

tion, magnetic field strength grows in proportion to the stretching of the magnetic field lines. Now consider the motion of a material point convected by the fluid flow. The location of such a point obeys the equation $d\mathbf{x}(t)/dt = \mathbf{v}(\mathbf{x}(t), t)$. According to the definition of chaos, the solution of this equation is chaotic when nearby points separate exponentially with time. Taking the two nearby points to be on the same magnetic field line, we see that chaos in the flow equation $d\mathbf{x}/dt = \mathbf{v}$ implies exponential stretching of the magnetic field line and thus suggests exponential magnetic field growth with time. Of course, this is not the whole story, and there are interesting twists (both literally and figuratively) to the problem, which are beautifully explained in the book.

As should be evident from the above, a book on this subject faces the double burden of explaining a physical problem while introducing concepts in chaotic dynamics, a field of mathematics. Furthermore, the necessary concepts in chaotic dynamics turn out to be rather sophisticated. The book handles this admirably. Statements of rigorous results are always accompanied by nice illustrative examples and careful insightful discussion. In fact, the reader will come away with not only an understanding of the kinematic dynamo but also an understanding of much of the theory of chaotic dynamics.

The book attempts to give a complete accounting of current developments. Many varied approaches and techniques are discussed. Some of the topics covered include the use of discrete time maps to model dynamos; the applicability of such concepts from chaos as topological entropy, Lyapunov exponents and summations over periodic orbits; the singular character of the spatial magnetic field structure; spectra and eigenfunctions; and flows with random temporal variation. All of this is well explained, and almost all of the important recent developments are thoroughly covered.

I highly recommend this book to those who wish to find out about the fascinating new developments addressing the question of why magnetic fields pervade so much of our universe.

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Physics of Optoelectronic Devices

Shun Lien Chuang
Wiley, New York, 1995. 717 pp.
\$69.95 hc ISBN 0-471-10939-8

Optoelectronic devices and device physics constitute a rapidly developing

field of research. The sale and commercial applications of optoelectronic devices, including light-emitting diodes, semiconductor laser diodes, waveguide modulators and switches, and semiconductor detectors are also increasing at an incredible rate. Shun Lien Chuang's *Physics of Optoelectronic Devices* is a comprehensive treatment of an extensive body of material, including the fundamentals of semiconductor electronics, quantum mechanisms and electromagnetics, waveguide theory and light propagation, semiconductor lasers and various types of modulators and detectors. It covers nicely the fundamentals of single-electron properties in semiconductors and includes a good discussion of the quantum-well states, including doped and modulation-doped structures.

Optical properties of semiconductor structures are discussed in terms of Fermi's golden rule, at the level of single-particle states. Electron-hole pairs and Coulomb effects are discussed only in chapter 13, in connection with electroabsorption. Such subjects as lasers, gain and the like are discussed at the level of noninteracting particles. There is no mention or explanation of the bandgap renormalization or of Coulomb enhancement. Nor is there any discussion of why gain occurs spectrally below the unrenormalized gap.

The book is timely and of interest not only to researchers but also to students who want to pursue careers in this field. It can be recommended for engineering or beginning physics students who want an introduction to the subject. It can also be recommended to people interested in an introduction to band-structure calculations in heterostructures.

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3 K: The Cosmic Microwave Background Radiation

R. Bruce Partridge
Cambridge U. P., New York, 1995.
373 pp. \$89.95 hc
ISBN 0-521-35254-1

3 K: The Cosmic Microwave Background Radiation by R. Bruce Partridge is a scholarly *tour de force* that is enjoyable to read. Partridge joined Robert Dicke's gravity group at Princeton University in 1965, the year the cosmic microwave background radiation was discovered, and he has been measuring its anisotropy in various

ways ever since. In his book—intended as background for researchers in the field and as an introduction for students of cosmology—he summarizes five decades of work on the CMBR, explaining its importance in cosmology, the techniques used to measure it and the reasons for continued interest in it.

Modern tools for measuring galactic distances and redshifts have made the large-scale structure of the universe remarkably interesting, revealing strings of galaxies and clusters and the enormous voids between them. Non-baryonic dark matter seems far more abundant than ordinary matter, surprising those who believed in the predictive power of Occam's razor.

