Giant Molecules: Here, There, and Everywhere . . .

Alexander Yu. Grosberg
and Alexei R. Khokhlov
Academic P., San Diego, Calif., 1997. 244 pp. $39.95 hc
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Polymer physics is blessed in having a rich literature, including technical classics such as Paul J. Flory's *Principles of Polymer Chemistry* (Cornell, 1953/1995) and Pierre G. de Gennes's *Scaling Concepts in Polymer Physics* (Cornell, 1979/1985), and historical works, such as Herbert Morawetz's *Polymers, The Origins and Growth of a Science* (Dover, 1995). This is as it should be: Polymer science is beautiful in its own right, of great fundamental importance in statistical mechanics, materials science and biological physics, and it is vital to industries such as the petroleum, chemical and textile industries.

Alexander Yu. Grosberg and Alexei R. Khokhlov, who have made significant contributions to polymer physics, have now added to this distinguished literature in the semipopular book, *Giant Molecules: Here, There, and Everywhere* . . . . The book reviews the fundamental concepts of polymer physics and discusses some of the modern frontiers of the subject, particularly in biology. The overall level is suitable for an advanced undergraduate in physics, chemistry or chemical engineering.

The authors discuss (in chapter 3) the various types of polymeric substances, including plastics, polymeric fibers and block copolymers, while chapter 6 contains an excellent elementary discussion of rubbers. The authors get enormous mileage out of ideal chain models for polymers, which form the basis of their treatment of rubber elasticity and of excluded volume, using the justly famous Flory argument, one of the first and most successful mean-field theories of statistical physics.

Ideal chain models treat polymers as Brownian random walks, with no interaction between nonadjacent parts of the polymer. This approximation is the foundation of polymer physics. Since the mathematics of Brownian walks is accessible to beginning students, the potential audience for this book is more extensive than just the graduate students who typically read de Gennes's or Flory's books.

The "polymers of life," including DNA, RNA and proteins, are a recurring theme of the book. The problem of the tertiary structures, or spatial conformations, of proteins is currently fashionable, since the role of proteins as biological machines depends upon their spatial structures. The result is the field of protein folding, devoted to the relationship between the sequence of proteins and the energy landscape formed by their various possible spatial structures. We are fortunate that the different configurations of DNA are approximately degenerate in energy, or else life would evolve to minimize the energy of DNA rather than optimize biological fitness. The discussion of biological polymers culminates in a provocative discussion of the role of polymer physics in understanding the origin of life.

One chapter is devoted to polymer dynamics, with an extensive discussion of reptation, the mechanism postulated by de Gennes, Sam F. Edwards and Masao Doi to explain the snakelike motion of polymers in a confining network. Another chapter addresses the ambiguous role of fractals in polymer physics.

Used as a supplementary text in undergraduate statistical mechanics or condensed matter courses, this book will subvert the view of statistical mechanics as a dry, overly mathematical subject, a view reinforced by standard textbooks. Students will also learn the role of qualitative and back-of-the-envelope reasoning in physical theory. Indeed, the main disadvantage of using this book with undergraduates is that its physical reasoning is often more sophisticated than its mathematics, the reverse of the normal situation in undergraduate physics instruction. Alas, this is an indictment of American physics teaching, and not of this book.

Practitioners will also find the book stimulating, although its occasional wordiness slows the pace for more advanced readers. The lack of an index also significantly reduces its usefulness for statistical mechanicians and polymer scientists. Why, in the digital age, do publishers continue to publish scientific books without indexes?

The CD-ROM that accompanies the book contains movies of various polymeric processes, including reptation, coil collapse and swelling and micelle formation in both Mac and PC formats. The movies will be interesting to students; however, the Macintosh front end is slow and inflexible, and the quality of the movies is inferior to that of QuickTime movies.

The book is marred by occasional sloppiness. Thus, the persistence length, the length over which chain angles in a polymer are correlated, is (persistently) rendered as "persistent length." Also, Benoit Mandelbrot may be surprised to find himself described as an "American physicist." The infor-

mal style wanders dangerously close to the fey, as in the occasional dialogues between the two authors and in the somewhat alarming title.

Notwithstanding its defects, the book capably fills a void between technical works and the few popularized materials science books. Many future polymer scientists will meet the intellectual love of their lives in its pages.

