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Synchronization of coupled stochastic limit cycle oscillators

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For a class of coupled limit cycle oscillators, we give a condition on a linear coupling operator that is necessary and sufficient for exponential stability of the synchronous solution. We show that with certain modifications our method of analysis applies to networks with partial, time-dependent, and nonlinear coupling schemes, as well as to ensembles of local systems with nonperiodic attractors. We also study robustness of synchrony to noise. To this end, we analytically estimate the degree of coherence of the network oscillations in the presence of noise. Our estimate of coherence highlights the main ingredients of stochastic stability of the synchronous regime. In particular, it quantifies the contribution of the network topology. The estimate of coherence for the randomly perturbed network can be used as means for analytic inference of degree of stability of the synchronous solution of the unperturbed deterministic network. Furthermore, we show that in large networks, the effects of noise on the dynamics of each oscillator can be effectively controlled by varying the strength of coupling, which provides a powerful mechanism of denoising. This suggests that the organization of oscillators in a coupled network may play an important role in maintaining robust oscillations in random environment. The analysis is complemented with the results of numerical simulations of a neuronal network.

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