Massachusetts Institute of Technology
Department of Physics

Condensed Matter Theory Seminar

"The second law of thermodynamics from unitarity and symmetry"

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Abstract: Most physical processes we observe in nature involve variations of macroscopic quantities over spatial and temporal scales much larger than microscopic molecular collision scales and thus can be considered as in local equilibrium. For a many-body system in local equilibrium a stronger version of the second law applies which says that the entropy production at each spacetime point should be non-negative. In this paper we provide a proof of the second law for such systems and a first derivation of the local second law. For this purpose we develop a general non-equilibrium effective field theory of slow degrees of freedom from integrating out fast degrees of freedom in a quantum many-body system and consider its classical limit. The key elements of the proof are the presence of a Z_2 symmetry, which can be considered as a proxy for local equilibrium and micro-time-reversibility, and a classical remnant of quantum unitarity. The Z_2 symmetry leads to a local current from a procedure analogous to that used in the Noether theorem. Unitarity leads to a definite sign of the divergence of the current. We also discuss the origin of an arrow of time, as well as the coincidence of causal and thermodynamical arrows of time. Applied to hydrodynamics, the proof gives a first-principle derivation of the phenomenological entropy current condition and provides a constructive procedure for obtaining the entropy current.

12:00pm
Tuesday, February 28, 2017
Duboc Room (4-331)

Host: Michael Pretko