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Fluctuations in epidemic modeling - disease extinction and control[1]

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The analysis of infectious disease fluctuations has recently seen an increasing rise in the use of new tools and models from stochastic dynamics and statistical physics. Examples arise in modeling fluctuations of multi-strain diseases, in modeling adaptive social behavior and its impact on disease fluctuations, and in the analysis of disease extinction in finite population models. Proper stochastic model reduction [1] allows one to predict unobserved fluctuations from observed data in multi-strain models [2]. Degree alteration and power law behavior is predicted in adaptive network epidemic models [3,4]. And extinction rates derived from large fluctuation theory exhibit scaling with respect to distance to the bifurcation point of disease onset with an unusual exponent [5]. In addition to outbreak prediction, another main goal of epidemic modeling is one of eliminating the disease to extinction through various control mechanisms, such as vaccine implementation or quarantine. In this talk, a description will be presented of the fluctuational behavior of several epidemic models and their extinction rates. A general framework and analysis of the effect of non-Gaussian control actuations which enhance the rate to disease extinction will be described. In particular, in it is shown that even in the presence of a small Poisson distributed vaccination program, there is an exponentially enhanced rate to disease extinction. These ideas may lead to improved methods of controlling disease where random vaccinations are prevalent.

Recent papers:
[1] E. Forgoston and I. B. Schwartz, "Escape Rates in a Stochastic Environment with Multiple Scales," arXiv:0809.1345 2008.
[2] L. B. Shaw, L. Billings, I. B. Schwartz, "Using dimension reduction to improve outbreak predictability of multi-strain diseases," J. Math. Bio. **55**, 1 2007.
[3] L. B. Shaw and I. B. Schwartz, "Fluctuating epidemics on adaptive networks," Physical Review E **77**, 066101 2008.
[4] L. B. Shaw and I. B. Schwartz, "Noise induced dynamics in adaptivenetworks with applications to epidemiology," arXiv:0807.3455 2008.
[5] M. I. Dykman, I. B. Schwartz, A. S. Landsman, "Disease Extinction in the Presence of Random Vaccination," Phys. Rev. Letts. **101**, 078101 2008.

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