School of Mathematics, Statistics and Applied Mathematics Research Day
30 April 2015

Programme

09:30–9:45	Ray Ryan	Opening remarks
09:45–10:00	Donal Leech	Dean's address
10:00–10:30	Michael Tuite	What can Newton can tell us about string theory
10:30–11:00	Tea and Coffee in IT202/IT203	
11:00–11:30	Rachel Quinlan	Peculiarities of nilpotent matrices
11:30–12:00	Ronan Egan	Shift representations on 2-cocycles
12:00–12:30	Nial Friel (UCD)	Noisy Monte Carlo: Bayesian inference for intractable likelihoods
12:30–12:45	Dawn Howard*	H2020 and NUIG Research Support
12:45–14:00	Lunch and Poster Session in IT202/IT203	
14:00–14:40	Brendan Guilfoyle (IT Tralee)	The shape of worn pebbles
14:40–15:30	Blitz Session	
15:30–17:00	Poster Session in IT202/IT203	
17:00	Reception and Presentation of Poster Prizes in Staff Club, Quadrangle	

* (Research Support Services)

1 Introduction

Welcome to the annual Research Day of the School of Mathematics, Statistics and Applied Mathematics. The programme for the day shows the breadth of activity in the School, ranging from basic research in Pure and Applied Mathematics to applications and collaborations in Biology, Biomedical Science, Economics, Psychology Engineering and other areas. And we are delighted to welcome as our guest speakers this year Professor Niall Friel from UCD and Dr Brendan Guilfoyle from IT Tralee.

The research activity in the School is driven by our three research clusters:

- **The De Brún Centre for Mathematics** supports mathematical research across a spectrum of areas, including Algebra, Analysis, Geometry and Mathematics Education.
- **The Biostatistics/Bioinformatics Cluster** develops and applies data modeling methods to address current research problems in genomics and the clinical sciences. Through extensive collaboration, the cluster supports biomedical research in the HRB Clinical Research Facility, across campus, and further afield.
- **The Stokes Applied Mathematics Cluster** applies advanced mathematical skills to the modeling of computational, physical and biological phenomena, with the aim of fostering interdisciplinary research across the NUI Galway campus and beyond.

Some highlights from the past year:

- Donal O'Regan won a President's Award for Research Excellence in the Established Researcher category. He was also named as one of the top 1% of researchers worldwide in the Thomson Reuters Highly Cited Researchers list.
- We have been very fortunate in being able to attract high quality PhD students and the past year has seen a significant upsurge in recruitment. Our thriving graduate school includes students from as far afield as Iran, China, Vietnam, Argentina, Libya, Iraq and Brazil along with students from all parts of Ireland.
- Groups in Galway was held in May 2014. This conference has been running on an annual basis since 1978.
- The School hosted the first QuanTI summer school in quantitative immunology in June 2014, followed by a research symposium, as part of the EU-funded QuanTI Initial Training Network
- The first SIAM Student Chapter in Ireland was established in NUI Galway this year by our graduate students in Applied Mathematics. The chapter ran a very successful research students conference in December and recently organized a workshop for undergraduate students.
- The 12th Irish Geometry Conference was held in NUI Galway in May 2014.
- 7th de Brún Workshop on Homological Perturbation Theory took place in December. The attendance included a wide range of international experts in the field.
- The Stokes Applied Mathematics Cluster, in collaboration with Mechanical Engineering, hosted the 2014 joint Irish Mechanics Society/Irish Society for Scientific Engineering & Computation (ISSEC). The cluster also ran the Stokes Modelling Workshop in June 2014. Nineteen students from seven institutions took part in a team-based modelling of real-world problems, extending over four days.
- Last year, John Hinde became President of the International Biometric Society for a two year term and is attending and presenting at meetings around the world.

Over the coming summer period, the School will be hosting a number of international conferences, including

- The 30th Summer Conference on Topology & Its Applications in June;
- The Workshop on Vertex Operator Algebras and Mock Modular Forms in May;
- The 37th Groups in Galway conference in May.

Ray Ryan,
Head of School

2 Presentations

Michael Tuite

A vertex operator algebra (VOA) is a mathematically rigorous formulation of ideas originating in string theory in theoretical physics. In this talk I will describe how VOAs are related to Newton's theory of forward differences. I also sketch other research on the relationship between VOAs and Riemann surfaces.

Rachel Quinlan

A square matrix A is called nilpotent if $A^n = 0$ for some positive integer n, or equivalently if all eigenvalues of A are equal to zero. It was established by M. Gerstenhaber in 1958 that a vector space consisting entirely of nilpotent $n \times n$ matrices can have dimension at most $\frac{n(n-1)}{2}$, and that every space attaining this bound is similar to the space of strictly upper triangular matrices. While a non-zero real symmetric matrix cannot be nilpotent, symmetric matrices over other fields can. This talk will focus on large spaces of symmetric and skew-symmetric nilpotent matrices over fields, with special attention to the strange case of characteristic 2.

Ronan Egan

For any finite group G and abelian group U, a map $\psi\colon G \times G \to U$ satisfying $\psi(g,h)\psi(gh,k) = \psi(g,hk)\psi(h,k)$ for all $g,h,k \in G$ is a 2-cocycle. The set of all 2-cocycles forms a group $Z^2(G,U)$ under pointwise composition, and the set of all cocycle classes forms the 2-cohomology group $H^2(G,U)$. Cohomology does not preserve orthogonality of cocycles, a requirement for the cocyclic development of many pairwise combinatorial designs such as generalized Hadamard matrices. We introduce and develop the concept of (linear) shift representation. This derives from an action of G on $Z^2(G,U)$ that preserves both cohomology and orthogonality, discovered by K. J. Horadam. Detailed information about fixed point spaces and reducibility are given. We also discuss results of computational experiments, including searching for orthogonal cocycles.

Nial Friel (UCD)

Markov chain Monte Carlo methods are the dominant tool for Bayesian inference. The essential idea is that one can generate a Markov chain whose invariant distribution is the posterior distribution. However these methods generally don't apply in situations where the likelihood function is intractable as sometimes occurs in spatial statistics and network analysis. This situation presents a major difficult for MCMC, as one cannot compute the transition kernel to generate the next state of the Markov chain. This talks explores the situation where one can instead use an approximate transition kernel and where it is possible to provide convergence guarantees that the resultant approximate Markov chain is close to the unavailable Markov chain which leaves the posterior distribution invariant.

Brendan Guilfoyle (IT Tralee)

The changing shape of a pebble being eroded by abrasion —for example, being tossed around on a beach— can be modeled by contracting the pebble surface by a function of its curvatures. While well-known examples of such curvature flows, including mean curvature flow and Gauss curvature flow, have been extensively studied, other physically realistic flows such as the Bloore flow, remain largely unexplored due to the non-homogeneity of the governing PDE. In this talk I will report upon recent work (in collaboration with Wilhelm Klingenberg) on general curvature flows where we explore qualitative features of the PDE and the geometric underpinning. In the process we uncover a canonical hyperbolic metric on the space of curvatures and obtain new methods for visualizing the flow. This leads to an associated Hamiltonian system of ODEs, and the extraction of bounded geometric quantities for the flows. The mysterious role of umbilic points—the quarks of classical surface theory—will also be discussed.

3 Blitz Session

- **Ted Hurley**: Codes, crypto and underdetermined systems
- **Lida Fallah**: Censoring
- **John Hinde**: Mixtures
- **Götz Pfeiffer**: Groups and relations
- **James Ward**: Diabolical determinants
- **Niall Madden**: All norms are equivalent (but some are more equivalent than others)
- **Michael Mc Gettrick**: Some experimental computational number theory
- **Giuseppe Zurlo**: The mechanical modelling of biological tissues and polymeric materials

---

4 Poster Session

Mixed (Hurewicz) Fiberation and Characteristic Cohomology Classes of the Bianchi Groups

Daher Albaydli
Supervisors: Dr Alexander Rahm and Dr Emill Skoeldberg

This poster presents a study on a concept called the mixed Hurewicz fiberation together with the mixed lifting function, which has been achieved prior to the author's PhD studies. In addition, the subject of the author's PhD studies characteristic Cohomology classes of the Bianchi groups. Only the definitions of this subject are given here.

[1] J. Dugundji. Topology, Allyn and Bacon. Boston, 1966.

[2] H. J. Mustafa. Some theroems of fibration and Cofibration. PhD thesis. Calisornia University, Los Angeles, 1972.

[3] Kottke, Chirs. Bundles classifing spaces and characteristic Classes. 2012.

[4] K. L. Petersen. One-cusped Congruence Subgroups of $SL_2(\mathcal{O}_k)$. Unversity Texas at Auston PhD thesis. 2005.

Supported by the Iraqi Ministry of Higher Education and Scientific Research.

A study of third-order rational difference equations

Faiza Alssaedi
Supervisor: Dr Niall Madden

I started a PhD at NUI Galway in Janurary 2015. My field of research is in numerical analysis of differential equations. Since my research is just begining, in this poster I describe the ideas from my Masters thesis, which was completed in 2008 at Sirte University.

The topic of my thesis was *difference equations*, which occur very frequently in many areas of mathematical modelling, as well as in finite difference methods for initial value differential equations.

The most famous difference equation is the celebrated *Fibonacci* sequence which, in the notation I use here, would be written as

$$y_{-1} = 1, y_0 = 1, \quad \text{and } y_{n+1} = y_n + y_{n-1}$$

for $n = 0, 1, 2, \ldots$.

The difference equations I studied in my thesis were of the form

$$y_{n+1} = \frac{\alpha + \beta y_n^p + \gamma y_{n-1}^p + \delta y_{n-2}^p}{A + B y_n^q + C y_{n-1}^q + D y_{n-2}^q}.$$

In this poster, I will look at third order rational equations:

$$y_{n+1} = \frac{\alpha y_{n-l} + \beta y_{n-2}}{A y_{n-l} + B y_{n-2}} \quad \text{with } l \in \{0, 1\}. \qquad (1)$$

Unlike the Fibonacci sequence, it is usually not possible to write down explicit solutions. Instead we are interested in such questions as:

1. For what values of α, β, A, B and l are the values of y_{n+1} bounded?
2. For what values of α, β, A, B and l does the equation have an equilibrium point?

I will give some conditions on these parameters that must be satisfied, and also some examples to show the results are sharp.

[1] M.R.S. Kulenović and G. Ladas. *Dynamics of second order rational difference equations, with open problems and conjectures.* Chapman & Hall/CRC, Boca Raton, FL, 2002.

[2] V.L. Kocic and G. Ladas. *Global behaviour of nonlinear difference equations of higher order with applications.* Kluwer Academic, Dordrecht, 1993.

Cut Points in Hausdorff Continua

Daron Anderson
Supervisor: Aisling McCluskey

A continuum is a finitely large object expressed in mathematical language. Continua occur widely in mathematical modelling of weather, workings of the brain and heart, laser optics, and earthquake faultlines. In practice a continuum is not a tangible object, but a complicated contiguous region of space whose shape reflects the properties and behaviour of the model. Some points of a continuum make a greater contribution to its global shape and properties than others. For example, removing either end point from the continuum $[0, 1]$ in the real line leaves a contiguous object. These are called non-cut points. A cut point then is one whose removal severs a continuum into several contiguous pieces that do not touch each other. That a cut point is essential to the shape of a continuum is reflected in the disparity caused by removing it. But even removing a non -cut point will change the continuum. When we examine how pronounced this disparity is, a deeper classification of points emerges. Cut points constitute the top tier of the hierarchy and are ranked as the most essential type of point. Removing a point of lower rank will have a less significant effect on the continuum's global properties.

Classical results of continuum theory state every continuum has two or more non-cut points. Recent research in the field has strengthened these results to replace non -cut points with a less essential type of point called a non-block point *in the context of metric continua.* Our current research aims at extending these results to non metric continua. Some facts about metric continua can be proved with greater effort for non-metric continua. Other facts fail spectacularly.

[1] D. Anderson: Shore and non-block points in Hausdorff Continua. (Submitted)

[2] J. Bobok, P. Pyrih, B. Vejnar, Non-cut points, shore points and blockers in continua, Glasnik Matematicki(preprint), 2015.

[3] R. Leonel, "Shore points of a continuum", Topology and its Applications,161 (2014) 433âĂŞ441 .

