Durham University

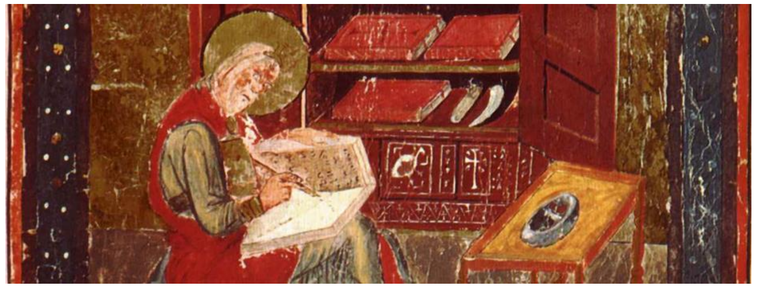
Mathematics at Durham

June 2025

Who are we?

Durham University

A seat of learning since the seventh century …



Durham University

The Department of Mathematical Sciences

Academic Staff

- 116 permanent faculty (↑↑)

Research Staff

- 23 postdoc researchers & fellows (↑)

Postgraduate Students

- 95 PhD students (↑)
- 47 MSc students (↑)

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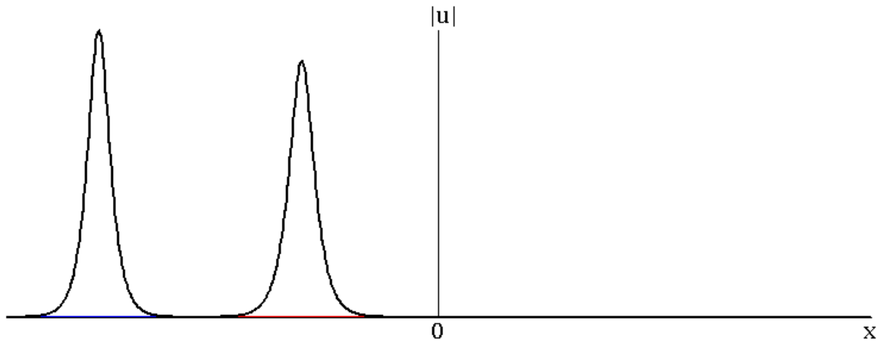
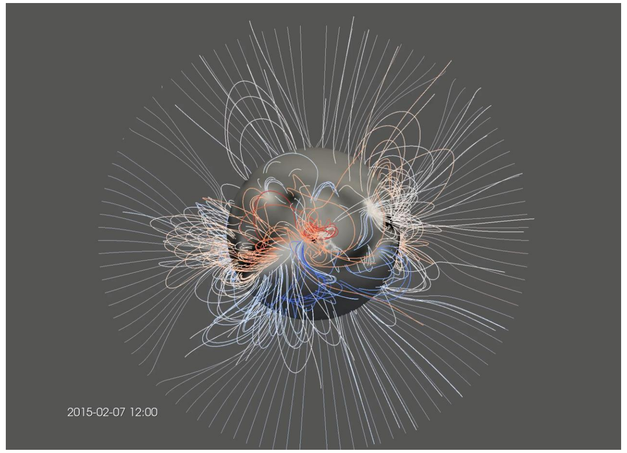
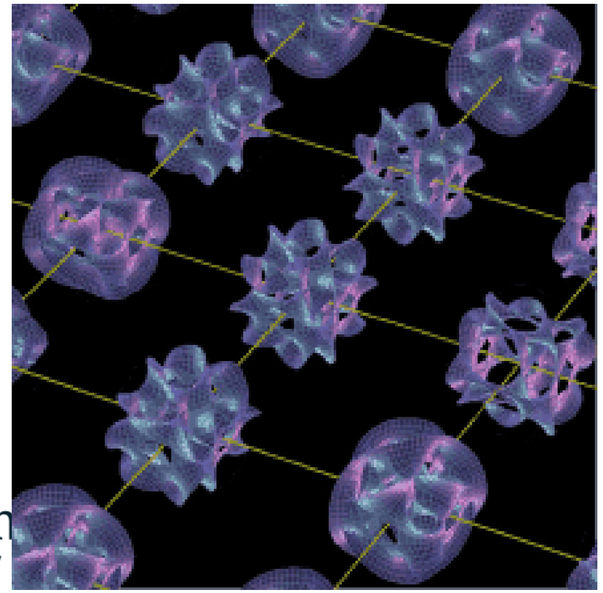
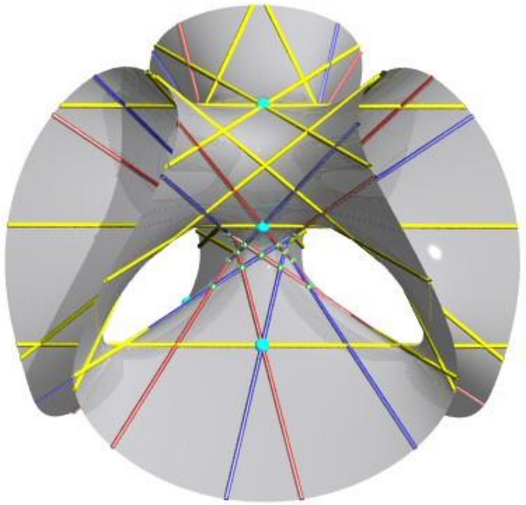
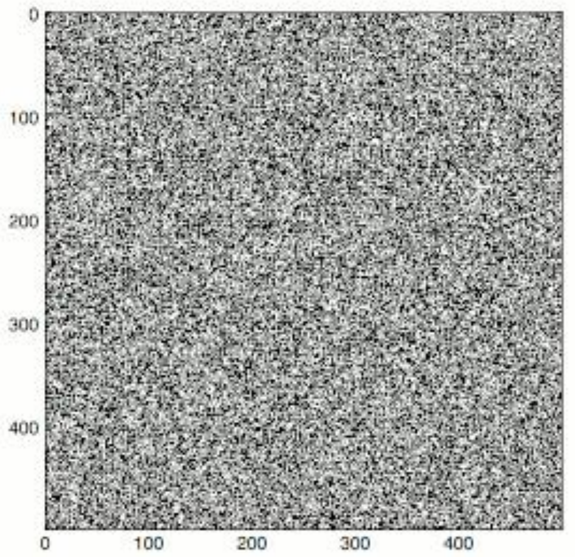
Research











