CAPTURE AND IONIZATION IN LASER–ASSISTED PROTON – HYDROGEN COLLISIONS

Thomas Niederhausen and Uwe Thumm

James R. Macdonald Laboratory, Kansas State University, Manhattan, KS 66506-2604, USA

The significant modification of capture and ionization probabilities in ion – atom collisions, assisted by a strong laser field (above 10^{12} W/cm^2), has been demonstrated theoretically [1–3]. So far, however, an experimental test has not been performed, due to the difficult synchronization of a collision with a laser pulse [1, 3].

We present electron capture and ionization probabilities for ion – collisions in a strong laser field (5×10^{13} W/cm^2) by numerically solving the 3-dimensional time–dependent Schrödinger equation. This allows us to *i*) compute *ab initio* capture and ionization cross–sections, and *ii*) assess the applicability of our previous approximate (reduced dimensionality) calculation [2]. For circularly polarized laser fields and an impact energy of 1.2 keV/amu, we find a substantial modification of the electronic dynamics in the H^+–H collision system as compared to field-free collisions. In particular, we observe a strong dependence on the initial laser phase and the impact parameter for both capture and ionization, which can be explained using semi-classical arguments [3].

A significant dichroism effect appears for capture between corotating and counterrotating vectors of the internuclear axis and the laser electric field. For the special case, when laser and collision plane coincide, the dichroism (1) obtained in our *ab initio* calculation [3] is in good agreement with our reduced dimensionality results [2]. Capture becomes largest when collision and laser plane are perpendicularly oriented. Furthermore, we find evidence for charge resonant enhanced ionization [3].

Even after averaging over the laser phase, this dichroism remains for capture, while ionization does not reveal any such a helicity dependence. For total integrated capture cross–sections in co– and couterrotating collisions, σ_{cap}^{co} and $\sigma_{cap}^{counter}$, respectively, we found a relative capture dichroism of

$$\frac{\left|\sigma_{cap}^{co} - \sigma_{cap}^{counter}\right|}{\sigma_{cap}^{co} + \sigma_{cap}^{counter}} = 7.2\%. \qquad (1)$$

References

[1] T. Kirchner, Phys. Rev. A **75**, 025401 (2007).

[2] T. Niederhausen, B. Feuerstein, and U. Thumm, Phys. Rev. A **70**, 023408 (2004).

[3] T. Niederhausen and U. Thumm, Phys. Rev. A **73**, R041404 (2006).

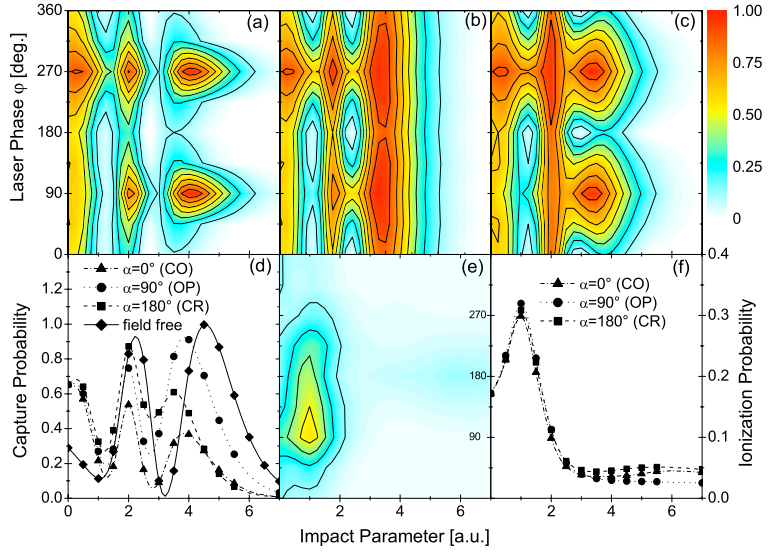

Fig. 1. Contour plots of the electron capture probability (a) - (c) and the ionization probability (e) as a function of impact parameter and laser phase for corotating (CO) (a) and (e), off-plane with $\alpha = \pm 90°$ (OP) (b), and counterrotating (CR) (c) collisions. Also shown are the phase-averaged results for capture (d) and ionization (f), together with the field-free probabilities.