2 for the price of 1: how double ionization becomes an efficient process

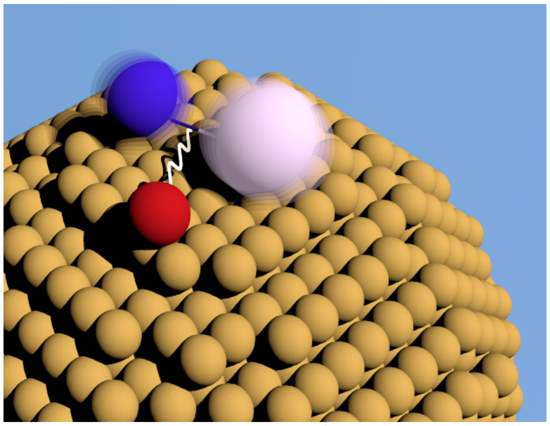

Fig. 1 Schematic of dICD

Double ionization is a unique mechanism where two electrons are simultaneously emitted from an atom or molecule. Typically, it's a very weak process occurring only a few percent of the time compared to single ionization where only one electron is emitted. This is due to double ionization requiring the correlated action of two electrons hit by an energetic photon or particle. However, in a recent experiment, is has been shown that double ionization doesn't necessarily need to be a minor effect and can even be the primary ionization mechanism [https://www.nature.com/articles/s41567-018-0376-5].

The enhancement is likely due to double ionization proceeding through a new type of energy transfer process termed double intermolecular Coulombic decay, or dICD, for short. To experimentally observe this mechanism, dimers consisting of two alkali metal atoms were attached to the surface of helium nanodroplets. The dICD process, schematically shown in Fig. 1, occurs through an electronically excited helium atom (red), produced by synchrotron radiation, interacting with the neighboring alkali dimer (blue and white) resulting in energy transfer and double ionization. To distinguish dICD from other processes, the kinetic energies of the emitted electrons were measured in coincidence with their alkali ion counterparts. Shown in Fig. 2 are the resulting kinetic energy distributions for different alkali dimers where the dICD electrons are observed at lower kinetic energies than the electron from single ionization, labeled ICD. Although an alkali dimer attached to a He nanodroplet is a model case, dICD is potentially relevant for any system where it is energetically allowed.

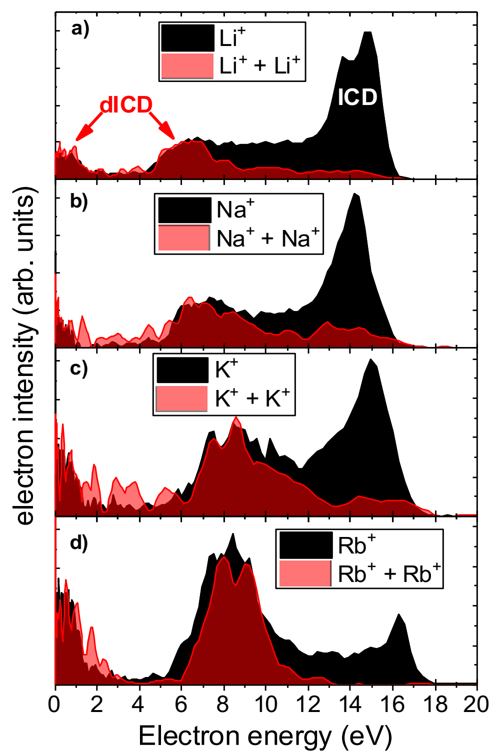

Fig. 2 Electron kinetic energy distributions from alkali dimers

dICD belongs to a special class of decay mechanisms where energy is exchanged between neighboring atoms or molecules leading to enhanced ionization rates. Seemingly ubiquitous in weakly-bound, condensed phase systems such as van der Waals clusters or hydrogen-bonded networks like water, these processes can contribute to radiation damage of biological systems by producing particularly harmful low-energy electrons. dICD could strongly enhance such effects through the production of two electrons for each decay.

The experiments were performed by an international group of researchers at the synchrotron, Elettra, in Trieste, Italy. There, electrons are accelerated to near the speed of light and then rapidly undulate through an alternating magnet field. In this way, the electrons emit short wavelength light which is needed to trigger dICD.

Reference: A. C. LaForge, M. Shcherbinin, F. Stienkemeier, R. Richter, R. Moshammer, T. Pfeifer & M. Mudrich, "Highly efficient double ionization of mixed alkali dimers by intermolecular Coulombic decay", Nature Physics (2019) DOI: 10.1038/s41567-018-0376-5