IMS Annual Scientific Meeting 2025
Maynooth University
28 – 29 AUGUST, 2025

The 38th *Annual Scientific Meeting of the Irish Mathematical Society* took place at Maynooth University on Thursday 28$^{\text{th}}$ and Friday 29$^{\text{th}}$ August 2025 in the Rye Hall Lecture Theatre. The local organising team in 2025 consisted of Stephen Buckley, Galatia Cleanthous, Christian Ketterer, and Ollie Mason.

We would like to gratefully acknowledge the financial support received from the Irish Mathematical Society, the Department of Mathematics and Statistics at Maynooth University, as well as the sponsorship of the UKIE section of SIAM for the poster competition.

The meeting had a mixture of 45 minute talks given by invited speakers, shorter contributed talks, and a poster session. The nine invited talks covered a diverse range of topics across pure and applied mathematics, statistics, and mathematics education. Details on the titles and speakers for these are given below.

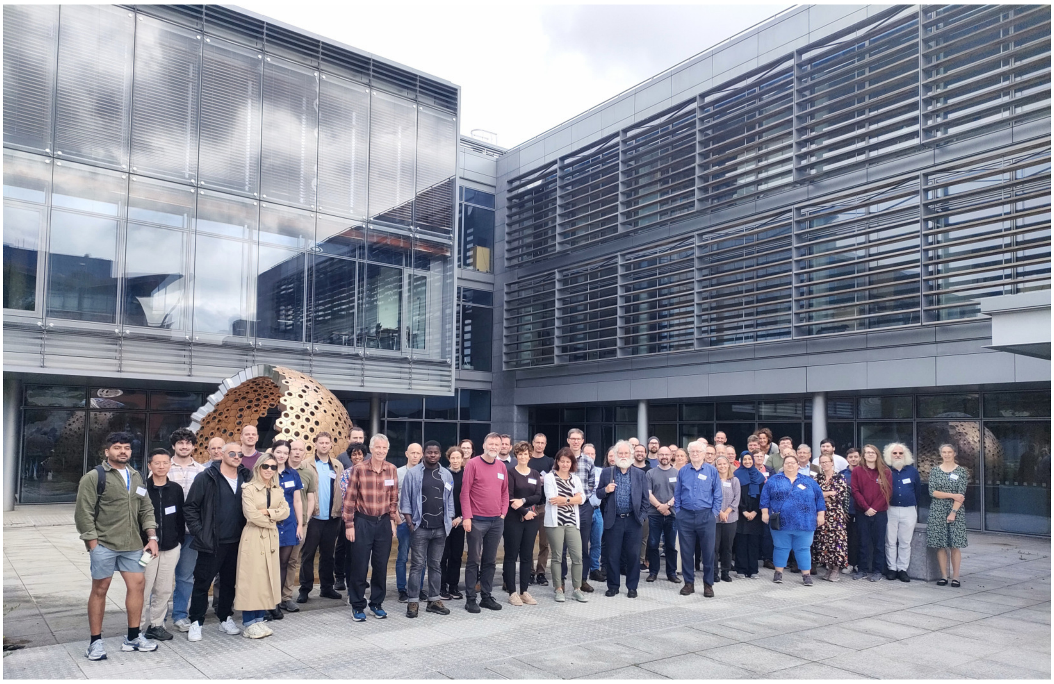
- David Barnes (Queen's University Belfast):
  Global dimension of incomplete Mackey Functors and incidence algebras.
- Niamh Cahill (Maynooth University):
  A Bayesian hierarchical spatio-temporal model for extreme sea-level prediction in Ireland.
- Stephen Coombes (University of Nottingham):
  Mathematical Neuroscience: Large-scale brain modelling.
- Aoife Hennessy (South East Technological University):
  A Riordan array framework for enumerating and transforming lattice paths.
- Elise Lockwood (Oregon State University):
  Integrating Computing into Mathematics Education: A Case of Python Programming in Combinatorial Contexts.
- Götz Pfeiffer (University of Galway):
  Reflection Groups in the Light of Formal Concept Analysis.
- Melanie Rupflin (University of Oxford):
  Quantitative estimates for geometric variational problems: Does almost solving a problem almost give you a solution?
- Ian Short (Open University):
  Integer tilings and hypertilings.
- Stephen Wills (University College Cork):
  Construction of quantum Markov processes.

