Elastic Scattering of Electrons By Positive Ions

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A program of study has been initiated for the calculation of differential cross sections for the elastic scattering of electrons from positive atomic ions of astrophysical interest. These angular distributions are applicable in two distinct manners: directly, to model astrophysical plasmas where elastic electron-ion scattering is an important process; and indirectly, as an aid in laboratory studies of differential cross sections for excitation in electron-ion collisions [1]. At present, the Rutherford cross section is routinely used in modelling; our results show that this can be an extremely poor approximation, especially for large angle scattering.

As a first step, the differential cross section (angular distribution) for elastic electron-ion scattering has been calculated for scattering from the ground states of all ions up to Zn (Z=30) using a relatively simple, but relatively accurate, Hartree-Slater central-field potential. The principal result of this study is that the Rutherford cross section, using the asymptotic charge, can be off at the larger angles by more than three orders of magnitude! In addition, it is generally (but not always) the case that the cross section at the larger angles is larger for the partially stripped ion than for the fully stripped, by as much as more than a factor of three, which shows that the process is not governed by the Z^2 dependence characteristic of Rutherford, but rather by the details of the complex interference among the various partial waves. The accuracy of our results are confirmed by direct experiment [2] and also by indirect results obtained from high-energy ion atom collisions where "quasi-elastic" scattering has been shown to be responsible for the so-called binary peak of ejected electrons [3]. But there is only a small amount of experiment of either type, so that theory and calculation are required.

Our intentions for the future are to increase the accuracy of the calculations by using all of the methodologies developed for atomic and ionic photoionization and apply them to the simpler problem of elastic scattering. We shall also extend this work by considering excited states, particular long-lived metastable states where the results could have astrophysical consequences.

References:

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