Exploring Critical but so far Uncharted Regions of the Human Genome

Sofia Barreira
Supervisors: Cathal Seoighe & Brian McStay

Nucleolar Organizer Regions, NORs, positioned on the short arms of the five human acrocentric chromosomes (13, 14, 15, 21 and 22) and containing tandem arrays of ribosomal genes are responsible for forming a major functional domain of the nucleus dedicated to ribosome biogenesis, the nucleolus1. Evidence suggests that sequences adjacent to the rDNA repeats are involved in the regulation of nucleoli2. The entire short arms of these chromosomes are missing from the current human genome assembly. The identification and characterization of these sequences is of critical importance, as nucleoli have a central role in growth-regulation and a long-established connection to tumorigenesis. To date, we have determined

nearly 600 kb of novel sequences neighboring ribosomal genes, in particular 380kb + 180kb, termed distal junction - DJ - and AL591856 on the distal side towards the telomere2. My work focuses on rDNA organization, extending and characterizing the distal sequences of the NORs and establishing the organization/structure of DJ chromatin. Using available Hi-C datasets combined with 454 sequencing reads of nucleolar DNA we have identified a BAC that maps on the distal side of rDNA and closer to the telomere on all acrocentric chromosomes. At low resolution Hi-C analysis confirms the relative spatial positioning of the rDNA repeats and the DJ in interphase cells, and at high resolution Hi-C reveals a striking chromatin feature centered over a large inverted repeat that might play a role in nucleolar function. Nucleolar PacBio reads were used to improve the sequence for the ribosomal gene.

[1] Floutsakou, I., Agrawal, S., Nguyen, T.T., Seoighe, C., Ganley, A.R., and McStay, B. (2013). The shared genomic architecture of human nucleolar organizer regions. Genome research 23, 2003-2012.

[2] Grob, A., Colleran, C., and McStay, B. (2014). Construction of synthetic nucleoli in human cells reveals how a major functional nuclear domain is formed and propagated through cell division. Genes & Development 28, 220-230.

[3] Lieberman-Aiden, E., van Berkum, N.L., Williams, L., Imakaev, M., Ragoczy, T., Telling, A., Amit, I., Lajoie, B.R., Sabo, P.J., Dorschner, M.O., et al. (2009). Comprehensive mapping of long-range interactions reveals folding principles of the human genome. Science (New York, NY) 326, 289-293.

Discrete Vector Fields and the Cohomology of Certain Arithmetic and Crystallographic Groups

Bui Anh Tuan
Supervisors: Graham Ellis

The general aim of my research project is to investigate how ideas from Discrete Morse Theory might be incorporated into the design of algorithms for algebraic topology. In particular, my PhD thesis and related publications will address two test problems.

(a) Low-dimensional integral homology of the arithmetic groups $SL_2(\mathbb{Z}[1/m])$. This problem was suggested by Dr. Kevin Hutchinson at UCD who is interested in this homology via his work on algebraic K-theory. I have developed an algorithm for computing $H_n(SL2(\mathbb{Z}[1/m]);\mathbb{Z})$ which is based on a discrete vector field on the tree underlying a free product of groups. The algorithm is practical for small integers m and all $n > 0$. The algorithm has been implemented and is now distributed with the gap computational algebra software system. The project will be continue to address the problem for larger integers m.

(b) Homology of crystallographic groups with cubical fundamental cell. I have already developed an algorithm in GAP for identifying crystallographic groups with cubical fundamental region and for computing their homology. The Algorithm is based on a discrete vector field on the cubical tiling of Euclidean n-space and works for many special cases. The project will be continue to addressed the unsolved cases.

[1] Wall, C.T.C., 1961. Resolutions of extensions of groups. Proc. Cambridge Philos. Soc. 57, 251–255.

[2] Dekimpe, K., and Petrosyan, N., 2009. Homology of Hantzsche-Wendt groups. AMS Discrete Groups and Geometric Structures 501, 87–102.

[3] Ellis, G., 2008. HAP – Homological Algebra programming, Version 1.8, an official package for the GAP computational algebra system. (`http://www.gap-system.org/Packages/hap.html`)

Exploiting Symmetry in Bases of Toric Ideals

Isaac Burke
Supervisor: Emil Skoeldberg

Here we present some recent results with regard to the symmetries of a special class of toric ideals. The behaviour of various bases (Markov, Groebner and Graver) for the class has been explored in detail, in some part leading from results in [1]. We aim to publish a complete characterization of these bases for this model in the near future.

[1] B. Sturmfels: Groebner Bases and Convex Polytopes. AMS University Lecture Series, Vol. 8 (1996).

Supported by the Irish Research Council and the NUI Galway Hardiman Scholarship Scheme.

Consensus of dynamic multi-agent systems

Richard Burke
Supervisor: Petri T. Piiroinen

My research project is a study of dynamic multi-agent systems in the context of evolving networks. Decentralised adaptive controls are utilised to feed information about the respecive agent's states and communication lines between one another to drive the larger group from initial states of disarray toward more desireable states of order. In particular we wish to effect a consensus in the network and investigate qualitative approximations of the consensus dynamics that reduce the order of our systems but track essential features such as the speed and profile of the larger system's convergence.

[1] Y. Cao, W. Yu, w. Ren and G. Chen, "An overview of recent progress in the study of distributed multi-agent coordination", IEEE Transactions on industrial informatics, vol. 9, no. 1 (2013) pp. 427Ű438.

[2] R. Olfati-Saber and R. M. Murray, "Consensus problems in networks of agents with switching topology and time-delays", IEEE Transactions on automatic control, vol. 49, no. 9 (2004) pp. 1520-1533.

[3] J. Yau, Z.H. Guan and D.J. Hill, "Passivity-based control and synchronization of general complex dynamical networks", Automatica, vol.45, no. 9 (2009) pp. 2107-2113.

Simulation and long-term behaviour of unconstrained planar rigid bodies with impact and friction

Shane Burns
Supervisor: Petri Piiroinen

This work introduces numerical techniques necessary for the implementation of an energetic impact law for rigid body impacts with friction. In particular the work focuses on methodologies for long-term simulating with various behaviours such as dynamic transitions and chatter. The methods are based on event-driven numerical ODE solvers together with system states to deal with the transitions. A slender rod impacting a periodically oscillating surface is used as an example to illustrate implementation and methods. The numerical scheme for the rod system is used to show how symmetry can play an important role in the presence friction for long-term dynamics. This will show that surface oscillations with low frequencies tend to lead to periodic motions of the rod that are independent of friction. For higher frequencies however the periodic solutions are not that common and irregular motion ensues.

[1] S.J. Burns, P.T. Piiroinen : Simulation and long-term behaviour of unconstrained planar rigid bodies with impact and friction. (Submitted)

[2] S.J. Burns, P.T. Piiroinen : The complexity of a basic impact mapping for rigid bodies with impacts and friction. Regular and Chaotic dynamics 19, 1 (2014) 20-36.

[3] A. Nordmark, H. Dankowicz, A. Champneys: Discontinuity-induced bifurcation in systems with impacts and friction: Discontinuities in the impact law. International Journal of Non Linear Mechanics 44 (2009) 1011-1023.

Mathematical modelling of seasonally migrating populations

John Donohue
Supervisor: Petri Piiroinen

Mathematical models of the interactions between biological populations have long been of interest to researchers, both in ecology and in dynamical systems. An understanding of how energy is transferred between organisms at different trophic levels is key to developing a theory of how ecological communities form and persist. Predator-prey models composed of two interacting species are frequently studied as a means of developing an intuition about the kind of relationships that may develop between two populations in a niche. In recent years, periodic forcing has been introduced to classical ecological models in order to illustrate the importance of including seasonal variation. This has often taken the form of a sinusoidally forced growth term with interesting dynamical behaviour generated by the addition of an independent frequency to the system [1,2].

However, many species respond to the seasonal variation in resources by migrating between geographically distinct regions each year. For such species, a sinusoidal variation may not accurately capture the temporal properties of the system. In this work, we use a piecewise-smooth dynamical system to represent the dynamics of species that interact for a short

period of time each year. In addition to predation, migratory populations are exposed to various other habitat-specific mortality factors, both natural and anthropogenic, during their annual cycles. Using the model outlined, we examine how these factors may interact to cause abrupt changes in population size.

[1] S. Rinaldi, S. Muratori, and Y. Kuznetsov. Multiple attractors, catastrophes and chaos in seasonally perturbed predator-prey communities. *Bull. Math. Biol.*, 55:15–35, 1993.

[2] R.A. Taylor, J.A. Sherratt, and A. White. Seasonal forcing and multi-year cycles in interacting populations: lessons from a predator-prey model. *Journal of Mathematical Biology*, 67:1741–1764, 2012.

Supported by the Irish Research Council and NUIG College of Science

---

Shift representations on 2-cocycles

Ronan Egan
Supervisor: Dane Flannery

For any finite group G and abelian group U, a map $\psi : G \times G \mapsto U$ satisfying $\psi(g,h)\psi(gh,k) = \psi(g,hk)\psi(h,k)$ for all $g,h,k \in G$ is a 2-cocycle. The set of all 2-cocycles forms a group $Z^2(G,U)$ under pointwise composition, and the set of all cocycle classes forms the 2-cohomology group $H^2(G,U)$. Cohomology does not preserve orthogonality of cocycles, a requirement for the cocyclic development of many pairwise combinatorial designs such as generalized Hadamard matrices. We introduce and develop the concept of (linear) *shift representation*. This derives from an action of G on $Z^2(G,U)$ that preserves both cohomology and orthogonality, discovered by K. J. Horadam. Detailed information about fixed point spaces and reducibility are given. We also discuss results of computational experiments, including searching for orthogonal cocycles.

[1] R. Egan, D. L. Flannery, and P. Ó Catháin, Classifying cocyclic Butson Hadamard matrices, Springer Proceedings in Mathematics and Statistics: Algebraic Design Theory and Hadamard Matrices, to appear 2015.

[2] D. L. Flannery and R. Egan, On linear shift representations, J. Pure Appl. Algebra **219**, Issue 8, (2015), 3482–3494.

[3] K.J. Horadam, *Hadamard matrices and their applications*, Princeton University Press, Princeton, NJ, 2007.

Supported by the Irish Research Council.

Modelling Homogeneous and Heterogenous Populations under Joint Progressive Type-II Censoring

Lida Fallah
Supervisors: Prof. John Hinde, Dr Haixuan Yang

Comparative life testing is commonly used in an industrial setting to study differences between items produced by different manufacturing lines and similar approached may be used to compare the survival of subgroups of patients in the medical setting, for example males and females. Considering the issue of multiple populations, we limit ourselves to two groups and suppose that we have two independent samples of sizes m and n that are put on test or followed up over time. The study is terminated as soon as some fixed number, r, of failures are observed, i.e. a Type-II censoring scheme. However, to save costs this is combined with joint progressive censoring in which at each observed failure time a number of units is randomly withdrawn from study, joint progressive Type-II censoring.

Addressing the heterogeneity of items in each group, containing susceptible and non-susceptible items to failure, for simplicity we use a two-level categorical variable to capture the heterogeneity, giving a two-component mixture for each group.

We consider the analysis of time to event data from two groups undergoing life-testing under a joint progressive Type-II censoring scheme for both homogeneous and heterogeneous situations. We consider maximum likelihood estimation for this complex sampling scenario and its behaviour under different censoring schemes. For heterogeneous populations we consider a mixture model formulation and maximum likelihood estimation using the EM algorithm. We study the behavior of the estimators through a simulation study and present an illustrative example.

References:

Achcar, J.A. and Pereira, G.D.A. (1999). Mixture models for Type-II censored survival data in the presence of covariates *Journal of Computational Statistics*, **14**, pp. 233 – 250.

Kuo, L. and Peng, F. (2000). A mixture-model approach to the analysis of survival data. *Generalized Linear Models: A Bayesian Perspective*, (Eds. D. K. Dey, S. K. Ghosh and B. K. Mallick), 255 – 267. New York: Marcel Dekker.

Rasouli, A. and Balakrishnan, N. (2010). Exact likelihood inference for two exponential populations under joint Progressive Type-II censoring *Journal of Communications in Statistics-Theory and Methods*, **39**, pp. 2172 – 2191.

