Projectile dependence of the saddle point electron emission in slow collision

L. Ph. H. Schmidt*, M. Schöffler, R. Dörner†

Institut für Kernphysik, Goethe-Universität, 60438 Frankfurt am Main, Germany

We investigated the reaction $H_2^+ + He \rightarrow p + H + He^+ + e^-$ in an experiment. The correlation between electron emission pattern, the momentum transfer to the ionized target and relative momentum of the H_2^+ fragments allow for testing different models of the reaction process.

The ionization process in slow ion atom collisions can classically be described by the saddle point mechanism. Thereby the electrons are stranded between the projectile and target ion and lifted into the continuum while the nuclei depart. Around 1990 several experimental works have been done to prove the existence of the saddle point mechanism by searching for a peak of the emitted electron velocity distribution located at the velocity of the saddle. This velocity depends on the impact velocity as well as the charges of the two collision partners.

About 1995 it became clear that the classical point of view on the ionization mechanism is too simple and quantum dynamical effects can even cause a minimum where the peak was expected. Meanwhile fully differential cross sections have been measured for protons and ions of noble gases at impact velocity v_p of about 0.5 a.u. to 2 a.u. Most measurements have been done using a He target. All results show the main part of the electron emission pattern being located between projectile and target in velocity space with transversal momentum distributions much smaller than v_p. The details of the emission pattern depend on v_p as well as on the momentum exchange between projectile and target nucleus. It remained unclear which of the features of the electron emission pattern can be assigned to the nuclear charge of projectile and target or the initial charge states of the collision partners.

In order to get closer to this aspect we used 30 keV hydrogen molecular ions as projectiles and investigated the ionization of a Helium target with simultaneous dissociation of the projectile into p + H.

$$30\text{ keV } H_2^+ + He \rightarrow p + H + He + e^-$$

Using COLTRIMS all particles of the final state are measured in coincidences. The experimental setup corresponds to the one used in [1] with an additional detector for the protons. Using the axial recoil approximation as well as the refection approximation one can determine the initial internuclear vector of the H_2^+ ion [2,3]. Thereby it is possible to preselect different properties of the molecular projectiles.

The fragmentation of the molecule can either occur by electronic excitation to the $H_2^+(2s\sigma_u)$ state or by excitation of the nuclear motion of the molecule to the vibration continuum. The multifarious features of the 7-fold differential cross section support the existence of at least 3 mechanisms contributing to the reaction.

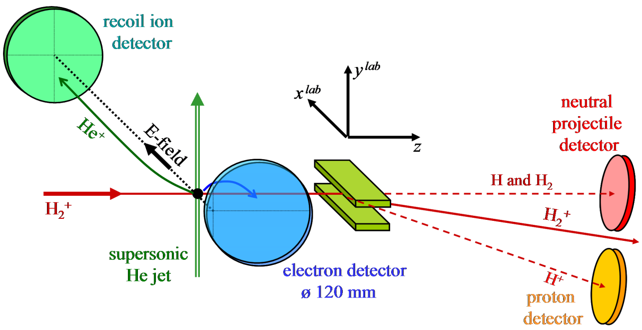

Figure 1. Sketch of the experimental setup consisting of a COLTRIMS (reaction microscope) and a spectrometer for the H_2^+ fragments.

References

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* E-mail: Lothar.Schmidt@atom.uni-frankfurt.de
† E-mail: Doerner@atom.uni-frankfurt.de