Streszczenie w j. angielskim rozprawy doktorskiej

„Chimera states in coupled multistable oscillators"

mgr Dawida Dudkowskiego

The theory of nonlinear dynamical systems in one of the fastest growing branches of modern applied mathematics. Its methods are widely used in many areas of science, like physics, biology or mechanics. One of the most fundamental concepts that are related with this theory are synchronization and chaotic motion, which have been thoroughly studied by researchers over the past decades. Recently, a new type of behaviour has been discovered, characterized by the co-existence of both phenomena (coherent and incoherent dynamics), known as the chimera states.

Chimeras have been observed in many different types of networks, including chemical oscillators, neuron models, or mechanical systems. All results obtained so far suggest that they are universal phenomena and can be widely observed in nature. However, the overwhelming majority of works is focused on networks, in which coupled units are strictly monostable. Nowadays, many of the complex behaviours (both theoretical, as well as experimental) are modeled by systems which can exhibit multistability, i.e. possess more than one attractor. Along with the increase of interest in this type of dynamics, the natural need to search for chimera states arise. In the Doctoral Thesis the problem of existence of chimeras in coupled multistable oscillators is considered.

The theoretical research is based in the major part on the externally excited van der Pol-Duffing model, which combines well-known van der Pol system with the Duffing type stiffness. The dynamics of a single oscillator, as well as simple network of two coupled units is studied. It has been shown that the system is highly multistable. Depending on the parameters values, many attractors co-exist, including regular (periodic orbits), as well as irregular ones (quasiperiodic and chaotic). Appearance of hidden oscillations, rare attractors and perpetual points have been presented. Observed multistability makes the van der Pol-Duffing model a good example to investigate the chimera states phenomenon in complex systems.

The appearance of chimeras is first studied in simple model of coupled bi-stable discrete-time systems, i.e. maps. The dependence of network parameters on considered states is investigated and the regions for various types of behaviour are presented. Existence and dynamics of observed patterns are discussed. Results obtained for this model allowed to characterize a new type of chimera state, for which both space-temporal and spatial chaos regions co-exist.

Then, the existence of states observed for the coupled map network has been shown for continuous-time model of forced van der Pol-Duffing oscillators. Parameters regions of different types of dynamics are determined, along with representative examples of typical chimeras patterns. The probability analysis of occurrence of chimera states is performed for varied initial conditions, as well as coupling radius and strength. Moreover, the influence of a failure of external excitations on the stability of observed states is discussed in few possible cases.

Results of the bifurcation analysis for varying coupling radius and coupling strength of considered network are presented. It has been shown that chimera may survive or be destroyed, which highly depends on the direction in which parameters are changed. Both scenarios are thoroughly investigated.

The appearance of chimeric behaviour in experimental multistable systems has been shown in the model of small network of four coupled double pendula. Depending on the external excitation parameters, single unit can exhibit the co-existence of different types of dynamics (multistability), which regions have been identified. In the coupled case, one can observe that chimera-like states are possible. Typical examples of patterns are described and discussed. Experimental observations have been validated in numerical simulations.

Results presented in the Doctoral Thesis confirm that chimera states are universal phenomena in networks of coupled multistable oscillators possessing two co-existing attractors. They can be widely observed in many types of systems (examples of which are included in the Dissertation) and depending on the initial conditions and parameters values, different chimeric patterns can be identified. Moreover, the scenarios in which one state is transformed into another can be traced and described. Results of performed research contribute in the study of chimera states and allow us to better understand this phenomenon at all.

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Dawid Dudkowski