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Book Review: *The Physics of Phase Transitions*

The Physics of Phase Transitions. P. Papon, J. Leblond and P. H. E., Meijer, Springer-Verlag, New York, 2002.

There is certainly no shortage of good books that treat specific aspects of phase transitions. The merit of the present book, as justly stated by de Gennes in the Foreword, is that it offers a "global introduction, accessible to students of physics entering graduate schools." It is based on condensed matter and thermodynamics courses given by the authors at the École Supérieure de Physique et Chimie Industrielles in Paris and The Catholic University of America in Washington DC. It is meant for graduate and doctoral students in the sciences and engineering. The book provides a valuable overview and synthesis of the subject to researchers in materials science and engineers who apply the phenomenology and theory of phase transitions.

The subject matter of the book revolves principally around the phenomenology and theoretical underpinnings of the major classes of phase transitions in fluids and solids. It gives a quite exhaustive general description of various phenomena that occur in the field of phase transitions, good overviews of experimental methods used in the study of phase phase transitions, together with introductions to some of the theoretical methods used to describe and understand phase transitions. An additional very useful feature is the description of various uses of phase transitions in industrial and large scale technical applications. The last two themes are, more often than not, unmentioned in other graduate texts on this topic. Throughout the book authors have struck a fine compromise between detail and synthesis. There is always enough detail in the phenomenological description of the various types of phase transitions, and in the broad outlines of the pertaining theoretical descriptions, so that most readers will not have a feeling that they are missing essentials of the subject. On the other hand, the details are not overpowering and the essential unity and connectedness of the various phenomena related to phase transitions in rather different systems is always evident. The book is phrased mainly in the

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language of thermodynamics. Microscopic details and models are discussed, but because a lot of ground is covered, such a unified approach to the theory is necessary. Because the book is addressed to students rather than specialists it doesn't assume a detailed familiarity with statistical mechanics beyond that covered in standard undergraduate courses. Theoretical methods and approaches are presented together with the most suitable phenomenology. I find this a rather appealing way to progress in a field that can otherwise, more often than not, get bogged down in a quagmire of theoretical finesse which stands in contrast to the more global approach adopted by the authors. Another attractive feature of the book is the discussion of some of the more important industrial applications that follow most of the chapters. Because of this I strongly recommend the book to graduate students. Industrial applications are indeed an important part of the phase transitions and should feature at least to some extent in any textbook on the subject. Furthermore, the book is also teacher-friendly and ready to use in a graduate course since it has exercises together with their solutions.

The book is voluminous but not intimidating. It consists of 11 chapters taking up 397 pages. As already stated, most of the chapters come with a section on industrial applications and exercises with solutions given at the end of the book. The first two chapters give a general description of the phenomenon of phase transitions in terms of equilibrium and non-equilibrium properties. Different categories of phase transitions are presented together with their standard classification and an introduction to the methods of investigating the phase transitions. Dynamical aspects of phase transitions are not left out and their exposition is built upon the examples of nucleation and spinodal decomposition. Since most of the chapters of the book are relatively self-contained, these two by themselves could be used in a short version of the course on phase transitions where only the general phenomenological and theoretical framework are discussed.

The bulk of the book, meaning the next six chapters, is dedicated to different specific phase transitions, explaining their characteristics, together with experimental methods for their study and the most important theoretical models for the prediction of their properties. These chapters discuss phase transitions of solidification and melting, phase transitions in fluids and their mixtures, the glass transition, gelation transition in biopolymers, collective phenomena in solids, such as magnetism, ferroelectricity, superconductivity and the universality in critical phenomena and collective phenomena in liquids, such as liquid crystals and superfluidity. These six chapters more than anything else present a global perspective on the phenomenon of phase transition in its various guises. The discussion is thus not exhaustive but it is definitely beautifully structured and unifying,

containing just about the right amount of microscopic detail in order not to get lost within it.

The last three chapters come as a sort of an afterthought and are dedicated to the nature of microsctructures and nanostructures in phase transitions, such as the martensitic transition in alloys, sintering, microemulsions, colloids and quasicrystals, phase transitions in thin films, such as phase transitions in monolayers and other surfactant systems, and phase transitions in large natural and technical systems, such as the geomaterials the plasma state of matter, the Bose–Einstein condensates and phase transitions in the ocean-atmosphere system. Their subject matter is thus a bit off what is usually covered in texts and monographs on phase transitions. It pertains partly to the field of soft matter and partly to technology but is definitely in the spirit of a global overview of the field.

To summarize, this is a well proportioned introductory book for the graduate student and can most certainly be used either whole or chapter by chapter as a part of any lecture course that deals with both the phenomenology and the theoretical underpinnings of the phase transitions. The books of this type are indeed many but this one stands out by its comprehensive perspective presented to the new student.

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