{BECMC}26

British Early Career Mathematicians' Colloquium 2026: Information and Abstract Booklet

University of Birmingham

24th June 2026 - 26th June 2026

Contents

Welcome and Additional Information

Hello and welcome to the 11th annual British Early Career Mathematicians' Colloquium (BECMC). We are delighted to host researchers from a large number of UK and international institutions, and a wide variety of mathematical disciplines. Throughout the three-day colloquium, we will be featuring plenary talks from postdoctoral researchers, contributed talks from PhD students, a poster session, and an open discussion with our plenary speakers about their research and careers in academia. Please be aware of the following additional information regarding our schedule:

- On the evening of the first day of the colloquium, we will be hosting a social at Hollywood Bowl, Birmingham Broadway Plaza. We will depart from the foyer of the Watson Building shortly after the final session of the day, and take the train from University Station to Five Ways Station. Please make sure you have registered to attend this social, as otherwise we will be unable to accommodate you.
- On the evening of the second day of the colloquium, we will be hosting an evening meal at The Plough in Harborne. Again we will depart from the foyer of the Watson Building shortly after the final session of the day, and walk as a group to the restaurant. Be aware that registration was also required for this event.
- Due to an open day occurring on the third day of the colloquium, talks will be hosted in a different building. We will be in The Old Gym and Aston Webb Dome. Please refer to the timetable for more information about where each talk is taking place. A committee member will also be waiting near the Watson Building to help people find their way to these places.

We hope you have a fantastic time at the BECMC! From the BECMC organising committee of 2026: Matthew Jenkins (co-chair), Adele Maltempo (co-chair), Jack Gidney, Adam Keyes, Joe McCusker, Anna Monger, Thomas Munn, Charlotte Norridge.

Plenary Talks

Blocks, Hochschild cohomology and Lie algebras

Jialin Wang

City St George's, University of London

Wednesday 24th June 11:00, Watson LTA

The study of blocks of finite group algebras is a fundamental piece in modular representation theory. In particular, a key problem is to classify distinct classes of blocks under various equivalences. Representation theorists study invariants under these equivalences, and how they relate to one another. In this talk we focus on a specific invariant: the Hochschild cohomology of blocks. These cohomologies associate Lie algebras to blocks, which raises the question of how to examine the structure of the Lie algebras in order to study the structure of the blocks themselves.

Choosing between interpretable and flexible models in precision medicine

Pedro Cardoso

University of Exeter

Wednesday 24th June 11:00, Watson LTC

In many applied settings, statistical modelling involves a trade-off between predictive performance and interpretability. This is particularly important in health data science, where statistical models support real-world decision-making. In this talk, I will explore this trade-off by examining treatment selection in type 2 diabetes using routinely collected clinical data. I will compare flexible machine learning approaches for estimating differential treatment response with simpler regression-based models that allow direct interpretation of covariate effects. While more complex models can capture non-linearities and interactions, they are often difficult to interpret and communicate. In contrast, simpler models can provide transparent, clinically actionable insights with only a modest loss in predictive performance. This case study highlights a broader question in applied statistics: when does increased model complexity meaningfully improve decisions, and when does it hinder practical use?

Determining the spectrum of additive triples in the group of integers modulo a prime

Laura Johnson
University of Bristol
Thursday 25th June 09:00, Watson LTA

For nontrivial subsets A and B of G, we define an additive triple to be a triple of the form $(a, b, a+b) \in A \times B \times B$. We say that $r(A, B, B)$ is the number of additive triples for two subsets A and B of G with cardinality s and t, respectively. For fixed values of s and t, it is an interesting problem to consider the spectrum of $r(A, B, B)$ values.

In the special case where $A = B$, the additive triples are equivalent to Schur triples. In the group $\mathbb{Z}_p$, the spectrum of $r(A, A, A)$ values for a subset A of G with fixed cardinality $s \leq p$ have been well studied in the literature. However, it is known that for certain values of p and s, not every value of $r(A, A, A)$ between the upper and lower bound in attainable.

In this talk, we will look at the case where A and B can be distinct. In this case, we can use Pollard's Theorem, which is a generalisation of the Cauchy-Davenport Theorem, to establish an upper and lower bound for the number $r(A, B, B)$ of additive triples of cardinality s and t. We demonstrate that in this case, it is possible to attain every value of $r(A, B, B)$ between the upper and lower bound.

This talk is based on joint work with Dr. Sophie Huczysnka (University of St. Andrews) and Professor Jonathan Jedwab (Simon Fraser University).

Volcanic fissure localisation and lava delta formation: Modelling of volcanic flows undergoing rheological evolution

Jesse Taylor-West
University of Bristol
Thursday 25th June 09:00, Watson LTC

Lava has a strongly temperature dependent rheology, which can evolve continuously through cooling or abruptly when solidifying and controls the dynamical evolution of volcanic features. In this talk, I will present two volcanological modelling problems, in which the rheological evolution of the material plays a significant role.

In the first, I will detail how thermoviscous localisation of volcanic eruptions is influenced by the irregular geometry of natural volcanic fissures. Fissure eruptions typically start with the opening of a linear fissure that erupts along its entire length, following which activity localises to one or more isolated vents within the first few days of an eruption. Previous work has proposed that localisation can arise through a thermoviscous fingering instability driven by the strongly temperature dependent viscosity of the rising magma. I will show that, even for relatively modest variations of the fissure width, a non-planar geometry supports strongly localised steady states, in which the wider parts of the fissure host faster, hotter flow, and the narrower parts of the fissure host slower, cooler flow. This geometrically-driven localisation differs from the spontaneous thermoviscous fingering localisation observed in planar geometries, and is potentially more potent for parameter values relevant to volcanic fissures.

The second problem concerns lava delta formation. A lava delta arises when a volcanic lava flow enters a body of water, extending the pre-eruption shoreline via the creation of new, relatively flat land. A combination of cooling induced rheological changes and the reduction in gravitational driving forces controls the morphology and evolution of the delta. I will present shallow-layer continuum models for this process, highlighting how different modes of delta formation manifest in different late-time behaviours. In particular, I will derive a late time similarity solution for the evolution of the shoreline when the viscous lava solidifies and fragments, forming "hyaloclastic" debris on contact with the water.

Impact in Mathematics Education: From Research Questions to the Real World

Bethany Woollacott
University of Nottingham
Thursday 25th June 13:00, Watson LTA

Mathematics education shapes knowledge, understanding and attitudes towards mathematics as a discipline, but teaching approaches are contested and not all learners fill their potential. So, how can we effect real world change in mathematics education? In this talk, I reflect on three strands of my work in both mathematical cognition and mathematical education research, illustrating three approaches to addressing this important question.

Beginning at the system level, I explore the multiple facets of mathematics education as a system in England – which pedagogies are most effective, what shapes pupils' attitudes towards mathematics, how can we support pupils to be successful in mathematics? I draw on initial findings from a longitudinal programme of research using survey data from over 38,000 pupils and nearly 1500 teachers in England. I then turn to the learner-level to consider how pupils learn mathematics from textbooks. I present findings from my research exploring how pupils read and use these commonplace resources, and how mathematics textbooks should be designed to support effective learning. To conclude, I reflect on how mathematics education research finds its way into mathematics classroom, considering how all of this evidence reaches teachers and informs teaching. I present findings from my work around the research-practice gap, discussing effective approaches that can help research achieve impact in the classroom.

Together, these examples provide insight into the complexity of mathematics education and how both mathematical cognition research and mathematical education research can deliver meaningful impact in mathematics classrooms.

A point is too small: The strength of weak formulations

Antonín Češík

University of Warwick

Friday 26th June 09:30, Old Gym LG10

We all know that $\mathbb{R}^d$ is used as a mathematical model for physical space, especially if $d = 3$. As a set, it consists of points where functions can be evaluated. However, in reality, one never observes a single point. Things can only be observed over small areas or volumes. This intuitive idea is the cornerstone of the modern analysis of partial differential equations (PDEs). In the so-called weak formulation, functions are evaluated by integrating them against test functions (best thought of as smooth bumps). This not only localizes the effects to a small volume, but it also allows us to bypass classical smoothness requirements. Derivatives are transferred to the smooth test function via integration by parts, effectively differentiating formerly non-differentiable functions. In this talk, we will build the intuition and understand these concepts visually.

The weak approach opens the problems up to a rich toolbox of functional analysis. It is, however, not just a convenient trick, but a mathematical necessity. We will demonstrate this necessity with an example, showing that smooth-looking PDEs can develop singularities such as jumps. At the moment of such a singularity, the classical solution breaks down, while the weak solution continues seamlessly.

Time permitting, we will look at how this philosophy scales up to modern research in geometric evolution problems. By treating complicated surfaces as measures, we can study their flow and render otherwise catastrophic geometric singularities completely harmless.

Adaptation In Dynamic Environments

Blaine Van Rensburg
University of Aberdeen
Friday 26th June 09:30, Old Gym LG12

Populations are subject to dynamic perturbations from their environment, such as natural disasters or interactions with other evolving populations, which they must adapt to, or else they risk extinction. A particularly important situation is when there is a bidirectional coupling between evolutionary and ecological changes (eco-evolutionary dynamics). These dynamics have been shown to be relevant among diverse species, complicating the very common idea that evolutionary changes only matter on long timescales. This motivates the need for mathematical models representing eco-evolutionary dynamics, as well as methods to make those models tractable. The aim of this talk is to introduce and discuss a selection of these model and methods.

From the Mathematical Past to Human Understanding: Why History Matters

Jason Yip
Middlesex University
Friday 26th June 14:30, Aston Webb Dome

The history of mathematics is often regarded as a backward-facing enterprise, concerned mainly with recovering past discoveries, celebrated figures, or obsolete methods. This talk argues instead that its value is also forward-facing. By examining how mathematics was practised, expressed, and understood across different times and places, we are reminded that what we now study and teach is not simply a timeless collection of settled facts, but also a body of knowledge shaped by historical choices, conventions, and intellectual traditions. Historical study therefore does more than illuminate the past: it offers perspectives from other mathematical worlds, and in doing so deepens our understanding even of ideas that may seem most familiar in the present.

