Laser-assisted inelastic electron scattering by excited hydrogen atoms

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Synopsis We study the *inelastic* electron-H($2s$) scattering in a linearly polarized laser field in the domain of high scattering energies and moderate field intensities. We investigate the angular distributions and the resonance structure of the differential scattering cross sections.

The purpose of this work is to study the *inelastic* scattering of fast electrons by hydrogen atoms in the metastable $2s$ state in the presence of a linearly polarized laser field. For elastic scattering the initial and final states of the target are the same, while for inelastic scattering the final state differs from the initial one. We consider the excitation of metastable hydrogen to an arbitrary state accompanied by one-photon absorption. It is important to evaluate the contribution of the laser-assisted *inelastic* electron-atom scattering to the total electron energy spectrum since in experimental studies it might be quite difficult to separate the signal of elastic and inelastic scattering channels [1].

Since the scattering process under investigation is a three-body problem, i.e., projectile, atomic target, and photon, the theoretical treatment becomes very complicated and we make several assumptions. We focus on moderate field intensities and fast projectile electrons in order to neglect the exchange scattering and the second Born approximation in the scattering potential. First, the interaction between the projectile electron and the laser field is described exactly by a Gordon-Volkov wave function. Second, the dressing of the hydrogen atom by the laser field is described within the first-order time-dependent perturbation theory in the field [2]. Finally, the interaction between the fast projectile electron and the hydrogen atom is treated in the first Born approximation [3]. Using the approach described in [4] we have obtained an *analytical formula* for the differential cross section (DCS) in the laser-assisted inelastic e-H($2s$) scattering.

We analyze the angular distributions and the resonance structure of the DCS's for the atomic excitation of the $n = 4$ subshells. In Figure 1 we show the DCS's with respect of the photon energy for one-photon absorption corresponding to the $2s \to 4s$ (short dashed line), $2s \to 4p$ (dot-dashed line), $2s \to 4d$ (long dashed line), and $2s \to 4f$ (solid line) excitation processes of H($2s$), in the scattering geometry where the laser field is linearly polarized in the same direction along the momentum of the ingoing electron. The DCS's are normalized to the laser intensity and calculated at the incident projectile energy of 500 eV and the scattering angle $\theta = 5°$.

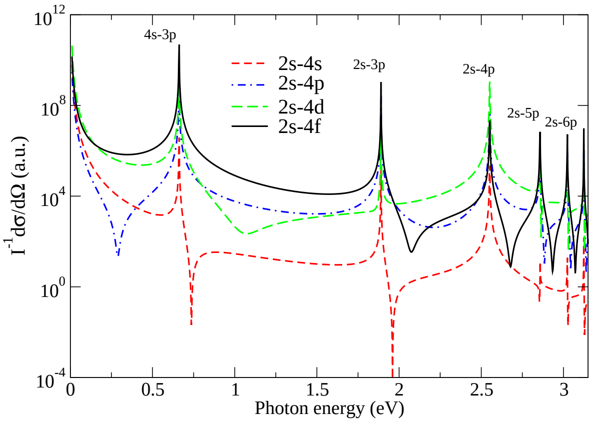

Figure 1. Differential cross sections for *inelastic* laser assisted e(E_i)+H($2s$)→ e(E_f)+H($4l$) scattering process with the excitation of the $4l$ subshells as a function of the photon energy.

Our preliminary results indicate that the laser-dressing effects are significantly stronger than for the elastic $2s \to 2s$ collision [5] (static dipole polarizability α_{2s}=120 a.u), in particular at small scattering angles. For the studied range of photon energy our analysis shows important differences from the case of laser-assisted elastic scattering, that are mainly due to the intermediate resonances in the laser-atom interaction.

References

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