Modelling cellular toxicity of nanoparticles

Paul Greaney
Supervisors: Martin Meere, Yury Rochev & Giuseppe Zurlo

Nanoparticles are particles whose dimensions vary between one and one hundred nanometers. They have been shown to have outstanding potential in areas such as drug delivery and cellular imaging. Many novel drug delivery therapies and biomedical applications depend on the uptake of nanoparticles by cells. However, the introduction of a foreign agent into a cell can have toxic effects and can lead to cell death via apoptosis (programmed cell death) or necrosis (cell death due to damage or disease). We introduce a compartment model to describe the response of a population of cells to the introduction of quantum dots, a particular type of nanoparticle made from semiconductor materials. The model consists of a system of ordinary differential equations describing the concentration of intracellular quantum dots, and the subpopulations of healthy, apoptotic, necrotic, and dead cells. Results are presented in the case of four types of CdTe quantum dots.

[1] R. Singh, H.S. Nalwa : Medical applications of nanoparticles in biological imaging, cell labelling, antimicrobial agents, and anticancer nanodrugs. Journal of Biomedical Nanotechnology 7 (2011) 489-503.

[2] J.A. Kim, C. Åberg, A. Salvati, K.A. Dawson : Role of cell cycle on the cellular uptake and dilution of nanoparticles in a cell population. Nature Nanotechnology 7 (2012) 62-68.

[3] S. Vranic, N. Boggetto, V. Contremoulins, S. Mornet, N. Reinhardt, F. Marano, A Baeza-Squiban, S. Boland : Deciphering the mechanism of cellular uptake of engineered nanoparticles by accurate evaluation of internalization using imaging flow cytometry. Particle and Fibre Toxicology 10:2 (2013)

Supported by the College of Science, NUI Galway

Exceptional Spaces of Matrices and the Trace Bilinear form - A first survey

Ha Van Hieu
Supervisor: Dr Rachel Quinlan

Many interesting matrix properties (for example nilpotence) are not generally preserved under addition. Nevertheless, it is possible to investigate large sets of matrices that have the property of interest and are closed under addition. A recent article by Dr Rachel Quinlan on a problem of this nature uses the trace bilinear form to establish for all fields a duality relationship between two particular properties of matrix spaces, and employs this duality to obtain tight dimension bounds [3]. The methods used in the work of Quinlan are new and relatively elementary. They have already been successfully applied to the study of completion problems for partial matrices, and they have ample scope for extension and wider application [2]. The research proposed here seeks first to extend the duality theorem of Quinlan and interpret it in the most general context possible, and then to explore the implications of this theorem and its variants for investigations involving the existence and construction of *exceptional spaces of matrices with particular properties.*

[1] Murray Gerstenhaber. On nilalgebras and linear varieties of nilpotent matrices, i. American Journal of Mathematics, pages 614-622, 1958.

[2] James McTigue and Rachel Quinlan. Partial matrices whose completions have ranks bounded below. Linear Algebra and its Applications, 435(9):2259-2271, 2011.

[3] Rachel Quinlan. Spaces of matrices without non-zero eigenvalues in their field of definition, and a question of Szechtman. Linear Algebra and its Applications, 434(6):1580-1587, 2011.

Summarising Survival Data: Comparing Mean Residual Life and Dynamic Prediction of Survivor functions

Amirhossein Jalali
Supervisors: Alberto Alvarez-Iglesias, John Hinde and John Newell

In the field of Survival Analysis, a great deal of research has been carried out to provide useful summaries of the distribution of survival times. The most common summary involves plots of the estimated survival and hazard functions, typically using the Kaplan-Meier estimator. In addition, the proportional hazards model is widely used to model the change in the hazard function as a function of one or more covariates/factors. The Mean Residual Life function and Dynamic Prediction of survivor function are two useful, but underused alternatives. Hence, we introduce them and highlight their benefits as graphical summaries of time to event data.

[1] A. Alvarez-Iglesias, J. Newell, C. Scarrott, J. Hinde: Summarising censored survival data using the mean residual life function. Statistics in Medicine 34, 11 (2015).

[2] E. Freireich, E. Gehan, *et al.*: The effect of 6-mercaptopurine on the duration of steroid-induced remissions in acute leukemia. Blood 21,6 (1963).

[3] H.C. Houwelingen, and H. Putter: Dynamic prediction in clinical survival analysis. CRC Press (2012).

Variable selection by penalized regression techniques in survival analysis

Olga Kalinina
Supervisors: Emma Holian and John Newell

Survival analysis methods play an important role in biostatistics, as they explains the effect of different treatments and risk factors. Every disease has its unique survival pattern and high-dimensional space of predictors. The aim of this study is to apply several penalized regression methods to identify a parsimonious set of predictors.

The data, collected by National Breat Cancer Research Institute, consists of 674 invasive breast cancer patients from the West of Ireland diagnosed between 1999 and 2006 with many predictors. Cox Proportional Hazard and three types of penalized regression models were fitted to the Complete Case (patients with missing data in any of the predictors were excluded) for disease recurrence and death. The first is L_1 penalized regression called Lasso [R. Tibshirani,1996] which shrinks some coefficients and sets others to 0. The second is L_2 penalized regression called Ridge [Hoerl,1970] which is a continuous process that shrinks coefficients, but does not set any coefficients to 0. Unlike lasso estimation, ridge regression conserves all parameters to construct the prediction model. The third is $L_1 - L_2$ penalised regression which called elastic net[Benner,2010]. The elastic net performs feature selection and parameter estimation as the Lasso regression,but by adding L_2 penalty it may select more predictors than the Lasso regression.

The elastic net penalized regression model showed better prediction performance than Lasso and Ridge penalized regression models. However due to the presence of missing values prediction performance may be improved by using methods to estimate missing values. Multiple Imputation methods will be applied as there is a high proportion of missing values present in the data and exclusion of missing values leads to reduction in sample size (number of patients reduced from 647 to 104), which reduces the precision of estimates and can lead to biased estimates. Multiple Imputation by Chain Equation method [van Buuren,2012] will be applied to data and then the variable selection by penelized regression techniques performed for imputed datasets.

[1] R. Tibshirani. Regression shrinkage and selection via the lasso *Journal of the Royal Statistical Society B* , **Volume 58**, pp. 267 – 288. 1996

[2] A. E. Hoerl and R. W. Kennard. Ridge regression: biased estimation for nonorthogonal problems *Technometrics* , **Volume 12**, pp. 55 – 67. 1970.

[3] A. Benner, M. Zucknick, T. Hielscher, C. Ittrich, and U. Mansmann. High-dimensional cox models: the choice of penalty as part of the model building process *Biometrical Journal* , **Volume 52**, pp. 50 – 69. (2010).

[4] Stef van Buuren. *Flexible Imputation of Missing Data.* (2012).

Intron length coevolution across mammalian genomes

Peter Keane
Supervisor: Cathal Seoighe

Introns have long been an area of fascination in molecular evolution. Although typically they do not contribute directly to the protein coding potential of genomes, they have been shown to play several important functional roles. They frequently contain regulatory elements and extend the protein coding potential of genomes through alternative splicing, giving rise in the process to additional modes of gene regulation. For some genes, the transcriptional delay resulting from the time taken to transcribe introns is functionally important. We have previously carried out an investigation of the conservation of intron length and found that genes associated with developmental processes, particularly, developmental patterning are enriched for high levels of conservation of intron length.

Sets of genes that require precise coordination in the timing of their expression may be particularly sensitive to evolutionary changes in intron length. A prediction of this hypothesis is that changes in intron length due to insertions and deletions should be correlated between such genes. To test this hypothesis we have carried out an investigation into intron length coevolution using whole genome alignments and reconstructed ancestral sequences from 15 eutherian mammals. We identified a number of sets of genes corresponding to functional modules that show evidence of intron length coevolution. Enriched functional modules include synaptic transmission and chromosome organization. Furthermore, genes that belong to the same protein complex or show similar patterns of gene expression across tissues (co-expressed genes) are significantly more likely to show evidence of intron length coevolution than randomly sampled genes. These results suggest that the time delay associated with the transcription of long introns is functionally significant. Coevolution of intron length maintains this coordination, allowing protein complexes and co-expression patterns to be conserved.

Supported by the Simulation Science PhD programme, which is funded by the Programme for Research in Third Level Institutions (PRTLI) Cycle 5 and co-funded by the European Regional Development Fund

---

The Table of Marks of a Direct Product

Brendan Masterson
Supervisor: Götz Pfeiffer

From Goursat's lemma it is known that a subgroup of a direct product of two finite groups, G_1 and G_2, can be expressed in terms of subgroups of G_1 and G_2 by triples of the form $((P_1, K_1), (P_2, K_2), \theta)$, where $K_i \trianglelefteq P_i \leq G_i$ and $\theta : P_1/K_1 \to P_2/K_2$ is an isomorphism. We will call these triples Goursat triples.

Based on their Goursat triple we observe that one subgroup of a direct product can be contained in another in one of three ways. These observations on the subgroup lattice of $G_1 \times G_2$ produce a decomposition of the unweighted table of marks of $G_1 \times G_2$ into three matrices. Each of these matrices can be understood and constructed from the table of marks of the factor groups and those of their subgroups. In this way we are able to construct the table of marks of $G_1 \times G_2$ from the tables of marks of G_1 and G_2 and their subgroups.

[1] K. Bauer, D. Sen, P. Zvengrowski: A Generalized Goursat Lemma, preprint, arXiv:1109.0024.

[2] K. Lux and H. Pahlings: Representations of Group, a computational approach. Cambridge studies in advanced mathematics, 2010.

Flags of Root Systems and Their Applications

Mohammad Adib Makrooni
Supervisor: John Burns

This work studies subroots systems and flags of subroot systems of a compact, connected Lie group G [1]. It also gives a selection of applications. We obtain a new description of the Exponents of a simple complex Lie Algebra [2] in terms of the Coxeter number and other root theoretic data associated to geometric objects. When the subroot system corresponds to a parabolic subgroup P we obtain uniform expressions for the nef values $\tau(X, L)$ of ample line bundles L on the corresponding homogeneous complex projective variety $X = G/P$. Recall that L is ample if the sections of some power of L give an embedding of X in some projective space. Finally we calculate a topological invariant ϕ, related to the Poincare polynomial for all complex homogeneous space G/H with non vanishing Euler characterstic.

We briefly recall two definitions of the exponents. We may pass from the first to the second using a Morse function on the associated flag manifold of G [1].

- Let W be the Weyl group of a compact, connected Lie group G. The manifold G has the same cohomology as a product of odd-dimensional spheres

$$H^*(G,\mathbb{R}) \cong H^*(\prod_{i=1}^{l} S^{2m_i+1},\mathbb{R}).$$

  The numbers m_i appearing above are by definition the exponents of G (or W).

- Let $\ell : W \to \mathbb{Z}_{\geq 0}$ be the length function. Then

$$\sum_{w\in W} t^{\ell(w)} = \prod_{i=1}^{l} \frac{1-t^{m_i+1}}{1-t}.$$

  Again the numbers m_i are the exponents of W (or G).

[1] R. Carles. *Méthode récurrente pour la classification des systèmes de racines réduits et irréductibles.* C. R. Acad. Sci. Paris **276** (1973) pp 355–358.

[2] B. Kostant, The Principal Three-Dimensional Subgroup and the Betti Numbers of a Complex Simple Lie Group, American Journal of Mathematics, Vol. 81, No. 4 (Oct., 1959), pp. 973-1032

[3] D. M. Snow, The Nef Value and Defect of Homogeneous Line Bundles, Transactions of The American Mathematical Society, Vol. 340, No. 1 (November 1993)

Supported by School of Mathematics, Statistics and Applied Mathematics

---

Bayesian Nonparametric Survival analysis: an illustration

Shirin Moghaddam
Supervisors: John Hinde and Milovan Krnjajić

This project involves development of flexible statistical regression models with a particular focus on the modelling requirements for types of data that arise in survival analysis. We apply nonparametric Bayesian (NPB) methods, which substantially enhance the flexibility of standard parametric models while providing a full probabilistic framework for inference. Under the NPB paradigm, the unknown distributions of the model are treated as random (infinite-dimensional) parameters necessitating specification of stochastic nonparametric priors, such as Dirichlet or Gaussian proceses, over spaces of distributions.

[1] C.E. Antoniak. *Mixtures of Dirichlet Processes With Applications to Nonparametric Problems.* The Annals of Statistics, 2 (1974) 1152-1174.

[2] T.S. Ferguson. *Bayesian Analysis of Some Nonparametric Problems.* The Annals of Statistics, 1 (1973) 209-230.

