When Nano-Bubbles Collide:

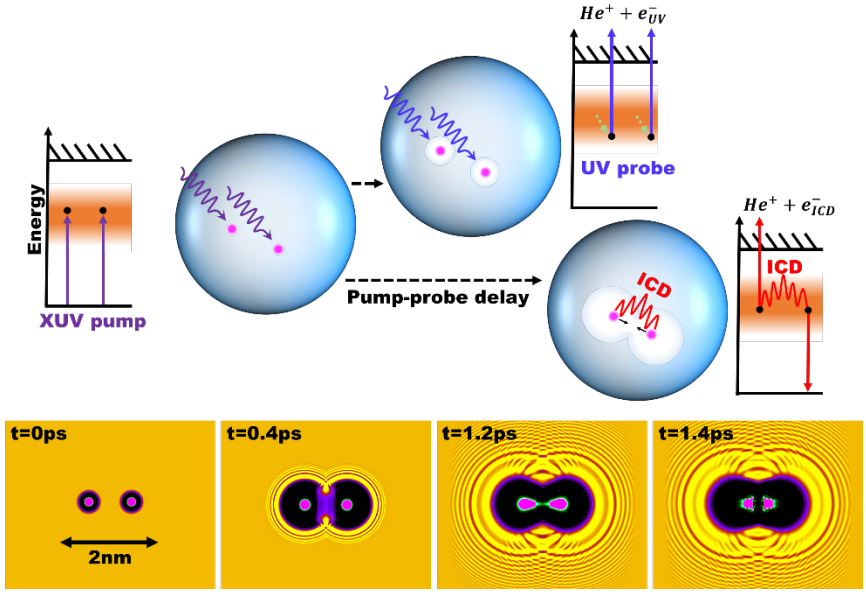
How attraction between bubbles can enhance intermolecular decay

TEASER:

Bubbles in helium droplets form around excited atoms and greatly accelerate interatomic Coulombic decay, showing how environment enhances this biologically relevant energy-sharing process among atoms and molecules.

SUMMARY:

When a free atom or molecule is excited by an energetic photon, the only means to release its energy is through internal decay or radiation emission. In contrast, when atoms or molecules are weakly bound to one another, the excitation energy from one site can be transferred to a neighboring one. A particularly interesting energy-sharing process is interatomic Coulombic decay (ICD), in which the release of energy from one atom or molecule leads to ionization of a neighbor. This process plays an important role in the response of biological tissue to radiation. Here, we show that ICD is dramatically enhanced by the response of the medium surrounding the excitations.



In many condensed systems, such as fluids and small droplets, not only do the interacting atoms and molecules matter, but the local environment can also strongly influence the interatomic decay process. To study this influence, we use ultrashort, extreme-UV laser pulses to directly map ICD of laser-excited superfluid helium nanodroplets over time. State-of-the-art theoretical modeling of the process reveals that a localized bubble, or cavity, forms around each excited atom. Neighboring bubbles then merge into one, thereby pushing the excited atoms together. This causes the atoms to decay by ICD within a few hundred femtoseconds, which is orders of magnitude faster than previously expected.

Similar processes are likely to occur in other fluids such as water, where the formation of nano-bubbles plays a role in the solvation of electrons and the unfolding and aggregation of proteins. Our results demonstrate the importance of bubble dynamics in interatomic decay processes and open up a new approach for understanding the basic processes causing radiation damage in biological systems.