WIMP 25/26 Round 1

Time	Imperial Talks (Room: MS.02)	Warwick Talks (Room: MS.01)
9 am	Arrival and Registration	
9:30 am - 10:30 am	**Plenary: Professor James Robinson** Dimensions, Experimental Observations, and Periodic Orbits	
10:30 am - 11:30 am	**John Zou:** Broadcast Gossip Algorithms	**Chung Chiu:** Geometry of Curves and Curve Shortening Flow
11:30 am - 12:30 pm	**Punter Piquer George:** Sobolev orthogonal polynomials for solving the Schrödinger equation	**Wayne Voo:** Adding fractions wrongly, an introduction to Diophantine Approximation
12:30 pm - 1:30 pm	Lunch	
1:30 pm - 2:30 pm	**Afjal Chowdhury:** Exploring Representational Alignment across Languages, Modalities, and Minds	**Hanwen Liu:** On Topology of Compact Hessian Manifolds
2:30 pm - 3:30 pm	**Chengyan Hu:** Group extension problem	**Patrick Gaudart- Wifling:** Inversion Number and the Dijoin Conjecture for Oriented Graphs
3:30 pm - 4 pm	Refreshments	
4 pm - 5 pm	**Lorraine Cheng:** Quasicrystaline metamaterials: the aperiodic monotile	**Ansh Pincha:** A Hierarchical Bayesian Framework for Estimating Goal Scoring Processes and Inferring Skill
5 pm - 6 pm	Closing Remarks and Networking	
6:30 pm	End	

Title: Dimensions, experimental observations, and periodic orbits
Speaker: Professor James Robinson
Time: 9:30 am - 10:30 am

Abstract: I will talk about some abstract results (due initially to Takens, 1981, and then, in the variant I will cover in this talk, to Sauer, Yorke, & Casdagli, 1991) that guarantee that you can "faithfully reconstruct" the dynamics of a system by taking a sufficient number of repeated observations at equally spaced times. The number of observations required turns out to be (roughly) twice the dimension of the attractor of the system.

However, one condition required by this result is that the time between these repeated observations has to be less than the period of the shortest periodic orbit in the system, which raises the question whether there is a simple way to find a lower bound on any possible period. Yorke (1969; the same Yorke as above) showed that the answer is yes, and I will discuss two proofs of this (one geometric, due to Yorke, and one more analytical) and a (simple-looking) variant of the problem that is still open.

Title: Broadcast Gossip Algorithms
Speaker: John Zou
Time: 10:30 am - 11:30 am

Abstract: Networks are essential for modelling collective human behaviour. By performing algorithms on such networks, we can begin to study asymptotic properties such as convergence. One such type of algorithms are gossip algorithms, first introduced in 1984, inspired by human gossiping. Although classical peer to peer algorithms demonstrated convergence, it had relatively high communication cost. This talk will discuss a second approach, broadcast gossip algorithms, which not only retain convergence to consensus almost surely, but also achieve lower communication cost when studied numerically.

Title: Geometry of Curves and Curve Shortening Flow.
Speaker: Chung Chiu
Time: 10:30 am - 11:30 am

Abstract: Curve shortening flow is a continuous deformation of a curve that makes it smoother (or in a more circular shape).

I will start with how to measure the curvedness of a plane curve (signed curvature) and two basic theorems about closed plane curves, Hopf Umlaufsatz and Fenchel's theorem. I will then introduce the curve shortening flow (CSF) and explain the most important result in CSF, Gage-Hamilton-Grayson theorem and why it cannot be generalised to higher dimensional cases (mean curvature flow).

The talk will have no assume knowledge other than basic set notations and computing partial derivatives, which is suitable for all undergraduate students.

Title: Sobolev orthogonal polynomials for solving the Schrödinger equation
Speaker: Punter Piquer George
Time: 11:30 am - 12:30 pm

Abstract: The talk is based on this paper:
https://www.sciencedirect.com/science/article/pii/S0168927423002106

I will begin by introducing the variational formulation of boundary value problems

(BVPs), and present key results that establish connections between the solutions of the classical BVP and its variational counterpart—specifically, a weaker version of the Lax-Milgram theorem. I will then discuss how to approximate the solution and a theorem regarding the quality of the approximation.

Next, I will introduce orthogonal polynomials and explore some of their general properties, with particular emphasis on the three-term recurrence relation and symmetric measures. Classical families such as Jacobi and Legendre polynomials will be covered, along with generalised Jacobi polynomials.

Then we will consider the 1 dimensional non-homogeneous Schrödinger equation with an harmonic potential. We will derive its variational formulation, which naturally leads to a Sobolev-type inner product. From this, we will construct the associated orthogonal polynomials and develop a set of test orthogonal polynomials to approximate the solution of the BVP.

To achieve this, we will employ generalised Fourier series expansions using the basis of test orthogonal polynomials. The theoretical framework will be supported by numerical experiments involving explicit examples of some Schrödinger equations.

Attendees should have a basic understanding of boundary or initial value problems, generalised inner products, and orthogonal polynomials. Familiarity with measure theory would be beneficial, although I could ommit that part by simply using weight functions. A basic knowledge of Fourier series is also recommended.

Title: Adding fractions wrongly, an introduction to Diophantine Approximation
Speaker: Wayne Voo
Time: 11:30 am - 12:30 pm

Abstract: What happens if we define the addition of fractions in the 'wrong' way: $a/b +c/d = a+c/b+d$? Surprisingly, this 'wrong' definition opens the door to a beautiful part of number theory: Diophantine Approximation, the study of how well the rationals can approximate real numbers. In this talk, we will uncover the structure of these 'wrongly added' fractions, and use it to prove a few of the fundamental results in the field, namely Dirichlet's Theorem, which guarantees infinitely many 'good' rational approximations, and Hurwitz's Theorem, which gives us the best possible bound for these approximations. We will explore how Diophantine Approximation connects to transcendental number theory, proving Liouville's Theorem and constructing explicit examples of transcendental numbers, thereby establishing their existence. The talk will be accessible to all undergraduates.

