

Atomic physics with highly-charged ions: Studies of few-electron systems in strong electromagnetic fields

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Highly-charged ions provide an ideal test-ground for exploring few-electron systems exposed to extremely strong electromagnetic fields of heavy nuclei. In the presence of these fields, the relativistic, many-body and quantum electrodynamics (QED) effects become of paramount importance and may significantly affect not only the electronic structure but also the dynamical behaviour of heavy atomic systems. In order to probe the structural and dynamical properties of high-Z ions and, hence, to improve our understanding of atomic physics under the extreme conditions, a wide range of experimental as well as theoretical studies has been initiated worldwide during the recent years. In this contribution, a review will be presented of recent theoretical activities in the field of high-Z atomic physics. Special attention will be paid to the investigations of fundamental symmetries in which highly-charged heavy ions can play a decisive role. Moreover, the advances in the non-perturbative treatment of basic atomic processes accompanying ion-ion collisions will be presented. Here we will focus not only on the ultra-relativistic collisions but also especially on the low-energy regime for which the quasi-molecular effects may become of great importance.