Book Reviews

Nuclear Reactions

Direct Nuclear Reactions. G. R. SATCHLER. Clarendon (Oxford University Press), New York, 1983. xxii, 834 pp., illus. $110. The International Series of Monographs on Physics, 68.

Direct Nuclear Reactions. NORMAN K. GLENDENNING. Academic Press, New York, 1983. xviii, 378 pp., illus. $62.

It has been well over a decade since the publication of a book summarizing the subject of direct reactions in nuclear physics. Now, two books on the subject have appeared, both with almost up-to-date expositions of the methods of quantum scattering theory and the application of the theory to nuclear physics. The two books treat methods at a high mathematical level, although they generally have excellent discussions of the results from an intuitive point of view. In addition, both books are illustrated with many figures showing results of calculations and comparisons with the data. Of the many techniques and models in the field, both books emphasize those that have enhanced our knowledge of nuclear structure.

The bombardment of atomic nuclei with light nuclei is an important source of information concerning many nuclear properties. Direct reactions are those whose interaction times are comparable to the transit times of the projectiles across the nucleus. These interaction times are thus short, usually limiting the projectile interaction to only a few degrees of freedom of the system of nucleons that make up the nucleus. Direct reactions also take place at high enough bombarding energy that the projectile is unlikely to amalgamate with the target nucleus.

Since nuclear reactions most often involve the scattering of particles, both books begin by discussing scattering theory, using an optical potential to describe the elastic scattering of nucleons from nuclei. The books stress the methods commonly used in practical computation of observable quantities, such as angular distributions of particles emitted during the reaction. Techniques are presented that are amenable to efficient computation by digital computers. Satchler has also included some important cases in which analytic forms have given insight into a reaction process that might have been overlooked had the same quantity been calculated by a computer.

The books go on to discuss the distorted-wave approximation of nuclear reactions and its applications to inelastic scattering and particle-transfer reactions. This very useful approximation takes into account the refraction and absorption of the initial and final waves of the particles during the reaction process. Both authors then discuss the natural extension of the first-order theory to a treatment using coupled channels. Here, processes involving more than a single direct step may be calculated but at the expense of solving sets of coupled equations. Satchler gives an extensive analysis of the modern extension of this theory to coupled reaction channels. In this theory the nucleons of the projectile and target are partitioned in several ways and then coupled in a set of equations. Since the different systems are not orthogonal as is the case in the inelastic coupled-equation theories, theoretical and calculational difficulties emerge. Some of the usual approximations are no longer valid and comparison with the data is more obscure. Satchler discusses this topic well and points out the subtleties and pitfalls the unwary may fall into. Researchers engaged in this area will find the complete coverage of it particularly useful.

The two authors diverge at this point in their choice of topics. Satchler assigns a full chapter to the symmetry properties of the transition amplitudes and another to polarization phenomena. The latter is particularly useful since observable spin quantities are becoming increasingly important as a tool in distinguishing between different theories. Glendenning, on the other hand, devotes two chapters to particular aspects of collisions between heavy ions, a subject of great interest to many laboratories. Neither author treats theories of macroscopic or hydrodynamical reactions in heavy ions.

Although each book reflects the interests and tastes of its author, the volume by Satchler presents a more balanced view of direct-reaction theories. The book contains a clear and detailed presentation of the methods, echoing the Satchler's papers. The reference lis the end of each chapter, though complete, are invaluable as a stai point for further investigations. Glen ning's book treats fewer topics with detail and discussion, and it tend emphasize the work of the author anc collaborators. Nevertheless, Glen ning gives a concise overview of field, and his book would be of inte to researchers in heavy-ion physics.

Both books are expensive and will their primary use in libraries, althc the specialist will profit from investir them.

P. D. K

Department of Physics,
University of Colorado, Boulder 803

Particle Physics

Concepts of Particle Physics. Vol. 1. K GOTTFRIED and VICTOR F. WEISSKOPF. (endon (Oxford University Press), New Y 1984. xvi, 189 pp., illus. $22.50.

The volume under review summai the basic theory of modern particle p ics without using sophisticated ma matics; a second volume (not yet I lished) will cover the same material deeper and more sophisticated level. pedagogic value of this multiple co age is obvious. Most of the stan physics curriculums are taught in way.

The present volume is aimed at vanced undergraduates and begin graduate students. A knowledge of q tum mechanics and some acquaint with atomic and nuclear physics is sumed, though a lightning review these fields is provided in the firs pages. Particle physics itself is there compressed into about a hundred pa One would think that such a con treatment would be impossible ur the book were either a marshma popularization without much conter a mathematical treatise without m explanation. Amazingly, the book is ther.

It is an extremely efficient discus of the modern understanding of str weak, and electromagnetic interacti Right from the start leptons, quarks, vector bosons are identified as the fu mental particles. Meson and bai spectroscopy is presented in consi able detail from the combinatoric four quark flavors (later six) posses spin, orbital angular momentum, color. Color gluon dynamics is give pages, in which confinement, quark, and gluon jets are emphasized. Deep inelastic scattering, scaling, and asymptotic freedom are omitted. Electroweak interactions are treated in 60 pages, and it is here that the authors' approach is most novel. A four-Fermi vertex of pairs of quarks or leptons is introduced to account for all the observed charge-changing weak processes. The observation that the fermion pairs always have charge ± 1 motivates the introduction of a $W^{\pm}$ and leads to Cabibbo mixing, quark-lepton universality, and the GIM (Glashow-Iliopoulos-Maiani) mechanism. An argument of weak isospin symmetry and state mixing leads to the Z° and γ and gives their correct coupling to fermions and the relation of the Weinberg angle to g and g'. Neutral kaons and CP violation are treated in some detail. All this is accomplished without the use of field operators, Lagrangians, second quantization, non-Abelian symmetries, and the like.

