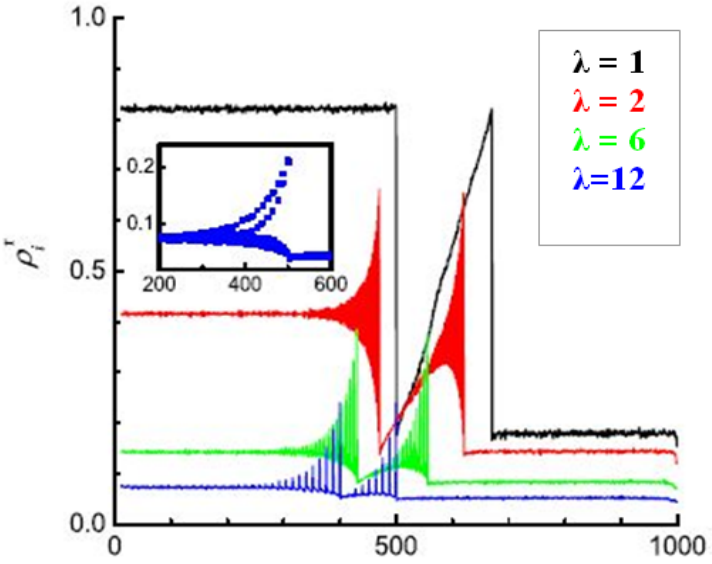
Statistical Mechanics of Systems far from Equilibrium

Beate Schmittmann and Royce K.P. Zia
Virginia Tech DMR-0705152

Statistical mechanics is the science that deals with systems with many interacting constituents, where complex unexpected co-operative phenomena often emerge from simple underlying dynamics at the microscopic level. By studying simple models, we gain insight on the essential aspects of complex behavior in physical or biological systems. An iconic model for protein synthesis or vehicular traffic is the totally asymmetric simple exclusion process. In the language of traffic, imagine a "road" of L spaces (sites), where "cars" of length λ (spaces or sites) enter from one end, hop *stochastically* to the next site if it is free, and exit the opposite end. If there are bottlenecks (slow sites, from which the forward hop-rate is lower), "jams" will develop behind each, associated with interesting structures. For example, the figure shows the probability of finding a car at each site, for a case with L=1000 and two bottlenecks. Here, they are separated by 100 or more sites, with hop-rates being 1/5 of those in the rest of the lattice. The structures of the jams are quite rich when λ is 2 or more, especially between the bottlenecks. The overall flow (current) is also seriously reduced if the slow sites are close together. In the inset, a new feature - "double tails" - appears when the sites are at 500 and 501 (λ=12). We explore the implications of such findings for protein synthesis and potential applications in creating "designer genes" for efficient drug manufacture.



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Education and outreach:

Our projects involves a wide spectrum of techniques, so that younger scientists can easily participate. Both undergraduate and graduate students, as well as summer interns form a core component of our research. In addition, two postdocs are supported in part by this grant. While junior researchers often discover new phenomena through computer simulations of simple models, full-scale and analytic studies are implemented by the more senior scientists. The work outlined here was carried out by *Jiajia Dong*, who just received her PhD in May and will join the faculty of Hamline University in August.

From left, back row:
Max Lavrentovich, Jonathan Cook, Izabella Benczik, Sayak Mukherjee, Abhishek Mukhopadhyay, Melvin Amos, Nasrin Afzal
front row:
Sarah Reeves, Royce Zia, Jiajia Dong, Beate Schmittmann
Not in photo:
Andrew Angel, John Hoffman