A collision process responsible for widespread formation of H anions

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A collision process responsible for widespread formation of H^- anions

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Synopsis The hydride ion H^- is widely understood to play a major role in many processes important for physics, cosmology, astrophysics and chemistry. Here we report that H^- ions can be formed by collision-induced fragmentation of molecules containing hydrogen and heavier nuclei. We observed H^- emission from OH^+ + Ar and OH^+ + acetone collisions at the energy of 7 keV. Our data reveal a process of electron-grabbing by fast hydrogen fragments emitted in hard collisions with large momentum transfer between atomic cores.

The formation of negative ions in various environments has been a subject of great interest over the past decades. Even a small concentration of anions has an appreciable effect on the physical and chemical properties of their environment.

In this work we observed H^- formation in collisions of OH^+ projectiles with Ar atoms and acetone molecules (CH_3-CO-CH_3). The experiments were conducted at the 14.5 GHz ECR ion source of the ARIBE facility, at GANIL in Caen, France. The molecular OH^+ beam with incident energy of 7 keV crossed an effusive gas jet of either argon atoms or acetone molecules. Electrons and negative ions produced in the collision were measured by an electrostatic spectrometer. The spectra were taken from 2° to 150° with respect to the beam direction.

The most remarkable feature of the spectra was the appearance of well-defined peaks [1]. These structures could not be attributed to electron emission. A kinematic analysis has shown that one of the peaks is due to the emission of H^- ions moving with nearly the velocity of the OH^+ projectile ion. The other peak corresponds to H^- emission from the acetone target in direct two-body collisions with the oxygen center of the projectile. Moreover, we compared the measured cross sections with a classical two-body potential-scattering calculation.

Figure 1 shows the measured cross sections for H^- emission in OH^+ + Ar collisions. Our new data recorded at small observation angles are indicated by full symbols, while our earlier data at larger angles are shown by open circle symbols. It is a notable feature that the H^- production cross section is proportional to the calculated H + Ar elastic scattering cross section. This fact can be explained by a two step process: (*i*) A large momentum transfer collision liberates a proton. (*ii*) The receding proton grabs two electrons in a double capture process with a practically observation-angle-independent probability. The agreement of the theoretical curve with earlier experimental data for H^{2+}+Ar collisions at the same velocity supports this picture and its generalization [2]. These earlier data are shown in Fig. 1 by open square symbols. Since the process is likely in any collisions of H-containing molecules at few-keV energies, it is important for both its generality and its fundamental understanding.

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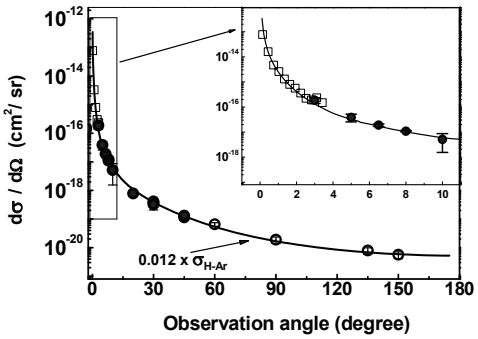

Figure 1. Measured cross sections for H^- ejection from the OH^+ projectile as a function of the observation angle for an Ar target. The curves represent 2-body elastic scattering cross sections multiplied by a factor of 0.012. Squares: data of Ref. [2] for H^{2+} impact on Ar.

References

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