its lack of mathematical details. Nevertheless, most mathematical theories on chaos are addressed in a cursory manner such that an interested reader can get a flavor of the physical and geometric concepts behind the mathematics and pursue the details elsewhere. It is hence an excellent reference for a course on nonlinear dynamics.

The writing style is concise and clear, a welcome departure from the overly flowery language of some chaos expositors. Colorful graphics, a must for a book on chaos, are also present but they are mercifully kept to a bare minimum. The exercises after some chapters are rather simplistic and are probably unnecessary for this kind of book.

All in all, I enjoyed reading the book and strongly recommend it to beginning researchers, especially those interested in the physical aspects of chaos.

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Granular Matter: An Interdisciplinary Approach

Edited by A. Mehta, Springer-Verlag, New York, 306 pp., 1994.

This book compiles a collection of interdisciplinary approaches for studying granular matters, with focus on the physics of granular matters. For instance, discussions on self-organized criticality and the lack of characteristic time and length scales at the critical state are useful to those who can benefit from viewing these phenomena as "generic examples" and derive implications for their specific granular systems. The same comment also applies to several other topics covered in this book, such as the entropy of a powder and the hard-sphere model for colloidal suspensions. Some intriguing experimental and computer simulation results are presented. These include pattern formation in a hopper flow, packing geometry as a function of vibration, and mixing and segregation of different size granular solids. Mathematical modeling for these phenomena is still in its embryo and thus only sketched in this book. The last chapter of the book offers a view that is closer to the traditional engineering concept of granular matters than the rest of the book. It discusses the possibility of modeling a granular matter as a continuum using the Mohr-Coulumb description or plastic theory with brittle and ductile fracture, as well as friction at walls. An overview of how to utilize micromechanics in the above three continuum modeling is also provided.

In summary, this book captures highlights of our current understanding of the physics of granular matters. Every chapter is written with great insight. It is a useful reference for those who are interested in knowing the complexity of granular matters, as well as our present approach in describing some complex phenomena arising from granular matters. It, however, is not for design engineers who handle granular matters.

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Polymeric Gas Separation Membranes

By R. E. Kesting and A. K. Fritzsche, Wiley Interscience Publishers, New York, 1993, XI+416 pp.

When reviewing a book, I try to decide if I would be willing to spend my own money to buy it. My willingness to open my wallet increased as I progressed through this book. On p. 1, I encountered the statement: "We feel, furthermore, that in the case of rigid glassy polymers, particularly those with high glass transition temperature (Tg), a gas separation model incorporating the concept of fixed micropores is worthy of consideration. It is our contention that the related field of reverse osmosis has suffered from the widely held, but nevertheless debatable, concept that a given polymer exhibits intrinsic permeability and selectivity."

From a quick glance at this 416-page book, I anticipated some painful reading, since I am one of those people who suffer from this widely held concept. Fortunately, after this initial shocking statement, I found that the book was not extreme and contained useful data on new materials, membrane structures, and even complete module systems. The information on module systems was covered better than most other treatments of the topic; since it was the last chapter, I closed the book with the feeling that it was worth adding to my library.

The information on materials, properties, and methods for making membranes was useful, but a bit questionable in places. I felt the authors ascribe too much importance to "transient templates" and the nonequilibrium nature of the glassy state compared to the intrinsic chemical backbone nature. They note that their perspective was biased by their experience in which a "new" material approach to membrane development was beaten by the program they helped pioneer at Monsanto, which has come to be known as the "prism α." Their highly successful membrane formation work produced a three- to fourfold improvement in productivity with no loss in selectivity.

In my opinion, the competing "new material" program they compare to was *not* actually a new material in the normal sense of the word, but rather a partially chemically modified old material. Truly new materials have properly selected novel backbone structures derived from well-defined monomers. This is quite different from an *ad hoc* chemical post treatment modification of an already-formed asymmetric membrane such as that referred to by these authors. In fact, *both* new materials and new membrane formation processes are critical for continued advances in the gas separation field.

Despite their stated tendency to favor membrane formation and processing in the pursuit of advances in gas separation systems, the authors have done a nice job in summarizing the tremendous amount of data on new materials. They have also provided some useful insights and interpretations with regard to the effects of molecular structure on permeation and separation properties. From my perspective, however, a problem does exist with some of the discussions in Chapter 4 regarding "nodules" and microvoids. The authors stretch the bounds of polymer physics beyond where I personally feel comfortable in interpreting nonequilibrium aspects of glassy films and membranes. Discussions of the source of the nonequilibrium nature of glasses are confounded with the existence of highly questionable nodular structures supposed to exist in liquid solutions and even in the amorphous solid state. Thus, read these sections with a critical eye and with the understanding that some of the

explanations do not have the complete agreement of the polymer science community or the majority of the membrane community.

