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Book Review: *Statistical Thermodynamics of Surfaces, Interfaces, and Membranes*

Statistical Thermodynamics of Surfaces, Interfaces, and Membranes. Samuel A. Safran, Addison-Wesley, Reading, Massachusetts, 1994.

This book, published as Vol. 90 of the Frontiers in Physics series, is a most welcome introduction to the study of internal interfaces found in complex multicomponent systems. The material is presented in the form of a set of lecture notes with an introductory chapter containing a brief review of the statistical mechanics, differential geometry and hydrodynamics on a level appropriate for a proper understanding of later developments. In this respect the book is basically self-contained. It also contains worked-out examples and problems at the end of each chapter. The book is intended to reach a wide interdisciplinary audience of physicists, physical chemists, chemical engineers, and materials scientists, and presents an elegant and unifying introduction to the field of interfaces in multicomponent systems.

After the introductory chapter, which also contains the pointers to more specialized texts and monographs concerning materials and experiments, the author starts appropriately with the surface/interfacial tension and surface-active agents. He also introduces the variational method for treatment of complex statistical mechanical problems arising in the theory of interfaces. The variational method is then profusively used throughout the text and presents one of the unifying features of the exposition. Based on the variational approximation, the author introduces a model free energy expression of a binary mixture and calculates the corresponding interfacial profiles.

The third chapter focuses on the thermal fluctuations of the interfaces. The free energy of interfacial fluctuations is derived in the quadratic approximation and the ensuing correlation functions, physical divergences, and capillary instabilities are discussed. The author then treats the roughening transition of solid surfaces in a way that combines the quadratic fluctuational free energy introduced in the beginning of this chapter with the variational method elaborated before.

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The next chapter treats the problem of wetting of interfaces. First a macroscopic free energy is introduced that gives the equilibrium profile and the contact angle of a fluid drop on a solid surface. Next the van der Waals interactions across the wetting layer are added to the free energy and their competition with the surface energy leading to a first-order wetting transition is discussed. Also the fluctuations in the contact line are studied in the quadratic approximation. Following this, a microscopic description of the wetting is derived in terms of the effective interaction between the substrate and the fluctuating contact line. Furthermore, hydrodynamic equations for the wetting profile are derived in the lubrication approximation.

Interactions between rigid, nonfluctuating surfaces are treated in the next chapter. Microscopic theory of van der Waals forces is invoked, which serves as an introduction to the continuum theory of van der Waals forces between macroscopic surfaces. The author uses the mode-summation approach to derive the free energy of van der Waals interactions in terms of the dispersion relations of the interacting media, which are then explicitly analyzed for planparallel geometry. Special cases of the general van der Waals free energy are discussed and some limiting formulas are given for the interaction energy. Electrostatic interaction between fixed surface charges is treated next. The approximation level is Poisson–Boltzmann and in general follows standard approaches. A nice addendum to the theory of electrostatic interactions is the treatment of the pressure tensor profile, which leads straightforwardly to the contact theorem, connecting the interaction pressure with the contact value of the density at the surface. Next the solute-mediated interactions are discussed especially in the context of polymer-mediated interactions.

The flexibility of the interfaces in relation to the interactions between them is treated in the next chapter. Curvature deformations, neutral surface, and curvature energy are introduced. A very thorough and clear discussion is given of the relation between the pressure distribution across a deformed surface and the corresponding curvature moduli. Next the fluctuations and their correlation function of the surface are treated in the quadratic approximation and the Helfrich fluctuation interaction of confined surfaces is derived. Many interesting problems in this connection are described briefly at the end of the chapter.

A chapter is devoted to colloidal dispersions. Different interactions and their relation to flocculation stability of dispersions are discussed. The Derjaguin approximation and the DLVO theory of colloid stability are also introduced in this chapter. A variational approximation is again used to derive the free energy of interaction in a charged colloid with counterions. Finally, stabilizing interactions provided by polymer brushes and the structure of colloidal aggregates are discussed in detail.

The final chapter is devoted to self-assembling interfaces. Simple treatments of the micelle and vesicle assembly are given and different contributions to their free energy are discussed. Microemulsions and bicontinuous phases are treated next, followed by a more formal introduction to the problem of random surfaces.

The book is an excellent introduction to the field of interfaces in multicomponent systems and to physics of colloids and colloid interactions in general. It is basically a self-contained text and I believe it can be profitably used in different graduate-level courses.

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