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Two- and many-body effects in cation emission from H_2O molecules by O^+ impact at keV energies: Similarities between ionization of atoms and proton emission from molecules

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Synopsis We demonstrate that energy and angle differential emission yields of fragment ions provide valuable information about the collisions of keV energy ions and molecules. For proton fragments, originating from larger molecules, there are striking similarities to the spectra of electrons emitted in fast ion-atom collisions.

The rich structure of the spectra of ejected electrons in fast ion-atom collision experiments provides deep insight into the details of the ionization process [1]. The key for clarity there is the large proton/electron mass ratio. Electrons move in the fields of much heavier centers.

Here we demonstrate that double differential emission yields of fragment ions provide similarly valuable information in ion-molecule collisions at keV energies. For protons emitted from heavier molecules, due to the large mass ratio, there are close similarities to ionization.

Figure 1 shows experimental double-differential cross sections (DDCS) for cation emission in 6.6-keV $^{16}O^+ + H_2O$ collisions. The experimental arrangement was identical with that of ref. [5]. The main component of each spectrum is a broad, slowly decreasing structure. There the relative contributions of H^+ and heavier fragments were derived from complementary time-of-flight measurements. The low energy part is mostly due to many-body processes with small momentum transfer, in analogy with the dipole-ionization dominated low energy electron emission in fast ion-atom collisions [1]. At forward angles (< 90°) pronounced peaks are observed at higher energies. These peaks are due to the different cations formed in hard binary collisions [2-5], similarly to electron emission. We note that the heavier oxygen ions are mostly recoils, appearing in the binary ridge, while proton emission is dominated by many-body effects, and it is almost isotropic at low energies. One should keep in mind that highly charged ion impact is somewhat different. There multiple charge-exchange processes, followed by Coulomb explosion, dominate the fragment ion spectra at low energies.

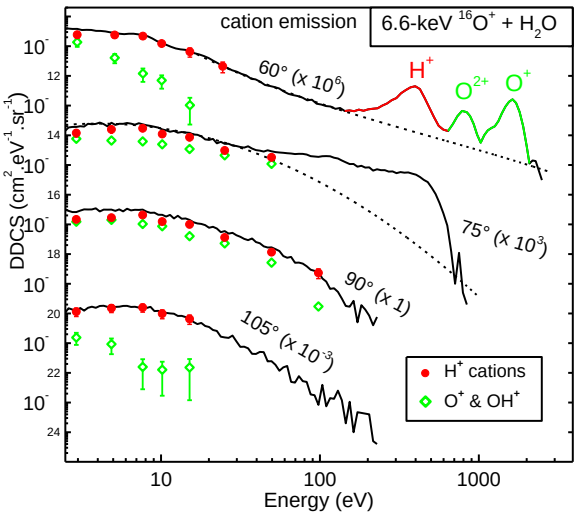

Figure 1. Full curves: Experimental DDCS for cation emission at various angles in 6.6-keV $^{16}O^+ + H_2O$ collisions; Full circles: H^+ contribution from TOF measurements. Open diamonds: O^+ and OH^+ contributions from TOF; Each spectrum is multiplied by the indicated factor.

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