] Vo Thi Ngoc Tuoi, Rongbing Yang, Yury Rochev, and Martin Meere, A mathematical model for drug delivery, *Progress in Industrial Mathematics at ECMI 2010, Mathematics in Industry, Vol. 17,* 521-528 (2012)

[3] William Finnegan, Martin Meere & Jamie Goggins, The Wave Excitation Forces on a Floating Vertical Cylinder in Water of Infinite Depth, *Proceedings of the World Renewable Energy Conference, Sweden,* 2175-2182 (2011)

Research Activities

Current Grants: MACSI and SFI research grant for a PhD student (06/MI/005)
Current Graduate Students: I currently supervise two PhD students, one of whom is co-supervised by Dr. Petri Piiroinen.
Research Visits: Visited the University of Nottingham for one week in June 2011.

Naughton, Liam

Current Research Interests

I am interested in the table of marks of a finite group and its associated Burnside Ring. My research involves developing and implementing software to compute the subgroup pattern of a finite group.

Publications

Most significant publications

[1] (with G. Pfeiffer) Computing the table of marks of a cyclic extension. 20 pages, to appear in *Math. Comp*.

Research Activities

Presentations at Ruhr University Bochum (Invited speaker), RWTH Aachen (Nikolaus Conference 2011) and

NUI, Galway (Seminar). Research visit to Rhur University Bochum and RWTH Aachen Summer 2011.

Newell, John

Current Research Interests

Statistical modelling, statistical computing, survival analysis and the application of statistics in Clinical Research and Sports Science.

Publications

Numbers of publications appearing in calendar year 2011: 7

Four significant publications

[1] Feil, S., Newell, J., Minogue, C., Paessler, H.H. (2011). The effectiveness of supplementing a standard rehabilitation program with superimposed neuromuscular electrical stimulation after anterior cruciate ligament reconstruction: a prospective, randomized, single-blind study. Am J Sports Med. Jun;39(6):1238-47.

[2] Hallahan, B., Newell, J., Soares, J.C., Brambilla, P., Strakowski , S.M., Fleck, D.E., Kiesepp, T., Altshuler, L.L., Fornito, A., Malhi, G.S., McIntosh, A.M., Yurgelun-Todd, D.A., Labar, K.S., Sharma ,V., MacQueen, G.M., Murray, R.M., McDonald, C. (2011). Structural magnetic resonance imaging in bipolar disorder: An international collaborative mega-analysis of individual adult patient data. Biological Psychiatry 69 (4):326-335.

[3] Murphy, K., Casey, D., Devane, D., Cooney, A., McCarthy, B., Mee, L., Ni Chlain, M., Murphy, A. W., Newell, J., O' Shea, E. (2011). A cluster randomised controlled trial evaluating the effectiveness of a structured pulmonary rehabilitation education programme for improving the health status of people with chronic obstructive pulmonary disease (COPD): The PRINCE Study protocol. BMC Pulmonary Medicine, 11:4.

[4] Raja Ali, R.A., Dooley, C., Comber, H., Newell, J., Egan, L. Clinical Features, Treatment, and Survival of Patients With Colorectal Cancer With or Without Inflammatory Bowel Disease (2011). Clinical Gastroenterology and Hepatology, Volume 9, Issue 7, 584-589.

Research Activities

Current research grants (2011): Health Research Board Interdisciplinary Capacity Enhancement Grant. ATLANTIC DIP 2: Gestational Diabetes Mellitus (GDM) Screening, Follow up and Intervention in the Community (Co-Principal Investigator). Funding awarded: 674,950.

SPHERE(Secondary Prevention of Heart Disease in General Practice) follow up study (Co-applicant). Funding awarded: 190,669.

Health Research Board Interdisciplinary Capacity Enhancement Grant Chronic pain in Ireland: Population prevalence, clinical management and professional education (Co applicant). Funding awarded: 705,300.

Numbers of graduate students:3; Journal submissions: 7; Conferences: 3; Visits: 3; Invited talks: 1; Research visits: 2; Papers refereed: 0; Memberships: Executive Committee of the International Statistical Modelling Society, Vice President of Irish Statistical Association; External posts: Senior Research Fellow, Department of Mathematics and Statistics, University of Canterbury, Christchurch, New Zealand.

Nolan, Louise

Current Research Interests

General relativity; Examining solutions to the field equations for cylindrically symmetric spacetimes using dynamical systems analysis, Self-similar gravitational collapse of a spacetime with different matter content, Matching spacetimes to investigate the existence of physical solutions.
Mathematical aspects of gravitational lensing; Using weighted projective spaces to investigate caustic singularities and gravitational lensing, (in collaboration with Dr. Patrick Browne).

