esting, incorporating some points of the model often ignored. His explanation of particle scattering serves to highlight an area that is important for experiments but not often touched in trying to explain the field. All in all, the book is comprehensive and covers most of the topics needed to explain microphysics to someone outside particle physics.

Who should read *What Is the World Made Of?* To start with, many physicists. Feinberg's book is a bench mark for explanations that really explain without resorting to in-group terminology. All too often physicists reaching out to a general audience too soon revert to their own jargon. Beyond physicists, it becomes harder to identify the readers. Feinberg's book, ambitious in its aims, is still heavy reading. Perhaps the most obvious candidates for readers are undergraduates seriously involved in science and scholars looking for a comprehensive overview of modern particle physics. Few casual fireside readers will work through the book to the end.

Midway in the book, Feinberg reminds us that "The relevance of all theoretical ideas to natural phenomena rests ultimately on the application of the inventions of these instrument makers. It is especially important to remember this because the greater ease of describing developments in theoretical physics can easily be distorted into the conclusion that such theoretical developments are the essential part of physics . . . ." In spite of this disclaimer it is clear that Feinberg favors the widely held view of the "hegemony of theory over experiments." Other viewpoints are possible. Nigel Calder, in his book *The Key to the Universe,* says that "theory and experimental discovery worked together like two hands on a double-ended saw."

Whether or not Feinberg's viewpoint serves the purpose of a physicist introducing his subject to a wider audience is still another question. Just after *What Is the World Made Of?* was completed Feinberg was present at a news briefing held at the Columbia Physics Department announcing the discovery of a charmed baryon. Feinberg along with other members of the department worked hard to explain the whys and ways of charm to a particularly obdurate science reporter who wanted to know how to explain the concept to the subway straphanger. After the briefing an august member of the department remarked that they should have talked about the experiment and forgot the theory.

When Feinberg does talk about experiments it is done well. He sees experiments with a clear eye, a clearer eye than most experimentalists. He is always in touch with the elements that would attract the attention of a non-physicist. His discussion of the CERN neutral-current experiment is just right.

In summary, *What Is the World Made Of?* is a wide-ranging text that gives complete coverage to microphysics. More experiments and illustrations might have sparked the book even more.

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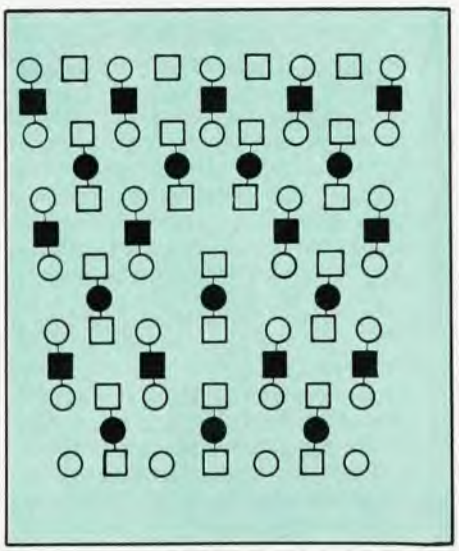
The Plastic Deformation of Simple Ionic Crystals

M. T. Sprackling
242 pp. Academic, London, 1977. £9.20

Our broad understanding of the mechanical properties of crystalline solids in terms of dislocation theory is on a relatively firm foundation. However, a quantitative understanding is frequently hampered by the details of crystal structure and bonding and by the history of the sample prior to investigation. Although the properties of dislocations or groups of dislocations are generally well established in crystalline materials, their detailed behavior as applicable to a particular class of material is frequently not available in introductory or standard text books on dislocation theory.

M. T. Sprackling's book provides a comprehensive review of the available information on dislocation-induced plastic deformation of ionic crystals. The author has carried out an extensive literature survey of this field, which should be invaluable as a source of reference or as a ready guide to a scientist starting out in this field. The book is concisely, perhaps too concisely, written. Although the author treads his way through introductory material on both the nature and properties of dislocations and ionic crystals, I found the treatment too brief and would guess that it might be difficult reading for someone uninitiated to dislocation theory or ionic solids. However, to someone somewhat familiar with these two fields, the book by Sprackling provides useful reading.



