WIMP AUTUMN 2024 ITINERARY

TIME	IMPERIAL TALKS (Room: MS01)	WARWICK TALKS (Room: MS02)
6:15am – 9:00am	**Travel from Imperial to Warwick**	
9:00am – 9:30am	**Registration**	
9:30am – 10:30am	**Plenary (Professor Keith Ball)** *Why is Everything so Bell-Shaped? (Room: MS02)*	
10:30am – 11:30am	**Aryam Rege & Gianmarco Del Pino†** *Maximum a Posteriori for ODE Parameter Estimation*	**Cody Zhao** *Integral Points Close to Smooth Plane Curves*
11:30am – 12:30pm	**Sihun Hwang** *Conformal Field Theory in 2D, Möbius Geometry, and the Highest Weight Representation of Virasoro Algebra*	**Hongxin Zhen** *Image Denoising via Neural Network Techniques*
12:30pm – 1:30pm	**Lunch**	
1:30pm – 2:30pm	**Elias Fink** *Quiver Gauge Theories*	**Matthew Masuege Fernando** *The Analytic Continuation of the Riemann Zeta Function*
2:30pm – 3:30pm	**Sidharth Hariharan** *Creating Mandala Artwork using Mathematics*	**Andrew Liu** *Construction of the p-adic Numbers and its Properties, with a Focus on the Teichmüller Lift*
3:30pm – 4:00pm	**Refreshments**	
4:00pm – 5:00pm	**Xialu Zheng** *Unravelling Time: The Power of Robust Filtering*	**Jakub Tucker** *An Upper Bound for the Dehn Function of Outer Automorphism Groups of Right-Angled Artin Groups*
5:00pm – 6:00pm	**Closing Remarks & Networking**	
6:30pm – end	**Travel from Warwick to Imperial**	

† Speakers from Warwick.

Remark on the Balance of Speakers: Due to the unavailability of one of the selected speakers from Imperial and constraints with the Warwick Student Union, this session of WIMP will have 6 speakers from Warwick and 4 speakers from Imperial. We have agreed with Warwick that the subsequent session of WIMP in Spring 2025 will have 6 speakers from Imperial and 4 speakers from Warwick.

Title Why is Everything so Bell-Shaped?
Speaker Professor Keith Martin Ball
Time 9:30-10:30
Abstract The Central Limit Theorem, which guarantees the appearance of the bell-shaped or normal curve, is one of the most fundamental principles in mathematics. It underlies much of statistics and is important in statistical mechanics, functional analysis and even number theory.

In this talk, I will explain why we have a right to expect this remarkable ubiquity by analogy with the second law of thermodynamics. I will also illustrate how the normal curve turns up in geometry and how this led to a proof that the analogy with thermodynamics does indeed make sense.

Title Maximum a Posteriori for ODE Parameter Estimation
Speaker Aryam Rege and Gianmarco Del Pino
Time 10:30-11:30
Abstract Standard parameter estimation methods involve minimising some loss function depending on the parameters and given data. As part of a summer research project, we extended such methods to incorporate prior industry information about the parameters; which we do via Maximum a Posteriori.

This prior belief about the parameter is used to derive a minimisation problem to be solved. Approximate solutions to such problems can be found using Nelder- Mead; a derivative-free, geometric algorithm.

Throughout this talk, we will outline the methodology behind MAP Estimation and Nelder-Mead as well as the benefits of avoiding derivatives when approximating solutions to optimisation problems.

We applied this to chemical reaction kinetics data and during our talk, we will explain the novel insights extracted using this Bayesian technique.

Title Integral Points Close to Smooth Plane Curves
Speaker Cody Zhao
Time 10:30-11:30
Abstract This is an exposition of a class of problems and results on the number of integral points close to plane curves. We give a detailed proof of a theorem of Huxley and Sargos, following the account of Bordelles. Along the way we correct an oversight in the proof, changing some of the explicit values of the constants in the theorem.

Title Conformal Field Theory in 2D, Möbius Geometry, and the Highest Weight Representation of Virasoro Algebra
Speaker Sihun Hwang
Time 11:30-12:30
Abstract This talk explores the foundational structures of two-dimensional Conformal Field Theory (CFT), starting with the conformal transformation group and Möbius geometry. We will introduce radial quantization and compactification, then discuss Noether's theorem and its connection to conserved currents and the stress-energy tensor. The conformal Ward identities will be derived using operator product expansions, leading to an examination of the Virasoro algebra and its mode expansions. We will cover the highest weight representations, differential realization of descendant fields, and the completeness of

the Hilbert space as a Verma module. The role of null descendants, the Kac determinant, and the construction of irreducible representations will also be discussed, highlighting the algebraic and geometric elegance of 2D CFT.

Title Image Denoising via Neural Network Techniques
Speaker Hongxin Zhen
Time 11:30-12:30
Abstract In this talk, I will share a popular technique for image denoising using the LISTA framework, which combines a deep learning model with a mathematical algorithm. Image denoising is crucial in fields from photography to medical imaging, where the existence of noise may significantly degrade the quality of images. Derived from the traditional Iterative Soft-Thresholding Algorithm (ISTA), LISTA achieved an excellent performance on the reconstruction of images while reducing a huge computational cost. By unrolling ISTA into a convolutional neural network, my model achieves superior results with significantly fewer iterations.

