# Photoelectron dynamics in alkali-doped He nanodroplets and nanoplasmas - correlated and collective processes

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In the paradigmatic quantum fluid clusters, He nanodroplets, we probed the correlated dynamics of electrons when they are doped with alkali atoms following extreme ultraviolet photoexcitation [1]. Quite remarkably, in this two-component system when He is either photo-excited or -ionized directly, the system undergoes a cascade of interatomic Coulombic decay (ICD) steps as it relaxes and fragments [2]. Electron-ion-ion coincidence spectroscopy reveals intriguing ICD pathways for very efficient the multiple ionization of the doped alkali cluster involving their inner-valence ionization.

Secondly, when these alkali doped clusters are subjected to intense near-IR femtosecond pulses leading to massive ionization of a nanodroplet into a nanoplasma, collective electron-ion dynamics dominates the progression of this system. The evolution of this nanoplasma involves dynamics from the femto- to nano-second timescales. Through single-shot coherent diffraction imaging enabled by x-ray free-electron lasers, here FLASH at Hamburg, in combination with photoelectron imaging, our work reveals contrasting expansion dynamics for the surface-resident alkali atoms in contrast to rare-gas dopants which reside in the droplet interior.

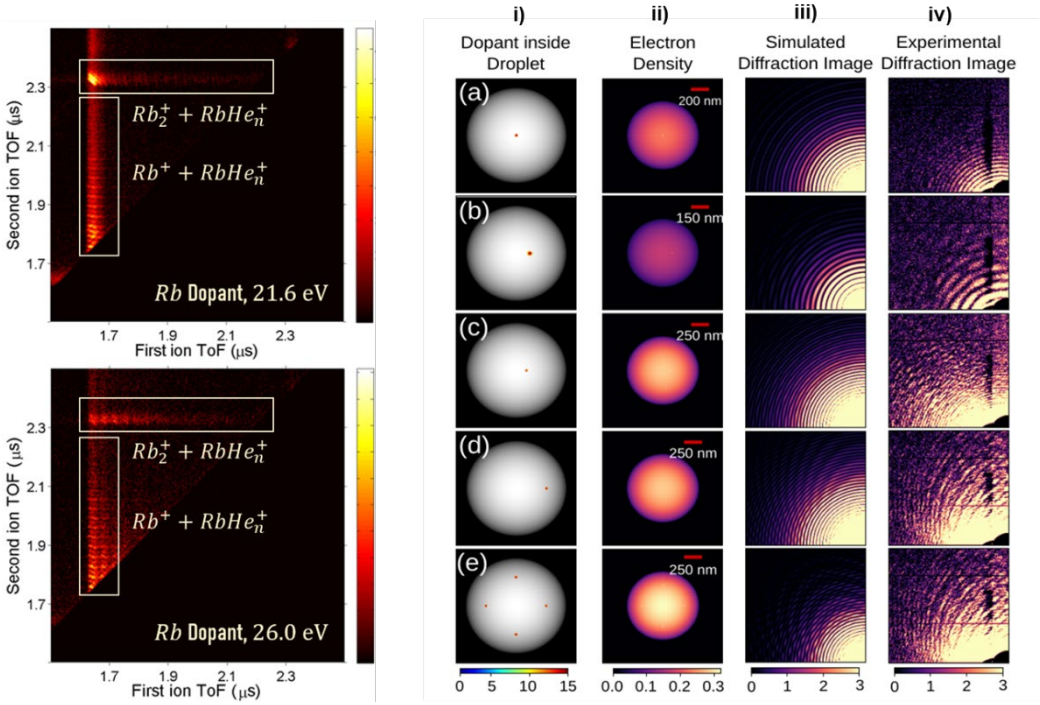


Figure 1: (*left* panel) Ion-ion time-of-flight coincidence maps displaying the correlated double ionization of dopant alkali, here Rb, photoions results from correlated interatomic Coulombic decay cascade when hosted on He nanodroplets. (*right* panel) A series of experimentally observed coherent diffractive imaging images, column iv) alongside the

corresponding simulated image, column iii), originating by considering the geometry shown in column i) of the dopant Xe cluster (red dot) positions in a He nanodroplet (grey sphere); the electron density map of each configuration in column i) is depicted in column ii).

References

[1] LaForge, A. C., et al. *Nature Physics* 15.3 (2019): 247-250.
[2] S. Mandal et al., under preparation.
[3] B. Langbehn *New Journal of Physics* 24.11 (2022): 113043.
[4] K. Sishodia et al., under preparation.