The first part of the talk will consider what historians of mathematics actually do, from working with historical sources to reconstructing mathematical practices and traditions. It will then address why this work matters, not only for scholarship, but also for cultivating a more reflective, humane, and culturally aware understanding of the subject. Finally, drawing on my own research into the integration of history in mathematics education, I will suggest how historical perspectives can enrich contemporary engagement with mathematics, both within and beyond the classroom.

Contributed Talks

Mirror Symmetry and Modular Forms

Henry Langer
University of Birmingham

Wednesday 24th June 13:00, Watson LTA

Mirror symmetry is a group of theories in algebraic geometry that suggest a connection between enumerative invariants of one surface and the periods of a 'mirror' surface. In this talk I will give a brief outline of how modular forms show up on one side of this relation as encoding enumerative data (log GW invariants) for del Pezzo surfaces with smooth anticanonical divisor. The main bulk of the talk however will be spent giving an accessible introduction to modular forms, families of elliptic curves and why they appear in mirror symmetry.

Fans Arising from Lattice Polytopes of Mixed Volume One

Linxuan Li
Queen Mary, University of London

Wednesday 24th June 13:30, Watson LTA

Tropical geometry is a relatively young area of algebraic combinatorics, with deep connections to toric geometry, matroid theory, and polyhedral geometry. It has attracted considerable attention since the work of Adiprasito–Huh–Katz on Hodge theory for combinatorial geometries (2018).

In this talk, I will introduce a conjectural classification programme for tropical cycles satisfying the Hodge–Lefschetz package, which we call the Tropical Minimal Model Program (Tropical MMP). Roughly speaking, the Tropical MMP seeks to classify a tropical k-cycle $[F]$ together with a regular sequence $(T_1, \ldots, T_k)$ on it, so that either $[F]$ is projected onto an element of a finite list of *minimal model classes*, with each T_i is the pullback of a regular function from the image; or $(T_1, \ldots, T_k, [F])$ itself forms a regular fibration. Precise definitions and the statements of the relevant conjectures and theorems will be given in the talk.

The starting point is the Esterov–Gusev classification of lattice polytopes of mixed volume one. Building on this, I will first describe a Tropical MMP for regular tropical cycles arising as stable intersections of polyhedral hypersurfaces.

I will then turn to the main results, which extend the programme to regular tropical cycles of dimensions one and two: in these low-dimensional settings we obtain a complete classification theorem in the spirit of the Tropical MMP. Finally, I will discuss our conjectural picture in higher dimensions, indicating both the structural predictions and the principal obstructions to a general proof.

The talk is intended to be accessible to a broad audience, and no prior familiarity with tropical geometry will be assumed.

A special family of K3 surfaces with hypergeometric properties

Thais Gomes Riberio

University of Birmingham

Wednesday 24th June 14:00, Watson LTA

I will introduce K3 surfaces with particular focus on smooth quartic hypersurfaces in $\mathbb{P}^3$. I will also define hypergeometric functions over the complex numbers and their analogues over finite fields. I will then consider a very special class of pencils of K3 surfaces – focusing on one specific example – whose zeta function has coefficients given in terms of hypergeometric functions. Finally, I will use the latter to obtain an explicit decomposition of the (incomplete) L-function of the family. The talk will be based on joint work with Adriana Salerno, Eli Orvis, Jessamyn Dukes, Leah Sturman, Rachel Davis and Ursula Whitcher, available at arXiv: 2508.15049.

Non-Classical Methods for the Numerical Solution of Fractional Differential Equations

Billy Hollis

University of Leeds

Wednesday 24th June 13:00, Watson LTC

Numerical methods for the solution of fractional differential equations often suffer the drawback of extraneous memory consumption due to the nonlocal nature of fractional differential operators. In recent years, the notion of a diffusive representation has been a successful alternative. In short, such methods reformulate the problem as a system of local differential equations which can be solved by traditional methods. At the current time, the development of these methods in the applied literature is somewhat ad-hoc. In this talk we discuss how many of the schemes labelled as novel can be obtained via transformations of a unique underlying representation. We then provide a new scheme making use of the double-exponential transform before outlining the future directions of our work.

Well-posedness of the MMT model

James Patterson
University of Birmingham
Wednesday 24th June 13:30, Watson LTC

We discuss the MMT model, a family of dispersive PDEs closely related to fractional nonlinear Schrödinger equations. In particular we share progress towards a sharp theory of well-posedness when posed on the real line and methods involved in showing essential trilinear estimates. When posed on the circle, further difficulty arises and previous methods fail, yet we can still exploit dispersive effects to obtain existence of solutions. Interestingly it appears the largest derivative nonlinearity that dispersion can accommodate differs between these two scenarios.

A heterogeneous nonlocal advection–diffusion system

Joe McCusker
University of Birmingham
Wednesday 24th June 14:00, Watson LTC

Heterogeneous nonlocal advection-diffusion systems are widely used to model phenomena such as aggregation, segregation and chemotaxis in systems that contain multiple subpopulations such as different species of bacteria in a biofilm. An investigation is presented on the global boundedness for a system of nonlocal advection-diffusion equations which models a heterogeneous population over whole space R^d, for any spatial dimension d. For each nonlocal advection of species i according to the distribution of species j, the corresponding convolution kernel K_{ij} describes the perception of species i towards species j. By allowing each kernel to have their own regularity it can be shown that, within an interaction cycle, 'bad' kernels can be offset by a sufficiently 'good' kernel. The proof of why these regularities 'average out' in a sense follows from a combination of energy estimates and a surprising connection to graph theory.

Continuum limits of graph-based joint reconstruction-segmentation

Matthew Phillips
University of Birmingham
Wednesday 24th June 13:00, Watson LTB

Joint reconstruction-segmentation is an approach to image analysis that aims to produce better results by finding optimal candidates for reconstruction and segmentation simultaneously. In order to establish consistency of such methods with increasing resolution, we study the approach of our discrete model to one defined on an idealised continuum image. In particular, we study a model utilising a graph-based learning approach to segmentation, and in doing so confront questions regarding graph-based learning in a realistic imaging context where many standard assumptions do not hold in the usual way. We tackle the complexities brought on by the simultaneous convergence of the image and the segmentation, and the convergence of Dirchlet energies defined on the sort of rough sets that arise as continuum images.

Statistical and Lyapunov approximation abilities of Neural ODEs

Patrick Cahill
Imperial College London
Wednesday 24th June 13:30, Watson LTB

When modelling the law of an autonomous continuous-time dynamical system with a neural network, known as a Neural Ordinary Differential Equation (neural ODE), it is important that the neural ODE is able to approximate the law. Work has been done showing that neural ODEs are approximators of the path-wise trajectories of a system generated by an ODE, however, it remains unclear whether neural ODEs can learn the statistical, long-run, properties of an ergodic system. Practically speaking, neural ODEs can approximate the short-term behaviour of chaotic weather systems, but it remains unclear if they can approximate the long-run statistical behaviour, i.e. the climate, of those same weather systems. We show that a k-times differentiable law resulting in an ergodic system with a positive SRB-measure, can have path-wise trajectories approximated arbitrarily well in the k-1-Sobolev norm and under suitable stability conditions can arbitrarily approximate the invariant measure. Furthermore, we show that if the system admits a dominated splitting, then neural ODEs are also approximators of the Lyapunov spectrum. This result goes towards confirming that neural ODEs can approximate the climate in addition to the weather which we demonstrate with respect to the Lorenz-63 system.

Modelling the Spread of Carbapenem-resistant Acinetobacter baumannii in an Intensive Care Unit

Feargus Ball
University of Birmingham
Wednesday 24th June 14:00, Watson LTB

Stochastic epidemic models allow for modelling of disease acquisition between individuals at a fine level of detail, incorporating information such as different groups within the population. The disease process can be modelled as a Coupled Hidden Markov Model (CHMM) in discrete time, where each hidden Markov chain represents the disease carriage state of an individual on a given day. The data for this model come from longitudinal diagnostic tests, which can be imperfect and are not usually available for every time point. We present a novel model for the spread of bacteria in a hospital ward, where data are also available on the presence of bacteria in the hospital environment associated with each patient. This allows us to include both patients and bed units in the model as two different types of individuals with their own transition and observation probabilities. Our model therefore consists of two interacting CHMMs, and we use Bayesian methods to impute the hidden carriage states, which is a computationally intensive task. For this we use a bespoke implementation of the individual Forward Filtering Backward Sampling (iFFBS) algorithm which we have adapted to our model. Simulation studies indicate that iFFBS in combination with Markov chain Monte Carlo can successfully estimate the parameters of the model. We apply this to previously unanalysed data on the spread of Carbapenem-resistant Acinetobacter baumannii in an Intensive Care Unit. This allows us to understand the spread of bacteria from the hospital environment to patients, answering clinical questions and informing further studies.

Can Mathematics Help Save Olive Trees?

Krishna Kumar
University of Birmingham
Thursday 25th June 10:30, Watson LTA

Olive Quick Decline Syndrome(OQDS), caused by the vector-borne bacterium Xylella fastidiosa, has devastated olive groves in southern Italy since 2013 and is now spreading across Europe, with annual economic losses exceeding 5.5 billion euros. A range of mathematical models such as lattice models, spatio-temporal models, ODE-based models and statistical and machine learning approaches has been developed to study the disease dynamics, each addressing specific aspects of the insect-olive system. Collectively, these models highlight broad control measures such as vector monitoring, host removal, and weed management.

