Chimera states in oscillatory dynamics

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Chimera states emerge in systems of nonlocally coupled identical oscillators and are characterised by coexistence of coherent and incoherent domains. These hybrid states appear unexpectedly since all elementary oscillators in the system are identical and are identically coupled. A characteristic feature of chimera states is their mean phase velocity (frequency) profile: in the coherent regions all elements have equal, constant mean phase velocity, while in the incoherent ones the frequency profiles take arc shapes. Experimental evidence of chimera states include coupled laser systems, coupled chemical oscillators and mechanical experiments of two subpopulations of linked metronomes. Applications are found in the unihemispheric sleep of birds and mammals and in brain dynamics, in general. Here we present synchronization properties leading to chimera states in networks of coupled neuronal oscillators. We study synchronization patterns and we show that the chimera multiplicity (number of coherent and incoherent regions) decreases as the coupling range increases. In systems consisting of limit cycles undergoing Hopf bifurcations we show that the incoherent regions merge as the parameters approach the bifurcation point, while the mean phase velocity of the oscillators shrink to zero. To understand the influence of connectivity in the chimera form we investigate the Leaky Integrate and Fire (LIF) model under different connectivity architectures. In the case of nonlocal connectivity we show evidence of a coexistence state where multileveled chimera patterns are formed and they coexist with domains consisting of near-threshold elements. The oscillating elements form complex mean phase velocity profiles while the potentials of the near-threshold elements present small fluctuations and never drop to the resting state. We study different synchronization patterns in the parameter space of the LIF system when the oscillators are nonlocally coupled in 1, 2 and 3 spatial dimensions. We also investigate the effects of different connectivity schemes: nonlocal connectivity, reflecting coupling, diagonal or hierarchical (fractal) connectivity.

[l] I. Omelchenko et al., Phys. Rev. E **12**, 022917 (2015).

[2] A. Schmidt et al., Phys. Rev. E **95**, 032224 (2017).

[3] N. Tsigkri-DeSmedt et al., EPJ-ST **225**, 11491164 (2016).