Lecture Notes in Physics

The Lecture Notes in Physics

The series Lecture Notes in Physics (LNP), founded in 1969, reports new developments in physics research and teaching – quickly and informally, but with a high quality and the explicit aim to summarize and communicate current knowledge in an accessible way. Books published in this series are conceived as bridging material between advanced graduate textbooks and the forefront of research and to serve three purposes:

- to be a compact and modern up-to-date source of reference on a well-defined topic
- to serve as an accessible introduction to the field to postgraduate students and nonspecialist researchers from related areas
- to be a source of advanced teaching material for specialized seminars, courses and schools

Both monographs and multi-author volumes will be considered for publication. Edited volumes should, however, consist of a very limited number of contributions only. Proceedings will not be considered for LNP.

Volumes published in LNP are disseminated both in print and in electronic formats, the electronic archive being available at springerlink.com. The series content is indexed, abstracted and referenced by many abstracting and information services, bibliographic networks, subscription agencies, library networks, and consortia.

Proposals should be sent to a member of the Editorial Board, or directly to the managing editor at Springer:

Christian Caron
Springer Heidelberg
Physics Editorial Department I
Tiergartenstrasse 17
69121 Heidelberg / Germany
christian.caron@springer.com

J.S. Al-Khalili
E. Roeckl (Eds.)

The Euroschool Lectures on Physics with Exotic Beams, Vol. III

Springer

J.S. Al-Khalili
University of Surrey
Dept. Physics
Guildford, Surrey
United Kingdom GU2 5XH
j.al-khalili@ surrey.ac.de

E. Roeckl
Gesellschaft for
Schwerionenforschung mbH
(GSI)
Planckstr. 1
64291 Darmstadt
Germany
R.Roeckl@gsi.de

Al-Khalili, J.S., Roeckl, E. (Eds.), *The Euroschool Lectures on Physics with Exotic Beams, Vol. III*, Lect. Notes Phys. 764 (Springer, Berlin Heidelberg 2009), DOI 10.1007/978-3-540-85839-3

ISBN: 978-3-540-85838-6 e-ISBN: 978-3-540-85839-3

DOI 10.1007/978-3-540-85839-3

Lecture Notes in Physics ISSN: 0075-8450 e-ISSN: 1616-6361

Library of Congress Control Number: 2008935358

Cover design: Integra Software Services Pvt Ltd.

Printed on acid-free paper

9 8 7 6 5 4 3 2 1

springer.com

Preface

This is the third and final volume in a series of Lecture Notes based on the highly successful Euro Summer School on Exotic Beams that has been running yearly since 1993 (apart from 1999) and is planned to continue to do so. It is the aim of the series to provide an introduction to Radioactive Ion Beam (RIB) physics at the level of graduate students and young postdocs starting out in the field. Each volume contains lectures covering a range of topics from nuclear theory to experiment to applications.

Our understanding of atomic nuclei has undergone a major re-orientation over the past two decades and seen the emergence of an exciting field of research: the study of 'exotic' nuclei. The availability of energetic beams of short-lived nuclei, referred to as 'radioactive ion beams' (RIBs), has opened the way to the study of the structure and dynamics of thousands of nuclear species never before observed in the laboratory. This field has now become one of the most important and fast-moving in physics worldwide. And it is fair to say that Europe leads the way with a number of large international projects starting up in the next few years, such as the FAIR facility at GSI in Germany. From a broader perspective, one must also highlight just how widely RIB physics impacts on other areas, from energy and the environment to medicine and materials science. There is little doubt that RIB physics has transformed not only nuclear physics itself but many other areas of science and technology too, and will continue to do so in the years to come.

While the field of RIB physics is linked mainly to the study of nuclear structure under extreme conditions of isospin, mass, spin and temperature, it also addresses problems in nuclear astrophysics, solid-state physics and the study of fundamental interactions. Furthermore, important applications and spin-offs also originate from this basic research. The development of new production, acceleration and ion storing techniques and the construction of new detectors adapted to work in the special environment of energetic radioactive beams is also an important part of the science. And, due to the fact that one is not limited anymore to the proton/neutron ratio of stable-isotope beams, virtually the whole chart of the nuclei opens up for research, so theoretical models can be tested and verified all the way up to the limits of nuclear existence: the proton and neutron 'drip lines'.

The beams of rare and 'exotic' nuclei being produced are via two complementary techniques: in-flight separation and post-acceleration of low-energy radioactive beams. Both methods have been developed in a number of European Large Scale Facilities such as ISOLDE (CERN, Switzerland), GANIL (Caen, France), GSI (Darmstadt, Germany), the Accelerator Laboratory of the University of Jyväskylä (Finland), INFN Laboratori Nazionali di Legnaro (Italy) and the Cyclotron Research Centre (Louvain-la-Neuve, Belgium). Indeed, so important is the continued running and success of the School that a number of these European facilities have committed to providing financial support over the coming years.

While the field of RIB physics is linked mainly to the study of nuclear structure under extreme conditions of isospin, mass, spin and temperature, it also addresses problems in nuclear astrophysics, solid-state physics and the study of fundamental interactions. Furthermore, important applications and spin-offs also originate from this basic research. The development of new production, acceleration and ion storing techniques and the construction of new detectors adapted to work in the special environment of energetic radioactive beams is also an important part of the science. And, due to the fact that one is not limited anymore to the proton/neutron ratio of stable beams, virtually the whole chart of the nuclei opens up for research, so theoretical models can be tested and verified all the way up to the limits of nuclear existence: the proton and neutron 'drip lines'.

Volumes I and II of this series have proved to be highly successful and popular with many researchers reaching for it for information or providing it for their PhD students as an introduction to a particular topic. They are now even available to download from the Euro School Website (http://www.euroschoolonexoticbeams.be/eb/pages/lecture_notes). We stress that the contributions in these volumes are not review articles and so are not meant to contain all the latest results or to provide an exhaustive coverage of the field but are written instead in the pedagogical style of graduate lectures and thus have a reasonably long 'shelf life'. As with the first two volumes, the contributions here are by leading scientists in the field who have lectured at the School. They were chosen by the editors to provide a range of topics within the field and will have updated their material delivered at the School (sometimes several years ago) to incorporate recent advances and results.

Finally, we wish to thank the lectures who have contributed to this volume for their hard work and diligence, and indeed for their patience, at a time when everyone finds it difficult to find the time to lay out their subject in such a careful, thorough and readable style. We also wish to thank Dr. Chris Caron and his colleagues at Springer-Verlag for their help, fruitful collaboration and continued support on this project.

Guildford, UK, *J. Al-Khalili*
Darmstadt, Germany *E. Roeckl*

Contents