Publications

[1] L. NOLAN, B. NOLAN. 'Global structure of self-similar cylindrically symmetric spacetimes', In preparation.

[2] L. NOLAN, B. NOLAN. 'On isotropic cylindrically symmetric stellar models', Class. Quantum Grav., Vol 21. (2004).

Research Activities

Research grants: NUIG University Fellow Annual Grant; Conferences: 1; Invited talks: 1; Memberships: Institute of Physics;

O'Keeffe, David

Current Research Interests

Currently I am jointly working with Dr.Emil Sköldberg in preparing a paper on the cohomology of graded algebras.

I am also interested in maths and education. I was chief organiser of Maths Week 2011 at NUI Galway. I invited Dr. Steve Humble (aka Dr Maths) to NUI Galway as part of 'Maths Week Ireland 2011'. He gave engaging presentations on 'Maths in the everyday life' to two seperate audiences of junior and senior cycle students from across Galway. I have also given a number of maths workshops to primary school audiences in Galway during 2011.

O'Regan, Donal

Current Research Interests

Differential Equations, Nonlinear Analysis and Fixed Point Theory.

47 publications in 2011. Four most significant publications

[1] Hernández, E. and O'Regan, D., *On a new class of abstract neutral differential equations*, J. Funct. Anal. **261** 3457-3481 (2011).

[2] O'Regan, D., *A note on fixed point theory for extension type maps*, Nonlinear Stud. **18** 587-593 (2011).

[3] Agarwal, R., O'Regan, D. and Taoudi, M-A, *Fixed point theorems for general classes of maps acting on topological vector spaces*, Asian-Eur. J. Math. **4** 373-387 (2011).

[4] Banas, J., O'Regan, D., Agarwal, R., *Measures of noncompactness and asymptotic stability of solutions of a quadratic Hammerstein integral equation*, Rocky Mountain J. Math. **41** 1769-1792 (2011).

Pfeiffer, Götz

Current Research Interests

Computational algebra, representations of finite groups and associative algebras, combinatorics and geometry of finite Coxeter groups.

Publications

Numbers of publications appearing in calendar year 2011: 1

Four significant publications

[1] Matjaž Konvalinka, Götz Pfeiffer and Class Röver. A Note on Element Centralizers in Finite Coxeter Groups. *J. Group Theory* **14** (2011), no. 5, 727–745.

Research Activities

Research grants: Numbers of graduate students: 2; Journal submissions: 3; Conferences: 2; Visits: 3; Invited talks: 4; Research visits: 5; Papers refereed: 5; Math review: 5; Editorships: Mathematical Proceeedings of the Royal Irish Academy; Memberships: Irish Mathematical Society, American Mathematical Society;

Piiroinen, Petri T

Current Research Interests

My main research interests are in the area of discontinuous dynamical systems with application to rigid-body mechanics, economics, psychology and biological systems. I am also involved in a few projects that deal with the analysis of evolving networks. An overarching aim of my research is to bridge the gap between mathematics and numerical analysis on one hand and biology, engineering and social sciences on the other to make mathematical theories more applicable to non-theoreticians.

Publications

Numbers of publications appearing in calendar year 2011: 4
Most significant publications

- Alzate, R., Piiroinen, P.T. and di Bernardo, M., *From complete to incomplete chattering: a novel route to chaos in impacting cam-follower systems*, Accepted for publication in International Journal of Bifurcation and Chaos, 2012.
- Humphries, N. and Piiroinen, P.T., *A discontinuity-geometry view of the relationship between saddle-node and grazing bifurcations*, Accepted for publication in Physica D, 2012.
- Mason, J. and Piiroinen, P.T., *Accessible Saddles and Grazing Bifurcations in an Impacting System*, CHAOS 22(1), Article no. 013106, 2012.
- Mason, J. and Piiroinen, P.T., *Interactions Between Global and Grazing Bifurcations in an Impacting System*, CHAOS 21(1), Article no. 013113, 2011.

Research Activities

During 2011 I supervised or co-supervised 3 PhD students and 2 MSc students. I attended 3 conferences and gave 3 academic seminars (University of Naples Federico II (Italy), University of Bari (Italy), The Institute of Mathematical Sciences (Chennai, India)). I am a guest editor for the Special Issue *Discontinuous Dynamical Systems: Theory and Numerical Methods* of the journal Mathematics and Computers in Simulation (MATCOM).

Quinlan, Rachel

Current Research Interests

My current research is primarily situated in the area of linear algebra and its interactions with combinatorics, field theory, group theory and representation theory. I am interested in the identification and classification of large linear or affine subspaces of matrix algebras whose elements possess prescribed properties not normally preserved under addition. Examples of such properties include invertibility, upper or lower bounds on rank, and nilpotency. This general theme arises in certain matrix completion problems, which have been a focus of my attention in 2011. I also have research interests in mathematics education at university level.