Fluorite structure with pure (001) [1$\bar{1}$0] edge dislocation. Ions in the plane of the paper are represented by circles; those at $a/4$ [110] by squares. The black circles and squares are cations (positively charged ions); the white ones are anions (negatively charged ions). From the book by M. T. Sprackling.

Following the introductory sections the author proceeds to examine dislocation interactions, nucleation and multiplication in ionic crystals. Dislocation mobility in ionic crystals is treated at some length. A variety of phenomena, such as the photoplastic effect charge flow, are touched upon. In the final chapters of the book the author develops the deformation behavior of single and polycrystalline materials under various loading conditions. He concludes with a chapter on strain hardening and describes the current state of our knowledge on the yield stress and work hardening of ionic crystals.

In summary this book provides a useful survey and extensive bibliography of plastic properties of ionic crystals. It is not a standard textbook but can serve as a source of reference. It should be a useful book for investigators in the field of ionic solids as well as for those interested in mechanical properties of solids.

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Dynamics of Polymeric Liquids, Vols. 1 and 2

R. B. Bird, R. C. Armstrong, O. Hassager, C. F. Curtiss
470 and 257 pp. Wiley, New York, 1977. $26.95

Those of us who work in the field of rheology, and particularly in polymer fluid dynamics, have long savored the rumor, and subsequently the imminence, of a text to be written by R. Byron Bird, professor of chemical engineering at the University of Wisconsin, and his colleagues. The waiting has ended; the book is outstanding in every respect.

Indeed we have two books. Volume 1 (Fluid Mechanics) is written by Bird and two of his young colleagues: Robert C. Armstrong (now at MIT) and Ole Hassager (now at the Instituttet for Kemiteknik, Denmark). In volume 2 (Kinetic Theory) these authors are joined by Charles F. Curtiss, Associate Director of the Theoretical Chemistry Institute of the University of Wisconsin.

Without detracting from the contributions of any of the authors, it is good to acknowledge the clarity of purpose and organization that one associates with Bird as a teacher and scholar and that is re-

flected so clearly in these two volumes. The work will appeal greatly to those looking for a text to provide the foundation for a course or courses in this field. Students will welcome the clarity of exposition as well as the aesthetics of the book's format. Industrially employed engineers and scientists in the polymer-processing industries will find the book (especially the first volume) relevant and valuable to the maintenance of the skills required to analyze and understand polymer flow processes.

In volume 1 problems in polymer fluid dynamics are treated through the methods of continuum mechanics. While the text really assumes some background and skill in Newtonian fluid dynamics, chapter 1 provides a brief review of this field, primarily as a basis for comparison to subsequent discussions of non-Newtonian fluid dynamics. A background in vector calculus, and particularly vector and tensor differential and integral operations, is assumed. (A 52-page appendix on these topics is provided.) A large number of problems (such as worked examples and "homework" problems, some with the steps toward solution outlined) amplify the material discussed in chapter 1 and help the student determine the adequacy of his or her background to continue.

Chapter 2 briefly reviews the important chemical aspects of polymers and is well referenced for further study. While the material is not essential to the study of the rest of volume 1, it is useful to the reader with no previous polymer background.

Chapter 3 provides interesting motivating illustrations of the complexity of polymeric flows, and describes odd phenomena that are not explicable or predicted through classical Newtonian fluid dynamics. Many of these phenomena are of industrial significance.

In chapter 4 the authors introduce the basic material functions that characterize fluids, and describe and analyze the flows used for their measurement. Typical experimental data are illustrated.

The most common rheological model employed to describe polymeric fluids is the generalized Newtonian fluid, in which the viscosity is taken as a function of the magnitude of the deformation rate tensor. Chapter 5 presents a discussion of the utility and limitations of this concept, followed by some 40 pages of examples of flow problems solved using a generalized Newtonian fluid. About 90% of the examples are solved using the power-law fluid, reflecting the utility of this model for most engineering calculations. Some introduction to other fluid models is presented here and in the fifteen pages of annotated homework problems that follow the chapter.