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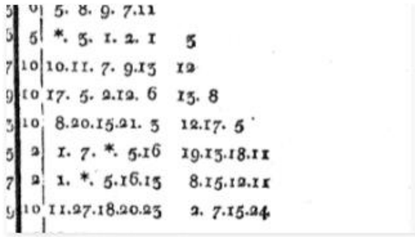
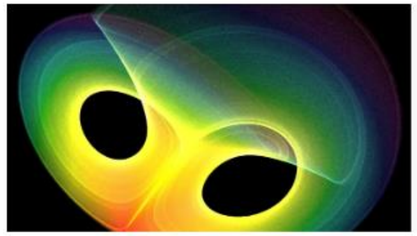


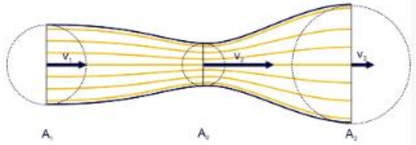
Algebra & Number Theory

Algebra studies mathematical structures that behave like but are not limited to the integers. Number theory studies integers and mathematical objects made from them.



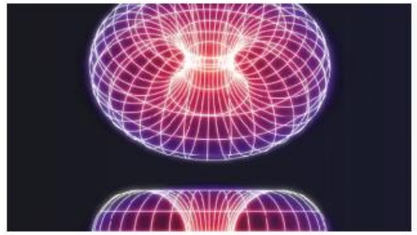
Analysis

The unifying theme among the members in this group is the use of analytic tools to study topics in analysis and its interactions with other areas of mathematics.



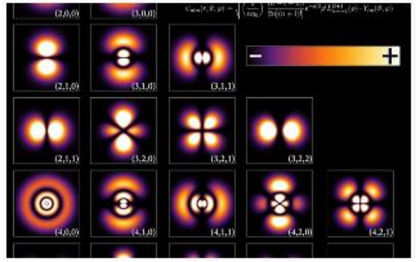
Applied Mathematics

We study fluids (astrophysical, biological, and geophysical) and biological phenomena using asymptotics, scientific computing, nonlinear dynamics, and applied topology.



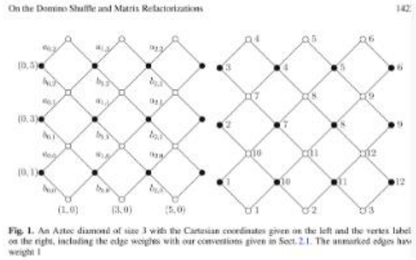
Geometry & Topology

The Geometry and Topology group have a wide range of interests including: aperiodic tilings cluster algebras complex geometry computational topology and...



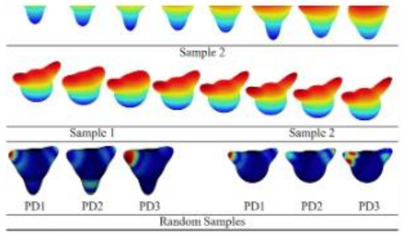
Mathematical & Theoretical Particle Physics

Our research activities fall into the broad categories of quantum field theory, string theory and gravity, cosmology and solitons in field theory.



Probability

Our areas of interest include stochastic processes, complex stochastic systems and phase transitions, and random structure and geometrical probability.



Statistics

Our interests range from statistical methodology and computation, to substantive applications in many different fields.

Education and Pedagogy

The mathematical sciences department has an active education group who do outreach, research, and hold a regular reading group to support staff

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Research

The Departmental Environment

- **Durham University Mathematical Society (@dumathsoc)**
  - Student run society; annual membership for only π GBP!
  - Colloquium series in collaboration with the maths faculty
  - Regular social events & formals (Christmas formal & joint ball w/ Physics Soc)
- **Durham University Women in Maths Society (new for 2024)**
- **Student Experience & EDI Committees**
- **First Generation Scholars Network** (student & staff members, events each term)

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The University Environment

- Durham has many many societies and clubs
- https://www.durhamsu.com/groups
- If you like any sport at all Durham has you covered (Sports Uni of the year 2023)

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The University Environment

- Vibrant nightlife — plus college formals

Durham University

Our undergraduate students (your colleagues)

- Around 275 maths undergraduates per year
- High average UCAS entry tariff (typically 3rd-5th highest nationally!)
- 80% State / 20% Independent School
- 30% Female / 70% Male
- 10% International / 90% UK

