Planning the Journey to the Red Planet

Expedition Mars

Martin J. L. Turner
Praxis/Springer-Verlag, New York, 2004. $39.95 (321 pp.). ISBN 1-85233-735-4

Reviewed by George D. Nelson

We astronomers and astrophysicists have engaged in the Mars argument at one time or another with our colleagues and our nontechnical friends. Should the US, with or without the cooperation of other nations, commit the resources to send humans to Mars and return them to Earth in the next few decades? In *Expedition Mars*, Martin Turner, a principal research fellow in the department of physics and astronomy at the University of Leicester in the UK, makes the case for the human exploration of Mars by providing historical background, describing the current state of spaceflight technology relevant to a Mars mission, and discussing the arguments for human space exploration. I have to say that while I appreciated the historical and technical discussions and personally support human space exploration, I didn't find Turner's arguments especially compelling.

I enjoyed the historical descriptions of the contributions of the early rocket pioneers Konstantin Tsiolkovsky, Robert Goddard, and Wernher von Braun, as well as the American and Russian manned programs. Military considerations clearly drove the political systems to support the scientific and engineering programs that built the *V2* and the *Saturn 5* boosters and put men on the Moon. They also drove the development of propulsion systems other than chemical rockets. These fascinating stories are not well known. Electric- and nuclear-powered rockets may contribute to future long-duration missions, and the book does a nice job of outlining their history and current status.

Expedition Mars does not follow a straight path through the material. The book starts with an executive summary of sorts that recaps the Apollo program, gives a brief description of Mars, and outlines the available technology and the political argument for human exploration. Next are a chapter recounting the World War II German program and von Braun's proposed "Marsprojekt"; a chapter on the orbital mechanics and the challenges involved in getting from Earth to Mars, landing on the surface of the planet, and returning home; three chapters that summarize chemical-, electric-, and fission-powered propulsion technologies; and a recap of proposals to use Mars materials to make fuel for the return flight. The final two chapters synthesize Mars proposals from the recent past—President George H. W. Bush's Space Exploration Initiative and NASA's Mars Reference Mission developed at the Johnson Space Center in 1997 and 1998—and summarize the technical and political hurdles to placing humans on Mars.

The book is aimed at the science-literate public, although the material varies in level of detail. The use of equations to illustrate points is not pitched at a useful level—not enough development for typical physics undergraduates and too much detail for the lay public or the professional. Some of the descriptions of the underlying science, such as the Hall effect as it pertains to electric thrusters, fall in this nether region between novices and experts.

Turner makes a believable case for our global technological capacity and does not shy away from acknowledging, if not resolving, potential political problems. For example, building and placing nuclear reactors in space to power the Mars transfer and return vehicles seem like technically desirable approaches. Whether the White House, Congress, or the public will embrace such a plan without a significant and as yet undefined motivator (such as World War II or the cold war) is doubtful. As an example of a political hurdle, Turner points out that researchers in the space-science community generally do not support the human-exploration program because they effectively use much more economical unmanned platforms for their work. Such lack of support from the space-science community leaves the aerospace industry and space-related government agencies as the primary advocates for the program. Turner also argues that with a 20-year price tag between $55 billion for the Mars Reference Mission and $450 billion for the Space Exploration Initiative, it is difficult to imagine that, in the current budget climate, Congress will authorize the funds. One can already see the evidence for that idea in Congress's tepid response to President George W. Bush's recent and more modest exploration initiative.

Turner's case for going to Mars, though basically sound, fails the political-imperative test. No matter how eloquently one expresses the most compelling argument I know, that the long-term return on investment in exploration—whether in space, the Superconducting Super Collider, or the biology laboratory—always exceeds any other initiative to improve the human condition, that argument alone is not enough. By itself, it cannot incite action from a society fully engaged with short-term issues. Von Braun's genius was the ability to tie his vision to the reality of the times.

