Evidence for Efficient Pathway to Produce Slow Electrons by Ground-state Dication in Clusters

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Synopsis We present an experimental evidence for a so-far unobserved, but potentially very important 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 report the ETMD of Ne^{2+} produced after Ne 1s photoionization in Ne–Kr mixed clusters.

When atoms or molecules are irradiated by X-rays, an inner-shell electron is ejected, followed by an emission of an Auger electron producing a dication [1]. If the dication is surrounded by other atoms or molecules, one of the neighbors may donate an electron to the dication and releases energy, which can be transferred to ionize at the same time another neighbor. This process is called electron transfer-mediated decay (ETMD) [2]. It was considered as an inefficient decay channel since it could not compete with other decay processes [3]. In 2013 however, Stumpf *et al.* predicted that the ETMD provides an efficient neutralization pathway for the majority of ions produced by Auger decay in NeKrKr 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. A COLTRIMS Reaction Microscope was used to image the electron and ion momentum vector in coincidence originating from same cluster [6].

The relaxation cascade triggered by Ne 1s ionization and terminating by ETMD can be written as:

$$\mathrm{NeKrKr} + h\nu \rightarrow \mathrm{Ne^{+}}(1s^{-1})\mathrm{KrKr} + e_{\mathrm{photo}}$$
$$\mathrm{Ne^{+}}(1s^{-1})\mathrm{KrKr} \rightarrow \mathrm{Ne^{2+}KrKr} + e_{\mathrm{Auger}}$$
$$\mathrm{Ne^{2+}KrKr} \rightarrow \mathrm{Ne^{+}Kr^{+}Kr^{+}} + e_{\mathrm{ETMD}}$$

One Ne^{+} and two Kr^{+} ions are produced by this process. We have selected only the events in which we detected these 3 ions, 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 implies that when a Ne 1s photoionization event occurs, almost always a slow electron is emitted from the cluster.

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References

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