New Developments In Small-Angle Electron Scattering: Aid To Measurements

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The understanding of the interactions of electrons with atoms/ions/molecules is fundamental to the development of innovative propulsion technologies of a spacecraft and its environment and communication systems. In particular, in ion propulsion technology, NASA's selected primary propulsion system for the New Millennium, spacecraft contaminations and interactions result from participating neutral and ionized atomic species in their ground and excited states. Small-angle electron differential cross sections (DCSs), which are generally poorly known, are important to spacecraft propulsion technologies and planetary atmospheres. The difficulties of obtaining reliable measurements of the electron DCSs for atomic, ionic and molecular transitions at and near zero scattering angles are well documented [1,2]. Hence, the need for reliable theoretical calculations.

Recently, three theoretical developments have been used to investigate and guide the measurement of small-angle, including zero, electron DCSs in atoms, ions and molecules. The first method, the momentum dispersion method (mdm) [3], based upon Regge pole theory, uses the analytical continuation of the generalized oscillator strength (GOS) function to obtain the smaller angle, including zero, data from the more reliably measured larger angular data. The second method, the forward scattering function (fsf) [4], uses the OOS as the only input. It represents a unique path of the GOS function to the OOS without traversing the non-physical region, which is always present for finite impact energies, E^2 as E varies from near threshold to the Born approximation limit. The fsf is, therefore useful for normalizing the measured relative electron DCSs through the GOSs [5]. In an appropriate representation, consistent with the mdm, the GOS for both dipole allowed and forbidden transitions varies linearly with K^2 for small scattering angles. This linear variation is more dramatic for values of E close to threshold, where it can involve scattering angles as large as 40 or more. We have exploited this linear variation in our international collaborations to investigate the electron DCSs at small scattering angles for transitions in $He, Cd, Xe, Hg, N_2, SF_6, N_20$, etc., including the normalization of the measured relative DCSs, and found that many measurements experience difficulties obtaining reliable data at and near zero scattering angles.

Very recently [6], we have found singular behavior in the electron-atom scattering at small momentum transfer K coming from second-order terms. This result, combined with a Regge pole representation, yields a new generalized two-term Lassettre expansion to evaluate OOSs from GOSs at $K^2 = 0$; the results for $H1s - 2p$ are outstanding even at low impact energies. Representative results will be presented.

References:

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