10 Abstract

This thesis is concerned with theoretical investigations of spatiotemporal pattern formation in electrochemical systems. Pattern formation results from an interplay of a positive feedback mechanism, i.e. an autocatalysis, with a transport process that mediates a 'communication' between different locations of the system.

According to the positive feedback mechanism, most electrochemical oscillators can be assigned to one of three classes of electrochemical systems. In two classes – the so-called NDR- (negative differential resistance) and HNDR- (hidden negative differential resistance) systems – the potential plays the role of the autocatalytic variable. The third class is characterized by an S-shaped polarization curve. Here, the autocatalysis originates from a chemical variable. The spatial coupling occurs via migration currents in the electrolyte and is long-range.

This thesis starts with a comprehensive investigation of the nature of this spatial coupling and its parameter dependence. Then, most of the attention is focused on typical patterns that will arise in each of the three system classes through the interaction of the spatial coupling with the reaction dynamics.

The spatial coupling through the electrolyte is shown to be characterized by two parameters: the specific conductivity of the electrolyte which determines the strength of the coupling, and a geometric factor of the cell which determines the range of the coupling. Moreover, when the system is operated under galvanostatic conditions or when an external resistance in series to the cell is present, an additional global coupling is imposed.

In systems that possess a negative differential resistance in their polarization curve (NDR systems), the long-range coupling gives rise to accelerated motion of waves in the bistable and excitable regimes. In the oscillatory regime, instabilities of the homogeneous oscillation were found.

In HNDR systems the dominant difference to the former systems is that they can develop stationary spatial structures through a Turing-type bifurcation. This bifurcation becomes the dominant one in systems possessing an S-shaped polarization curve. Here, spatial self-organization occurs in the largest parameter regime.