Once, during the days when I was a NASA astronaut, I naively dared to dream that I might get to fly to Mars. Times are different today. Now, I hope to live long enough to experience the voyage to Mars vicariously. At least *Expedition Mars* helps show how it might be done.

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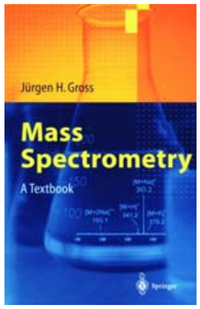
Mass Spectrometry: A Textbook

Jürgen H. Gross
Springer-Verlag, New York, 2004. $79.95 (518 pp.). ISBN 3-540-40739-1

Mass spectrometry is a diverse topic to learn and teach. The instruments are applied to a variety of analytical problems, ranging from elemental isotope separation to mapping the genome, the proteome (the set of proteins expressed by a cell or organ), and the metabolome (the metabolic products within a cell or organ). The



technique is often the last in a long line of chemical or physical analyses. In other words, mass spectrometry is tailored to the research; it is the tail wagged by the dog.

Physics, chemistry, biochemistry, and all their various subdisciplines find their way into the general topic of mass spectrometry. Sorting out this diversity in a suitably pedagogic way is hardly trivial. Although monographs on various aspects of the subject are available, as are thousands of published papers regarding its applications to particular problems or sets of problems, no textbook existed, to my knowledge, that offered an integrated perspective. Even Jürgen Gross realized, as he states in his preface to *Mass Spectrometry: A Textbook*, that "the ideal textbook still seemed to be missing." But maybe that statement is no longer true: Gross's textbook comes close to the ideal.

Gross does two important things in his book. First, he admittedly focuses on organic mass spectrometry—which is by no means a shortcoming. In terms of samples analyzed and the diversity of analyses, organic mass spectrometry vastly overwhelms all other applications combined. Moreover, various aspects of it have direct applications to inorganic analyses.

The second important aspect of Gross's work is that he organizes the text so that the fundamental and underlying elements of the field are discussed evenly and in detail in the first four chapters. Electron ionization and gas-phase ion chemistry are covered in the fifth and sixth chapters. The fundamentals are subsequently woven into discussions of various ionization methods. Anyone who would be a mass spectrometrist would do well to study the first six chapters in depth.

Chapters 7 through 11 can each be viewed as a standalone. The chapters are based on the principles of mass spectrometry addressed in the first five chapters, and each discusses a specific ionization method. Methods covered include chemical ionization, field ionization and desorption, fast-atom bombardment, matrix-assisted desorption and ionization, and electrospray ionization. The methods, in modern practice, result largely from bimolecular processes and lead to the formation of pseudomolecular ions, such as protonated molecules. The relative abundance of the ions, their fragments, and their adducts is the stuff of modern mass spectrometry. Yet each ionization method is different, characterized by its own protocols for sample preparation, loading, mass dispersion, mass spectral analysis, optimal instrumentation, and artifacts and pitfalls. Gross describes and contrasts the characteristics of each method clearly and in detail.

Gross's consistent yet familiar and engaging style is educational, and the text is effectively integrated with graphics and diagrams—some 357, according to the title page. These photographs and diagrams address a range of topics, from tentatively identified compounds and reconstructed ion chromatograms, to fragmentation energetics, ion trajectories, and mass-spectrometer source design. The author uses well-placed, framed text-boxes to provide summaries, add technical and historical notes, address peculiarities, and give pointers. The approach is endearing, especially for students in the lab who would otherwise be left wondering why the mass spectrum did not turn out the way the book said it should.

Mass Spectrometry could easily serve as a laboratory handbook. Every chapter is exceptionally well documented, with up to 200 appropriate and current literature citations. To someone working in the field, such citations are invaluable. In addition, at the end of each chapter, Gross summarizes the effectiveness of each ionization method for compound class, polarity, and molecular weight. The book also contains what might be called anecdotal sections. For example, the brief section on buying an instrument is alone worth the price of the book. Although it is unlikely that a senior undergraduate or graduate student would be purchasing a mass spectrometer, timely reference to this section in a working laboratory would prevent any number of future headaches.

