Structure and spontaneous symmetry breaking in the fluctuations of driven systems

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Macroscopic fluctuations have become an essential tool to understand physics far from equilibrium. This interest is rooted in the prominent role that fluctuations play in equilibrium, where their statistics is directly linked to the relevant thermodynamic potentials via the Einstein formula. Similarly, it is nowadays expected that a deeper understanding of nonequilibrium fluctuations will pave the way to a sound definition of nonequilibrium potentials, though we already know that these functions do typically have some striking features peculiar to nonequilibrium behavior (as e.g. non-local behavior leading to long- range correlations).

The optimal path leading to a fluctuation encodes key information on this problem, shedding light on e.g. the physics behind the enhanced probability of rare events out of equilibrium, the possibility of dynamic phase transitions and new symmetries. This makes the understanding of the properties of these optimal paths a central issue. In this talk we will unveil a fundamental relation which strongly constraints the architecture of these optimal paths for general d-dimensional nonequilibrium diffusive systems, and implies a non-trivial structure for the dominant current vector fields. Interestingly, this general relation (which encompasses and explains previous results) makes manifest the spatio-temporal non-locality of the current statistics and the associated optimal trajectories.

Another key problem concerns dynamic phase transitions (DPTs) at the fluctuating level. DPTs constitute one of the most intriguing phenomena of nonequilibrium physics, but their nature in realistic high-dimensional systems remains puzzling. In this talk we will also describe a DPT in the current statistics of an archetypal two-dimensional (2d) driven diffusive system, and characterize its properties using macroscopic fluctuation theory. The complex interplay among the external field, anisotropy and currents in 2d leads to a rich phase diagram, with different symmetry-broken fluctuation phases separated by lines of 1st- and 2nd-order DPTs. Order in the form of coherent jammed states emerges to hinder transport for low-current fluctuations, revealing a deep connection between rare events and self-organized structures which enhance their probability, an observation of broad implications.

[l] N. Tizón-Escamilla et al, arXiv:1606.07507.

[2] N. Tizón-Escamilla et al, Phys. Rev. E **95**, 032119 (2017).

[3] C. Pérez-Espigares et al, Phys. Rev. E **93**, 040103(R) (2016).