Interference effect in electron emission in a molecular double slit

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Synopsis We present here the recent studies on the Young type interference induced oscillations in the electron DDCS spectrum arising from diatomic molecules H_2, N_2, and O_2. The results from the earlier studies on H_2 molecules are used for a overall comparison. The oscillation patterns, the frequency parameter and angular asymmetry of the DDCS shows certain characteristic features which are somewhat different for different exciting projectile, such as, fast heavy ions, electrons and synchrotron photons. The asymmetry parameter, obtained from the measured DDCS of two complementary angles provide convincing insight on the Cohen-Fano type oscillations: both first and second order interference.

The electron emission spectrum in atomic ionization by electrons, photons or heavy ions reveals the important mechanisms which are well known for decades. The revelation of the proposed and observed Young type interference effect in electron emission spectrum from a homonuclear diatomic molecule H_2 is an added facet to the study of ionization[1-14]. Quantum coherence, a property of matter that separates the classical from the quantum world, is most clearly demonstrated in such a double-slit experiment. A system of two indistinguishable, and hence inversion-symmetric emitters, such as, a homonuclear diatomic molecule H_2, is a genuine source of spatial coherence.Several experimental and theoretical work have been carried out over the past decade not only on the proof on such interference but also to study accurately the structure and bond-length of several complicated hydrocarbon molecules. These investigations have also enlightened our understanding about the theoretical techniques i.e. regarding the approximations, the molecular wavefunctions etc.

Experimental observation of the interference oscillations generally depends on the DDCS ratios (molecular-to-atomic). Typically for atomic cross sections one depends on the theory. Only in one experiment the DDCS could be measured for atomic-H. In a possible effort to avoid this bottleneck of using atomic-H one has also demonstrated to use the forward-backward asymmetry parameter which emerges as a valuable tool for deducing the oscillations. In case of simplest molecules H_2 the derivation of the oscillations is relatively simple.But in case on multielectronic molecules, such as, N_2 and O_2 the appearance of oscillation is often debated. This is due to the phase mismatched oscillations ionized resulting somewhat cancellations. But in case of N_2 and O_2, a clear oscillation has been observed from each individual orbitals upon photoionization. Very recent studies using very fast (v~25 a.u.) electrons owing to have much less Coulomb perturbation strength has revealed the oscillations in the DDCS ratios as well as in angular asymmetry parameter. The derived frequency parameter for H_2 shows certain angular distribution with a minimum at 90^0. From our recent study we demonstrate that this distribution is quite different for e-impact ionization of N_2 for which a flat distribution up to 90^0 is seen. The observation of a second order component of double frequency has also been debated between theorists and experimentalists. Such component, although observed, shows different results for H_2, N_2 and O_2. Finally, the interference effect as observed for different diatomic molecules under different projectiles reveals an interesting and rich topic of study which still needs attention, due to some of its unresolved issues. A brief review of recent work will be presented.

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