The final chapter, "Hyphenated Methods," represents a paradigm shift. It is not about an ionization method at all but about combining separation with mass spectrometry. Coupling the gas chromatograph to the mass spectrometer was a monumental accomplishment 40 years ago. However, by the time a sample is run by gas chromatography–mass spectrometry (GC/MS), the mass spectrometry is pretty much a formality and chromatography becomes the main issue. Although the final chapter conveys the information necessary for a textbook, it lacks the enthusiasm generated by earlier chapters; that lack clearly reflects the fact that Gross is, after all, a mass spectrometrist, and subjects like GC/MS are fairly tame.

The book could have benefited from an expanded discussion of automated mass-spectral data handling, or perhaps even an added chapter. Mass spectrometers can generate data at a ferocious rate that necessitates automated methods, and the programs are commonplace. Currently, for example, there are at least 25 000 mass spectrometers that use automated search and retrieval systems for electrospray ionization spectra alone. Moreover, without automated analyses of mass spectra obtained from protein and DNA samples, the spectra would be practically useless: They simply contain too many peaks. Data retrieval and automated interpretation intrinsically fall into the domain of computer programming, but the programs were developed by mass spectrometrists using the very approach discussed in this book. In order for Gross to be consistent with the rest of the book, a discussion of the logic of these programs seems appropriate.

Taken as a whole, *Mass Spectrometry* is simply excellent. The book not only removes the label "black box" from the mass spectrometer but also conveys overall what might be termed as the central core of the philosophy of the mass spectrometrist. Many espouse the notion that mass spectrometry can be applied to analytical problems ranging from the obvious measurement of isotope ratios to the more subtle determination of the tertiary structure of proteins. If a problem isn't solved, it simply isn't solved *yet*. Scientists reading Gross's book as students, teachers, or practitioners will understand why mass spectrometrists are so optimistic.

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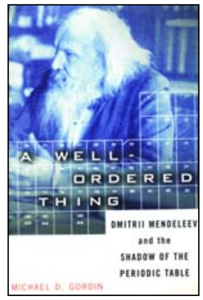
A Well-Ordered Thing: Dmitrii Mendeleev and the Shadow of the Periodic Table

Michael D. Gordin
Basic Books, New York, 2004.
$30.00 (518 pp.).
ISBN 0-465-02775-X

In March 1869, when Dmitrii Mendeleev (1834–1907) was in the thick of work on his periodic system of the chemical elements, he left St. Petersburg, Russia, to visit cheese dairies in the countryside. Coming back, he lectured to students at the University of St. Petersburg on the breeding of dairy cattle and the analysis of soil on experimental fields. Far from devoting time and energy exclusively to the solution of vexing theoretical and taxonomic problems, Mendeleev was fascinated with agricultural reform and the social and political modernization of his country. He was 35 years old, and his ambitions were not satisfied by restructuring chemical science. He also dreamt of a new, unified, and rational Russian empire, and would continue to do so his entire life.

Like other Russian intellectuals, Mendeleev wholeheartedly supported the so-called Great Reforms of Tsar Alexander II that began in 1861. Rational and consensual decision making in science became the model for fundamental social reform in imperial Russia. Chemists, in particular, provided useful expertise for the reforming state to improve agriculture and industry. While Michael Gordin's engaging book, *A Well-Ordered Thing: Dmitrii Mendeleev and the Shadow of the Periodic Table*, follows Mendeleev's scientific career, it also vividly depicts the man's many political, economic, and social endeavors. He consulted for the Baku oil industry in the 1860s and 70s, fought against spiritualism in the 1870s, became director of the Chief Bureau of Weights and Measures in 1893, and contributed to the introduction of the metric system for optional use in Russia in 1899. Gordin's narrative is at once a biography of a multifaceted man; a history of imperial Russia from the beginning of the Great Reforms to the revolution of 1905; an intriguing case study of the entanglement of science, industry, and politics in the 19th century; and a history of 19th-century chemistry and physics. As far as I know, Gordin's book is the most comprehensive biography in English about Mendeleev.

