Preface

This book is based on a short graduate course given by one of us (M.G) at New York University and at Bar-Ilan University, Israel. The decision to publish these lectures as a book was made, after some doubts, for the following reason. The theory of phase transitions, with excellent agreement between theory and experiment, was developed some forty years ago culminating in Wilson's Nobel prize and the Wolf prize awarded to Kadanoff, Fisher and Wilson. In spite of this, new books on phase transitions appear each year, and each of them starts with the justification of the need for an additional book. Following this tradition we would like to underline two main features that distinguish this book from its predecessors.

Firstly, in addition to the five pillars of the modern theory of phase transitions (Ising model, mean field, scaling, renormalization group and universality) described in Chapters 2–5 and in Chapter 7, we have tried to describe somewhat more extensively those problems which are of major interest in modern statistical mechanics. Thus, in Chapter 6 we consider the superfluidity of helium and its connection with the Bose–Einstein condensation of alkali atoms, and also the general theory of superconductivity and its relation to the high temperature superconductors, while in Chapter 7 we treat the x–y model associated with the theory of vortices in superconductors. The short description of percolation and of spin glasses in Chapter 8 is complemented by the presentation of the small world phenomena, which also involve short and long range order. Finally, we consider in Chapter 9 the applications of critical phenomena to self-organized criticality in scale-free non-equilibrium systems. While each of these topics has been treated individually and in much greater detail in different books, we feel that there is a lot to be gained by presenting them all together in a more elementary treatment which emphasizes the connection between them. In line with this attempt to combine the traditional, well-established issues with the recently published and not yet so widely known and more tentative topics, our fairly short list of references consists of two clearly distinguishable parts, one related to the classical theory of the sixties and seventies and the other to the developments in the past few years. In the index, we only list the pages where a topic is discussed in some detail, and if the discussion extends over more than one page then only the first page is listed.

We hope that simplicity and brevity are the second characteristic property of this book. We tried to avoid those problems which require a deep knowledge of specialized topics in physics and mathematics, and where this was unavoidable we brought the necessary details in the text. It is desirable these days that every scientist or engineer should be able to follow the new wide-ranging applications of statistical mechanics in science, economics and sociology. Accordingly, we hope that this short exposition of the modern theory of phase transitions could usefully be a part of a course on statistical physics for chemists, biologists or engineers who have a basic knowledge of mathematics, statistical mechanics and quantum mechanics. Our book provides a basis for understanding current publications on these topics in scientific periodicals. In addition, although students of physics who intend to do their own research will need more basic material than is presented here, this book should provide them with a useful introduction to the subject and overview of it.

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