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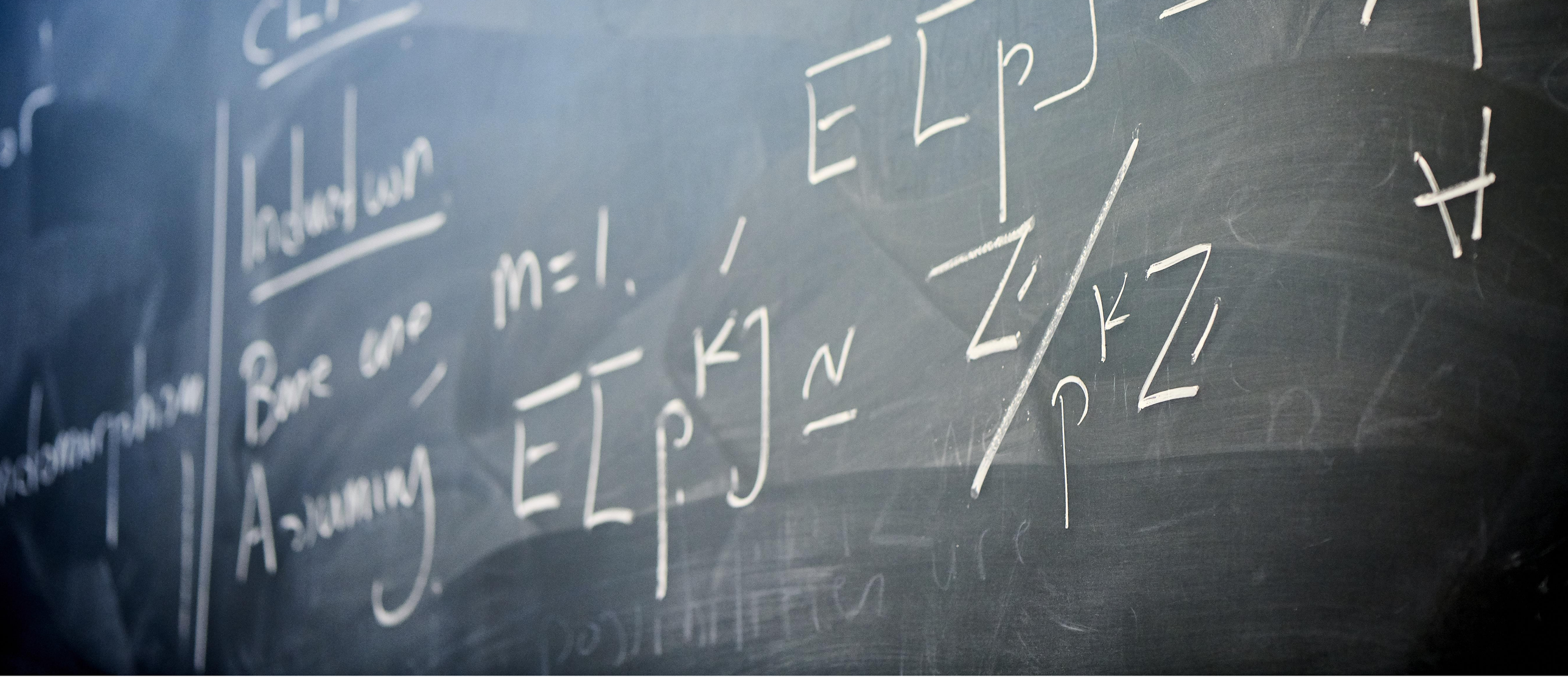

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Degree programmes

Many Degree options!

- **G100** Maths / **G111** Maths + Stats: 3 year BSc
- **G103** Maths / **G114** Maths + Stats: 4 Year MMATH

} Apply for one of these for straight Maths

- Placement Degrees **G108**
- MMATH (Year Abroad) **G101**
- BSc (Year Abroad) **G109**

} Can transfer to one of these

- Typically would transfer in at the end of Year 1
- May need language requirement for study at a European University
- involve spending Year 3 away from Durham (except Natural Sciences and joint honours)

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Many Degree options!

- Natural Sciences, joint **Maths + X degrees**
- In these degrees you share the content with another subject (X = Physics, Chemistry, Economics etc)
- All the Maths modules are the exact same modules the straight Maths students take

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6 modules per year - First Year of Maths

Core Modules:

- Calculus 1
- Linear Algebra 1
- Analysis 1
- Programming+Dynamics
- Probability+Statistics

One Elective Module:

- Discrete Maths
- Modules from other Departments

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2nd Year (Maths)

2 Core (compulsory) Modules:

- Complex analysis
- Mathematical Methods

then choose 2 from …

- Algebra
- Computational Maths
- Statistical Inference

and 2 from …

- Data science & statistical modelling
- Methods of Mathematical Physics
- Probability

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2nd Year (Maths + Stats)

