Book Review

The Theory of Neutron Resonance Reactions. By J. E. Lynn. Oxford University Press, Inc., New York (1968). 503 pp. $16.00.

The reactor physicist lives on neutron cross sections, and the latter are dominated by resonance phenomena. A full-size book on this topic by an expert thus raises high expectations. The author states, in the preface, "The original intention governing the scope of this monograph was to provide a coherent theoretical background for experimental physicists working in the field of slow neutron spectroscopy," and again, "From the theoretical standpoint, then, the scope of this book can be defined as the study of neutron cross section phenomena exhibiting or involving resonances." Unfortunately, it does not quite live up to these claims. It covers a great deal of material, but not much in depth. It does not give complete derivations but abounds in remarks, e.g., "It can be shown that . . ." or "The result is . . .," sometimes with and sometimes without a reference to the original source. The effect is most pronounced in the basic Chap. II, "Formal Nuclear Reaction Theories." This is essentially a shortened version of Lane and Thomas' famous but difficult article, "R-Matrix Theory of Nuclear Reactions" [*Phys. Rev.*, **30**, 257 (1958)], with many details omitted. The effect of this quoting but not deriving final results is that one has to hunt constantly for the definitions of the symbols involved without getting too good a feeling for the physics situation.

Part of the difficulty stems from the present state of nuclear physics. We are in an era of model building. There are the independent-particle models, such as the shell model and Nilsson's extension to deformed nuclei. Then there are the models with collective features, such as the liquid drop, the pairing energy, and the so-called uniform model. All these have been introduced on semiempirical bases to correlate various properties. Indeed, they permit the interpretation of a very large amount of data. However, we are only at the beginning of understanding or deriving these models from first principles and of having criteria for when they should or should not be applied. The models are all in the book, generally introduced by a few words. The results are quoted, but no effort has been made to mold them into a unified whole.

In summary, the book is not suited as a first introduction to the subject. It is useful for the sophisticated reader as a guide to the literature. It brings out the richness of the phenomena, gives numerous tables and graphs, and shows where further information can be obtained. References are fairly complete through 1966 with a few 1967 titles. All this is supported by good indices.

After an introduction giving some historical and experimental background, Chap. II, as already mentioned, deals with the formal theory of resonance reactions. Besides the R-matrix theory, the S-matrix formulation following the Humblet-Rosenfeld approach is treated, and the relations between the two are discussed. In preparation for later, more complex considerations, Chap. III reviews the single-particle model of neutron reactions. Chapter IV deals with the spacing of nuclear resonances. Since this topic requires assumptions on the structure of nuclei, the various models are introduced, and their relevance with respect to resonance spacing is discussed. Chapter V, on the statistical distribution of resonance spacings, is based on the random-matrices concept by Wigner, Porter, Dyson, and others. Since this is a well-defined mathematical method, independent of model details, a good coherent picture is developed. Chapter VI, on neutron elastic scattering, covers the average cross sections and strength functions, the statistical distribution of neutron widths, and the average properties on the basis of the optical model (called in the book the "complex potential" model) and its various refinements. Chapter VII treats radiative capture. After a review of the formal theory (again following Lane and Thomas), it covers such topics as statistical properties and gamma-ray spectra, the giant resonance model, valency neutron transitions, direct capture, and magnetic dipole transitions.

The last chapter, Chap. VIII, deals with neutron-induced fission. It is the most interesting one in the book, since it discusses fully the modern concept of the channel structure at the transition point due to A. Bohr. It is also the only place where interferences between resonances are of real importance and where single-level approximations are clearly inadequate. It is also brought out that multilevel analyses are at present far from unique and that there is much more work required before one will be able to arrive at a good statistics of fission parameters. The experimental data for the fissionable nuclei for slow neutrons are described in detail, as are the higher energy data for the fertile isotopes. Also, short remarks are made on such topics as angular and mass distribution of the fission products and intermediate structure in neutron-induced fission.

This brief recapitulation does not reflect adequately the richness of the content of the book, which unfortunately is not matched by comparable skill in exposition.

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About the Reviewer: Lothar Nordheim is a Senior Research Advisor at Gulf General Atomic. He received his PhD degree from Goettingen, Germany, in 1923. In his long career at universities, at national laboratories, and in industry, he watched and participated in the development of quantum mechanics, solid-state physics, cosmic-radiation interpretation, and nuclear and reactor physics. He is a Fellow of the American Nuclear and American Physical Societies and a member of the Advisory Committee on Reactor Physics of the AEC and of the Editorial Advisory Committee of Nuclear Science and Engineering.