[3] A. Kottas. *Nonparametric Bayesian survival analysis using mixture of Weibull distributions.* Journal of Statistical Planning and Inference, 136 (2006) 578-596.

An Analysis of a Boundary-Layer Preconditioner for a Singularly Perturbed Problem

Thái Anh Nhan
Supervisor: Niall Madden

We consider the linear reaction-diffusion boundary value problems in one and two dimensions

$$-\varepsilon^2 u'' + b(x)u = f(x) \quad \text{on } \Omega := (0,1) \tag{2}$$

and

$$-\varepsilon^2 \Delta u + b(x,y)u = f(x,y) \quad \text{on } \Omega := (0,1)^2, \tag{3}$$

with homogeneous Dirichlet boundary data. Here ε is a positive parameter, but which may arbitrarily small. Finite element discretizations of (2) and (3) on a mesh with N intervals (on each direction) leads to a linear system to be solved:

$$AU = F, \tag{4}$$

where A is a symmetric positive definite matrix.

The system (4) can be solved by direct methods (such as Gaussian Elimination, Cholesky factorisation, or LU factorisation). However, in recent study, MacLachlan and Madden [1] point out that direct solvers may not be robust for small ε, and identify that the source of the problem is that many of the entries in the Cholesky factors as so small as to fall into the range of subnormal numbers, which are expensive to compute. A thorough investigation for the underlying reasons behind this phenomenon is given in [3].

Since direct solvers are not robust, iterative solvers must be used. However, the condition number of the discrete system (4) depends badly on ε, see [2]. Therefore, a preconditioner is required in order to solve (4) robustly and efficiently. Following the approach in [1], we propose a boundary layer preconditioner that is optimised for a Galerkin finite element discretization of (2) and (3) using bilinear elements on a layer-adapted mesh. The preconditioner is motivated by the layer-adapted nature of the scheme. We give an analysis of the spectral equivalence of this specially designed preconditioner for (2). Suitable stopping criteria associated with both energy and maximum norms are also derived [2].

[1] Scott Maclachlan and Niall Madden, Robust Solution of Singularly Perturbed Problems Using Multigrid Methods, SIAM J. Sci. Comput., 35 (2013), pp. A2225-A2254.

[2] Scott Maclachlan, Niall Madden and Thái Anh Nhan, Boundary layer preconditioners for finite element discretizations of reaction-diffusion problems in one and two dimensions, in preparation.

[3] Thái Anh Nhan and Niall Madden, Cholesky factorisation of linear systems coming from finite difference approximations of singularly perturbed problems, submitted, November 2014.

Supported by IRC under Grant No. RS/2011/179.

Identification of Translational Cis-regulatory SNPs in Human Cancer Cell Line Using Allele-specific Gene Expression Analysis

Ngoc T. Nguyen and Thong T. Nguyen
Supervisor: Cathal Seoighe

Regulation of mRNA translation plays an important role in determining protein abundance in cells and genetic variants that affect the rate of protein synthesis may give rise to human genetic diseases and phenotypes. Here we developed a computational pipeline to detect the differences between alleles in the rate of protein translation, referred to as allele-specific translation (AST). Our method makes use of samples, for which both RNA-seq and Ribo-seq data are available [1] and is sensitive to differences in the relative abundance of ribosome-associated and non ribosome-associated mRNA between alternative alleles in heterozygous samples. We applied the pipeline to identify AST in the HeLa cancer cell line and found 453 AST candidate genes, carrying 1949 genetic variants. This set of genes is significantly enriched for genes that have been shown experimentally to be associated with genetic variation in protein abundance [2] (Fisher's exact test p-value = 2.05e-10). A variant rs114238154 in the start codon of cancer-associated NQO1 showing a strong statistical evidence of AST, have been validated experimentally with the average 30-fold difference in translational rate. Application of our pipeline to the HeLa cell line was facilitated by the recent availability of the complete haplotype-resolved genome of HeLa [3]. However, we demonstrate that existing high-throughput sequencing data can be used to recover the haplotype-resolved genome of other samples with sufficient accuracy to infer AST. This approach has the capacity to provide insights into the etiology of a subset of mapped genetic diseases for which the causal variant remains undiscovered.

[1] Guo, H. et al. Mammalian microRNAs Predominantly Act to Decrease Target mRNA Levels. Nature 466, 835–840 (2010).

[2] Wu, L. et al. Variation and genetic control of protein abundance in humans. Nature 499, 79–82 (2013).

[3] Adey, A. et al. The Haplotype-Resolved Genome and Epigenome of the Aneuploid HeLa Cancer Cell Line. Nature 500, 207–211 (2013).

Minimal Primitive Graphs of Exponent 2

Olga O'Mahony
Supervisor: Dr Rachel Quinlan

A simple graph G is primitive if for all vertices u and v in G there exists a positive integer k such that there is a walk of length k between them. The exponent $\gamma(G)$ is the smallest such k. A graph G minimally has exponent two if there is a walk of length two between all pairs of vertices in G, and deleting any edge means G no longer has exponent two any more. This poster looks at minimal primitive graphs of exponent two, and considers the problem of classifying such graphs. It also explores the maximum number of edges in a graph that minimally has exponent two.

[1] B.Kim, B.Song and W.Hwang *Nonnegative primitive matrices with exponent 2*, Linear Algebra and its Applications $407(2005)162-168$

Supported by The College of Science, NUIG

Dynamic Visualization in R and beyond

Davood Roshan Sangachin
Supervisors: Dr. John Newell, Dr. Patricia Gunning

Various types of plots are used to display relationships between variables in a data set. While basic functionality in R (open source statistical software) allows for the creation of simple plots, this is often inadequate for more complex scenarios. Newly developed high-level R packages such as ggplot2 and rCharts address this limitation through the provision of tools to create elegant static and dynamic statistical graphics. In this poster, I will provide examples of basic and high level graphical capabilities in R. A review of additional features available in proprietary software such as Tableau will be given.

[1] Wickham, H.: ggplot2: Elegant Graphics for Data Analysis (Use R!) (2009).

[2] Vaidyanathan, R.: Interactive Charts from R using rCharts.
Available at: http://ramnathv.github.io/rCharts/

[3] Murray, D. and Chabot, Ch.: Tableau Your Data!: Fast and Easy Visual Analysis with Tableau Software(2013).

A multiscale sparse grid finite element method for a two-dimensional singularly perturbed reaction-diffusion problem

Stephen Russell
Supervisor: Dr. Niall Madden

Standard finite element methods (FEMs), such as the Galerkin method with the usual polynomial basis functions are impractical for very large problems, especially in higher dimensions. Sparse grid methods try to break this "curse of dimensionality" by delivering the same order of accuracy as a classical FEM but, through careful choice of basis functions, with far fewer degrees of freedom (ideally, independent of the problem dimension).

Classically, a *hierarchical basis* has been the preferred choice of basis used when analysing and implementing sparse grid methods, see e.g., [1]. In [4] and [5] a *combination sparse basis* is used. This basis is derived from the combination sparse grid technique of Pflaum and Zhou, [3], and the two-scale sparse grid method of Liu et al., [2].

In this poster we investigate the similarities, advantages and disadvantages associated with these two choices of basis. Both choices represent the same finite dimensional space, and so require the same number of degrees of freedom. The hierarchical basis is somewhat more intuitive, and easier to implement in certain settings, while the combination sparse basis can be easier to analyse, and have a lower computational cost.

[1] Hans-Joachim Bungartz and Michael Griebel. Sparse grids. *Acta Numer.*, 13:147–269, 2004.

[2] 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.

[3] C. Pflaum and A. Zhou. Error analysis of the combination technique. *Numer. Math.*, 84(2):327–350, 1999.

[4] Stephen Russell and Niall Madden. A multiscale sparse grid finite element method for a two-dimensional singularly perturbed reaction-diffusion problem. *Adv. Comput. Math. (to appear)*, 2015.

[5] Stephen Russell and Niall Madden. A sparse grid finite element method for a two-dimensional singularly perturbed convection-diffusion problem. *(submitted)*, 2014.

Supported by College of Science fellowship, National University of Ireland, Galway.

Road Systems and Hyperspaces

Qays R. Shakir
Supervisors: Dr. Aisling McCluskey

The notion of one point being *between* two distinct points on a straight line is well understand and hardly surprising. However, the notion lend itself to many interesting generalizations. For example, we may consider such notion for points is a partially ordered set. A more recent interpretation of (pointwise) betweenness, due to Banckston, introduces the concept of a road system $\mathcal{R}$ for a given set X. An extension of the pointwise betweenness of *set betweenness* . We seek to explore this notion via hyperspaces..

[1] Paul Bankston. Road systems and betweenness. Bull. Math. Sci. , 3(3):389âĂŞ408, (2013).

[2] G. Beer,R.Tamak. On hit-and-miss hyperspace topologies, Commentat. Math. Univ. Carol. 34 , No.4, 717-728, (1993).

Supported by the Iraqi Ministry of Higher Education and Scientific Research.

LymAnalyzer: a tool for comprehensive analysis of next generation sequencing data of T cell receptors and immunoglobulins

Yaxuan Yu
Supervisors: Cathal Seoighe & Rhodri Ceredig

The adaptive immune system contains populations of B and T cells capable of binding a range of foreign peptides via antigen specific receptors, called immunoglobulin (IG) for B cells and the T cell receptor (TCR) for T cells. In order to provide protection from a wide range of pathogens, B and T cell populations maintain a highly diverse repertoire of IGs and TCRs. This is achieved through combinatorial rearrangement of multiple gene segments, together with somatic hypermutation. Next generation sequencing technology has revolutionized the analysis of the diversity of these repertoires by enabling deep TCR/IG profiling. However, the volume of sequence data involved and the effects of sequencing errors demand a versatile bioinformatics pipeline to annotate such data accurately. Here we present LymAnalzyer, a software package that significantly improves the accuracy of TCR/IG profiling from deep sequence data, providing a comprehensive set of functionalities for this task. It uses a fast-tag-searching algorithm for rapid identification of recombined gene segments, integrating within the pipeline SNP calling procedures to identify novel alleles of gene segments and the construction of mutation trees to visualize somatic mutations. Utilizing real and simulated datasets, we show that LymAnalyzer is capable of estimating the diversity of the TCR/IG repertoire with high accuracy.

[1] Bolotin, Dmitry A., et al. "Next generation sequencing for TCR repertoire profiling: PlatformâĂŘspecific features and correction algorithms." European journal of immunology 42.11 (2012): 3073-3083.

[2] Thomas, Niclas, et al. "Decombinator: a tool for fast, efficient gene assignment in T-cell receptor sequences using a finite state machine." Bioinformatics 29.5 (2013): 542-550.

[3] Bolotin, Dmitriy A., et al. "MiTCR: software for T-cell receptor sequencing data analysis." Nature methods 10.9 (2013): 813-814.

---

5 Abstracts of PhD Theses

Completions of partial matrices
James McTigue
Supervisor: Dr Rachel Quinlan

A *partial matrix* over a field $\mathbb{F}$ is a matrix whose entries are either elements of the field or independent indeterminates. A *completion* of a partial matrix is any matrix that results from assigning a field element to each indeterminate. The set of completions of an $m \times n$ partial matrix forms an affine subspace of $M_{m\times n}(\mathbb{F})$.

This thesis investigates partial matrices whose sets of completions satisfy particular rank properties - specifically partial matrices whose completions all have ranks that are bounded below and partial matrices whose completions all have the same rank. The maximum possible number of indeterminates in such partial matrices are determined and the partial matrices that attain these bounds are fully characterized for all fields. These characterizations utilize a duality between properties of affine spaces of matrices that are related by the trace bilinear form.

Precise conditions (based on field order, rank and size) are provided to determine if a partial matrix whose completions all have the same rank r must possess an $r \times r$ partial sub–matrix whose completions are all nonsingular.
Finally a characterization of maximal nonsingular partial matrices is provided – a maximal nonsingular partial matrix is a square partial matrix each of whose completions has full rank, with the property that replacement of any constant entry with an indeterminate results in a partial matrix having a singular completion.

The work in this thesis is both motivated by and extends some recent results of Brualdi, Huang and Zhan.