3 Core (compulsory) Modules:

- Statistical Inference
- Data science & statistical modelling
- Mathematical Methods

then choose 1 from …

- Algebra
- Computational Mathematics

and choose 2 from …

- Complex analysis
- Methods of Mathematical Physics
- Probability

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3rd Year

	Applied	Probability	Pure	Statistics
Mutually exclusive lists	MATH3XX1 General Relativity III MATH3231 Solitons III	MATH3251 Stochastic Processes III MATH3301 Mathematical Finance III	MATH3XX1 Galois Theory, Groups & Geometry III MATH3XX1 Number Theory III	MATH3411 Advanced Statistical Modelling III MATH3421 Bayesian Computation & Modelling III
Main list (no exclusions)	MATH3101 Fluid Mechanics III MATH3171 Mathematical Biology III MATH3111 Quantum Mechanics III MATH3481 Mathematics into Schools III	MATH3141 Operations Research III MATH3XX1 Group Project III	MATH3XX1 Codes & Knots III MATH3021 Differential Geometry III MATH3291 Partial Differential Equations III MATH3XX1 Analysis & Topology III MATH3XX1 Individual Project III	MATH3071 Decision Theory III MATH3431 Machine Learning & Neural Network III MATH3452 Internship Project III

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4th Year

	Applied	Probability	Pure	Statistics
Mutually exclusive lists	MATH4271 Superstrings IV MATH4XX1 Geometry of Mathematical Physics IV	MATH4431 Advanced Probability IV MATH4261 Stochastic Analysis IV	MATH4171 Riemannian Geometry IV MATH4161 Algebraic Topology IV	MATH4391 Nonparametric Statistics IV MATH4341 Spatio-Temporal Statistics IV
Main list (no exclusions)	MATH4411 Advanced Mathematical Biology IV MATH4421 Geophysical & Astrophysical Fluids IV MATH4XX1 Quantum Field Theory IV MATH4231 Statistical Mechanics IV	MATH4072 Project IV	MATH4371 Functional Analysis & Applications IV MATH4151 Topics in Algebra & Geometry IV MATH4241 Representation Theory IV MATH4281 Topics in Combinatorics IV MATH4352 Internship Project IV	MATH4XX1 High Dimensional Statistics & Deep Learning IV MATH4XX1 Uncertainty Quantificat'n & Clinical Trials IV

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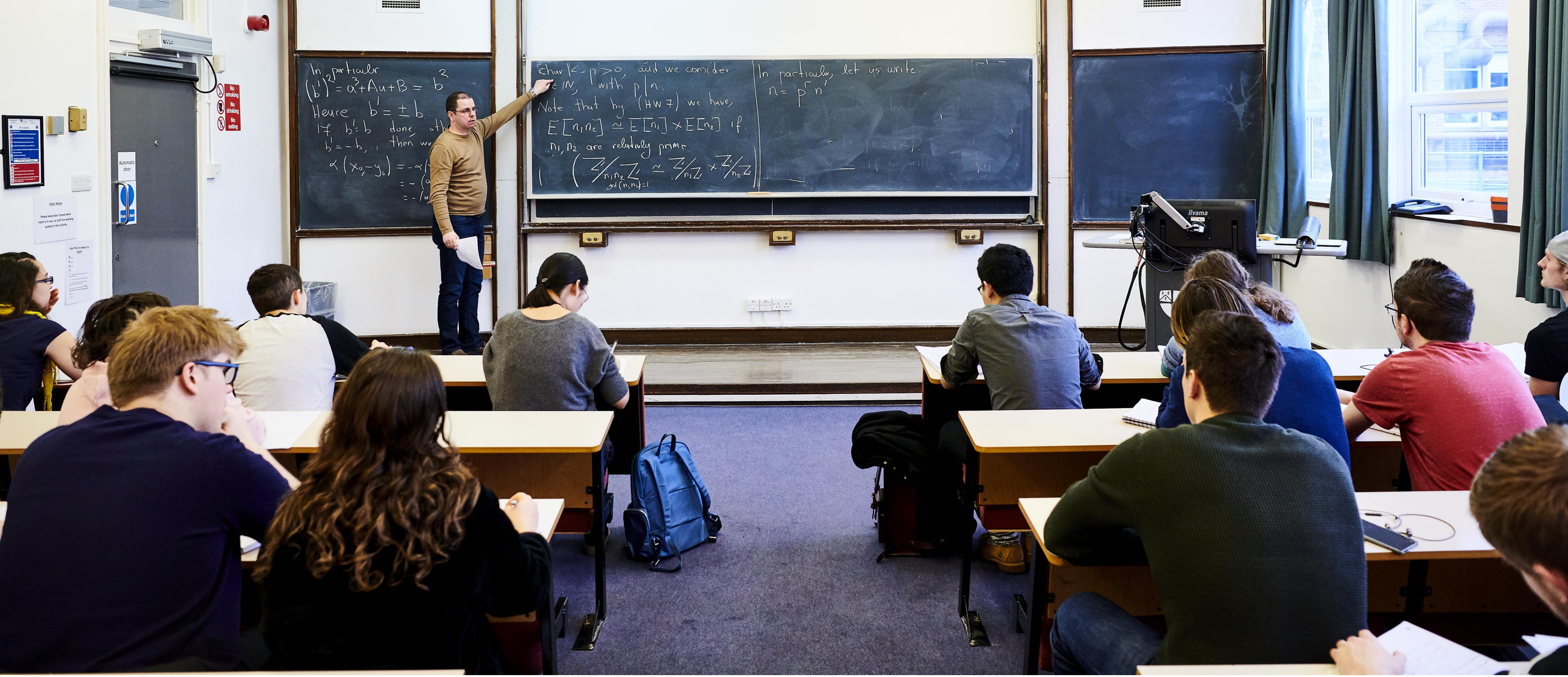

