Chimera States in Laser Delay Dynamics

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Systems modeled by delay differential equations (DDE) may exhibit very complex behavior, because of their infinite dimensional phase space. Recently, a new class of nonlinear DDE involving a second order differential model, has attracted a growing interest. Their model is derived from physical optoelectronic setup [1,2] and they also provide qualitatively new solutions compared to conventional scalar DDE (Ikeda or Mackey-Glass dynamics). An example of such solutions, so-called *virtual chimera states* discovered recently in [3], is emphasized in this contribution for a new optoelectronic setup. They are characterized by spontaneous symmetry breaking when observed in a space-time representation of DDE [4]. The dynamical system of concern is governed by an Ikeda-like model comprising an integral term :

$$\varepsilon \dot{x} = -x - \delta \int_{t_0}^{t} x(\xi)\,\mathrm{d}\xi + \beta F[x(t-\tau)], \tag{1}$$

where ε and δ are typically small bifurcation parameters, β is the third one, and F is some function describing the nonlinear delayed feedback of the dynamics. In our optoelectronic setup, F is provided by the wavelength-to-intensity nonlinear transformation obtained from a Fabry-Pérot interferometer, i.e. $F[x] = [1 + m\sin^2(x + \varPhi_0)]^{-1}$, $m = 8$, $\varPhi_0 = -0.4$.

We report on the particular bifurcation scenario for the chimera states appearance as β increases, observed both numerically for the model (1) and experimentally for the setup. On the other hand, with increase of ratio δ/ε, in the system-which exhibits multistability-a higher number of chaotic "heads" may appear. We explore the probability of different chimera solution occurrences in the $\delta - \varepsilon$ bifurcation region. It is crucial to admit the close correspondence between numerical and experimental results.

Références

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