(Charles Alcock), asymmetric type II supernova explosions (Peter Goldreich, Dong Lai and Mikael Sahrling), the structure of neutron stars (Malvin Ruderman), accretion flows around black holes (Ramesh Narayan), the highest-energy cosmic rays (James Cronin), and gamma-ray bursts (Tsvi Piran). Almost all of these take their charge—summarizing the field at an introductory level and pointing out future directions—quite seriously. One of these, read just before bedtime, kept me awake for several hours while I puzzled over the research challenges.

The third section, though quite brief, serves an important function in reminding the reader about problems more on the astronomical side of astrophysics. Scott Tremaine argues for the presence of massive black holes at the cores of many galaxies, discussing the influence the central black hole might have on the structure and dynamics of the galaxy. This theme is extended by Martin Rees, who explores in more detail the connection between quasars and the formation and growth of a black hole in a host galaxy. He describes the compelling evidence provided by observations of gas motion in spiral galaxy NGC 4258 for a central black hole, and he discusses exotic secular events that then might arise (for example, the "flares" produced when a star, deflected toward a central black hole, is ripped apart tidally, or the gravitational radiation from the merging of two such massive black holes). Finally, Richard Ellis describes progress made in surveying faint galaxies with the new high-technology telescopes and the picture emerging of regular- and dwarf-galaxy evolution. This chapter is particularly well done, carefully pointing out pitfalls in the interpretation of surveys while stressing the relevance of the work to theoretical efforts on galaxy formation.

*Unsolved Problems* succeeds because of the efforts made by the editors and authors to keep the material accessible to nonspecialists. Graduate students and colleagues were recruited to referee each chapter for both accuracy and clarity. A nice touch is the inclusion, in addition to references, of bibliographic notes for each chapter in which supporting, introductory material can be found.

I would have argued for only one change in the volume: the inclusion of two additional chapters. The vexing problem of a robust type II supernova mechanism would have nicely complemented the existing chapters on neutron stars (Ruderman) and asymmetric supernova explosions (Goldreich *et al.*). Similarly, a chapter on "Why Inflation?" could have helped a new graduate student to better understand the context of several of the chapters in the cosmology section.

Many of us are concerned that overly technical journal publications are an obstacle to communication between physicists from even slightly different subfields. It occurred to me, on reading this volume, that the second-year graduate student might have been a ruse: Perhaps this book is intended for all of us. In any case, on finishing the last chapter, I thought about what fun I could have teaching a special-topics astrophysics course using this book. Who would learn more, the graduate students or the teacher?

**Wick C. Haxton**
*University of Washington*
*Seattle, Washington*

## Introduction to Mesoscopic Physics

Yoseph Imry
*Oxford U. P., New York, 1997.*
*234 pp. $49.95 hc*
*ISBN 0-19-510167-7*

Yoseph Imry's *Introduction to Mesoscopic Physics* is a propitious beginning for Oxford University Press's series Mesoscopic Physics and Nanotechnology. This is an area of physics in which there has been recent explosive development, made possible by nanofabrication methods and equipment, the development of which has been driven in turn by the technological goal of achieving ever denser digital electronic circuitry. As the physical limits of conventional electronic devices are approached, the understanding of the remarkable new physics of very small devices will be crucial for continued technological progress.

Imry, who is one of the central figures in the development of this field, provides in this text a valuable overview of these new physical phenomena. Despite its informal style and use of heuristic arguments to minimize heavy theoretical formalism, this compactly written book is demanding reading. But it should be accessible to graduate students and research scientists in condensed matter physics, particularly those with an interest in theory. Unfortunately, the book is marred by an unusually large number of typographical errors; they are irritating, but they do not seriously detract from its readability.

To give an idea of the scope of the text, there are chapters devoted to such subjects as Anderson localization, dephasing of electron waves by coupling to the environment, the Landauer formulation of conductance in terms of a scattering matrix, the quantum Hall effect, mesoscopic structures which include superconducting elements, and noise in mesoscopic systems. There are also ten appendices, ranging from a review of the Kubo formalism to the conductance of ballistic point contacts. Also noteworthy is the 20-page list of references, which provides a guide to a large selection of the relevant literature.

It may be appropriate to try to summarize the themes of the book by paraphrasing the author's concluding remarks on some of the interesting physics in this mesoscopic regime: 1) Elastic and inelastic scattering are very different: The first gives the electron a well-defined, albeit possibly complicated, phase; the latter induces a phase uncertainty that washes away quantum interference effects after a time $\tau_\phi$. 2) These interference effects thus exist up to a length scale $L_\phi = \sqrt{D\,\tau_\phi}$, and they induce such quantum phenomena as Anderson localization, nonohmic addition of quantum resistances and various Aharonov–Bohm oscillations. 3) The sample-specific nature of mesoscopic systems leads to sample-to-sample fluctuations in conductance and orbital magnetic response, some of which are universal in magnitude. 4) The phase coherence of the normal electrons on the scale of $L_\phi$ enables them to carry superconducting phase information over distances longer than the conventional normal metal coherence length $L_T \sim \sqrt{D\hbar/k_BT}$.

Among the things that appeal to me about this book is that Imry takes pains to identify issues that have engendered controversy, such as the "correct" relation of the Landauer formalism to measured resistances. He then explains the resolution of this controversy by more careful specification of the problem. Another formerly controversial issue is the existence and observability of persistent currents in normal metal rings. Imry also goes out of his way to identify areas that are incompletely understood and thus offer particular promise for future research. These include mesoscopics involving superconductors in addition to normal metals and semiconductors.

In conclusion, this interesting and relatively brief new book brings the reader into contact with some exciting developments in a very active area of condensed matter physics. It provides a ready reference to the main themes and results and belongs on the desks of all workers in this field.

**Michael Tinkham**
*Harvard University*
*Cambridge, Massachusetts*