The Society's AGM was held during the lunch break on the 29$^{\text{th}}$ of August. There was also a conference dinner for participants held on the previous evening at a restaurant in Maynooth.

In addition to the invited talks, there were five shorter, 25-minute contributed talks, covering topics in algebra, dynamical systems, and the history of mathematics. The list of shorter contributed talks is given below.

- Mariam Al-Hawaj (Trinity College Dublin):
  Generalized pseudo-Anosov maps and Hubbard trees.
- Anton Baykalov (University of Galway):
  Computing zeta functions of groups and algebras.
- Patrick Browne (Technological University of the Shannon)
  Chord Diagrams and Weight systems.
- Ted Hurley (University of Galway):
  Units and zero-divisors: Building blocks for required communications' systems.

- Siobhán McGarry and Ciarán Mac an Bhaird (Maynooth University):
  Euclid's Elements as Gaeilge – Beginnings.



Nearly all of the participants at IMS2025 pictured outside the Iontas building at Maynooth University.

There was also a poster session which ran during coffee breaks on the 28th and 29th of August. During these breaks, participants had an opportunity to mingle and discuss the posters with their presenters. The UKIE Section of SIAM sponsored a prize of €100 for the best poster, which was awarded to Michael Joyce Maher (University of Galway). The poster titles and their presenters are listed below.

- David Cormican (University of Galway):
  Ask Zeta Functions of Unitary Lie Algebras.
- Conor Curtin (Technological University Dublin):
  Hamiltonian & Lagrangian Models for Waves and Currents.
- Joseph Dillon:
  Properties of the square of the modulus of the xi function along the real line.
- Niamh Fennelly (University College Dublin):
  Synaptic Plasticity and Spatial Patterning in the Next-Generation Neural Field Model.
- Ramen Ghosh (Atlantic Technological University):
  Learning Criticality: Statistical Limits of Predicting Phase Transitions in Random Networks.
- Maniru Ibrahim (University of Limerick):
  Modeling Drug Release from Drug-Eluting Devices with Finite Dissolution Rates.
- Michael Joyce Maher (University of Galway):
  Odd inversion sets and their associated Turán graphs.
- David Malone (Maynooth University):
  Pollard's Rho Method.
- Brian Skelly (University College Dublin):
  A biophysical model of AMPA receptor Dynamics.

Generalized pseudo-Anosov maps and Hubbard trees

Mariam Al-Hawaj
Trinity College Dublin

In this talk, I will present a result from my PhD thesis where I develop a new connection between the dynamics of quadratic polynomials on the complex plane and the dynamics of homeomorphisms of surfaces. In particular, given a quadratic polynomial, we show that one can construct an extension of it which is a generalized pseudo-Anosov homeomorphism. Generalized pseudo-Anosov means the foliations have infinite singularities that accumulate on finitely many points. We determine for which quadratic polynomials such an extension exists. My construction is related to the dynamics on the Hubbard tree, which is a forward invariant subset of the filled Julia set that contains the critical orbit.

Computing zeta functions of groups and algebras

Anton Baykalov
University of Galway

In this talk, I will report on ongoing work on explicit computations of zeta functions associated with various types of counting problems attached to groups, algebras, and related algebraic structures. The goal of this project is to combine systematic methods (which can be very computationally involved and limited in scope) and ad hoc approaches driven by human insight intuition.

Global dimension of incomplete Mackey Functors and incidence algebras

David Barnes
Queen's University Belfast

The representation ring R(G) of a finite group G encodes rich structural information about G. To gain deeper insight, one can consider the collection R(H) for each subgroup H of G, along with the natural operations of restriction and induction between them. This leads to the framework of Mackey functors, with further examples such as the Burnside Mackey functor (based on finite H-sets) and the stable equivariant homotopy groups of a topological space with a continuous G-action.

Recent developments in equivariant stable homotopy theory have motivated a generalisation: incomplete Mackey functors, where only a subset of the induction maps is available. These arise naturally in computations and constructions within the field, making it important to understand the algebraic complexity of their categories. One such measure is global dimension, a generalisation of the notion of global dimension for rings, where dimension 0 corresponds to semi-simple rings and dimension 1 to hereditary rings.

In this talk, I will present a somewhat unexpected connection between this modern question (in the case of rational coefficients) and classical work from the 1990s on incidence algebras of partially ordered sets. These algebras, a type of path (or quiver) algebra that received significant attention in the 1970s and 1980s, have well-understood global dimensions. This connection provides insight on the algebraic complexity of categories of rational incomplete Mackey functors.

