Book Reviews

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Time Description of Nuclear Reactions is discussed by Shiro Yoshida. The success of the crystal blocking effect in determining nuclear lifetimes in the range of 10^{-14} to 10^{-18} sec suggests that, in the near future, it will be possible to observe the time-dependent behavior of nuclear reactions by measuring the intensity of the escaping particles as a function of the time elapsed since the formation of the compound nucleus. The present review sets out, in a somewhat dull format, the mathematical framework in which such experiments can be interpreted.

In *Resonance Fluorescence of Excited Nuclear Levels in the Energy Range of 5-11 MeV*, B. Arad and G. Ben-David give a short review of resonance fluorescence measurements in the energy range of 5 to 11 MeV. The emphasis is on outlining the equations needed to analyze the different measurements and on reporting the results of the measurements, not on describing the different experimental methods. To comprehend fully the different methods, analysis techniques, and results, a reader would need to make use of the references. Little effort is made to assess or interpret the reported information. Thus, the usefulness of the experimental technique could be misleading. There are a few typographical mistakes and occasionally a choice of phrasing that could be misleading. However, the authors have done an excellent job of putting together concisely the varied aspects of this subject and have written a summary particularly useful to the experimentalist just entering this field or to the student interested in an overview of resonance fluorescence.

Y. E. Kim and A. Tubis, in *The Theory of Three-Nucleon Systems*, do a splendid job of presenting a comprehensive and extremely well-documented review of the vast and diverse field of the three-nucleon problem in a very limited space. The basic purpose for studying three-nucleon systems is to extract knowledge of the two-nucleon T-matrix off the energy shell. As to its importance, however, the picture that has emerged so far is not as clear as it could have been, basically because most of the two-nucleon T-matrices used in the studies are not equivalent on the energy shell. We are cautioned that the three-nucleon system might not be sufficiently sensitive to the off-shell property. Important progress made since 1969 in our understanding of the meson-exchange currents in three-nucleon systems is also reviewed in the article.

Shell-Model Effective Interactions and the Free Nucleon-Nucleon Interaction is considered by T. T. S. Kuo. Understanding the drastic difference between the free nucleon-nucleon interaction and the effective interaction between nucleons embedded in the nuclear medium is one of the most challenging problems in nuclear physics today. Kuo, in this review, introduces in a nonrigorous manner, the "folded diagram" expansion for an energy-independent effective interaction, and he gives some discussion but no solution to the convergence problems associated with the expansion. The circumvention of difficulties imposed by the strong short-range nature of the free nucleon-nucleon interaction—the construction of a G-matrix—is reviewed, but like many sections of the article, it suffers from the necessity to be brief. The section on empirical interactions was perhaps unnecessary.

Post-Fission Phenomena by Darleane C. Hoffman and Marvin M. Hoffman is a review of the recent experimental studies of the fission process after scission of the fissile nuclide into two fragments of roughly comparable mass. Topics covered include investigations of the mass, charge, and kinetic-energy distributions of the fragments as well as the prompt emission of neutrons and photons. During the past few years, a considerable amount of new experimental data has been obtained for fission induced by both low- and high-energy particles and/or radiation. This article provides an excellent summary of these new data as well as limited comparisons with the predictions of current theoretical models of nuclear fission.

Atomic Structure Effects in Nuclear Events by Melvin S. Freedman treats nucleus-atomic electron interaction; specifically, (a) electron ionization by the "shakeoff" or excitation of electrons to unbound orbitals by the "shake-up" mechanisms, and (b) the influence of the energetics of the atomic electron system on the nuclear processes of alpha-particle decay, beta-particle decay, orbital electron capture, and internal conversion from a uniform point of view. After a discussion of the latter effects, which are predicted to be $\lesssim 0.1\%$ and are usually very difficult to measure experimentally, the author gives a detailed description of the theory of the shaking process together with a comprehensive summary of available experimental data. Except for the case of shaking in alpha-particle decay, the basic theoretical concepts appear to be verified. This well-written and well-documented review can be appreciated by novice and expert alike.

Meson-Nucleus Scattering at Medium Energies, as reviewed by Morton M. Sternheim and Richard R. Silbar, is mainly restricted to elastic and inelastic (but no target breakup) pion-nucleus scattering, with ~100 to ~400 MeV pions. The theory of optical potential is discussed in some detail and is used in most of the reported calculations. To achieve a qualitative fit to the data, which are still very scarce and in general of poor quality, it is essential to incorporate (many ways are possible) into the optical potential the p-wave pion-nucleon amplitude that exhibits the famous (3,3) resonance. In addition, the potential needs a strong absorptive part. This field is relatively young, and will not be in full bloom until after high-intensity meson beams at the Clinton P. Anderson Meson Facility at Los Alamos (LAMPF) and the Tri-University Meson Facility (TRIUMF) have been in production for some time.

