Statistics Seminar Series

Diffusion Ratchets and Biomolecular Motors

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Mathematics and Computer Science (MCS) Building, Room 135
111 Cummington Street, Boston
Tea and Cookies at 3:30pm in MCS 137

Abstract: Biomolecular motors are proteins, or structures of multiple proteins, that play a central role in accomplishing mechanical work in the interior of a cell. While chemical reactions fuel this work, it is not exactly known how this chemical-mechanical conversion occurs. Recent advances in microbiological techniques have enabled at least indirect observations of molecular motors which in turn have led to significant research in the mathematical modeling of these motors in the hope of shedding light on the underlying mechanisms involved in intracellular transport. Kinesin which moves along microtubules that are spread throughout the cell is a prime example of the type of motor that will be discussed in this talk. On one end of the motor, there are twin heads that move step by step on the microtubule. The other end consists of a long amino acid chain which attaches itself to cargo that must be transported. The motion is linked to the presence of a chemical, ATP, but how the ATP is involved in motion is not clearly understood.

One commonly used model for Kinesin in the biophysics literature is the Brownian ratchet mechanism. In this talk, a precise mathematical formulation of a Brownian ratchet (or more generally a diffusion ratchet) will be given via an infinite system of stochastic differential equations with reflection. This formulation will be seen to arise in the weak limit of a natural discrete time/space model that is used to describe motor dynamics in the literature. Numerical techniques will be provided to compute asymptotic quantities such as asymptotic velocity, effective diffusivity, and the randomness parameter for this model and other closely related models.

Linearly progressive biomolecular motors often carry cargos via an elastic linkage. A two-dimensional coupled stochastic dynamical system will be introduced to model the dynamics of the motor-cargo pair. Some mathematical and numerical issues pertaining to the coupled system and associated asymptotic quantities related to the system will be discussed. Frequently in experiments, the motor is too small to be tracked; only the cargo which is much larger can be dynamically observed. Filtering algorithms to infer the position of the motor and to estimate model parameters based on cargo observations will be presented.