Forward-backward asymmetry in electron impact ionization of O_2 and interference oscillation

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Synopsis We present a study of the double differential cross section (DDCS) measurements of secondary electrons emitted from the homonuclear diatomic molecule O_2 in collisions with fast electrons. The measured DDCS spectra, along with corresponding atomic DDCS calculations are further used for revealing the Young type interference effect. The asymmetry parameter, obtained from the measured molecular DDCS of two complementary angles also provide convincing proof of the interference oscillations.

The revelation of Young type interference effect from a homonuclear diatomic molecule was initially proposed by Cohen and Fano [1]. The two atoms of the diatomic molecule act as the two slits of the double slit experiment. In case of the simplest diatomic molecule H_2, interference effect was initially observed in experiments upon heavy ion impact [2-5] and was subsequently also seen for photons and fast electrons as projectiles. In case of multi-electronic targets, like O_2 and N_2 the interference oscillations have been observed from each individual orbitals upon photoionization [6], but are phase shifted from each other. In case of heavy ion impact on N_2 and O_2, in the observation of interference effect [7,8] is more complicated due to multiple ionization of different orbital. Fast electrons imparting much less perturbation to the target system are expected to be a cleaner probe to study the interference for multielectronic targets which was evident from our recent study for the N_2-molecule [9-10].

Here we report the DDCS measurements of the secondary electrons emitted from O_2 under the impact of fast electrons of energy 7 keV, using the electron spectroscopy technique. The DDCS ratios have been obtained by dividing the measured molecular DDCS by its corresponding theoretical atomic-O DDCS, which was calculated using the first Born model. The DDCS ratios for each individual angle showed signature of interference oscillation. The oscillatory structures obtained for each angle were fitted with the Cohen-Fano model for interference to estimate the frequency and amplitude of oscillations. The frequency parameter, as obtained from the fitting, is found to be bit larger for backward angles than that in forward angles.

As a result of this the forward backward asymmetry parameter, α(k), defined as the ratio: *(DDCS(θ)-DDCS(π-θ))/(DDCS(θ)+DDCS(π-θ)),* showed full sinusoidal oscillations (Fig 1). The fitting parameter, backward-to-forward frequency ratio, is found to be 1.15. The asymmetry parameter has also been compared with an atomic target, helium. The, α(k), increases monotonically (see inset) with increase in electron velocity. The present results for O_2 using fast electrons thus provide a clear signature of interference oscillation, unlike that observed for heavy ion impact [11].

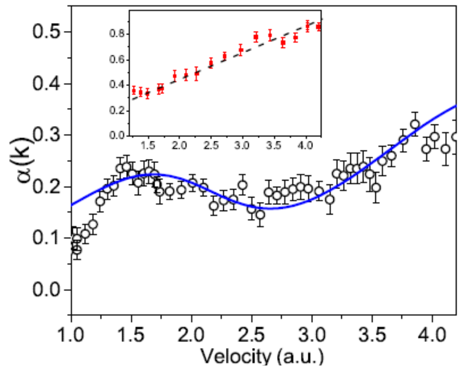

Figure 1. Asymmetry parameter (α(k)) for O_2 along with the Cohen-Fano fitting. Inset : α(k) for He.

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