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On the switch-type convergence for stochastic differential equations

Consider an ordinary differential equation with a fixed point that is a hyperbolic global attractor. Assume that the fixed point is the origin. Under general conditions, at times goes by any solution of this equation approaches the fixed point exponentially fast. Now add a small random perturbation to this equation. It is well known that, again under very general conditions, as times goes by the solution of this stochastic equation converges to an equilibrium distribution that is well approximated by a Gaussian random variable of variance proportional to the strength of the perturbation. General theory of stochastic processes allows to show that this convergence, for each fixed perturbation, is again exponentially fast. We show that the convergence is actually abrupt: in a time windows of small size compared to the natural time scale of of the process, the distance to equilibrium drops from its maximal possible value to near zero, and only after this time window the convergence is exponentially fast. This is what is known as the cut-off phenomenon in the context of Markov chain of increasing complexity. Under a proper time scaling, we are able to prove convergence of the distance to equilibrium to a universal function, a fact known as profile cut-off. Moreover, when the attractor is not hyperbolic then we are able to prove that the cut-off phenomena does not appears. Joint work with Milton Jara.