Interference effect in e-emission spectrum from a molecular (N_2) double slit in collisions with fast electrons

Madhusree Roy Chowdhury*, C. R. Stia†, O. A. Fojon†, R. D. Rivarola† and Lokesh C. Tribedi*[1]

* Tata Institute of Fundamental Research, Colaba, Mumbai 400005, India
† Institute de Fisica Rosario (CONICET-UNR), Universidad Nacional de Rosario, 2000 Rosario, Argentina

Synopsis Double differential cross sections (DDCS) of electrons ejected in ionization of N_2 by fast electrons have been measured. Signature of interference effect was revealed in the DDCS ratio (N_2/2N). Interference oscillation was also confirmed from the asymmetry parameter, determined from the DDCS of two complementary angles. Traces of second order effect was also observed from the asymmetry parameter.

Ionization of diatomic molecules by electrons, heavy ions and photon to investigate the Young type interference effect has been a subject of study for more than a decade, although initially proposed by Cohen and Fano in 1966 [1]. Its application towards fundamental quantum mechanical issues as well as structural and collisional aspects involving di- and multi-atomic molecules are well known. Several experimental measurements have been performed for the simplest diatomic molecule H_2 using different probes and in all cases the observation of interference oscillations were consensual [2-4]. This work was extended further for multi electronic targets like N_2 and O_2. Though oscillations were observed in individual orbital for both the targets upon photoionization [5], but, for heavy ions, there exists an ambiguity in the evidence of interference oscillations [6,7]. According to a theoretical prescription, interference effect may not be readily observed in case of heavy ion collision with N_2 because of the cancellation of phase mismatched oscillations contributing from each individual orbitals [8]. For fast electrons as projectile, the Coulomb perturbation strength is much small, resulting in negligible multiple ionization. Hence it is expected that the interference effect may be observed much clearly in case of electrons than heavy ions.

In this work, we report the measurement of DDCS of secondary electrons emitted from ionization of N_2 in collision with 7 keV electrons. The DDCS have been measured for electron energies between 1 and 550 eV and emission angles from 15^0-145^0 using a hemispherical electrostatic analyzer. The atomic DDCS were calculated using B1 model. The experimental-to-theoretical DDCS ratios (N_2/2N) revealed clear signature of interference oscillations [9,10] which was fitted by the Cohen-Fano model. The difference in the frequency of oscillation between forward and backward angles causes an oscillation in the forward-backward asymmetry parameter (α(k), Fig.1).

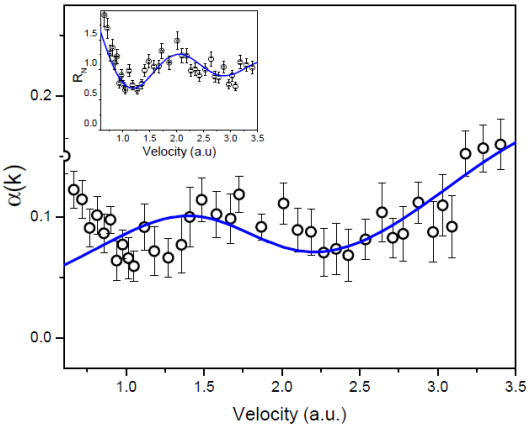

Figure 1: α(k) from measured DDCS for 35^0 and 145^0. Inset : α(k) divided by first order fitting reveals 2^{nd} order effect.

References

[1] H. D. Cohen and U. Fano 1966 *Phys. Rev.* **150** 30
[2] N. Stolterfoht *et al.* 2001 *PRL* **87** 023201
[3] D. Misra *et al.* 2004 *Phys. Rev. Lett.* **92** 153201
[4] S. Chatterjee *et al* 2009 *J Phys B* **42** 065201
[5] M. Ilchen *et al.* 2014 *Phys. Rev. Lett.* **112** 023001
[6] J. Baran *et al.* 2008 *Phys. Rev. A* **78** 012710
[7] S. Nandi *et al.* 2015 *Eur Phys J D* **69** 192
[8] C. A. Tachino *et al.* 2012 *J. Phys. B* **45** 025201
[9] M. Roy Chowdhury *et al.* 2016 *PRA* **94** 052703.
[10] M. Roy Chowdhury *et al. EPJD* (submitted)

[1]E-mail: lokesh@tifr.res.in