In this talk, we will introduce a novel mathematical model based on a system of integro-difference equations. The model aims to complement the existing OQDS models, and is designed to represent species with non-overlapping generations of the insect vector. We explain the features of the model that captures the complex interplay among insect vector dispersal, population abundance, and other human factors that affect the rate of infection spread in olive trees at the orchard scale. The proposed integro-difference framework lays the foundation for identifying threshold conditions for the epidemic spread and predicting spatial patterns of the infection.

Quantifying Tissue Architecture with Multi-Parameter Persistent Homology

Kylie Savoye
University of Birmingham

25th June
11:00
Watson LTA

Spatial transcriptomics has revolutionised our ability to measure gene expression while preserving tissue architecture. Yet extracting meaningful patterns from the complex interaction of spatial organisation and molecular profiles remains challenging, particularly in the heterogeneous tumour microenvironment (TME). Here we apply Multi-Parameter Persistent Homology (MPH), a topological data analysis framework that can simultaneously track cellular organisation patterns across spatial proximity and gene expression levels, to reveal disease-relevant tissue architecture in cancer that may be invisible to conventional methods.

MPH constructs two-parameter filtrations combining spatial distance with gene expression gradients, enabling quantitative characterisation of topological features as they emerge and persist across both parameters. This approach captures how cells organise relative to both their neighbours and their molecular states, which provides a unified signature of tissue structure well suited to characterise the spatial and molecular heterogeneity central to tumour plasticity.

We demonstrate MPH's capabilities in a cancer cell line derived from colorectal cancer tumour, revealing spatial immune and stromal compartmentalisation patterns relevant to understanding TME organisation. Notably, we find differences in topological signatures across fibroblast populations that are not observed in macrophage populations, suggesting that stromal heterogeneity in the TME may have structure beyond purely spatial organisation. We are currently extending this framework to additional human cancer datasets, with ongoing data collection and methods development aimed at broadening its applicability to clinical contexts.

MPH's quantitative characterisation of tissue architecture offers potential for identifying pathology-specific spatial patterns that may inform treatment outcome prediction and disease progression monitoring. Topological approaches like MPH provide a bridge between molecular measurements and the architectural context essential for understanding tumour plasticity, stromal remodelling, and therapeutic response.

From genome sequencing to metabolic modelling and dynamic flux balance analysis extensions

Thomas Munn

University of Birmingham

Thursday 25th June 11:30, Watson LTA

Genomic sequencing data can be used to identify gene-protein-reaction (GPR) rules for microbial species, which determine how the genes corresponding to enzymes catalyse specific metabolic reactions. GPRs can thus be combined to create genome-scale metabolic models (GEMs) for any organism for which a genome sequence is available. Mathematically, GEMs are large stoichiometric matrices that can be used to predict which reactions are vital for their metabolism. GEMs are then used to construct kinetic models, which are often very large systems of ODEs. In this talk, I will describe how GEMs are constructed and how flux balance analysis (FBA) is used to calculate a biologically feasible combination of fluxes for an organism at steady state. Next, I will extend FBA to consider dynamic environments (dFBA) to describe scenarios such as growth in a bioreactor where resources are finite. This requires a quasi-steady-state approximation where the intracellular metabolism is assumed to be at steady state. dFBA has been applied with much success to model microbial metabolism, both in industry and research. In the remainder of this talk, I will present my own work on extending dFBA to consider variable objective functions, including how an organism's cellular objective might change in response to a dynamic environment. Notably, this will include an algorithm for solving these extended problems efficiently, minimising the number of times the LP problem must be solved.

Topological Patterns within Limit Order Book data

Mingjie Shen
University of Birmingham
Thursday 25th June 10:30, Watson LTC

Financial markets generate enormous amounts of limit order book (LOB) data, which records buy and sell orders at different prices over time. However, this data is highly irregular and constantly changing across both time and price scales, making it difficult for standard deep learning models to capture realistic market behaviour.

In this talk, we will introduce how we can apply Topological Data Analysis (TDA), a mathematical framework for studying the "shape" and structure of data, to analyse how market liquidity evolves over time. By examining persistent patterns in the distribution of trading volumes across price levels, we extract topological summaries such as persistent entropy and related structural measures.

These quantities provide information about the stability, fragmentation, and organization of market liquidity that traditional statistical methods may miss. We then incorporate these topological features into generative deep learning models as additional loss functions, encouraging the models to learn not only price movements but also the evolving structural geometry of the market.

Our goal is to build more realistic simulations of financial markets by teaching generative models to reproduce the hidden topological patterns underlying limit order book dynamics.

Risk Neutral Distributions: Estimation in Higher Dimensions

Jack Hopkins
University of Birmingham
Thursday 25th June 11:00, Watson LTC

Empirical estimation of risk-neutral distributions has been an important area of financial mathematics since Breeden and Litzenberger (1978) established the relationship between traded option prices and the risk-neutral density function. Estimating these distributions provides important insights into market-implied beliefs, investor preferences, and the relationship between risk-neutral and physical return distributions. This survey reviews the literature on empirical risk-neutral density estimation, including recent advances by Bernard and Bondarenko (2024), who extend these methods to higher-dimensional settings. I will also discuss applications of this work and outline potential areas for future research.

Oscillations in Social Opinion: An Agent-Based Approach

Jacob Asmat

University of Birmingham

24th June 11:30, Watson LTC

What causes opinions in a population to swing back and forth over time? We investigate how extremism, social influence, and cognitive bias shape collective opinion dynamics, and how these interactions can generate persistent oscillations.

Drawing on ideas from psychology, sociology, and dynamical systems, we show that periodic opinion change is far more robust than previously recognised, even in fully deterministic models. In particular, we demonstrate that sustained oscillatory behaviour can arise in one-dimensional opinion spaces with as few as three interacting agents.

We also explore how a small number of stubborn agents holding extreme opinions can exert a disproportionate influence on the wider population, driving continual shifts in the attitudes of an otherwise moderate majority.

More broadly, this work highlights how relatively simple agent-based models can produce rich and realistic collective dynamics, offering insight into oscillatory phenomena observed across social, biological, and economic systems.

Groups of maximal class

Pete Gautam

University of Manchester

Thursday 25th June 10:30, Watson LTB

One of the biggest accomplishments in group theory has been the classification of finite simple groups. Using this result, we have "classified" groups by breaking them down into simple subquotients. There are other ways of trying to classify groups, and the one we will be looking at is by order. When we do so, it becomes quite clear that we need to specifically consider groups of prime power order, called p-groups. But, due to their abundance, we cannot hope to classify all p-groups! We shall be looking at a subfamily of these groups, called groups of maximal class, and consider some recent progress aiming to classify such groups.

Normal subgroups and degrees of minimal invariant characters

Iris Gilabert
Universitat Politècnica de València

Thursday 25th June 11:00, Watson LTB

It is well known that character theory is a powerful (sometimes even unavoidable) tool to work on finite groups. There are, in fact, celebrated theorems studying the structure of groups exclusively through the degrees of their irreducible characters. For example, Thompson's theorem states that if a prime p divides the degree of every nonlinear irreducible character of a group G, then G has a normal p-complement. In this talk, we aim at introducing results analogous to Thompson's, as well as other theorems, so as to deduce properties of a normal subgroup N within a group G by studying the degrees of the characters of N. To this purpose, the concept of minimal G-invariant characters is defined. We present some recent progress, and how these results fit within other lines of research.

Robustness Analysis via Horofunction Compactification

Harry Bennett
University of Birmingham

Thursday 25th June 14:00, Watson LTC

Robustness analysis plays a central role in the verification and design of computational and hybrid systems, particularly when system behaviour depends continuously on parameters subject to perturbation. Existing domain□theoretic frameworks provide a principled foundation for reasoning about such perturbations via monotone maps on lattices of closed sets. However, these frameworks face significant limitations when the underlying state space is not locally compact, as is the case for many infinite-dimensional spaces that arise in analysis, machine learning, and control theory (e.g., ℓ_p and L_p spaces). In these settings, the lattice of closed subsets fails to be continuous, and classical compactifications either sacrifice precision or lack computable structure.

We propose Gromov's horofunction compactification as a new tool for robustness analysis over a class of separable metric spaces of practical importance, including separable reflexive Banach spaces. Given a metric space S, we show that its horofunction extension yields a compact metric space together with a Lipschitz embedding, which enables robust approximations of monotone maps via Scott□continuous maps on the compactified domain. For separable spaces, the horofunction compactification is metrizable, which provides a path toward effective domain-theoretic constructions.

Constructing non-rectifiable Delone sets

Ash Bhat
University of Birmingham
Thursday 25th June 14:30, Watson LTC

Separated nets, also known as Delone sets, are point sets in Euclidean space that are both relatively dense and uniformly discrete. Delone sets are good models for crystalline structures, which have been of great interest in mathematical chemistry since Schectman won the Nobel Prize for Chemistry in 2011 for first observing naturally occurring quasicrystals. Many lines of research have emerged about the structural properties of Delone sets; an interesting question asked independently by Furstenburg and Gromov in the 1990s concerns, for each dimension at least 2, whether all Delone sets in that dimension are bi-Lipschitz equivalent. The remarkable papers of McMullen and Burago and Kleiner answered this question in the negative by transforming it into a continuous problem about Jacobians of bi-Lipschitz maps. In this talk, we discuss their method of 'encoding' a non-realisable density into a Delone set, and how versions of this have been implemented in modern metric geometry.

Fractal analysis of soot agglomerates

Jonathan Hodgson
University of Birmingham
Thursday 25th June 14:00, Watson LTB

Fractals are geometric objects which have non-integer dimension. Combustion engines emit soot nanoparticles (called agglomerates) which can be modelled as having a fractal structure. These agglomerates are composed of a large number of spherical primary particles, bound together in some random arrangement. The calculation of these agglomerates' fractal dimension can quantify how irregular this arrangement is; this can help to inform the design of filters which prevent the release of these particles into the atmosphere.

