J Stat Phys (2007) 129: 191–192
DOI 10.1007/s10955-007-9388-8

C. de Dominicis and I. Giardina: Random fields and spin glasses: a field theory approach

Cambridge University Press, Hardback, 2006

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Received: 24 July 2007 / Accepted: 30 July 2007 / Published online: 17 August 2007

The Wilsonian field theoretic approach has made its important and lasting mark on the theory of critical phenomena. Many heavy tomes have been dedicated to its mastery and explanation of its baroque details. This book comes on the wake of the Wilsonian revolution and deals with the intricacies of applying the field theoretic methods to the analysis of disordered systems, most notably the Random Field Ising Model and the Ising Spin Glass. It is written in masterly and elegant fashion by two remarkable researchers who have themselves, in particular prof. De Dominicis, fundamentally contributed to the subject. It is definitely not an introductory book, assumes a detailed knowledge of the field theory, and as such I can only recommend it either to researchers already working on disordered systems or advanced graduate students and postdocs. The authors masterly wield the various methods of field theory in order to "clarify and unify" via its mathematical language some of, in their opinion, more cryptic and pointed details of the theory of disordered systems. As already stated, this is not an introductory book but it is an interesting treatise on the intricacies of the various advanced and little known methods and techniques of the field theory, that can be applied to the various aspects of the theory of disordered systems.

The book grew out of a set of lectures delivered by Prof. De Dominicis at Saclay and Porto Alegre that later grew into a book with the participation of his postdoc, Irene Giardina. The focus of this book are the unifying features of the disordered systems that can be adequately represented within the field theoretic language. The book is not exhaustive but represents rather a set of beautiful formal vignettes on some aspects of the field theoretic approach to disordered systems that do not require too much space and do not completely exhaust the reader with arcane details, but are never really very far from this. It is written in lapidary style and tells just enough to provide a meaningful framework for the formal developments. A typical example of its style being the first chapter, "A brief introduction", that sets down the basics of the disordered systems in seven pages starting with quenched

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and annealed averages, the replica method and the generating functional. Each of the eleven chapters ends with a summary and a list of important references.

The second chapter introduces the random field Ising model and its replicated field theoretic representation. This is then analyzed in terms of the perturbation expansion, analysis of the divergent graphs and one-loop renormalization at the single and multi replica level. The replica approach is juxtaposed with the dynamical approach in the following chapter. This alternative approach is based on the Langevin equation for the generic Landau-Ginzburg-Wilson Hamiltonian. Apart from the perturbative approach the authors introduce also the more sophisticated Martin-Siggia-Rose formulation that is more convenient for the systems that exhibit quenched disorder. At the end of this chapter the comparison between the replica formalism and the dynamical approach allows the authors to connect the two in the static limit.

The rest of the book is dedicated manly to the description of the spin glass state of the disordered system and characterization of its properties. This is done first for the case of a spherical model constrained to pairwise interacting spins that can be solved exactly. Within this context the authors introduce the Wigner distribution, Langevin dynamics with random-like initial conditions and the generalized fluctuation dissipation theorem. Next the mean field spin glass models, especially within the context of the random energy model, allow them to introduce the one-step replica symmetry breaking and discuss the metastability and complexity of the glassy behavior. The Sharrington-Kirkpatrick model that follows in the next two chapters allows them to introduce the Parisi replica symmetry breaking, the replica Fourier transform, overlap distribution, multiple symmetry breakings and the Thouless-Anderson-Palmer formalism.

The next three chapters deal with the formal aspects of the generality of the results derived within the assumption of the (mean-field) long range interaction. They set out to derive a field theory that would have the Sharrington-Kirkpatrick mean field limit and then investigate its behavior by building a perturbation expansion around it. Within this program they analyze the replica symmetric as well as broken propagators which are quite complicated because of the complex nature of the order parameters. The replica Fourier transform method is used extensively as well as the invariance properties of the spin glass Lagrangian. The book closes with a discussion of alternative approaches such as the droplet model.

Again, this is a deep formal treatise on the intricacies of the field theoretic approach to disordered systems. It is not an introductory book but is rather a set of lectures concentrating on an insightful discussion of the various formal methods used in the analysis of the effects of disorder and the nature of the corresponding phases and order parameters. I am sure it will find its, unavoidably small, but nevertheless dedicated readership.