Electron-Collision Induced Interatomic Coulombic Decay in Argon Clusters: from Dimers to Trimers

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Synopsis We study the interatomic relaxation processes in argon trimers (Ar_3) induced by electron ionization and subsequent dissociation into $Ar^+ + Ar_2^+$. The experiment was performed with the multiple particles coincidence (electrons and ions) method using a reaction microscope in which the kinetic energies of final state electrons and ions are determined. Two peaks are observed in the kinetic energy release (KER) of the two fragment ions. The relaxation processes taking place at the different KER regions are identified by the measurements of the coincident scattered and ejected electron spectra.

In weakly bond systems, e.g. in the Ar clusters, due to the presence of the neighboring atoms new autoionization channels as Interatomic Coulombic Decay (ICD) can be opened. Here internal excess energy is transferred to a neighbor ionizing it and resulting in a low-energy electron and a pair of energetic ions. After its first prediction in 1997 by Cederbaum and co-workers [1], ICD soon led to a strong interest due to its important roles in various reactions of radiation biology and chemistry [2]. Importantly, ICD becomes more efficient the more neighbors the system has. I.e., ICD is particularly relevant for systems embedded in an environment where several neighbors are naturally present [3].

In the present work, we study ICD in Ar dimers (Ar_2) and trimers (Ar_3) induced by electron-impact ionization using a reaction microscope [4, 5] in which the kinetic energies of final state electrons and ions are measured in coincidence. Thereby, the kinetic energy release (KER) spectra for the fragment ions and the scattered and ejected electron energy spectra can be obtained in our experiment. The measured KER spectra are presented in Fig. 1 for the trimer dissociating into $Ar^+ + Ar_2^+$ and for the $Ar^+ + Ar^+$ dissociation channel due to ICD in Ar dimer [5]. The internuclear distance at which the two ions are dissociated can be deduced from the measured KER. The Ar dimer KER spectrum shows two peaks at 3.8 and 5.2 eV which is in good agreement with theoretical predictions [6]. The KER peak at 3.8 eV is a contribution of a fast ICD channel which occurs at the equilibrium internuclear distance of Ar dimer (3.8 Å). The KER peak at 5.2 eV corresponds to the decay at the shorter internuclear distance (2.8 Å) which is attributed to a slow ICD channel as described in [6] and another relaxation process named radiative charge transfer (RCT) in which one atom is doubly ionized, and an electron is transferred from a neighbor atom to the doubly charged Ar^{2+} ion and emitting a photon. The KER spectrum for trimers shows a dominant peak at 3.65 eV and a less pronounced side peak at smaller KER ($\approx$ 2.3 eV). This peak indicates decay reactions at large internuclear distances. The relaxation mechanisms in Ar trimer will be discussed using the projectile energy loss spectra and the ejected low-energy electron spectra at the different KER regions. Detailed results will be presented at the conference.

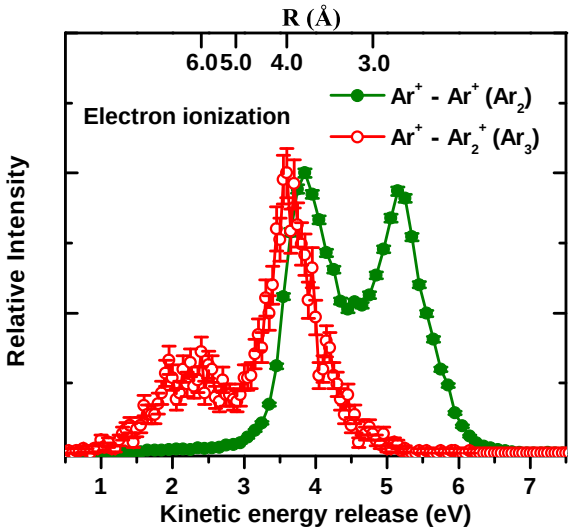

Figure 1. KER spectra for the fragmentation channels of $Ar^+ - Ar^+$ and $Ar^+ - Ar_2^+$ from electron-collision induced ICD in Argon dimer and trimer, respectively.

References

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