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Disease Extinction as a Dynamical System: Stochastic controls from single to multistrain epidemics

The eradication or fade-out of infectious diseases is a penultimate goal for improving public health. In order to promote and design control methods, such as vaccination and social group quarantine, one must predict how the disease spreads probabilistically. However, modeling the dynamics of an outbreak includes many complicating features, such as deterministic and stochastic chaotic-like behavior. Such complicated dynamics can enhance the probability of extinction. In large populations, although extinction is a rare event, extinction will eventually occur.

In this talk, we show that the most likely path to extinction possesses a maximal sensitivity to initial conditions which is similar to local measures of chaotic behavior, and may be quantified by computing finite time Lyapunov exponents. As a result, the extinction path emerges naturally from the underlying dynamical geometry and may be constructed explicitly. The theory will be applied to several stochastic epidemiological models ranging from single to multistrain epidemic outbreaks. In addition, we will show how the theory of stochastic control may be applied to enhance the extinction process in single strain models, but may be deficient in multistrain models such as the control of dengue fever.

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