Interatomic Coulombic Decay Processes after Multiple Valence Excitations in Ne Clusters

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Interatomic Coulombic Decay Processes after Multiple Valence Excitations in Ne Clusters

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Synopsis We present a comprehensive analysis of autoionization processes in Ne clusters (∼5000 atoms) after multiple valence excitations by free electron laser radiation. The evolution from 2-body interatomic Coulombic decay (ICD) to 3-body ICD is demonstrated when changing from surface to bulk Frenkel exciton excitation. Super Coster-Kronig type 2-body ICD is observed at Wannier exciton which quenches the main ICD channel.

Previously, Yase *at al* [1] investigated multiple excitation of Wannier type excitons (corresponding to the $2p \rightarrow 3d$ atomic resonance) at 20.26 eV in Ne clusters by the intense extreme ultraviolet free electron laser (EUV-FEL) at SCSS (SPring-8 Compact SASE Source, Japan) and found that the electron emission is dominated by low energy electron emission that originates from a nanoplasma.

In the present experiment, we have extended our observations to multiple excitations of surface and bulk Frenkel type excitons (corresponding to the $2p \rightarrow 3s$ atomic resonance) at 17.12 eV and 17.65 eV, respectively, using the new seeded EUV-FEL, FERMI (Trieste, Italy) [2].

At the lowest surface Frenkel exciton we can clearly see the pure 2-body ICD peak at ∼11.5 eV, predicted by Kuleff *at al* [3], with its multistep ICD tail which is similar to direct multistep ionization in Ar clusters [4]. The situation changes for the bulk Frenkel exciton, where the broad structure around 5 eV is identified as 3-body ICD of knock-off type (also known as collective autoionization [5]) and becomes dominant over 2-body ICD at high FEL intensities. For the Wannier exciton we can see complete quenching of the main 2-body ICD by super Coster-Kronig type ICD in which one 3d electron relaxes to a 3s orbital and another 3d electron is ejected with ∼1.8 eV kinetic energy (see Fig. 1).

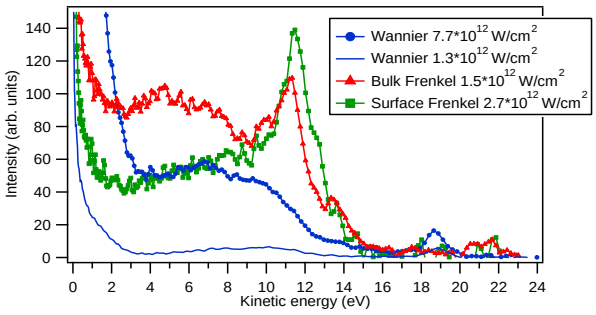

Figure 1. Electron emission spectra for excitation of different excitons and selected FEL intensities.

References

[1] S. Yase *et al.* 2013 *Phys. Rev. A* **88** 043203
[2] E. Allaria *et al.* 2012 *Nat. Photonics* **6** 699
[3] A. I. Kuleff *et al.* 2010 *Phys. Rev. Lett.* **105** 043004
[4] C. Bostedt *et al.* 2008 *Phys. Rev. Lett.* **100** 133401
[5] Y. Ovcharenko *et al.* 2014 *Phys. Rev. Lett.* **112** 073401

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