Gordin's narrative starts with a historical reconstruction of Mendeleev's major scientific achievement—the natural periodic system of chemical elements and periodic law. Yet the actual start of Mendeleev's work on the periodic table was not stimulated by pure scientific interests alone. Gordin argues convincingly that Mendeleev's teaching and pedagogical goals played important roles as well. In early 1869, when Mendeleev published his first attempt at a periodic system of elements, he was not concerned with establishing a new basic law of chemistry but with writing an introductory textbook for chemistry students at the University of St. Petersburg. The



Karlsruhe Congress in 1860, at which chemists from all over Europe reached agreement on the calculation of atomic weights, provided important insights for Mendeleev's approach to a natural classification of the chemical elements. Equally important for his approach were earlier attempts by chemists such as Jean Dumas and Johann Döbereiner who used atomic weights for the natural classification of elements. The periodic law, the proposition that the physical and chemical properties of chemical elements are periodically dependent on their atomic weight, was first established in November 1870 by Mendeleev as an originally unforeseen result of two years of intensive work that was both scientific and pedagogical.

In its final version, Mendeleev's periodic table predicted three new elements, designated "ekaboron" (scandium), "ekaaluminum" (gallium), and "ekasilicon" (germanium). But before these predictions were partially confirmed by the discovery of gallium in 1875, Mendeleev began work on new ambitious research at the border between chemistry and physics—studying gas laws, the celestial ether, and meteorological issues. Although that early form of "large-scale, organized scientific research" in Russia led to the determination of deviations in gas behavior from Robert Boyle's, Edmé Mariotte's, and Joseph Gay-Lussac's laws, it failed at its most ambitious goal—the experimental identification of celestial ether.

Under the successors of Alexander II, Mendeleev rose through the imperial hierarchy to become a major consultant. Gordin carefully follows Mendeleev's many political and scientific engagements from the 1880s until his death in 1907. He proposed educational reforms and participated in a mission to Siberia (his childhood home) to survey iron production and forests.

Gordin also covers the scientist's protectionist economic thought, his political theory, his participation in a balloon ascent for scientific observation in 1887, and the substantial revisions of his chemical textbook, *Principles of Chemistry*, in 1889. Gordin's book concludes with scientific and political events that would put Mendeleev's achievements into question: the discoveries of the noble gases, radioactivity, and the electron, as well as Russia's political revolution in 1905.

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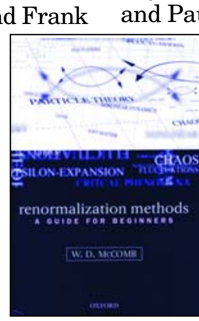
Renormalization Methods: A Guide for Beginners

W. D. McComb
Oxford U. Press, New York, 2004. $89.50 (330 pp.).
ISBN 0-19-850694-5

Renormalization originated in quantum field theory as a method of removing UV divergences in perturbation expansions. The subsequent development in the 1960s of the renormalization group introduced the novel concept of running couplings, which depend on the energy scale at which they are measured, and led to such groundbreaking discoveries as asymptotic freedom in quantum chromodynamics, for which David Gross, David Politzer, and Frank Wilczek received the Nobel Prize in Physics last year. Yet renormalization methods and the renormalization group probably have had an even more profound impact on condensed matter theory and statistical mechanics than on quantum field theory.



