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Anion and cation emission via binary-encounters in OH^+ + Ar collisions: The role of dissociative excitation and statistical aspects

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Synopsis Emission of H^- and H^+ ions via nucleus-nucleus collisions were observed in OH^+ + Ar collisions in wide angular range. They show similar angular distributions, which indicate a statistical distribution of the final charge states. Non-vanishing emission at small angles show that dissociative excitation of the projectile has a crucial role in the process.

In a previous work, we observed that H^- ions can be formed from OH^+ ions when the H center is collisionally removed from it by the target atom [1-3]. It was found that the angular distribution of the so created H^- ions is proportional to the calculated one for H scattering on the target atomic center. The question arose whether it holds for the collisionally removed H^+ ions, too. So, molecular fragmentation leading to the formation of negatively and positively charged hydrogen ions in 7-keV OH^+ + Ar collisions was investigated experimentally at the Grand Accélérateur National d'Ions Lourds (GANIL) in Caen, France [4].

We have found that negative and positive hydrogen ions are indeed emitted with very similar angular dependences, which are proportional to simple H scattering cross sections (see figure 1). Also, the kinetic energy distribution of the H^+ fragment shows strong similarities with that of the ejected H^- ion. These findings indicate that the final charge state distribution of the emitted H center does not depend on how closely the atomic centers approach each other during the collision. Rather, it seems to follow simple statistical laws.

Below 5° scattering angle, one could expect a diminishing H^- formation, since the kinetic energy transferred to the H center is not enough to release it from its parent molecular ion. However, we found a rather high emission rate in this range, too. This is possible only if the OH^+ molecular ion gets into an excited state resulting in weak molecular bound or spontaneous dissociation. The later process leads to a kinetic energy release (KER) contributing to the energy of the emitted fragments. Indeed we found that the energy of the emitted H^- and H^+ centers is somewhat larger than expected in this angular range. We performed model calculations, which demonstrate the effects of KER.

The process is of general relevance where collisions of hydrogen containing ions or molecules are involved, because it is not specific on the target or projectile species as experiments on other collision systems have already shown. The created highly reactive species H^- and H^+ are relevant in astrophysics and life sciences.

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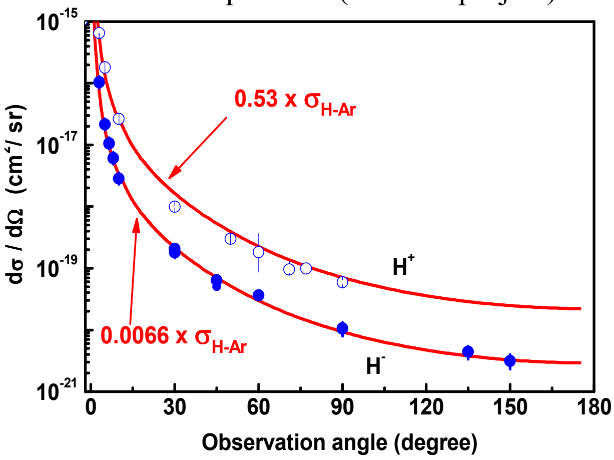

Figure 1. Single differential cross sections (SDCS) for H^- (full circles) and H^+ (open circles) emission as a function of the observation angle. Curves: calculated cross section for two-body elastic scattering of 412-eV H on Ar, multiplied by factors representing the fraction of the different charge state components.

References

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