UNIVERSITY OF CAMBRIDGE

Cambridge Mathematics Placements (CMP) Presentation Day
Wednesday 23 August 2023, Centre for Mathematical Sciences

Tea & Coffee (Central Core), 10:30 - 11:00

	Meeting Room 12	Meeting Room 4	Meeting Room 3
11:00	**Magnetic Flux Concentration in Protoplanetary Disks** *Teresa Su, Astrophysical Fluid Dynamics and Nonlinear Dynamics (DAMTP)*	**Modelling diffusion through plant cells** *Lianne Liu, Sainsbury Laboratory Cambridge University*	**Data Driven Decision Frameworks for Multimodal High Content Data** *Francis Wang, GSK*
11:20	**Science Communication at the Institute of Computing for Climate Science** *Aleksandra Higson, ICCS (DAMTP)*	**Microtubule alignment in 3D simulations** *Harry Chen, Sainsbury Laboratory Cambridge University*	**Time Series Modelling and Forecasting of Epidemics using Leading Indicators** *Thomas Chen, Judge Business School*
11:40	**Cosmological Collider Physics** *Okasha Uddin, High Energy Physics (DAMTP)*	**Modelling tree growth responses to climate change** *Yishui Sun, Department of Geography & Sainsbury Laboratory Cambridge University*	**Statistical methods for estimating chemical bioaccumulation in fish** *Nikita Khomich & Shreyas Pandit, Unilever SEAC*
12:00		**Classification of Single Molecule Trajectories** *Eddy Guo, MRC-LMB and PDN*	*The above talk continues until 12:20*

Lunch (Central Core), 12:30 - 13:50

	Meeting Room 12	Meeting Room 4	Meeting Room 3
13:50	**Differentially private synthetic data** *Nikolija Bojkovic, Statistical Laboratory (DPMMS)*	**Polyhedral molecules** *Elvar Wang Atlason, Yusuf Hamied Department of Chemistry, Nitschke Group*	**Variability in the assessment of flower bouquets** *Charlie Clarke, APEX Horticulture*
14:10	**Realizability of Tropical Curves via Hurwitz Theory** *Mia Lam, Algebraic Geometry (DPMMS)*	**Formalising Puiseaux Series in Isabelle/HOL** *Artie Khovanov, Department of Computer Science and Technology*	**Si/SiC crystal representation for Monte Carlo simulation of implantation** *Matas Urbonas, Silvaco*
14:30	**Investigating the synchronisation of Quasi-Biennial Oscillation of zonal winds from ozone forcing** *Madeleine Heideman, Atmosphere-Ocean dynamics (DAMTP)*	**Formalisation of the Polygonal Number Theorem on Isabelle/HOL** *Zhengkun Ye, Department of Computer Science and Technology*	**Multiple-instance-learning-based detection of coeliac disease in histological whole-slide images** *Gift Mungmeeprued & Dan O'Herlihy, Lyzeum Ltd / Department of Pathology*

Tea & Coffee (Central Core), 15:00 - 15:30

	Meeting Room 12	Meeting Room 4	Meeting Room 3
15:30	**Preparing a Tridiagonal Skew-Hermitian Differentiation Matrix on the Real Line** *Philipp Wiedemann, Numerical Ananlysis (DAMTP)*	**Simulating Boson Sampling** *Tamsin Sandhu, ORCA Computing*	**Forecasting Energy Prices** *Keval Gandhi, Tierra Underwriting*
15:50	**Polynomials with many rational preperiodic points** *Aaron Kim, Mara-Ioana Postolache, & Vivian Szeto, Number Theory and Algebra (DPMMS)*	**Analysis of performance and energy efficiency of four supercomputers in Cambridge** *April Xu, Cambridge Open Zettascale Lab*	**Revealing the biological significance of graph embeddings** *Conor Rajan, Novo Nordisk Research Centre Oxford*
16:10	*The above talk continues until 16:30*	**Reproduction of a particular art form** *Zhimei Liu, Anglo Scientific Ltd and Dazlus AG*	**Reasoning, causal, and embedding approaches on Biomedical KG for the identification of alternative candidates** *Lawrence Phillips, Novo Nordisk Research Centre Oxford*

CMP programme review and feedback seminar (Meeting Room 4), 16:45
Philippa Fawcett & Cambridge Mathematics Open Internships review and feedback seminar (Meeting Room 12), 16:45

