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A Modern Approach to Critical Phenomena by Igor Herbut, Cambridge University Press, Cambridge, 2007, pp. xi + 210. Scope: monograph/advanced text. Level: postgraduate and professional physicist.

Why do physicists devote serious time and effort to the study of continuous (i.e. 2nd order or lambda) phase transitions, given that most of the phase changes in nature are actually discontinuous (1st order)? Igor Herbut poses this highly pertinent question near the beginning of his book, which is devoted to the critical phenomena that occur near continuous transitions. He also provides the answer: the experimental observation that many physical properties close to a continuous transition turn out to be the same for completely different physical systems, a fascinating and seemingly counter-intuitive result. The occurrence of this universal behaviour shows that continuous phase transitions are independent of the underlying inter-particle interactions, which seems astonishing at first sight. Although there are, in fact, different universality classes depending on quantities like dimensionality and symmetry, the physicist can feel satified that he or she is studying truly fundamental phenomena. Thus the results obtained are of broad relevance to systems as diverse as e.g. critical point phenomena in condensed matter, liquid helium, superconductiviy, magnetic systems, and the early universe.

The origin of the text lies partly in a course of graduate lectures on the theory of phase transitions and renormalization group at Simon Frazer University. The opening chapter sets the scene with accessible introductory accounts of phase transitions, the Ising, XY and Heisenberg models, critical exponents, universality, scaling and correlations. The main part of the book then follows, with chapters covering Ginzburg-Landau-Wilson theory, the renormalization group, and then applications to different examples of continuous transitions. The latter include the superconducting, lower-dimensional, Kosterlitz-Thouless, higher dimensional, and quantum phase transitions. There are appendices on the Hubbard-Stratonovich transformation, the linked cluster theorem and gauge-fixing for long-range order, followed by a select bibliography.

The physics of the superfluid phase transition provides an underlying theme running throughout most of the book. The author explains in the Preface that there are three good reasons for this. First, Ginzburg-Landau-Wilson theory is most naturally introduced for a system of interacting bosons and can then easily be generalized for other universality classes. Secondly, the superfluid order parameter accommodates vortices which, as the simplest topological defects, play an important role at the transition. Thirdly, the superfluid critical point is the best quantified phase transition in nature – the celebrated lambda-point experiment on the Space Shuttle having provided excellent data over six orders of magnitude in the temperature difference from the transition – and therefore the most stringent test of the theory.

It is evident that much care and thought have been applied to optimizing the presentation and content. Each chapter starts with a succinct summary explaining in about three sentences its purpose and content. Numerous worked examples are provided and, unusually, these are placed within the text with the fully-worked solution following immediately after the statement of the problem in each case. The exposition is careful and precise, with well-chosen words, and an empathy with the reader which is all-too-often missing in advanced texts of this kind. It is an excellent, accessible and very well written book covering an important but difficult topic, and it is a pleasure to be able commend it warmly to both PhD students and lecturers working in the area.

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