Single and double ionization of He by slow antiproton impact

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Synopsis We present accurate ionization cross sections for helium by slow antiproton impact. The cross sections result from time-dependent ab initio calculations for impact energies from 1 keV to 100 keV.

The collision of antiprotons with helium atoms is a fundamental process in many-body atomic physics which long has attracted considerable interest. Due to the negative charge of the antiproton, no electron transfer can occur which facilitates the theoretical treatment of the problem.

So far, total cross sections for single and double ionization have been obtained, both experimentally and theoretically, for a wide range of impact energies from 3 keV up to a few MeV (see [1, 2] and references therein). For high impact energies theory and experiment agree very well. However, below ~ 30 keV discrepancies between different theoretical approaches and experiments emerge.

We will show the results from *ab initio* calculations in this energy range. Our approach is based on the numerical solution of the time dependent Schrödinger equation (TDSE) using the time dependent close-coupling (TDCC) method. The inter-electronic interaction is treated without approximation. The incoming antiproton is treated as a classical point-like charge and taken into account by its time-dependent Coulomb potential. The wave function is expanded in coupled spherical harmonics, and the radial part is discretized using a finite element discrete representation (FEDVR). For temporal propagation we employ the short iterative Lanczos method with adaptive time-step control. The fully correlated ground state wave function for helium is obtained via imaginary time propagation.

We will present total, integrated, single and double ionization cross sections and compare them with experimental data and other recent theoretical calculations [3]. In addition, we will show (doubly) differential cross sections (with respect to the energies of the emitted electrons). We also aim towards angle-energy differential cross sections which, so far, could not be calculated using ab initio methods. Differential cross sections are expected to be obtained in the future at the Facility for Antiproton and Ion Research (FAIR) [4] where kinematically complete measurements might be feasible.

References

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