Exploring different momentum-transfer regimes in proton-helium collisions

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Synopsis We calculated fully differential cross sections for proton-impact helium double ionization under different momentum transfer and energy regimes. By observing the relative heights of the binary, recoil and back-to-back structures we identify which mechanisms are predominant within each regime.

In this contribution we present a systematic study of fully differential cross sections (FDCS) for the double ionization of helium by proton impact: we consider different kinematic conditions going from intermediate momentum transfers up to within the impulsive regime.

We assume the projectile is fast enough as to use a first Born frame. The ionization process is then described by a first order non-homogeneous equation whose driven term depends on a given momentum transfer **q**. We use the generalized Sturmian function (GSF) method [1] to solve this three-body problem, and extract the FDCS from the asymptotic range of the calculated three-particle continuum wavefunction [2]. The proposed approach yielded satisfactory agreement with the relative experimental data [3] measured for protons impinging with 6 MeV.

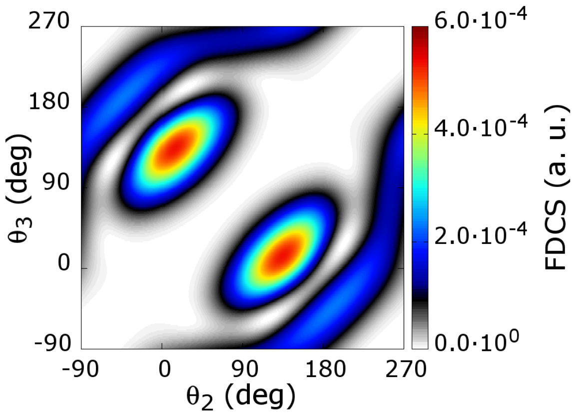

Figure 1. FDCS for $q = 0.853$ a.u. and both electrons emerging with 10 eV in coplanar geometry.

Figure 1 shows a contour plot – as a function of both emission angles θ_2 and θ_3 – of the FDCS for a moderate momentum transfer, $q = 0.853$ a.u., and an excess energy of 20 eV for equal energy sharing, i.e., for two electrons ejected with $E_2 = E_3 = 10$ eV. The overall picture is clearly far from that expected in the dipole regime: the recoil structure is completely different in shape to the binary one, and back-to-back emission is present.

Turning to the impulsive regime, $q = 3.0$ a.u. and $E_2 = E_3 = 20$ eV, the FDCS in Fig. 2 shows a picture where the dominant mechanism is by far the binary collision, with some relatively small back-to-back emission also present. This is understood as the electrons, emitted with 20 eV each, are unlikely to perform a recoil off the nucleus implying finally small relative amplitudes for recoil and back-to-back mechanisms.

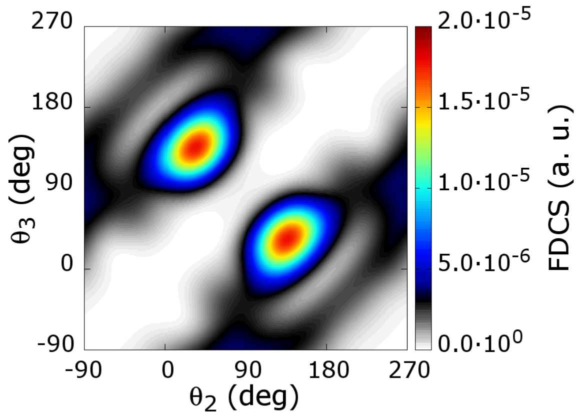

Figure 2. FDCS for $q = 3.0$ a.u. and both electrons emerging with 20 eV in coplanar geometry.

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