

Tom Weinreich (mentor: Eric Smith)

My project will address the thermodynamic properties of driven systems far from equilibrium through the application of large deviations principles. Eric has previously written about extensions of the methods from classical thermodynamics into the nonequilibrium domain; the idea now is to apply them to a system of interest. The choice of that system is not yet final, but the details are less important than the methods. For the sake of being concrete, I'll write here about one likely candidate.

Chemical reaction networks, such as those observed in biology, continuously receive and dissipate energy from their environment, and as a result never reach equilibrium. Despite this, they are stable over the lifetime of a cell, usually many orders of magnitude longer than the time to complete a cycle. They also seem to be very finely tuned; the most extreme example of this is the metabolic network in cells, which evolution has not altered meaningfully in any organism for approximately 4 billion years. We hope that we will be able to explain this robustness by asking questions about the properties of stable configurations of the networks under typical driven conditions, and the types of large deviations results that can be derived from them.