Journal of Physics: Conference Series **488** (2014) 032027 doi:10.1088/1742-6596/488/3/032027

Carrier-Envelope Phase effect for Dissociation of Molecular Hydrogen

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Synopsis We studied the dependence on the dissociative ionization of H2 as a function of carrier-envelope phase (CEP) of few-cycle (6 fs) near-infrared (NIR) laser pulses. For low-energy channels, we present the first experimental observation of CEP dependence for combined dissociation yield (with protons emitted in both directions) and the highest degree of asymmetry reported to date (40%).

The CEP control with few-cycle pulses was the scheme first demonstrated experimentally by Kling et al. [1] More recently, Kremer et al. observed a significant (~15%) asymmetry for these low energy channels in H2 [2]. Neither of these studies reported on CEP dependence of the combined dissociation yields including fragments emitted in all directions. We report such measurements of the CEP-dependent total dissociation yield. We also report the highest degree of asymmetry ever measured for dissociation fragments with KER between 1.8 and 3 eV for this control scheme of 40% [3].

Generally, all CEP-dependent effects could be viewed as resulting from the interference between two (or more) quantum pathways corresponding to different numbers of absorbed photons [4]. The observed modulations in both asymmetry and combined yield could be understood in terms of interference between different n-photon dissociation pathways - n and (n+1) photon channels for asymmetry, n and (n+2) photon channels for yield.

The experimental apparatus includes a 1 KHz CEP-stable few-cycle laser system and a Reaction Microscope (REMI). The estimated CEP noise (root mean square) was less than 360 mrad and was sufficiently stable for clear experimental observation of CEP dependent effects. From the measured proton momenta we calculated the kinetic energy spectra separately for protons emitted towards (up) and away from (down) the detector for all values of CEP (figures 1(b) and 1(c)). By adjusting the peak laser intensity at the we achieved a high degree of asymmetry (40%) for fragments with KER between 2 and 3 eV. We assign the two energy regions as corresponding to interfering 1- and 2-photon pathways (BS and ATD, 03-1.3 eV) and 2- and 3-photon pathways (ATD and 3PD, 1.5-3.5 eV). The dependence of combined dissociation yield (meaning yield in both directions for a particular KER range rather than energy-integrated yield) on CEP are measured (figures 1(e) and 1(g)). We do see pi-periodic modulations of combined dissociation yield with modulation depth of up to 5% for fragments with KER between 2 and 3 eV, which results from the interference between pathways of BS (n = 1) and 3PD (n = 3).

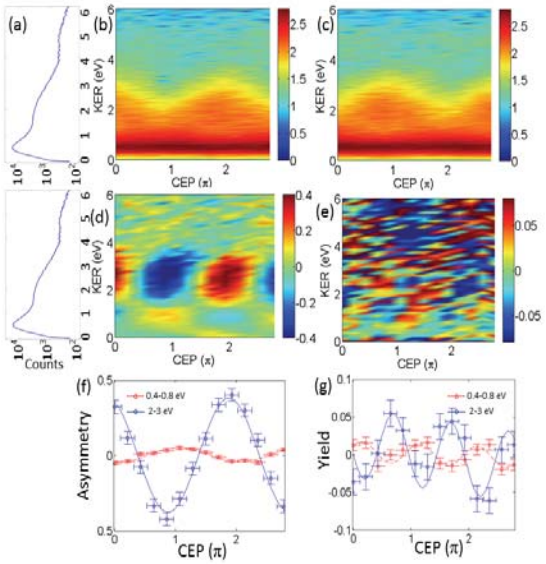

Figure 1. Measured CEP dependent asymmetry and combined proton yield.

References

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