Aside from providing a mathematical framework from which to derive scaling laws and obtain nonclassical critical exponents near continuous phase transitions, in the past three decades, the renormalization group approach has provided a solid conceptual foundation for exploring such paradigmatic notions as universality, relevant degrees of freedom, and fixed points in parameter space. In fact, one may argue that any reduction of a complex interacting system to an effective model described by only a few variables and governed by a small set of control parameters tacitly relies on renormalization ideas. In any such model, "irrelevant" degrees of freedom are somehow integrated out to arrive at a fixed-point theory that then contains "dressed" particles and effective couplings between the remaining degrees of freedom.

W. David McComb, an expert in the field of fluid turbulence, is an avid supporter of the above overarching and almost philosophical view of renormalization. He set for himself the ambitious goal of rendering renormalization techniques and the ideas of the renormalization group accessible to advanced undergraduates and beginning graduate students in physics and neighboring sciences. I admire his courage in attempting to teach, essentially from scratch and in a mere 300 pages, technically demanding topics that encompass field-theoretic formulations based on path integrals and stochastic nonlinear hydrodynamics.

A text is certainly needed to bridge the gap between basic undergraduate course material in statistical mechanics and modern research topics. Excellent classic texts in the field, including H. Eugene Stanley's *Introduction to Phase Transitions and Critical Phenomena* (Clarendon Press, 1971) and Shang-keng Ma's *Modern Theory of Critical Phenomena* (W. A. Benjamin, 1976), miss the wide applications that the renormalization group has enjoyed more recently. Although those applications are aptly reflected in Nigel Goldenfeld's *Lectures on Phase Transitions and the Renormalization Group* (Addison-Wesley, 1992), John Cardy's *Scaling and Renormalization in Statistical Physics* (Cambridge U. Press, 1996), and Paul Chaikin and Tom Lubensky's *Principles of Condensed Matter Physics* (Cambridge U. Press, 1995), most undergraduates and beginning graduate students will find the level of those texts quite demanding. Moreover, the field theory classics such as Daniel Amit's *Field Theory, the Renormalization Group, and Critical Phenomena* (McGraw-Hill International Books, 1978) and Jean Zinn-Justin's *Quantum Field Theory and Critical Phenomena* (Clarendon Books/Oxford U. Press, 1989) most likely will be even more out of their reach.

In part 1 of *Renormalization Methods*, McComb introduces the basic ideas of renormalization. He begins on a very elementary level, which implies that he needs to explain fundamental mathematical tools such as Gaussian integrations, Green's functions, perturbation theory, and high-temperature expansions. His tour de force works quite well. He manages to cover a wide range of topics, which include anharmonic oscillators, Debye–Hückel screening, fractals, percolation, mean-field theory, dynamical systems, and diagrammatic representations and renormalization in quantum field theory. However, I find it unfortunate that Lev Landau's Fermi-liquid theory for interacting electron systems is not mentioned at all, because it so beautifully illustrates the renormalization paradigm. In addition, I noticed that quantum mechanics receives a somewhat rough treatment in chapter 1: Erwin Schrödinger's surname is misspelled, the equation named in his honor is stated incorrectly, and observables are not properly represented by operators.

Parts 2 and 3 of McComb's book describe, on a generally accessible level, the technical framework and ideas of the renormalization group for applications in statistical mechanics—from the standard topic of equilibrium critical phenomena to nonlinear stochastic dynamics. The concise treatment manages to cover the essentials appropriately, although certainly a more careful proofreading could have eliminated a few lapses. For example, I find it important to state that the renormalization procedure constitutes a semi-group and that the Ising model does display "net magnetism," namely, paramagnetism, at high temperatures. I also certainly do not understand what the author is trying to convey in chapter 7 with the misleading statement that "the Ising model is equivalent to an assumption that there are no correlations."

