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Long-term fluctuations in globally coupled phase oscillators with general coupling: Finite size effects

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We investigate the diffusion coefficient of the time integral of the Kuramoto order parameter in globally coupled nonidentical phase oscillators. This coefficient represents the deviation of the time integral of the order parameter from its mean value on the sample average. In other words, this coefficient characterizes long-term fluctuations of the order parameter. For a system of N coupled oscillators, we introduce a statistical quantity D, which denotes the product of N and the diffusion coefficient. We study the scaling law of D with respect to the system size N. In other well-known models such as the Ising model, the scaling property of D is D \sim O(1) for both coherent and incoherent regimes except for the transition point. In contrast, in the globally coupled phase oscillators, the scaling law of D is different for the coherent and incoherent regimes: D \sim O(1/N^a) with a certain constant a>0 in the coherent regime and D \sim O(1) in the incoherent regime. We demonstrate that these scaling laws hold for several representative coupling schemes.

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