Theory of Nuclear Reactions

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Theory of Nuclear Reactions

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World Scientific

Singapore • New Jersey • London • Hong Kong

Published by

World Scientific Publishing Co. Pte. Ltd.

P O Box 128, Farrer Road, Singapore 9128

USA office: 687 Hartwell Street, Teaneck, NJ 07666

UK office: 73 Lynton Mead, Totteridge, London N20 8DH

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ISBN 9971-50-481-2

9971-50-482-0 (pbk)

Printed by Singapore National Printers Ltd

To my dear daughter Alla

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PREFACE

This book is an extended version of the second part of the lecture course on nuclear theory which has been given by the author for some years at the physical faculty of Kiev State University. The first part deals with the nuclear structure. It was published before, Ref. 1. The second part considers the nuclear reactions. It concerns the nonrelativistic theory; problems of relativistic nuclear physics are not discussed.

The nonrelativistic theory of nuclear reactions, as well as the nonrelativistic scattering theory,² essentially employ the scattering matrix (S-matrix) concept. Since no consistent microscopic theory has been worked out up to now, the scattering matrix is obtained phenomenologically under special assumptions about the nuclear interaction nature. Nuclear processes can occur through a variety of mechanisms. Among these, compound-nucleus reactions and direct nuclear reactions are the most important. The book gives a detailed discussion of reaction mechanisms and considers their relationship. Much attention is paid to the R-matrix theory and its applications to the description of resonance nuclear processes, as well as to different approaches (the dispersion method among them) to the study of direct nuclear reactions. A detailed account is given of both the optical model, describing low-energy nuclear processes, and the diffraction phenomena which accompany nucleon-nucleus interactions. Few-body nuclear reactions, in particular, three-particle processes, are discussed. The dispersion theory treating direct nuclear reactions in terms of Feynman graphs, is considered in detail. High-energy diffraction processes involving composite nuclear particles are studied by means of multiple scattering theory.

Though the present theory of nuclear reactions is phenomenological and has some inherent disadvantages, it provides, nevertheless, a satisfactory description of nonrelativistic nuclear processes and a reliable ground for practical calculations in applied physics and nuclear power engineering. Though present settled understanding of nuclear processes

has been developed for several decades and discussed in a number of monographs, no consistent and sufficiently detailed account of the theory of nuclear reactions has been written up to now. This prompted the author to propose the present book. The main attention is paid to basic conceptions of the theory of nuclear reactions. Nevertheless, it also covers many problems which have been considered only in original papers and have not been included in existing manuals. In the concluding part of the book, a list of most important books on nuclear theory³⁻¹⁵ and original papers is given which does not pretend, however, to be complete. Though writing this book has cost the author much time and effort, he is aware of its disadvantages and will appreciate any critical or constructive remarks.

The author is thankful to Prof. V.F. Kharchenko for his assistance in preparing certain sections of Chaps. 1 and 2.

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