Programme & Abstracts

Irish Mathematical Society

September Meeting 2021

Contents

Welcome

Tom Carroll, President of the IMS

I am delighted to welcome you to our 34th September meeting. This annual opportunity to meet with colleagues from across the island is particularly valuable in advance of what is sure to be another challenging teaching year. Brien Nolan and Niamh O'Sullivan did a superb job of organising the 2020 meeting held online earlier this year and made sure that the tradition of this annual meeting did not falter in the face of a global pandemic. This year, Cónall Kelly and J.P. McCarthy have put together a superb programme within a dual online/in-person format that signals a gradual return to post-Covid normality. Their extra effort in this regard should not be underestimated, and merits all of our understanding and cooperation. Sincere thanks also to the speakers who have been so cooperative in this regard. May I wish Cónall and J.P, all speakers, and you the attendees a most enjoyable and stimulating meeting.

David Goulding, Head of Department of Mathematics, MTU

It is my pleasure, on behalf of the Department of Mathematics in Munster Technological University, to welcome you to Cork for the 34th Annual Meeting of the Irish Mathematical Society. We are delighted to have the opportunity to jointly host this event with our colleagues in University College Cork. This event marks the beginning of a return to normality following the challenges that the Covid pandemic has thrown at us over the past year and a half and allows us to look forward to brighter days ahead. Huge credit must go to J.P. McCarthy and Cónall Kelly who have put together a fantastic programme for this event and have worked tirelessly to ensure that the meeting can proceed in a blended format. We also would like to acknowledge the work of colleagues across the two institutes who have helped bring the meeting to fruition. Finally, I would like to wish you all a successful and most enjoyable meeting over the coming days.

Kevin Hayes, Head of School of Mathematical Science, UCC

On behalf of the School of Mathematical Sciences University College Cork I would like to extend my warmest welcome to all delegates of the 34th Annual Conference of the Irish Mathematical Society. As we emerge from the shadow of COVID, collaboration between the sciences and building society's trust in science have never been more important. The Mathematical Sciences have a pivotal role in this regard, underpinning both the rigour and associated precision of good scientific outputs, and further communicating these to decision makers and the general public. In this spirit it is appropriate that this year's conference is jointly hosted by the mathematics schools of two universities collaborating together. I wish you a successful conference in every regards, demonstrating how today's mathematical challenges can be resolved and anticipating those that will arise in the future.

Meeting Schedule

Day One: Thursday 2 September, IT3, Berkely Building, MTU

10:00 Registration

10:30 COVID-19 Briefing

10:45 Welcome and opening remarks by Prof. Maggie Cusack, President MTU and Prof. John O'Halloran, President UCC.

11:10 Pauline Mellon — **UCD** — *Interplay of holomorphy and algebra in Jordan structures*

11:50 Mark Howard — **NUIG** — *A resource theory for quantum computation*

12:30 Lunch

13:30 John Appleby — **DCU** — *Mean Square Characterisation of Discrete and Continuous Linear Stochastic Equations with Memory*

14:10 Anna Zhigun — **QUB** — *Cell migration in fibrous environments: a multiscale approach*

14:50 Break

15:10 Spyridon Dendrinos — **UCC** — *Affine invariant measures in harmonic analysis*

15:50 Violeta Morari — **MTU** — *SPIRIT Maths: From student perceptions to targeted digital resources*

16:30 Poster Session

16:45 IMS Committee Meeting

19:30 Meeting Dinner

Meeting Schedule

Day Two: Friday 3 September, IT3, Berkely Building, MTU

09:20 Alberto Caimo — **TUD** — *Statistical modelling advances for valued networks*

10:00 Linda Daly — **UCC** — *Seasonal Mortality at Older Ages in Ireland 1986 to 2017 and the implications for Longevity Risk*

10:40 Break

11:00 Natalia Kopteva — **UL** — *Numerical solution of time–fractional parabolic equations*