Chord Diagrams and Weight systems

Patrick Browne

Technological University of the Shannon

In this talk, we explore weight systems in knot theory, i.e. linear functionals on chord diagrams. Chord diagrams, while motivated by singular knots, can be viewed as purely combinatorial objects with rich mathematical structure. The significance of weight systems stems from the fundamental result that every Vassiliev knot invariant determines and is determined by a weight system. Moreover, Lie algebras provide a powerful framework for constructing these weight systems.

This presentation will introduce the connection between chord diagrams, weight systems, and Lie theory. We'll explore this interplay as preliminary research that may reveal new insights into both knot theory and combinatorial structures. The talk will be accessible to those without specialized background in knot theory or Lie algebras, focusing on the connections between these objects.

A Bayesian hierarchical spatio-temporal model for extreme sea-level prediction in Ireland

Niamh Cahill

Maynooth University

Rising sea levels increase the risk of flooding, coastal erosion, and extreme sea-level events. Coastal communities in Ireland are particularly vulnerable due to a combination of long, varied shorelines, low-lying urban areas, and exposure to both Atlantic storm systems and surges propagating from the Irish Sea. Accurate risk assessment depends on understanding the drivers of extreme sea levels, especially storm surges. A Bayesian hierarchical spatio-temporal model is developed to estimate extreme sea-level surges at both gauged and ungauged locations, drawing on tide-gauge records from Ireland and the west coast of Great Britain in the Global Extreme Sea Level Analysis (GESLA) database. Data from Great Britain are incorporated to compensate for the relatively short record lengths at most Irish tide gauges. Annual maxima of sea-level surges are modelled using the Generalised Extreme Value (GEV) distribution, incorporating both spatial and temporal dependencies. A barrier model captures complex spatial correlations along irregular coastlines.

Model evaluation shows that combining spatial and temporal components improves predictive skill. This is particularly valuable for Ireland, where short records limit site-specific analysis; the model's ability to share information across locations enhances estimates for data-sparse areas. The analysis reveals key patterns in extreme sea-level variability and detects an upward trend in surge annual maxima, with the east coast emerging as a higher-risk region. By explicitly integrating spatio-temporal dependencies, the framework offers a flexible, data-driven approach to representing extreme sea-level behaviour, supporting risk management and coastal planning in Ireland and similar coastal settings.

Mathematical Neuroscience: Large-scale brain modelling

Stephen Coombes

University of Nottingham

Neural mass models have been actively used since the 1970s to model the coarse-grained activity of large populations of neurons and synapses. They have proven especially fruitful for understanding brain rhythms. Although inspired by neurobiological principles, these models are largely phenomenological and often fall short of reproducing the complex dynamical repertoire observed in real neural tissue. In this talk I will discuss a simple integrate-and-fire spiking neuron network model that has recently been shown to admit to an exact mean-field description for synaptic interactions. This has many of the features of a neural mass model coupled to an additional dynamical equation that describes the evolution of population synchrony. I will show that this next generation neural mass model is ideally suited to understanding the patterns of brain activity that are ubiquitously seen in whole brain non-invasive neuroimaging recordings. Additionally, I will outline key mathematical challenges in linking structural and functional brain connectivity and discuss how phase-amplitude reduction techniques may provide a path forward. Time permitting, I will also describe the Haken model – a spiking network that can be analysed without mean-field approximations – highlighting its relevance in the era of high-resolution neural recordings from hundreds to thousands of simultaneously monitored neurons.

A Riordan array framework for enumerating and transforming lattice paths

Aoife Hennessy
South East Technological University

This talk explores how Riordan arrays can be used to enumerate and transform families of lattice paths. We introduce a promotion framework that takes classical Dyck paths to more general Motzkin and Schröder paths via two key transformations: the Binomial and Chebyshev transforms. The framework is further extended to study grand paths, which are not restricted by the x-axis. By uncovering patterns within this framework, we construct explicit bijections linking different path families. The Riordan transform approach provides new combinatorial insights and a fresh perspective on lattice paths.

Units and zero-divisors: Building blocks for required communications' systems

Ted Hurley
University of Galway

The talk is about how units and zero-divisors in abstract algebra are used, and can be used, in building required types of structures for communications' systems, such as for Coding Theory, Cryptography, Filter Banks and others.