But more important, in the chapter on the field-theory approach, McComb fails to explain the connection between UV divergences and the infrared singularities that are physically relevant for critical phenomena. I warmly welcome the inclusion of noisy hydrodynamics and stochastic differential equations of the Langevin type. However, McComb discusses neither the Einstein relation, which in thermal equilibrium connects the white-noise correlation strength with the relaxation rate, nor the crucial impact the functional form of the stochastic force correlator may have on the scaling properties of nonequilibrium systems. Given that McComb does introduce many of the required tools in field theory, I would have found it beneficial had he included an exposition of the path-integral representation of stochastic processes and developed from there the dynamic perturbation expansion, rather than using the somewhat cumbersome iteration of the equations of motion.

My feeling is that the author's own research expertise has influenced his choice of topics, perhaps too much. Stochastically driven Navier–Stokes equations and turbulence cascades do not represent the simplest, most accessible examples of dynamic scaling. I would have first discussed the noisy Burgers equation, which McComb does mention, and simple relaxational kinetics, and then ventured into, for example, the critical dynamics of isotropic ferromagnets.

In summary, McComb manages to convey the essence of the renormalization group philosophy to uninitiated readers. The scope of his text is admirable; however, I see his book as only partially successful in explaining the required formalism in a way that would allow careful students to proceed with their own detailed calculations. In that respect, I would probably still recommend to true beginners *The Theory of Critical Phenomena* (Oxford U. Press, 1993) by James J. Binney and coauthors, which should be supplemented with the more advanced texts mentioned earlier. Nevertheless, *Renormalization Methods* should be an excellent source of material for anyone who plans to lead advanced undergraduates and first-year graduate students beyond the standard course material toward current research topics. I shall certainly keep the book in close reach when preparing my classes.

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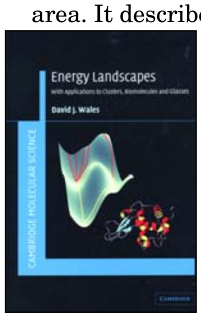
Energy Landscapes: With Applications to Clusters, Biomolecules and Glasses

David J. Wales
Cambridge U. Press, New York, 2004. $90.00 (681 pp.). ISBN 0-521-81415-4



The quest for new lands and landscapes has always been a pursuit of inquiry born out of curiosity and adventure, but also out of anticipated gains. Mapping out landscapes—recently, even beyond the planet Earth—and putting them on the map, literally and figuratively, is an essential element of that pursuit. David J. Wales's *Energy Landscapes: With Applications to Clusters, Biomolecules and Glasses* takes us on a journey of discovery and exploration of a different type of terrain—energy landscapes of systems larger than just a few atoms. It is the first textbook on this subject.

Although more nebulous, at least in the eyes of nonspecialists, energy landscapes present an expert explorer—physicist, chemist, or biologist—with the same type of features (valleys, ridges, peaks, and passages) as their planetary cousins. Why would one want to know the peculiarities of the energy landscapes of different physical, chemical, and biological systems? Because in an analysis performed at the atomic or molecular level, the energy landscapes are the ultimate reason for the structural forms these systems can assume and the complex transformations, including chemical reactions, they can undergo. Another central role of energy landscapes is to furnish a common language for describing a broad variety of seemingly disparate systems and phenomena and for identifying common, even universal, elements in them.

In most cases, the topographies of energy landscapes are much more complex than the ones we experience in our hiking and climbing expeditions. The reason is that the potential energy surface of an N-atom system is embedded in a space whose dimensionality scales as $3N$. Devising tools, which are appropriate and efficient for the exploration and mapping of these multidimensional surfaces, is a challenge that demands ingenuity and is the focus of ongoing efforts by many experts. Wales's book gives an account of the state of the art in this area. It describes, even if only tersely, the various techniques used to locate minima and saddle points and presents a fairly detailed discussion of how the knowledge of these can be synthesized into a distilled but representative and informative picture of a complex energy landscape (for example, in the form of disconnectivity graphs).

Energy Landscapes also offers readers a survey of dynamical and statistical mechanical techniques for exploration of structural transformations and thermal properties as defined by the features of the underlying potential or free energy surfaces. Applications and illustrations are given for three types of systems: clusters, biomolecules, and glasses.

