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Nuclear Physics with Polarized Particles

Springer

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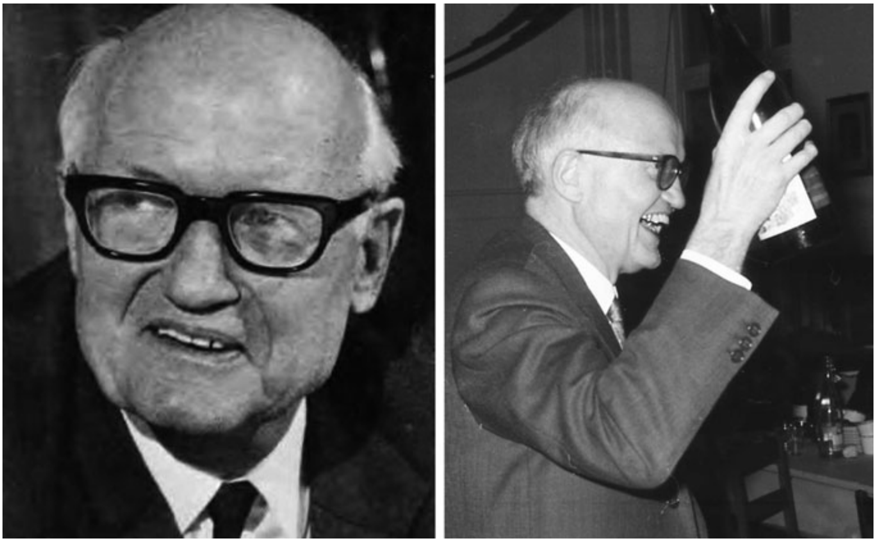
In memoriam



This book is dedicated to the memory of **Paul Huber** (1910–1971) who—at the University of Basel—pioneered an entire new field of nuclear physics: polarization phenomena, and with it the series of spin-physics (or polarization-phenomena) conferences and workshops. He was a brilliant teacher of physics, wrote a four-volume physics textbook, and worked in many international organizations such as IUPAP. Many of his former Ph.D. students became internationally renowned researchers and university teachers. Left photo reprinted with permission from AIP, New York. Copyright Physics Today 24(6) p. 71 (1971). Right photo by the author.

Preface

Over 30 years a nuclear spin-polarization program has been maintained at the Institut für Kernphysik of the University of Cologne. The successful implementation of such a program requires not only the necessary equipment much of which has to be developed in-house but it rests on specially instructed and trained collaborators. These come about from undergraduate and graduate students who often start to work in experimental groups already as "mini-researchers", develop into diploma or masters and later into Ph.D. students. Besides the standard education in physics, then by specializing in nuclear physics, and finally in specialized lectures and seminars they may become involved in fields like spin physics. In order to give them a knowledge basis in view of a lack of literature different scripts were written to accompany the lecture topics. One of the scripts was on the formal description of spin polarization, another on polarized-ion sources. It seems worthwhile to collect and conserve this knowledge in the form of a printed lecture note.

This lecture note consists of several parts. A large part is devoted to introducing the formal theory, the description of polarization and of nuclear reactions with polarized particles. Another part describes the physical basis of methods and devices necessary to perform experiments with polarized particles and to measure polarization and polarization effects in nuclear reactions. A brief review of modern applications in medicine and fusion-energy research will conclude the lecture note. However, the many contributions of polarization to the widespread field of nuclear physics, especially nuclear reactions, i.e. its results and achievements in that context can only be touched upon within this more methodical survey.

Especially in the more experimental parts of the lecture note it appears impossible to cite all relevant references completely. Therefore, only original references to important developments of the field or selected references to the more recent literature, preferably containing further more complete references, can be cited here. They have been selected in view of their exemplary (not necessarily priority) value or, when discussing devices of polarization physics, the author will show examples with which he is acquainted in order to introduce the principles and more recent developments. Therefore, the examples are mainly taken from low-energy installations such as tandem-Van-de-Graaff laboratories although the emphasis of present research is shifting to medium- and high-energy nuclear physics and the number of low-energy installations is waning. Consequently the description is entirely non-relativistic and focussed on the energy range from astrophysical energies ($\approx$10 keV) to tens of MeV. Also it is restricted to polarization of hadronic particles i.e. the polarization effects of electrons or γ radiation are not treated.

Acknowledgments

It is a pleasure for me to thank all colleagues and especially my students over many years who not only have worked on improving the theoretical understanding of polarization phenomena but also on developing and improving the technical means and relevant devices which were used successfully for nuclear physics, especially in the field of low-energy few-body reactions.

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Part III Devices