Publications

Most significant publications

[1] Rachel Quinlan. Spaces of matrices without non-zero eigenvalues in their field of definition, and a question of Szechtman. Linear Algebra and its Applications, Vol. 434 (2011), no. 6, 1580–1587.

[2] James McTigue and Rachel Quinlan. Partial matrices whose completions have ranks bounded below. Linear Algebra and its Applications, Vol. 435 (2011), no. 9, 2259–2271.

[3] Rachel Quinlan. Acts of knowing in university mathematics curricula. Proceedings of the 4th National Conference on Mathematics Education, St. Patrick's College Drumcondra (2011).

Research Activities

Conference and seminar presentations :

- University of Auckland workshop on group theory, February 2011
- University of Auckland Mathematics Education Colloquium, February 2011
- "Groups, Rings and Group Rings" Conference, University of Alberta, Edmonton, July 2011
- 17th Conference of the International Linear Algebra Society, Braunschweig, August 2011.
- 4th National Conference on Mathematics Education, St Patrick's College Drumcondra, September 2011.
- NUI Galway Mathematics Seminar, November 2011.

Supervision of the research of one PhD student, James McTigue.

External examiner for the PhD thesis of Ronan Flatley (UCD)

Mathematical Reviews : 3 reviews in 2011

Referee for the following journals in 2011 : Linear Algebra and its Applications, Journal of Pure and Applied Algebra, Transactions of the American Mathematical Society.

Memberships : Irish Mathematical Society, American Mathematical Society, International Linear Algebra Society.

Röver, Claas

Current Research Interests

Group Theory

Publications

Ryan, Ray

Current Research Interests

Functional Analysis: multilinear, polynomial and holomorphic functions on Banach spaces. Tensor products of Banach spaces and Banach lattices. Regular polynomial and holomorphic functions on Riesz spaces and on Banach lattices.

Publications

Most significant publications

[1] "Introduction to tensor products of Banach spaces", Springer Monographs in Mathematics, Springer-Verlag, London, 2002.

[2] with C. Boyd, "Geometric theory of spaces of integral polynomials and symmetric tensor products", J. Functional Analysis 179 (2001), no. 1, 18–42.

[3] with B. Grecu, "Polynomials on Banach spaces with unconditional bases", Proc. Amer. Math. Soc 133 (2005), no. 4, 1083–1091.

[4] with C. Boyd, "The norm of the product of polynomials in infinite dimensions", Proc. Edinburgh Math. Soc. (2) 49 (2006), no. 1, 17–28.

Research Activities

Refereeing papers for journals, membership of editorial board of journal, hosting of visiting researcher, preparation of papers for submission to journal.

Seoighe, Cathal

Current Research Interests

Research in my group spans several areas of bioinformatics/computational biology: Genomics and epigenetics, including gene expression analysis, mRNA splicing and analysis of chromatin structure; development and application of probabilistic models of evolution, especially the use of evolutionary models to identify immune epitopes in HIV-1. Bioinformatics is interdisciplinary and I collaborate with several other research groups on campus. A major focus of recent collaborations involves the analysis of data from deep sequencing technologies. These technologies can be used to sequence genomes or for studying gene expression or the binding of proteins to DNA, which exerts control over gene expression.

Publications

Seven journal articles appeared in 2011.

Most significant publications

[1] Evidence for intron length conservation in a set of mammalian genes associated with embryonic development. Seoighe C, Korir PK. BMC Bioinformatics. 2011 Oct 5;12 Suppl 9:S16.

[2] Semi-supervised Nonnegative Matrix Factorization for gene expression deconvolution: A case study. Gaujoux R, Seoighe C. Infect Genet Evol. 2011 Sep 10.

[3] Induced stem cell neoplasia in a cnidarian by ectopic expression of a POU domain transcription factor. Millane RC, Kanska J, Duffy DJ, Seoighe C, Cunningham S, Plickert G, Frank U. Development. 2011 Jun;138(12):2429-39.

[4] Inhibition of human BK polyomavirus replication by small noncoding RNAs. Tikhanovich I, Liang B, Seoighe C, Folk WR, Nasheuer HP. J Virol. 2011 Jul;85(14):6930-40. Epub 2011 May 4.

Research Activities

My research group consisted of eight PhD students in 2011. Research is currently supported by SFI (Stokes Programme), IRCSET, through a graduate education programme in collaboration with UCD and PRTLI, through a graduate programme in simulation science, again led by UCD. Continued development and establishment of new research collaborations across NUIG took place in 2011. Academic community service included memberships of editorial boards of Bioinformatics and Trends in Evolutionary Biology and refereeing for a wide range of journals. In 2011 I also hosted one international conference - the ninth RECOMB comparative genomics satellite workshop, with approximately 90 delegates. I co-edited the conference proceedings, which was published as a supplementary issue by BMC Bioinformatics.