The first three chapters are aimed at those who are at the beginning of the road. As an introduction to the main subject, they sketch methods used to compute potential energy surfaces, introduce issues relevant to systems discussed later, review the essence of the Born–Oppenheimer approximation and the normal modes, and present an overview of the role of symmetry. The seven chapters that follow focus on the central subject of energy landscapes and their applications and discuss a variety of other issues, including those of general conceptual and methodological nature. Among the latter are phases and phase changes in finite systems, and scaling laws.

The book is theoretical, with some mention of the relevant key experimental findings. Its scope is extensive; as a consequence, not all the subjects are covered with equal detail. Some associated issues—for example, fitting potential energy surfaces and the effect of rotation on potential energy landscapes—are not touched upon at all. The author might consider including these topics in the second edition. The balance between the formal mathematical and descriptive parts is about right for the intended broad readership, from graduate students to experts. The main value of the book lies in its being a rich resource that captures the current status of its subject matter. The style and presentation are engaging and the excellent illustrations, many in beautiful color, only heighten curiosity and enhance the desire to read on. The extensive lists of references at the end of each chapter will lead the inquiring reader to the original literature.

Energy Landscapes will be invaluable, as a roadmap and guide, to both novices and the seasoned in the expanding group of explorers of energy landscapes. University professors will find it most useful in introducing the subject to their students.

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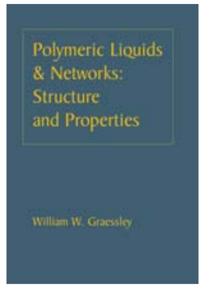
Polymeric Liquids and Networks: Structure and Properties

William W. Graessley
Garland Science, New York, 2004. $84.95 (559 pp.).
ISBN 0-8153-4169-5



Polymer science by its very nature is an interdisciplinary field that has attracted many researchers. It uses methods that range from the practical fields of synthetic chemistry, engineering, and biology to the more theoretically oriented fields of high-energy physics and condensed matter physics. Many people who call themselves polymer scientists started their careers with classic training in chemistry, biology, physics, or mathematics but find themselves confronted with problems of polymer science in their projects as industrial scientists or engineers. Academic researchers often drift into the field, drawn by the many interesting phenomena that arise in these materials, the deep and beautiful mathematics invoked to explain these phenomena, and, of course, the prospect of fundable basic research.

Given the constantly evolving nature of polymer science and its diverse practitioners, it is difficult to construct a unified description of its basic concepts and phenomenology. In *Polymer Liquids and Networks: Structure and Properties*, William Graessley approaches the problem by addressing his book to a specific audience—industrial engineers and research scientists trying to learn about polymer science in the course of their applied work, education, or research in allied fields. He makes the task more manageable by confining his treatment to synthetic polymers of well-defined molecular architectures, and by avoiding the many complexities of glass formation in polymer liquids.

Graessley, a professor emeritus in Princeton University's chemical engineering department, is perhaps best known for his studies on the rheological flow and dynamical–mechanical properties of polymer fluids. His new book, however, focuses primarily on the equilibrium properties of polymeric fluids as a foundation for understanding their dynamics. The author is preparing a second book, which will focus on the rich phenomenology of the dynamics of these complex fluids.

The attractive feature of *Polymeric Liquids and Networks* is that it starts from an elementary viewpoint emphasizing molecular chemical structure. Graessley then integrates this chemistry-dominated description with one that focuses on the universal properties of polymers that are the primary concern of physicists and mathematicians. The universal properties derive from chain connectivity, topology (ring, star, and comb—for example), and the existence of well-defined random processes that govern the conformations of polymers at equilibrium. Due attention is also given to the polydispersity of chain structure and mass, as well as other topics of practical interest to engineers and materials scientists. In the course of his interdisciplinary discussion, Graessley introduces coarse-grained models of polymers and a wide range of theoretical concepts. This broad approach is made credible by a wealth of data for numerous polymer fluids, data that support the polymer science principles introduced earlier.