Analysis of hepatic microRNA expression in postpartum dairy cows in negative energy balance
Attia Fatima
Supervisor: Dermot Morris & Cathal Seoighe

This thesis set about to answer three research questions grounded in transcriptional regulation of hepatic genes in the high-yielding postpartum dairy cows under negative energy balance (NEB). For this purpose we used liver tissue from a previously developed dairy cow model comprising cows under mild negative energy balance (MNEB) and severe negative energy balance (SNEB). The first research question relates to what is the overall expression profile of hepatic miRNAs in the early postpartum period under both conditions and whether hepatic miRNA expression is altered during SNEB. The second question is an in silico identification of the gene targets of these miRNAs among sets of differentially expressed hepatic genes previously reported in this same animals. The third question relates to the functional role of miRNAs in regulating putative target mRNAs. Two high-throughput techniques were used to determine hepatic miRNA expression under NEB in a dairy cattle model. First microarray expression profiling was done to determine the differential expression of hepatic miRNAs under SNEB. Five miRNAs were differentially expressed including miRs 140, 31, 17-5p, 1281 and 2885. For all differentially expressed miRNAs, in-slico target prediction was carried out on a set of 418 differentially expressed liver genes previously reported in the same animals. A custom Perl script from Targetscan was used to identify putative target sites on bovine 3'UTRs retrieved from Ensembl. Overall 32 down-regulated target genes were identified, including those relevant to NEB such as genes involved in lipid and glucose metabolism and homeostasis and in the somatotropic axis. miR-2885 has binding sites in the 3âĂŹUTR of FADS2, a lipogenic gene which is strongly down-regulated under SNEB. In addition, an up-regulated hepatic transcription factor, HNF3-gamma involved in IGF-1 expression is a putative target of miR-31.

In the second study the overall abundance and distribution of miRNAs under both MNEB and SNEB was profiled using next generation sequencing. Overall, liver-specific miR-122 constituted 75% of expressed miRNA. SNEB resulted in the down-regulation of miR-143, which has been associated with fatty acid metabolism. 16 up-regulated putative target genes of miR-143 were identified in a combined set of differentially expressed hepatic genes from microarray and RNA-seq based expression profile studies reported previously in the same animals. Among these SLC2A12 and LRP2 have roles in glucose and lipid metabolism. The third study aimed to determine the functional role of miR-2885 in the regulation of FADS2 expression. The inhibition of miR-2885 was carried out in an MDBK (Madin Darby Kidney) cell line through lipid based transfection of a miR-2885 inhibitor and its effect on the expression of FADS2 was determined. FADS2 expression was up-regulated over 5-fold validating a role for miR-2885 in FADS2 regulation.

Shift representations on 2-cocycles

Ronan Egan
Supervisor: Dr Dane Flannery

For any finite group G and abelian group U, a map $\psi : G \times G \mapsto U$ satisfying $\psi(g,h)\psi(gh,k) = \psi(g,hk)\psi(h,k)$ for all $g,h,k \in G$ is a 2-cocycle. The set of all 2-cocycles forms a group $Z^2(G,U)$ under pointwise composition, and the set of all cocycle classes forms the 2-cohomology group $H^2(G,U)$. Cohomology does not preserve orthogonality of cocycles, a requirement for the cocyclic development of many pairwise combinatorial designs such as generalized Hadamard matrices. We introduce and develop the concept of (linear) *shift representation*. This derives from an action of G on $Z^2(G,U)$ that preserves both cohomology and orthogonality, discovered by K. J. Horadam. Detailed information about fixed point spaces and reducibility are given. We also discuss results of computational experiments, including searching for orthogonal cocycles.

Estimation and Analysis of Gene Expression and Alternative Splicing: Perspectives from Development and Disease

Paul Korir
Supervisor: Cathal Seoighe

The development of high-throughput genomics technologies has contributed substantially to the understanding of gene expression regulation. With the growing appreciation of the importance of alternative splicing, quantitative techniques have had to keep in step with the demand for an accurate and high resolution view of the transcriptome. In this thesis, we use results and methods from quantitative genomics to explore how gene regulation may be modified in development and disease.

Precise regulation of gene expression timing can be critical for some biological processes. This is particularly the case for genes with oscillating patterns of expression. Oscillations can be brought about through negative feedback loops, with a delay between gene activation and negative autoregulation. The time required for gene transcription contributes to the delay in gene activation and, thus, the intron content of genes involved in negative autoregulatory loops can be functionally significant. An example of this occurs in *Hes7*, in which oscillation is coupled to the formation of segmental body plans during animal development. To identify further examples of genes in which the transcriptional delay introduced by introns may be functionally significant, we carried out a search for genes with conserved intron content across a diverse panel of 19 mammals and found that the set of genes with the most extreme conservation was enriched for genes involved in embryonic development. We found that these genes had both fewer insertions and deletions as well as a balance between the cumulative insertions and deletions, suggesting that selection functions to prevent indels in these introns and to balance the impact of insertions and deletions.

There has been considerable success in mapping local (*cis*) variants associated with phenotypes such as disease. Many *cis*-acting variants that cause disease disrupt splicing. However, mapping distant (*trans*) acting variants that act splicing is a more formidable task. By exploiting high-density transcriptome microarrays, we show that a mutation in the splicing factor PRPF8, causally associated with *retinitis pigmentosa*, is a *trans*-acting splicing variant. We estimate that up to 20% of all exons are mis-spliced through higher exon inclusion in acted individuals. Characteristics of acted exons suggest that they tend to be spliced co-transcriptionally and via the exon-defined splicing pathway.

The importance of gene expression microarrays in quantitative genomics has led to the development of numerous algorithms to estimate gene expression from raw microarray intensities. But microarrays have several shortcomings relative to more recently developed sequencing-based methods for measuring gene expression. We exploited the benefits of quantitative transcriptome sequencing (RNA-Seq) by using a statistical learning approach to obtain better expression estimates from arrays, based on a high-quality dataset for which both microarray and RNA-Seq data are available. Our analyses show that this approach compares favourably to existing algorithms for microarray analysis, with the added advantage of providing estimates of the abundance of individual transcript isoforms on an absolute scale.

---

6 Research Activity from 1 Jan 2014 to 31 Dec 2014

Permanent and Contract Staff

Burns, John

Current Research Interests

My current research interests are Algebra (Lie algebras, Lie groups, Weyl groups) and Differential Geometry (Homogeneous manifolds, Symmetric spaces). Research in all of the above areas is ongoing with various authors:

Adib Makrooni and I are studying relations between root theoretic data, such as the Coxeter number and the exponents, of a parabolic sub-root system and that of its parent. We are also studying topological invariants (related to the Poincare polynomial) of compact homogeneous spaces with non vanishing Euler characteristic.

Patrick Browne and I are working on graded Lie Algebras and their application to the geometry of homogeneous submanifolds of noncompact symmetric spaces. These spaces are interesting as they contain a large class of Einstein manifolds.

Publications

Research Activities

Publications 2014-15: COMPACT HOMOGENEOUS SPACES WITH POSITIVE EULER CHARACTERISTIC AND THEIR 'STRANGE FORMULAE' , Quart. J. Math. (2015), 1-10, doi:10.1093/qmath/hav009 (with M. Makrooni).
Invited talks: N.U.I.M., Oct. 2014.
Refereeing: 1 paper.
Conferences and workshops: Riemannian and Sub-Riemannian geometry of Lie groups & homogeneous spaces, IHP - Paris, Nov. 2014. Irish Geometry Conference 2014 (co-organizer) May 2014. Groups in Galway, May 2014.
Postgraduate supervision: 1 Ph.D. student.
Visitors: Tristan Audam, Ecole Central de Marseille, France (March-August 2014).

Cruickshank, James

Current Research Interests

1. Geometric graph theory - in particular rigidity of bar-joint frameworks and other related structures.
2. Rank properties of spaces of matrices.
3. Random geometric graphs.

Publications

Number of publications appearing in calender year 2014: 3

[1] On spaces of infinitesimal motions and three dimensional Henneberg extensions. *Discrete Comput. Geom.* 51 (2014), no. 3, 702–721.

[2] The smooth structure of the moduli space of a weighted series-parallel graph. *Topology Appl.* 164 (2014), 242–247. (joint with Jonathan McLaughlin)

[3] Unitary groups over local rings. *J. Algebra Appl.* 13 (2014), no. 2, 1350093, 23 pp. (joint with Allen Herman, Rachel Quinlan and Fernando Szechtman)

Research Activities

Graduate Students: Christine Marshall (cosupervised with Colm O Riordan, Discipline of Information Technology)

Rigidity Workshop, Lancaster University, June 2014. (Invited talk)

Editorships: Editorial board of the Bulletin of the IMS

Journal Submissions: 1 article submitted and 2 in preparation

---

Destrade, Michel

Current Research Interests

I apply the principles of Continuum Mechanics to the modelling of "soft matter materials", which include soft silicones, gels, and biological tissues such as the human skin and brain matter. I am mainly working in problems and applications of elastic wave propagation, elastic stability, and proper computational solid mechanics.

First I try to elaborate sound, physically based constitutive models to describe the behaviour of these solids and their response to mechanical solicitations; then I design and implement experimental protocols to confront theory to reality and also to evaluate material

parameters; finally I feed these models and parameters into finite element codes, with a view to obtain reasonably predictive simulations.

Recently I made great progress in implementing all these steps into the study of skin and brain matter, by working with colleagues at the NCBES, at UCD, and at Tsinghua University.

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

Publications

Number of publications appearing in calendar year 2014: six articles in international scientific journals, including two in special issues.

Four significant publications :

[1] D.R. Nolan, A.L. Gower, M. Destrade, R.W. Ogden, J.P. McGarry. A robust anisotropic hyperelastic formulation for the modelling of soft tissue, Journal of the Mechanical Behaviour of Biomedical Materials, 39 (2014) 48-60.

[2] M. Destrade, R.W. Ogden, I. Sgura, L. Vergori. Straightening wrinkles, Journal of the Mechanics and Physics of Solids, 65 (2014) 1-11.

[3] P. Ciarletta, M. Destrade. Torsion instability of soft solid cylinders, IMA Journal of Applied Mathematics, Special Issue in Honour of Ray W. Ogden [invited contribution] 79 (2014) 804-819.

[4] B. Rashid, M. Destrade, M.D. Gilchrist. Mechanical characterization of brain tissue in tension at dynamic strain rates, Journal of the Mechanical Behavior of Biomedical Materials, Special Issue on Forensic Biomechanics, 33 (2014) 43-54.

Research Activities in 2014

Research grants: Postdoctoral IRC Fellowship for Sara Roccabianca (successful/declined), Postgraduate IRC Fellowship (applied with Joanne McCarthy/unsuccessful), Postgraduate IRC Fellowship for Artur Gower (co-I), NUI Galway start-up grant (PI), NUI Galway Hardiman Scholarship (applied with Joanne McCarthy/shortlisted), Italian Institute of Higher Mathematics INdAM Visiting Professor Programme (PI), Carnegie Trust Small Grant with Luigi Vergori (co-I), NUI Galway College of Science Postgraduate Grant (applied with Joanne McCarthy/unsuccessful), COST European Science Foundation (applied with International Brain Mechanics and Trauma Lab/unsuccessful); British Science Association Media Fellowship (PI), Dobbin Scholarship (PI/unsuccessful), Marie Curie Association Communication Prize (shortlisted).
Numbers of graduate students: 1;
Conferences/Seminars: 5;
Outreach talks: 10;
Guest Visits: 3 (UCD, DCU, Modena);
Host Visits: 3 (Vergori/Glasgow, Ogden/Glasgow, Ciarletta/Paris 6);
Papers refereed: 9;
International Grant referee: 2 (EPSRC, Carnegie Trust);
External Examiner: 3 (Oxford, Trento, Tsinghua);
Editorial Board Member: 6 (Proceedings of the Royal Society A, Quarterly Journal of Mechanics and Applied Mathematics, International Journal of Applied Mechanics, International Journal of Non-Linear Mechanics, Journal of the Acoustical Society of America, SIAM Journal of Applied Mathematics);
Memberships: Acoustical Society of America, Society for Industrial and Applied Mathematics, International Society for the Interaction of Mechanics and Mathematics;
External positions: Media Fellow at The Irish Times; Visiting Professor of Mechanical Engineering (University College Dublin); Directeur de Recherche, Institut d'Alembert, CNRS, Paris, France (on leave); International Brain Mechanics and Trauma Lab (Oxford); Biomechanics Research Centre (NUI Galway).

Detinko, Alla

Current Research Interests

Computational group theory and its applications.

Publications

Most significant recent publications:

[1] A. Detinko, D. Flannery, A. Hulpke *Algorithms for arithmetic groups with the congruence subgroup property*, Journal of Algebra, 421 (2015) 234-259.

