BOOK REVIEWS

New problems in the theory of nonequilibrium phase transitions

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L. Garrido, Ed. *Far from Equilibrium Phase Transitions: Proceedings of the Xth Sitges Conference on Statistical Mechanics. Sitges, Barcelona, Spain, June 6–10, 1988.* Springer–Verlag, Berlin; Heidelberg; New York; London; Paris; Tokyo, 1988-340 pp. (Lecture Notes in Physics V. 319).

The contents of the book *Far from Equilibrium Phase Transitions* consist of 15 reports of the X Conference on Statistical Mechanics which took place in the small Spanish city Sitges on 6–10 June 1988.

The term "nonequilibrium phase transition" is commonly used to denote the instability in the behavior of the system which is in a state far from thermodynamic equilibrium as a result of which a new state or regime of action of the system is formed. This term is applied both to the transition from one nonequilibrium state to another nonequilibrium state (such a situation is realized in open systems), and also in a transition between equilibrium states under strongly nonequilibrium conditions.

It turned out that such instabilities are characteristic of nonequilibrium systems of very different nature, these are not only (and even not so much) physical systems, but also chemical, biological, and social systems. The nonequilibrium phase transition serves as the basis for the process of self-organization, which is the essence of processes occurring in our environment. During the last 15–20 years many investigators from very different fields of modern natural science have joined in the work of studying nonequilibrium phase transitions. The development of a wide class of models which enable one to give a qualitative, and occasionally also a quantitative, description of processes occurring in nonequilibrium strongly nonlinear systems has been the result of these joint efforts. The impressive successes of modeling have been due to the relatively simple structure of the systems being studied.

At the same time in recent years the process of enlarging the class of basic models which enable one to describe complex systems, in the definition of which the words "disordered", "multiphase and distributed", "non-steady-state", and "in a noise field" appear, is taking place in the theory of nonequilibrium phase transitions. The importance of constructing realistic models of such systems is quite obvious, while the development of simple and effective methods of analysis is only beginning. The materials of the conference reflect quite explicitly this situation, present the results of analysis of many concrete systems and at the same time introduce a number of general ideas and approaches to the description of complex nonequilibrium systems. We note finally that at the basis of a nonequilibrium phase transition is bifurcation, and therefore the language of the descriptions adopted in the book is the language of the theory of dynamic systems.

The most widely represented in the book is research in which different aspects of the description of nonequilibrium phase transitions in nonlinear optical systems are investigated. In the paper "Time-dependent phase transitions" (P. Mandel, H. Zeglache and T. Erneux) it is shown that, as a result of the effect of dynamic stabilization due to the change in time at a finite rate of the governing parameter near a bifurcation value, the criterion for the stability of the regime of the operation of the system must be modified. The paper "Spontaneous symmetry breaking and spatial structures in optical systems" (L. A. Lugiato, C. Oldano, L. Sartirana, *et al.*) is devoted to an examination of the conditions of appearance in passive nonequilibrium and active systems of a phase transition associated with Türing instability and leading to the formation of a complicated picture of spatial distribution of the intensity of the radiation field. The paper "Fluctuations in the transient dynamics of nonlinear optical systems" (M. San Miguel) successfully supplements the two preceding papers by the technique of taking into account the effect of fluctuations on the relaxation process to a new stable state which arises as a result of the nonequilibrium phase transition. The paper "Quantum treatment of dispersive optical bistability" (H. Risken and K. Vogel) is devoted to the description of the process of switching in a bistable optical system brought about by quantum flucutations. The tunneling time between two "bistable" states is calculated for the Drummond-Walls model. In the paper "Phase and frequency dynamics in laser instabilities" (N. B. Abraham) attention is directed to a long list of cases when the description of laser instabilities with the aid of only amplitude equations turns out to be insufficient. Using the example of a single-mode laser with a homogeneously and inhomogeneously broadened line and of a laser with a ring resonator a discussion is given of the influence of frequency and phase dynamics on the regime of laser generation and its stability. The paper "From deterministic chaos to noise in retarded feedback systems" (M. Le Berre, Y. Pomeau, E. Ressayre, *et al.*) is devoted to a discussion of the recently (1987) discovered possibility of going over in a continuous manner from the regime of dynamic chaos to a purely random behavior (exponentially falling-off correlation function), which corresponds to the regime of Brownian movement in systems described by a differential equation with a retardation. Characteristics of such transitions were discovered that are universal for a number of systems that had been examined.

In the papers "Two nonequilibrium phase transitions: stochastic Hopf bifurcation and onset of relaxation oscillations in the diffusive sine-Gordon model (L. L. Bonilla) and "Fluctuations and critical phenomena in reaction-diffusion systems" (A. S. Mikhaĭlov) the influence of distributed noise on the characteristics of nonequilibrium phase transitions in distributed systems is discussed.

In the papers "Theoretical methods in pattern formation in physics, chemistry and biology" (M. C. Cross) and

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"Convection in binary mixtures: propagating and standing patterns" (M. Lucke) modern methods of analyzing instabilities of various kinds are presented which arise in inhomogeneous distributed systems, and the application of these methods to the study of a number of concrete systems is described.

Several papers are devoted to the description of the kinetics of nonequilibrium phase transitions in complex condensed media. These are the papers "Nonlocal and nonlinear problems in the physics of disordered media" (E. Guyon, S. Roux, and A. Hanson), "Scaling for an interfacial instability" (D. Jasnow), and "Field theory for growth kinetics" (G. F. Mazenko). The long list of present-day problems of the theory of nonequilibrium phase transitions presented in the book is completed by the papers "A review of current issues in the quantum theory of envelope solitons" (K. Lindenberg, D. Brown and X. Wang) and "Exactly solvable multistable Fokker-Planck models with arbitrarily prescribed N lowest eigenvalues" (H. R. Jauslin).

On the whole the book gives a useful general overview of the problem of nonequilibrium phase transitions and of a set of problems requiring solution. The papers presented in the book contain interesting and promising approaches to the analysis of complex systems near a nonequilibrium phase transition.

The book is well illustrated and contains a comprehensive bibliography at the end of each article. This makes it not only convenient for reading, but also provides a possibility for the interested reader to get involved in the solution of difficult problems in the theory of nonequilibrium phase transitions.

Translated by G. M. Volkoff