The main method currently used for the computation of such fractal quantities relates to a simple power law equation which connects an agglomerate's number N_p of primary particles (radius r) to its radius of gyration R_g by $N_p = K_f(R_g/r)^{D_f}$, where D_f is the agglomerate's fractal dimension and K_f its fractal prefactor. This talk discusses the use of simulations of the formation of soot agglomerates to highlight the extent to which overlapping between an agglomerate's composite primary particles affects the output values of D_f and K_f.

Multiscale Modeling of Moving Boundary Dynamics and Phase Transitions in Deep Eutectic Systems

Liming Li
University of Warwick
Thursday 25th June 14:30, Watson LTB

Hydrophobic eutectic molecular liquids and glasses present dynamical systems characterized by highly tunable physicochemical parameters. This study investigates the non-equilibrium transport phenomena and thermodynamic phase transitions of deep eutectic systems using a dual-model approach, integrating macroscopic empirical kinetics with atomistic stochastic simulations. While these systems are conventionally modeled in their liquid states, this work analyzes the mathematical utility of their glassy counterparts for predicting controlled mass-release profiles.

To model macroscopic dissolution kinetics, we evaluate the 4-hydroxychalcone and bifonazole (Cha/Bif) system. We frame the dissolution phase as a moving boundary problem characterized by the spontaneous formation of a spatial core-shell morphology. Driven by the preferential diffusion of the highly soluble component, the system generates a passivation layer that acts as a time-dependent, self-healing boundary condition restricting further mass transport. Kinetic analysis demonstrates that empirical mass release rates significantly exceed theoretical equilibrium predictions, an anomalous transport phenomenon driven by the high-energy, disordered state of the amorphous matrix.

In parallel, we investigate the atomistic thermodynamics of a structurally distinct curcumin and bifonazole (Cur/Bif) system using stochastic Molecular Dynamics (MD) simulations. By calculating diffusion coefficients across varying thermal states, we map the system's phase space and try to predict the macroscopic glass transition temperature.

Together, these parallel investigations establish a validated computational and kinetic framework for modeling non-linear release kinetics and structural bifurcations in high-energy disordered systems.

Nonlinear Interfacial Stability of Core-Annular Film Flows in Vertical Pipes, including the Effects of Gravity

Maïté Guerin

Imperial College London

Thursday 25th June 15:30, Watson LTA

Core-annular flows have been extensively studied experimentally and analytically over the past century. Some experimental observations remain unexplained by existing theory though. The issue being, since linear stability analysis has inherent limitations, it cannot fully capture con- figurations of core-annular flows that are at least weakly, if not strongly, nonlinear, hence the need to study this phenomenon in a nonlinear framework.

In this work, new nonlinear asymptotic developments of the interface evolution equation are derived for bipahsic vertical flows : oil being at the centre (core) surrounded by water (annulus), gravity is not neglected. This work is based mainly on the analytical and numerical research of Papageorgiou et al. 1990 and on the experimental study of Bai, Chen and Joseph 1990, 1992.

Working with gravity and stronger nonlinearity led us to a new equation describing the profile of the interface between the two flows.

Core-annular flow different type of profiles are well-known but not always well-understood. One profile in particular called bamboo-shaped that cannot be explained by existing linear non gravitational theory was observed during our numerical simulation.

Designing experiments that record the temporal evolution of the interface under different configurations could prove especially useful for confronting theory with numerical predictions. Further numerical investigations are required to extend our analytical understanding of this phenomenon.

Modelling static capillary phenomena using phase field models: The interaction of wetting potentials with the LBFGS minimiser under pressure and volume constraints.

Eva Mokhtari

University of East Anglia

Thursday 25th June 16:00, Watson LTA

We examine how the explicit inclusion of a surface potential within a static free-energy minimization framework modifies equilibrium wetting characteristics, and we compare this to the standard implicit representation typically employed in lattice Boltzmann methods. Using a phase-field model based on the Ginzburg–Landau functional, we combine analytical zero-dimensional calculations with fully three-dimensional simulations to study linear, cubic, and quartic forms of the wetting potential.

An analytical analysis of the zero-dimensional formulation reveals that the linear model is fundamentally constrained, restricting attainable contact angles to approximately 20°–160°. Moreover, it suffers from unphysical liquid enrichment due to substrate-induced shifts in the order parameter. While the cubic model mitigates this enrichment problem, it introduces phase undersaturation at small contact angles, arising from its inherently asymmetric free-energy landscape. We also identify a previously overlooked mechanism of apparent liquid depletion in static simulations, which is driven by substrate-size-dependent energy redistribution rather than the usual phase-field shrinkage effect. To overcome these issues, we introduce a quartic formulation that provides stable, artifact-free behavior over a wide contact-angle range (0°–160°), with an optimal choice of the volume-penalty parameter $\lambda = 10^{-2}$.

For large contact angles, all models predict the development of an air film at the substrate. Interestingly, within the pressure-based formulation, the cubic model performs particularly well, surpassing both the linear and quartic variants.

Complexity of Constant Length Substitutions

Josiah Aitchison
Open University
Thursday 25th June 15:30, Watson LTC

A substitution is a rule that replaces each symbol from a finite collection with a concatenation of symbols (word) from the same collection. For example, the period doubling substitution is the rule $a \to ab$, $b \to aa$. Iterating a substitution gives rise to a right-infinite sequence that is non-periodic under shifting.

In this talk, I will present some recent results on the complexity of substitution sequences. The complexity function of a sequence counts the number of distinct words of a given length that appear in the sequence. It is well known from classical theory that the complexity function of a sequence generated by a substitution grows linearly. However, the linear growth rate has only been ascertained for isolated examples. I will present a systematic approach to determining this growth rate, under mild assumptions on the generating substitution. This is joint work with Andrew Mitchell (Loughborough).

Structural properties of dynamical survivor sets

Richard Howat
University of Birmingham

Thursday 25th June 16:00, Watson LTC

We determine the Newhouse thickness of the set $\overline{S_{T_n}([0,t))}$ this denoting the closure of the set of points whose orbit under T_n never falls into the hole $[0,t)$, where T_n denotes the $n-$ary expansion.

Using these results, given an at most countable set of values $(t_k)_{j\in J}$ less than one, we can provide lower bounds for the Hausdorff dimension of the intersection $\bigcap_{j\in J}\overline{S_{f_j}([0,t_k))}$ where the function f_i is either an $n-$ary expansion or the Gauss map.

The fourth moment problem in quantum probability

Yasmin Giles
Lancaster University

Thursday 25th June 15:30, Watson LTB

The fourth moment theorem is a central limit type result: Given a sequence of random variables in a fixed Wiener chaos, the convergence of the second and fourth moments are sufficient to deduce convergence in distribution to a Gaussian. I will discuss analogous results in the setting of q-Brownian motion, a quantum deformation of (classical) Brownian motion by a parameter $q \in [-1,1]$ with an associated q-Gaussian distribution. In this setting, one can ask "When is the convergence of the second and fourth moment sufficient to deduce converge in distribution (to a q-Gaussian)?". I will present a functional-analytic approach to the classical fourth moment theorem that leads to partial answers to this question.

Polynomial Ergodicity of the Generalized Relativistic Langevin Equation

Ethan Baker

University of Birmingham

Thursday 25th June 16:00, Watson LTB

Relativistic Langevin equations are stochastic differential equations which describe the motion of a particle in a relativistic environment, subject to an external potential and a noise. We will first introduce a relativistic Langevin equation which attains the Markov property, and describe the long-time behaviour of the process. We will then introduce a Relativistic Langevin Equation with memory, called the Generalized Relativistic Langevin Equation (GRLE), by considering a memory kernel and an additional noise. As observed in experimental data, such an equation is useful in the modelling of the dynamics of heavy ion collisions in the relativistic heavy ion collider. We re-formulate the equation as a Markov process by approximating the memory kernel as a sum of exponentials. In order to establish the long-time behaviour of the process, we describe a method of computing Lyapunov functions in order to obtain a convergence rate of the transition densities to the invariant measure. We will then apply this method to the GRLE to obtain a polynomial convergence rate to the invariant measure.

Discovered in the archives: D'Arcy Thompson's recreational mathematics

Kate Hindle

University of St. Andrews

Friday 26th June 11:00, Old Gym LG10

D'Arcy Thompson (1860 - 1948) is remembered as one of the first biomathematicians for his 1917 book On Growth and Form. Mathematics was used throughout the book as a tool to understand biology, and Thompson emphasized elsewhere in his works that biologists should look to mathematics as a guide. These paint a view of Thompson having a very practical approach to mathematics.

However there are several instances of him appreciating mathematics for its own sake, for example calling mathematical results beautiful. Thompson also engaged in some mathematics with no discernible link to his biological work, and which he did not publish anywhere. Though some of the areas he was doing this with may not be immediately recognised as recreational mathematics today, this is what Thompson was doing here.

This talk will explore Thompson's recreational mathematics through archival evidence of Thompson's correspondence and papers, and highlight areas in which Thompson's approach to recreational mathematics mirrors his more practical work.

Through the lens of Thompson's recreational mathematics this talk will demonstrate the materials that can be found in archives, the information we can obtain from them, and some of the limitations of archival research.

Engagement across the years: student insights into the teaching and learning experience of mathematics at university

Niamh Brereton

University of Birmingham

Friday 26th June 11:30, Old Gym LG10

Although there exists previous work exploring the challenges that students may face at the transition to studying mathematics at university, much of it focuses on whether students engage with support and resources rather than exploring how and why they do – or do not – engage. Moreover, many studies concentrate on student engagement with institution-wide mathematics learning support, and as a result, are not necessarily addressing the challenges of specialist mathematics students and their experience with in-course learning and teaching activities.

In this talk, we present the results of a thematic analysis performed on qualitative interview data from 42 undergraduate mathematics students at a research-intensive university in the UK which explored the following research questions:

How do students engage with the teaching and learning on their mathematics course?

What, if any, differences exist between how students engage with their course and their year of study?