[2] A. Detinko, D. Flannery, W. de Graaf *Integrality and arithmeticity of solvable linear groups*, Journal of Symbolic Computation, 68 (2015) 138-145.

Research Activities

- Invited speaker at
  - November 2014 Algorithms for Linear Groups (Banff International Research Station, Canada) "Algorithms for arithmetic groups: a practical approach".
  - June 2014 Groups, Computation and Geometry (Colorado State University, USA) "Computing with arithmetic groups that have the congruence subgroup property".

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

5 publications appeared in 2014

Most significant publications

(a) Brendel, Piotr; Dlotko, Pawel; Ellis, Graham; Juda, Mateusz; Mrozek, Marian; Computing fundamental groups from point clouds. Appl. Algebra Engrg. Comm. Comput. 26 (2015), no. 1-2, 27–48.

(b) Ellis, Graham; Murillo, Aniceto; Real, Pedro; Saenz-de-Cabezon, Eduardo; Editorial. Appl. Algebra Engrg. Comm. Comput. 26 (2015), no. 1-2, 1–3.

(c) Ellis, Graham; Le, Luyen Van Homotopy 2-types of low order. Exp. Math. 23 (2014), no. 4, 383–389.

(d) Tuan, Bui Anh; Ellis, Graham The homology of $SL_2(\mathbb{Z}[1/m])$ for small m. J. Algebra 408 (2014), 102–108.

(e) Ellis, Graham; Hegarty, Fintan Computational homotopy of finite regular CW-spaces. J. Homotopy Relat. Struct. 9 (2014), no. 1, 25–54.

Research Activities

I supervised two PhD students. One PhD submitted his thesis in April. 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.

In 2013-14 I took a sabbatical year and visited the IST at Vienna where I worked with Herbert Edelsbrunner's team on problems in applied topology. The Institute of Science and Technology Austria (IST Austria) (http://ist.ac.at) is a new institute dedicated to basic research and graduate education in the natural and mathematical sciences, located in the Vienna Woods.

Flannery, Dane

Current Research Interests

Active in two main fields: linear groups (especially computational aspects), and algebraic design theory.

Continuing to expand the new area of computing with infinite matrix groups. This encompasses the development of innovative techniques and implementation of algorithms for the study of solvable-by-finite groups and arithmetic subgroups of linear algebraic groups.

The book *Algebraic design theory* by de Launey and Flannery describes a unifying paradigm for pairwise combinatorial designs, of which Hadamard matrices and their generalisations form a special case. We have established machinery to analyse the regular subgroup structure of the automorphism group of such designs. This forms the basis of effective solutions to existence and classification problems for cocyclic designs.

Publications

Most significant recent publications:

(a) *On linear shift representations*, Journal of Pure and Applied Algebra **219**, 3482âĂŞ3494, 2015 (with R. Egan).

(b) *Classifying cocyclic Butson Hadamard matrices*, Springer Proceedings in Mathematics and Statistics (PROMS): Algebraic Design Theory and Hadamard Matrices, in press, 2015 (with R. Egan and P. Ó Catháin).

(c) *Algorithms for arithmetic groups with the congruence subgroup property*, Journal of Algebra **421**, 234–259, 2015 (with A. S. Detinko and A. Hulpke).

(d) *Integrality and arithmeticity of solvable linear groups*, Journal of Symbolic Computation **68**, 138–145, 2015 (with W. de Graaf and A. S. Detinko).

Research Activities

- Invited speaker at
  - · Groups, Computation and Geometry, June 9–13 2014, Colorado State University, USA;
  - · Algebraic Design Theory and Hadamard Matrices, July 8–11 2014, University of Lethbridge, Canada;
  - · Algorithms for Linear Groups, November 16–21 2014, Banff International Research Station, Canada.
- Organizer, Algebraic Design Theory with Hadamard Matrices: Applications, Current Trends and Future Directions, Banff International Research Station, July 11–13 2014.
- Editor, Journal of the Australian Mathematical Society.
- Irish Research Council New Foundations 2015 grant.
- Supervisor of doctoral student Ronan Egan (Hardiman & Irish Research Council postgraduate scholarships).
- Distinguished visitor: Professor Robert Craigen, University of Manitoba (Algebraic Design Theory).
- 5 papers refereed.
- 2 Mathematical Reviews.

Jennings, Kevin

Current Research Interests

I am interested in difference sets, particularly those with classical parameters. The study of these involves techniques from finite fields, linear algebra, combinatorics and finite groups. Last year I had been working on a problem in linear algebra, to do with enumerating the number of distinct ranks arising in two-dimensional subspaces of $M_n(F)$. More recently I have begun working on a problem in design theory, with a hope to discovering some interesting designs over non-abelian groups.

Research Activities

During 2014 I gave one research seminar at UCD on the distribution of ranks in two-dimensional subspaces of $M_n(F)$. (I also gave a blitz presentation in NUIG at this event last year on the same topic). I made a two day research visit to the University of Ghent in March 2014 to a workshop on finite geometries and to do some maths with a postdoc there whom I know.

Madden, Niall

Current Research Interests

I am interested in the theory and application of numerical methods for solving ordinary and partial differential equations whose solutions feature boundary and interior layers. I am particularly focused on the development of highly efficient algorithms, such sparse-grid methods, and fast linear solvers. I am also interested in the use of modern numerical techniques that accelerate computer models of physical phenomena.

Publications

Most significant recent publications

(a) S. Russell and **N. Madden**. *A multiscale sparse grid finite element method for a two-dimensional singularly perturbed reaction-diffusion problem.* Advances in

Computational Mathematics (to appear). 2015.

(b) S. MacLachlan and **N. Madden**. *Robust solution of singularly perturbed problems using multigrid methods.* SIAM J. Sci. Comput. 35-5 (2013), pp. A2225-A2254

(c) C. Xenophontos, M. Melenk, **N. Madden**, L. Oberbroeckling, P. Panaseti, and A. Zouvani. *hp-Finite Element Methods for Fourth Order Singularly Perturbed Boundary Value Problems.* Dimov, FaragÃş, Vulkov (Eds.): Proc. NAA 2012, Springer Lecture Notes in Computer Science, Vol 8236, pp. 532-539, 2013

(d) C.G. Enright, M.G. Madden, and **N. Madden**. *Bayesian Networks for Mathematical Models: Techniques for Automatic Construction and Efficient Inference.* International Journal of Approximate Reasoning, Vol. 54 (2), 2013, pp 323-342.

Research Activities

In 2014, I worked with James Adler (Tufts) and Scott MacLachlan (Memorial) on developing a novel least-squares finite element method for reaction-diffusion problems that computes numerical solutions to reaction-diffusion problems in a so-called *balanced* norm, using only piecewise linear elements. With Thái Anh Nhan, I worked on a new analysis of Cholesky factorisations that completely explains previously observed phenomena relating to the presence of *subnormal* floating point numbers in factors. Motivated by this, we also produced an analysis of an incomplete Cholesky factorization as a preconditioner. Stephen Russell and I submitted two papers containing analyses of sparse grid techniques for convection-diffusion and reaction-diffusion problems. Preprints of the submitted papers are available at `www.maths.nuigalway.ie/ niall/Research`

In January 2014, I was one of the key note speakers at the annual meeting of the UK & Ireland section of SIAM, held in University College London. I also gave conference talks at the Irish Mathematical Student Association Annual Meeting (Maynooth, March), the 11th workshop on problems with layer phenomena (Novi Sad, March), the 2nd Irish Linear Algebra and Matrix Theory Meeting (UCD, August), and the joint Irish Mechanics Society/ISSEC Symposium (NUIG, December). I gave an invited seminar at TU Dresden in May.

I am currently supervising three Ph.D. students: Thái Anh Nhan, who is due to complete his thesis June, Stephen Russell, who is in Year 3 of his studies, and Faiza Alssaedi, who started in January.

I refereed papers for several international journals during 2014, including Applied Mathematics & Computation, BIT Numerical Mathematics, and Numerical Algorithms, Computational & Applied Mathematics, and the International Journal of Computer Mathematics, as well as reviewing for Zentralblatt

---

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. Other ongoing research concerns continua theory in the context of both a natural associated order (a notion of "betweenness"), and of discrete dynamical systems.

Additionally, my research interests encompass research in undergraduate mathematics education. Specifically, I am interested in the development of and facility with proof and proving in abstract analysis-based mathematical subjects typically taken in mathematics-major degree programmes.

Publications

Numbers of publications appearing in calender year 2014: 2

Most significant publications

(a) A. McCluskey and B. McMaster, "Undergraduate topology: a working textbook", Oxford University Press, 2014.

(b) J. L. Bruno and A. E. McCluskey, "Topologies as points within a Stone space: lattice theory meets topology", Topology Appl. 160 (2) (2013), 273 - 279.

Research Activities

Publications:

Topology - 1 paper published in Applied General Topology in January 2015; 1 paper

submitted to Order; 1 book, co-authored with B. McMaster, published by OUP in July 2014. Mathematics Education - 1 paper submitted to CERME Conference Proceedings.

Events: Book launches at NUI Galway in October 2014 and at QUB in December 2014.

Conferences:
Participant at the 29th Summer Conference in Topology and its Applications at CUNY, Staten Island in July 2014.
Host of 18th Galway Topology Colloquium at NUI Galway in June 2015.
Host of the international 30th Summer Conference in Topology and Its Applications at NUI Galway in June 2015.
International Steering Committee of DELTA 2015

Research funding: 10,000 euros awarded by SFI Conferences and Workshops programme; 2100 euros from FÃąilte Ireland; 300 euros from IMS; 0 euros from IRC New Foundations.

Research visit to University of Loughborough in December 2014 as a part of international Mathematics Education project.

Graduate students: 3; 3 IRC postgraduate applications in process.

Government of Ireland Postdoctoral application in process.

Reviewer of papers submitted to Topology and its Applications and International Journal of Research in Undergraduate Mathematics Education.

Mc Gettrick, Michael

Current Research Interests

My main interests are in quantum information / quantum computation. More specifically I construct and analyze models in quantum random walks and quantum game theory.

Publications

Most significant recent publications

(a) "Quantum walks with memory on cycles", Mc Gettrick, M., Miszczak, J.A., **Physica A** Volume 399, 1 April 2014, Pages 163âĂŞ170

(b) "Quantum Walks on Two Kinds of Two-Dimensional Models", Li, D., Mc Gettrick, M., Zhang, W.W., Zhang, K.J., **International Journal of Theoretical Physics** 01/2015

Research Activities

I had a visiting PhD student (Dan Li, Beijing University of Posts and Telegraphs) from 9/2013 to 9/2014. In July 2014 I participated in the conference "New Frontiers of Quantum Information Theory" in Ascoli Piceno (Italy). In September 2014, Dihua Zhang finished his masters thesis on "Multiplayer Quantum Prisoner's Dilemma Game on Cycles" under my supervision (joint with Colm O'Riordan). In January 2015 I completed an invited review of a grant proposal on "Quantum Information processing with severely limited memory and communication" for the National Science Center, Poland. I am joint organizer of a special session on "Computer Algebra in quantum computing and quantum information theory" to be held at the 21st. International Conference on Applications of Computer Algebra 2015 (ACA2015).

Meere, Martin

Current Research Interests

Mathematical modelling of nanoparticle uptake and cytotoxicity. Analysis of reaction diffusion models describing drug release from affinity hydrogels. Modelling drug release from novel drug eluting stents. Modelling drug transport in nanoporous solids.

Recent Publications

[1] Sean McGinty, Tuoi T.N. Vo, Martin Meere, Sean McKee & Christopher McCormick, Some design considerations for polymer-free drug-eluting stents: a mathematical approach, *Acta Biomaterialia*, doi:10.1016/j.actbio.2015.02.006 (2015)

[2] Tuoi T.N. Vo & M.G. Meere, A mathematical model for the release of peptide-binding

drugs from affinity hydrogels, *Cellular and Molecular Bioengineering*, doi:10.1007/s12195-014-0375-2 (2015)

[3] Kevin Doherty, Martin Meere & Petri T. Piiroinen, Some Mathematical Models of Intermolecular Autophosphorylation, *Journal Of Theoretical Biology*, doi:10.1016/j.jtbi.2015.01.015 (2015)

[4] Tuoi T.N. Vo & M.G. Meere, The mathematical modelling of affinity-based drug delivery systems, *Journal of Coupled Systems and Multiscale Dynamics*, in press (2015)

Research Activities

Postgraduate students: One PhD student, Mr Paul Greaney.

