Rydberg Atoms

T. F. Gallagher
Cambridge U. P., New York, 1994. 495 pp. $100.00 hc
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Ex Africa semper aliquid novi—There is always something new out of Africa. Had Pliny the Elder been a contemporary physicist, he might have expressed this sentiment about Rydberg atoms, atoms containing one and usually no more than two highly excited electrons. Now a noted researcher is presenting an overview of their properties and various ways of producing and analyzing them.

Much like the ancient continent whose constant stream of new marvels enthralled Pliny and his contemporaries, Rydberg atoms are still a source of much remarkable and fundamental physics. They owe this pride of place to a peculiar constitution that keeps their physical properties simple yet exaggerates them to the point where experiments unthinkable in most systems become feasible in these atoms. Today Rydberg atoms are atomic-scale laboratories in which, among other things, the quantum mechanics of nonlinear systems and the correspondence-principle limit of quantum mechanics are studied. Yet many decades ago Rydberg atoms were catalysts for the dawning of modern physics, and ultimately quantum mechanics itself, through Johann Jacob Balmer's research in line spectra and Niels Bohr's theory of planetary atoms.

The methods by which Rydberg atoms are studied have evolved, of course, since the days of Balmer, and they form the subject of this monograph. A third of *Rydberg Atoms* is devoted to collisions, and these chapters, with their detail and up-to-date references, are a must for those studying atomic collisions. I was also delighted to see the attention paid to interactions with electric fields, because most experiments on Rydberg atoms use field ionization for detection (a subject to which the author, Tom Gallagher, has made seminal contributions).

In a surprising recent development, pulsed field ionization of Rydberg molecules has become the method of choice for analyzing the vibration–rotation structure of molecules, through the so-called ZEKE technique; the book's coverage of this technique will provide valuable background as well as technical reading for photochemists. Other subjects include radiative interactions, microwave ionization, magnetic-field interactions, quantum defect theory, autoionization and double Rydberg states. In reviewing a book with such a wide scope, it is tempting to recount what is not covered: Cavity electrodynamics (a subject of frontline experimentation) is omitted, as are the semiclassical behavior of electronic motion and its broader implications for spectroscopy, chaos and wavepacket motion.

It would be a disservice to the author and the community not to give a taste of some of the directions described in *Rydberg Atoms*. Gallagher describes a set of experiments he performed on the interaction of Rydberg atoms with circularly polarized microwave fields. These experiments precipitated a flood of theoretical and experimental investigations, which have provided new insights into the effects of velocity-dependent Coriolis forces in the ionization of Rydberg atoms and molecules and, further, have revealed how such interactions might be used to produce harmonic-oscillator-like atomic coherent states, a longstanding Holy Grail of atomic physics.

This timely and beautifully produced book provides the background needed to delve into the recent literature in the area. Moreover, given the paradigmatic nature of Rydberg states in illustrating the interplay of classical and quantum mechanics, it also constitutes a rich source of experimentally realizable and elegant illustrations of basic physical principles.

TURGAY UZER
Georgia Institute of Technology
Atlanta, Georgia

Statistical Physics of Macromolecules

Alexander Yu. Grosberg
and Alexei R. Khokhlov
AIP, New York, 1994. 350 pp.
$80.00 hc ISBN 1-56396-071-0

A major class of modern society's materials and several key elements in biological machinery are based on polymers. Spectacular technological advances are now possible due to our increasing knowledge of such systems. In support of the experimental studies, mechanisms from theoretical physics have been vital in achieving our current understanding, and new developments have been blooming in recent years. The goal of *Statistical Physics of Macromolecules* is to provide a comprehensive description of these theoretical tools.

There is a limited number of books on statistical mechanics in macromolecules, and this volume makes a nice new addition. No general knowledge

of polymers is assumed, and the mathematics required is at the university level, so this text would be an appropriate choice for graduate students.

Several topics not found in most polymer textbooks are found here. Texts often focus only on the phenomena relevant to artificial high-molecular-weight polymers. Alexander Grosberg and Alexi Khokhlov's book covers those conventional theoretical problems, but subjects such as the coil–globule transition and polyelectrolytes can also be found.

This text also treats several topics of relevance to biology. New developments in molecular biology and biochemistry are occurring rapidly these days, leading to entirely new physics problems, and a well-timed chapter on biopolymers has been included. Considering the importance of this area in today's research, however, this chapter does not give a complete perspective of the field. The discussion of nucleic-acid and protein structure is very limited and fails to address all the relevant issues of molecular architecture as revealed by x-ray crystallography. A particular omission is a description of how spin-glass ideas are now used for describing protein folding and biomolecular kinetics.

A general problem of this book is its limited referencing. The number of citations presented is extremely small, making it hard for a reader to search for the relevant papers in a given topic. The book's positive contributions, however, overshadow its weaknesses. *Statistical Physics of Macromolecules* is nicely written, and I can strongly recommend it. Its overall positive aspects make it a welcome contribution to the field.

José N. Onuchic
University of California
San Diego, California

Neutrons and Solid State Physics

Ludwik Dobrzynski
and Konrad Blinowski
Ellis Horwood (Simon and Schuster), New York, 1994.
306 pp. $84.95 hc
ISBN 0-13-617192-3

Neutron scattering as a technique for probing the structure and dynamics of condensed matter was first developed at the research reactors that came into being at the end of World War II. The past year has been in some ways a period of retrospection for the field, with the awarding of the 1994 Nobel Prize in Physics to its two foremost living practitioners, Bertram Brockhouse and Clifford Shull (see PHYSICS TODAY, December 1994, page 17).

Fortuitously, 1994 was also the year in which Ellis Horwood published *Neutrons and Solid State Physics* as part of its series Physics and Its Applications. The authors, Ludwik Dobrzynski and Konrad Blinowski, senior practitioners in the field from major research centers in Poland, point out that there is already a significant number of more or less advanced monographs on neutron scattering. They have therefore aimed at a more elementary treatment, providing the graduate student or researcher approaching the field for the first time with a qualitative overview of the basic principles, instrumentation and techniques. After this basic education and some hands-on experience of neutron scattering experiments, the researcher should be able to advance to the more theoretical monographs *Theory of Neutron Scattering from Condensed Matter* by S. W. Lovesey (Clarendon Press, 1984) or *Introduction to the Theory of Thermal Neutron Scattering* by A. L. Squires (Cambridge U. P., 1978), and thence to the comprehensive reviews of Kurt Sköld and David Long Price, *Neutron Scattering Parts A–C* (Academic, 1986–87), and the recent Oxford series on Neutron Scattering in Condensed Matter published by Clarendon Press.

The authors have been largely but not completely successful in their objective. On the one hand it is extremely helpful to find in an introductory text a concise description of the basic properties of neutrons and the ways in which they are generated, scattered and detected. It is also gratifying to find a treatment of neutron wave optics integrated into the development of the subject early on, rather than treated as a curiosity on the side. The summary of neutron techniques and instrumentation is helpful, although the choice of topics is somewhat unrepresentative. The treatment of neutron spin echo that follows, however, is clear and concise, and it represents a welcome inclusion of this important development at the high-resolution limit of neutron scattering techniques.

On the other hand, it is unfortunate that the reader has to wait until half way through the book to arrive at a description of the way neutrons are actually used to study the structure and dynamics of solids. One consequence is that many important modern applications of neutron scattering are omitted. For example, there is no mention of the use of quasi-elastic scattering to study relaxation phenom-