MIMUC
By students. For students.

Heilbronn Institute for Mathematical Research

MIMUC 2023

The Annual Manchester Interdisciplinary Mathematics Undergraduate Conference

Programme

of events

- Accelerate your career in STEM
- Develop skills not taught in lecture theatres
- Network with industry experts and alumni

Email: MIMUC.organisers@manchester.ac.uk

22nd-23rd March

Engineering building **A**

SCAN TO REGISTER NOW

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Wednesday 22nd March

11-11:15	**Registration**	*Ground Floor Main Event Space*
11:15-11:20	**Welcome**	*Theatre B*
11:20-11:50	**Dr. Nikita Nikolaev** Research Associate (Marie Curie Fellow) University of Birmingham	*Theatre B*
12-13	**Lunch**	*Blended Theatre 1*
13-14	**Student Talks (Parallel Sessions)**	
	Session A (*Location: 2A.014)* **Keith Nicholas Gironella** Differential rings and the Ritt-Raudenbush basis theorem **Mateusz Salamon** Tensor networks: a graphical tool for physics and beyond	**Session B** (*Location: Theatre B)* **Jess Watson** Fractals and Geometry in Architecture **Riccardo Ali** Different flavours of “sameness”: a categorical perspective
	-15 minute break-	
14:15-15	**Dr. Eleanor Johnstone** Postdoctoral Researcher University of Edinburgh	*Theatre B*
15-15:45	**Networking Session**	*Ground Floor Main Event Space*
15:45-16:30	**Dr. Michail Vamavakaris** ML Quantitative Researcher Bloomberg	*Theatre B*
16:30-17:30	**Alumni Panel**	*Theatre B*
17:30-18	**Mauricio Ramos** Data Scientist Meta Reality Labs	*Theatre B*

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Thursday 23rd March

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Thursday 23rd March

12-13	**Lunch**	*Blended Theatre 1*
13-13:30	**Student Talks (Parallel Sessions)**	
	Session A (*Location: 3A.012)* **Ugne Milasiunaite** What can a collaboration network tell us?	**Session B** (*Location: Theatre A)* **Jakub Stavina** Spacetime as a mathematical structure
13:30-14:30	**Academic Panel**	*Theatre A*
14:30-16	**Student Talks (Parallel Sessions)**	
	Session A (*Location: 2A.012)* **Daniel Chiang** Causal abstraction **Jerry Bard** Demystifying Fortune's formula **Rebecca Maver** B-splines and solving the Schrödinger equation	**Session B** (*Location: Theatre A)* **Jonty Male** Operational research in conflict **Robin Lyster** PageRank and beyond: Ranking every page on the web **William Zhang** Convex programming with CVXPY
16:15-17	**Student Prizes**	*Blended Theatre 1*

Have a question?
Please email MIMUC.organisers@manchester.ac.uk.

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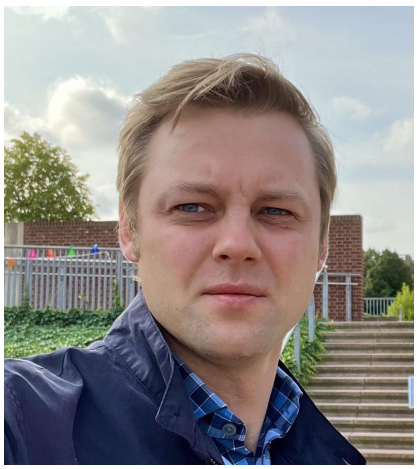


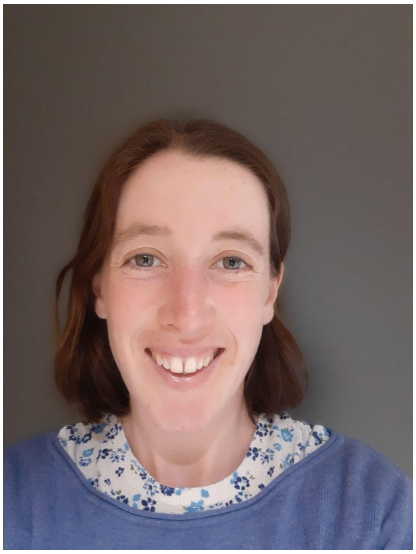
Dr. Nikita Nikolaev...

