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# Observation of interatomic Coulombic decay in Ne dimer above and below the Ne $2s^{-1}$ threshold

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## Introduction

It is well now that, in rare gas atoms, inner-shell core holes usually decay by emitting a secondary Auger electron. This pathway is forbidden in case of inner valence holes, for their binding energy lies below the lowest double ionization potential. Consequently, they can only experience a radiative decay. However, when the rare gas atom is a part of a weakly bound van der Waals cluster, an alternative interesting decay path is opened whereby the initially ionized atom transfers its energy to a neighboring atom. We have demonstrated that this process occur in Ar, Kr and Xe dimers [1]. The Ne dimer case is even more spectacular as the transferred energy is sufficient to ionize the neighboring atom. Such a decay process is called Inter-atomic Coulombic Decay (ICD) and was for the first time theoretically predicted by Cederbaum and co-workers [2,3] to be much faster than the competing intra-atomic radiative decay.

## Results and Discussion

Ne dimer is the most suitable species in order to investigate the ICD mechanism. The process can be schematically depicted in the following way: an inner-valence 2s electron is photoionized from a Ne atom inside the Ne dimer ([Ne---Ne]), the hole then decays by transferring its energy to the neighboring Ne atom and ejecting an outer-valence 2p electron, that is:

$$[Ne\text{---}Ne] + h\nu \xrightarrow{photoionization} [Ne^{+}(2s^{-1})\text{---}Ne] + e_{photoelectron} \xrightarrow{ICD} [Ne^{+}(2p^{-1}) \text{ --- } Ne^{+}(2p^{-1})] + e_{ICD}.$$

The final state is thus a doubly charged Ne dimer that dissociates through charge separation. Recently, ICD was observed experimentally in 2s ionized Ne dimer by detecting the two $Ne^{+}$ fragments and the ICD electron in coincidence at an excitation energy 10eV above the 2s ionization threshold [4].

In the present study, we used a very simple and sensitive experimental approach to investigate ICD process in Ne dimer, namely coincidence between the two receding energetic $Ne^{+}$ ions. Experiment was performed at undulator beamline BL16B. Ne dimers are produced in a supersonic expansion with a proper stagnation pressure in order not to produce large size clusters. The two fragment ions were detected in coincidence by two apparatus: a simple ion filter that rejects low energy or thermal ions and a hemispherical electrostatic analyzer [5] which allows the measurement of the kinetic energy distribution of energetic $Ne^{+}$ ions. We confirmed the ICD occurrence by detecting two $Ne^{+}$ ions simultaneously with the two detectors. The ICD cross section were measured as a function of the photon energy, which is strongly affected by resonances due to double excitations, $[Ne^{*}(2p)^{4}(3s)(np)\text{---}Ne]$, located just above the ionisation threshold of the $[Ne^{+}(2s^{-1})\text{---}Ne]$ state. The $Ne^{+}$ kinetic energy observed in the present study is in good agreement with the previous theoretical prediction [3] and experimental observation [4] and remains constant within a few eV above threshold. Surprisingly, we observed that ICD process is also present below the 2s ionization threshold. Work is in progress to understand this phenomenon which we attribute to a spectator process upon excitation of a 2s electron to a Rydberg orbital.

## References

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