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Gaussian noise and the two-network frustrated Kuramoto model

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Abstract

We examine analytically and numerically a variant of the stochastic Kuramoto model for phase oscillators coupled on a general network. Two populations of phased oscillators are considered, labelled 'Blue' and 'Red', each with their respective networks, internal and external couplings, natural frequencies, and frustration parameters in the dynamical interactions of the phases. We disentagle the different ways that additive Gaussian noise may influence the dynamics by applying it separately on zero modes or normal modes corresponding to a Laplacian decomposition for the sub-graphs for Blue and Red. Under the linearisation *ansatz* that the oscillators of each respective network remain relatively phase-sychronised centroids or clusters, we are able to obtain simple closed-form expressions using the Fokker-Planck approach for the dynamics of the average angle of the two centroids. In some cases, this leads to subtle effects of metastability that we may analytically describe using the theory of ratchet potentials. These considerations are extended to a regime where one of the populations has fragmented in two. The analytic expressions we derive largely predict the dynamics of the non-linear system seen in numerical simulation. In particular, we find that noise acting on a more tightly coupled population allows for improved synchronisation of the other population where deterministically it is fragmented.

Keywords: synchronisation, oscillator, Kuramoto, network, frustration
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