Sheahan, Jerome

Current Research Interests

Combinatorial techniques to unify apparently different enumeration problems in various areas of scientific endeavour

Publications

1 publication in an international referred journal

Research Activities

Statistical consulting service to researchers in most of the College on Campus. Problems solved run the gamut of statistical methods, including Generalised Linear Modelling for the analysis of experimental data, time series, multivariate analysis, and the design and analysis of social surveys.

Sköldberg, Emil

Current Research Interests

I am interested in combinatorial methods in algebra, in particular for studying the structure of free resolutions in both commutative and non-commutative algebra. I am also interested in computational aspects of resolutions and homology, and related techniques, such as Gröbner bases.

Publications

Most significant publications

[1] G. Ellis, E. Sköldberg, *The $K(\pi, 1)$ conjecture for a class of Artin groups.* Comment. Math. Helv. **85** (2010), no. 2, 409415

Research Activities

Tuite, Michael

Current Research Interests

Vertex operator algebras (VOAs), conformal field theory, Riemann surfaces, elliptic and modular functions in number theory, Lie algebras, combinatorics. In the past year I have worked on generalizations of the classical MacMahon Master Theorem in combinatorics, the VOA partition function for arbitrary genus Riemann surfaces and generalizations of Fay's Trisecant Identity for the Szego kernel on a Riemann surface (with Sasha Zuevsky), constraints arising from the Virasoro structure on exceptional VOAs and SuperVOAs (with Dinh Van Hoang) and on constructing a genus two version of Zhu theory for VOAs (with Tom Gilroy).

Publications

Most significant publications

[1] Tuite, M.P. and Zuevsky, A., *Genus two partition and correlation functions for fermionic vertex operator superalgebras I*, Commun.Math.Phys. **306** 419–447 (2011).

[2] Tuite, M.P. and Zuevsky, A., *The Szego kernel on a sewn Riemann surface*, Commun.Math.Phys. **306** 617–645 (2011).

[3] Tuite, M.P. and Zuevsky, A., *The bosonic vertex operator algebra on a genus g Riemann surface*, RIMS Kokyuroko **1756** 81–93 (2011).

Research Activities

- I currently hold one SFI RFP grants and an IRCSET Embark Studentship.
- Donny Hurley had his PhD conferred. I also supervised two other PhD students Dinh Van Hoang and Tom Gilroy.
- I have one paper in press and three papers under review and I refereed 2 papers.
- I gave seminars in UCD, NUI Galway, Cardiff University and spoke at conferences in ETH Zurich and at Heidelberg.
- Member of the board of the School of Theoretical Physics at the Dublin Institute for Advanced Studies.
- Member of the RIA Mathematical Sciences Committee and the Research subcommittee.

Ward, James

Current Research Interests

Permutability and subnormality criteria in certain classes of infinite soluble groups.
History of Mathematics: Transmission of Greek and Arabic Mathematics in the early medieval era; Mathematics in Queen's College, Galway.

Visitors

Berkove, Ethan

Dates of visit: August 10–23

Research Interests

Computing invariants like the lower algebraic K-groups, which can be used in the context of showing that the Fibered Isomorphism Conjecture of T. Farrell and L. Jones holds for various mapping class groups, and invariants like the integral cohomology of the Bianchi groups, namely SL_2 of the imaginary quadratic integers. In Galway, Berkove plans to extend recent results on the on the PSL_2 case [Rahm, article in press at Transactions of the Amer. Math. Soc.] to SL_2, jointly with the author of the latter article in press.

Burillo, José

Dates of visit: 01-03-2012/30-04-2012

Research Interests

My research interest are in the area of Geometric Group Theory, studying properties of groups that can be understood from the point of view of the spaces the groups act upon. Subjects like the Dehn functions, decision problems, amenability, metric properties of groups, distortion of subgroups, are examples of properties that fall under this denomination.

My relation to the School of Mathematics at NUI Galway is through Dr. Claas Rver, who is my coauthor from a 2008 paper, and who has collaborated with me for the last few years. Also, Dr. Javier Aramayona's research is related to Dr. Rver's and mine.

Demétrio, Clarice, ESALQ/USP, Piracicaba, Brazil

Dates of visit: 22 April to 6 May 2011 and 14 to 28 August

Research Interests

The purpose of this visit was to continue collaborative work with Professor John Hinde, specifically the writing

of a book *Overdispersion: models and estimation*. The purpose of this book is to provide an overview of methods for handling overdispersion in generalized linear models, show the links between different approaches, and provide extended models for structured random effects.

