Asymmetric electron capture in HCI collisions with rare gas dimers

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Asymmetric electron capture in HCI collisions with rare gas dimers

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Synopsis Low-energy collisions between different rare gas dimers (Ar_2, Ne_2) and different projectiles (O^{3+}, Ar^{9+}, Xe^{20+}) show that the weight of the different fragmentation processes, Coulomb explosion and Radiative Charge Transfer, strongly depends on the projectile charge state. This result is understood in term of impact parameter from which the electrons are captured on the projectile.

In a previous paper concerning ionic fragmentation of Ar dimers induced by electron-capture collision, we have shown that, due to reduced electron mobility across the dimer, the fragment ions preserve information of the electron removal location [1, 2]. Usually, such information is lost for covalent molecules, where the electrons freely move from one atom to the other, thus building the binding covalent bond. We report on fragmentation of different rare gas dimers (Ar_2 and Ne_2) multiply ionized by collisions with projectiles of different charge state (O^{3+}, Ar^{9+} and Xe^{20+} ions) at an energy of 15 qkeV. The experiments were performed on the ARIBE beam line at the GANIL facility (Caen, France) using a COLTRIMS setup. The fragment ions from doubly to quadruply ionized dimers and the scattered projectile ions were detected in coincidence. The different fragmentation channels, the branching ratios as well as the kinetic energy release (KER) distributions were determined. This kinematically complete experiment allows the orientation of the dimer with respect to the projectile beam to be analyzed.

For all the projectile charge states, the KER spectra for double ionization of Ar_2 and Ne_2 followed by ionic fragmentation always show two peaks: one assigned to Coulomb explosion (CE) and the other to Radiative Charge Transfer (RCT) processes respectively. It has been observed that the RCT process is systematically reduced as the projectile charge state increases (Fig. 1). These results are readily understandable in the view of the classical-over-barrier model. The higher charge state projectiles capture electrons from the target at larger impact parameters, thus the preference in electron captures from one site, which is associated to RCT process, fades out. The correlation between the projectile scattering angle and target orientation was derived for the asymmetric channels. The results show that the projectile is preferentially scattered in the same direction as the fragment with the higher charge state. Namely, the projectiles capture more electrons from the nearest site and then fragmentation occurs while keeping the primary dimer orientation. This scenario is again consistent with the semi-classical picture.

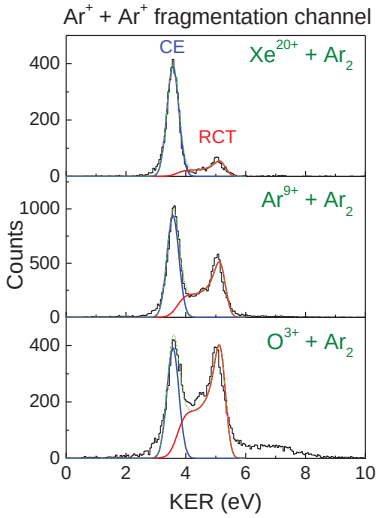

Figure 1. Kinetic Energy Release Distribution for the (Ar^+ + Ar^+) fragmentation channel obtained with different projectile charge states. CE: Coulomb explosion process. RCT: Radiative Charge Transfer process.

References

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