CMP Presentation Day Dinner (Christ's College),
Drinks from 19:00 for dinner at 19:30

Meeting Room 12, 11:00am - 12:30am

11:00am

UNIVERSITY OF CAMBRIDGE
Department of Applied Mathematics and Theoretical Physics
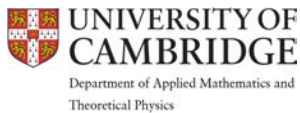
Teresa Su

Magnetic Flux Concentration in Protoplanetary Disks

Protoplanetary disks are the nurseries for planets, and their evolution is governed by a set of complex magnetised dynamics. In this project, we analysed such dynamics to explore the magnetic flux concentration that occurs in weakly ionised disks. In particular, we compared the turbulent properties, and energy spectra of two vastly different models to gain an insight into their distinct evolutionary journeys.

11:20am

Institute of Computing for Climate Science

Aleksandra Higson

Science Communications at the Institute of Computing for Climate Science

Have you ever wondered if your research has impact? This talk is about my experience as a science communicator for the Institute of Computing for Climate Science. I go through my thought processes as I piece together relevant bits of information that help bring the science to life. I include my take on communicating research effectively, the promotion of events and how I have attempted to increase ICCS visibility and reach.

11:40am

UNIVERSITY OF CAMBRIDGE
Department of Applied Mathematics and Theoretical Physics
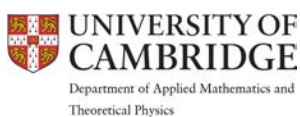
Okasha Uddin

Cosmological Collider Physics

The inflationary period of early cosmology provides a regime of extremely high energy processes that could prove to be a promising window for observing new physics beyond what our particle accelerators on earth can probe. A formalism is developed which allows us to place consistency constraints on the Lagrangian/dynamics of matter during this epoch. We cover some examples, learning quantum field theory on curved spacetime along the way!

Meeting Room 12, 1:50pm - 3:00pm

1:50pm
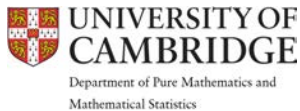
Nikolija Bojkovic

Differentially private synthetic data

We live in an era where it is increasingly important to preserve data privacy. How can we understand important things from data without revealing who the data belongs to? That's where differential privacy comes in. But what makes this technique so special?

2:10pm

Mia Lam

Realizability of Tropical Curves via Hurwitz Theory

Tropical geometry takes objects of algebraic geometry as input, such as Riemann surfaces, and outputs objects of combinatorics, such as finite graphs with additional structure. This project is about understanding the inverse problem: which objects can be realized via algebraic geometry?

2:30pm
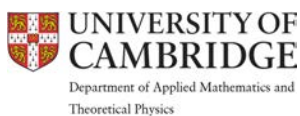
Madeleine Heideman

Investigating the synchronisation of Quasi-Biennial Oscillation of zonal winds from ozone forcing

The Quasi-Biennial Oscillation of wind is regarded as the heartbeat of the stratosphere. Atmospheric dynamics drive feedback in ozone and temperature, and we want to produce climate models that accurately represent these interactions. We're investigating the mathematics of why some climate models struggle with describing the relationship between the oscillations of both wind and ozone.

Meeting Room 12, 3:30pm - 4:30pm

3:30pm

Philipp Wiedemann

Preparing a Tridiagonal Skew-Hermitian Differentiation Matrix on the Real Line

There is a robust theory on the convergence of series of functions on compact intervals, but not on the whole real line. This is an issue, especially since quantum theory tells us that it is unphysical to limit particles to a confined space, but this is exactly what most modern numerical methods do. Here we make a first step by finding bases supported on R with properties useful for the study of differential equations.

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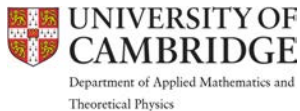
3:50pm

Aaron Kim, Mara-Ioana Postolache, & Vivian Szeto

Polynomials with many rational preperiodic points

We present some recent progress in finding a lower bound on the number of rational preperiodic points of rational polynomials. We show the lower bound is close to optimal for the special family of polynomials considered. We also consider a family of two-dimensional Henon maps, where we found surprisingly long cycles.

