Preface

Particle traps are successful tools for a broad range of high-precision spectroscopy experiments on all frequency scales. Single particles or defined particle ensembles can be well-isolated from external influences, prepared with respect to their internal and external states and confined for times up to months. Traps provide a multitude of manipulation and measurement techniques including nondestructive detection methods down to the single-particle level. They are hence nearly ideal surroundings for fundamental physics at low energies, particularly for high-precision measurements of fundamental physical quantities which employ spectroscopic methods.

In this book, we intend to give detailed insight into fundamental physics with particles confined in traps. This comprises experiments and theoretical predictions at the highest precisions reached so far. Such investigations allow stringent tests of quantum electrodynamics and the Standard Model, antiparticle and antimatter research, study of fundamental symmetries, constants, and their possible variations with time and space. They are key to fundamental aspects in metrology such as mass measurements and time standards, as well as promising to further developments in quantum information processing. We focus on experiment and theory of magnetic moments, both for unbound and bound electrons, as well as on the particle–antiparticle cases of the electron and the positron and of the proton and the antiproton. This is directly connected with antimatter research on the antihydrogen system, the bound state of the positron and the antiproton. We treat precision mass measurements of radionuclides using traps and quantum information processing with confined particles. A second focus is on fundamental physics with highly charged ions, which feature a number of unique properties that make them interesting under various aspects to be discussed.

Darmstadt, October 2013

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http://www.springer.com/978-3-642-45200-0

Fundamental Physics in Particle Traps
Quint, W.; Vogel, M. (Eds.)
2014, XXI, 411 p. 166 illus., Hardcover
ISBN: 978-3-642-45200-0