Finally and perhaps most disappointing was the incomplete discussion of the processing involved in forming the so-called prism α membrane or other competitive gas separation membranes. Indeed, since both of the authors know the details of such processes intimately they could have offered a wealth of details on what is done and why it is done in the actual spinning, drying and post treatment of these membranes. I would have found this "how to" discussion more useful than the highly speculative explanations of the *effects* of the process on the substrate and skin morphology. I had expected that this book would be the "inside story" of how the membranes are really made with some treatment of the considerable art involved in formulating dopes and balancing the processing variables to arrive at the graded density morphology that characterizes the prism α structure. It does not do this.

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Fluctuational Effects in the Dynamics of Liquid Crystals

By E. I. Kats and V. V. Lebedev, Springer-Verlag, New York, 1994, 170 pp.

This is a highly specialized monograph dealing with the fluctuation dynamics of liquid crystalline systems about their equilibrium state. Although primarily a book written for theoretical physicists by theoretical physicists, it may have limited appeal to the chemical engineering community as well.

The authors focus very narrowly on the near-equilibrium dynamics of nematic, smectic, columnar and chiral liquid crystalline phases. They discuss these phases only very briefly; a much more detailed introduction to liquid crystals is contained in the recently revised text by de Gennes and Prost (*The Physics of Liquid Crystals*, 2nd ed., Oxford, New York, 1993). However, Kats and Lebedev take great care in setting up the governing fluctuating hydrodynamic equations, discussing both the derivation of the reversible terms arising from Poisson brackets and the irreversible terms involving transport coefficients. This presentation is somewhat more detailed than the corresponding material in de Gennes' and Prost's text, but is not as elegant as in the classic article by Martin et al. (*Physical Review A* **6**, 2401, 1972).

After setting up the appropriate continuum description for each type of liquid crystal phase, the authors embark on a very careful analysis of fluctuation effects. In particular, they discuss the role of fluctuations in renormalizing the elastic constants and the linearized transport coefficients, such as the various viscosities that characterize liquid crystalline phases. A nice feature of the monograph is that all of these different phases are treated within the same theoretical framework. The formalism, however, is a bit heavy at times. The authors adopt the functional integral representation of stochastic dynamics due to de Dominicis and Janssen, but have a nonstandard way of dealing with the functional Jacobian that enters the theory and preserves causality. In my opinion, the use of Fermi fields and associated Grassmann algebra to represent the Jacobian is a bit of an overkill for the problem at hand.

I suspect that the technical details of this monograph may be inaccessible to many chemical engineers. In particular, there are probably very few engineers with a sufficient background in quantum field theory to fully appreciate the calculations outlined in this book. Nevertheless, the conclusions are potentially of importance to engineers: thermally excited fluctuations in liquid crystalline systems can lead to unusual *linear* elastic and dissipative properties. For example, if one is to understand why certain of the viscosity coefficients of smectics are larger than others, these fluctuation effects must be considered. On the other hand, engineers are often concerned with the processing of liquid crystalline materials under conditions where *nonlinear* rheological behavior is the norm. The text makes no attempt to address such far-from-equilibrium dynamical behavior.

Overall, I strongly recommend this monograph for that rare engineer who has a strong background in theoretical physics and who needs to understand in detail the linear response properties of liquid crystalline systems. Chemical engineers not in this category will probably benefit more from the broad coverage in the text of de Gennes and Prost or from a rheology text that has some discussion of liquid crystalline systems, such as that of Larson (*Constitutive Equations for Polymer Melts and Solutions*, Butterworths, Stoneham, MA, 1988).

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Reduced Kinetic Mechanisms for Applications in Combustion Systems

Edited by N. Peters and B. Rogg, Spring-Verlag, New York, Lecture Notes in Physics, Monograph 15, 1993, 360 pp.

This monograph describes the status of a reaction-engineering approach developed almost solely by mechanical engineers: reducing large sets of elementary reactions into minimum sets of species and global combustion reactions. Almost no chemical engineers work in this specific area, even though many chemical engineers are active in combustion research (e.g., four sessions at the 1994 AIChE Annual Meeting). On the other hand, the approach is relevant to chemical processes from steam cracking to plasma processing to catalysis.

A survey of the technique and its applications is reported, growing out of a series of mechanism-reduction workshops beginning in 1987. Contributors started with a common 87-reaction set for gas-phase combustion of C_1 to C_3 hydrocarbons and methanol. (Note that "mechanism" is used in this context to mean the set of reactions, not a specific sequence of steps by which an overall reaction takes place.)

The book first describes this reaction set, the transport models, and laminar flame-speed data for comparisons. Then, it divides its cases by separately considering simple premixed flames and counterflow diffusion flames. For each flame type, mechanisms are reduced and calculations are analyzed for fuels of increasing complexity—H_2, H_2/CO, CH_4, C_2H_6, C_2H_4, C_2H_2, C_3H_8, and CH_3OH. NO_x chemistry is also considered briefly.

The methods are like those used in developing Lindemann, Langmuir-Hinshelwood-Hougen-Watson, Monod, or Michaelis-Menten rate expressions. A