Experimental and Theoretical studies of Reaction Channels in Fullerene-Fullerene Collisions

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Abstract

$C_{60}^+ + C_{60}$, $C_{60}^+ + C_{70}$, $C_{70}^+ + C_{70}$ collisions in the gas phase were studied as a function of the collision energy and scattering angle. The deep inelastic scattering, fusion, multi-fragmentation and charge transfer reaction channels were investigated in the collision energy range of 50 – 3000 eV. The energy dependencies of the fusion cross section were measured and the energy window for fusion was determined. A simple phenomenological model was proposed to explain the observations. The fusion barrier lies in the range of 60 – 80 eV and increases with increasing number of atoms involved in the collision. The decrease of the fusion cross section for energies beyond 130 eV can be understood in terms of centrifugal instability of the fused compound. The fragments of the fusion compounds were detected up to a collision energy of 400 eV and for a wide range of scattering angles. Quantum molecular dynamics simulations support the experimental data and aid the interpretation. The mass distribution of the fragments produced in the collisions has been determined as a function of the collision energy. In the range 130-180 eV, the mass distribution shows a bi-modal structure. It becomes single-modal above 180 eV, in agreement with the results from the quantum molecular dynamics simulations and a statistical maximum entropy model indicating the on-set of a phase transition. Scattered non-fused projectiles and their fragments were detected and the distribution of parent ions compared with the classical differential scattering cross section, calculated using the Girifalco potential. The charge transfer cross sections for $C_{60}^+ + C_{60} \rightarrow C_{60} + C_{60}^+$ collisions were also measured. The results are in good agreement with simple models from atomic physics.