By calibrating results with previously collected staff perspectives on the transition to university study, our analysis offers insight into the extent of alignment between staff and student views. It highlights what students value in their teaching and learning experience and considers how practices identified from mathematics learning support might be used to enhance mainstream teaching and learning in university mathematics.

Mitochondrial Transport Constraints Drive Metabolic Plasticity in SDH-Deficient Cells

Ramin Nashebi
University of Birmingham
Friday 26th June 11:00, Old Gym LG12

Cellular metabolism can be viewed as a compartmental reaction network constrained by stoichiometry, transport processes, and enzymatic capacities. Mitochondrial transporters couple mitochondrial and cytosolic metabolism, yet their impact on feasible flux states remains poorly understood. Mutations in succinate dehydrogenase (SDH), observed in several cancers and mitochondrial disorders, lead to accumulation of succinate, an oncometabolite, and metabolic rewiring. SLC25A10, the mitochondrial dicarboxylate carrier, catalyses exchange of succinate and malate with phosphate and other inorganic anions across the inner mitochondrial membrane. Here, we analyse how transport perturbations reshape flux distributions. We combine stable-isotope labelling experiments (13C-glucose) with constraint-based metabolic modelling to infer condition-specific flux states in wild-type, SDH-deficient, SLC25A10-deficient, and combined SDH/SLC25A10-deficient cells. In SDH-competent cells, SLC25A10 sustains mitochondrial-cytosolic malate exchange and supports anaplerotic coupling of the tricarboxylic acid cycle. Under SDH deficiency, isotope-consistent model solutions suggest that SLC25A10 contributes to succinate export, while its loss requires compensatory flux through alternative carriers, with SLC25A1 emerging as a plausible route. These results show how transport processes shape feasible flux states and enable metabolic plasticity under mitochondrial dysfunction. This reveals hidden rewiring.

Ionising Radiation and Mutant Clone Dynamics in the Colonic Epithelium

Linus Chang
University of Birmingham
Friday 26th June 11:30, Old Gym LG12

Radiotherapy (RT), an established colorectal cancer treatment modality, is often associated with side-effects that cause premature ageing in exposed tissues, which in turn increases the risk of developing age-related disease. However, a quantitative understanding on how ionising radiation affects stem cell dynamics is currently unknown. By employing experimental lineage-tracing methods combined with stochastic mathematical models and Bayesian inference, we have quantified the impact of RT on the accumulation of mutant clones in normal human colonic epithelium. With this, the long-term effects of RT treatment on mutant clone dynamics can be simulated, and gives one of the first quantitative assessments of the impact of cancer treatment on stem cell dynamics. This is joint work with CRUK Cambridge.

In this talk, I will first give a brief overview of the biology and existing mathematical models describing the mutant stem cell dynamics in the colon. Then, I will give an overview on how to extend the model to incorporate the effects of ionising radiation.

Supersymmetric Partition Functions on Curved Spaces

Adam Keyes
University of Birmingham
Friday 26th June 13:30, Old Gym LG10

The path integral is a central object in quantum field theory, but is often difficult to define rigorously and harder still to compute explicitly. By introducing supersymmetry and placing theories on curved backgrounds, one can obtain situations in which these quantities become exactly computable. I will give a schematic overview of this progression, culminating in the higher-dimensional A-model formalism, where such infinite-dimensional functional integrals reduce to finite sums over distinguished field configurations.

Adiabatic Invariant Actions for Partially Integrable Systems

Amir Khodaeian Karim
Imperial College London
Friday 26th June 14:00, Old Gym LG10

We introduce action variables for partially integrable systems. We prove that for slow-fast partially integrable systems, these actions are adiabatic invariants of motion, and give rise to integrals for the averaged system, provided that the system is ergodic, for each fixed value of the slowly varying parameters, on the common levels of their integrals. We would also discuss the averaged system, when there is no ergodicity assumption. This work raises questions that stand in the crossroads of Ergodic Theory, Symplectic Topology, and Thermodynamics.

Methods: We apply tools from Differential Topology, along techniques from theory of Ordinary Differential Equations, and Ergodic Theory.

Main Results: We introduce new adiabatic invariants. The search for such quantities is the topic of statistical mechanics.

Significance: We proposed an answer to a question of Vladimir Arnold from 1963. The work establishes several important links between seemingly disconnected topics.

Wigner Representations and Weighted L^2 Inequalities for the Fourier Extension Operator to Curves

Amy Tierney
University of Birmingham
Friday 26th June 13:00, Old Gym LG12

Weighted L^2 inequalities for the Fourier extension operator are a topic of considerable current interest, particularly in light of recent progress surrounding the Mizohata-Takeuchi conjecture. One avenue for progress is to find tomographic representations of the extension operator in modulus-square.

Bennett, Gutiérrez, Nakamura and Oliveira proved such a representation for the extension operator to hypersurfaces in terms of a surface-carried Wigner transform. Inspired by their work, we seek Wigner representations of the Fourier extension operator associated with curves in $\mathbb{R}^n$. The focal point of this work is the construction of an appropriate curve-carried Wigner transform yielding representations from which we can prove weighted L^2 inequalities.

In this talk we will discuss the form the Wigner representation takes in the curve setting, and how it departs from what one might initially expect.

L^q Bounds for Orthonormal Functions on Manifolds with Concave Boundary

Karim Elmallakh
Loughborough University
Friday 26th June 13:30, Old Gym LG12

The central question for this project is the existence of an extension of the results of Frank and Sabin on bounding the $L^{q/2}$ norm of the spectral cluster operator on a manifold with (strictly geodesic) concave boundary, with dimension greater than or equal to 2. The result is known for one function over a manifold with concave boundary and is a celebrated result of Smith and Sogge, and Frank and Sabin proved this for a compact manifold without boundary. The goal is to merge the two results to develop a bound on the spectral cluster for manifolds with concave boundary by formulating the problem in terms of Schatten spaces to exploit the structure of these spaces to prove the required result.

Tangential convergence for elliptic boundary value problems in rough domains

Arnaud Dumont
University of Birmingham
Friday 26th June 14:00, Old Gym LG12

A classical result in harmonic analysis states that the Poisson extension of a function $f \in L^p(\mathbb{R}^n)$ is a harmonic function in the upper half-space which converges to f almost everywhere as it approaches the boundary within so-called 'non-tangential' conical regions. In their 1982 paper, Nagel, Rudin and Shapiro showed that this a.e. convergence at the boundary could be improved to larger 'tangential' approach regions provided that the boundary data f exhibited higher regularity than mere p-integrability, in a way quantified using Bessel potential spaces.

More recently, Azzam–Hofmann–Martell–Mourgoglou–Tolsa have obtained a complete geometric characterisation of those domains for which the L^p Dirichlet problem for Laplace's equation is solvable for some $p > 1$.

In this talk we will explain how the tangential convergence results of Nagel–Rudin–Shapiro can be generalised to the setting of rough domains.

Towards Posa's Conjecture for 3-graphs

Debmalya Bandyopadhyay
University of Birmingham
Friday 26th June 13:00, Old Gym LG6

A classic result in extremal combinatorics is Dirac's theorem, which states that any graph on n vertices with minimum degree at least $n/2$ has a Hamilton cycle. In 1995, Komlós, Sárközy and Szemerédi showed that if the minimum degree is at least $2n/3$, then there is the square of a Hamilton cycle. (A square of a Hamilton cycle is a graph with vertices $v_1, v_2, v_3, ..., v_n$ such that any three consecutive vertices (modulo n) form a triangle.) In this talk, we discuss its extension to hypergraphs, in particular, to 3-uniform hypergraphs. We prove that any large 3-uniform hypergraph on n vertices with a minimum codegree $7n/9 + o(n)$ contains the square of a tight Hamilton cycle. This strengthens a theorem of Bedenknecht and Reiher that $4n/5 + o(n)$ is sufficient.

The Classification of Type A Decomposition Classes

Joel Summerfield
University of Birmingham
Friday 26th June 13:30, Old Gym LG6

Decomposition Classes provide a way to decompose the Lie algebra of an algebraic group into unions of orbits relating to the Jordan decomposition. In this talk we consider the case of simple algebraic groups of type A, over an algebraically closed field, and classify their decomposition classes in terms of multisets of partitions. We will describe how to determine their dimension, and the covering relation of the closure order, in terms of their combinatorial descriptions.

Reductive pair problem of SL_3

Shuo Feng
University of Essex
Friday 26th June 14:00, Old Gym LG6

A reductive pair is a pair (G, H), where H is a reductive subgroup of G, such that the Lie algebra of H is a direct summand of the Lie algebra of G as an H-module. In this talk, I will discuss this problem for representations of SL_3. For a representation V, the question becomes whether the adjoint module $L(1, 1)$, which corresponds to SL_3, appears as a direct summand of $V \otimes V^*$. I will introduce the background using partitions, Young diagrams, Schur polynomials, and the Littlewood–Richardson rule, and then explain how these tools help decompose tensor products such as $\Delta(a, b) \otimes \nabla(b, a)$. I will also describe a decomposition tree that makes the structure more visual. Finally, I will discuss how these decompositions can be used to study when the reductive pair property holds in different alcoves in characteristic p.

Rapid Fire Talks

The rapid fire session will take place on Wednesday 24th June at 15:00 in Watson Lecture Theatre A. Each talk will last for three minutes, with no questions. Please see the list of abstracts below.

