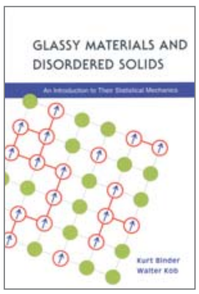
Glassy Materials and Disordered Solids

An Introduction to Their Statistical Mechanics

Kurt Binder and Walter Kob
World Scientific, Hackensack, NJ, 2005. $78.00 (442 pp.).
ISBN 981-256-510-8

The physics of glasses and disordered solids is one of the most puzzling fields in contemporary condensed matter physics. The growing interest in these materials stems from their practical significance coupled with a deficiency in understanding the nature of glass formation, structures, and properties. A not-yet-developed general theory of the amorphous state is the missing link in the chain of matter phases: ideal gas, liquid, amorphous solid, and ideal crystal.



Amorphous materials are difficult for a theoretical study because the interaction of atoms or molecules forming a glass is not weak, which makes fully irrelevant all approaches developed for studying weakly interacting molecules in gases. Also, modern numerical methods of molecular dynamics, very efficient in liquids, are hardly extendable to glasses and supercooled liquids, where the dynamics are so slow that they cannot be simulated by existing computational facilities. And the lack of periodicity prohibits the application of powerful methods of group theory. Switching from crystalline materials to those in which the long-range order is absent requires giving up familiar concepts of conventional solid-state band theory for electrons and phonons. If space periodicity is absent, for example, excitations with a certain quasi-momentum become non-stationary, even at 0 K.

Such circumstances have called for a drastic revision of traditional solid-state concepts. No general theory of the glassy state exists yet, and the scattering of various models and approaches over numerous publications can make it hard for beginners to even define a good starting point for learning. Kurt Binder and Walter Kob's *Glassy Materials and Disordered Solids: An Introduction to Their Statistical Mechanics* helps resolve the issue by connecting standard statistical physics and thermodynamics to the contemporary physics of disordered solids and glasses. Their book will attract many prospective readers, from junior-level undergraduate students making their first independent investigation of disordered matter to senior-level scientists extending their research to amorphous or disordered materials.

The book's clear introduction to the whole set of problems at the physical level helps readers feel comfortable with various complex mathematical models of disordered systems. The authors clearly explain the physical origin of those models, which are quite naturally connected to significant physical properties of glasses, such as thermodynamics, relaxation, and aging. Those connections are explored in the very beginning of the book. The authors then discuss in more detail magnetic spin glasses and other significant models. Although those models are too complex to be understood in full detail, the use of simple concepts—percolation and its consequences, for example—allows readers to reach at least basic understanding of the underlying physics. The book also guides readers to such complicated models as Potts glasses, quadrupole glasses, diluted molecular crystals, and spin glasses with quenched random fields. In the closing chapter, concepts and ideas are also considered in relation to the liquid–glass transition.

To my knowledge, and that of my colleague Il'ya Polishchuk, who assisted me in examining the book, other texts dedicated to similar problems are more specific, with authors preferring to cover narrower classes of systems and methods. Thus *Glassy Materials and Disordered Solids* can serve as a perfect general introduction. Because it covers a wide variety of physical systems, it does not provide a complete understanding of all problems readers are interested in; but more details can be found in the literature cited in its huge reference list.

Although my specific area of interest is related to the thermodynamics and kinetics of amorphous solids at very low temperatures, which is not the direct subject of this book, I have found much useful information about the correlation between high- and low-temperature glassy behavior, information that will help me in future research. I recommend that students of the physics and chemistry of glasses and disordered materials or experienced researchers in the subject not pass up this book. If developing a general theory of amorphous states is possible, *Glassy Materials and Disordered Solids* is an excellent starting point for that work.

Alexander Burin
Tulane University
New Orleans, Louisiana

new books

acoustics

Innovations in Nonlinear Acoustics. A. A. Atchley, V. W. Sparrow, R. M. Keolian, eds. *AIP Conference Proceedings 838*. Proc. symp., State College, PA, July 2005. AIP, Melville, NY, 2006. $225.00 (677 pp.). ISBN 0-7354-0330-9, *CD-ROM*

astronomy and astrophysics

Astronomical Polarimetry: Current Status and Future Directions. A. Adamson, C. Aspin, C. J. Davis, T. Fujiyoshi, eds. *Astronomical Society of the Pacific Conference Series 343*. Proc. mtg., Waikoloa, HI, Mar. 2004. Astronomical Society of the Pacific, San Francisco, 2005. $77.00 (530 pp.). ISBN 1-58381-210-5

Gamma-Ray Bursts in the *Swift* Era. S. S. Holt, N. Gehrels, J. A. Nousek, eds. *AIP Conference Proceedings 836*. Proc. conf., Washington, DC, Nov.–Dec. 2005. AIP, Melville, NY, 2006. $205.00 (733 pp.). ISBN 0-7354-0326-0

Modern Meteor Science: An Interdisciplinary View. R. Hawkes, I. Mann, P. Brown, eds. Proc. conf., London, ON, Aug. 2004. Springer, Dordrecht, the Netherlands, 2005. $149.00 (732 pp.). ISBN 1-4020-4374-0, *CD-ROM*

Planetary Nebulae Beyond the Milky Way. L. Stanghellini, J. R. Walsh, N. G. Douglas, eds. *ESO Astrophysics Symposia*. Proc. wksp., Garching, Germany, May 2004. Springer, New York, 2006. $99.00 (370 pp.). ISBN 3-540-31011-8

Scientific Detectors for Astronomy 2005: Explorers of the Photon Odyssey. J. E. Beletic, J. W. Beletic, P. Amico, eds. *Astrophysics and Space Science Library 336*. Proc. wksp., Taormina, Sicily, June 2005. Springer, Dordrecht, the Netherlands, 2006. $199.00 (771 pp.). ISBN 1-4020-4329-5

The Three-Body Problem. M. Valtonen, H. Karttunen. Cambridge U. Press, New York, 2006. $80.00 (345 pp.). ISBN 0-521-85224-2

The Transient Milky Way: A Perspective for MIRAX. F. D'Amico, J. Braga, R. E. Rothschild, eds. *AIP Conference Proceedings 840*. Proc. wksp., São José dos Campos, Brazil, Dec. 2005. AIP, Melville, NY, 2006. $105.00 *paper* (144 pp.). ISBN 0-7354-0332-5

atomic and molecular physics

Molecular Nanomagnets. D. Gatteschi, R. Sessoli, J. Villain. *Mesoscopic Physics*