Preface

The idea of having a symposium on the hydrogen atom arose from our many discussions of the fact that the simplicity and generality of physics are often obscured by the endless sophistication of the theoretical analyses and the enormous variety of experimental techniques.

Nowadays we have periodic international conferences on atomic physics, on laser spectroscopy, and on quantum electronics, where all aspects of the theory of interaction of radiation with matter are discussed and new techniques and experimental results are presented. However, none of these conferences brings together and shows the connections between the major physical ideas on which the different branches of modern physics are based. It occurred to us that a good way to achieve this goal would be to organize a symposium around the simplest bound quantum system, the system which stimulated the birth of modern physics, the system in which effects associated with electro-magnetic interactions, quantum physics, and relativity can be measured with the highest accuracy, thus making possible the most rigorous tests of the theories of these effects. That system is, of course, the hydrogen atom.

The fact that the solutions of the Schrödinger and of the Dirac equations for hydrogen are given in textbooks as well as treatments of hyperfine splittings and quantum electrodynamic corrections, and the long history of these subjects, could make people think that this is an old-fashioned topic, not appropriate for a stimulating symposium. But as we went on to review the progress recently made in studies of the hydrogen atom, we found the opposite to be true. The exploration of hydrogen has led to the development of powerful new techniques and experimental tools, greatly advancing the frontiers of spectroscopy. The possibility of producing new hydrogenic atoms with all types of particles and antiparticles has opened up completely new fields, further extending the role of the hydrogen atom as an ideal testing ground for the theory of elementary particles and their interactions, and for the quantum theory of matter and radiation.

After that we invited people from all over the world, belonging to different scientific communities, to present the latest results of their investigations of hydrogenic systems. We were gratified by their enthusiastic response and by their participation. The symposium was held at the Scuola Normale in Pisa at the end of June, and we believe the participants became more convinced than ever of the unity of physics and of the key role that the hydrogen atom is playing and will continue to play in the future. We wish to thank all the participants, and in particular F.T. Arecchi, R. Barbieri, B. Cagnac, L. Foà, J. Gay, A. Gozzini,

H. Layer, G. zu Putlitz, L.A. Radicati, and F. Strumia, who agreed to chair the various sessions. We are also grateful to the sponsoring institutions listed before this preface.

In organizing the material for these proceedings, we decided to subdivide it into four chapters, according to the most recent developments in the exploration of hydrogenic systems.

In the first chapter we have included a number of subjects which originate from the enormous improvements in spectroscopic techniques, such as those involving two-photon spectroscopy, atom trapping and Rydberg state transitions. Values of universal constants of extreme accuracy, as well as of hyperfine splittings and of radiative corrections have been obtained by these methods.

In the second chapter we consider more exotic two-particle systems: the hydrogen-like ions with large relativistic effects, positronium and muonium with their large hyperfine splittings, antihydrogen, and a new atom formed by a proton and an antiproton – with excitation spectrum in the X-ray region.

In the third chapter we present the contributions dealing with quantum electrodynamics corrections, including the weak interaction effects which lead to parity non-conserving transitions. An original presentation of the field by C. Cohen-Tannoudji has not been reported here, because it appears in the new book on the interaction of photons and atoms by him, J. Dupont-Roc, and G. Grynberg.

Finally, in the last chapter, we include all papers dealing with transitions in strong fields to discrete and continuum states, where chaotic behavior becomes relevant.

Though many of the above described phenomena are treated in a number of books, and some of them in the new book on the spectrum of atomic hydrogen edited by G.W. Series, we hope that our effort to collect in one book information on as many as possible of the fascinating aspects of the physics of the hydrogen atom will be found useful.

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