TRANSITION TO DIFFUSION CHAOS IN AN EXCITABLE REACTION–DIFFUSION MODEL

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FitzHugh-Nagumo type systems of differential equations describing nonlinear processes occurring in so-called excitable media are a special case of reaction-diffusion systems. Those are such processes as the propagation of pulses in nerve membrane and cardiac muscle and different types of autocatalytic chemical reactions. In this paper an example of an excitable system, the catalytic CO oxidation on a Pt(1 1 0) surface is studied. A model for this system in one spatial dimension is given by a two-species reaction–diffusion system [1]:

$$\begin{cases} \dfrac{\partial u}{\partial t} = -\dfrac{1}{\varepsilon} u(u-1)(u - \dfrac{b+v}{a}) + \dfrac{\partial^2 u}{\partial x^2}, \\ \dfrac{\partial v}{\partial t} = f(u) - v, \end{cases} \tag{1}$$

where $f(u)$ is an experimental fit to the rate of change in surface structure:

$$f(u) = \begin{cases} 0, & 0 \le u < 1/3, \\ 1 - 6.75u(u-1)^2, & 1/3 \le u \le 1, \\ 1, & 1 < u, \end{cases}$$

u represents the CO adsorbate coverage and v is the fraction of surface in the reconstructed 1×2-phase. The parameters of the model satisfy conditions $0 < a < 1$, $b > 0$, $\varepsilon > 0$ and are directly related to the physical parameters (partial pressures of O and CO, and temperature).

In this paper it is shown, that the system (1) of partial differential equations with fixed parameter values can have an infinite number of different stable wave solutions, traveling along the space axis with arbitrary speed, and an infinite number of different states of spatiotemporal (diffusion) chaos. These solutions are generated by cascades of bifurcations of cycles and singular attractors according to the FSM theory [2] (Feigenbaum-Sharkovskii-Magnitskii) in the three-dimensional system of ordinary differential equations, to which the system (1) reduces with a suitable self-similar change of variables.

References

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