Chimera states in two interacting populations of nonlocally coupled Stuart-Landau oscillators

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Chimera states are intriguing spatiotemporal patterns coexisting with synchronized and desynchronized oscillations and it has brought out considerable attention towards the study of coupled networks with nonlocal topology. Such a remarkable phenomenon was initially found in nonlocally coupled identical oscillators [1]-[2]. Another interesting pattern, that is imperfect chimera state has also been reported with coupled pendula and this state is characterized by a certain small number of solitary oscillators (solitary state) which escape from the synchronized chimera's cluster (where solitary oscillator represents a single repulsive oscillator splitting up from the fully synchronized group). Such escaped oscillators oscillate with different average frequencies [3]. A novel mechanism for the creation of chimera states via the appearance of the solitary states is also reported in Kuramoto model with inertia and with time delayed feedback oscillators .

In this talk, we discuss different kinds of imperfect synchronized states and chimera states (for spatially prepared initial conditions) in two interacting populations of nonlocally coupled oscillators. The imperfect synchronized state is characterized by certain small number of solitary oscillators exhibiting quasi-periodic oscillations which escape from the synchronized group.

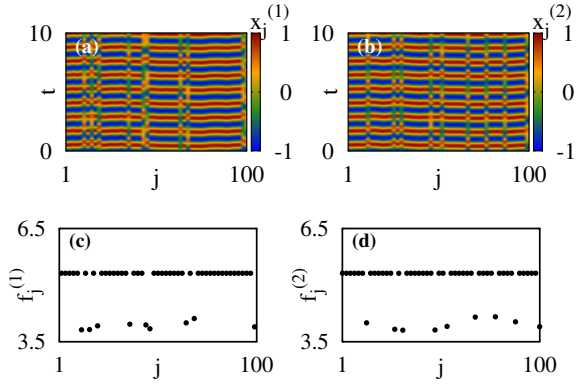

Figure 1: (Color online) Space-time plots of the variables $x_j^{(1,2)}$ for mixed imperfect synchronized state (a) for population-I and (b) for population-II. Corresponding oscillator average frequencies of (c) population-I and (d) population-II. Parameter values: $c = 5$, $\sigma = 0.1$, $\eta = 0.25$, $\omega = 1.0$ and $r = 0.1$.

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Taking into account the above facts, we discuss the dynamics of nonlocally coupled two interacting populations of Stuart-Landau oscillators. We analyze how does the nonisochronicity parameter (c) affect the emergence of different kinds of imperfect synchronized states and chimera states in such a system with nonlocal coupling. We find that for given strengths of inter- and intra-population couplings the emergence of imperfect synchronized states for sufficiently smaller values of nonisochronicity parameter (c) which means that the synchronized and escaped oscillators from synchronized state exist within population-II while the population-I remains synchronized. By increasing the strength of this parameter, we find that the synchronized oscillators from both the populations get locked to a common average frequency while the solitary oscillators are distributed with random average frequencies and we term such a state as a mixed imperfect synchronized state and is demonstrated with space-time plots in Figs. 1(a,b) and average frequency profiles of the oscillators in Figs. 1(c,d). In addition, synchronized oscillators exhibit periodic motion around the origin, whereas the desynchronized oscillators exhibit quasiperiodic motion but their center of rotation is shifted from the origin. In this region, for spatially prepared initial conditions, we can observe the coexistence of synchronized and desynchronized oscillations in both the populations, namely mixed chimera states, which is distinct from the results discussed in Ref. [4] where the chimera state represents the complete synchronization in one population while desynchronization occurs among the oscillators in the other population under global coupling. We also observe that the imperfect synchronized states can drift with time by increasing the parameter c. We also find that these states are robust against an introduction of frequency mismatch between the natural frequencies of the population with significant values of nonisochronicity parameter.

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