Statistical and Lyapunov approximation abilities of Neural ODEs

Patrick Cahill
Imperial College London

When modelling the law of an autonomous continuous-time dynamical system with a neural network, known as a Neural Ordinary Differential Equation (neural ODE), it is important that the neural ODE is able to approximate the law. Work has been done showing that neural ODEs are approximators of the path-wise trajectories of a system generated by an ODE, however, it remains unclear whether neural ODEs can learn the statistical, long-run, properties of an ergodic system. Practically speaking, neural ODEs can approximate the short-term behaviour of chaotic weather systems, but it remains unclear if they can approximate the long-run statistical behaviour, i.e. the climate, of those same weather systems. We show that a k-times differentiable law resulting in an ergodic system with a positive SRB-measure, can have path-wise trajectories approximated arbitrarily well in the k-1-Sobolev norm and under suitable stability conditions can arbitrarily approximate the invariant measure. Furthermore, we show that if the system admits a dominated splitting, then neural ODEs are also approximators of the Lyapunov spectrum. This result goes towards confirming that neural ODEs can approximate the climate in addition to the weather which we demonstrate with respect to the Lorenz-63 system.

Fractal analysis of soot agglomerates

Jonathan Hodgson
University of Birmingham

Fractals are geometric objects which have non-integer dimension. Combustion engines emit soot nanoparticles (called agglomerates) which can be modelled as having a fractal structure. These agglomerates are composed of a large number of spherical primary particles, bound together in some random arrangement. The calculation of these agglomerates' fractal dimension can quantify how irregular this arrangement is; this can help to inform the design of filters which prevent the release of these particles into the atmosphere.

The main method currently used for the computation of such fractal quantities relates to a simple power law equation which connects an agglomerate's number N_p of primary particles (radius r) to its radius of gyration R_g by $N_p = K_f(R_g/r)^{D_f}$, where D_f is the agglomerate's fractal dimension and K_f its fractal prefactor. This talk discusses the use of simulations of the formation of soot agglomerates to highlight the extent to which overlapping between an agglomerate's composite primary particles affects the output values of D_f and K_f.

Multiscale Modeling of Moving Boundary Dynamics and Phase Transitions in Deep Eutectic Systems

Liming Li
University of Warwick

Hydrophobic eutectic molecular liquids and glasses present dynamical systems characterized by highly tunable physicochemical parameters. This study investigates the non-equilibrium transport phenomena and thermodynamic phase transitions of deep eutectic systems using a dual-model approach, integrating macroscopic empirical kinetics with atomistic stochastic simulations. While these systems are conventionally modeled in their liquid states, this work analyzes the mathematical utility of their glassy counterparts for predicting controlled mass-release profiles.

To model macroscopic dissolution kinetics, we evaluate the 4-hydroxychalcone and bifonazole (Cha/Bif) system. We frame the dissolution phase as a moving boundary problem characterized by the spontaneous formation of a spatial core-shell morphology. Driven by the preferential diffusion of the highly soluble component, the system generates a passivation layer that acts as a time-dependent, self-healing boundary condition restricting further mass transport. Kinetic analysis demonstrates that empirical mass release rates significantly exceed theoretical equilibrium predictions, an anomalous transport phenomenon driven by the high-energy, disordered state of the amorphous matrix.

In parallel, we investigate the atomistic thermodynamics of a structurally distinct curcumin and bifonazole (Cur/Bif) system using stochastic Molecular Dynamics (MD) simulations. By calculating diffusion coefficients across varying thermal states, we map the system's phase space and try to predict the macroscopic glass transition temperature.

Together, these parallel investigations establish a validated computational and kinetic framework for modeling non-linear release kinetics and structural bifurcations in high-energy disordered systems.

Numerical Simulation of Single Particle Dissipative Particle Dynamics (sDPD)

Mengna Li
University of Birmingham

Dissipative Particle Dynamics (DPD) is a powerful mesoscale simulation technique for modeling complex fluids and soft matter. However, standard DPD relies only on central pairwise forces, meaning it requires hundreds of particles to accurately represent the hydrodynamics of a single bluff body, significantly increasing computational cost. The Single Particle DPD (sDPD) formulation resolves this by incorporating a shear drag coefficient and angular momentum, allowing a solitary particle to correctly capture non-central shear forces and preserve exact hydrodynamics. While sDPD greatly improves efficiency , the addition of rotational dynamics and the strict requirements for realistic Schmidt number scaling place high demands on the underlying numerical integration schemes.

This poster explores the theoretical origins, recent developments, and numerical advancement of sDPD. Specifically, we investigate the implementation of the high-order ABOBA splitting method to integrate the sDPD equations of motion. Because standard integration methods (such as modified Velocity Verlet or leapfrog schemes) can struggle with thermodynamic drift and timestep limitations when handling velocity dependent friction, the ABOBA method is evaluated for its potential to provide superior temperature control and configurational sampling. We detail the algorithmic implementation of this high-order scheme within the sDPD framework and discuss its impact on thermodynamic stability. Ultimately, establishing this highly accurate and stable numerical baseline is a critical first step toward future large-scale, highly efficient simulations of colloidal suspensions, polymer solutions, and complex biological flows.

Early Excess Methylation at Disease-Associated CpGs in Endometrial Cancer Inferred from Bulk Tissue

Kefan Meng
University College London

Endometrial carcinoma is an epithelial malignancy, making the epithelial compartment central to understanding how DNA methylation change relates to disease development. However, methylation studies are typically performed in bulk tissue, where epithelial, fibroblast, and immune signals are combined. We asked whether epithelial-associated methylation change can be assessed from bulk DNA methylation data at CpG resolution, and whether disease-associated CpGs show excess methylation across the endometrial disease trajectory.

We analysed matched tumour and normal-adjacent samples from TCGA UCEC using cell type deconvolution and CpG-specific linear mixed modelling. For each CpG, we derived an adjusted expected tumour methylation level from estimated cell type proportions and compared this with observed tumour methylation. This identified CpGs with higher observed methylation than expected in tumour samples, including loci in GYPC and ZSCAN12.

In cancer-free hyperplasia, highlighted CpGs already showed elevated methylation relative to normal-adjacent tissue, and CpGs gaining methylation in hyperplasia tended to fall in the region of positive deviation in the tumour analysis. By contrast, metastatic comparison showed little evidence of widespread additional methylation gain beyond that expected from matched primary tumour and tissue composition.

Finally, higher prognostic scores based on mean observed-minus-expected methylation across a selected CpG set were associated with poorer overall survival in TCGA UCEC. Together, these findings show that bulk tissue methylation data can be used to assess epithelial-associated methylation change at CpG resolution and detect early excess methylation at disease-associated CpGs.

Optimal Estimation in Orthogonally Invariant Generalized Linear Models

Ibby Sajid
University of Leeds

Potts models are toy lattice models with particular interest in physics due to their ability to exhibit phase transitions. We detail the computation of their partition functions, explaining some computation tricks that may be used. We also show some cool properties of the zeros of these functions.

Quantifying Tissue Architecture with Multi-Parameter Persistent Homology

Kylie Savoye
University of Birmingham

Spatial transcriptomics has revolutionised our ability to measure gene expression while preserving tissue architecture. Yet extracting meaningful patterns from the complex interaction of spatial organisation and molecular profiles remains challenging, particularly in the heterogeneous tumour microenvironment (TME). Here we apply Multi-Parameter Persistent Homology (MPH), a topological data analysis framework that can simultaneously track cellular organisation patterns across spatial proximity and gene expression levels, to reveal disease-relevant tissue architecture in cancer that may be invisible to conventional methods.

MPH constructs two-parameter filtrations combining spatial distance with gene expression gradients, enabling quantitative characterisation of topological features as they emerge and persist across both parameters. This approach captures how cells organise relative to both their neighbours and their molecular states, which provides a unified signature of tissue structure well suited to characterise the spatial and molecular heterogeneity central to tumour plasticity.

We demonstrate MPH's capabilities in a cancer cell line derived from colorectal cancer tumour, revealing spatial immune and stromal compartmentalisation patterns relevant to understanding TME organisation. Notably, we find differences in topological signatures across fibroblast populations that are not observed in macrophage populations, suggesting that stromal heterogeneity in the TME may have structure beyond purely spatial organisation. We are currently extending this framework to additional human cancer datasets, with ongoing data collection and methods development aimed at broadening its applicability to clinical contexts.

MPH's quantitative characterisation of tissue architecture offers potential for identifying pathology-specific spatial patterns that may inform treatment outcome prediction and disease progression monitoring. Topological approaches like MPH provide a bridge between molecular measurements and the architectural context essential for understanding tumour plasticity, stromal remodelling, and therapeutic response.

Mathematical Modeling To Understand the Treatment of Adrenal Insufficiency

Ariba Shakeel
University of Birmingham

The cortisol hormone is essential for the physiological response to stress and in maintaining endocrine homeostasis. In patients with adrenal insufficiency, the exogenous replacement treatment is given by intravenous bolus injections (IV) or continuous in fusion (CIV). Following administration, circulating cortisol is reversibly converted into cortisone. Both cortisol and cortisone bind to plasma proteins, primarily corticosteroid binding globulin (CBG) and albumin, while a small fraction remains unbound and biologically active. These mechanisms introduce distinct fast and slow processes, producing multi-timescale pharmacokinetic behaviour that motivates a multiscale modelling and asymptotic analysis. Accordingly, this thesis develops three models to investigate these dynamics. Using matched asymptotic expansions, a nonlinear model describing reversible cortisol–CBG binding is formulated and analysed, with analytical results validated against numerical simulations. This model is expanded to include cortisol-cortisone interconversion mediated by 11β-hydroxysteroid dehydrogenase enzymes and reversible cortisol-cortisone-CBG binding. Model parameters were estimated within a frequentist framework by fitting both the cortisol–CBG-binding (CPB) and cortisol–cortisone–CBG binding (CCPB) models to experimental data from repeated intravenous bolus dosing (50–100 mg every 6 hours) and continuous intravenous infusion (200 mg over 24 hours). Lastly, a 4-compartment formulation including protein binding (CBG, albumin) and distribution into peripheral tissues are examined to analyze the post-dosing asymptotic dynamics. Overall, this work provides a mechanistic and asymptotic framework for cortisol replacement therapy that can be used to analyse and compare intravenous bolus and continuous infusion dosing strategies, quantify nonlinear protein-binding effects, and characterise the resulting multiscale pharmacokinetic behaviour. It provides information bridging theoretical mathematics with biomedical applications in endocrinology.

