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### Intracluster Coulombic decay following intense NIR ionization of clusters

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Synopsis We report on the observation of a novel intracluster Coulombic decay process following Rydberg atom formation in clusters ionized by intense near-infrared fields. A new decay channel emerges, in which a Rydberg atom relaxes to the ground state by transferring its excess energy to a weakly bound electron in the environment that is emitted from the cluster. We find evidence for this process in the electron spectra, where a peak close to the corresponding atomic ionization potential is observed. For Ar clusters, a decay time of 87 ps is measured, which is significantly longer than in previous time-resolved studies of interatomic Coulombic decay.

When an excited atom or molecule is located in an environment, novel decay channels can emerge that are absent for isolated particles. Relaxation of the excited species can take place by a transfer of its excess energy to an atom or molecule in the environment that gets ionized, a process known as interatomic (intermolecular) Coulombic decay [1]. Thus far, the observations of such energy transfer mechanisms have been limited to dimers [2] and clusters [3] ionized by extreme-ultraviolet (XUV) pulses.

Here we present highly surprising results on a novel intracluster Coulombic decay (ICD) process that is of universal nature, as it is not restricted to a certain system or wavelength regime. In the experiment, we observe ICD following electron-ion recombination and extensive Rydberg atom formation in clusters interacting with intense near-infrared (NIR) laser pulses [4, 5]. When a highly excited Rydberg atom decays by transferring its excess energy to a second Rydberg atom in the environment [6], an electron is emitted whose initial kinetic energy is close to the atomic ionization potential. In Fig. 1, an electron spectrum from Ar clusters ionized by intense NIR pulses shows evidence for this process, where in addition to a thermal distribution, a peak is visible just below the ionization potential of Ar that can clearly be attributed to ICD. The novel ICD mechanism was observed in all systems under investigation, including Ar, Kr, Xe,  $O_2$  and  $CH_4$ clusters. We have further measured the decay time of the ICD contribution as 87 ps [7], which is significantly longer than the decay time of 150 fs recently reported for ICD in Ne dimers ionized by XUV pulses [8].

be important in a large variety of systems, including biomolecules interacting with intense X-ray pulses. The novel findings offer unprecedented opportunities in the future for an improved investigation of correlated electronic decay processes.



Figure 1. Electron kinetic energy spectrum from Ar clusters with an average size of  $\langle N \rangle = 1000$ atoms ionized by NIR pulses at an intensity of  $9 \times 10^{13}$  W/cm<sup>2</sup>. The peak just below the ionization potential of Ar (15.76 eV) is attributed to ICD between two Rydberg atoms (see inset). The gray area represents thermal electron emission. References

- [1] L. S. Cederbaum et al 1997 Phys. Rev. Lett. **79** 4778
- [2] T. Jahnke et al 2004 Phys. Rev. Lett. 93 163401
- [3] S. Marburger et al 2003 Phys. Rev. Lett. 90 203401
- [4] B. Schütte et al 2014 Phys. Rev. Lett. 112 073003
- [5] B. Schütte et al 2014 Phys. Rev. Lett. **112** 253401
- [6] A. I. Kuleff et al 2010 Phys. Rev. Lett. 105 043004
- [7] B. Schütte et al submitted
- [8] K. Schnorr et al 2013 Phys. Rev. Lett. 111 093402

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Intracluster Coulombic decay is expected to

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