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Teaching & Learning

The Academic Year

MICHAELMAS Term (10 Weeks)

(Lectures - Tutorials - Assignments)

EPIPHANY Term (10 Weeks)

(Lectures - Tutorials - Assignments)

EASTER Term (9 Weeks)

(2 weeks Revision - 4 Weeks Exams -

3 Weeks post exam activities)

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Lectures

Most modules contain 40 or 50 lectures; 2 or 3 lectures per week

50 minutes long, typically with some recap of previous material

Most popular style is “chalk and talk”, some involve slides or interactive activities

“Live lectures” typically complement more detailed typed or handwritten notes

Textbooks usually as references materials or for further reading

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Example — the Simple Harmonic Oscillator

The Hamiltonian for 1D SHO is

$$\hat{H} = \frac{\hat{p}^2}{2m} + \frac{1}{2} m\omega^2 x^2 \qquad -17.6$$

This is a bound system

These is a very neat method of determining the energy spectrum of such systems called creation and annihilation operators, or "ladder" operators

First let's show that energies are positive.

$$\langle \psi | \hat{H} | \psi \rangle > 0 \quad \forall \ |\psi\rangle \neq 0 \qquad -17.7$$

Consider an arbitrary self-adjoint operator $\hat{A} = \hat{A}^\dagger$

then $$\langle \psi | \hat{A}^2 | \psi \rangle = \langle \psi | \hat{A}^\dagger \hat{A} | \psi \rangle = \sum_a \langle \psi | \hat{A}^\dagger | a \rangle \langle a | \hat{A} | \psi \rangle$$
$$= \sum_a |a|^2 \, |\langle \psi | a \rangle|^2 \geq 0$$

But $$\langle \hat{H} \rangle = \left\langle \frac{\hat{p}^2}{2m} + \frac{1}{2} m\omega^2 \hat{x}^2 \right\rangle = \frac{\langle \hat{p}^2 \rangle}{2m} + \frac{1}{2} m\omega^2 \langle \hat{x}^2 \rangle > 0$$

Outline
"live lecture notes"

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Typed course notes

- More detailed
- Contains full course content

Definition 2.3 *Let $\Omega \subseteq \mathbb{R}^n$ be an open set, and $\psi : \Omega \to \mathbb{C}$ be a function. Then ψ is a test function if:*

(i) $\psi \in C^\infty(\Omega)$, i.e. ψ has finite derivatives of all orders on Ω (smoothness)

(ii) the support of the function ψ, i.e. the closure of the set of points in which the value of ψ is not zero, is compact. We denote the support of ψ by,

$$\operatorname{supp}\psi = \overline{\{\mathbf{x} \in \Omega \,|\, \psi(\mathbf{x}) \neq 0\}}.$$

The space of test functions on Ω is denoted $\mathcal{D}(\Omega)$.

Remark 2.4 Since $\operatorname{supp}\psi$ is closed by definition, and since the closed bounded subsets of a Euclidean space are precisely those subsets which are compact, it is enough to ask for the support to be bounded. □

So test functions are smooth functions, which means that they guarantee a trouble-free ride through the theory of distributions, in particular because all their derivatives are also test functions. But do they exist? The answer is yes, however we never need to know much more than the fact they exist: they are a background tool. Here is an example.

Example 2.5 The bump function is the prototype example of a test function in one dimension. It is defined as

$$\Psi(x) := \begin{cases} e^{-1/(1-x^2)} & \text{for } |x| < 1 \\ 0 & \text{else} \end{cases}$$

and is shown in Figure 7. □

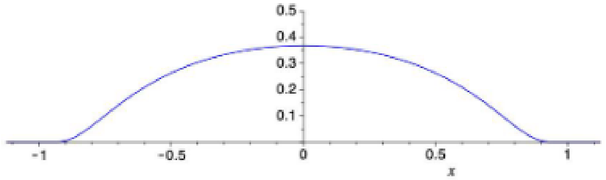

FIGURE 7: *The bump function $\Psi(x)$*

Proposition 2.6 *The space $\mathcal{D}(\Omega)$ is a vector space.*

Proof: Let $\psi, \varphi \in \mathcal{D}(\Omega)$ and $a, b \in \mathbb{C}$. If we can show that $a\psi + b\varphi \in \mathcal{D}(\Omega)$, we are done.

- Since $\psi, \varphi \in \mathcal{C}^\infty$, it follows that $a\psi + b\varphi \in \mathcal{D}(\Omega) \in \mathcal{C}^\infty$
- Let $A = \operatorname{supp}\psi$ and $B = \operatorname{supp}\varphi$. Then $a\psi(\mathbf{x}) + b\varphi(\mathbf{x}) = 0$ for $\mathbf{x} \notin A \cup B$. But $A \cup B$ is closed so $\operatorname{supp}(a\psi + b\varphi) \subseteq A \cup B$. Since A and B are bounded, $\operatorname{supp}(a\psi + b\varphi)$ is bounded too.

■

Actually, $\mathcal{D}(\Omega)$ is an uncountably infinite-dimensional vector space, whose 'vectors' are test functions.