Posters

The poster session will take place at 16:00 on Wednesday 24th June in the Physics Bridge, on the first floor of the Watson Building. Please see below for a list of presenters, and poster abstracts.

1. Feargus Ball
2. Niamh Brereton
3. Adarsh Bura
4. Patrick Cahill
5. Jack Gidney
6. Iris Gilabert
7. Thais Gomes Riberio
8. Jonathan Hodgson
9. Angus Howat
10. Richard Howat
11. Adam Keyes
12. Amir Khodaeian Karim
13. Peter Kissack
14. Liming Li
15. Mengna Li
16. Labix Liu
17. Joe McCusker
18. Kefan Meng
19. Christian Ndjanda
20. Ibby Sajid
21. Kylie Savoye
22. Joel Summerfield
23. Piscopia

Modelling the Spread of Carbapenem-resistant Acinetobacter baumannii in an Intensive Care Unit

Feargus Ball
University of Birmingham

Stochastic epidemic models allow for modelling of disease acquisition between individuals at a fine level of detail, incorporating information such as different groups within the population. The disease process can be modelled as a Coupled Hidden Markov Model (CHMM) in discrete time, where each hidden Markov chain represents the disease carriage state of an individual on a given day. The data for this model come from longitudinal diagnostic tests, which can be imperfect and are not usually available for every time point. We present a novel model for the spread of bacteria in a hospital ward, where data are also available on the presence of bacteria in the hospital environment associated with each patient. This allows us to include both patients and bed units in the model as two different types of individuals with their own transition and observation probabilities. Our model therefore consists of two interacting CHMMs, and we use Bayesian methods to impute the hidden carriage states, which is a computationally intensive task. For this we use a bespoke implementation of the individual Forward Filtering Backward Sampling (iFFBS) algorithm which we have adapted to our model. Simulation studies indicate that iFFBS in combination with Markov chain Monte Carlo can successfully estimate the parameters of the model. We apply this to previously unanalysed data on the spread of Carbapenem-resistant Acinetobacter baumannii in an Intensive Care Unit. This allows us to understand the spread of bacteria from the hospital environment to patients, answering clinical questions and informing further studies.

Engagement across the years: student insights into the teaching and learning experience of mathematics at university

Niamh Brereton
University of Birmingham

Although there exists previous work exploring the challenges that students may face at the transition to studying mathematics at university, much of it focuses on whether students engage with support and resources rather than exploring how and why they do – or do not – engage. Moreover, many studies concentrate on student engagement with institution-wide mathematics learning support, and as a result, are not necessarily addressing the challenges of specialist mathematics students and their experience with in-course learning and teaching activities.

In this talk, we present the results of a thematic analysis performed on qualitative interview data from 42 undergraduate mathematics students at a research-intensive university in the UK which explored the following research questions:

How do students engage with the teaching and learning on their mathematics course?

What, if any, differences exist between how students engage with their course and their year of study?

By calibrating results with previously collected staff perspectives on the transition to university study, our analysis offers insight into the extent of alignment between staff and student views. It highlights what students value in their teaching and learning experience and considers how practices identified from mathematics learning support might be used to enhance mainstream teaching and learning in university mathematics.

The shadowing property for β-transformations

Adarsh Bura
University of Birmingham

The property of shadowing has been shown to be fundamental in both the theory of symbolic dynamics as well as continuous dynamical systems. A quintessential class of discontinuous dynamical systems are those driven by intermediate β-transformations, namely transformations of the form $T_{\beta,\alpha} : x \mapsto \beta x + \alpha \mod 1$ acting on $[0, 1]$. We provide a short and elegant proof which shows that this class of dynamical systems do not possess the property of shadowing.

Statistical and Lyapunov approximation abilities of Neural ODEs

Patrick Cahill
Imperial College London

When modelling the law of an autonomous continuous-time dynamical system with a neural network, known as a Neural Ordinary Differential Equation (neural ODE), it is important that the neural ODE is able to approximate the law. Work has been done showing that neural ODEs are approximators of the path-wise trajectories of a system generated by an ODE, however, it remains unclear whether neural ODEs can learn the statistical, long-run, properties of an ergodic system. Practically speaking, neural ODEs can approximate the short-term behaviour of chaotic weather systems, but it remains unclear if they can approximate the long-run statistical behaviour, i.e. the climate, of those same weather systems. We show that a k-times differentiable law resulting in an ergodic system with a positive SRB-measure, can have path-wise trajectories approximated arbitrarily well in the k-1-Sobolev norm and under suitable stability conditions can arbitrarily approximate the invariant measure. Furthermore, we show that if the system admits a dominated splitting, then neural ODEs are also approximators of the Lyapunov spectrum. This result goes towards confirming that neural ODEs can approximate the climate in addition to the weather which we demonstrate with respect to the Lorenz-63 system.

Normal Coverings of the Finite Classical Groups

Jack Gidney
University of Birmingham

The normal covering number of a finite group is the smallest number of proper subgroups whose union of conjugates cover the group. By a theorem of Jordan, this number must be at least two for any finite group.

Building on the work of Britnell and Maróti on the general linear group, I am investigating bounds on the normal covering number of the symplectic, orthogonal and unitary groups.

Normal subgroups and degrees of minimal invariant characters

Iris Gilabert
Universitat Politècnica de València

It is well known that character theory is a powerful (sometimes even unavoidable) tool to work on finite groups. There are, in fact, celebrated theorems studying the structure of groups exclusively through the degrees of their irreducible characters. For example, Thompson's theorem states that if a prime p divides the degree of every nonlinear irreducible character of a group G, then G has a normal p-complement. In this talk, we aim at introducing results analogous to Thompson's, as well as other theorems, so as to deduce properties of a normal subgroup N within a group G by studying the degrees of the characters of N. To this purpose, the concept of minimal G-invariant characters is defined. We present some recent progress, and how these results fit within other lines of research.

Thais Gomes Riberio
University of Birmingham

In this poster we explain how to construct a geometric model for Appell hypergeometric functions under suitable conditions.

Fractal analysis of soot agglomerates

Jonathan Hodgson
University of Birmingham

Fractals are geometric objects which have non-integer dimension. Combustion engines emit soot nanoparticles (called agglomerates) which can be modelled as having a fractal structure. These agglomerates are composed of a large number of spherical primary particles, bound together in some random arrangement. The calculation of these agglomerates' fractal dimension can quantify how irregular this arrangement is; this can help to inform the design of filters which prevent the release of these particles into the atmosphere.

The main method currently used for the computation of such fractal quantities relates to a simple power law equation which connects an agglomerate's number N_p of primary particles (radius r) to its radius of gyration R_g by $N_p = K_f(R_g/r)^{D_f}$, where D_f is the agglomerate's fractal dimension and K_f its fractal prefactor. This talk discusses the use of simulations of the formation of soot agglomerates to highlight the extent to which overlapping between an agglomerate's composite primary particles affects the output values of D_f and K_f.

Forecasting breast cancer survival data using Bayesian model averaging

Angus Howat
University of Sheffield

The pervasive approach to modelling in statistics is to select a single model from a list of plausible candidates and to use that for inference and forecasting. You can argue this approach as suboptimal as it neglects uncertainty in the model selection. Bayesian model averaging approaches this by fitting all models and averaging their estimates to identify, and propagate uncertainty more precisely. In this analysis Bayesian model averaging is implemented on survival models for a breast cancer data set to compare the predictive uncertainty with common approaches.

Structural properties of dynamical survivor sets

Richard Howat
University of Birmingham

A new notion of thickness for subsets of $B[0,1] \subset \mathbb{R}^n$ called affine thickness is defined; this notion of thickness is a generalisation of Falconer-Yavicoli thickness and is adapted to be used in the study of certain sets with affine cut outs.

Thick sets are proven to be winning for the matrix potential game introduced by Howat, Mitchell and Samuel and as an application we can prove that for a thick set, there exists $M \in \mathbb{N}$ depending on the thickness of the set, such that the set contains a homothetic copy of every finite set with at most M elements.

Additionally, a counter-example to the gap lemma in $\mathbb{R}^n$ ($n \geq 2$) for Falconer-Yavicoli thickness is given proving this result does not hold in the generality stated. We go on to provide a gap lemma for affine thickness in $\mathbb{R}^n$ (for $n \geq 2$) under additional conditions to the classical Newhouse gap lemma.

Supersymmetric Partition Functions on Curved Spaces

Adam Keyes
University of Birmingham

The path integral is a central object in quantum field theory, but is often difficult to define rigorously and harder still to compute explicitly. By introducing supersymmetry and placing theories on curved backgrounds, one can obtain situations in which these quantities become exactly computable. I will give a schematic overview of this progression, culminating in the higher-dimensional A-model formalism, where such infinite-dimensional functional integrals reduce to finite sums over distinguished field configurations.

Adiabatic Invariant Actions for Partially Integrable Systems

Amir Khodaeian Karim
Imperial College London

We introduce action variables for partially integrable systems. We prove that for slow-fast partially integrable systems, these actions are adiabatic invariants of motion, and give rise to integrals for the averaged system, provided that the system is ergodic, for each fixed value of the slowly varying parameters, on the common levels of their integrals. We would also discuss the averaged system, when there is no ergodicity assumption. This work raises questions that stand in the crossroads of Ergodic Theory, Symplectic Topology, and Thermodynamics.

Methods: We apply tools from Differential Topology, along techniques from theory of Ordinary Differential Equations, and Ergodic Theory.

Main Results: We introduce new adiabatic invariants. The search for such quantities is the topic of statistical mechanics.

Significance: We proposed an answer to a question of Vladimir Arnold from 1963. The work establishes several important links between seemingly disconnected topics.

