Plasma Physics

Principles of Plasma Diagnostics. I. H. Hutchinson. Cambridge University Press, New York, 1987. xvi, 364 pp., illus. $65.

Recent experiments conducted within plasma devices worldwide have tested the skills of physicists in developing diagnostic equipment to measure the many parameters of the plasma. Understanding the transport properties of plasmas in a modern tokamak requires a comprehensive set of data. Since most values must be inferred from indirect measurements, one must understand the strengths and weaknesses of the measurement techniques. Ian Hutchinson's book describes the principles upon which these techniques are based.

One parameter of plasmas in a tokamak, the temperature of the electrons, can be measured in at least three standard ways. The first, Thomson scattering, depends on dispersion of coherent light by the free electrons in the plasma and evaluation of the Doppler broadening of the spectral line. The second, far-infrared Fourier transform spectroscopy, depends on the radiation emitted at the cyclotron frequency of the free electrons in the local magnetic field, whose strong gradient provides spatial information. The third, bremsstrahlung emission in the soft x-ray spectral region from the electron acceleration in the electric field close to an ion, depends directly on the electron temperature. It is evident that different principles underlie these techniques and that their sensitivities to nonideal plasma behavior might also be very different.

It is this dependence of plasma parameters on different physical processes that leads plasma physicists to seek confirmation of their data by comparing concurrent measurements. *Principles of Plasma Diagnostics* provides a firm theoretical basis for the diagnostic techniques and a clear understanding of the principles involved. Hutchinson extends the theory beyond the ideal cases. He considers the effects of high-energy tails in the electron- or ion-distribution functions that are so integral a part of plasmas heated by resonant radio frequency or by high-energy particle beams and explains how these effects can distort the measurement. Alternatively, he shows that these effects can be used to infer other properties, such as an additional driven current in the plasma.

The author has organized his chapters according to the physical principle involved rather than the plasma parameter of interest. This enables him to develop the theoretical arguments in each area. Relevant material is cited at the end of each chapter, and comprehensive, up-to-date references to actual observations are provided at the end of the book.

Hutchinson describes the book as at the intermediate graduate level. But the self-contained nature of the chapters and of the referenced source material will make it useful as well to scientists trying to understand the principles behind particular measurements. The book focuses on laboratory plasmas, especially magnetically confined plasmas, but the physics discussed is fully applicable to inertially confined or space plasmas.

This book is an important contribution and should be on the shelves of most plasma physicists. It is easy for theorists and modelers to use graphs of electron temperature or some other plasma parameter as functions of time or position without being aware of the complex physics involved in achieving the measurement. This book can provide that awareness. It gives diagnostic physicists access to physical descriptions of their own techniques as well as to the physics of complementary observations. It provides graduate students with an effective guide for applying theoretical concepts to their experiments.

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Dynamism and Invariance

Symmetries, Asymmetries, and the World of Particles. T. D. Lee. University of Washington Press, Seattle, 1988. xii, 66 pp., illus. $9.95. The Jessie and John Danz Lectures.

Thirty Years Since Parity Nonconservation. A Symposium for T. D. Lee. (New York, Nov. 1986.) Robert Novick, Ed. Birkhäuser Boston, Cambridge, MA, 1987. viii, 198 pp., illus. $25.

In the prologue to his fascinating book, set in the world of particle physics, Tsung Dao Lee recounts a conversation he had with Chairman Mao Zedong in 1974. Mao's opening question was "Tell me, why should symmetry be of importance?" Symmetry Mao had imagined as a purely static concept, something that ran against his dynamic grain. Lee responded instantly. He could produce a homely but brilliant demonstration—nothing more than a pencil rolling on a tilting pad of paper—that clearly brings out a dynamic aspect of symmetry. The Chairman was satisfied. T. D. Lee's clarity and inventiveness as teacher are now put at our service in this all-too-slim volume. He invents for a general audience some marvelous illustrations of mirror symmetry, translation invariance, charge symmetry, and time reversal invariance; and he brings out by means of concrete examples how symmetry principles are connected with conservation laws—for example, translation invariance with conservation of momentum.

In fact, however, several hitherto sacred symmetry principles have been experimentally overthrown over the past few decades, and other symmetry notions have been known from birth to be only approximate. This raises the question, Where there is no symmetry, why focus on symmetry? There are two answers. For one thing, certain symmetry principles, though not obeyed exactly, are almost exact—they hold true to good approximation over large, reasonably well-defined domains of particle phenomena. In such instances symmetry concepts are clearly of immediate service, to within small corrections. More fascinating, however, is the contemporary focus on other symmetries that are not even remotely hinted at in empirical observations. Back of this seeming madness is a notion that the laws of physics at their deepest in fact incorporate certain *exact* symmetries, which, however, do not show up in phenomena; that the breakdown of symmetry in the observed world is attributable not to the basic laws of physics but to asymmetry of the vacuum. The vacuum, a churning physical medium, is pictured on this view as the hiding place of missing symmetries. The successful unification of electromagnetism with the weak interactions is based on a scheme of this sort.

It is slightly more than 30 years now since the breakdown of parity invariance (mirror symmetry) was discovered in the weak interactions. Throughout this class of processes (nuclear beta decay, decay of the mu meson, of hyperons, and so forth) the observable asymmetry effects are large and unmistakable, once one thinks to look for them. It was, however, not until the tau-theta puzzle of the middle 1950s that doubts about parity conservation began to surface. In their celebrated paper of 1956, Lee and C. N. Yang, after a careful analysis of the literature, pointed out that in fact no one *had* looked yet (an exception came to light later on), and they told the community what to look for. The rest, as one says, is history. Within a very short time asymmetry effects were being discovered all over the place and the weak interactions blossomed out as a major subdiscipline of particle physics. That history is relived in the proceedings of a symposium for Lee held at Columbia University in the fall of 1986, 30 years after the overthrow of parity. It was the occasion also of T. D.'s 60th birthday and hence the start of his second cycle on the Chinese calendar. The proceedings contain the reminiscences