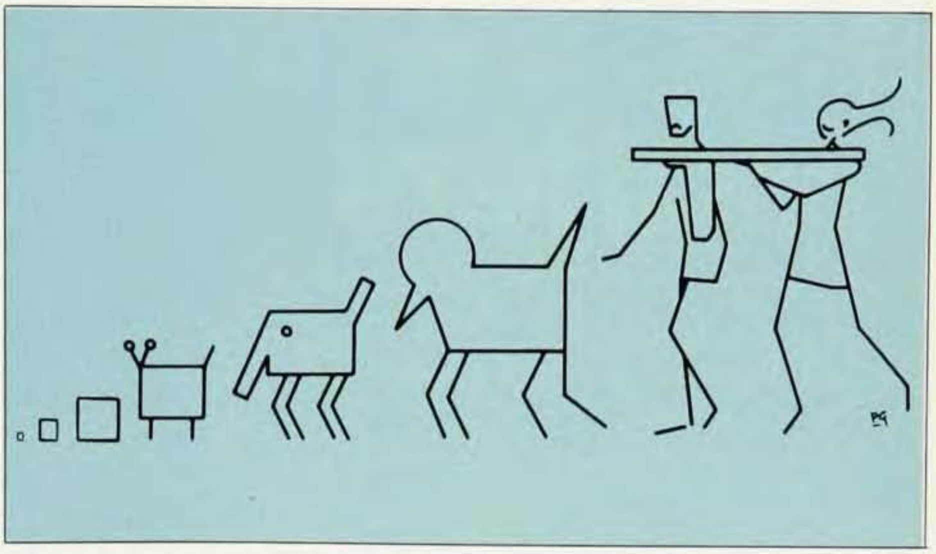
books

Applying recent advances to the study of polymers



"Various animals attempting to follow a scaling law." P. de Gennes's sketch accompanies his discussion of the spatial conformation of polymers in *Scaling Concepts in Polymer Physics.*

Scaling Concepts in Polymer Physics

P. G. de Gennes
324 pp. Cornell U., Ithaca, N.Y., 1979. $38.50

Reviewed by Thomas A. Witten

Polymers and other macromolecules are increasingly important in technology because of the fascinating range of properties they display. Some of these properties pose fundamental conceptual puzzles: A flexible linear polymer in solution is a many-body system without the usual thermodynamic behavior. Its free energy is not proportional to its length and its size grows as its length to an anomalous power. In 1972 Pierre de Gennes showed that there was a direct mathematical connection between a long polymer and another puzzling many-body system—a ferromagnet undergoing a phase transition to a paramagnet. This meant that polymers should show the whole gamut of anomalous scaling properties known in phase transitions. It also opened up to polymer theorists the powerful new renormalization methods devised to treat phase transitions.

De Gennes's new book, *Scaling Concepts in Polymer Physics*, assimilates the phase-transition ideas into previous theories of polymers. The first compilation of a decade of fruitful research by the author and his associates in Paris, Saclay and Strasbourg, it is long awaited and most welcome.

The book treats an impressive range of phenomena. Part I describes spatial conformations of linear and branched polymers in a pure phase or in solution, in confining geometries or with special external forces acting. In Part II the temporal fluctuations of polymers and their associated viscous, elastic and diffusive behavior are treated, with special emphasis on entanglement effects. Notably, de Gennes introduces the recent idea of reptation, a snakelike motion that allows entanglements to relax. Part III gives descriptive sketches of several theoretical methods used to treat these many-body systems. Here the equivalence between a polymer and a zero-component magnet is discussed for the first time in book form.

De Gennes has achieved an admirable degree of coherence for a work of such broad scope. He attains this coherence by a unifying methodological approach: the use of scaling concepts. These scaling ideas arose in the 1960's as a powerful tool for interrelating critical exponents. De Gennes shows that the same ideas can explain the power-law behavior of a great range of polymer phenomena. To be believed, scaling arguments like these must be based on a carefully laid foundation. This is the more true for de Gennes, since he aims to show why some earlier predictions were too naive and why the new phase transition ideas must be used in their place. Accordingly he takes care to discuss the "mean field" approximations made in earlier theories and to indicate where fluctuation effects like those seen in phase transitions make the mean-field approximations break down. He shows that the mean-field approximations to a self-repelling polymer break down in a space of fewer than four dimensions, and that classical gelation theory should not be rigorous in fewer than six dimensions.

Like the author's previous works on superconductivity and on liquid crystals, this book is full of physical insight. In case after case de Gennes finds an argument that shows the desired physical effect with the utmost simplicity and economy. But the simplicity carries a cost. At times the arguments lack the completeness and care necessary to convince the serious student or the skeptical expert. And occasionally, the reasoning seems to run awry, as in his discussion of the "mesh size" and the "correlation length" in a solution of overlapping chains.

Such blemishes as these are minor and hardly detract from what is intended as a book of *concepts*. For those who read it in that spirit a wealth of new phenomena and interrelations await discovery. This is particularly true for students of critical phenomena who want to learn about polymers; such readers will be at home with the scaling arguments. The book will also be valuable to polymer scientists curious about the connections between polymers and critical phenomena. For those who know polymers on the level of atoms and bonds, the airy generality of de Gennes's approach may prove unsettling. But the approach is worth getting used to, for these ideas will expand

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the current notion of what polymer science is about.

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Atomic and Molecular Collisions

Sir Harrie Massey
327 pp. Halsted (Wiley), New York, 1979. $34.95

This most recent book by Sir Harrie S. W. Massey differs somewhat from his well-known previous volumes (*The Theory of Atomic Collisions, Electronic and Ionic Impact Phenomena* and *Negative Ions*) that have served a valuable resources for those involved in the field of electronic, atomic or molecular collision physics. It is different because it is not written for the same audience; it is intended for the undergraduate physics major. In fact, the author indicates his desire for the text to be one "...which can be read with profit by a *first* year undergraduate..." He is not, however, referring to the traditional freshman physics major in an American university. A more reasonable description of a possible audience would include an undergraduate physics major whose senior thesis is in the field of atomic and molecular collisions or, possibly, an advanced undergraduate group interested in what is often referred to as a "special topics" course.

Following a brief introduction, the first four chapters contain discussions of some of the tools of quantum mechanics that are essential to the field and a review of atomic and molecular structure. The author uses a minimum of formal mathematics, and the student must accept some things on faith. The treatment is brisk, somewhat descriptive, but surprisingly complete for only 67 pages. The remainder of the text is devoted to the various subfields that fall within the general area of atomic and molecular collisions and includes discussions of both experimental techniques and theoretical methods pertinent to each subfield. Although the names of various researchers or research groups are sometimes mentioned, there are no specific references to the literature anywhere in the text. This may frustrate students who wish to refer to original

M16 star cluster and nebula in Serpens: an example of the color plates of Messier objects found in *The Messier Album: An Observer's Handbook* by J. H. Mallas and E. Kreimer (Cambridge U. P., New York, and Sky Publishing, Cambridge, Mass., 1979, $11.95).