11:40 Brendan Guilfoyle — **MTU** — *From CAT scans to 4–manifold topology*

12:20 Lunch/AGM of the IMS

15:00 Adamaria Perotta — **UCD** — *Why computation matters? An active student–led and practice–based approach to design a computational finance module in higher education*

15:40 Tony Lyons — **WIT** — *Geophysical flows in the presence of underlying currents*

16:20 Closing remarks/Prizegiving

Abstracts of talks

John Appleby

Dublin City University

Mean Square Characterisation of Discrete and Continuous Linear Stochastic Equations with Memory

Day One: 13:30

Necessary and sufficient conditions for the asymptotic stability of deterministic linear autonomous equations with memory have been long understood. However, the situation for stochastic equations with memory, whether in continuous or discrete time, is not so well settled. In this talk, we concentrate on the scalar case (in discrete and continuous time) and on the asymptotic behaviour of the mean square of the solution.

In the case of difference equations with finite memory or stochastic differential equations without delay, ideas laid out by Bellman can be used to resolve the asymptotic behaviour completely. In the scalar, discrete case, however, this comes at the cost of high-dimensional conditions. Moreover, these ideas do not seem to transfer so smoothly to delayed equations in the continuous case. Ideas from the theory of Lyapunov functionals allow some progress to be made, but only in some special cases.

To resolve this, our approach is to create a new auxiliary dynamical system whose leading order asymptotic behaviour can be determined exactly. This enables us to characterise the asymptotic behaviour of the original stochastic equation in terms of a functional of the fundamental solution of the underlying deterministic equation. Fortunately, a formula for the functional can always be found in terms of the problem data, and in some cases it can be computed in closed-form. Furthermore, one can deduce a "characteristic equation", again in terms of the data, whose unique real solution gives the exact exponential rate of growth or decay of the mean square.

In particular, one can provide a closed-form characterisation of the mean square behaviour of scalar stochastic delay differential equations with a single delay, and give an explicit characteristic equation for its top Lyapunov exponent. This is satisfactory, since the deterministic case has been understood to this degree since the 1950s.

This is joint work with Emmet Lawless, School of Mathematical Sciences, DCU.

Alberto Caimo

Technological University Dublin

https://acaimo.github.io/

Statistical modelling advances for valued networks

Day Two: 09:20

We introduce new modelling approaches to analyse valued (weighted and signed) networks using two approaches. The first is a multilayer exponential random graph model describing both the between-layer and across-layer network processes and thus facilitating the interpretation of the parameter estimates associated to the network effects included in the model. The second is a joint generative process consisting of two models: an interaction model which describes the overall connectivity structure of the relations in the network without taking into account neither the weight nor the sign of the dyadic relations; and the conditional weighted signed network model describes how the edge signed weights form given the interaction structure. Applications of the methodology are illustrated on well-known datasets.

Linda Daly

University College Cork

Title: Seasonal Mortality at Older Ages in Ireland 1986 to 2017 and the implications for Longevity Risk

Day Two: 10:00

Ireland experiences higher deaths in the winter relative to the other seasons with the seasonal differences in mortality increasing with age. As the population ages it becomes increasingly important to understand seasonal mortality trends and the implications for an ageing population. This presentation presents the results of a seasonal mortality investigation in Ireland for ages 60-90 for all causes of death combined over the period 1986-2017. Mortality improvements differed between the seasons but generally the winter experiencing greater improvements over the period compared with the summer for both males and females. Given temperature changes as a result of climate change is an increasing threat to modern day society, seasonal differences in mortality in Ireland should be considered when modelling mortality at older ages.

