Time-resolved measurement of Interatomic Coulombic Decay in small helium clusters

M. Kircher[*1], F. Trinter[*], M. Weller[*], J. B. Williams[†], N. Sisourat[‡], S. Kazandjian[‡], M. Waitz[*], C. Goihl[*], A. Hartung[*], H. Sann[*], A. Schottelius[*], G. Kastirke[*], M. Pitzer[§], D. You[¶], T. Deselaers[*], Y. Herrmann[*], M. Tia[*], M. Schöffler[*], R. Dörner[*], T. Jahnke[*2]

[*] Institut für Kernphysik, Goethe-Universität, D-60438 Frankfurt am Main, Germany
[†] Department of Physics, University of Nevada, Reno, NV 89557, USA
[‡] Sorbonne Université. UPMC University Paris 06, CNRS, Laboratoire de Chimie Physique Matière et Rayonnement, F-75005 Paris, France
[§] Experimental Physics IV, University of Kassel, D-3413 Kassel, Germany
[¶] Institute of Multidisciplinary Research for Advanced Materials, Tohoku Univ. (IMRAM), Sendai 980-8577, Japan

Synopsis Interatomic Coulombic Decay (ICD) in small helium clusters has been investigated in a time-resolved measurement using synchrotron radiation. The results are compared to a time-resolved measurement on ICD in He_2.

In 1997 a new decay mechanism for atoms was postulated by Cederbaum *et al.* [1] and its existence proven later experimentally [2, 3, 4]. During the last decade its properties were investigated in numerous experiments. The decay mechanism – so called "Interatomic Coulombic Decay" (ICD) – is dependent on the chemical environment of the electronically excited state in which the atoms or molecules exist. The atoms or molecules transfer their excitation energy to a neighboring particle which is then usually ionized. ICD is a rather common decay route in nature as it occurs in many van der Waals and hydrogen bound systems. The time evolution of ICD is expected to be rather complex as it depends strongly on the internuclear distances of the participating particles.

Here we present a measurement of the time evolution of ICD in small helium clusters using the same method as a preceding experiment on He_2 by Trinter *et al.* [5]. Helium clusters of size N were ionized and excited with photons of an energy of 65.505 eV (150 meV above the $He^{+*}(n = 2)$ threshold) using synchrotron radiation. The populated intermediate state He^{+*}-He_{N-1} undergoes ICD resulting in the doubly ionized He_N^{2+}-state which breaks up in a Coulomb explosion. The photoelectron is detected in coincidence with the two He-ions using a COLTRIMS setup. Due to Post Collision Interaction (PCI) the measured energy of the photoelectron is dependent on the decay time. By measuring the photoelectron energy we are able to gain insight about IC-decay times.

Figure 1 shows the energy of the photoelectron plotted versus the Kinetic Energy Release (KER) of the two He^+-ions for helium dimers, measured by Trinter *et al.*, and for small helium clusters. In atomic units, the KER equals the inverse of the internuclear distance of the two He^+-nuclei. The photoelectron energies are translated to decay times, shown on the right axis of the graphs, respectivly. These plots show that the overall structure is independent of the clustersize, although in the case of small clusters, for short decay times fewer events occur with low KER (large internuclear distance) and more events occur with high KER (small internuclear distance).

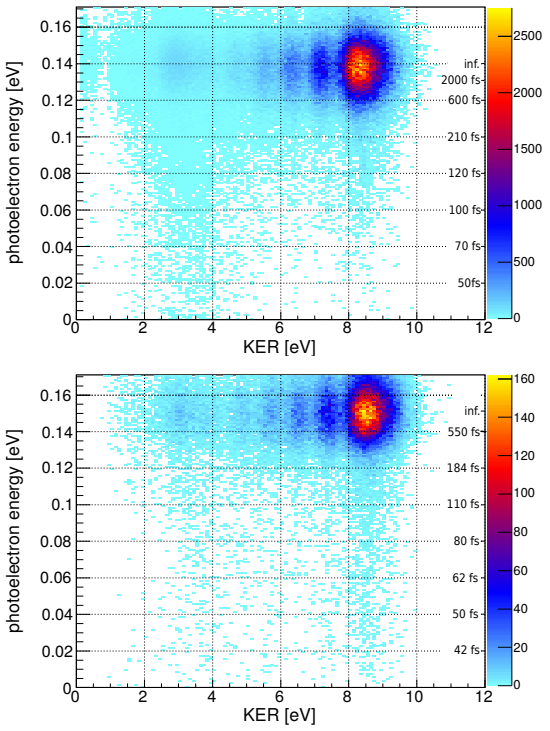

Figure 1. Photoelectron energy vs. KER for He_2 (top panel, measurement by Trinter *et al.*) and $He_{3...5}$ (bottom panel).

References

[1] L. S. Cederbaum *et al.* 1997 *Phys. Rev. Lett.* **79** 4778
[2] S. Marburger *et al.* 2003 *Phys. Rev. Lett.* **90** 203401
[3] T. Jahnke *et al.* 2004 *Phys. Rev. Lett.* **93** 163401
[4] G. Öhrwall *et al.* 2004 *Phys. Rev. Lett.* **93** 173401
[5] F. Trinter *et al.* 2013 *Phys. Rev. Lett.* **111** 093401

[1] E-mail: kircher@atom.uni-frankfurt.de
[2] E-mail: jahnke@atom.uni-frankfurt.de