Research visit: One week at the Department of Mathematics & Statistics, University of Strathclyde, April 2014

Invited talk at the *18th European Conference on Mathematics for Industry - ECMI 2014*, Taormina, Sicily, June 2014

Invited talk at the workshop *Optimal Coronary Stent Design and the Role of Modelling*, University of Limerick, June 2014

Invited talk at the conference *WCCM-ECCM-ECFD2014*, Barcelona, Spain, July 2014

Newell, John

Publications

Most significant recent publications

(a) O'Shea, E,Devane, D,Cooney, A,Casey, D,Jordan, F,Hunter, A,Murphy, E,Newell, J,Connolly, S,Murphy, K (2014) 'The impact of reminiscence on the quality of life of residents with dementia in long-stay care'. International Journal Of Geriatric Psychiatry, 29 :1062-1070.

(b) Glynn, LG,Hayes, PS,Casey, M,Glynn, F,Alvarez-Iglesias, A,Newell, J,OLaighin, G,Heaney, D,O'Donnell, M,Murphy, AW (2014) 'Effectiveness of a smartphone application to promote physical activity in primary care: the SMART MOVE randomised controlled trial'. British Journal Of General Practice, 64 :384-391

(c) Casey D, Murphy K, Devane D, Cooney A, McCarthy B, Mee L, Newell J, et al (2014). The effectiveness of a structured education pulmonary rehabilitation programme for improving the health status of people with moderate and severe chronic obstructive pulmonary disease in primary care: the PRINCE cluster randomised trial. Thorax, 1-7. doi:10.1136/thoraxjnl-2012-203103

(d) Counihan, TJ,Duignan, JA,Gormley, G,Saidha, S,Dooley, C,Newell, J (2014) 'Does long-term partial sodium channel blockade alter disease progression in MS? Evidence from a retrospective study'. Irish Journal Of Medical Science, 183 :117-121.

Research Activities

- Current research grants: 1 (Co-PI), 9 (Co-Applicant)
- Numbers of graduate students: 3, 2 joint supervision in School of Medicine
- Journal submissions: 14 publications in 2014
- Conferences: Presented at 35th Annual Conference of the International Society for Clinical Biostatistics, Vienna 2014.
- Conferences: Presented at 34th Conference on Applied Statistics in Ireland, Templepatrick 2013.
- Memberships: Member of Irish Statistical Association and International Society for Clinical Biostatistics
- External post: Adjunct Senior Research Fellow, Department of Mathematics and Statistics,University of Canterbury,Christchurch New Zealand

---

Park, Sejong

Current Research Interests

Representation theory of finite groups and associated algebras and categories, fusion systems, biset functors, double Burnside rings

Publications

Most significant recent publications:

(a) *Mackey functors and sharpness for fusion systems*, to appear in Homology, Homotopy Appl. (joint work with A. Díaz)

(b) *Counting conjugacy classes of cyclic subgroups for fusion systems*, J. Group Theory **17** (2014), 661–666

(c) *Tate's and Yoshida's theorems for control of transfer for fusion systems*, J. London Math. Soc. **84** (2011), 475–494 (joint work with A. DÃŋaz, A. Glesser, and R. Stancu)

(d) *Minimal characteristic bisets and finite groups realizing Ruiz–Viruel exotic fusion systems*, J. Algebra **336** (2011), 349–369

Research Activities

Grant application: Ulysses Program (accepted for 15 Apr 2015 – 14 Apr 2016; NUI Galway team: Sejong Park (project leader), Götz Pfeiffer, Brendan Masterson; Université de Picardie team: Radu Stancu (project leader), Serge Bouc, Maxime Ducellier, Mulla Aktham) *Talks:* 2 invited talks in international conferences, 3 seminar talks *Papers refereed:* 3 papers refereed for Journal of Algebra and Journal of Pure and Applied Algebra

---

Pfeiffer, Kirsten

Current Research Interests

Publications

Most significant recent publications

(a) Mac an Bhaird, C., Nolan B., OShea A., Pfeiffer K. (2014) An analysis of the opportunities for creative reasoning in undergraduate calculus courses. Proceedings of Science and Mathematics Education Conference 2014 (SMEC), Dublin.

(b) Pfeiffer, K. and Quinlan R. (2015) Proof-Evaluation as a Step towards Proof Authorship. In: MAA Notes. Volume 'Beyond Lecture: Techniques to Improve Student Proof-Writing Across the Curriculum'.

(c) Pfeiffer, K. and Quinlan R. Proof evaluation tasks as tools for teaching? Proceedings of the Ninth Congress of the European Society for Research in Mathematics Education (CERME 9). February 4th - 8st 2015, Prague (Czech Republic)

Research Activities

- Co-leader in thematic working group "Argumentation and proof" at the 9th Congress of European Research in Mathematics Education (CERME 9) in Prague,
- Post-doc researcher in a joined project ("An analysis of the opportunities for creative reasoning in undergraduate Calculus courses") funded by *3U NStep*

Pfeiffer, Götz

Current Research Interests

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

Publications

Number of publications appearing in calendar year 2014: 1

Four significant publications

(a) (with J. Matthew Douglass and Gerhard Röhrle)
Cohomology of Coxeter Arrangements and Solomon's Descent Algebra.
Trans. Amer. Math. Soc. **366** (2014), no. 10, 5379–5407.

(b) (with J. Matthew Douglass and Gerhard Röhrle)
On Reflection Subgroups of Finite Coxeter Groups.
Comm. Algebra **41** (2013), no. 7, 2574–2592.

(c) (with Liam Naughton)
Integer Sequences Realized by the Subgroup Pattern of the Symmetric Group.
J. Integer Seq. **16** (2013), no. 5, Article 13.5.8, 23 pages.

(d) (with Marcus Bishop)
On the Quiver Presentation of the Descent Algebra of the Symmetric Group.
J. Algebra **383** (2013), 212–231.

Research Activities

Numbers of graduate students: 1; Journal submissions: 2; Conferences: 3; Invited talks: 2; Research visits: 3; Papers refereed: 8; Math reviews: 5; Editorships: Mathematical Proceeedings of the Royal Irish Academy; Memberships: Irish Mathematical Society (Treasurer), 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, evolving networks, economics, psychology and biological systems. 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

Most significant publications

- Bernard Brogliato, Luciano Lopez, Petri T. Piiroinen, and Tassilo Küpper, *Special Issue Editorial: Discontinuous dynamical systems: Theory and numerical methods*, Mathematics and Computers in Simulation 1, 2014.
- Doherty, K., Meere, M. and Piiroinen, P.T., *Some Mathematical Models of Intermolecular Autophosphorylation*, Journal of Theoretical Biology 370, pp. 27–38, April 2015.
  (DOI: 10.1016/j.jtbi.2015.01.015)
- Donohue, J.G. and Piiroinen, P.T., *Mathematical modelling of seasonal migration with applications to climate change*, Ecological Modelling 299, pp. 79–94, March 2015.
  (DOI: 10.1016/j.ecolmodel.2014.12.003)

Research Activities

During 2014 I supervised 3 PhD students and 1 MSc student. I gave 4 talks at conferences and workshops.

Quinlan, Rachel

Current Research Interests

My research interests are primarily in the area of linear algebra and its interactions with other areas of algebra such as field theory and representation theory. I also have research interests in mathematical education at university level, especially in the teaching and learning of proof and proving.

Publications

Number of publications appearing in calendar year 2013: 2 Most significant recent publications

(a) James McTigue and Rachel Quinlan, *Partial matrices of constant rank*, Linear Algebra and its Applications, Vol. 446, 177–191 (2014)

(b) J. Cruickshank, A. Herman, R. Quinlan and F. Szechtman, *Unitary groups over local rings*, Journal of Algebra and its Applications, Vol. 13 (2014)

(c) James McTigue and Rachel Quinlan, *Partial matrices whose completions all have the same rank*, Linear Algebra and its Applications, Vol 438, no. 1, pages 348–360 (2013)

(d) Kirsten Pfeiffer and Rachel Quinlan, *Proof evaluation tasks as tools for teaching?*, Proceedings of CERME 9 (2015)

Research Activities

I am currently supervising the research of two PhD students: Olga O'Mahony and Ha Van Hieu. I was also the supervisor of James McTigue, who successfully defended his thesis on completions of partial matrices in 2015. In the past year I have given invited talks at the 19th International Linear Algebra Society Conference in Seoul (August 2014) and in the UCD Algebra Seminar (April 2015), as well as a contributed talk at the 9th Congress on European Research in Mathematics Education (February 2015). I have worked as a referee for *Linear and Multilinear Algebra*, *Linear Algebra and its Applciations* and *Transactions of the American Mathematical Society*, and as a reviewer

for *Mathematical Reviews*. I am a member of the Irish Mathematical Society (of which I am secretary), the American Mathematical Society and the International Linear Algebra Society.

Rahm, Alexander D.

Current Research Interests

Algebra, Geometry & Topology, e.g. homology of arithmetic groups, isometries of hyperbolic space.

Publications

Most significant recent publications:

(a) Alexander D. Rahm and Matthias Wendt, *A refinement of a conjecture of Quillen*. Comptes Rendus Mathématique (2015)

(b) Alexander D. Rahm, *Complexifiable characteristic classes*. Journal of Homotopy and Related Structures (2014)

(c) Alexander D. Rahm, *Accessing the cohomology of discrete groups above their virtual cohomological dimension*. Journal Of Algebra (2014)

(d) Alexander D. Rahm, *The homological torsion of PSL_2 of the imaginary quadratic integers*. Transactions of the American Mathematical Society (2013)

Research Activities

Grants: ICHEC grant of 900,000 processor hours (value: 30,000 Euro); IHÉS grant for one-month funded research stay; MFO grant for two-weeks funded research collaboration stay at Oberwolfach, joint with Rob de Jeu, Herbert Gangl and Dan Yasaki. *PhD student:* Daher Al-Baydli (jointly supervised with Emil Skoldberg); *Master student:* Katherine Wilkie. *Papers in progress:* Manuscripts with Matthias Wendt, resp. Ethan Berkove submitted to journals; preprint with Rob de Jeu; preprint on orbifolds which is under completion joint with Fabio Perroni. *Talks:* 3 international conference/workshop contributions in 2014 (3 confirmed so far in 2015), 2 invited seminar talks in 2014 (3 confirmed so far in 2015). *Papers refereed* for Mathematische Annalen, Journal fÃijr die reine und angewandte Mathematik (Crelle's Journal), Journal of Pure and Applied Algebra (JPAA), Homology, Homotopy and Applications (HHA), Discrete & Computational Geometry. Editorial board member of *Research Matters*, NUI Galway. Member of IMS, EMS, SMF and DMV.

Seoighe, Cathal

Research interests in several areas of bioinformatics/computational biology: Genomics and epigenetics, including gene expression deconvolution, mRNA splicing and analysis of chromatin structure using high throughput sequencing data. 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 high throughput sequencing technologies. These technologies can be used to sequence genomes or for studying gene expression or the binding of proteins to DNA.

Current Research Interests

The focus of my research is on modeling molecular biological data, including epigenetic data, gene expression, alternative mRNA splicing and molecular evolution, including the evolution of viruses such as HIV-1.

Publications

Six journal articles appeared in 2013.

Most significant publications

(a) Population genetics inference for longitudinally-sampled mutants under strong selection. Lacerda M, Seoighe C. Genetics. 2014 Nov;198(3):1237-50.

(b) Promiscuous mRNA splicing under the control of AIRE in medullary thymic epithelial cells. Keane P, Ceredig R, Seoighe C. Bioinformatics. 2015 Apr 1;31(7):986-9

(c) The shared genomic architecture of human nucleolar organizer regions. Floutsakou I, Agrawal S, Nguyen TT, Seoighe C, Ganley AR, McStay B. Genome Res. 2013 Dec;23(12):2003-12.

(d) CellMix: a comprehensive toolbox for gene expression deconvolution. Gaujoux R, Seoighe C. Bioinformatics. 2013 Sep 1;29(17):2211-2.

Research Activities

My research group consisted of six PhD students in 2014. Research is supported by the IRC, through a graduate education programme in collaboration with UCD, as well as an individual PhD bursary; PRTLI, through a graduate programme in simulation science and the EU, through an international training network coordinated by Leeds University. Academic community service included memberships of editorial boards of Bioinformatics and Briefings in Bioinformatics, review of grants for the Natural Sciences and Engineering Research Council of Canada and the South African National Research Foundation and refereeing for a range of journals.

