INTERNSHIP PROPOSAL

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Thesis possibility after internship: YES
Funding: NO If YES, which type of funding:

Bridging stochastic thermodynamics and contact Hamiltonian mechanics

Stochastic thermodynamics is an extension of thermodynamics that allows us to describe small thermodynamic systems undergoing large fluctuations (i.e., fluctuations with variance and mean of the same magnitude). All thermodynamic quantities, such as heat, work, entropy, and entropy production, are defined precisely based on an assumed stochastic dynamics (e.g., a Markov jump process or a diffusion process). For systems on a lattice, an effective Hamiltonian dynamics exists at large volume. Interestingly, this so-called statistical (classical) Hamiltonian is a constant of motion (null in the stationary state) that is related to the highest eigenvalue of the generator of the dynamics. Hence, it should be related to the relaxation of the dissipative systems toward a nonequilibrium stationary state.

In the alternative viewpoint of contact geometries, relaxations of nonequilibrium systems are studied in $2n+1$ dimension. The additional dimension compared to $2n$ symplectic space introduces dissipation. Thereby, the structures of analytical mechanics and thermodynamics are merged: Contact Hamiltonians are functions of an ``entropy'' that precisely produces the dissipation. However, a precise link between statistical and contact Hamiltonians remains elusive. A long-term objective (Ph.D.) is to determine if stochastic thermodynamics and contact Hamiltonian dynamics share some common ground.

As a short-term objective for an internship, we could study some specific topics on nonequilibrium processes described in analytical mechanics:
1) Generalized canonical changes of variables. Detailed Hamiltonians display an asymmetry in their conjugate variables: They have more forces than state variables, as opposed to standard Hamiltonians that have variables in conjugate pairs. Therefore, the question is to determine if a canonical change of variables followed by a reduction from detailed to standard Hamiltonian is equivalent to the comparable operation in opposite order (reduction followed by a canonical change of variables).
2) Conjecture extending Perron-Frobenius theorem. We conjectured that a statistical Hamiltonian must have two global solutions to the Hamilton-Jacobi equations, one being stable and the other being unstable. These solutions must cross on a dominant critical submanifold. However, the assumptions of our conjecture must be tightened to guarantee its validity beyond a few simple one-dimensional systems. The goal is to determine, for specific models, whether accessibility of the phase space and topological constraints (equivalent to matrix irreducibility) are better assumptions for the conjecture.

Prerequisite: Applications from candidates with a strong background and interest in analytical mechanics, symplectic or contact geometry, and mathematical physics are expected.

Condensed Matter Physics: YES	Soft Matter and Biological Physics: NO
Quantum Physics: YES	Theoretical Physics: YES