Interplay between internal time scales and network topology in coupled nonlinear oscillators

Jordi Zamora-Munt, Manuel A. Matías, and Pere Colet

IFISC (CSIC-UIB), 07122 Palma de Mallorca, Spain

An interesting phenomenon arising in coupled oscillators is the transition from a quiescent state to synchronized oscillatory behavior as the number of elements is increased: the Dynamical Quorum Sensing (DQS) transition [1]. This transition has been observed in a variety of systems typically coupled through a common media such as yeast cells [2], catalyst particles [3], pedestrians walking on a bridge [4], or semiconductor lasers [5]. In this work we consider the situation in which we have two coupling layers: i) the oscillators, with pairwise links; ii) a common element (hub) that couples to all the oscillators.The N oscillators are Landau-Stuart and identical that describe the turning on of oscillations in a supercritical Hopf bifurcation (SHB), and so naturally describe the transition from quiescent behavior to oscillations, and are coupled both directly and through the common element.
The behavior of the system depends on the detuning between the natural frequency of the oscillators and the central frequency of the hub, and also on the character of the direct coupling among them. If these two frequencies are identical and the interactions are attractive, synchronization is guaranteed. Instead, a desynchronization transition is observed when some interactions are repulsive, leading to rotating waves, inhomogeneous amplitude regimes, etc. An even richer scenario is obtained if both frequencies are detuned. The most interesting is the case in which one has both attractive and repulsive links and where a moderate detuning stabilizes synchronized behavior (that is unstable for zero detuning), for suitable parameter values.

References

[1] S. De Monte *et al.*, Proc. Natl. Acad. Sci. **104**, 18377 (2007).

[2] J. Aldridge and E. K. Pye, Nature **259**, 670 (1976).

[3] A. F. Taylor*et al.*, Science **323**, 614 (2009).

[4] S. H. Strogatz *et al.*, Nature **438**, 43 (2005).

[5] J. Zamora-Munt *et al.*, Phys. Rev. Lett. **105**, 264101 (2010).