During these visits Prof Demétrio also contributed to the activities of the statistics group and worked with her student Mariana R. Urbano, who is visiting NUI Galway for the calendar year 2011 as a Sandwich Student. The visit concluded with attendance at the ISI Congress in Dublin.

Madaiah, Chandrashekar

Dates of visit: 23/8/2011 to 27/8/2011

Research Interests

Dr. Madaiah visited Dr. M. Mc Gettrick to progress research on quantum random walks, in particular to extend recent work on 1 and 2 dimensional walks to higher dimensions. Dr. Madaiah works in UCC in the "Ultracold Quantum Gases" group of Dr. Thomas Busch.

Mason, Geoffrey

Dates of visit: April 10th - April 16th

Research Interests

Discussions on joint research on vertex operator algebras on genus two Riemann surfaces. Discussions on Mathieu Moonshine, elliptic genera and K_3 surfaces.

Murphy, Jerry

Dates of visit: Feb 18 - Feb 19

Research Interests

Dr Murphy is Lecturer at the Centre for Medical Engineering Research, Dublin City University. He visited M. Destrade to deliver a seminar at the School, to conduct joint research work on nonlinear modelling of fibrous protein hydrogels in simple shear, and to explore possibilities of formalising the collaboration.

Ogden, Ray

Dates of visit: Mar 09 - Mar 13 and Oct 23 - Oct 31

Research Interests

Prof. Ogden FRS is the 6th Century Chair in Solid Mechanics at the School of Engineering, University of Aberdeen. He visited M. Destrade to deliver a talk at the School seminar, and also for joint research work on acoustic waves in skin and other soft tissues, an International Joint Project funded by the Royal Society.

Parnell, William

Dates of visit: Jan 17- Jan 20

Research Interests

Dr Parnell is Reader at the School of Mathematics, University of Manchester. He visited M. Destrade for joint research work on the appearance of wrinkle instabilities on the interior of a cylindrical annulus under radial compression.

Urbano, Mariana R. , ESALQ/USP, Piracicaba, Brazil

Dates of visit: January to December 2011

Research Interests

Mariana R. Urbano visited NUI Galway for the calendar year 2011 as part of her PhD studies and while here worked under the supervision of Professor J. Hinde. Her thesis topic is random effects models for bioassays with natural mortality and her supervisor at ESALQ/USP is Professor C. G. B. Demétrio.

Madaiah, Chandrashekar

Dates of visit: 23/8/2011 to 27/8/2011

Research Interests

Dr. Madaiah visited Dr. M. Mc Gettrick to progress research on quantum random walks, in particular to extend recent work on 1 and 2 dimensional walks to higher dimensions. Dr. Madaiah works in UCC in the "Ultracold Quantum Gases" group of Dr. Thomas Busch.

Zuevsky, Sasha

Dates of visit: Dec 4- Dec 11

Research Interests

Joint research work on the genus two partition function for the fermionic super vertex operator algebra on a genus two Riemann surface formed by sewing a handle to a torus. We also obtained a generalization of Fay's trisecant identity concerning the Szego kernel on a general genus Riemann surface.

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de Jeu, Rob M. H.

Dates of visit: August 1–7

Research Interests

Searching for explicit elements in the algebraic K-theory of imaginary quadratic rings. De Jeu has found a method to relate these elements to geometric images coming from the Bianchi groups. The latter images have been determined in a recent preprint [Rahm, *On a question of Serre*], and the author of the latter preprint will cooperate with de Jeu on this task in Galway.

Postdoctoral Researchers

Chadha, Naresh Mohan

Current Research Interests

Designing and analyzing numerical methods for advection-diffusion problems and singularly perturbed differential equations; *a posteriori* error estimates and adaptive mesh construction; weighted finite difference methods; optimal time-stepping.

Publications

Most significant publications

[1] N.M. Chadha and N. Kopteva, Maximum norm a posteriori error estimate for a 3d singularly perturbed semilinear reaction-diffusion problem. Adv. Comput. Math. 35 (2011), no. 1, 3355.

[2] N.M. Chadha and N. Kopteva, A robust grid equidistribution method for a one-dimensional singularly perturbed semilinear reaction-diffusion problem. IMA J. Numer. Anal. 31 (2011), no. 1, 188211.

[3] N. M. Chadha and N. Madden. A two-weight scheme for a time-dependent advection-diffusion problem. *Lect. Notes Comput. Sci. Eng.*, 81:99–108. Springer, 2011.

Coffey, Norma

Current Research Interests

Funded under the SFI Bio-SI programme (joint with UL). Research involves applying standard functional data analysis techniques to time-course gene expression data, clustering time-course gene expression data using the linear mixed effects model, and clustering SNP data using finite mixtures of orthogonal regression lines. Has also been involved in some consultancy projects with the Clinical Research Facility.

