Pattern formation by local coupling of individual oscillators undergoing the Belousov-Zhabotinsky reaction in a structured medium

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Spatio-temporal dynamics of many biological and chemical systems depend on details of the coupling of individual oscillators. Prominent examples are the propagation of action potentials in the heart and in neuronal networks, or the propagation of chemical concentrations fields in the presence of catalyst particles. To investigate the influence of local coupling, we perform experiments of the Belousov-Zhabotinsky reaction [1] in a gel with a catalyst distribution in form of a micro-spot pattern and compare these with numerical calculations based on the FitzHugh-Nagumo (FHN) equations [2,3]. The coupling strength between the catalyst spots is changed by varying the spot size and spot distance.

We first analyze the critical spot distance, above which independent oscillation of the individual spots sets in. Below this critical distance, different types of excitation patterns are found: Either a spiral wave is formed or a 'target pattern', where one spot acts as a pacemaker for the other spots. The reason for the occurrence of different types of patterns lies in uncertainties in the experimental system preparation, which cause spot properties (size, distance, catalyst concentration) to vary slightly.

It is discussed how the characteristics such as frequency distribution, synchronisation and correlation properties of the emerging patterns change with the spot size and spot distance for three different spot shapes, and the number N of spots in the $N \times N$ array.

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