Physics Colloquium

Jordan Horowitz

"Thermodynamic limits far from equilibrium"

Thermodynamics is a remarkably successful theoretical framework, with wide ranging applications across the natural sciences. Unfortunately, thermodynamics is limited to equilibrium or near-equilibrium situations, whereas most of the natural world, especially life, operates very far from thermodynamic equilibrium. Without a robust nonequilibrium thermodynamics, we cannot address a whole host of pressing research questions regarding the energetic requirements to operate outside of equilibrium, like the energetic cost to form a pattern, replicate an organism, or sense an environment, to name a few. Cutting-edge research in nonequilibrium statistical thermodynamics is beginning to shed light on these questions. In this talk, I will present two such recent predictions. The first is a novel linear-response-like bound that quantifies how dissipation shapes fluctuations far from equilibrium. Besides its intrinsic allure as a universal relation, I will discuss how it can be used to probe the energetic efficiency of molecular motors, offer energetic constraints on chemical clocks, and bound the dissipation in complex materials, both biological and synthetic, allowing us to gain insight into the fundamental energetic requirements to operate out of thermodynamic equilibrium. The second is an extended second law of thermodynamics with information that quantifies the precise energetic costs to process information, which I will apply to the energetic requirements of sensory adaptation in E. coli.

Jordan M. Horowitz *is currently a Physics of Living Systems Fellow in the Physics Department at the Massachusetts Institute of Technology. After receiving his B.A. in Physics and Mathematics from Columbia University, Horowitz went on to the University of Maryland were he earned a Ph.D. in Physics under the supervision of Christopher Jarzynski. Subsequently, he worked as a postdoctoral fellow at the Universidad Complutense de Madrid and the University of Massachusetts Boston. Horowitz's research is in the area of nonequilibrium statistical thermodynamics. His work focuses on the development and application of universal energetic constraints to far-from-equilibrium processes.*

Physics Faculty and Search Committee Candidate

Tuesday, February 27th in LL 316 at 4:10

Refreshments available at 3:45