

Spin glasses, optimization, and biological applications

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M. Mezard, G. Parisi, M. Virasoro. *Spin Glass Theory and Beyond*. World Scientific, Singapore (1988). p. 476 (World Scientific Lecture Notes in Physics V.9).

At the present time there are already available several books on the theory of spin glasses—each has its own virtues, and its defects, and each has its (as a rule, somewhat pessimistic) point of view on the state of affairs in the subject under consideration. This book by scientists with a worldwide reputation—Mezard, Parisi and Virasoro, who may be regarded as some of the founders of the scientific theory of spin glasses, is the first book on this subject whose authors really know what they are writing about and, moreover, are able to communicate their knowledge to the interested reader. But when we are dealing with pure knowledge, there is no room for emotion, and therefore for pessimism.

The book consists of three parts: “Spin glasses”, “Optimization”, and “Biological applications”. At the end of each part there is provided a set of reprinted original papers, which will enable the reader to sort out the details of the computations.

The first part of the book is devoted to spin glasses proper, or more precisely, to that brilliant and amazing theory which has been constructed in recent years for the Ising model of spin glasses with an infinite range of interaction (the Sherrington-Kirkpatrick model). At the beginning of this part a detailed description is given of the traditional approach of the average-field theory and the replicating method. Then a thorough discussion is given of the essence of the solution with a violated replication symmetry and how from this formal solution there arises a very sensible concept of the structure of the spin-glass state. The nub of this part, and perhaps of the entire book, is the chapter on the nature of the spin-glass phase, in which in a simple and natural manner the concept is introduced of the ultrametric structure of

the space of metastable states and a description of this space is given in terms of the hierarchical (evolutionary) tree. This is that pure knowledge which gave rise to many rumors among uninformed readers, and also to powerful and somewhat unexpected extensions in optimization theory, in biology, and even in social sciences in order to justify the inevitability of hierarchical organizations.

The second and third parts of the book are devoted to the rapidly developing fields of “applications” of spin-glass theory to problems of optimization and biology. In problems of optimization the spin-glass concepts of hierarchical structure of metastable states turn out sometimes to be very useful for finding the desired optimal configurations, which in terms of spin glasses correspond to ground states at zero temperature.

In biological applications there are two principal directions. The first is the entirely natural attempt to describe biological and prebiological evolution in terms of the spin-glass model, because DNA molecules are possibly the system existing in nature that is the closest to the Sherrington-Kirkpatrick model. The second direction, a somewhat more unexpected and, apparently, an exceptionally promising one is the modeling of associative memory and of certain other functions of the neuron networks of the brain in terms of statistical Ising systems (the Hopfield model). Here some quite tangible (and not only theoretical) results have already been achieved and a portion of them is presented in the book under review.

On the whole this book is not only able to communicate to the thoughtful reader certain latest achievements of modern theoretical physics, but will give him the feeling that in the now famous statement of one of the pioneers of spin-glass theory David Sherrington: “Everything in the world is a spin glass” there is not a grain of exaggeration.

Unitary transformations in solid state theory

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M. Wagner. *Unitary Transformation in Solid State Physics*. North Holland, Amsterdam; Oxford; New York; Tokyo (1986) pp. 357. (Modern Problems in Condensed Matter Sciences/Gen. Eds. V. M. Agranovich and A. A. Maradudin. V. 15)

The appearance of the series of books indicated above which combines contributions of Soviet and foreign physicists should be welcomed both in its scientific and its generally humanistic aspects. It is in tune with the progressive tendencies of our time. The parallel publication of books in