The role of homoclinic and heteroclinic cycles in neuronal models: individual and networked

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Abstract

In this talk we present two applications of complete biparametric analysis of the bifurcations and different behaviours of single-neuron models, both giving a detailed information of the single-cell model as basic information to analyze small neuron networks (CPGs).

First, we characterize the systematic changes in the topological structure of chaotic attractors that occur as spike-adding and homoclinic bifurcations are encountered in the slow-fast dynamics of neuron models. This phenomenon is detailed in the Hindmarsh-Rose neuron model and in the inter-heart leech neuron model, where we show that the periodic orbits appearing after each spike-adding bifurcation have specific symbolic sequences in the canonical symbolic encoding of the dynamics of the system. This allows us to understand how these bifurcations modify the internal structure of the chaotic attractors.

Second, we reveal the existence of relevant bifurcations (heteroclinic cycles) in CPGs that creates slow switching oscillations that achieve the level of robustness and stability observed in nature. To study biologically plausible CPG models it is necessary to use specially adapted techniques to take into account that the equations are grouped by each neuron. But standard computational continuation techniques use the complete system without considering the internal structure of the network, while our techniques permits to detail the complete bifurcation process.

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