I will explain the LISTA approach using visualizations from my implementation in PyTorch on the BSD500 dataset and demonstrate the effectiveness of the model via numerical Peak Signal to Noise Ratio (PSNR) and Normalised Mean Squared Error (NMSE). In addition to implementation, I will also share some insights about regularization and Proximal Gradient Descent (PGD) in model optimization, as well as key architectures in neural networks.

Title Quiver Gauge Theories
Speaker Elias Fink
Time 13:30-14:30
Abstract Quiver gauge theories, which arise from the representation theory of quivers, play a central role in modern string theory. We will explore brane systems and how to represent them in quiver diagrams. Additionally, we will discuss their moduli spaces and the implications for both theoretical insights and physical applications. By bridging geometry and physics, this presentation aims to highlight the significance of quiver gauge theories in advancing our understanding of supersymmetries.

Title The Analytic Continuation of the Riemann Zeta Function
Speaker Matthew Masuege Fernando
Time 13:30-14:30
Abstract In this talk, I will introduce the zeta function for $Re(s) > 1$, then extend it analytically to $Re(s) > 0$, and eventually to the entire complex plane, except at $s = 1$ where there is a simple pole. I also make use of the functional equation of the zeta function and the gamma function to explain the origin of the trivial zeros of the zeta function. Furthermore, I will provide a proof of the theorem stating that the zeta function has no zeros on the line Re(s) = 1, and conclude with a proof of the Riemann-Von Mangoldt formula, which estimates the number of non-trivial zeros of the zeta function in height T , given by $N(T) = \frac{T}{2\pi}\log\left(\frac{T}{2\pi}\right) - \frac{T}{2\pi} + O(\log(T))$.

Title Creating Mandala Artwork using Mathematics
Speaker Sidharth Hariharan
Time 14:30-15:30
Abstract The tradition of Mandala art goes back over a millennium, tracing its origin to the Indian subcontinent. Mandalas are characterised by layers of concentric circles with various motifs. The aesthetics tend to be pleasing to the eye due to certain symmetry properties

of the motifs in question. My talk will explain how motifs can be constructed to satisfy certain symmetry properties using simple mathematics

Title Construction of the p -adic Numbers and their Properties, with a Focus on the Teichmuller Lift

Speaker Andrew Liu

Time 14:30-15:30

Abstract The p -adic numbers were invented/discovered by Kurt Hensel in 1897, and it is still a very active area for ongoing research. The field of p -adic numbers, denoted $\mathbb{Q}_p$, is constructed from $\mathbb{Q}$ by the exact same method as $\mathbb{R}$, but with respect to the p -adic metric, which measures the divisibility of a rational number by a prime number p . Despite the similarity in construction, the fields $\mathbb{R}$ and $\mathbb{Q}_p$ are almost completely different. For example, $\mathbb{Q}_p$ is totally disconnected and not Hausdorff.

In this talk, I plan to begin with an outline of the rigorous construction of $\mathbb{R}$ from $\mathbb{Q}$ and then give the construction for $\mathbb{Q}_p$. Then I would like to discuss some surprising properties of the topology of $\mathbb{Q}_p$ and provide the intuition for the space of $\mathbb{Q}_p$. In particular, I will also give the identification of elements of $\mathbb{Q}_p$ with the one-tail Laurent series of p and discuss the Teichmuller lift and existence of $(p-1)$th roots of unity in $\mathbb{Q}_p$ (In contrasts to $\mathbb{R}$, which only contains 1). At the end, I will survey through various analytic spaces constructed from $\mathbb{Q}_p$, such as $\mathbb{C}_p$ and the Berkovich space.

Title Unravelling Time: The Power of Robust Filtering

Speaker Xialu Zheng

Time 16:00-17:00

Abstract This talk will present an exploration of robust filtering methods in time-series analysis, emphasizing analytical approaches for density and higher-order moments. With the increasing demand for resilient models capable of handling diverse data distributions, robust filtering has emerged as an essential technique in fields such as finance, environmental monitoring etc. This talk aims to introduce the fundamental concepts behind robust filtering, followed by an in-depth look at closed-form solutions for density estimation and moment calculations.

Title An Upper Bound for the Dehn Function of Outer Automorphism Groups of Right-Angled Artin Groups

Speaker Jakub Tucker

Time 16:00-17:00

Abstract To obtain an upper bound on the Dehn function of the outer automorphism group $Out^0(A_\Gamma)$ for a right-angled Artin group A_Γ with defining graph Γ , we use the subnormal series defined by Day and Wade to decompose $Out^0(A_\Gamma)$. This yields a decomposition tree where each vertex G has two descendants N and Q , satisfying a short exact sequence

$$1 \to N \to G \to Q \to 1.$$

We prove an upper bound for the Dehn function of the group G in relation to the Dehn functions of the groups N and Q . The Dehn functions of the leaves of the decomposition tree are known, with these we can bound above the Dehn function of their root, and by extension that of the group $Out^0(A_\Gamma)$.