Title: Exploring Representational Alignment across Languages, Modalities, and Minds
Speaker: Afjal Chowdhury
Time: 1:30 pm - 2:30 pm

Abstract: This talk explores the emerging idea that representations learned by artificial and biological systems share a common geometric structure. This is a key tenet in mechanistic interpretability and explainable AI. Much of the work in this field is interdisciplinary, drawing from areas like linguistics, neuroscience and philosophy; the main innovations stem from developments in high-dimensional statistics. This talk is beginner friendly and requires only basic understanding of linear algebra.

Title: On Topology of Compact Hessian Manifolds
Speaker: Hanwen Liu
Time: 1:30 pm - 2:30 pm

Abstract: A Hessian manifold is a Riemannian space where the infinitesimal metric is locally determined by the second derivatives of a convex potential function. This talk investigates how the local geometric structure of a compact Hessian manifold severely restricts its global shape and topology.

We begin by establishing fundamental restrictions, showing that compact Hessian manifolds must have a vanishing Euler characteristic, and an infinite torsion-free fundamental group, which confirms a long-standing conjecture by S.S.Chern in our special case.

The next central focus is on compact hyperbolic affine manifolds, which are characterized by admitting Hessian metrics of Koszul type. We explore the deep structural implications of this condition, in particular derive powerful fibration theorems showing these manifolds must be mapping tori with periodic monodromy. After that, we present a convex splitting theorem for dimensions up to six, reducing the study of a general compact Hessian manifold to that of its hyperbolic affine part.

As an application, this framework finally provides thorough topological classifications for complete Hessian surfaces and closed orientable Hessian 3-manifolds, along with constraints on the intersection forms in dimension four.

Attendees are expected to be familiar with the basic terminology used in differential geometry and algebraic topology, although all relevant concepts will be recalled during the talk.

Title: Group extension problem
Speaker: Chengyan Hu
Time: 2:30 pm - 3:30 pm

Abstract: This is actually a brief introduction to homological algebra. I'm just assuming basic understanding of Group, rings and modules, and aiming to introduce the idea of homology without a lot of technical detail and category theory. The speak will be like the following:

1. Definition of exact sequence, chain complex, and homology group. (Just as Ker/Im) By intuition, homology group measures how far we are from being exact.
2. Snake lemma. The only thing we may give a proof.
3. Projective resolution. Definition and intuition of homotopy. Good and easy

remembering properties of chain homotopy without proof.
4. Definition of Ext. Easy answer of module extension problem, and in particular abelian group.
5. An idea of how to generalize this to group extension, but again, it will only be an idea without proof.

Title: Inversion Number and the Dijoin Conjecture for Oriented Graphs
Speaker: Patrick Gaudart- Wifling
Time: 2:30 pm - 3:30 pm

Abstract: Given an oriented graph G and a subset of its vertices X, the inversion of X in G is the graph obtained by flipping the orientation of every edge with both ends in X. The inversion number inv(G) is the minimum number of such inversions needed to remove all directed cycles from G.

A central question in this area is how the inversion number behaves when two directed graphs, G and H, are joined together by adding an edge from every vertex of G to every vertex of H. This question, known as the Dijoin Conjecture, asks whether the inversion number of the combined graph is simply the sum of the two original ones. This turns out to not always be true, however it does hold in many cases.

In this talk, I will give an overview of the theory of inversions in oriented graphs and the development of the Dijoin Conjecture, including key known results and counterexamples. I will then present some new results. By relating inversions to certain associated matrices, we are able to use insights from linear algebra to identify further cases where the conjecture holds and we suggest a new, weaker form of the conjecture.

Title: Quasicrystaline metamaterials: the aperiodic monotile
Speaker: Lorraine Cheng
Time: 4 pm - 5 pm

Abstract: Derived from my UROP with the Waves group (Maths department), I aim to explain how other studies and my own project use aperiodic tiles (like Penrose tilings/the einstein hat) to study wave properties. This is more applied maths/related to Physics and will maybe require some explanation of the physical acoustic wave system we have, some basic rules about tilings and an introduction to the aperiodic monotile which was discovered in 2023, but I hope to illuminate the use of quasicrystalline structures (that have 5-fold/10-fold symmetries/other properties not present in regular crystals) which isn't as commonly known. May also discuss cut-and-project schemes as we were interested in a paper that discussed a 6D eigenvector basis for the einstein hat (but for its metatiles).

Title: A Hierarchical Bayesian Framework for Estimating Goal Scoring Processes and Inferring Skill
Speaker: Ansh Pincha

Time: 4 pm - 5 pm

Abstract: We propose a hierarchical Bayesian framework to model and infer the latent goal-scoring process in football matches. Specifically, we assume a Poisson generative model for goals, with log-linear dependence on observed match-specific covariates via a generalized linear model. Uninformative Gaussian priors are placed over the regression coefficients, and full Bayesian inference is performed via Hamiltonian Monte Carlo, specifically the NUTS algorithm. Posterior predictive distributions are used to estimate probabilities over future outcomes. We further introduce a Laplace approximation scheme for sequential belief updating and propose a hierarchical extension where pre-match features inform latent covariates. A simulation study validates the inference procedure, and application to English Premier League 2024–25 data demonstrates the model's predictive capacity and interpretability. We also consider extensions to team-varying parameters to enable skill-based team ranking within the same probabilistic framework.