the evidence for warm gas from radio, optical, and infrared observations. I found the papers on optical emission lines particularly interesting inasmuch as they show that conditions at the center of the cooling flow are much more complex than a naive interpretation of the x-ray data would indicate. In short, attempts to keep the core region hot by plausible processes, such as radiation from regions of star formation, shock heating, and conduction of heat from the outer regions, appear to be inconsistent with the observations or are more likely to produce thermal instabilities (adjacent regions of intense cooling and rapid heating) than a smooth, stable core. A large amount of gas has to be cooling, although its ultimate fate is unknown.

One final uncertainty is the persistence of the cooling flows. Although the cooling times in the core region are shorter than the age of the universe, they are not particularly short by anyone's standard. Estimates of the total mass accreted from these cooling flows necessarily invoke an age for the flow which can only be considered approximate. A few papers attempt to estimate the time variability of specific flows using model-dependent arguments. No consensus has emerged on whether the flows are increasing or decreasing in intensity, but it does appear that no allowable variation could alter the conclusion that a substantial amount of mass is dropping out of the flow at small radii.

On the whole, I would recommend this book to anyone with a serious interest in the origin and evolution of galaxies. The observational papers included here provide a fairly impressive case for the widespread existence of cooling flows. The theoretical papers are not as conclusive but do strongly suggest that alternative models of the observations are not plausible. It is clear that the addition of matter to galaxies through cooling flows is a widespread phenomenon, which may dominate the evolution of a substantial number of galaxies. It may even be true that the problem of dark matter in galaxy clusters will find its resolution here. This is not necessarily welcome news for cosmologists, who need more exotic forms of dark matter to explain galaxy formation and to close the universe.

This book suffers from a few minor, but irritating, problems. It is a little jarring to find pages transposed at the very beginning of the papers. In addition, it is peculiar that a book intended to interest a larger audience does not open with a general review of the topic.

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Conduction Electrons

Magnetoresistance in Metals. A. B. PIPPARD. Cambridge University Press, New York, 1989. xiv, 253 pp., illus. $59.50. Cambridge Studies in Low Temperature Physics, vol. 2.

In 1965 A. B. Pippard published a collection of his notes under the title *The Dynamics of Conduction Electrons* and provided one of the first sensible discussions of the intricate behavior of conduction electrons in metals. For a generation of students that monograph served as a starting point for learning how the electronic structure of a metal determines the response of electrons to applied electric and magnetic fields. Now Pippard crisply and clearly summarizes what has happened in this discipline since his classic was written. Although the study of the magnetoresistance in pure metals is not usually considered to be in the forefront of research today, the lessons learned from it have often paved the way for the active research on the magnetoresistance and quantum effects in one- and two-dimensional systems that is now fashionable. This fact makes Pippard's book a valuable effort that should be well received by current researchers.

The study of the electrical conductivity tensor as a function of an applied magnetic field, the magnetoresistance of a metal, forms the unifying theme for the book. The various topics discussed adequately represent the wide variety of physical effects that occur when an electric current passes through a metal cooled to liquid-helium temperatures and subjected to an applied magnetic field. The book gives strong emphasis to the interpretation of the magnetic-field–dependent changes in the conductivity tensor in terms of the underlying electronic structure and scattering mechanisms of electrons in metals. It nicely illustrates the change in emphasis from the early exactly solvable, analytical models of magnetoresistance developed by Wilson and the efforts of later investigators to interpret experimental data based on models for the electronic structure of real metals. The book discusses many of the classic problems in the magnetoresistance of bulk metals and analyzes their current status.

After presenting the obligatory treatment of the basic principles for the study of the electrical conductivity tensor, Pippard devotes an excellent chapter to experimental technique. This chapter is a valuable collection of examples that illustrate how wrong things can go when a measurement of the voltage drop across a metallic sample at low temperatures is attempted. The book gives adequate coverage to magnetoresistance effects in real metals and provides the required coverage of relevant Fermi surface details. It discusses the quantum theory of magnetoresistance in a coupled orbit network and reviews the status of this challenging problem. The coupled orbit network is a good example of a traditional (and still unresolved) problem in which the quantum state of the electron is delocalized over a periodic, two-dimensional array of orbits that (in the fully coherent limit) are connected by magnetic breakdown effects. Fundamental questions regarding the flux quantization in such a network and the resulting fractal energy band structure are nicely illustrated. Pippard also reviews the interesting case of potassium but makes no serious effort to include recent evidence from outside the realm of magnetoresistance that supports the charge-density wave model for the ground state in this metal. A topic of current interest, the magnetoresistance in small wires and rings, receives only limited attention. No discussion of magnoresistance effects in semiconductors or a two-dimensional electron gas is attempted. The book contains a list of references that will introduce the reader to a few germane articles on any given topic but that is far from complete and emphasizes the work of the Cambridge group.

Pippard succeeds in producing a readable summary of his efforts to understand the behavior of the magnetoresistance in metals. His analysis coupled with his physical insight makes the book enjoyable reading even when one thinks one knows what the outcome of any of its discussions will be. It will no doubt serve as the traditional introduction to the topic until another author with talents comparable to Pippard's devotes attention to this subject.

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