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

Vignettes: Nature Stories

Two Canadian hikers were startled to find a grizzly bear coming up fast behind them. They immediately started to run, the bear in hot pursuit. Suddenly, one of them stopped, searched frantically in his haversack and pulled out his running shoes. "You surely don't think that will help you to outrun the bear," panted his astonished companion. "No. But it will help me to outrun you," was the reply.

—*Helena Cronin*, in *The Ant and the Peacock: Altruism and Sexual Selection from Darwin to Today* (Cambridge University Press)

If there is any doubt, write the term out. Otherwise, your reader may be in the position of the farmer who shot a crow and read the tag on his leg that said "Wash. Biol. Surv." The farmer remarked that he washed the crow, boiled it, and served it, but it still tasted awful. If there is any doubt, write the term out.

—*Deborah C. Andrews* and *Margaret D. Blickle*, as quoted by Robert A. Day in *Scientific English: A Guide for Scientists and Other Professionals* (Oryx Press)

nervous system in terms of expression of neurotransmitter phenotype, response to trophic factors and regulation of receptors; and (ix) advances in the understanding of the central control of the autonomic nervous system. These important concepts will be elaborated and illustrated in this new series.

Geoffrey Burnstock has been instrumental in developing many of these newer concepts of autonomic function, so it is entirely appropriate that he has chosen to edit a series of 14 books on the autonomic nervous system. *Autonomic Neuroeffector Mechanisms* is the first of the series. Burnstock intends to "allow individual expression by chapter contributors" in the hope that the resulting lack of uniformity may add to the appeal of the series and in this first volume, coedited by Charles Hoyle, this approach works well. Morphology, electrophysiology, and signal transduction mechanisms are discussed in the first four chapters and individual neurotransmitter mechanisms in the last five.

In G. Gabella's chapter on the fine structure of neuroeffector junctions, he surveys the literature with an emphasis and appreciation that could never be gleaned from a literature search. The same can be said for the intriguing overview of cotransmission and neuromodulation by J. L. Morris and I. L. Gibbins. Their chapter is broadly based, provocative, and well written. The chapter by J. A. Brock and T. C. Cunnane on the electrophysiology of smooth muscle includes a more critical review of the literature. Though the review would have been improved by the inclusion of additional diagrams, the description of the authors' own important work on neurotransmitter release and its modulation is exemplary and more than compensates for the lack of clarity in the first section of the chapter. C. D. Benham approaches the almost insurmountable task of reviewing signal transduction mechanisms and presents a crisp, logical, and comprehensive update of current concepts. M. Fillenz's review of noradrenergic transmission is also well organized and contains critical evaluations of alternative hypotheses. In this chapter, basic concepts are spelled out once and then reiterated in more detail later. Other good chapters include that by G. J. Dockray, which features a useful historical overview and a logical classification and description of autonomic neuropeptides, and that by J. M. Hills and K. R. Jessen, which collates the available evidence for GABAergic, serotonergic, and dopaminergic transmission in the autonomic nervous system. This chapter is useful because it outlines some of the technical difficulties associated with demonstrating a neurotransmitter role for these substances.

Two of the chapters fall short of the standard of the other seven. The chapter on purinergic transmission by C. H. V. Hoyle is disappointing in its lack of any reference to the molecular biology and structure of adenosine receptors or description of the adenosine uptake system (or systems). In the chapter on acetylcholine by N. J. Buckley and M. Caulfield there are several errors, including a misleading use of the term "paraganglia" and some apparent confusion about the mechanism of muscarinic inhibition within autonomic ganglia.

In general, this is an excellent source and introduction to the literature in an important and rapidly expanding area. I look forward to other books in this series. Many of them will likely be required reading for our graduate students.

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Developments in Vision

The Changing Visual System. Maturation and Aging in the Central Nervous System. P. BAGNOLI and W. HODOS, Eds. Plenum, New York, 1991. x, 420 pp., illus. $105. NATO Advanced Science Institute Series A, vol. 222. From a workshop, San Martino al Cimino, Italy, May 1991.

This is a collection of 36 papers on change in the visual system and, in keeping with the changing times, several papers concern aging and senescence. There also are contributions on development, maturation, and evolution.

Those on development of the visual system offer interesting new ideas. Juergen Bolz and his colleagues present results on the changing morphology of projection neurons in rat visual cortex as they develop and make connections. Differences in morphology in adult layer 5–cortical projection neurons are not present in infants. In the authors' words, "There appears to be an initial common morphological prototype of projection neurons in layer 5, and the characteristic distinctions between two projection systems are then sculptured during postnatal development" (p. 237).

Another interesting report, by Andreas Burkhalter, discusses the development of corticocortical connections in humans. In his research, Burkhalter observed lateral connections in all layers in adult but not infant visual cortex, in which lateral connections were confined to layers 4B and 5. This indicates a possible immaturity in signals carried by the parvocellular stream in human visual cortex and a surprising maturity in the magnocellular pathway.

There is also a provocative paper by Luciano Domenici and colleagues about nerve growth factor (NGF) in cortical development. Monocular deprivation causes functional disconnection of the deprived eye from visual cortex, but Domenici and colleagues' new finding is that infusion of the cortex with NGF prevents such disconnection. Their assumption is that disconnection may be a result of competition for a trophic factor, and NGF may be the factor. Much more work will be required to prove that concept.