codes that solve the Navier–Stokes equations are well tested and widely used.

The codes are excellent for simple flow in simple geometries, but life becomes more tricky when tortuous boundaries, turbulence, or multiphase flows become important. And, of course, the investigator's goal is always to encompass ever larger systems on increasingly fine grids.

Hence the excitement when, in 1986, Uriel Frisch, Brosl Hasslacher, and Yves Pomeau proposed a lattice-gas cellular automaton able to solve two-dimensional flow. Particles hopping on a hexagonal lattice, interacting at the nodes via simple collision rules, were shown to obey the Navier–Stokes equations for sufficiently long length and time scales.

Here was a new approach to computational fluid dynamics that was free of round-off errors and ideally suited to parallel computers. But there were problems: statistical noise, a lack of Galilean invariance, and limitations to low Reynolds number.

In the Frisch-Hasslacher-Pomeau model, the particle collisions conserve mass and momentum and the hexagonal lattice has just enough symmetry to reproduce the rotational isotropy of 2D space. Essentially, the conservation laws are fed in, and the Navier–Stokes equations drop out. This idea has spurred the development of a wide range of novel Navier–Stokes solvers. Perhaps most successful of those is the lattice Boltzmann algorithm of Succi's book. The book's first few chapters give an account of the way in which lattice Boltzmann ideas developed from lattice-gas cellular automata. Succi was closely involved in those developments and one of the driving forces behind them. The evolution of the different approaches and the excitement of the research come across clearly in his book.

How does lattice Boltzmann compare to more conventional computational fluid dynamics approaches? The second part of the book discusses the technical details of irregular grids and boundary conditions and outlines applications of lattice Boltzmann algorithms to flow in porous media and to turbulence. Succi has experience with a wide range of Navier–Stokes solvers and presents a balanced view, although he is obviously fond of the lattice Boltzmann approach and pleased when it performs well. For standard applications, lattice Boltzmann is unlikely to displace more conventional methods, but for certain problems, such as multiphase flow in porous media, it is a strong contender for the best fluid-simulation approach currently available.

The lattice Boltzmann equation can also be thought of as a discrete, simplified version of the continuum Boltzmann equation of nonequilibrium statistical mechanics. This connection has the tantalizing consequence that lattice Boltzmann may contain more mesoscopic physics than the Navier–Stokes equations themselves. For example, the lattice Boltzmann algorithm is particularly adept at describing the flow of complex fluids in which thermodynamic and hydrodynamic information comes into play.

Applications to multiphase fluids, colloids, reaction–diffusion equations, and other problems at the forefront of research, such as a lattice Boltzmann description of quantum mechanics, are summarized in the final third of the book. Inevitably, the treatment is already somewhat dated and superficial, but it provides a flavor of the possible and the exciting.

This is a book for the enthusiast that reminds the expert how much fun he can have investigating the physics and applications of this rich field.

Julia M. Yeomans
Oxford University
Oxford, England

The Glass Transition: Relaxation Dynamics in Liquids and Disordered Materials

E. Donth
Springer-Verlag, New York, 2001. $99.00 (418 pp.).
ISBN 3-540-41801-6

Ernst-Joachim Donth's *The Glass Transition* is a welcome addition to the literature on a subject that is currently attracting a very heavy research interest. Early in the book, it becomes clear that, by the title term "glass transition," the author means the entire process of viscous slowdown and vitrification. This process takes a material from the moderately viscous liquid, in which the liquid dynamics departs from the exponentially relaxing character of the "simple" liquid state, down to the rigid solid, well below the temperature known as the "normal" glass transition temperature, T_g. The study of slowdown and vitrification, often characterized by the broader description "viscous liquids and the glass transition," is currently like an Arizona brushfire, with active tongues from many previously disparate but individually active areas merging into one large intellectual conflagration.

Donth approaches his subject from a very broad perspective; he may well be the best-read author in this field. I found information that was new and interesting to me in nearly every section of the book. There seems to be no element of the subject on which Donth has not read widely and thought deeply. We may not agree with every one of the conclusions he reaches, and—like most authors—he is capable of making errors in reporting what others have written. But there can be no doubt that he has addressed the enormous literature diligently and open-mindedly, and has drawn his own conclusions only after much intelligent reflection.

Donth has a distinct style, to which I am partial. He is an unreconstructed "figure freak." There are pages of diagrams, nearly every one of which focuses on several different elements of a given problem segment, each segment represented by its own succinct small diagram. It seems that a whole phenomenology may be represented on the single page. This use of figures, backed up by appropriate text, can be an effective way of conveying a lot of information about (and insight into) the system behavior. In some cases, though, the information provided in caption or text was too compressed for me to see the full meaning of the diagrams.

The book is divided into two main parts that deal, respectively, with phenomenological descriptions of the molecular slowdown in all its distinct aspects (chapter 2) and with theoretical approaches to interpreting these phenomena (chapters 3 and 4). There is also a brief introduction and an epilogue. The organization within the two main parts is a little convoluted, with themes being introduced in one section, and then being elaborated only later, after more descriptive background has been supplied.

While the book is comprehensive in its coverage of the phenomenology of the glass transition in the broad sense, and gives unusually detailed coverage to such little-understood phenomena as Fischer clusters and speckle phenomena, some themes are particularly stressed. A major one, not surprising in view of the work for which the author is best known, is fluctuations. The crossover point, or crossover temperature (T_c), above the glass temperature, at which the structural fluctuations change character, is given special attention. The crossover temperature is the point at which the "slow β" relaxation process usually separates from the slower (and diverging) main (α) relaxation process. The crossover temperature generally coincides with the mode-coupling-theory critical temperature (also called T_c). In his laboratory, Donth has produced provocative, complex, ac-calorimetry-based information on the complicated character of this crossover region.

A large part of chapter 3 is devoted to a comparison of thermodynamics according to Josiah Willard Gibbs on the one hand and to Max von Laue on the other, with the differences centering on the presence or absence of temperature fluctuations. The chapter also deals with the apparent breakdown of fluctuation–dissipation theorem equations when ergodicity is broken at the glass transition. It also covers the characteristic length of fluctuations in relation to fictive temperature. Both are subjects of current interest; a proper handling of fluctuations is clearly of major importance. This aspect of the book is profound, and I found myself thinking that the author must be well ahead of the rest of the field in his understanding of glassforming systems. In other places, however, I found reassuring evidence that Donth remains as confused or as incomplete as the rest of us about this fascinating problem. As the book makes clear, the sources of potential confusion are many and varied. People entering the field often stumble over the many time scales and several length scales that interplay in the viscous liquid and glass transition phenomenology. Donth has them all under consideration. This book is an excellent choice of reading material for someone newly entering the field, who wants to be made aware of all of its elements. It also provides much food for thought for the experts.

C. Austen Angell
Arizona State University, Tempe

Band Theory and Electronic Properties of Solids

John Singleton
Oxford U. Press, New York, 2001. $70.00, $35.00 paper (222 pp.). ISBN 0-19-850645-7, ISBN 0-19-850644-9 paper

As the field of condensed matter physics grows, finding the perfect text for an advanced undergraduate or beginning graduate course becomes more and more difficult. To cover the