ESD2011: Absolute photon-induced cross-sections for electron detachment and fragmentation of Al_4^- cluster

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We recently reported on a systematic study of the competition of delayed electron detachment and delayed monomer fragmentation of photo-excited Al_4^- cluster using a bent electrostatic ion beam trap (EIBT) [1,2], which allowed for a simultaneous measurement of both decay channels. Hot Al cluster anions were produced in a sputter source and allowed to cool down by storing them for at least 100 ms prior to their excitation by a short laser pulse. Delayed electron detachment and fragmentation was observed for photon energies between 1.55 eV and 2.25 eV, and decay spectra as well as time integrated relative cross sections were determined as a function of photon energy and storage time. The results show the characteristic pattern expected for a purely statistical decay of the photo-excited Al_4^- cluster.

In the present study we determined the absolute total (prompt and delayed) photo-destruction cross section of the Al_4^- clusters as well as the total branching ratio between monomer fragmentation and electron detachment as a function of the photon energy between 1.5 eV and 2.7 eV. The absolute destruction cross section σ_{tot} was measured by depletion (see e.g. [3]): the cluster ions stored in the linear trap configuration were overlapped with the pulsed laser beam and the ratio between the surviving and originally stored ions was determined as a function of the laser pulse power by emptying the trap alternatively before and after the laser pulse, using the deflector introduced into the bent EIBT [1] to guide the ions towards a fast detector. The absolute cross section σ_f for monomer fragmentation was determined by deflecting the resulting Al_3^- products towards the fast detector and analyzing their ratio with respect to the total number of depleted clusters. All other fragmentation channels were found to be negligibly small, in agreement with our previous findings [4].

As observed already earlier for the delayed emission [2], the fragmentation cross section σ_f is dominating the destruction cross section at small photon energies; at higher energies σ_f reaches a maximum at ~2.1 eV and drops down to zero at ~2.4 eV. The total electron detachment cross section $\sigma_e=\sigma_{tot}-\sigma_f$ starts to dominate for photon energies above ~2.2 eV and is likely governed by prompt detachment processes as delayed electron emission was found to be small for higher photon energies [2]. The detachment cross section is steadily increasing with increasing photon energy and exhibits two steps at ~2.2 eV and ~2.45 eV, which correspond approximately to the energies of the double structure observed in photoemission spectroscopy (PES) of Al_4^- published by Li *et al.* [5]. It will be discussed that the measurement of the photon energy dependence of the electron detachment cross sections may provide an alternative access to the valence electron energies in clusters with the prospect of an increased energy resolution.

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References

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