Tata Institute of Fundamental Research
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Seminar

Large deviations: a road to non-equilibrium statistical physics

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A remarkable success of 20th-century physics is the framework of statistical physics, which bridges the atomistic and macroscopic worlds. However, this framework is limited to systems in thermal equilibrium. In reality, most natural systems are outside equilibrium. A cup of coffee left on a table reaches thermal equilibrium in about an hour by releasing heat, but over longer periods, it evaporates. Living matter, such as bacteria, generates energy currents from burning ATP to self-organise at large scales. The statistics of these systems do not follow the principals of equilibrium statistical physics. In fact, at present, there is no general conceptual framework, akin to Gibbs-Boltzmann statistics, to describe non-equilibrium physics from first principles.

An emerging idea is to build such a unifying theory at a mesoscopic scale, similar to the Landau-Ginzburg theory for equilibrium fluctuations. I will discuss, how the theory of large deviations offers such an avenue by extending the idea of the Landau free energy outside equilibrium in terms of large deviation functions. This way, non-equilibrium phase transitions appear as singularities in large deviations, as in equilibrium; generic non-local response of non-equilibrium states is a consequence of non-local large deviation functions, and fluctuation relations arise from symmetries of large-deviations.

Many important recent advances in non-equilibrium physics have emerged from this large deviation approach, driven by experiments, computer simulations, and theoretical analysis of minimal models. In this talk, I will review these new ideas in a pedagogical style, illustrating them with examples from both theory and experiment, making the talk accessible to anyone with a basic background in statistical physics.

Thursday, Jan 23rd 2025

16:00 Hrs (Tea / Coffee 15:45 Hrs)

Auditorium, TIFRH