Sheahan, Jerome

Current Research Interests

Publications

Most significant recent publication: one book (3 co-authors).

Research Activities

Tuite, Michael

Current Research Interests

Vertex operator algebras (VOAs), Riemann surfaces, elliptic and modular functions in number theory and combinatorics. I am particularly interested in computing partition and correlation functions on higher genus Riemann surfaces for various VOAs. I am also interested in exceptional VOAs and their relationship to Virasoro constraints.

Publications

2 publications in calendar year 2014 and three other papers in press.

(a) G. Mason and M.P. Tuite, Free bosonic vertex operator algebras on genus two Riemann surfaces II. "Conformal Field Theory, Automorphic Forms and Related Topics", Contributions in Mathematical and Computational Sciences **8** 183–225, (Springer Verlag), (2014).

(b) M.P. Tuite and Hoang Dinh Van, On exceptional vertex operator (super) algebras, "Developments and Retrospectives in Lie Theory", Developments in Mathematics Volume **38** 351–384 (Springer Verlag) (2014).

Research Activities

- I currently hold one SFI RFP grant.
- Supervising 1 MSc student since Sept 2014.
- I refereed 4 papers.
- Invited speaker Irish Quantum Foundations Meeting, TCD, May 2014.
- Invited speaker at Groups in Galway 2014.

Zurlo, Giuseppe

Current Research Interests

I am deeply interested in those phenomena that can be modeled by Continuum Mechanics and Thermodynamics. My research is focused on the modeling of material behavior at the intersection of Continuum Mechanics with Biology, Medicine and Electromagnetism. More in detail, I work on growth in biological materials, on the mechanical behavior of cell membranes, on the modelling of damage and healing phenomena in rubber materials, on the theory of finite elasticity with a specific focus on the mechanics of thin bodies, on the electromechanics of highly deformable materials.

Publications

Most significant recent publications

(a) De Tommasi D., Puglisi G., Zurlo G., Failure modes in electroactive polymer thin films with elastic electrodes, J. Phys. D: Appl. Phys. 47 065502 (13pp) (2014)

(b) De Tommasi D., Puglisi G., Zurlo G., Hysteresis in electroactive polymers, Europ. J. Mechanics A/Solids 48, 16–22 (2014)

(c) Colonnelli S., Saccomandi G., Zurlo G., Damage induced dissipation in electroactive polymer harvesters, Applied Physics Letters 105, 163904 (2014)

Research Activities

(a) co-supervisor (with Dr Martin Meere) of 1 PhD thesis (student: Paul Greaney)

(b) invited talk at the School of Mathematics, Statistics and Applied Mathematics, March 6, 2014

(c) invited talk at the *Mechanics in Biology* workshop at Gran Sasso Science Institute, May 6-9, 2014

(d) invited talk at the *Jean Mandel seminar* in the Ecole Polytechnique, June 12, 2014

(e) invited talk at the *University of Glasgow*, October 16, 2014

(f) 5 journal submissions

(g) over 10 research visits in Ecole Polytechnique and Institut Curie (Paris), Università di Perugia, Politecnico di Bari.

(h) reviewer for various scientific journals (Proceedings of the Royal Society A, Journal of Elasticity, Journal of Physics D,...)

(i) member of the Italian group of Mathematical Physics (GNFM)

Visitors

Professor Robert Craigen

Dates of visit: August–October 2014.

Research Interests

Worked with D. Flannery on projects in Algebraic Design Theory, dealing with generalized Hadamard matrices, and ambient rings for pairwise cocyclic designs.

Professor Aodhan de Bruen

Dates of visit: November 6–7 2014.

Research Interests

Gave a School seminar on results bounding the number of bases in a given spanning set of a finite dimensional vector space.

Ciarletta, Pasquale

Dates of visit: 04-07 August 2014 Dr Ciarletta is a Chargé de Recherche in Mechanics, based at the Institut d'Alembert, Université Pierre et Marie Curie-Paris 6. He visited Professor Michel Destrade and Mr Artur Gower to work on the mechanics of growth.

Research Interests

A totally new approach to the modelling of residual stresses existing in biological soft tissues is being elaborated.

Vergori, Luigi

Dates of visit: 01-05 December 2014 Dr Vergori is Lecturer in Applied Mathematics at the University of Glasgow. He visited Professor Michel Destrade to work on mechanical instability of soft matter.

Research Interests

A complete treatment of the problem of wrinkling under torsional shear is proposed.

Ogden, Ray

Dates of visit: 01-10 December 2014 Professor Ogden FRS is the George Sinclair Chair of Applied Mathematics at the University of Glasgow. He visited Professor Michel Destrade to work on the modelling of seismic waves.

Research Interests

A complete treatment of the problem of surface wave propagation under gravity is proposed.

Li, Dan

Dates of visit: September 2013 - September 2014

Research Interests

Adler, James

Dates of visit: May 10–18.

Research Interests

James is based at Tufts University, MA. His visit was funded by the Simulation Science Programme at UCD, and combined delivery of several classes and labs at the `http://www.maths.nuigalway.ie/~niall/MA519/workshop`, Graduate Workshop on Numerical Linear Algebra, 12-14 May, and working with Niall Madden on research problems in finite element analysis.

Postgraduate Students

Student	**Degree**	**Supervisor**	**Supervisor**
Daher Al-Baydli	PhD	Emil Sköldberg	Alexander Rahm
Faiza Alssaedi	PhD	Niall Madden	
Daren Anderson	PhD	Aisling McCluskey	
Nhan Anh Thai	PhD	Niall Madden	
Bui Anh Tuan	PhD	Graham Ellis	
Alan Barnicle	PhD	Cathal Seoighe	Laurence Egan
Sofia Barreira	PhD	Cathal Seoighe	Brian McStay
Isaac Burke	PhD	Emil Sköldberg	
Richard Burke	PhD	Petri Piiroinen	
Shane Burns	PhD	Petri Piiroinen	
Simone Coughlan	PhD	Tim Downing	Cathal Seoighe
John Donohue	PhD	Petri Piiroinen	
Liam Doonan	PhD	Uri Frank	Cathal Seoighe
Michelle Duane	MSc	Aisling McCluskey	
Ronan Egan	PhD	Dane Flannery	
Lida Fallah	PhD	Haixuan Yang	John Hinde
Artur Gower	PhD	Michel Destrade	
Paul Greaney	PhD	Martin Meere	
Ha Van Hieu	PhD	Rachel Quinlan	
Amirhossein Jalali	PhD	John Newell	John Hinde
Olga Kalinina	PhD	Emma Holian	John Newell
Peter Keane	PhD	Cathal Seoighe	Rod Ceredig
Dan Li	PhD (visiting)	Michael McGettrick	
Adib Makrooni	PhD	John Burns	
Barbara Martinelli	PhD	Cathal Seoighe	
Brendan Masterson	PhD	Götz Pfeiffer	
James McTigue	PhD	Rachel Quinlan	
Shirin Moghaddam	PhD	John Hinde	Milovan Krnjajic
Olga O'Mahony	PhD	Rachel Quinlan	
Thanh Ngoc Nguyen	PhD	Cathal Seoighe	
Davood Roshan	PhD	John Newell	
Stephen Russell	PhD	Niall Madden	
Qays Shakir	PhD	Aisling McCluskey	
Eoghan Staunton	MSc	Petri Piiroinen	
Philip Vernon	MSc	Michael Tuite	
Yaxuan Yu	PhD	Cathal Seoighe	

Seminars

(a) Neil Dobbs, University of Helsinki. **Typical behaviour in one-dimensional dynamical systems**, 09/01/2014. (Contact: Petri Piiroinen)

(b) David Malone, NUI Maynooth. **Guessing and Passwords**, 16/01/2014. (Contact: Niall Madden)

(c) Marcelo Forets, Université Joseph Fourier (Grenoble). **The Cauchy problem for the continuous limit of Quantum Walks**, 27/02/2014. (Contact: Michael Mc Gettrick)

(d) Giuseppe Zurlo, NUIG. **The Mechanical Modelling of Cell Membranes**, 06/03/2014. (Contact: Michael Mc Gettrick)

(e) Nina Snigereva, University College Dublin. **Dynamics of Lorenz maps**, 13/03/2014. (Contact: Göz Pfeiffer)

(f) Tom Weber, NUI Maynooth. **Quantifying the length and variance of the eukaryotic cell cycle phases by a stochastic model and dual nucleoside pulse labelling**, 20/03/2014. (Contact: Cathal Seoighe)

(g) Stephen Power, Lancaster university. **The Rigidity of Infinite Graphs and Crystals**, 27/03/2014. (Contact: James Cruickshank)

(h) Norbert Hoffmann, Mary Immaculate College (University of Limerick). **Rational families of instanton bundles on P^{2n+1}**, 03/04/2014. (Contact: Götz Pfeiffer)

(i) John Murray, NUI, Maynooth. **Symplectic Modules and Induction**, 10/04/2014. (Contact: Rachel Quinlan)

(j) Robert Osburn, University College Dublin. **The mock modularity of q-hypergeometric series**, 08/05/2014. (Contact: Rachel Quinlan)

(k) Jeremie Guilhot, Universite Francois Rabelais de Tours. **Cellularity of the lowest two-sided ideal of an affine Hecke algebra**, 22/05/2014. (Contact: Götz Pfeiffer)

(l) Brien Nolan, Dublin City University. **Can group-work work? Notes on group-work tutorials in a large service teaching module?**, 11/06/2014. (Contact: Kirsten Pfeiffer)

(m) Rob Craigen, University of Manitoba. **Structure and Permutation Symmetry of Matrices**, 11/09/2014. (Contact: Dane Flannery)

(n) Catherine Hurley, NUI Maynooth. **Improving data visualisations with dendrogram seriations**, 18/09/2014. (Contact: John Hinde)

(o) Doug Wiens, University of Alberta. **Robustness of Design: A Survey**, 02/10/2014. (Contact: Jerome Sheahan)

(p) Graham Ellis, NUIG. **Pictures from Austria**, 09/10/2014. (Contact: Sejong Park)

(q) Paul Bankston, Marquette University. **A betweenness perspective on dendrons and their kin**, 16/10/2014. (Contact: Aisling McCluskey)

(r) Aodhan de Bruen, Carleton University. **The basics of bases**, 06/11/2014. (Contact: Dane Flannery)

(s) Alexander Rahm, NUIG. **Cryptosystems made in Galway - closing a gap in internet security?**, 13/11/2014. (Contact: Emil Skoeldberg)

(t) Antonio Díaz, Universidad de Málaga. **The cohomology of J_2 at p=3**, 20/11/2014. (Contact: Sejong Park)

(u) Nghia Thi Hieu Tran, Ho Chi Minh City. **The Artinianess of graded generalized local cohomology modules**, 27/11/2014. (Contact: Alexander Rahm)

(v) Ethan Berkove, Lafayette College. **The colored cubes puzzle: a tribute to Percy MacMahon**, 08/12/2014. (Contact: Alexander Rahm)

(w) Cliff Gilmore, University of Helsinki. **Commutator Maps and Chaos**, 17/12/2014. (Contact: Ray Ryan)

Specialist seminar series

Conferences and Workshops

Conference: The 12th annual Irish Geometry Conference Organiser: John Burns, James Cruickshank Dates: 9–10 May

Conference: Groups in Galway 2014 Organisers: Sejong Park and Alexander D. Rahm Dates: 23–24 May 2014

Conference: First QuanTI workshop on quantitative immunology Organiser: Cathal Seoighe Dates: 23–25 June 2014

Conference: Stokes Modelling Workshop Organiser: Shane Burns Dates: 23–26 June 2014

Conference: 7th de Brún Workshop on Homological Perturbation Theory Organiser: Graham Ellis Dates: 1–5 December 2014

Conference: ISSEC – Irish Society for Scientific Engineering and Computation Organiser: Michel Destrade, Giuseppe Zurlo, Artur Gower Dates: 8–9 December 2014

Conference: Irish Applied Mathematics Research Students Meeting Organiser: Stephen Russell, Richard Burke, Shane Burns, Niall Madden, John Donohue, Artur Gower, Paul Greaney, Eoghan Staunton, Thai Anh Nhan Date: 11 December 2014