Electron Transfer to Ground-state Ions in Loosely-bound Systems Producing Slow Electrons

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Synopsis We present experimental evidence for a so-far unobserved, but potentially imperative step relaxation cascades following inner-shell ionization of a composite system: Multiply charged ionic states created after Auger decay may be neutralized by electron transfer from a neighboring species, producing at the same time a low-energy free electron. This electron transfer mediated decay (ETMD) called process is effective even after Auger decay into the dicationic ground state. Here, we show the ETMD of Ne^{2+} produced after Ne 1s photoionization in Ne-Kr mixed clusters.

When X-rays irradiate atoms or molecules, an inner-shell electron is ejected, followed by an emission of an Auger electron producing a dication[1]. If other atoms or molecules surround the dication, one of the neighbors may donate an electron to the dication and releases energy, which can be transferred at the same time to ionize another neighbor. This process is called electron transfer mediated decay (ETMD)[2]. It has been considered as an inefficient decay channel since it could not compete with other decay processes[3].

Recently, however, Stumpf *et al. (2013)* predicted that the ETMD provides an efficient neutralization pathway for the majority of ions produced by Auger decay in $NeKr_2$ trimer[4]. In this study, we report the experimental identification for that process using Ne-Kr mixed clusters[5].

The experiment was carried out at beamline BL17SU in SPring-8 synchrotron facility. The photon energies were set to 878 eV and 888 eV, corresponding 8 eV and 18 eV above Ne 1s ionization threshold of 870 eV. A COLTRIMS Reaction Microscope was used to image the electron and ion momentum vector in coincidence originating from same cluster[6] [6].

The following formula shows the relaxation cascade of $NeKr_2$ trimer triggered by Ne 1s ionization and terminating by ETMD:

$$\begin{aligned} NeKr_2 + h\nu &\rightarrow Ne^+(1s^{-1})Kr_2 + e_{\text{photo}} \\ Ne^+(1s^{-1})Kr_2 &\rightarrow Ne^{2+}Kr_2 + e_{\text{Auger}} \\ Ne^{2+}Kr_2 &\rightarrow Ne^+Kr^+Kr^+ + e_{\text{ETMD}} \\ Ne^+Kr^+Kr^+ &\rightarrow Ne^+ + Kr^+ + Kr^+ . \end{aligned}$$

We expect the production of three singly charged ions i.e. one Ne^+ and two Kr^+ ions in this experimental condition. To search for the process, we have selected only the events in which we detected these three ions, and identified the photo- and the ETMD electrons from electron spectra in coincidence with the events. The relative intensity of the ETMD electrons is ~70 % of that of the photoelectrons. This index implies that when a Ne 1s photoionization event occurs, almost always a slow electron is emitted from the cluster.

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