The density variations and acoustic oscillations in the photon-baryon fluid, excited by the gravitational potentials remaining from the first moments of the Big Bang and augmented by the flow of dark matter, should be visible as spatial fluctuations in the temperature of the cosmic background radiation. They are also the initial conditions leading to the large-scale distribution of galaxies, so the comparison of CMBR data with clustering measurements has become a very rich field. The Cosmic Background Explorer found large-scale 0.001% anisotropies in the CMBR temperature, with the size spectrum predicted by inflationary theories and grand unified theories of elementary particles. The spectrum of the radiation has a black-body form within 0.01% of the peak intensity, a result that demands the hot Big Bang.

It is no wonder that thousands of papers on the implications of the CMBR measurements have been published, particularly since the launch of COBE, the Cosmic Background Explorer, in 1989. A measurement of the angular spectrum of the fluctuations down to a fraction of a degree scale would tell us the parameters of the Big Bang with an accuracy of a few percent, including the total density, the fractions of hot and cold dark matter and the Einstein lambda constant. To do these measurements, NASA has selected the Microwave Anisotropy Probe, proposed by Charles L. Bennett of Goddard Space Flight Center and David T. Wilkinson of Princeton University, as one of its mid-size Explorer missions. Additionally, there is strong European Space Agency interest in the more ambitious COBRAS/SAMBA (for Cosmic Background Anisotropy Satellite and Satellite for Measurement of Background Anisotropies) mission, proposed respectively by Nazzareno Mandolesi, of the Istituto TERRE—CNR in Bologna, Italy, and by Jean-Loup Puget, of the Institut d'Astrophysique Spatiale in Orsay, France, to map the CMBR and sub-

millimeter sky.

There is no shortage of fine books about cosmology; my favorite is the paperback by Jim (P. J. E.) Peebles, *Principles of Physical Cosmology* (Princeton U. P., 1993). However, Partridge's book has no competitor in explaining the hazards and joys of the experimental physicist seeking to measure the faint whisper of cosmic noise from the beginning of time. It reviews the physics of the Big Bang, the early predictions by Ralph Alpher, Robert Herman and George Gamow, the physics of radio astronomy and the stories of the initial discovery by Arno Penzias and Robert Wilson, as well as the reasons so many people came so close but missed it. It covers experimental approaches including radio receivers, thermal detectors, spectrometers, calibration, beam switching and error analysis.

The sensitivities of receivers have improved by many orders of magnitude since the original discovery, so the calibration and the modeling of atmospheric and our own Galactic emission are now the limiting factors. The book covers the relevant theory in depth, with some two-thirds of the space devoted to it. If there is any weakness in the book, it is the impossibility of keeping up with the flow of recent papers. Most of the references end in early 1992, but Appendix C summarizes work through early 1994. This period includes the main COBE results and first detections of the acoustic oscillations of the photon-baryon fluid. In short, the book is a well-written and thorough review of a difficult and exciting experimental and theoretical domain.

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The Three Big Bangs: Comet Crashes, Exploding Stars and the Creation of the Universe

Philip M. Dauber
and Richard A. Muller
Addison-Wesley, New York, 1996.
207 pp. \$25.00 hc
ISBN 0-201-40752-3

In *The Three Big Bangs*, Philip M. Dauber and Richard A. Muller have written a delightfully readable book about the three singular events—the emergence of the early universe, the supernova synthesis of our elements and the Cretaceous-Tertiary impact of a giant comet or asteroid—that shaped

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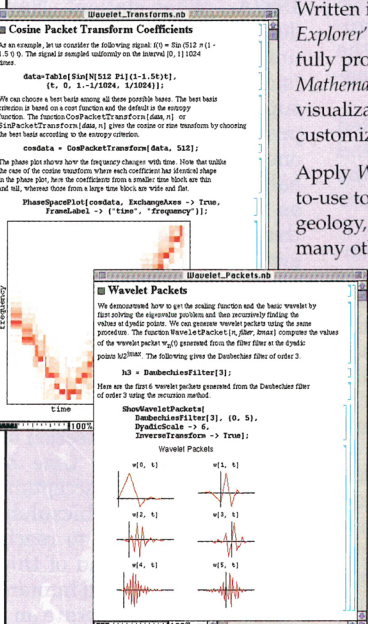


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