Polymeric Liquids and Networks seems to be organized as a field guide to polymer science, with extended sections on matters of personal interest and engineering importance. Graessley covers statistical thermodynamics in a few pages and concisely describes some essentials of scattering theory required for reading the modern polymer-science literature. He also introduces various liquid-state models of polymer fluids and some of the important ideas behind them. The remaining chapters, which are perhaps the most novel aspect of the book, attempt to digest information from the vast field of network theory. In those chapters, Graessley discusses diverse models of network elasticity and the results of key experimental studies. Readers should be impressed by the extent to which the author reveals the gaps in our knowledge in this important area. His critical review of network elasticity theory and measurements will no doubt attract new researchers to this classic area of polymer science.

Despite the brevity and impressionistic nature of many of the remaining chapters, the author manages to work in several comments about the history of the ideas presented. His discussions are often augmented by the strategic use of references for topics that are only briefly treated or beyond his area of expertise.

Concepts covered in the book include random-walk and wormlike chain models of polymers, the notions of a polymer-overlap concentration and screening of excluded volume interactions, topological interactions, free-draining versus nonpenetrating hydrodynamic interactions of polymer chains, definitions of branched polymer types, and mean-field network theories. In addition to offering general tutorials on core polymer science concepts, Graessley dwells on topics of particular interest to engineering polymer scientists and on areas of research to which he has contributed. For example, he devotes much space to the equation-of-state description of the thermodynamic properties of polymer liquids. He also covers in detail the theoretical attempts to understand the solubility of polymer blends based on measurements of cohesive energy densities, or solubility parameters, in conjunction with the Flory–Huggins model of the free energy of mixing polymer fluids.

Moreover, Graessley offers an extended and clear discussion of the dilute-solution properties of polymers that includes his experimental contributions to this basic area of polymer science. His treatment of dilute-solution properties simultaneously considers this problem from the standpoint of testing theoretical understanding of polymer structure–property relationships, and as a source of information about polymer interactions. Thus, practical experimental methodologies are emphasized in addition to theoretical models and their validation. Examples of the experimental methodologies include plotting procedures to deduce virial coefficients from scattering, viscosity, and diffusion data; observing the comparative advantages of neutron and light scattering from such plotting procedures; and using chromatography for polymer characterization and universal calibration.

In summary, *Polymeric Liquids and Networks* manages to capture much of the conventional wisdom of the science of synthetic polymers and highlights some of the rich phenomenology of polymer networks and theories attempting to describe those observations. The text is a wealth of information on the more technical matters of characterizing the structure and interactions of polymer solutions and understanding the miscibility of polymer blends in terms of polymer structural properties and measures of interpolymer interaction. The book should be a valuable resource for newcomers who are trying to understand essential concepts of polymer science, learn some of the history of the field, and find direction for further reading.

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New Books

Acoustics

Acoustical Imaging. W. Arnold, S. Hirsekorn, eds. *International Symposium on Acoustical Imaging 27.* Proc. symp., Saarbrücken, Germany, Mar. 2003. Kluwer Academic, Norwell, MA, 2004. $219.00 (774 pp.). ISBN 1-4020-2401-0

High Frequency Ocean Acoustics. M. B. Porter, M. Siderius, W. A. Kuperman, eds. *AIP Conference Proceedings 728.* Proc. conf., La Jolla, CA, Mar. 2004. AIP, Melville, NY, 2004. $165.00 (549 pp.). ISBN 0-7354-0210-8

Astronomy and Astrophysics

Astrophysics: A New Approach. 2nd ed. W. Kundt. Springer-Verlag, New York, 2005 [2001]. $64.95 (223 pp.). ISBN 3-540-22346-0

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