# IBEC International PhD Programme Fellowships

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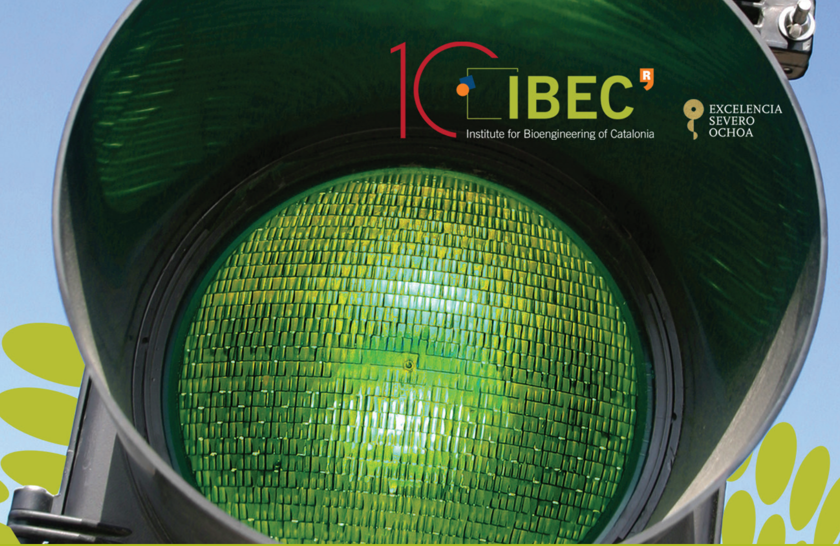

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## Coexistence of synchronization and desynchronization: Data-driven analysis of coupled network models

Often systems based on strikingly simple rules can give rise to rich and complicated structure and behavior. A simple quadratic map, for example, can yield fractal geometry in space and chaotic motion in time. A further paradigm for this type of complexity are networks of coupled phase oscillators showing so-called chimera states. All oscillators in these networks are identical and all are coupled in an identical manner. The system can therefore be described by a single-line differential equation. If one moves in such a system, it looks everywhere the same. In chimera states, however, this symmetry in the system's structure is broken by its temporal evolution. The system spontaneously falls apart into two complementary groups. One group of oscillators rotates coherently at an almost constant frequency, while the remaining oscillators perform a seemingly irregular motion. This counter-intuitive segregation into synchronous and non-synchronous motion has been studied using both analytical and numerical approaches.

More recently chimera states were reported in experimental setups and an increasing number of conceptual links between chimera states and different real-world phenomena were drawn. This includes some recent work of our nonlinear time series analysis group, where we discovered an intriguing analogy between the collapse of so-called chimera states in non-locally coupled phase oscillators and epileptic seizures. (For more detailed information, we refer candidates to the links given below).

In further work we studied the interaction of chimera states across separate networks. It showed that a simple driver-response coupling between networks can lead to so-called generalized synchronization across networks while both networks maintain their inner segregation into synchronized and desynchronized domains. The proposed project aims to continue in these lines of research. It involves the data-driven study of signals derived from the oscillator network models in chimera states as well as biomedical data provided by clinical partners. The latter includes, but does not have to be limited to, electroencephalographic recordings from epilepsy patients. Both the implementation of the networks as well as the signal analysis is purely numerical.

The programming language Matlab will be used for this purpose. Analytical aspects can be added, but shall not be the main focus of this work. This thesis involves no laboratory or experimental work. The ideal candidate should have a background in physics, mathematics or related fields. Previous experience in the study of dynamical systems is a plus.

http://www.nature.com/articles/srep23000    http://ntsa.upf.edu/system/files/biblio/Andrzejak_etal_Chaos2017_0.pdf