Multivariate resting-state EEG markers differentiate people with epilepsy and functional seizures

Peter Kissack
University of Birmingham

Background: Distinguishing epilepsy from functional/dissociative seizures (FDS) is an ongoing diagnostic challenge. Using a well-controlled clinical EEG dataset, we run the first diagnostic accuracy study assessing the potential of multivariate resting-state EEG markers to directly discriminate between the two conditions at the time when a diagnosis is suspected and prior to treatment initiation.

Methods: The dataset, previously examined in a published study, includes 148 age- and sex-matched individuals with suspected seizure disorder, later diagnosed with non-lesional epilepsy (n=75) or FDS (n=73). Functional network measures in the 6-9 Hz range were extracted from normal-looking, eyes-closed resting-state EEG data acquired while participants were medication-free. Machine learning was implemented to assess their predictive potential; different model configurations were tested to identify the most promising approach for translational implementations.

Results: EEG-derived network measures discriminate between conditions at levels significantly above chance (maximum balanced accuracy: 67.5%). Their sensitivity to epilepsy (81.8%) is higher than their sensitivity to FDS (53.3%). Improving the features' temporal stability through epoch-wise averaging improves accuracy (62.6% to 67.5%). Multiple nonlinear models succeed on the classification problem, but model choice remains a determinant of overall accuracy.

Conclusion: We establish evidence for the clinical validity of selected network-based markers to discriminate between a diagnosis of non-lesional epilepsy and FDS prior to treatment initiation, highlighting the measures' potential to support post-test probability estimation in the clinic. These measures are more specific to epilepsy than FDS and should not be interpreted as markers of a positive diagnosis of FDS.

Multiscale Modeling of Moving Boundary Dynamics and Phase Transitions in Deep Eutectic Systems

Liming Li
University of Warwick

Hydrophobic eutectic molecular liquids and glasses present dynamical systems characterized by highly tunable physicochemical parameters. This study investigates the non-equilibrium transport phenomena and thermodynamic phase transitions of deep eutectic systems using a dual-model approach, integrating macroscopic empirical kinetics with atomistic stochastic simulations. While these systems are conventionally modeled in their liquid states, this work analyzes the mathematical utility of their glassy counterparts for predicting controlled mass-release profiles.

To model macroscopic dissolution kinetics, we evaluate the 4-hydroxychalcone and bifonazole (Cha/Bif) system. We frame the dissolution phase as a moving boundary problem characterized by the spontaneous formation of a spatial core-shell morphology. Driven by the preferential diffusion of the highly soluble component, the system generates a passivation layer that acts as a time-dependent, self-healing boundary condition restricting further mass transport. Kinetic analysis demonstrates that empirical mass release rates significantly exceed theoretical equilibrium predictions, an anomalous transport phenomenon driven by the high-energy, disordered state of the amorphous matrix.

In parallel, we investigate the atomistic thermodynamics of a structurally distinct curcumin and bifonazole (Cur/Bif) system using stochastic Molecular Dynamics (MD) simulations. By calculating diffusion coefficients across varying thermal states, we map the system's phase space and try to predict the macroscopic glass transition temperature.

Together, these parallel investigations establish a validated computational and kinetic framework for modeling non-linear release kinetics and structural bifurcations in high-energy disordered systems.

Early Excess Methylation at Disease-Associated CpGs in Endometrial Cancer Inferred from Bulk Tissue

Kefan Meng
University College London

Endometrial carcinoma is an epithelial malignancy, making the epithelial compartment central to understanding how DNA methylation change relates to disease development. However, methylation studies are typically performed in bulk tissue, where epithelial, fibroblast, and immune signals are combined. We asked whether epithelial-associated methylation change can be assessed from bulk DNA methylation data at CpG resolution, and whether disease-associated CpGs show excess methylation across the endometrial disease trajectory.

We analysed matched tumour and normal-adjacent samples from TCGA UCEC using cell type deconvolution and CpG-specific linear mixed modelling. For each CpG, we derived an adjusted expected tumour methylation level from estimated cell type proportions and compared this with observed tumour methylation. This identified CpGs with higher observed methylation than expected in tumour samples, including loci in GYPC and ZSCAN12.

In cancer-free hyperplasia, highlighted CpGs already showed elevated methylation relative to normal-adjacent tissue, and CpGs gaining methylation in hyperplasia tended to fall in the region of positive deviation in the tumour analysis. By contrast, metastatic comparison showed little evidence of widespread additional methylation gain beyond that expected from matched primary tumour and tissue composition.

Finally, higher prognostic scores based on mean observed-minus-expected methylation across a selected CpG set were associated with poorer overall survival in TCGA UCEC. Together, these findings show that bulk tissue methylation data can be used to assess epithelial-associated methylation change at CpG resolution and detect early excess methylation at disease-associated CpGs.

Cohomological Rigidity in Toric Topology

Labix Liu
Queen Mary, University of London

A class of topological spaces is said to be cohomologically rigid if isomorphisms in their cohomology ring can be lifted to isomorphisms in the corresponding category (e.g. homotopy equivalences / homeomorphisms / diffeomorphisms). In toric topology, moment angle complexes are spaces constructed with combinatorial data that comes with the action of a torus. The combinatorial nature is also visible on the level of algebraic invariants such as cohomology. Based on this information, a number of conjectures relating the diffeomorphism type or the homotopy type of these moment angle complexes are made, and no counter example for cohomological rigidity has been found yet. In my poster, I will show how the cohomology can be computed in terms of the combinatorial data, with some of my own examples. I will introduce known results that show certain classes of moment angle complexes are homotopy equivalent / diffeomorphic to a connected sum of products of spheres, where the defining conditions of the classes are purely combinatorial. I will also discuss the techniques used to achieve these results.

A heterogeneous nonlocal advection–diffusion system

Joe McCusker
University of Birmingham

Heterogeneous nonlocal advection-diffusion systems are widely used to model phenomena such as aggregation, segregation and chemotaxis in systems that contain multiple subpopulations such as different species of bacteria in a biofilm. An investigation is presented on the global boundedness for a system of nonlocal advection-diffusion equations which models a heterogeneous population over whole space R^d, for any spatial dimension d. For each nonlocal advection of species i according to the distribution of species j, the corresponding convolution kernel K_{ij} describes the perception of species i towards species j. By allowing each kernel to have their own regularity it can be shown that, within an interaction cycle, 'bad' kernels can be offset by a sufficiently 'good' kernel. The proof of why these regularities 'average out' in a sense follows from a combination of energy estimates and a surprising connection to graph theory.

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LaTeX PDF Search

Christina Ndjanda
Coremont

A tool to search for mathematical text in PDFs using $\LaTeX$ code. Think Ctrl+F for maths.

Optimal Estimation in Orthogonally Invariant Generalized Linear Models

Ibby Sajid
University of Leeds

Potts models are toy lattice models with particular interest in physics due to their ability to exhibit phase transitions. We detail the computation of their partition functions, explaining some computation tricks that may be used. We also show some cool properties of the zeros of these functions.

Quantifying Tissue Architecture with Multi-Parameter Persistent Homology

Kylie Savoye
University of Birmingham

Spatial transcriptomics has revolutionised our ability to measure gene expression while preserving tissue architecture. Yet extracting meaningful patterns from the complex interaction of spatial organisation and molecular profiles remains challenging, particularly in the heterogeneous tumour microenvironment (TME). Here we apply Multi-Parameter Persistent Homology (MPH), a topological data analysis framework that can simultaneously track cellular organisation patterns across spatial proximity and gene expression levels, to reveal disease-relevant tissue architecture in cancer that may be invisible to conventional methods.

MPH constructs two-parameter filtrations combining spatial distance with gene expression gradients, enabling quantitative characterisation of topological features as they emerge and persist across both parameters. This approach captures how cells organise relative to both their neighbours and their molecular states, which provides a unified signature of tissue structure well suited to characterise the spatial and molecular heterogeneity central to tumour plasticity.

We demonstrate MPH's capabilities in a cancer cell line derived from colorectal cancer tumour, revealing spatial immune and stromal compartmentalisation patterns relevant to understanding TME organisation. Notably, we find differences in topological signatures across fibroblast populations that are not observed in macrophage populations, suggesting that stromal heterogeneity in the TME may have structure beyond purely spatial organisation. We are currently extending this framework to additional human cancer datasets, with ongoing data collection and methods development aimed at broadening its applicability to clinical contexts.

MPH's quantitative characterisation of tissue architecture offers potential for identifying pathology-specific spatial patterns that may inform treatment outcome prediction and disease progression monitoring. Topological approaches like MPH provide a bridge between molecular measurements and the architectural context essential for understanding tumour plasticity, stromal remodelling, and therapeutic response.

The Classification of Type A Decomposition Classes

Joel Summerfield
University of Birmingham

Decomposition Classes provide a way to decompose the Lie algebra of an algebraic group into unions of orbits relating to the Jordan decomposition. In this talk we consider the case of simple algebraic groups of type A, over an algebraically closed field, and classify their decomposition classes in terms of multisets of partitions. We will describe how to determine their dimension, and the covering relation of the closure order, in terms of their combinatorial descriptions.

The Piscopia Initiative: Building Community and Allyship in Mathematics

The Birmingham Piscopia Committee of 2025, Rahma Abdulahi, Keya Mahavir, Hibah Sadal, Kylie Savoye and Amy Tierney
University of Birmingham

The Piscopia Initiative is a growing network supporting women and underrepresented genders across all stages of their study from undergraduate to research level in mathematics and related fields; currently comprised of local committees at 15 institutions across the UK. This poster introduces a range of events we host both locally and nationally, including weekly coffee mornings, monthly seminars, and an annual conference, and invites you to reflect on how we can foster a more inclusive culture within mathematics departments across the UK. Here, we present ideas for community-building based on the success of events we run here at the University of Birmingham, as well as ways to connect with others across institutions and advice on how to be a more effective ally.