Spyridon Dendrinos

University College Cork

http://publish.ucc.ie/researchprofiles/D019/sd

Title: Affine invariant measures in harmonic analysis

Day One: 15:10

A fundamental question in harmonic analysis is to understand what surfaces that underly averaging operators and Fourier restriction are the most nondegenerate, i.e. give us the widest possible range of L^p to L^q boundedness. I will present a measure related to certain curvature properties of the surfaces in question, that seems to be a good candidate and outline the proof of this fact for surfaces of co-dimension 2 in even ambient dimension. This is joint work with Andrei Mustata and Marco Vitturi (UCC).

Brendan Guilfoyle

Munster Technological University

From CAT scans to 4-manifold topology

Day Two: 11:40

Integration over lines is the mathematical basis of many modern methods of tomography, including CAT scans. In this talk, recent work with G. Cobos is presented on a geometrization of the seminal work in the 1930's by Fritz John which first formulated the problem. In particular, novel reconstruction algorithms will be presented that could improve scanning in various ways. The broader mathematical background is 4-manifold topology and the use of neutral metrics to tackle some of the biggest problems in the field will also be discussed.

Mark Howard

NUI Galway

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A resource theory for quantum computation

Day One: 11:50

Focusing on the mathematics, rather than the physics, I will discuss the notion of a so-called resource theory and how it can be usefully applied to problems in quantum information theory. I will illustrate the concept with reference to a particular resource theory that arises naturally in the field of fault-tolerant quantum computation. Elements of group theory and coding theory that arise in the field of quantum error correction will be discussed, alongside relevant concepts from high-dimensional convex geometry.

Natalia Kopteva

University of Limerick

https://staff.ul.ie/natalia/

Numerical solution of time-fractional parabolic equations

Day Two: 11:00

Over the past decade, there has been a growing interest in evolution equations of parabolic type that involve fractional-order derivatives in time of order in $(0, 1)$. Such equations, also called subdiffusion equations, arise in various applications in engineering, physics, biology and finance. Hence, it is quite important to develop efficient and reliable computational tools for their numerical solution. In this talk, I will touch on the main differences of fractional-parabolic equations from their classical counterparts, including the non-local nature of fractional-order derivatives, initial-time solution singularities, and slower long-term solution decay. Then we shall consider some robust numerical methods for such equations, as well as the derivation of a-priori and a-posteriori estimates of the computational errors.

Tony Lyons

Waterford Institute of Technology

Geophysical flows in the presence of underlying currents

Day Two: 15:40

The exact description of geophysical flows using the so-called Lagrangian formalism has been an active area of mathematical research in recent years. This talk will present an introduction to recent research of geophysical flows at mid-latitudes in the presence of currents. Pollard waves are an exact three-dimensional solution for the geophysical fluid dynamics governing equations, valid at mid-latitudes. This talk will investigate Pollard like solutions in the presence of general currents flowing in the meridional direction. It is found that by imposing fundamental physical constraints on these flows, one may establish the form these currents must assume, if such Pollard type solutions are to be supported in their presence. Surprisingly, it is found that a vertical counterpart to the meridional current is also required, whose magnitude is also found to be related to the strength of the meridional current.

This talk is based on recent research carried out in collaboration with Dr D Henry at UCC, which may be found at https://www.ams.org/journals/proc/2021-149-03/S0002-9939-2021-15309-4/home.html

Pauline Mellon

University College Dublin

https://people.ucd.ie/pauline.mellon

Interplay of holomorphy and algebra in Jordan structures

Day One: 11:10

Many operator algebras have a natural underlying Jordan structure. Indeed, every Banach space with a homogeneous open unit ball, B, admits Jordan structure; for example, all Hilbert spaces, C^*-algebras, JB^*-algebras and $L(H, K)$, for Hilbert spaces H and K. A deep result proves that such homogeneous balls are synonymous with the bounded symmetric domains and, in fact, the symmetry is encoded in a Jordan triple product rather than any binary product. This Jordan structure, arising from biholomorphic maps on B, denoted Aut(B), facilitates the use of complex analytic techniques and allows a fruitful interplay of holomorphy and algebra. Jordan techniques have thus led to new results even on many classical spaces, such as the Hilbert space.

