ION-ION COLLISIONS INVOLVING MOLECULAR TARGETS: ELECTRON CAPTURE FROM H_2^+ by He^{2+} AND Ar^{2+}

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We investigated electron capture in collisions of positive ions with H_2^+, the simplest molecular target. Such experiments can be carried out only through ion-ion collisions. In particular, He^{2+} - H_2^+ is a true one-electron molecular collision system, providing a more stringent test for theoretical models[1,2,3,4]. The aim of this present study is to explore whether electron capture from a molecule can be thought of as coherent capture from two isolated centers. So far, this relatively simple picture for an ion-molecule collision has been adapted and compared to H_2 targets[2,4]. Our choice of a true one-electron molecular target enables to focus on the two-center aspect only. The first step towards this goal was to determine the absolute total electron capture cross sections for the reactions

$$H_2^+ + He^{2+} \rightarrow H^+ + H^+ + He^+ \quad (1)$$
$$H_2^+ + Ar^{2+} \rightarrow H^+ + H^+ + Ar^+ \quad (2)$$

with relative velocities ranging from 0.7 a.u. to 1.3 a.u. .

The experiment has been carried out at the crossed-beam ion-ion collision facility in Giessen[5]. Both molecular and atomic ions were produced in ECR ion sources. After intersecting each other at an angle of 17.5°, both ion beams were charge-state analyzed through electrostatic analyzers. The atomic charge-exchange products were detected with a channeltron detector. The molecular fragments were detected on a position-sensitive MCP detector in order to verify the collection of the entire Coulomb-sphere of exploding H_2^{2+}. The experimental results for the H_2^+ - He^{2+} collision system are shown in fig. 1.

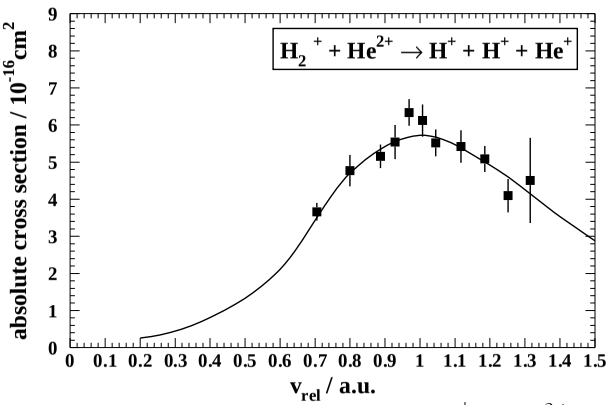

Figure 1. Total cross sections for H_2^+ + He^{2+} → H^+ + H^+ + He^+. Symbols: Experiment, Line: Theory (s. text)

We also calculated cross sections for reactions (1) and (2), following the one-electron part of a model proposed by Shingal and Lin[2]. Within this model, atomic transition amplitudes for the collision between the projectile and each one of the hydrogenlike atoms are added coherently. The atomic capture amplitudes were obtained through a close-coupling calculation for a He^{2+} (Ar^{2+}) - H(1s) (q_{eff}=1.25) collision and added coherently for two molecular centers separated by 2 a.u. , the equilibrium separation of H_2^+. One obtains the electron capture cross section for a fixed alignment of the molecule with respect to the projectile velocity. In order to compare to the data, we averaged over all molecular alignments. The comparison of the calculated TCS with the data shows very good agreement.

The next step in this study will be to extend the measurements to cross sections as a function of alignment angle in order to observe interference of the molecular centers.

This work was supported by the Chemical Sciences, Geosciences and Biosciences Division, Office of Basic Energy Sciences, Office of Science, U. S. Department of Energy, the Deutsche Forschungsgemeinschaft (DFG) and the Alexander von Humboldt fundation (H.B.).

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