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Ultralong-range energy transfer by interatomic Coulombic decay in the giant helium dimer

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Interatomic (molecular) Coulombic decay (ICD) is an ultrafast non-radiative electronic decay process for excited atoms or molecules embedded in a chemical environment. Via ICD, the excited system can get rid of the excess energy, which is transferred to one of the neighbors and ionize it. It should be stressed that whereas the same excited atom when isolated relaxes only by emitting a photon in a time range of picoseconds to nanoseconds, ICD takes place in the femtosecond range. Thus, ICD is generally the most favorable decay process. A key feature of ICD is that the energy transfer between the two involved atoms can take place over large distances, even beyond distances where the overlap of the involved wavefunctions becomes negligible. A question which arises is how far two atoms can exchange energy? The giant helium dimer is a perfect candidate to investigate this issue. It is the most weakly bound system in nature, with a binding energy of about 10^{-7} eV ($\approx$ 1.1 mK) and a very large average bond length of around 52 Å! Thanks to the extremely large interatomic distance distribution of the helium dimer, the latter allows to study ICD over such large distances. The presentation will focus on recent theoretical results on ICD in helium dimer. It be will shown that after simultaneous ionization and excitation of one helium atom in the dimer, the excited ion can relax through ICD. From the kinetic energy release (KER) spectra, it will be demonstrated that the two helium atoms can exchange energy via ICD over distances up to 14 Å and that the observed oscillatory structures in the KER spectra reflect the nodal structures of vibrational wavefunctions involved in the decay process. Finally, computed time-resolved KER spectra will be presented and discussed.