Reactions Between Medium and Heavy Nuclei and Heavy Ions of Less than 15 MeV/amu by Alain Fleury and John M. Alexander reviews the wide field of heavy-ion reaction mechanisms and the properties of the composite system at the time of collision. The reactions discussed in some detail include elastic scattering; soft collisions, i.e., inelastic scattering and few-nucleon transfer reactions; hard collisions that involve large mass and/or energy transfers but exhibit forward-peaked angular distributions; and complete fusion collisions. In every case the present status of experimental information and reaction theory is outlined and experimental examples are chosen that illustrate the relative successes of various theoretical models.

Proton-Nucleus Scattering at Medium Energies is discussed by Jean Saudinos and Colin Wilkin. For some years the only medium-energy (proton energy ranging roughly from 0.5 to 2 GeV) proton-nucleus scattering data were those taken at the Cosmotron at Brookhaven. Since 1972 other laboratories have joined in the effort and the amount of data taken has increased significantly. The motivation for such experiments is to extract structural information about the scattering nucleus at very short distances. Saudinos and Wilkin review calculations that interpret the new and old data. The method used (Glauber Approximation) requires only nucleon-nucleon amplitudes and density distribution of the nucleus as input. In most cases the approximation has worked well, the less successful cases being attributed to uncertainties in the empirical nucleon-nucleon amplitudes. The authors succeed in showing us that this type of experiment is a viable alternative for extracting nuclear structural information.

Gauge Theories of Weak Interactions by M. A. B. Bég and A. Sirlin points out that, in recent years, there has been an explosion in the number of theoretical models introduced to resolve the divergency of the classical current × current interaction and, at the same time, to unify the weak and electromagnetic interactions. All these theories (models) invoke neutral currents, heavy leptons, or both. Bég and Sirlin, in this timely review, survey a large number of such models, albeit in a superficial manner, and yet excusably restrict their choice to gauge theories on the grounds that the model must permit calculation and must yield a reasonable number of experimental testable predictions while incorporating the classical current × current interaction in a natural way. This review is not for laymen.

In *Inclusive Reactions* by H. Bøggild and T. Ferbel, the rather modern term "inclusive" means a reaction in which only a part of the product is specified, as opposed to an "exclusive" one where all products are specified. Bøggild and Ferbel give a brief account of the motivation for measuring the cross sections of such reactions at very high energies (up to 500 GeV) and then proceed to review the fascinating hybrid of hypothesis (hypothesis of limited fragmentation), theorem (Mueller's generalized optical theorem for inclusive reactions), and phenomenology (Regge-pole dominance) used to analyze and correlate these data. The basic conjecture is that at sufficiently high energies certain aspects of production processes will have a smooth and simple energy dependence and will be independent of the nature of the colliding particles. We are shown that to some extent this conjecture has been substantiated by the measurements, but that we are still very far from understanding high energy phenomena.

Environmental Aspects of Nuclear Energy Production are narrowly viewed by Thomas H. Pigford. Regulations are not distinguished from science. Effects of transgressing regulation limits are not validly discussed, and, by hypothesis, biological effects are undetectable if the regulations are observed. How plutonium might find its way into the environment from nuclear-energy production as distinct from nuclear weapon explosions is left to vague presumption. Table 11 shows interestingly the many (6 to 14) times larger amount of plutonium in process when plutonium recycle in water reactors or when fast breeder reactors are used.

In discussing how tritium and ^{85}Kr may be kept out of the environment the author appears unaware that the oxide skin on zirconium fuel cladding makes tritium-escape there negligible. The mentioned slower diffusion of tritium in zirconium than in stainless steel is not limiting.

Nickel-59, which prevents recycle of irradiated stainless steel, is unmentioned.

Fission-product yields are modified by neutron capture but, since this effect is not mentioned, presumably it is not included in the graphs presented. The effects make extra care necessary in the rare earths. In commenting on skyshine from $^{16}N_2$ the easy way out by a short delay, due to the short half-life of 7.36 sec, might have been noted. Curies are overworked and discussed as if they are permanent; half-life, the radiation energy, and whether the daughter product is stable or radioactive are neglected. The environment considered is that within the United States, not Europe or even Canada.

Applications of Nuclear Science in Crime Investigation by Vincent P. Guinn is very illuminating and well referenced. Neutron activation analysis is proving a valuable and wideranging technique. The problems of interpretation are stressed and, in particular, the evidence derivable from analysis of hair is excellently reviewed.

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About the Reviewers: We are pleased to have had a four-man team from Canada prepare this review of the multitopic 1973 Annual Review.

W. Bennett Lewis, now retired, was senior vice-president, Science, of Atomic Energy of Canada Limited. He maintains his interest in nuclear fuel cycles, especially with thorium for very low cost energy, and in radiation effects in materials and biology. Dr. Lewis is a former President of the Society.

Gordon C. Ball is an experimental nuclear physicist who has recently contributed to such diverse fields as three-body final-state interactions, exotic transfer reactions, precise nuclear mass determinations, lifetime measurements on very short-lived nuclear states, and the stopping powers of heavy ions in various materials. Dr. Ball received his early education in Calgary and graduated in honors chemistry from the University of Alberta. He has worked at the Chalk River Nuclear Laboratories since