How higher-order interactions modify the synchronization transition

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Abstract: Synchronization is a ubiquitous phenomenon wherein multiple units behave in unison, ensuring coherence across a wide range of systems. To understand the mechanisms underlying synchronization, the Kuramoto model was introduced in the 1970s. This simple yet effective model elucidates the synchronization transition in weakly interacting units. However, most studies have traditionally focused on pairwise interactions. In recent years, it has become evident that higher-order (multibody) interactions are pivotal for accurately describing dynamics.

Given the limited understanding of synchronization influenced by higher-order interactions, we propose the simplest extension of the Kuramoto model incorporating three-body interactions. Our model's simplicity facilitates a comprehensive analysis of its dynamics, revealing novel transitions to synchrony. Notably, under certain parameters, synchronization arises amidst significant multistability or from two-cluster states. Moreover, our extended Kuramoto model, since it is derived from phase reduction, represents a generic scenario applicable to systems of coupled units. We hope this work expands our understanding of synchronization in complex systems, highlighting the role of multibody interactions.

References: