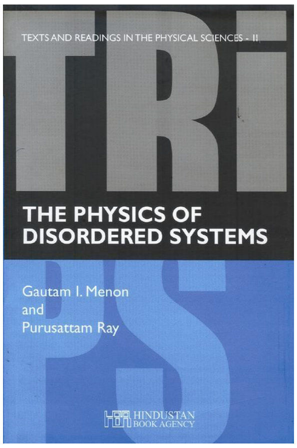

The Physics of Disordered Systems. Texts and Readings in Physical Sciences-II. Gautam I. Menon and Purusattam Ray (eds). Hindustan Book Agency, P-19 Green Park, New Delhi 110 016, 2012. 171 pp. Price: Rs 300.

This book is a collection of pedagogical articles describing the physics of disordered systems. It is based on courses given at a SERC school held at the Institute for Mathematical Sciences, Chennai. The target audience is graduate students who plan to work in the subject of disordered systems. The editors note that while the field of disordered systems has been an important area in theoretical condensed matter physics for many years, there is still no single textbook that is devoted to this subject. The student has to wrestle with a large number of more specialized review articles, or books that deal only with some of the topics discussed here. This is not a monograph; different chapters are written by different authors, each an expert in the topic covered. The unifying thread is provided by the first chapter, which has been written by the editors, and gives a clear and crisp introduction to the general subject, and the topics covered in different chapters later in the book.

The second chapter by B. K. Chakrabarti and A. Das discusses phase transitions in quantum mechanical disordered systems. They start by introducing a single particle in a double-well, which is in contact with a heat bath at a finite temperature. The transitions between the two minima can be due to quantum mechanical tunnelling, or thermally induced escape over a barrier. They study the phase transition from a coherent tunnelling to incoherent jumps as the temperature is increased in this one degree of freedom system, and then extend the discussion to the case of a linear chain of Ising spins. A large number of illustrative simple cases of the dynamics of quantum spin models with disorder are discussed. An interesting application of the theory is the idea of using quantum annealing to get an efficient algorithm to get near-optimal solutions to the classical NP-hard optimization problems like finding the ground state of a system of N Ising spins with competing interactions.

Glassy materials form an important class of disordered materials, and our understanding of these materials has increased significantly in recent years. The article by S. Sastry discusses the physics of structural glasses, like the window glass. It has interesting facts that may not be common knowledge, e.g. most of the water in the universe is presumably to be found not as liquid, or vapour form, but in the form of amorphous ice in cometary tails. Liquids, when cooled very fast, fail to reach the crystalline form and get arrested into a glassy state with very high viscosity and slow relaxational dynamics. The rate of rise in viscosity on cooling is very fast, and is often phenomenologically described by the Vogel–Fulcher–Tammann form (viscosity coefficient $\eta \sim \exp[K/(T - T^*)]$). Classical theories of glass formulation like the mode-coupling theory, and the Gibbs–di-Marzio–Adams theory are introduced. The more modern theoretical approaches are generically described as free-energy landscape theories, which consider the many possible states of the glassy system as local minima of free energy, with very slow relaxation between different minima. Computer simulations have helped understand this slow dynamics of glass. A good introduction to the basic techniques and the results obtained from these studies are provided.

In diluted ferromagnets, some fraction of magnetic atoms are randomly replaced by non-magnetic atoms. If the concentration of non-magnetic atoms is large enough, the magnetic atoms break into disconnected finite clusters, and no long-range order is possible. If the magnetic atoms form a percolating cluster, but the system is near the percolation threshold, one gets interesting effects caused by the interplay of geometrical fluctuations of the connectivity structure of the percolating cluster and thermal effects. The article by D. Kumar expertly discusses these issues.

The article by P. Shukla discusses the problem of ferromagnets in a random field. This problem was first discussed by Imry and Ma, who showed that if in an Ising ferromagnet, disorder is added in the form of an independent quenched random field with zero mean at each site, the long-range order is lost, and the system breaks into small domains of different magnetizations, even for an infinitesimal strength of the random field, in dimensions $d < 2$. However, a field theory argument using dimensional reduction indicated that the lower critical dimension should be 3 and not 2. For many years, it was not clear which was correct. Eventually, it was realized that the argument using field theory was more of a prayer than a proof, and incorrectly assumed that in the infinite perturbation series expansion, a certain infinite subset of terms if summed, would be adequate to give the correct answer. Shukla discusses the problem in a clear fashion.

In type-II superconductors put in an intermediate-strength magnetic field, the field penetrates the sample in the form of quantized vortex lines, each carrying a quantum of flux. These flux lines form a perfect lattice in the case of homogenous materials, but in the presence of disorder, there are regions where the flux lines have lower energy, and these act as pinning centres for the flux lines. As a result, the flux lines no longer form a periodic lattice with long-range order, but an amorphous, disordered glassy structure. This has important consequences: the flux lines are pinned and a small current does not cause loss of superconductivity, and the response to time-varying magnetic fields shows metastable states, and slow hysteresis and slow relaxation. The article by G. Ravikumar has a clear introduction to this subject.

The aim of the book series, as stated, is to cover the subject in a detailed manner from a personal viewpoint, and to be accessible, pedagogic and contemporary. I think this particular volume meets the goals set very well. It is recommended strongly for all students, and more seasoned workers in the subject.

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