The book has been written very carefully. Statements are phrased precisely (including necessary qualifications and exceptions) so that they do not have to be modified later on. Early discussions (for example, of parity, helicity, and CPT) point out subtleties that are later crucial. Naturally such concise, focused writing demands a lot from the reader. The emphasis throughout is on quantum numbers, symmetry arguments, and selection rules. Mastery of this book will not enable one to calculate a cross section or a lifetime. It will enable one to understand much of modern particle physics.

H. A. WELDON
Department of Physics, University of Pennsylvania, Philadelphia 19104

Avogadro and His Work

Amedeo Avogadro. A Scientific Biography. MARIO MORSELLI. Reidel, Boston, 1984 (distributor, Kluwer Boston, Hingham, Mass.). xii, 375 pp., illus. $59.50. Chemists and Chemistry.

There are two books here, a biography and a history of an idea. The first takes us through the scientific career of the Piedmontese physicist who first proposed, in 1811, the hypothesis that all gases under the same conditions of temperature and pressure contain the same number of particles: Avogadro's hypothesis, or, as Morselli calls it, the "molecular hypothesis." An opening chapter on the man and his times is followed by chapters on his early electrical and electrochemical researches, on his later essays on points of chemical theory, on his ponderous *Fisica dei corpi ponderabili* (four volumes, 1837–41), and on a miscellany of papers he published in the last 25 years of his life. Apart from the opening chapter, which sketches Piedmont's odd position in Revolutionary, Napoleonic, and Restoration Europe and Avogadro's placid ability to go on thinking about science amid the turbulence, these biographical chapters present Avogadro's arguments and findings against the background of contemporary work on the various problems he addressed. They usually end, a little regretfully, stating that Avogadro's efforts either attracted no attention at all or caused Berzelius (in his *Jahresbericht über die Fortschritte der Chemie*) to sneer.

The one exception to the desuetude into which most of Avogadro's work fell makes up the second book. Here Morselli relates the history of Avogadro's hypothesis from its inception to its acceptance late in the 19th century as a fundamental law of chemistry and a strategic bridge between physical and chemical conceptions of gases. Avogadro, putting together Dalton's chemical atomism and Gay-Lussac's observations on the numerically simple way gases combine by volume, suggested "as the first hypothesis to present itself in this connection, and apparently even the only admissible one . . . that the number of integral molecules in any gases is always the same for equal volumes." (The quotation is from Avogadro's 1811 paper.) This requires, of course, that the particles of elementary gases be divisible, or molecular. Although a number of chemists restated this idea in the first half of the century, and Avogadro himself reiterated its importance in several of his publications over the years, it did not come in for serious consideration as a way of sorting out the era's profusion of atomic weight determinations until midcentury. After Stanislao Cannizzaro's formal presentation of the hypothesis at the Karlsruhe conference of 1860 scientists had to reckon with it. The interval between publication and general acceptance (or at least acknowledgement), or the "delay" in the recognition of Avogadro's insight, or the "neglect" of his work, has been the main source of active historical interest in his career. Scientists are supposed to spot and welcome true and important contributions at once; when they do not, historians prick up their ears. Also, Avogadro's case, like Ohm's and Mendel's, brings out the public defender in some historians, anxious to do justice to the obscure, the provincial, and the powerless in a world where the metropolis is plenty smart but often has pharisaical vested interests.

Morselli's thorough, detailed account of Avogadro's *oeuvre* is as complete as we are likely to get. I wish it were better. It is evident that Morselli set himself the task of presenting Avogadro whole, but inasmuch as Avogadro contributed almost nothing to 19th-century science except his famous hypothesis Morselli is left without a standard for the selection or omission of detail. As a result, Avogadro's shorter papers appear in brute summary, whereas the longer ones—and Avogadro tended to prolixity—defeat Morselli, who tries valiantly without success to connect them with the scientific mainstream. In the course of this labored and laborious exposition he even gets annoyed with Avogadro for his blurry definitions (pp. 306, 307), his "natural inclination to uphold a preconceived hypothesis rather than to accept empirical data" (p. 312), and his elaborate, obscure, "involute" prose style (pp. 17, 95, 304).

Interest in Avogadro must remain with his hypothesis, and Morselli's account picks up when he deals with it. Despite much careful scholarship on the problem of its delayed acceptance, historians do not agree on the reasons for it, or even on whether there is a delay to explain. Some scholars assert that the hypothesis was adopted precisely when it was needed, and that therefore attempts to explain its earlier neglect miss the point. This argument has swayed Morselli but has not fully won him over. His own explanation adduces three main obstacles in the way of the scientific world's immediate acceptance of Avogadro's hypothesis: from within the sphere of scientific thought, disbelief in the possibility of polyatomic elementary particles; from the "culture" (Morselli is vague about what that means), disapproval of speculation; and from Avogadro's own retiring and "bland" personality, unwillingness to press his claims or to go to Paris (as Volta did earlier) to woo the big shots.

Of these three hindrances, only the first had force, in my opinion. Other scientists as stay-at-home as Avogadro got a hearing in the capitals—Joseph Louis Proust, for example, who successfully challenged Berthollet on the principle of constant combining proportions, worked in Spain and published his papers in the same second-class journal (Lamétherie's *Journal de Physique*) that printed Avogadro's 1811 paper. Further, can it be maintained that the age was