... is a mathematician and a postdoctoral research associate at the University of Birmingham. He is a member of the Geometry and Mathematical Physics research group. He studied at the universities of Waterloo and Toronto, graduating with a PhD on the Abelianisation of Logarithmic Connections. He has previously held postdoctoral positions in Geneva and Sheffield and he is a a second-generation mathematical descendant of Nigel Hitchin!

Academic Guest Speakers

Dr. Eleanor Johnstone...

... is a postdoctoral fluid dynamics researcher at the University of Edinburgh, studying glacial melt of the glacial fjords in Greenland. She recently graduated from a PhD in Applied Mathematics from the University of Manchester. She has also studied at Imperial College London and the University of Cambridge. Her research centres around understanding the behaviour of fluids in many different physical situations, from turbulent flow around wings, to small-scale processes such as inkjet printing, to understanding dynamics of the oceans.



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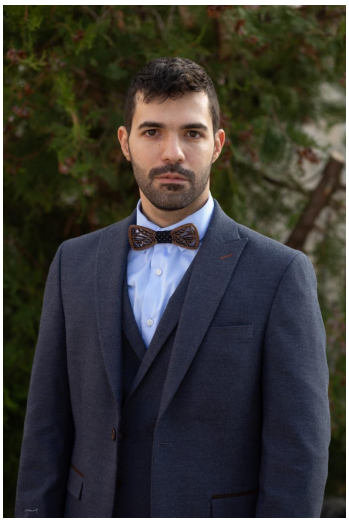


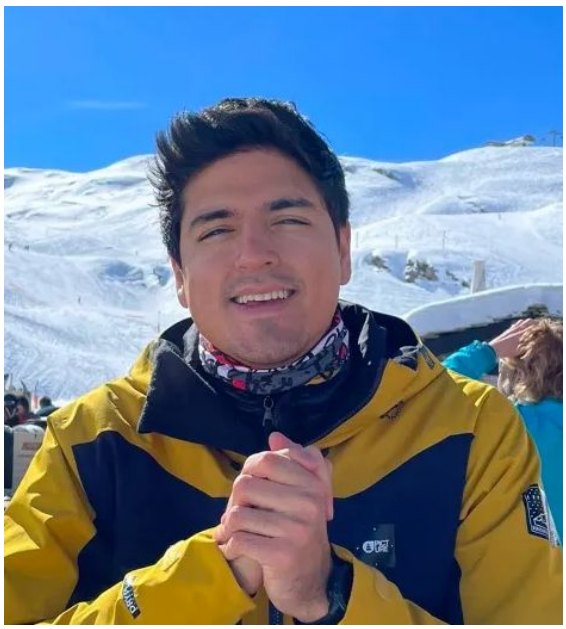
Dr. Michail Vamavakaris…

...is a Machine Learning Quant Researcher in the Bloomberg AI team who graduated with a PhD in Machine Learning from the University of Manchester Computer Science department. He has previously worked as a senior ML research engineer at Canopy (Ford), the head of data science at Data Technics, the team lead for ML Quant Research at Barings and the the team lead for ML Research at Greensill.

Industry Guest Speakers

Mauricio Ramos...

...is a Data Scientist at Meta (parent company of Facebook, Instagram, Whatsapp and others) working on augmented reality in the Reality Labs division. He graduated from the University of Manchester with a BSc in Economics and later did a Masters in Economics and Management. He is passionate about Econometrics, Statistics and cycling(!). He has previously worked in data at Jumia and Criteo.



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Ask questions and gain insight into the careers of our Alumni Panellists…

Simona Stoycheva
ML Engineer
Peak AI

Dr Deacon Linkhorn
Technical Support Engineer
Couchbase

Hermant Patel
CEO and Founder
Anumana

Shaun Barton
Mathematics Teacher
Trinity Church of England High School

Dr Eleanor Johnstone
Postdoctoral Researcher
University of Edinburgh

Thomas Knowles
Client Services Trainee
Point74

University of Manchester Alumni Panel

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Ask questions and gain insight into life as an academic…

Prof. Louise Walker
Professor of Mathematics
Focus: Teaching and Scholarship

Dr. Aram Dermenjian
Heilbronn Fellow in Mathematics
Research Focus: Algebraic Combinatorics

Dr. Jonathan Rawlinson
Teaching Fellow in Mathematics
Research Focus: Mathematical Physics

