Cross-Section Measurements With Interacting Beams

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Abstract. Interacting beams were first employed to determine absolute cross sections for atomic processes nearly a half century ago. Significant advances in many technologies have improved the precision and sensitivity of such experiments to the degree that the high quality of those early measurements seems remarkable today. Despite their early successes and these continuing advances, interacting beams experiments and the determination of absolute cross sections and rate coefficients from them remain a challenge. This presentation will concentrate on one large-scale technical advance, the synchrotron light source, which has facilitated interacting-beams measurements of cross sections for photoionization of atomic and molecular ions. Third-generation electron synchrotrons with insertion devices provide intense, continuously tunable and highly collimated beams of light at extreme ultraviolet wavelengths for which tunable lasers are currently unavailable. Such a photon beam may be merged with an ion beam to determine absolute photoionization cross sections for atomic and molecular ions. Typical results will be presented from such a setup at the Advanced Light Source (ALS), Lawrence Berkeley National Laboratory for free atomic and molecular ions. The C_{60} molecule has an empty spherical cage structure with a diameter of nearly 1 nm, within which an atom may be trapped, forming a so-called endohedral fullerene molecule. The 4d subshell photoionization of a Xe atom inside C_{60} ($Xe@C_{60}$) has been predicted theoretically to produce so-called "confinement resonances" that significantly redistribute the Xe 4d oscillator strength relative to that for a free Xe atom. Their origin is multipath interference of photoelectron waves due to possible reflection by the C_{60} cage. This fundamental phenomenon was observed experimentally for the first time using the merged-beams setup at the ALS with a $Xe@C_{60}^{+}$ ion beam current of less than 1 picoampere ($< 10^7$ ions/second). This measurement is believed to set a record for the sensitivity of a merged-beams experiment.