Trends in Theory 2022 - Title and Abstracts -

Clélia de Mulatier (UvA)
Title : Identifying communities in binary data with spin models: when simple matters
Abstract:

Finding the model that best captures patterns hidden within noisy data is a central problem in science. In this context, the Ising model has been widely used to infer pairwise patterns in binary data. In recent years, attention has been brought to high order patterns of data and the question of how to detect them. We will discuss the use of (classical) spin models with interactions of order higher than pairwise to extract such patterns in binary data, and why this problem is challenging. By analyzing the information theoretic complexity of spin models, we will see that, despite their appearance, models with high order interactions are not necessarily more complex than pairwise models. Finally, we will focus on the family of spin models with minimal complexity and see that they can be used to uncover community structures hidden in data. This approach opens up new ways to analyze high dimensional data.

Farshid Jafarpour (UU)
Title: Effects of Noise and Correlations in Bacterial Populations Dynamics
Abstract:

Genetically identical bacterial cells, even in identical environments, exhibit significant variability in their phenotypic behavior such as their growth rates, division sizes, and generation times. With recent advances in single-cell technologies, we now can measure not only the distributions of these quantities but also the correlations between these variables both within and across generations. These statistical descriptions have paved the way for more accurate models of cellular growth and division. In this talk, I will discuss how the details of these new phenomenological models, such as the distributions of single-cell growth rates and the mechanism of cell-size control, affect various population-level quantities.

Ana Achucarro (UL)
Title: The Handmade Tail, and other (multifield inflation) stories
Abstract:

Cosmic inflation gives a (quantum) explanation for the tiny, primordial density fluctuations that seeded the distribution of matter and galaxies in the Universe. If this explanation is correct, many properties of the quantum fields and particle interactions at the time of the Big Bang are still imprinted today on the statistics of the density fluctuations, and can be extracted from cosmological observations. I will discuss how to turn the Universe into the ultimate collider to do "particle physics in the sky" at the earliest moments, a fraction of a second away from the Big Bang.

Ben Freivogel (UvA)
Title: Wormholes: from science fiction to science
Abstract:

In the past 5 years, traversable wormholes have moved from the realm of science fiction to science. I will describe what types of traversable wormholes can exist in our universe. I will also describe how wormholes have allowed us to calculate quantum gravity effects, partially resolving the black hole information problem, concluding with some open questions.

Eliska Greplova (TU Delft)
Title: Quantum Matter and the Multiverse of Engineered Topology
Abstract:

The field of condensed matter physics is currently being transformed by a series of exciting theoretical discoveries of intriguing properties of quantum materials and remarkable experimental progress that allows us to test the novel theories contemporaneously. In this talk, I will illustrate this condensed matter renaissance with two examples that also connect condensed matter to the two emerging fields of artificial intelligence and quantum computing. First, I will discuss a top-down example that considers solving existing models with the aid of artificial intelligence tools. In a second, bottom-up approach, I will discuss on-chip engineering of topological features using scalable quantum computing building blocs.

Melissa Beekveld (Oxford/Nikhef)
Title: Frontiers of parton-shower accuracy
Abstract:

Monte Carlo generators are an essential tool to understand the physics of high-energy particle collisions. Their core is represented by parton-shower algorithms, which account for the radiation of soft and collinear partons. The formal accuracy of parton-shower algorithms was for long unknown, limiting the assessment of theoretical uncertainties when using these tools. In this talk I will discuss the criteria introduced by the PanScales collaboration to determine the accuracy of showers. I will present the first family of showers for hadronic particle collisions whose accuracy exceeds that of standard showers.

Jonas Helsen (QuSoft)
Title: Random quantum circuits: a Drosophila fly for quantum computation
Abstract:

In this talk I will give a whirlwind tour of (theoretical) quantum computation, through the lens of random quantum circuits. We will address the benchmarking of quantum systems, efficient quantum classical interfaces (often called "shadows"), and quantum supremacy experiments. Through these examples I hope to illustrate the utility of random quantum circuits as a toy model for general quantum computations, for which we can make rigorous claims. I will also discuss some of the fascinating mathematical properties of random quantum circuits, and highlight what we don't yet know (and would like to know) about them.

Badri Krishnan (RU)

Title: The simplicity of binary black hole mergers

Abstract:

Before the first successful numerical simulations of binary black hole mergers in 2005, it was considered plausible that the gravitational wave signal could have complicated modulations and even be chaotic. After all, general relativity is a non-linear theory and these non-linearities are especially important near the merger. However, the reality is that the signals are so far seen to be rather simple. This does not mean that the signals are trivial, rather that the complications due to e.g. precession, eccentricity etc. are contained in the deviations from a simple underlying model. In this talk, I will propose a reason for this simplicity based on the framework of "singularity theory" developed by Arnold, Zeeman and Thom in the 1960s. We shall see that binary black hole mergers are similar to other common observed physical phenomena such as caustics and rainbows in optics, and this theory provides hints for deeper mathematical structures in binary black hole dynamics.