Soinbhe Nic Dhonncha
PhD Student
Research Focus: Representation Theory

Kai Prince
PhD Student
Research Focus: Ergodic Theory

University of Manchester Academic Panel

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Student Abstracts

Keith Nicholas Gironella

Differential rings and the Ritt-Raudenbush basis theorem

The theory of commutative rings has been essential in the development of pure mathematics over the centuries, for example applications to algebraic number theory and algebraic geometry. In this talk, we will discuss commutative rings equipped with an additive homomorphism $\delta : R \to R$, that follows the Leibniz product rule, $\delta(ab) = a\delta(b) + \delta(a)b$ called differential rings. Definitions are first stated to gain an understanding of how they work and various lemmas concerning division and remainders are provided. The ideals of differential rings and their properties are then introduced, which culminate in the Differential Basis Theorem by Ritt and Raudenbush.

Riccardo Ali

Different flavours of "sameness": a categorical perspective

Why do linear maps and matrices behave in exactly the same way? How is studying the fundamental group of a space the same as studying the topology of the space itself? Category Theory offers a framework to make these intuitions precise by adjusting the strictness of the notion of "sameness". In this talk, we will introduce the main concepts of Category Theory and many examples that showcase its power in formally encoding our "natural" intuition. Despite being traditionally used in pure Mathematics, the generality of its language made Category Theory popular in some applied domains as well, such as Machine Learning, for example in *natural* graph networks, or theoretical computer science and theory of programming languages.

Mateusz Salamon

Tensor networks: a graphical tool for physics and beyond

Having a visual way of thinking about mathematical objects and operations can often help in gaining a deeper insight into the structure of what is calculated. It might also lead to discovering new techniques of simplifying some calculations. Possibly one of the most striking examples are the famous Feynman diagrams used in particle physics. The idea of visualising mathematical objects has also been applied in physics to tensors – generalisations of matrices to higher dimensions – resulting in the development of tensor networks. Associated with tensor networks is the so-called diagrammatic notation, which makes thinking about highdimensional tensors easy and intuitive.

In my talk I would like to introduce you to the ideas and notation behind tensor networks, where these ideas came from and in what other areas they might be applicable. In particular, I will focus on Matrix Product States (or Tensor Trains), which allow for efficient representations of high-dimensional tensors as a series of many smaller ones. The technique has seen a lot of success in quantum information or condensed matter physics and has recently also attracted interest from the machine learning community.

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Student Abstracts

Jess Watson

Fractals and Geometry in Architecture

A lot of architecture is inspired by nature, we reference its forms to create a familiar surrounding in the man-made world. Nature manifests in an irregular, fractal-like way so it's no surprise that fractal-like geometry appears in architecture in order to recreate the complex patterns found in nature. Fractals appear on a smaller scale in modular construction and inthe tectonics and structure of buildings, but can also be seen on a larger scale in the organisation of complex structures such as cities and the diffusion algorithms for cartographic systems. The use of fractals in design engages with an emotional connection to space and nature that humans naturally seek. Natural patterns also have various health benefits and appeal on a humanistic scale. This talk will present a fractal analysis of significant architectural buildings such as Munich Olympiastadion, Gaudi's La Sagrada Familia, Tom Beddards fantasy architecture, and SOM Mumbai Airport Canopy and the importance of these geometries in design.

Ugne Milasiunaite

What can a collaboration network tell us?

Science is a social endeavour. Unsurprisingly, social scientists have been analysing how researchers work together to drive innovation and achieve success. They ask questions such as: how fractured or well-connected is the field? Who is the most influential scientist, and how do we measure this? Is she the most collaborative? Maybe someone who regularly works with other respected researchers? Perhaps he works with the most diverse set of people within the field? Although arguing which measure best approximates influence is outside the realm of computational sciences, we can try to put numbers to these questions. To do this, we will look at the collaboration graph - a type of social network. We will consider various measures proposed by network scientists, and by doing so, we will learn about complex network analysis, which has applications in many different areas, including but not limited to anthropology, environmental sciences, and biology.

