Finite-size Effect in Kuramoto Oscillators with Higher-order Interactions

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Finite-size systems of Kuramoto model display intricate dynamics, especially in the presence of multi-stability where both coherent and incoherent states coexist. We investigate such a scenario in globally coupled populations of Kuramoto phase oscillators with higher-order interactions and observe that fluctuations inherent to finite-size systems drive the transition to the synchronized state before the critical point in the thermodynamic limit. Using numerical methods, we plot the first exit time distribution of the magnitude of complex order parameter and obtain numerical transition probabilities across various system sizes. Further, we extend this study to a two-population oscillator system, and, using the velocity field of the associated order parameters, show the emergence of a new fixed point corresponding to a partially synchronized state arising due to the finite-size effect, which is absent in the thermodynamics limit.