PREFACE

Motivated initially by the will to understand the strange behavior of certain magnetic alloys (which it has not fully explained yet), the theory of spin glasses has acquired by now an independent existence. The theory developed at the mean field level demonstrates a very rich and complex structure; and yet we believe that the results so derived are applicable to a wide range of complex systems.

Our aim in this book is first to provide a self contained and coherent description of spin glass theory and second to point out some of its applications in other fields.

We are firmly convinced that the techniques developed for spin glasses: the replica theory, the TAP approach and the cavity method can be applied to a myriad of other problems that otherwise are very difficult to handle. On the other hand a newcomer, even convinced of the importance of the subject may feel rejected by the apparent difficulty of the complicated algebra. We think that the moment is ripe to try a presentation of these techniques that demonstrates their essential simplicity.

This is not a review on spin glasses. The interested reader is referred to the recent and complete one by Binder and Young (1986) and to the proceedings of the Heidelberg Conferences (Morgenstern and Van Hemmen eds, 1983, 1987).

In the first part on spin glass theory we present a rather complete account of our personal point of view on the subject. Emphasis is put on clarity and coherence, sacrificing somehow the historical development and giving up completely the idea of describing the various streams of the enormous literature.

The last two parts have a different objective. We try to give examples of the diffusion of the ideas and techniques of spin glass theory in two other domains: optimization and biology. These are new and very rapidly evolving research subjects. We give the highlights of the most active among them today. The understanding and even the focal points of attention may change a lot here, but perhaps some of the basic ideas and analogies inspired by spin glasses that we present will remain.

The space dedicated to the "Cavity Method" has grown all along while working on this book. In preparing a book one painfully realises how dispersive history is and one feels compelled to do something to unify the presentations. We were happy to find out that the cavity method originally introduced to replace the physically less explicit Replica Method could be used also to: 1) Derive TAP-like equations; 2) Analyse the fluctuations around the mean field solution and 3) Analyse the dynamical behavior.

Most of this work is new and presented here for the first time, though in general the same results are derivable by other methods.

Each part of the book is complemented by a collection of reprints. They will provide the reader with the details and the explicit calculations which are not given in our presentation. The collection is not a representative subset of the literature. Neither do they imply a judgement on historical relevance. They have been chosen simply because they complement the presentation.

It is a pleasure for us to thank our colleagues with whom the vision of this subject was shaped. In the first place our collaborators: C. De Dominicis, D. Gross, J. P. Nadal, G. Paladin, N. Parga, R. Rammal, N. Sourlas, G. Toulouse, J. Vannimenus but also P. W. Anderson, C. Bachas, E. Brézin, B. Derrida, C. Itzykson, S. Kirkpatrick. Special acknowledgement is due to D. Amati, Anderson, Kirkpatrick and Toulouse for carefully reading the first version of this book and helping us to improve it through useful comments.

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This book is dedicated to our children: Diego, Leonardo, Lorenza, Sabine, Vincent.

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