[1] Coffey, N., Hinde, J. (2011) Analyzing time-course microarray data using functional data analysis - a review. *Statistical Applications in Genetics and Molecular Biology*. **10**(1), Article 23.

[2] Glynn, R. W., Kelly, J. C., Coffey, N., Sweeney, K. J. And Kerin, M. J. (2011) The effect of breast cancer awareness month on internet search activity a comparison with awareness campaigns for lung and prostate cancer, *BMC Cancer*, **11**(442).

[3] Coffey, N., Donoghue, O., Harrison, A.J. and Hayes, K. (2011) Common functional principal components analysis - a new approach to analysing human movement data. *Human Movement Science*.

Mason, Joanna

Current Research Interests

My current research is motivated by three real engineering problems with nonsmoothness: magnetic bearings, the great bell of Cologne Cathedral, and cam-follower devices. Nonsmooth systems can exhibit extraordinarily complicated and chaotic dynamics, which are often manifested as undesirable behaviour, such as noise, vibration, and wear. The objective of my work is to develop numerical and analytical techniques to study these example impact and friction problems.

Publications

Numbers of publications appearing in calendar year 2011 = 2

Most significant publications

[1] J. F. Mason, P. T. Piiroinen. Saddle-point solutions and grazing bifurcations in an impacting system Chaos 22(1) (2012) article no. 013106

[2] J. F. Mason, P. T. Piiroinen. Interactions between global and grazing bifurcations in an impacting system, Chaos 21(1) (2011) article no. 013113

[3] J. F. Mason, P. T. Piiroinen. The effect of codimension-two bifurcations on the global dynamics of a gear model, SIAM Journal on Applied Dynamical Systems, Vol. 8 (2009), p 1694-1711

[4] J. F. Mason, P. T. Piiroinen, R. E. Wilson, and M. E. Homer. Basins of attraction in nonsmooth models of gear rattle, International Journal of Bifurcation and Chaos, Vol. 19 (2009), p 203-224

Research Activities

I joined the school of Mathematics, Statistics and Applied Mathematics in December 2010. I currently hold an IRCSET postdoctoral fellowship.

J.F. Mason, N. Humphries and P.T. Piiroinen. Numerical analysis of codimension-one, -two, and -three bifurcations in a periodically-forced impact oscillator with two discontinuity surfaces (2011). Submitted.

Invited talks:

- Seminar at the Centre for Applied Dynamic Research, University of Aberdeen, October 2011
- Mini-symposium Hybrid Systems, European Nonlinear Oscillations Conference (ENOC), Rome, Italy, July 2011
- Seminar at the University of Cologne, June 2011

Organising committee member of:

- Women in Mathematics Day Ireland, University of Limerick, April 2011
- MACSI Mathematical Modelling summer school, University of Limerick, June 2011
- 82nd European Study Group with Industry, University of Limerick, June 2011
- Mathematical Frontiers in the Life Sciences, University of Limerick, July 2011

Rahm, Alexander D.

Current Research Interests

Analyzing the invariants of infinite discrete groups of isometries. A technique herefore developed by Rahm is Torsion Subcomplex Reduction, which has been applied to the Bianchi groups as successfully as to express all their homological torsion by elementary number-theoretical information. Rahm now applies this technique to classes of groups such as Coxeter groups and higher rank modular groups, and extends it to systems of invariants such as Equivariant K-homology and Quantized Orbifold Cohomology.

Publications

Most significant publications in the year 2011

[1] *The homological torsion of PSL_2 of the imaginary quadratic integers*, **Transactions of the AMS**, article in press.

[2] (jointly with Mathias Fuchs), *The integral homology of* PSL_2 *of imaginary quadratic integers with non-trivial class group*, **Journal of Pure and Applied Algebra**, vol. 215, 2011, pp. 1443–1472.

[3] *Homology and K-theory of the Bianchi groups*, **Comptes Rendus Mathématique** of the Académie des Sciences - Paris, vol. 349, iss. 11-12, 2011, pp. 615–619.

[4] *Bianchi.gp*, Validated software of the PLUME project of the **CNRS**, certified with the label *Compétences en Calcul Intensif* of the Conférence des Présidents d'Universités and the GENCI.

Vergori, Luigi

Current Research Interests

Flows in piezo-viscous fluid: convection, viscous dissipation and shallow-water approximation.

Mechanics of nematic liquid crystals and vesicles.

Publications

Most significant publications

[1] K.R. Rajagopal, G. Saccomandi, L. Vergori. Stability analysis of Rayleigh-Benard convection in a porous medium. ZEITSCHRIFT FUR ANGEWANDTE MATHEMATIK UND PHYSIK Volume 62 Issue 1 (2011) Pages 149-160.