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The Theory of Intermolecular Forces

Anthony J. Stone
Oxford U. P., New York, 1996.
264 pp. $90.00 hc ($50.00 pb)
ISBN 0-19-855884-8 hc
(0-19-855883-X pb)

Intermolecular forces (or, equivalently, intermolecular interactions or intermolecular potentials) determine properties of the (nonmetallic) condensed phase, of atomic and molecular clusters and of biomolecular aggregates. Their importance was recognized by Richard Feynman who, in the introduction to his *Lectures on Physics*, included a description of intermolecular forces in his "single sentence [to be] passed on to the next generation of creatures" if our civilization were to be destroyed by some cataclysm. In the not-too-distant past, our ability to predict intermolecular potentials quantitatively was very limited; theoretical investigations of condensed matter, clusters and biomolecules had to rely on very simplified models of the interactions, often on the simplest possible one: the hard-sphere model. Anthony Stone's monograph, *The Theory of Intermolecular Forces*, covers the theoretical developments that changed this unsatisfactory situation.

The modern theory of intermolecular interactions was introduced soon after quantum mechanics was conceived. The fundamental 1930s work by Fritz London is discussed in most texts on quantum mechanics. In recent decades our knowledge of intermolecular potentials improved dramatically, due to the increased capabilities of computers and the development of powerful theoretical methods for solving the many-electron problem.

These newer developments have not been covered adequately in the existing monographs, and Stone's book fills this gap admirably. He does not review, however, the numerous papers appearing each year that are devoted to calculations on specific systems. A very thorough compilation of such results up to 1984 can be found in *Intermolecular Complexes* by Pavel Hobza and Rudolf Zahradnik (Elsevier, 1988).

I believe that Stone's book will be very popular in the upcoming years, as the first-principles approach to the condensed phase and molecular clusters, based on *ab initio* computed intermolecular potentials, becomes more widespread. Stone provides quite broad coverage of intermolecular interactions. The presentation is most extensive in description of the long-range perturbation approach, which has been the author's field of research. Here, Stone gives all the detailed formulas, including appendixes listing explicit forms of the angular functions appearing in this theory. This is the first such compilation available, and for this reason alone, *The Theory of Intermolecular Forces* will be a useful reference for anybody working in this field.

Stone discusses various aspects of the so-called distributed long-range expansions. For the interaction of larger molecules, the familiar single-center multipole expansion of intermolecular potential is so quickly divergent that it is of no use except for very large intermolecular separations. The solution to this problem, developed within the last decade or so (with major contributions from Stone and his coworkers), is to divide molecules into smaller fragments and introduce the multipole expansion between the fragments. Perhaps even too much space is devoted to electrostatic and induction (polarization) interactions in the multipole approximation, compared to that devoted to the short-range components of the interaction energy and the associated exchange symmetry adaptation problem. This may give a somewhat biased perspective of the field.

The book is very well written. The style is light and the reading enjoyable, and I noticed only a few minor errors. Further, although it is a part of the Oxford University Press Monographs on Chemistry series, the book is in fact closer to a textbook than to a typical monograph. This feature is a significant asset: For most if not all of the included subjects, Stone provides a very elementary introduction, often accompanied by simple examples. In places where full explanations would be too long, Stone always gives good references to the literature.

The combination of a didactic approach and full and deep coverage of the subject matter makes the book accessible to advanced undergraduates and, at the same time, very useful for seasoned researchers in the field.

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Theory of Interplanetary Flights

G. A. Gurzadyan
Gordon and Breach, Newark, N.J., 1996. 383 pp.
$120.00 hc ($44.00 pb)
ISBN 2-88449-074-4 hc
(2-919875-15-9 pb)

Theory of Interplanetary Flights by G. A. Gurzadyan takes the reader through the processes and applications of basic and advanced astrodynamics in a clear and concise manner. While emphasis is given to the commonly known and much-published fundamentals of perturbation theory, it is enlightening to read a fresh approach that presents many real-life and current examples. Topics addressed range from manned and unmanned spaceflight to astronomical aspects of binary star systems and comets, as well as stability and chaos in the Solar System.

The introductory chapter, on the historical aspects of astrodynamics, is informative and unique, as it presents the problem of the determination of orbits from the viewpoint of early astronomers, including their difficulties and the advances each made. The theoretical and operational experience of the author comes through clearly on each topic, as he takes the reader from a beginning set of equations and examples to the most stringent and complex methods.

In each subsequent chapter, Gurzadyan develops the equations as building blocks for the reader. The description and development of the formulas of Kepler, Newton, Lagrange and many others are commendable in that the author clearly describes the reasoning, limitations and logic behind each. The presentation of perturbation theory is well documented and easy to follow. Transitions of two-body formulation and the essence of perturbation functions to other chapters flow smoothly. I found the explanation of the N-body and restricted three-body problems and the related material clearly discussed and comprehensible.

Most equations are derived in an easy formulation and then uniquely applied in the subsequent text for a complete illustration of their use. I found the derivation and discussion of the Jacobi integral and null velocity very notable—the best that I have read. While the focus of the book is interplanetary transfer trajectories, the author provides material on multiplanetary flights, gravity assist and change of influence by planetary bodies. Treatment is also given to such advanced topics as solar sailing, low-