End of Unit 2 Lect 1

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Assignments

- Assignments weekly or fortnightly in years 1 and 2
- Mix of formative and summative (roughly 20-30% counts towards final mark)
- Convenient online submission and return of marked work (via Gradescope)
- Mixture of written assessments and “electronic" assessments in year 1
- Collaboration on formative assignments is encouraged!

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Tutorials

Tutorials

- Interactive and collaborative - focus on actually doing mathematics!
- Typical tutorial group around 16 students (small group teaching)
- Led by faculty members or PhD or L4 MMath students
- One per module per fortnight in years 1 and 2
- Extra revision tutorials (& lectures) before exams

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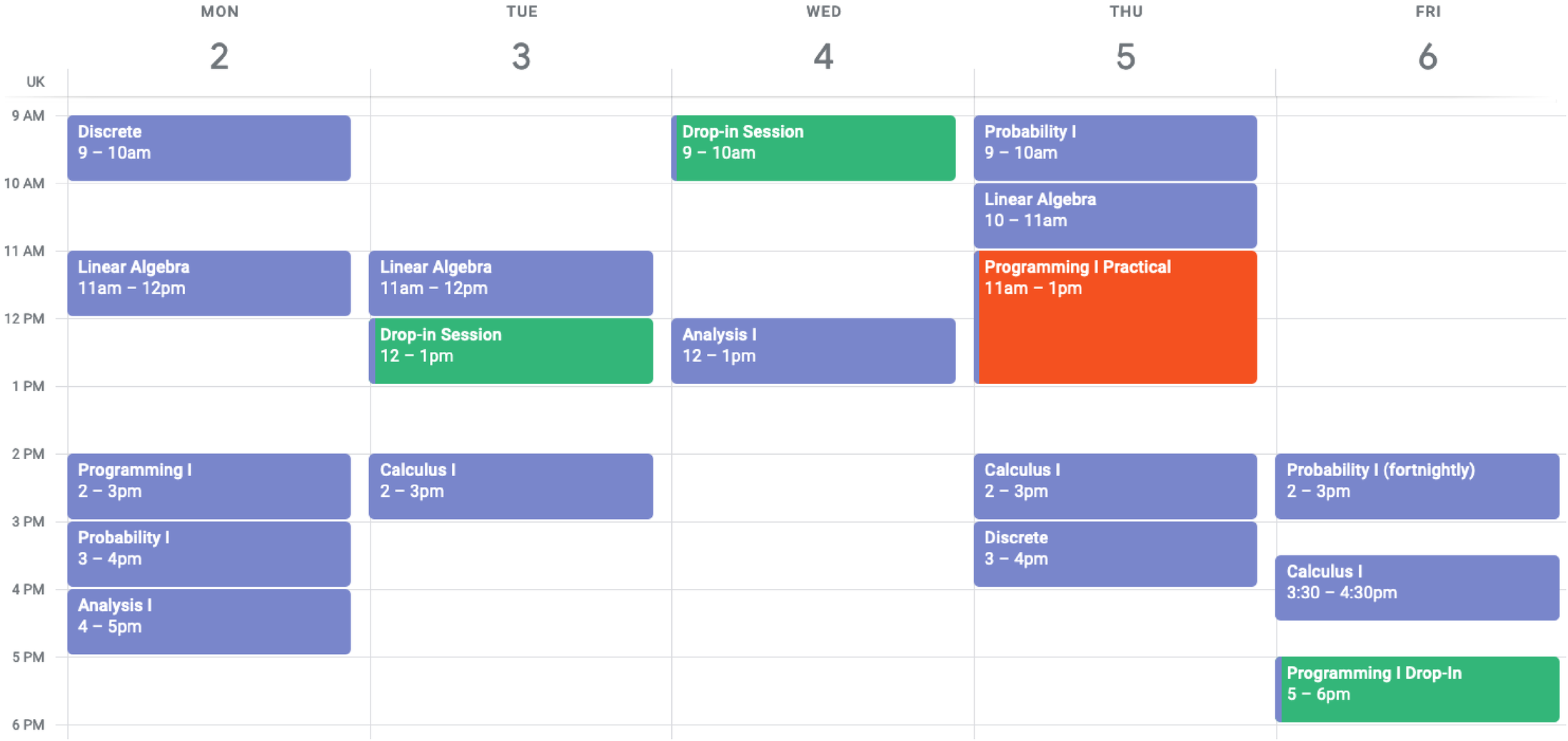
Typical 1st Year weekly timetable (Michaelmas)



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Not shown: 1 Analysis tutorial per week, fortnightly tutorials in all other modules, i.e. 3 more hours per week on average

Projects

Every final year student does a project (weighted equal to two “normal” modules)

MMATH students also take a group work project in year 3.

