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Book Review: *An Introduction to the Theory of Spin Glasses and Neural Networks*

An Introduction to the Theory of Spin Glasses and Neural Networks. V. Dotsenko, World Scientific, Singapore, 1994.

In his 1978 Les Houches lectures, Phil Anderson discussed the mean-field theory of the Ising spin glass using the replica trick and the assumption of replica symmetry, that is the assumption that all of the replicas are identical. He then noted that, "In fact, Thouless and a student [J. R. O. de Almeida] claim to have recently shown that the correct solution is surely unsymmetric with broken symmetry in the $\alpha\beta$ space. This has led to a subculture of very complicated arithmetic" [P. W. Anderson, In *Ill-Condensed Matter*, (North-Holland, Amsterdam, 1979)]. Soon after Anderson spoke these words Parisi developed his replica-symmetry-breaking scheme for the infinite-range Ising spin glass and the study of the statistical mechanics of disordered systems acquired a fascinating new set of techniques. These techniques are also the subject of some controversy because the relevance of the mean-field results for disordered systems (especially spin glasses) with finite-range interactions has been questioned, leading some researchers to doubt whether any real physical systems exhibit the exotic properties of the mean-field theories that break replica symmetry.

The present book is compact, readable introduction to the "subculture of very complicated arithmetic"; it is *not* an introduction to the theory of spin glasses and neural networks, as the title proclaims. The spatial scaling theories of the spin-glass state initiated by McMillan and by Bray and Moore are mentioned in one paragraph and their pioneering papers, which still are well worth reading, are not even cited. Fluctuations and other non-mean-field behavior are only mentioned in the context of an attempt to combine Parisi's replica-symmetry-breaking ideas with renormalization-group concepts. Therefore, the controversies mentioned above are effectively ignored. Experiments are discussed only to support the results of replica-symmetry-breaking calculations and dismiss the controversies associated with the mean-field theories. The discussion of neural networks is even more narrow. The only neural network model studied in any kind

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of detail is the original Hopfield model and the only property studied is the storage capacity of the network. Therefore, readers looking for introductions to spin glasses or neural networks are advised to go elsewhere. Good introductions to spin glasses include the long review article by K. Binder and A. P. Young, "Spin Glasses: Experimental Facts, Theoretical Concepts and Open Questions, *Rev. Mod. Phys.* **58**:801–976 (1986), and the book by K. H. Fischer and J. A. Hertz, *Spin Glasses*, (Cambridge University Press, Cambridge, 1991). An excellent introduction to neural networks from a statistical physicist's point of view is J. A. Hertz, A. S. Krogh, and R. G. Palmer, *Introduction to the Theory of Neural Computation* (Addison-Wesley, Reading, Massachusetts, 1991).

This book looks better when viewed as an introduction to the replica trick in the statistical mechanics of disordered systems. Anyone who has tried to do a replica calculation, especially one involving the breaking of replica symmetry, rapidly discovers a surfeit of "very complicated arithmetic." The challenge in these calculations for the beginner is the need to manipulate the jumble of indices and unintuitive limits in such a way that respectable physics results after all of the dust has settled. This book provides as good a guide to these manipulations as I have found. The book's 156 pages is enough to give clear coverage of most of the technical aspects of replica-symmetry-breaking calculations and to describe the interpretation of the results of these calculations in a formal manner. Since I think that the replica formalism has uses beyond spin glasses and neural networks, I think that this book deserves a place in the statistical physics literature.

Unfortunately, the production values of this book are extremely poor. It appears that the book was typeset directly from the author's TeX or LaTeX file, with no checks to see if the document-even *looked* correct. Although the resulting ubiquitous errors did not affect my ability to understand the physics discussed in the book, I did find these errors annoying after only a few pages of reading.

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