The above talk continues until 4:30pm

UNIVERSITY OF CAMBRIDGE
Department of Pure Mathematics and Mathematical Statistics

Meeting Room 4, 11:00am - 12:30am

11:00am

Lianne Liu

Modelling diffusion through plant cells

Plant tissues are built of rigidly connected cells which comes in all kinds of configurations, including four or three way junctions as well as adopting different shapes. This project studies the potential difference in these setups regarding cell to cell communication.

11:20am

Harry Chen

Microtubule alignment in 3D simulations

Microtubules are thin, stiff protein filaments within cells which form part of the cytoskeleton in eukaryotic cells. In plants, they play an important role in morphogenesis via controlling the anisotropic growth in cells. The behaviour of microtubule arrays is highly dynamic and exhibit a high levels of self-organization. We use a simulation software to investigate the behaviours of microtubules under different conditions using an agent based model.

11:40am

Yishui Sun

Modelling tree growth responses to climate change

Tree growth is typically considered as a direct function of photosynthesis. In this project, however, we reassess this approach by focusing more on the process of growth itself, mainly considering the effect of temperature, atmospheric CO_2 concentration, daylength, and soil moisture. We are also growing small trees in growth chambers and in the field, measuring them, and developing and testing model approaches to simulate their growth dynamics.

12:00am

Eddy Guo

Classification of Single Molecule Trajectories

My presentation delves into the challenge of classifying single-molecule trajectories, offering insights into transcription factor mechanisms within cell nuclei. I will present five distinct classification approaches, including how to use the Hurst exponent estimates to classify trajectories. An adaptive version of the Benjamini and Hochberg procedure to do multiple testing will also be presented.
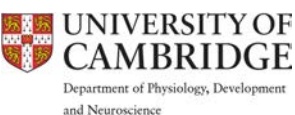
Meeting Room 4, 1:50pm - 3:00pm

1:50pm

UNIVERSITY OF CAMBRIDGE | Yusuf Hamied Department of Chemistry

Elvar Wang Atlason

Polyhedral molecules

Polygonal molecular building blocks will self-assemble into polyhedra, similar to viral capsids. This has potential applications in drug delivery and purification of chemicals. We will look at the geometric and topological principles underlying these systems.

2:10pm

UNIVERSITY OF CAMBRIDGE | Department of Computer Science and Technology

Artie Khovanov

Formalising Puiseaux Series in Isabelle/HOL

Puiseaux series over real closed fields (RCFs) are an important tool in computational real algebraic geometry. I am working on formalising the theory of Puiseaux series over an RCF in Isabelle/HOL, a proof assistant, primarily by transferring previously-formalised work to my context. My talk will focus on what it's like to formalise definitions and theorems in Isabelle/HOL.

2:30pm

UNIVERSITY OF CAMBRIDGE | Department of Computer Science and Technology
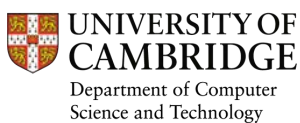
Zhengkun Ye

Formalisation of the Polygonal Number Theorem on Isabelle/HOL

This presentation delves into Isabelle/HOL, an interactive proof assistant, explaining its functions and applications. It introduces the classical result Polygonal Number Theorem in number theory and concludes with an examination of the advantages of formalisation. In the end, there will be a brief discussion of the future for mathematicians through the aid of increasingly powerful AI tools.

Meeting Room 4, 3:30pm - 4:30pm

3:30pm

Tamsin Sandhu

Simulating Boson Sampling

Boson sampling is a form of non-universal quantum computing and has some very interesting potential applications. Simulating boson sampling is at the heart of understanding those potential applications and what level of quantum advantage boson sampling provides. This talk will give a brief overview of boson sampling and some of the methods of simulating it.

3:50pm

April Xu

Analysis of performance and energy efficiency of four supercomputers in Cambridge

I examined how runtime and energy-to-solution is related on four HPC clusters (Skylake, Cascade Lake, Icelake and Sapphire Rapids) provided by the CSD3 service at the University of Cambridge. The analysis revealed that in terms of runtime, researchers would gain advantages by transitioning to the next generation. However, regarding energy efficiency, the decision depends on the specific research domain and the group's consideration of energy consumption sensitivity.

4:10pm

Zhimei Liu

Reproduction of a particular art form

My project is about creating new portraits in the style of the artist Tobias Gutmann. The methods I used include performing style transfer techniques such as Dual StyleGAN, and building convolutional neural network model to categorise dataset.

