THE UNIVERSITY OF CHICAGO

Department of Statistics

STATISTICS COLLOQUIUM

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Molecular Motor-based Models of Random Intermittent Search

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133 Eckhart Hall, 5734 S. University Avenue
Refreshments following the seminar in Eckhart 110

ABSTRACT

Random search strategies occur throughout nature as a means of efficiently searching large areas for one or more targets of unknown location, which can only be detected when the searcher is within a certain range. Examples include animals foraging for food or shelter, the motor-driven transport and delivery of macromolecules to particular compartments within cells, and a promoter protein searching for a specific target site on DNA. One particular class of model, which can be applied both to foraging animals and active transport in cells, treats a random searcher as a particle that switches between a slow motion (diffusive) or stationary phase in which target detection can occur and a fast motion "ballistic" phase; transitions between bulk movement states and searching states are governed by a Markov process.

In this talk we review recent work on the analysis of random intermittent search models of motor-driven transport in the dendrites of neurons. The stochastic search process is modeled in terms of a system of Chapman-Kolmogorov equations, which are reduced to a scalar Fokker-Planck equation using perturbation methods. The reduced FP equation is used to compute various quantities that characterise the efficiency of the search process, including the mean first passage time (MFPT) to target detection. We then consider a number of applications. First, we analyze the effects of dendritic branching on the efficiency of motor-driven transport and show that bidirectional rather than unidirectional transport is more effective. Second, we analyze a biophysical model of bidirectional transport, in which opposing motors compete in a "tug-of-war," and use this to explore how local signaling mechanisms could regulate the delivery of molecular cargo to subcellular targets such as synapses. We end by discussing extensions to higher dimensional searches and models of multiple searchers.

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