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Book Review: *Structured Fluids, Polymers, Colloids, Surfactants*

Structured Fluids, Polymers, Colloids, Surfactants. T. A. Witten and P. A. Pincus, Oxford University Press, Oxford, 1997.

This is a book based heavily on the scaling approach as set forth in the book on polymers by P. -G. de Gennes. It sets out to provide a unified, pedagogical scaling-based introduction to a broad area of soft-matter phenomena. Unity and simplicity are the desiderata guiding the authors, both renowned researchers in the field of soft-matter physics. I believe they have done a splendid job. The book was written by Tom Witten, with the chapter on colloids based heavily on an earlier draft written by Phil Pincus, who is also acknowledged as an inspiration for the whole project. The book, intended for advanced undergraduate students in physical sciences and engineering, covers most of what is usually classified as soft-condensed matter physics. Polymer physics is the paradigmatic example of this subject. The book contains numerous illuminating problems, good reference lists and is sufficiently user-friendly to serve as a basis for a one semester course on soft-matter physics. More technical or formal aspects of the soft-matter physics are relegated to appendices that conclude the main chapters.

The seven chapters of this book cover polymers, polymer solutions, colloids, interfaces and surfactants. The first two chapters give a phenomenological introduction to the field, the basics of statistical mechanics, and some fundamentals of experimental studies of soft matter. The book does not aim for advanced formalism but is very strong in conceptual foundations and physical intuition. Many of the well-known results presented in this book are derived in very original fashion that will give the students a solid conceptual basis to build on. The price to pay is that one has to have a sufficiently strong foundation in physics in order to follow the elegant conceptually-based arguments and derivations. This book will thus be a tough nutshell to crack for students without that preparation.

The chapter on polymer molecules deals with fairly standard subject matter: random-walk models of polymers, self-avoidance and self-interaction, solvent quality and electrostatics. The interesting twist given to this subject is the way dilation invariance, i.e. invariance of statistical properties of the polymer chain, when all of the distances are multiplied by an arbitrary constant, are brought to center stage in discussing the size and the interior structure of the chain in terms of its fractal dimension. The discussion in this chapter basically sets the model for later chapters.

Polymer solutions are introduced in the second chapter. The osmotic pressure of dilute and semi-dilute solutions, as well as concentrated solutions and melts, is introduced in terms of a scaling framework. The book also contains very illuminating suggestions for simple table-top experiments. I tried a few myself and they are very appropriate for the subject matter as well as fun. The students should love this part. It would not be a bad idea for other authors to follow this lead since illuminating simple experiments make theoretical arguments much more vivid and fun to follow. The second part of the chapter deals with motion of polymer chains in solution. This part of the book requires the reader to have a pretty good background in hydrodynamics. Intrinsic viscosity, hydrodynamic opacity and hydrodynamic screening are all introduced and discussed together with unentangled and entangled dynamics of semi-dilute solutions. Scaling arguments again take center stage. The conceptual foundations are reinforced by cool table-top experiments on sedimentation and jello-elasticity.

The chapter on colloids is as already stated, based heavily on an earlier draft written by Phil Pincus. It opens with the discussion of standard DLVO interactions and an interesting way to introduce the ubiquitous structural attractions called by the authors the perturbation–attraction theorem. It is illustrated nicely by the depletion forces. The discussion on the repulsive part of colloidal interactions includes steric stabilization and electrostatic stabilization. Though scaling approach is of limited value here, if applicable at all, the whole discussion is again firmly based on conceptual developments and intuitive scaling-like arguments. Salting out in the case of casein aggregation in milk is suggested, among others, as a very illuminating table-top experiment. I really cannot emphasize how pedagogically appealing and altogether cool this feature of the book is. The chapter on colloids ends with organized states in colloids such as colloidal crystals, liquid crystals and fractal aggregates and an introduction to electrophoresis and the Soret effect.

Interfaces are discussed next. Simple fluids and polyatomic fluids are dealt with in separate sections. Surface tension and surface flows together with wetting dynamics are treated extensively and the scaling approach is

again used extensively. The interfacial phenomena that are not discussed in detail, like capillary and Marangoni flows, are nevertheless described phenomenologically and explained in intuitive terms. Polymer adsorption is mostly treated in the section on polyatomic fluids in terms of its thermodynamics as well as kinetics.

The last chapter is dedicated to surfactants. They are introduced via the mixing principles, such as positivity, additivity, transitivity, reciprocity and the effect of charges, that describe the miscibility in different liquids. This is followed by descriptions of different structural features of surfactant molecules and the physics of micelles. The CMC and the mass action for wormlike micelles are discussed in detail. The most appealing part of this chapter are the sections dealing with micelle interactions, elasticity, fluctuations and Helfrich interactions. Microemulsions and amphiphilic polymers are then discussed mostly on a phenomenological level. The chapter ends with a section on dynamics and rheology, specifically dealing with micellar entanglement, rheology of lamellar solutions and shear- induced restructuring of surfactant solutions.

All of this book is superbly written with a clear emphasis on conceptual foundations and intuitive argumentation. The set of table-top experiments and a number of illuminating problems makes it very user-friendly and I am sure that the students will like it. I would certainly recommend it for a one semester course on soft-matter physics. Some interesting twists to the standard derivations found in many other textbooks should make the book fun to read even for experienced researchers in the field of soft condensed matter.

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