In this talk, we show how complex analytic methods can sometimes give simple insightful proofs of otherwise deep algebraic results.

Violeta Morari

Munster Technological University

https://mathematics.cit.ie/staff/violeta-morari-profile

SPIRIT Maths: From student perceptions to targeted digital resources

Day One: 15:50

SPIRIT Maths is a project that was established in Munster Technological University (MTU) in 2020 to investigate students' attitudes towards mathematics and to explore a more student-centred development of mathematics resources. This talk presents an overview of the SPIRIT Maths project.

First, we will discuss some of the findings of a survey of first-year students in MTU that focused on students' expectations and the realities of experiencing mathematics in college, their views on remote delivery and approaches to learning.

Informed by the findings of this survey, three interlinked digital resources were developed: (1) a series of H5P interactive self-assessment questions, (2) corresponding videos showing worked solutions and (3) an associated bank of practice questions developed through Numbas.

Next, we will explain how the resources that were created are being promoted to students. We also report on the feedback received from a number of students who tested the resources and discuss how to measure student engagement with the resources over the coming academic year.

Finally, we consider how to measure the impact that the resources might have on students' success in their mathematics modules. The talk will be of interest to mathematics lecturers who wish to explore the use of targeted digital resources to support learners.

Adamaria Perrotta

University College Dublin

Why computation matters? An active student-led and practice-based approach to design a computational finance module in higher education

Day Two: 15:00

In this talk we describe the design of ACM30070 "Computational Finance" and a related in-progress education research study, aimed to investigate to what extent a practice-based approach and the modern definition of "inclusive computation" provides a potential for students to master financial mathematics.

Computational Finance is a stage 3 core module in the BSc in Financial Mathematics, in the UCD School of Mathematics and Statistics. The over-arching purpose of this module is to help students to develop mathematical, statistical and coding skills, along with significant knowledge and critical thinking, that allows them to effectively construct, manipulate and visualize financial datasets and to build financial mathematical models. The use of computation (VBA, Python) and a FinTech software (FinCad Analytics) are pointed out as essential to facilitate sensemaking to quantitative finance. More broadly, in this talk we discuss the pedagogical framework chosen for designing ACM30070, and we show how the modern definition of "inclusive computation" has been embedded into specific real-world case studies and computational practices. An accurate description of the design process and implementation plan is also presented. Samples of practices are discussed. Finally, we introduce the discipline-based education research associated to this module design, the current activity of data collection and we conclude the talk with a description of the future data analysis.

Anna Zhigun

Queen's University Belfast

https://sites.google.com/view/anna-zhigun

Cell migration in fibrous environments: a multiscale approach.

Day One: 14:10

Migration of a cell population is a complicated process. It is influenced by effects occurring on various scales, calling for a multiscale approach. In this talk I will present a derivation of a model starting from a system describing the movement of individual cells, through a mesoscopic kinetic transport equation (KTE), and resulting in a macroscopic equation for cell density. A key to this procedure is a novel approach to upscaling of KTEs.

Posters

Arinjoy Bhanja and Christopher Noonan

University College Cork

Supervised by Cónall Kelly

Stochastic Volatility Modelling and Sensitivity Analysis with ORE.

Guillem Cobos

Munster Technological University

Supervised by Brendan Guilfoyle

Admissible line complexes.

Fearghus Downes

Institute of Technology Sligo

Supervised by Leo Creedon

Applying a Predator-Prey model to the production of Progesterone and Estradiol from Pregnenolone.

Michael Rosbotham

Queen's University Belfast

Supervised by Martin Mathieu

A Global Dimension Theorem for C*-algebras.

Yen Thuan Trinh

University College Cork

Supervised by Bernard Hanzon

Option Pricing And CVA Calculations Using The Monte Carlo-Tree (MC-Tree) Method With The Distribution Correction Factor.