[2] K.R. Rajagopal, G. Saccomandi, L. Vergori. Couette flow with frictional heating in a fluid with temperature and pressure dependent viscosity. INTERNATIONAL JOURNAL OF HEAT AND MASS TRANSFER Volume 54 Issue 4 (2011) Pages 783-789.

[3] K.R. Rajagopal, G. Saccomandi, L. Vergori. Linear stability of Hagen-Poiseuille flow in a chemically reacting fluid. COMPUTERS & MATHEMATICS WITH APPLICATIONS Volume 61 Issue 2 (2011) Pages 460-469

[4] G. Napoli, L. Vergori. Extrinsic curvature effects on nematic shells. Accepted for publication in Physical Review Letters.

Wendt, Matthias

Current Research Interests

Examining the motivic or $\mathbb{A}^1$-homotopy theory of schemes, a very recent field of algebraic geometry which applies methods and constructions of algebraic topology and the theory of model categories to schemes. Since the early days of Grothendieck-style algebraic geometry, intuition and methods from topology have always played an important role in the investigation of algebraic varieties and their structure. To give just one example, the study of algebraic K-theory and vector bundles on schemes, which has led to deep insights into the nature of linear algebra over general rings, would never have taken the shape it nowadays has without an existing theory of vector bundles on manifolds, and the use of elaborate methods from algebraic topology.

Publications

Most significant publications in 2010 and 2011

[1] *Rationally trivial torsors in $\mathbb{A}^1$-homotopy theory* - J. K-Theory 7(3), 2011, pp. 541–572.

[2] *Classifying spaces and fibrations of simplicial sheaves* - J. Homotopy Relat. Struct. 6(1), 2011, pp. 1–38.

[3] *$\mathbb{A}^1$–homotopy of Chevalley groups* - J. K-Theory 5 (2), 2010, pp. 245–287.

[4] *On the $\mathbb{A}^1$-fundamental groups of smooth toric varieties* - Adv. Math. 223 (1), 2010, pp. 352–378.

Postgraduate Researchers

Current Postgraduate Research Students

Student	**Degree**	**Supervisor**	**Supervisor**
Alberto Alvarez	PhD	John Newell	John Hinde
Nhan Anh Thai	PhD	Niall Madden	
Bui Anh Tuan	PhD	Graham Ellis	
Alan Barnicle	PhD	Cathal Seoighe	
Sofia Barreira	PhD	Cathal Seoighe	
Jorge Bruno	PhD	Aisling McCluskey	
Richard Burke	PhD	Petri Piiroinen	
Shane Burns	MSc	Petri Piiroinen	
Hoang Dinh Van	PhD	Michael Tuite	
Kevin Doherty	PhD	Martin Meere	Petri Piiroinen
John Donohue	PhD	Petri Piiroinen	
Cara Dooley	PhD	John Hinde	
Ronan Egan	PhD	Dane Flannery	
Attia Fatima	PhD	Cathal Seoighe	
Paul Geeleher	PhD	John Hinde	
Thomas Gilroy	PhD	Michael Tuite	
Artur Gower	PhD	Michel Destrade	
Fintan Hegarty	PhD	Graham Ellis	
Neil Humphries	PhD	Petri Piiroinen	
Peter Keane	PhD	Cathal Seoighe	
Paul Korir	PhD	Cathal Seoighe	
Brendan Masterson	PhD	Götz Pfeiffer	
Nur Fatihah Mat Yusoff	PhD	John Hinde	
James McTigue	PhD	Rachel Quinlan	
Thi Ngoc Tuoi	PhD	Martin Meere	Petri Piiroinen
Thong Nguyen	PhD	Cathal Seoighe	
Eoghan O'Brien	MSc	John Hinde	John Newell
Stephen Russell	MSc	Niall Madden	
Thomas Shanahan	PhD	Javier Aramayona	James Cruickshank
Guranda Tevdoradze	PhD	Graham Ellis	
Le Van Luyen	PhD	Graham Ellis	
Deirdre Wall	PhD	John Newell	
Rachel Wallace	PhD	Götz Pfeiffer	

Seminars

[1] Laura Ciobanu Radomirović, University of Fribourg **Visible elements in free and surface groups** 13/1/2011

[2] Saša Radomirović, University of Luxumbourg **On Sequences Containing All Permutations of a Set as Subsequences** 14/1/2011

[3] Paul Wilson, NUI, Galway **Comparing Statistical Models Using Multiple Simple Hypotheses Tests** 20/1/2011

[4] Norma Coffey, NUI, Galway **Clustering time-course microarray data using the linear mixed effects model** 27/1/2011

[5] Victor Bovdi, University of Debrecen **Group rings whose group of units is hyperbolic** 3/2/2011

[6] José Burillo, UPC Barcelona **The Automorphism Group of Thompson's Group F** 10/2/2011

