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Fragmentation of He and Ne dimers by swift heavy ions

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All atoms and molecules can – even in their ground state – form clusters, weakly bound molecules, held together by the van der Waals force. The smallest if this type is the dimmer, composed of two atoms/molecules. While the Ne dimer is a representative for rare gas dimers in general, the He dimer is a quite exotic object, with a broad internuclear distribution, stretching up to several 100 a. u. Here we investigated the ionization and fragmentation dynamics of He2 and Ne2 induced by ion impact (11.4 MeV/u, S14+). We employ the technique of COLTRIMS reaction microscopes to determine the momenta of all fragments in coincidence. Thereby different pathways are accessible depending on how the electrons have been removed from the atomic sites. The two dominant mechanisms are:

1.) The direct mechanism: Here the projectile ionizes each of the two atoms individually. The dimer's constituents have ionization properties similar to those of a single atom, completely different than what is known for a covalent bound molecule. The ionization dynamics strongly varies with the impact parameter b. But its measurement is rather difficult, if possible at all. Especially for large b, which dominate ionization, are believed not resolvable. Here the nuclear scattering is smaller than the typically exchanged momentum with the electron. Leading to ambiguities, the impact parameter is inaccessible through any momentum transfer measurement between the nuclei. Here we show that the large internuclear distance of rare gas dimers opens a new way to this puzzling question. Focusing on the two electron release, the impact parameter dependent ionization probability P(b) leads to a maximum angle between the molecular axis and the ion beam. Further tilts result in the ionization of only one atom.

2.) In some cases, an ionized atom stays electronically excited. This energy is efficiently release via the Interatomic Coulombic decay (ICD). Predicted in 1997 and in photoionization experiments observed in 2004, ICD is an extermely efficient source for the production of low energetic electrons. It probably plays a significant role for radiation damage in living tissue and for ion radiation therapy.

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