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Book Reviews

Statistical Mechanics of the Liquid State. C. A. Croxton. J. Wiley, New York, 1980, 345 pp.

The interfacial region between a bulk liquid and its vapor is one of the most striking, important and omnipresent facets of the world of condensed matter. Until recently, our awareness of this fact was in no way matched by our understanding of the structure of the region. The advent of reliable computer simulation has changed this situation dramatically, and has made a survey of empirical information and theoretical approximations a reasonable and desirable undertaking. C. A. Croxton, who has contributed in no small way to developments in this field, has written a monograph that is generally impressive in breadth and in depth, with unavoidable—but very effective—accent on the former.

Croxton opens with a disclaimer: electrolytes and fluids in their critical region do not appear in the book, which indeed cuts out two large, very active areas. But there is no paucity of remaining material. The presentation starts of course with an introductory description—at the level of extended local thermodynamics—of the transition region. Anyone who has written a survey is well aware of the difficulty of constructing a flowing, compelling, yet accessible introduction, and this seems no more successful than most, with its share of *a posteriori* and unconvincing arguments. I am sure I would do no better. The author then proceeds to his longest chapter, a detailed account of the microscopic structure—density and correlations, as well as energetics—of the liquid–vapor interface for simple classical fluids. A nicely graded series of analytic approximations is presented and compared with simulation data, and the nature of the controversy surrounding capillary waves is discussed. The distinction between canonical and grand canonical ensembles is left a bit murky, as is usual in the field. This chapter, lengthy because it is comprehensive, is probably too terse for the neophyte, but is a very useful survey for those a bit more advanced.

With simple classical fluids disposed of, Croxton is now prepared to discuss a broad array of liquid–vapor interfaces, and does so with a flourish. The topics are diverse, and so after appropriate background is supplied, a variety of approximation methods are used for their analysis.

This is all to the good. The systems covered are, in order (Chs. 3–9), molecular (nonspherical) liquids, multicomponent liquids, liquid metals, simple quantum liquids, water, polymer solutions, and liquid crystals. Machine simulations of complex liquids are of course fewer and less reliable, so that much of the information available is from honest-to-goodness experiments on surface tension (and more recent ones on metallic interface profiles). Thus, detailed profiles and correlations are not usually available, making approximations much less easy to assess. It is then reasonable to pay more attention to simplified models—Flory's are typical—and less to systematic approaches to the exact statistical mechanics. Indeed, this is done. Another good reason is that—perhaps with the exception of simple quantum fluids—analytic approximations tend to be so formal that it is virtually impossible to evaluate them critically in any sort of meaningful detail. At any rate, the mix of techniques that Croxton discusses in this highly heterogeneous portion of the book seems quite well selected to exemplify concepts and accord with utility.

In the next chapter, Croxton returns to the general topic of computer simulation, and a number of its realizations, paying considerable attention to the validity of the (monotonic or oscillatory) density profiles that have been obtained. He then concludes with an updating of the material of the book, a potpourri of theoretical and simulation results, including some on substrate–bounded liquids. This is almost gilding the lily, since the book is in fact quite up to date, considering the level of activity in the field.

If you want a presentation that will serve as a beacon for future generations, this is not it. But if you want an overview, well written and not shallow, of the general concepts and formal techniques that many of us are currently struggling with in an attempt to understand a substantial slice of nature, Croxton's tome is certainly to be recommended.

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Solitons—Mathematical Methods for Physicists, Series in Solid-State Sciences, Vol. 19, Edited by G. Eilenberger, Springer-Verlag, Berlin, 1981, 192 pages, 31 figures.

"Solitons" joins a growing list of textbooks and monographs on solitons, the inverse scattering method, and conservation laws. Although the author intended to provide a self-contained introduction to systems exhibiting soliton solutions for "those who might want to investigate applications of the systems," he falls short of this goal. The book was written in connection with a graduate-level course in theoretical physics, but it seems unsuitable for that purpose. It does, however, present much information on soliton systems and at times with a perspective different from the literature. Therefore, this book may prove interesting to the cognoscenti.

The book consists of seven chapters plus an appendix of Mathematical Details and includes an Introduction in which the "concept" of a soliton is introduced and some aspects of wave propagation are discussed. Chapter 2 discusses the Korteweg–deVries equation (KdV) in some detail and Chapter 3 develops the inverse scattering transformation (IST) in the context of the KdV equation. An extensive discussion of the IST for other evolution equations takes up Chapter 4, the longest chapter in the book. For solid state physicists, the remaining three chapters will be the most interesting. Chapters 5 and 6 treat the "classical" sine–Gordon equation and the statistical mechanics of this equation, respectively. Chapter 7 deals with the Toda lattice, a system of differential-difference equations for discrete systems. Chapters 5 and 7 contain a few exercises.

Emphasis has been placed on the fact that physicists are really interested in perturbations of integrable systems. Thus the study of integrable systems is but a first step towards treating more realistic physical problems. Some discussion is given of results for perturbations of most of the equations treated in the book.

The partially annotated reference list is incomplete and hence presents difficulties in trying to locate original references. Compounding this frustration which will be experienced by the reader is the author's decision to omit from the text most references to the literature. Very little is done in the way of providing details of calculations and in particular in motivating many of the formulas given. The reader is thus at a loss as to where such formulas

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might come from. These formulas were originally derived systematically but the author presents them unmotivated.

The Introduction contains a number of misleading and inaccurate statements. Equation (1.1.2) is not generally referred to as the FitzHugh–Nagumo equation. The given equation does not contain a recovery variable and hence it has a stable traveling wave-front solution but not a stable solitary wave solution. The "nerve pulse" is not a traveling wave front. The author does not distinguish between a solitary wave and a traveling wave front. The derivative of a traveling wave front is a solitary wave, i.e., a localized traveling pulse. Another imprecision occurs on pg. 8. A conservation law does not yield a constant of motion unless the flux terms cancel at the boundaries and the integral of the local density exists.

Although the book is entitled "Solitons," no precise description or definition of a soliton is ever given. This lack of a good understanding of what is a "soliton" has led to much confusion in the literature so that now any solitary wave is called a soliton. One intuitive description of a "soliton," as originally intended, is that it is a solitary wave with the additional property that when two or more of them are allowed to interact, they emerge from the interaction preserving their wave shapes and speeds. A more precise description would require a discussion of the wave shapes and speeds as time goes to plus and minus infinity. Luckily, the author had decided not to discuss topological solitons which are not solitons but only solitary waves.

In summary, the book is not suitable as an introduction to the theory of solitons. The novice would be better off to look at a textbook such as *Elements of Soliton Theory* by G. L. Lamb, Jr. For the "experts," there are new ways of viewing old results and there are some new results. The book may be used as a reference book although the index is rather limited.

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