# Multiple excitation ICD in neon dimers and clusters

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**Synopsis** We investigated interatomic Coulombic decay (ICD) processes in multiply excited neon (Ne) dimers and clusters by using seeded intense extreme ultraviolet free-electron laser (XUV FEL) FERMI. Doubly excited neon dimers $[Ne^*(2p^{-1}3s)]_2$ undergo ICD and produces $Ne_2^+$ as dominant product. Measuring the yield of $Ne_2^+$ as a function of delay between the XUV pump and UV probe pulses, we extracted lifetime of the ICD process as 390 (-130/+450) fs.

Extreme ultraviolet free-electron lasers (XUV FELs) breaks new ground of atomic and molecular physics. Italian XUV FEL facility FERMI generates fully coherent, intense XUV laser pulses with the precise tunability and narrow bandwidth. We investigated interatomic Coulombic decay (ICD) processes in multiply excited neon (Ne) dimers and clusters [1,2].

ICD is a relaxation process of electronically excited atoms in the environment [3]. These excited atoms can relax non-radiatively by transferring their energy to neighboring species which release the energy by emitting an electron. Recently, a new ICD process induced by two-photon double excitation in Ne dimer ($Ne_2$) was proposed [4]. First, each 2*p* electron of both Ne atoms in $Ne_2$ is promoted to the 3*s* orbitals

$$Ne_2 + 2\hbar\omega_{XUV} \rightarrow [Ne^*(2p^{-1}3s)]_2, \quad (1)$$

which is then followed by the ICD transition

$$[Ne^*(2p^{-1}3s)]_2 \rightarrow Ne^+(2p^{-1})Ne + e_{ICD}^-. \quad (2)$$

In this study we tried to observe the ICD process (eq. 2) in doubly excited $Ne_2$ [1]. To produce doubly excited state of $Ne_2$, an intense and narrow band width photon beam with the photon energy of ~16 eV is required.

We carried out the two-photon double excitation of $Ne_2$ (eq. 1) and time-resolved measurement of this ICD process (eq. 2) by the XUV FEL pump-UV laser probe technique. The delayed UV pulse ionizes a 3*s* electron of one of the excited Ne atoms

$$[Ne^*(2p^{-1}3s)]_2 + \hbar\omega_{UV} \rightarrow Ne^+(2p^{-1}) + Ne^*(2p^{-1}3s) + e^-. \quad (3)$$

This measurement was performed at the Low Density Matter (LDM) end-station of FERMI. The $Ne_2$ was produced by adiabatic gas expansion technique. Product ions and electrons were detected by a time-of-flight ion spectrometer and velocity map imaging electron spectrometer, respectively.

We measured $Ne_2^+$ yield as a function of FEL photon energy. The ion yield curve clearly showed resonant enhancement around the photon energy 16.39 eV, in good agreement with the theoretical prediction [4]. Using FEL pulse with resonant photon energy, we performed time-resolved measurement. Figure 1 depicts the $Ne_2^+$ yield measured as a function of the time delay between the XUV and UV pulses. By theoretical fitting procedure to experimental data points (solid line shown in Fig. 1), we can extract the ICD lifetime of 390 (-130/+450) fs.

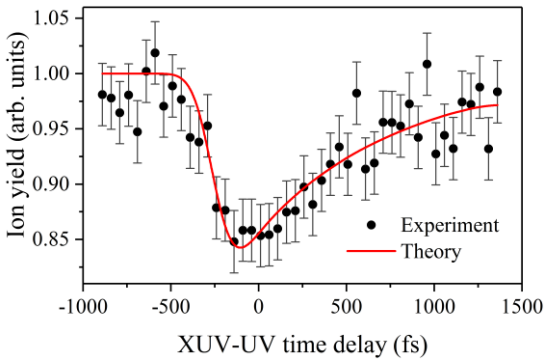


**Figure 1.** The yield of $Ne_2^+$ measured as a function of time delay between the XUV and UV pulses. (This figure adapted with permission from [1]. Copyrighted by the American Physical Society.)

In the presentation, results from the measurement of ICD in multiply excited Ne cluster using FERMI [2] will also be discussed.

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## References

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