**Irreversible langevin samplers and variance reduction: a large deviations approach and diffusion on graphs**

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Monte Carlo methods are very popular methods to sample from high-dimensional target distributions, which very often are of Gibbs type. Markov processes that have the target distribution as their invariant measure are used to approximate the equilibrium dynamics. In this talk, we explore performance criteria based on the related large deviations theory for random measures and we focus on the diffusion setting. We find that large deviations theory can not only adequately characterize the efficiency of the approximations, but it can also be used as a vehicle to design Markov processes, whose time average optimally (in the sense of variance reduction) approximates the quantities of interest. We quantify the effect that added irreversibility has in the speed of convergence to a target Gibbs measure and to the asymptotic variance of the resulting estimator. One of our main finding is that adding irreversibility reduces the asymptotic variance of generic observables and we give an explicit characterization of when observables do not see their variances reduced in terms of a nonlinear Poisson equation. Connections to averaging problems for Hamiltonian systems and diffusion graphs will be given. Time permitting, I will also discuss recent developments on related numerical methods. Theoretical results are supplemented by simulations.