Attoclock and Tunelling Delay in Atomic Hydrogen

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Synopsis We present the results of attosecond angular streaking of atomic Hydrogen using elliptically polarized, 5.5 fs pulses that are centered around 770 nm, within the intensity range of 1.65 to 4 X 10^{14} W/cm^2. We measure angular offsets in the photo-electron momentum distribution relative to the peak of the electric field of light in the polarization plane .We find a strong agreement in these results with the solutions of complete 3D-TDSE simulations. Further, we compute the contribution of coulomb effects (between the ionized electron-parent ion) to the measured angular offsets using Yukawa potential, subtracting which yields the real 'tunneling delays'.

The 'attoclock' technique [1], also known as attosecond angular streaking, employs near-circularly polarised few-cycle femtosecond pulses, wherein the peak electric field is strong enough to suppress the Coulomb barrier and facilitate electron tunnel ionisation. The ionised electrons and ions get streaked in the residual (post-peak) circular field of light mapping the instant at which electrons appear in the continuum to its final momentum. Thus measuring the peak field and photo-electron momenta gives us the time difference between the instant of peak electric field and the instant at which electron appears in the continuum. The time-difference materialises as an angular offset in the photo-electron momentum distribution in the polarisation plane relative to the polarisation ellipse of the light.

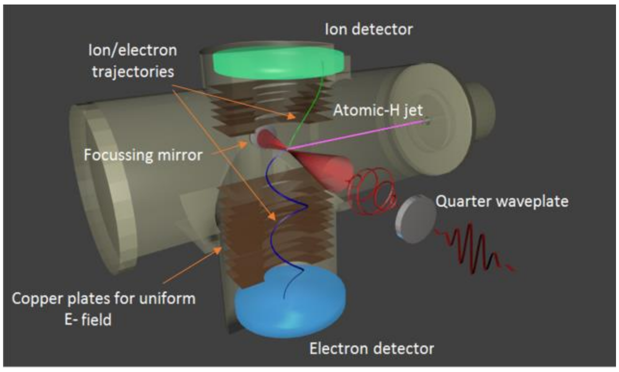

Figure 1: A schematic of the experimental set-up wherein the atomic-H gas jet interacts with the elliptic polarised light inside the COLTRIMS.

Although previous attoclock experiments [1,2] hinted at zero tunnelling delays, exact theoretical solutions were not available to study the ionisation dynamics in detail. Atomic Hydrogen (H), being the simplest atomic system, can be solved exactly using 3D-TDSE. That enables us to benchmark the field and also can be used to validate various theoretical models that help us in understanding ionisation dynamics in complex atomic systems.

We performed the attoclock experiment with H using COLTRIMS and 770 nm, 6fs pulses at intensi-ties from 0.165-0.39 PW/cm2. The H gas jet source [3] is an RF-discharge tube that dissociates H_2 with a dissociation fraction of 60%. We present and compare these results with the full solution of 3D-TDSE codes calculated using exactly the same ex-perimental parameters. Further, using simulations with Yukawa potential we present the contributions of coulomb potential to the angular offsets and finally present an upper bound for 'tunnelling delays'.

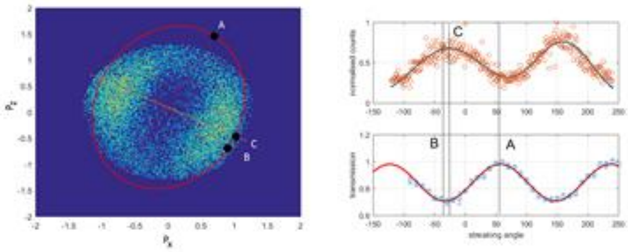

Figure 2: Experimental data of momentum distribution of photoelectrons in the polarisation plane. A corresponds to the peak electric field and B & C are the expected and measured peaks of photoelectron-momentum distribution in the polarisation plane

References
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