Simulation by the Monte Carlo method in statistical physics

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K. Binder, and **D. W. Heermann**, *Monte Carlo Simulation in Statistical Physics*. Springer-Verlag, Berlin; Heidelberg; New York; London; Paris; Tokyo, 1988. 127 pp. (Springer Series in Solid State Sciences. V. 80)

The book under review is a textbook on computer simulation in statistical physics utilizing pseudo-random numbers. Being bound by their nature to the availability of high-capacity computers these methods have been developing in recent decades and have significantly extended the boundaries of the possible in the investigation of many-particle systems. In fact they represent an experiment carried out on a system which is described exactly by some sort of a model Hamiltonian. The phenomenon being studied is in such a case free from the influence of any kind of side effects which are always present in an ordinary experiment. On the other hand, there are no uncontrollable approximations characteristic of the analytical method of theoretical physics. The assertion of the authors of the book concerning a revolution produced by modern methods of simulation in physics (and generally in natural sciences) and on the formation of a specific branch of science which is incompatible with the traditional separation into experimental and theoretical branches, is quite justified.

In spite of the great and ever-increasing importance of the Monte-Carlo methods in statistical physics the world (and, even more so, our country's) literature suffers from an extreme deficiency of consistent presentations of these methods suitable for an initial study. Many fundamental and completely established approaches and concepts are presented only in journal articles and in proceedings of conferences. Such a situation, associated to a great extent with the relative youth of this field of science, leads to its noticeable isolation, and hinders the recruitment of new manpower, and also the understanding of its concepts and possibilities by scientists of adjacent fields. In connection with this, it is difficult to overestimate the significance of the appearance of the first textbook on the application of simulation in statistical physics.

The authors of the book are well-known and authoritative researchers who have made a significant contribution to the theory and practice of simulation and who are also active propagandists of the Monte Carlo methods. In particular, K. Binder is the editor of, and a participant in the collection of reviews *Monte Carlo Methods in Statistical Physics* (Springer-Verlag, Berlin, 1979, Russ. transl., Mir, M., 1982). The materials of the textbook have been tested at the Summer School which took place in Figueira da Foz (Portugal) in 1987 and in a number of courses at Mainz University (FRG).

The book consists of two parts equal in volume and in importance, and presupposes a more or less parallel study of both parts. The first part describes models to be discussed later and presents the theoretical basis of simulation. Corresponding to the pragmatic spirit of the science being studied the presentation is carried out at the physical level of rigor without proving statistical theorems and without a detailed discussion of the analytical results attained by the models being examined, but contains all the necessary references. The principal attention is devoted to the practical problems of reducing statistical error, selfaveraging, the role played by the finite dimensions of the system and by the boundary conditions, etc. A detailed discussion is given of the methods of indicating phase transitions and of discovering scaling relations.

The second part is devoted to a practical realization of such ideas and represents a sequence of "laboratory exercises" which presuppose individual execution, for example, on a personal computer. The problems posed are of gradually increasing complexity and are provided with detailed and very specific recommendations, and also by fragments of programs realizing the algorithms being discussed.

The authors have consciously limited themselves to the simplest and clearest classical lattice models: random walks and self-avoiding random walks, percolation, and Ising, Potts, Heisenberg, XY, and φ^4 models. These models are very appropriate for the study of the subject and the techniques described provide a sufficient basis for a deep penetration into the "kitchen" of modern Monte-Carlo methods. However, it is regrettable that the quantum spin and multifermion systems, the simulation of which is at present at the leading edge of the physics of the condensed state, have remained outside the contents of the book. Apparently this is explained not only by the more complex physics of such systems and the elaboration of the algorithms for simulating them, but also by the interests and field of activity of the authors.