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Talk 1:

The interplay between stochasticity and delay I

Time delays are present in many dynamical systems. Typical situations include the delay between a person gets infected by a contagious disease and the time this person can infect others, or the delay between the expression of a gene and the production of the associated protein, just to mention a few. In these and other examples, there are important stochastic effects that need to be taken into account for a detailed description of the process. Despite the fact that stochasticity and delay appear simultaneously in a large variety of processes of relevance in many areas of science, such as physics, ecology or chemistry, their combined effects are not completely understood. From the mathematical point of view, the main problem is the apparent non-Markovian character of the resulting stochastic process. While most of the previous approaches have focused on stochastic differential equations or random walks in discrete time, the consideration of discrete variables and continuous time are the natural description of many systems such as gene regulations, chemical reactions, population dynamics or epidemic spreading, in which discreteness can be a major source of fluctuations.

In the first talk I will introduce some simple, yet general, stochastic birth and death processes including delay and will discuss some of the inherent difficulties for their study. Most often, the delay time is taken to be a constant with zero fluctuations, a non very realistic assumption for the applications, since it is unusual to have a deterministic delay when the rest of the dynamics is stochastic. I will take this consideration into account by allowing the delay times to be random variables with arbitrary probability density functions. In the case of delay in the degradation I will explain the use of an effective Markovian reduction technique and derive, some exact and some approximate, results about the evolution of mean values and fluctuations. A typical effect of delay in deterministic systems is the induction of oscillations and I will discuss its relevance under the stochastic dynamics.