Highly commended by external examiners

Valuable research and independent learning experience

Vast choice informed by the research expertise of our faculty members

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Projects

Techniques for the Simulation of Diffusion-limited Aggregation

Matthew Clough, MMath

Supervisors:

Dr Conrado Da Costa (Probability)

& Dr Debleena Thacker (Probability)

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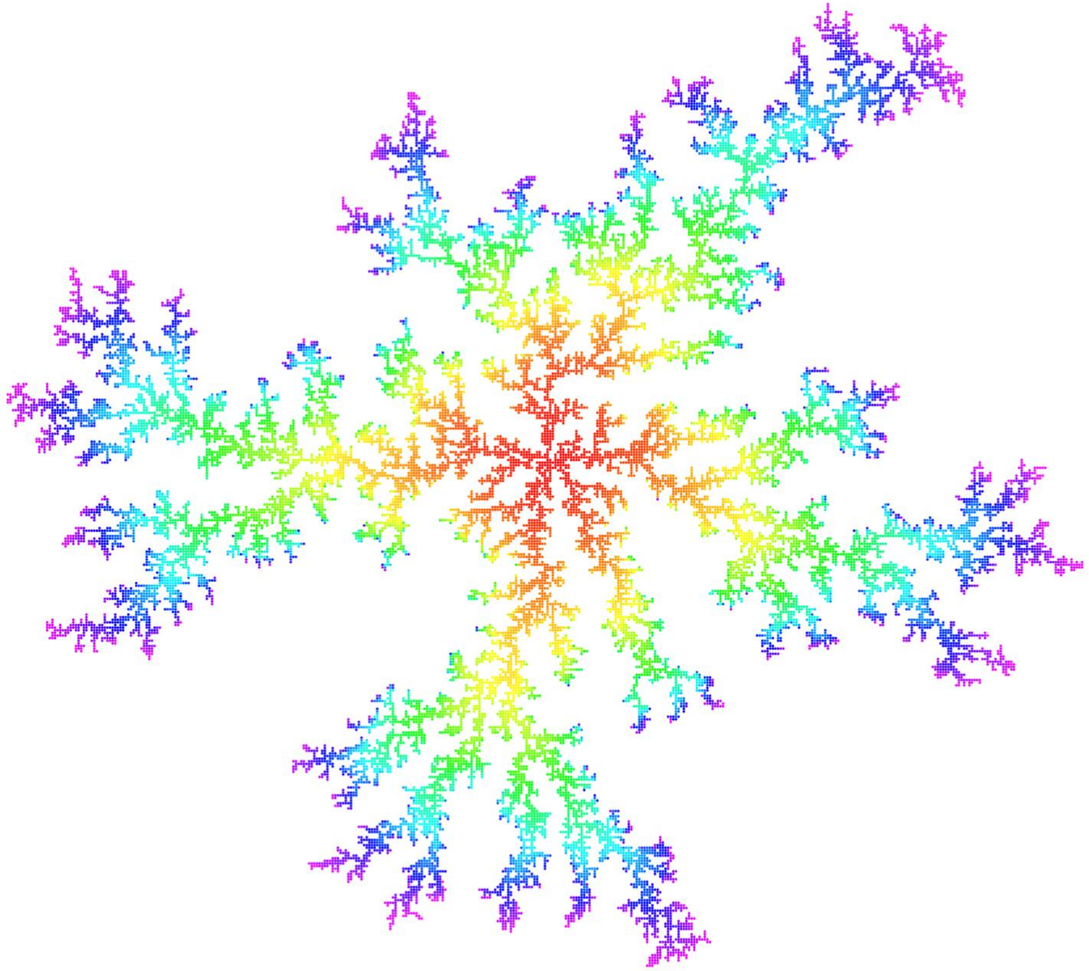


20,000 particle simulations of Meakin random walks

Projects

Numerical Continuation of Reaction-diffusion systems

Alexander Chudusama, MMath

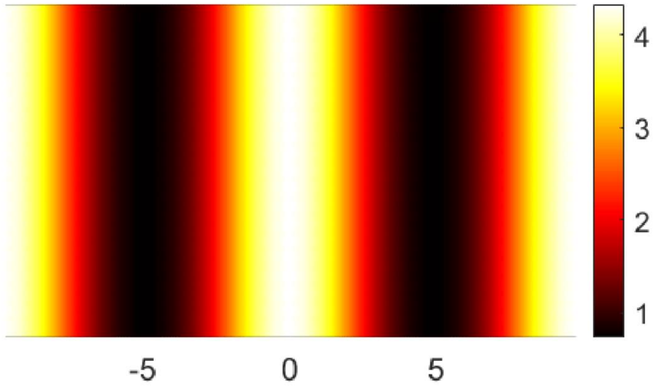
Supervisors:

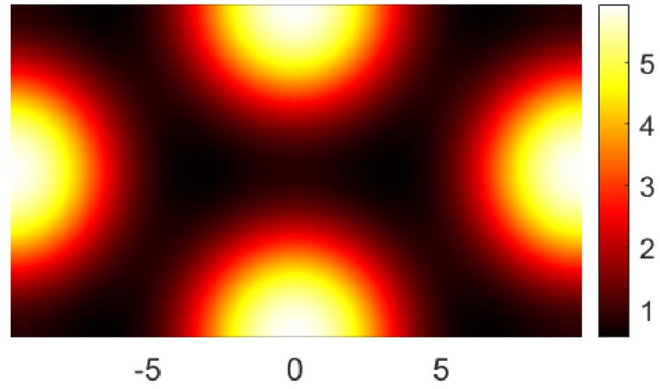
Dr Andrew Krause (Applied)

& Dr Adam Townsend (Applied)

Schnakenberg system & numerical solutions

$$\frac{\partial}{\partial t}\begin{pmatrix} u \\ v \end{pmatrix} = \underbrace{\begin{pmatrix} \nabla^2 u \\ D\nabla^2 v \end{pmatrix}}_{\text{Diffusion}} + \underbrace{\begin{pmatrix} u^2 v - u \\ \lambda - u^2 v \end{pmatrix}}_{\text{Reaction Kinetics}}$$





