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Vieri Mastroprieto: Non-Perturbative Renormalization

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The concept of renormalization has played a prominent role in the development of quantum field theory, statistical mechanics, and condensed matter physics and is nowadays familiar in these disciplines. Renormalization is generally presented by means of perturbation analysis. However, the development of new mathematical techniques in recent years has put it on a broader mathematical basis. This book is written to provide an introduction to rigorous non-perturbative renormalization and its application to the previously mentioned areas. It offers two novelties with respect to previous books on the theme. First, the focus is mainly on fermionic functional integrals whose theory has only been developed more recently. Second, the book presents an implementation of Ward Identities which allows a more rigorous and complete analysis of this class of models.

This strategy is a timely and useful reference point from which to delve deeper into the notion of renormalization. It presents a self-consistent theoretical introduction to renormalization in physics. The mathematical tools are presented in a clear and concise way. The book starts with an introduction to renormalization together with different mathematical methods to compute fermionic functional integrals thus allowing a unified treatment of models in quantum field theory, statistical mechanics and condensed matter physics. The second part is devoted to constructive quantum field theory. It provides a mathematical formulation of models at low dimensions and discusses the removal of the ultraviolet and infrared cut-off, as well as the verification of the axioms and the validity of Ward identities. The next part discusses statistical physics models in two dimensions, analyzing in particular the theory of universality in perturbed Ising models and the computation of non-universal critical indices in vertex or isotropic Ashkin-Teller models. It shows that the renormalization methods developed previously can also be applied to these models. The book ends with the analysis of the low temperature properties of systems of interacting fermions which describes conduction electrons in metals. It develops the theory of quantum liquids like Luttinger or Fermi

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liquids considering models of interest in condensed matter like the Hubbard model or the Heisenberg spin chain.

The book is organized and edited in a cohesive manner to facilitate learning. It is recommendable for researchers in the renormalization group techniques and their applications for which it constitutes a compendium of the different modern approaches used to deal with current problems in the field. Some parts could be taken as a Ph.D. course. Physicists and mathematicians can find an interesting and enlightening introduction to the modern theory of renormalization.