Meeting Room 3, 11:00am - 12:30am

11:00am

GSK

Francis Wang

Data Driven Decision Frameworks for Multimodal High Content Data

In order to find the top-tier chemicals curing the targeted disease, professionals expect to select compounds carrying certain toxicophore to function effectively (distinctness) and consistently in different biological environment (reproducibility). This project focuses on adapting the current metric for measuring distinctness and metric to reduce misidentifications (Type-I error) and omissions (Type-II error).

11:20am

UNIVERSITY OF CAMBRIDGE
Judge Business School

Thomas Chen

Time Series Modelling and Forecasting of Epidemics using Leading Indicators

Predicting cases and deaths of an epidemic in real-time is a crucial task and a valuable asset for policymakers. Tsgc, an R-package in development, utilises a simple time series model capable of making reliable predictions within short time frames, adapting to additional waves, and integrating data from leading indicators to improve its accuracy. It also holds potential applications in many fields beyond healthcare.

11:40am

Unilever

Nikita Khomich & Shreyas Pandit

Statistical methods for estimating chemical bioaccumulation in fish

Mathematical and statistical models play an increasingly important role in the area of Environmental Risk Assessment as they facilitate the use of in-vitro-based approaches to support safety decisions. In this talk, we discuss two statistical approaches to predicting chemical bioaccumulation in fish: one using hierarchical Bayesian modelling and another using machine learning methods on data from chemical descriptors.

The above talk continues until 12:20

Meeting Room 3, 1:50pm - 3:00pm

1:50pm

APEX
HORTICULTURE

Charlie Clarke

Variability in the assessment of flower bouquets

APEX Horticulture have been performing simulations of different flower varieties under retail conditions, given the past 5 years of subjective & qualitative observations from the assessment, I go through different methods I used to visualise and quantify the variability between different assessors.
Which areas need improvement?
What recommendations can be made to the team?

2:10pm

SILVACO

Matas Urbonas

Si/SiC crystal representation for Monte Carlo simulation of implantation

In this talk, I will introduce the physical process of ion implantation, a way it can be efficiently modelled for computer simulations, and show the patterns obtained using said method for Si and 4H-SiC crystal structures in different orientations.

2:30pm

UNIVERSITY OF
CAMBRIDGE
Department of Pathology

Lyzeum Ltd

Gift Mungmeeprued & Dan O'Herlihy

Multiple-instance-learning-based detection of coeliac disease in histological whole-slide images

Coeliac disease is an autoimmune condition that affects 1% of people in the UK, yet only a third are diagnosed. In this talk, we look at novel applications of machine learning techniques to achieve automated diagnosis.

Meeting Room 3, 3:30pm - 4:30pm

3:30pm

Keval Gandhi

Tierra Underwriting

Tierra Underwriting is an insurance firm specialising in facilitating projects that help with the Green Transition. As part of this they need to be able to assess the risk in the energy markets and predict the long-term trends in electricity prices. This presentation provides background information about the energy markets and discusses how I explored the energy forecasting problem using Gaussian Process Regression.

3:50pm

Conor Rajan

Revealing the biological significance of graph embeddings

Graph embeddings are being used increasingly in the biomedical field for various prediction and discovery tasks, but there has been little work on verifying the quality of these embeddings. In this presentation I will propose a statistical test for verifying the significance of these embeddings.

4:10pm

Lawrence Phillips

Reasoning, causal, and embedding approaches on Biomedical KG for the identification of alternative candidates

A key issue in drug discovery is finding alternative drug-target candidates for an initial candidate that despite having relevant support does not have a suitable druggability profile. In this presentation, we walk through the computational approaches we used to contextualise the candidate, find alternative ones, and hypothesize a mode of action (MoA) for the candidate for experimental validation. Specifically, starting with BACH2 as Proof-of-Concept drug-target candidate with a non-ideal druggability profile. We built a workflow that first uses the deep learning method called iDPath, which uses a multi-layer biomedical KG. With iDPath we explore neighbourhood of BACH2 to identify alternative candidates. Then we use a causal approach called QuaternaryProd, which identifies the directionality of regulation in a disease state given as input a set of differentially expressed genes. Finally, we use the embedding analysis package BioteQue, which identifies biological associations between two variables thereby revealing potential novel functions for the alternative candidates.