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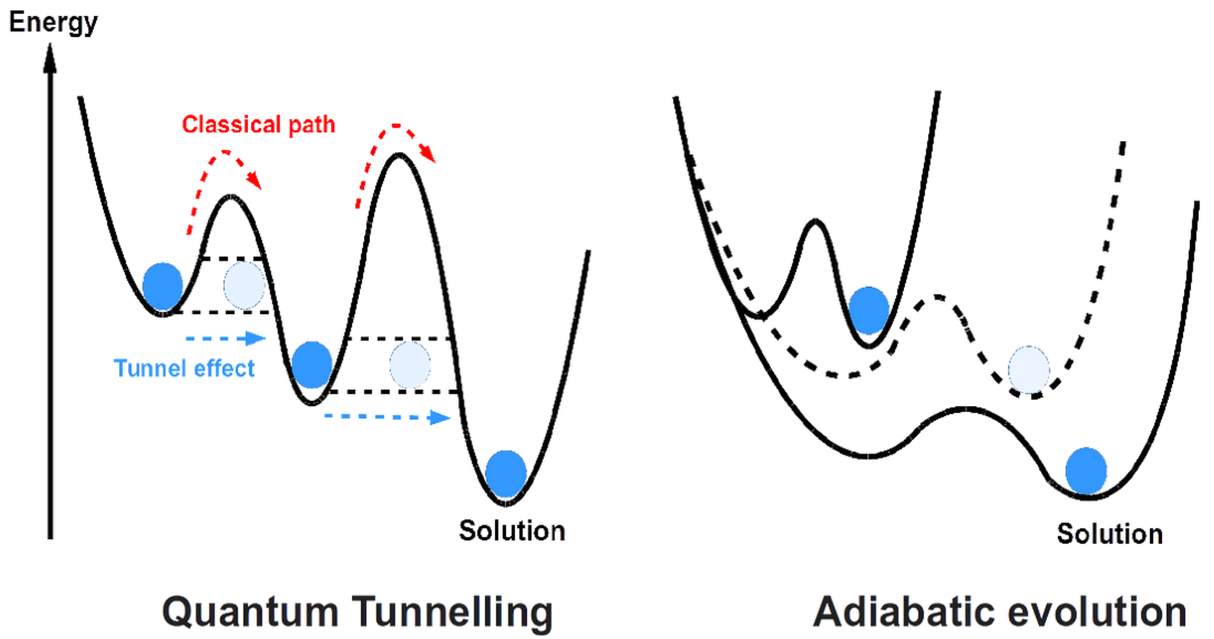
Projects

Quantum computing for portfolio optimisation

Cameron Girdler

Supervisor:

Prof. Steve Abel (Theoretical Physics)



Solving the Markowitz model to maximize return and minimise risk

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Support

Drop-in Sessions

- Maths Faculty/PhD students on-hand to answer questions on any module
- 2 hours per week in first year, 1 hour per week in second year
- Attendance is optional, attend as much (or as little) as you like!
- Staff can answer questions and offer support on an individual or group-basis, including help with formative assignments.
- **Great source of flexible additional support**

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Academic Advisor

- Every student is assigned a member of academic staff who will act as their personal academic advisor while studying at Durham
- One-to-one meeting at the start of each new term
- Offers advice on module choices, study habits, or other academic issues
- At later stages, can write references and offer career advice
- **Don’t know who to ask about something? Ask your academic advisor!**

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Applying

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Offers in Maths with A-levels

- **A*A* (Maths + Further Maths) + A** (*standard offer*)
- **TMUA5.0 + A*A (Maths + Further Maths) + A (or A*A*+B)** *(reduced offer)*
- We do not accept General Studies and Critical Thinking.
- We have no preferences for third A: History is as good as Physics.
- **Contextual offers can be lower than this (e.g for those coming from low-participation neighbourhoods).**

No Further maths?

- We prefer full A-level Further Maths.
- AS-level Further Maths is the minimum FM requirement.
  - If Further Maths is not available at school, it can be taken via the “Advanced Mathematics Support Programme” (AMSP)
- It is possible to have an offer with only AS-level Further Maths:
  - TMUA5.0 + A* (Maths) + AA + a (in AS level Further Maths).

Many equivalent non A-level offers

- IB: TMUA 5.0 + 38 points including 766 (higher level) with a 7 in Maths.
- IB: 38 points + 776 (higher level) with a 7 in Maths

The TMUA test — run by UAT

- Used by Durham, Cambridge, Imperial, LSE, Warwick, UCL
- 2 x 75 minute multiple choice papers

Two sittings

- October 13/14 2025
- January 8/9 2026

Cost £75 for UK residents (Free if on free school meals/bursary support/universal credit etc)

Important Evidence:

- **TMUA score**: TMUA5.0 gets a reduced offer, but anything > 3.5 counts as positive evidence. ***(We do not use the score as negative evidence.)***
- **Achieved and Predicted Grades**: Predictions should at least meet our offer.
- **Personal Statement**: We look for motivation to study the programme, and initiative in taking your studies further.
- **Reference**: We expect very strong references. Quantitative evidence is most useful.
- Quality is more important than quantity. We don’t focus on GCSE grades.

Thank you for coming! — Any Questions?

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Next up: Feel free to wander round, have a look at projects