[7] David Borchers, University of St. Andrews **Some Hidden State Models for Inference from Marine Survey Data** 17/2/2011

[8] Jeremiah Murphy, Dublin City University **Homeostatic strain in elastic arteries** 18/2/2011

[9] Dankmar Böhning, University of Reading **Chao's Lower Bound Estimator of Population Size with Covariate Information** 24/2/2011

[10] Ray Ogden, University of Aberdeen **Structure tensors and invariants in nonlinear elasticity: applications to cardiovascular biomechanics and initially-stressed solids** 10/3/2011

[11] Madeeha Khalid, St. Patrick's College **Non commutative geometry on K3 surfaces** 24/3/2011

[12] Ted Hurley, NUI, Galway **Abstract algebra: 'Pure' or 'Applied'?** 7/4/2011

[13] Geoffrey Mason, UC Santa Cruz **Frobenius-Schur Indicators** 14/4/2011

[14] Edwin O'Shea, University College Cork **Bachet's Problem as Integer Points in Polyhedra** 12/5/2011

[15] Jim Cruickshank, NUI, Galway **Mechanical Linkages** 19/5/2011

[16] Carl Scarrott, University of Canterbury **Tails of a Statistical Extremist** 9/6/2011

[17] Robert Curnow, University of Reading **The Planning of Clonal Selection Programmes** 13/6/2011

[18] Carlo Di Franco, University College Cork **Two-dimensional quantum walks with reduced experimental resources** 8/9/2011

[19] Marlos Viana, University of Illinois at Chicago **Dihedral Fourier Analysis of Symmetry Preference Data** 15/9/2011

[20] Chris Glasbey, Biomathematics and Statistics Scotland (BioSS) **Dynamic programming versus graph cut algorithms** 16/9/2011

[21] Rachel Quinlan, NUI, Galway **What I did on my sabbatical** 29/9/2011

[22] Giuseppe Tinaglia, King's College London **The geometry of constant mean curvature surfaces embedded in R^3** 6/10/2011

[23] Avi Berman, Technion (Israel Institute of Technology) **Diagonal stability and completely positive matrices** 13/1/2011

[24] Niall Madden, NUI, Galway **Fast solvers for singularly perturbed problems** 20/10/2011

[25] Ben McKay, University College Cork **Rolling balls, complex manifolds and the Lie algebra G2** 27/10/2011

[26] Clifford Nolan, University of Limerick **Microlocal Analysis of Bistatic Synthetic Aperture Radar Imaging** 3/11/2011

[27] Götz Pfeiffer, NUI, Galway **Monomial representations of finite Coxeter groups** 17/11/2011

[28] Carmen Molina-Paris, University of Leeds **Lymphocyte populations: homeostatic regulation and receptor diversity maintenance – a stochastic modelling approach** 24/11/2011

[29] Victor Bovdi, University of Debrecen **Lie nilpotency indices of modular group algebras** 1/12/2011

[30] Stephen Kirkland, NUI Maynooth **Load balancing for Markov chains** 8/12/2011

- Bioinformatics seminar series (Organiser: **Cathal Seoighe**);
- Linear Algebra seminar series (Organiser: **Rachel Quinlan**);
- MONO (the MOdelling and NOnlinear systems) seminar series (Organisers: **Joanna Mason and Petri Piiroinen**);
- Statistics Reading Group (Organiser: **John Hinde**);
- MathSoc seminar series (Organisers: **Padraig Ó Catháin and Kevin Doherty**.

Conferences and Workshops

- Fifth Irish Workshop on Maths Learning and Support Centres (Organiser: **Kevin Jennings**), 04 Feb 2011
- Fifth De Brún Workshop: Groups, Combinatorics, Computing (Organisers: Groups, Computing, Designs research cluster, led by **Dane Flannery**), 11–16 Apr 2011
- Groups in Galway 2011 (Organiser: **Claas Röever**), 06–07 May 2011
- Irish Geometry Conference 2011 (Organisers: **Javier Aramayona, John Burns, James Cruickshank**), 13–14 May 2011
- CASI 2011: 31st Annual Conference on Applied Statistics in Ireland (Organisers: **John Newell and John Hinde**) 18–20 May 2011
- International Biometric Society Summer Meeting 2011 of British and Irish Region (Organiser: **John Hinde**) 10 Jun 2011
- Ninth Annual RECOMB Satellite Workshop on Comparative Genomics (Organiser: **Cathal Seoighe**) 08–10 Oct 2011
- CORE Conference: Self-Organization, Emergence and Nonlinearity in Physical, Natural and Social Systems (Organisers: Complex Systems Research Centre (CORE), led by **Petri Piiroinen** and Raghav Srinivas) 21–23 Oct 2011.
