BOOK REVIEWS

Low-Energy Particle Physics

Ultra-Cold Neutrons. ROBERT GOLUB, DAVID J. RICHARDSON, and STEVE K. LAMOREAUX. Hilger, Philadelphia (distributor, American Institute of Physics, New York), 1992. xii, 304 pp., illus. $80.

In the popular vocabulary of science, use of the terms "particle physics" and "high energy physics" has evolved to the point where the two have become virtually synonymous. Such nominal interchangeability is perhaps understandable given the massive efforts (and massive investments) that have characterized accelerator-based physics during the past several decades. However, it should be noted that not all experimental particle physics utilizes high-energy beams. Significantly, there is an important class of measurements for which extremely low energies are required. Particularly noteworthy among these is a major international effort, which has developed during the last two decades, using neutrons of extremely low kinetic energies on the order of about 10^{-7} eV, some 19 orders of magnitude less than present-day high-energy proton beams.

Such low kinetic energies correspond to typical effective neutron potential energies arising from the coherent scattering of neutrons by the nuclei in condensed matter. A remarkable consequence of this correspondence is that neutrons of sufficiently low energy can be confined in material "bottles" and studied for periods that approach and sometimes exceed the beta decay lifetime of a free neutron (about 900 seconds). Such neutrons have come to be known as "ultra-cold neutrons" (UCN). (An appreciation of the extremely low particle energies involved may be gained by noting that a typical ultra-cold neutron has a velocity of around 5 meters per second, or about 10 miles per hour.)

These novel particles can only be acquired with some difficulty. Typically, modern UCN sources are located at the high-flux research reactors of facilities such as the Institut Laue Langevin in Grenoble, France, or the Petersburg Nuclear Physics Institute in Gatchina, Russia. Much of the research associated with ultra-cold neutrons has been carried out in the former Soviet Union, and until recently there have been no thorough reviews of the field available in English. *Ultra-Cold Neutrons* by Golub, Richardson, and Lamoreaux rectifies this situation by providing an excellent introduction to the production, handling, and uses of UCN. Focusing heavily on experimental work and with considerable attention to recent measurements and advances in UCN technology, this work is far more current and rather more accessible to the nonspecialist than the recently translated monograph by Ignatovich, *The Physics of Ultracold Neutrons* (Oxford University Press, 1990).

The most striking scientific results from UCN research to date have concerned measurements of important neutron properties. For example, advances in UCN technology have led to impressive improvements in measuring the neutron lifetime. The magnitude of this quantity is of great importance in astrophysics, cosmology, and weak-interaction physics. Until recent refinements in UCN technology, measurements of neutron lifetime were rather inaccurate and in a state of some disarray. Also revolutionized by the use of UCN has been the study of time-reversal symmetry through the search for a neutron electric dipole moment. The discussion in this volume of these fundamental measurements is by far the best available review of this area of research.

Although the use of UCN as a tool for investigating issues in particle physics has reached a significant level of maturity, it is less widely appreciated that there are other potentially important uses for these intriguing particles. Perhaps the most exciting is the application (given adequate fluxes) of UCN technology to the study of the dynamics of bulk polymers and biological molecules. Owing to the extremely low energy of UCN, scattering measurements on such materials could provide information in a region of (Q,ω), which is less accessible by other techniques. Such measurements could conceivably provide important insights into biological processes. The prospects for such investigations are adequately reviewed in the volume, as are other possible applications such as the use of UCN scattering as a tool for condensed matter studies, a technique still in its infancy. The thoughtful reader will find intriguing hints of the possibilities that lie ahead for this field.

There are at present plans for several major neutron facilities in the United States and Europe, and there is a significant likelihood that ultra-cold neutron beams (possibly with significantly higher fluxes) will be more accessible in the coming decade. Those engaged in the planning of such facilities as well as potential users will benefit from this concise overview. It will be of particular interest to members of the neutron scattering community concerned with extending the applicability of their field.

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Autonomic Advances

Autonomic Neuroeffector Mechanisms. GEOFFREY BURNSTOCK and CHARLES H. V. HOYLE, Eds. Harwood, New York, 1992. xii, 546 pp., illus. $48. Autonomic Nervous System, vol. 1.

The autonomic nervous system makes your heart beat faster when you exercise, makes your mouth water when you eat something nice, makes you perspire when it's too hot, and makes you shiver when it's too cold. The classical picture of this system is that it comprises cholinergic parasympathetic nerves and adrenergic sympathetic nerves that are controlled by the autonomic outflow from the central nervous system. Over the last 30 or so years, however, it has been recognized that sophisticated peripheral mechanisms play a major role in autonomic regulation. Among the advances that have led to this new understanding are (i) a better understanding of the morphology of autonomic neuroeffector junctions; (ii) the discovery of non-adrenergic, non-cholinergic nerves in the autonomic nervous system and the demonstration of purinergic, aminergic, and peptidergic neuromodulators, and perhaps γ-aminobutyric acid and nitric oxide, within them; (iii) the recognition of the concept of "neuromodulation," the process by which neuromodulators control the release and post-junctional effect of neurotransmitters; (iv) the acceptance of the idea of "co-transmission" and "chemical coding" wherein a given neuron may contain more than one neurotransmitter; (v) the recognition of the importance of "sensory-motor" regulation of various visceral organs; (vi) the recognition of the integrative capacity of autonomic ganglia; (vii) the identification of new receptor subtypes and a better understanding of their associated transduction mechanisms; (viii) the recognition of the plasticity of the autonomic