Continuous media and cellular automata

V. K. Semenov

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P. Manneville, N. Boccara, G. Y. Vichniac, and R. Bidaux (editors). *Cellular Automata and Modeling of Complex Physical Systems: Proceedings of the Winter School. Les Houches, France, February 21-28*, 1989, Springer-Verlag, Berlin; Heidelberg; New York; London; Paris; Tokyo; Hong Hong, 1989, 319 pp.

The book is one of the well-known series *Springer Proceedings in Physics* published by Springer-Verlag. It includes about 30 papers which were presented at the International Winter School "Cellular Automata and Modeling of Complex Physical Systems", which took place in France on February 21–28, 1989. These papers are devoted to a very broad spectrum of questions–to the general theory of cellular automata and their connection with statistical physics, to the theory of grids of "gaseous" automata and its uses, to the modeling of the macroscopic behavior of complicated physical objects in the framework of microscopic (quantum) theory, and to the design of specialized computers. They are presented by specialists in mathematics, physics, information theory, and other scientific disciplines.

The papers of the volume are unified by the concept of cellular automata, which was introduced by von Neumann and Ulam in 1948 for the formal description of a periodic grid of discrete devices (or of finite automata), each of which is functionally connected only with its nearest neighbors. In turn, a finite automaton is an object whose reaction to input signals depends on its internal state. This state, in turn, is changed by the action of those same input signals into one of a finite number of possible states.

From a physical point of view, the concept of a cellular automaton is directly associated primarily with a model replacement of continuous physical space by a discrete one. Here the internal state of each discrete automaton can characterize, for example, the number of particles that are found in a corresponding elementary volume. A grid of such automata can completely describe the motion and collisions of such particles. A conversion to such grids of "gaseous" automata in which all particles move discretely, i.e., they are moved from cell to cell, simplifies the mathematical formulation of the problem very much, and this opens up the possibility of completing the numerical modeling of the behavior of large molecular systems even while using very complicated microscopic models for the interactions of individual particles.

Three (of five) sections of the monograph under review are devoted to different aspects of this approach. From a theoretical point of view, the main interest in a grid of gaseous automata is connected with the possibility for a detailed analysis of low frequency, long wavelength disturbances in a homogeneous medium and with the possibility for studying the macroscopic diffusion caused by the microscopic interactions of individual particles. In particular, the fractal properties of a diffusion front are directly modeled in this approach. From a practical point of view, this approach enables one to solve certain difficult hydrodynamical problems with large Reynolds numbers.

One large section of the monograph is devoted to the general theoretical questions of the connection of the theory of cellular automata with information theory and statistical physics. Different approaches to the classification of such automata and discussion of the characteristics of the chaotic behavior of continuous media take up a significant part of this section. In addition, investigations are presented of three more specific modeling problems: the equilibrium behavior of a two-dimensional Ising model, the kinetics of the growth of domains in a two-dimensional medium, and finally, the critical properties of the growth of clusters.

As a whole, the book is an example of a multiplan approach to one concept, (in this case, to the concept of a cellular automaton), and therefore, it may be of interest primarily to specialists with broad interests who are interested in the general or even philosophical questions of science. Furthermore, because of the comprehensiveness of the information presented, it definitely will be useful to specialists who are associated in one way or another with the modeling and theoretical study of processes in single-phase and multiphase media. Structurally, however, the monograph under review is simply a collection of papers which, because of their fragmented and discontinuous nature, are difficult to recommend for a systematic study. To a significant degree this drawback is compensated for by a good bibliography, which not only exists for each paper, but is also presented in the form of a separate paper.

Translated by Frederick R. West