Because the generalized Newtonian fluid can not describe time-dependent flows or flows in which there are strong spatial accelerations (as in flow through

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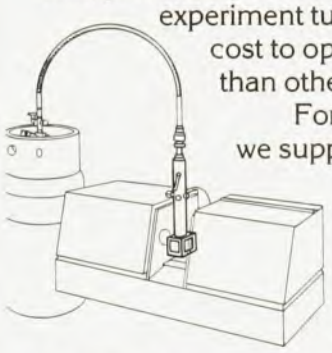

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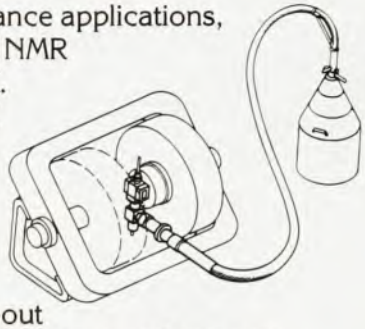

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sudden contractions), it is necessary to go on to a consideration of viscoelasticity. Chapter 6 gives an introduction to linear viscoelasticity; the authors recommend John D. Ferry's *Viscoelastic Properties of Polymers* (2nd ed., Wiley-Interscience, 1970) for a more extensive grounding.

The final three chapters of volume 1 present material necessary to the understanding and exposition of flows other than those in which viscous steady shear effects dominate. Thus here the reader finds the background required to deal with such complex and important topics as normal stresses accompanying shear flows that are unsteady in time (including in the Lagrangian sense), and unsteady elongational flows. These flows include such industrially important phenomena as fiber spinning, bubble growth in foaming polymers, die entry flows, melt fracture and die swell.

Chapter 7 develops the concept of the corotating reference frame. The tensorially timid will lose their way here, and as the authors point out in their preface, this material might be skipped in an introductory course. Several quasilinear corotational constitutive equations are introduced, and their predictions evaluated. The authors are careful to expose their motivation here (and elsewhere), and this feature should have a positive effect on the reader who is insecure about the mathematical details, but is looking for something other than a set of rubberstamp constitutive equations. It is possible to read this material, gloss over some of the more difficult and tedious mathematical detail, and still retain a sense of the logic and motivation that underlies the development of complex constitutive equations.

In chapter 8 a series of nonlinear corotational models is examined. These are presented as natural extensions of classical viscoelastic models, and a large number of examples illustrates the behavior accommodated by these models.

The final chapter of volume 1 introduces the concept of the co-deformational reference frame, and then parallels the material of chapters 7 and 8.

Volume 2 (Kinetic Theory) sets as its goal the description and development of constitutive models that connect bulk-flow properties to molecular structure. The first four chapters follow a parallel outline: the introduction of a specific "molecular" model (the elastic dumbbell in chapter 10, the rigid dumbbell in chapter 11, the flexible chain in chapter 12, and the general bead–rod–spring model in chapter 13), the derivation of a "diffusion equation" for the configurational distribution function, the use of kinetic theory to obtain an expression for the stress tensor, and then the examination of several simple flows in order to show the nature of the material functions predicted by each model. The material is presented with great care and clarity,

but the casual reader will find more difficulty here, because the underlying physical and mathematical structure is more complex than that of continuum mechanics.

These first four chapters deal essentially with dilute solution behavior. Chapter 14 presents a "phase-space" kinetic theory that considers a system of many polymer molecules interacting with each other in solution. The results are very formal, in the sense that (by contrast to earlier chapters of the volume) no specific results are presented whereby one may draw curves of various material functions.

The final chapter presents a different, and in some sense more useable, approach. A molecular "network" theory of solids is subsequently modified to be applicable to fluids with strong intermolecular interactions, thus developing the rheology of concentrated solutions.

Volume 2 is in many respects the more difficult part of this two-volume presentation, for both the teacher and the learner. The rewards of measuring this material will be great, however, and thus will justify a significant expenditure of intellectual energy. In particular, the appreciation of the interrelationships of continuum and molecular rheology will provide the learner with a much improved perspective from which to carry on research in polymer fluid dynamics.

The authors are to be congratulated for their accomplishment in preparing this outstanding presentation of the foundations of a very complex and very important field of study.

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