Integrating Computing into Mathematics Education: A Case of Python Programming in Combinatorial Contexts

Elise Lockwood
Oregon State University

Computational activity, and programming in particular, comprise an increasingly essential aspect of scientific activity, and engaging in computing is as accessible as it ever has been. In mathematics education, there is a need to investigate the ways in which students' computational activity can support their reasoning about mathematical concepts. In this talk, I will present results from a study in which undergraduate students engaged with Python programming tasks designed to support combinatorial thinking. I highlight noteworthy aspects of students' experiences with computing in this mathematical context, including benefits and drawbacks of working in a computational environment. I suggest that even for students with little programming experience, the computational environment supported their combinatorial reasoning in valuable ways. Overall, I seek to frame these specific findings about Python programming in combinatorics as an instance of a broader phenomenon, namely highlighting the ways in which computing may be leveraged to support students' engagement with mathematical concepts and practices.

Euclid's Elements as Gaeilge – Beginnings

Siobhán McGarry & Ciarán Mac an Bhaird
Maynooth University

The title 'Additional Irish ms 2a' in UCD Special Collections reveals nothing of its remarkable mathematical content. The first 16 pages of this manuscript are a translation in Irish of the start of Euclid's Elements from around 1850 by the famous Irish language scholar John O'Donovan (1806 –1861). In this talk, we will provide some background on O'Donovan, including his work for the Ordnance Survey. We will present evidence that suggests that O'Donovan's original source was Robert Simson's Elements, and that O'Donovan may have been aware of the controversy around the parallel postulate. Regarding the translation itself, the terminology that O'Donovan employed is particularly interesting. It attracted a commentary from the leading Irish language expert Eoin MacNeill (1867–1945) and included the repurposing and combination of existing Irish words, and references to original Greek terms. We will close with a brief overview of how the manuscript ended up at UCD and mention other partial Irish language translations of the Elements that have thus far been uncovered.

Reflection Groups in the Light of Formal Concept Analysis

Götz Pfeiffer
University of Galway

Formal Concept Analysis (FCA) is a branch of applied lattice theory, concerned with the study of concept hierarchies derived from collections of objects and their attributes. Introduced by R. Wille in the 1980s, FCA now has found applications in machine learning and related fields. An application of FCA to hyperplane arrangements yields a new Galois connection on the (conjugacy classes of) parabolic subgroups of a finite reflection group. Combined with methods from Serre's recent work on involution centralizers, we obtain a refinement of Howlett's description of the normalizers of parabolic subgroups of a finite Coxeter group. This is joint work G. Roehrle and J.M. Douglass.

Quantitative estimates for geometric variational problems: Does almost solving a problem almost give you a solution?

Melanie Rupflin
University of Oxford

Many interesting geometric objects are characterised as minimisers or critical points of natural geometric quantities such as the length of a curve, the area of a surface or the energy of a map.

For the corresponding variational problems it is important to not only understand the properties of potential minimisers, but to obtain a more general understanding of the energy landscape.

It is in particular natural to ask whether an object with almost minimal energy must essentially "look like" a minimiser, and if so whether this holds in a quantitative sense, i.e. whether one can bound the distance to a minimiser in terms of the energy defect. In this talk we will discuss this and related questions concerning the behaviour of almost critical points and the convergence of gradient flows for some classical geometric problems, including the Dirichlet energy of maps between spheres whose minimisers correspond to meromorphic functions.

Integer tilings and hypertilings

Ian Short

Open University

We begin by discussing frieze patterns, which are periodic arrays of integers introduced by Coxeter in the 1970s. Conway and Coxeter discovered an elegant way of classifying frieze patterns of positive integers using triangulated polygons. Frieze patterns are closely related to certain integer tilings of the plane known as n-tilings. Motivated by Conway and Coxeter's triangulated polygons, we describe geometric models in the hyperbolic plane for n-tilings and their three-dimensional counterparts. These models allow us to construct all rigid integer tilings and hypertilings explicitly. This is joint work with Karpenkov, Van Son, and Zabolotskii.

Construction of quantum Markov processes

Stephen Wills

University College Cork

After giving a brief introduction to the idea and uses of quantum probability spaces and noncommutative random variables, I will discuss the various methods for the construction of continuous-time quantum Markov processes, in particular considering these as dilations of an underlying quantum Markov semigroup. My aim will be to give a flavour of what goes on, explaining some of the challenges that come when working in noncommutative analysis, but without with getting bogged down in technical detail.

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