Jakub Stavina

Spacetime as a mathematical structure

The concept of spacetime is central modern theoretical physics. In this talk, we will take an informal approach to understanding spacetime as a mathematical structure, drawing on our intuitions about Newtonian mechanics. As we explore the structure of spacetime, we will encounter fascinating areas of mathematics, including topology, differential geometry, and algebra. We will consider the philosophical implications of thinking about spacetime from the perspective of these fields of study. Throughout the talk, we will highlight the benefits of having precise mathematical formulation of seemingly vague concepts, and we will explore the extraordinary interplay between mathematics and physics which arises once effort is made to understand the suitable mathematical structure. This talk aims to provide attendees with a deeper appreciation of the role that mathematical physics plays in our understanding of the physical world

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Student Abstracts

Daniel Chiang

Causal abstraction

A causal abstraction of a system is a low dimensional summary that throws out most information about the system yet maintains the ability to make accurate predictions. Consider the full state of the solar system: It consists of the position and momentum of every single atom of each planet. However, just by keeping track of a small number of variables such as the mass and center of mass of each planet, we can predict planetary motion with substantial precision.

As intelligent agents, we are a part of this universe. This entails that our brains cannot contain all information about the current state of the world: A map cannot tell you everything about the territory if it's contained within it. As a result, we must navigate using incomplete models, and this can be successful only if our models are good abstractions with respect to the factors we care about.

Causal abstractions highlight universal properties of intelligent agents regardless of whether they're implemented on a biological or digital substrate. This makes it a suitable tool for reasoning about future artificial intelligence system, and opens up potential directions for aligning transformative AIs.

Jonty Male

Operational research in conflict

Humans have been fighting with each other since the beginning of recorded history, and we have used mathematics to understand and improve our ability to do so. Have the same patterns and rules always applied? Do just humans follow these rules? How can we use the mathematics created for combat to understand other conflicts, ecosystems, and even workplaces?

Jerry Bard

Demystifying Fortune's formula

This talk will describe, motivate, and explore one of the most important developments to risk management within quantitative finance: fortunes formula. Fortunes formula, or more formally known as the Kelly criterion, describes a way to size a position in face of a favorable edge (or a betting game with a positive expectation). For instance, one could use the Kelly criterion to size a position of an investment in a portfolio or a bet in gambling games. The talk will include motivation of the Kelly criterion with a simple binomial game of coin tossing, include a thorough quantitative and qualitative discussion of the importance of risk management, will describe the criterion along with notable historical influences, and finally make the criterion operational to participants with a discussion of the models' assumptions. Participants will also be left with a Jupyter Notebook that will enable them to implement the criterion on their own time with further resources to enrich their understanding of the criterion after the presentation.

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Student Abstracts

Robin Lyster

PageRank and beyond: Ranking every page on the web

Every time you enter a search query into Google, millions of relevant results are returned in order of importance, almost magically, in a fraction of a second. Considering there are over 50 billion web pages on the internet, you may be wondering: how on Earth does Google Search work so quickly yet so effectively? The answer is, as is often the case, an incredibly complex and very closely guarded secret that earns Google billions of dollars every year, but at its core lies the PageRank algorithm.
In my presentation, I will dive into the world of information retrieval, and explain the mathematical basics of PageRank and the ingenuity of what exactly happens every time you make a search query. However, you may be wondering if such a powerful algorithm could have other applications elsewhere. I will also be exploring other ways PageRank could be used, including finding the most important page on Wikipedia (and what that even means). I hope to see you at the MIMUC!

Rebecca Maver

B-splines and solving the Schrödinger equation

Curve fitting has been an essential tool for centuries and now the draftsman's spline has found its way into quantum mechanics. In this talk I introduce and define splines, a powerful mathematical tool that breaks down complex curves into simpler connected curves, making it more manageable and malleable. A particularly useful spline is the B-spline, with unique characteristics that make it ideal for developing a basis set from which functions can be approximated. We will explore the properties of B-splines and the recurrence relation that forms them. B-splines have a vast number of applications across mathematics, with this talk zooming in on uses in atomic physics. Specifically, we will use B-splines to approximate the radial wave function of atoms and ultimately provide a new method to solve Schrodinger's equation.

William Zhang

Convex programming with CVXPY

Optimization generally deals with finding an ideal solution for a given problem. This often comes in the form of finding a minimum or maximum for an equation with some contraints. Convex optimization is a field of mathematics that specializes in finding the minimum of convex functions. Naturally one might ask, what is a convex function and why would you want to optimize them? During the first half of this talk, we will get a brief overview of convexity and its crucial role in optimization, along with general rules to determine convexity.
CVXPY is a python library that allows users to solve optimization problems in a simple and efficient manner. In the second half, we will dive into how CVXPY works and some applications of convex optimization will be shown using code snippets. If time permits, a short example of a new feature in progress for CVXPY will be shown, namely adding support for complex convex problems. Finally, resources about convex analysis for further learning will be provided.

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