

# 2026 APCTP In-House Symposia

Date: October 15, 2026 (Thu.)

Place: #512, APCTP

| Time        | Program                                                                                    | Presenter            |
|-------------|--------------------------------------------------------------------------------------------|----------------------|
| 15:00-15:30 | Complexity, Disorder, Dynamics -- quantifying and harnessing messiness                     | Dr. Mathias CASIULIS |
| 15:30-16:00 | Multidirectional hopping generates generic power laws in higher-dimensional lattice models | Dr. Animesh HAZRA    |
| 16:00-16:30 | Toward a Nonlinear Description of Primordial Cosmological Perturbations                    | Dr. Xiao-Han Ma      |
| 16:30-17:00 | The Early Universe in a Box: Nonlinear Dynamics During and After Inflation                 | Dr. Pankaj SAHA      |
| 17:00-18:00 | Dinner in the common room                                                                  |                      |

## Talk 1 by Mathias CASIULIS (15:00-15:30)

### Title: Complexity, Disorder, Dynamics -- quantifying and harnessing messiness

**Abstract:** Over the past century, statistical physics has successfully described a variety of systems with widespread industrial applications, from the LCD screens we stare at for hours on end to the AC units that keep us cool in summer. Yet, most of statistical physics' predictive power relies on a very limited framework: thermodynamic equilibrium, i.e. a steady state in which a system displays no currents. Worse, most predictions rely on minimal models in which all elements are similar. What, then, should we do with all the messy systems that surround us? From sandpiles to living organisms, many examples display not just deeply non-equilibrium features such as a sustained consumption of energy, but also strong irregularities between components. My research group aims to understand the physics of these disordered, complex, dynamical systems.

In my talk, I present a few examples of recent and current interests, particularly the design and emergence of correlated disorder, the measurement of entropy and entropy production in simple non-equilibrium systems, and the study of active matter -- with a twist.

## Talk 2 by Animesh HAZRA (15:30-16:00)

### Title: Multidirectional hopping generates generic power laws in higher-dimensional lattice models

**Abstract:** We show that lattice models in  $d > 1$  dimensions with mass-conserving, multidirectional hopping dynamics exhibit power-law correlations for generic parameter values, even far from any phase transition point. The key mechanism is multidirectional hopping — several chunks of mass, or particles, hopping out simultaneously from a lattice site in multiple directions — which breaks detailed balance while the dynamics remains a diffusive, lattice-rotation-symmetric, spatially homogeneous continuous-time Markov process with no net mass current. Using hydrodynamic and exact microscopic theory, we show that the steady-state density-density and "activity"-density correlation functions decay universally as  $\sim 1/r^{d+2}$  at large distance  $r$  in the thermodynamic limit, with the amplitude calculated exactly for several models in terms of the density-dependent bulk-diffusion coefficient and mobility tensor. This theory explains why center-of-mass-conserving dynamics, used to model a novel disordered hyperuniform state of matter, generically results in long-ranged correlations.

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## Talk 3 by Xiao-Han Ma (16:00-16:30)

### Title: Toward a Nonlinear Description of Primordial Cosmological Perturbations

**Abstract:** Understanding the nonlinear evolution of cosmological perturbations is essential for connecting the physics of the early Universe with potentially observable signatures. In this talk, I will briefly introduce my research background and give an overview of my work on nonlinear primordial perturbations. I will focus in particular on the  $\delta N$  formalism and primordial non-Gaussianity, which provide useful tools for describing nonlinear perturbations on superhorizon scales and for studying how the statistics of primordial fluctuations are generated and evolved. I will also discuss some of my current interests in developing a more systematic understanding of nonlinear cosmological perturbation theory and its possible connections to observable phenomena..

## Talk 4 by Pankaj SAHA (16:30-17:00)

### Title: The Early Universe in a Box: Nonlinear Dynamics During and After Inflation

**Abstract:** In this talk, I will present recent efforts to develop a framework and associated computational tools for nonlinear dynamics in the early Universe. I will discuss the phenomenology revealed by simulating the early Universe in a box, both during and after inflation.