The transition from random to oriented target properties in the photoionization of the hydrogen molecule

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The photoionization of a molecule produces electrons and ions which can be analyzed with respect to photoabsorption cross sections and angular distributions applying time-of-flight spectroscopy. The analogy of photoemission processes in homonuclear diatomic molecules to the Young type double slit experiment has been topic of a large amount of photoionization investigations. One example is the oscillation in the photoionization cross section of N_2 which Cohen and Fano [1] interpreted as an interference effect and which was experimentally proven by Ilchen et al. [2] in 2014. This two center interference is caused by electron non-locality in homonuclear molecules. Here, the oscillation in the cross section of molecular hydrogen is analyzed over a wide photon energy range distinguishing between molecules that are oriented randomly in space and those with a molecular axis fixed in space (the so-called oriented sample) [3,4]. Furthermore, a transition effect from random to oriented target properties is detected if the de Broglie wavelength of the photoelectron is small enough to resolve the internuclear distance (see figure 1). The ion fragment angular distribution given by the β_m parameter is analyzed and found as a reason for this transition. At high photon energies the β_m value converges to -1 resulting in a preferred molecular orientation for the ionization process. The experiments were performed PETRA III P04 (265 – 1200 eV, in May and November 2013) facilities covering almost two oscillation periods. At P04 we used the installed electron-ion-coincidence time-of-flight detector setup by S. Deinert et al [5]. Additionally, we also analyzed total ion yield for the inner shell ionization of the nitrogen and oxygen molecule and recorded electron time-of-flight data of neon Auger-cascade decay at P04.

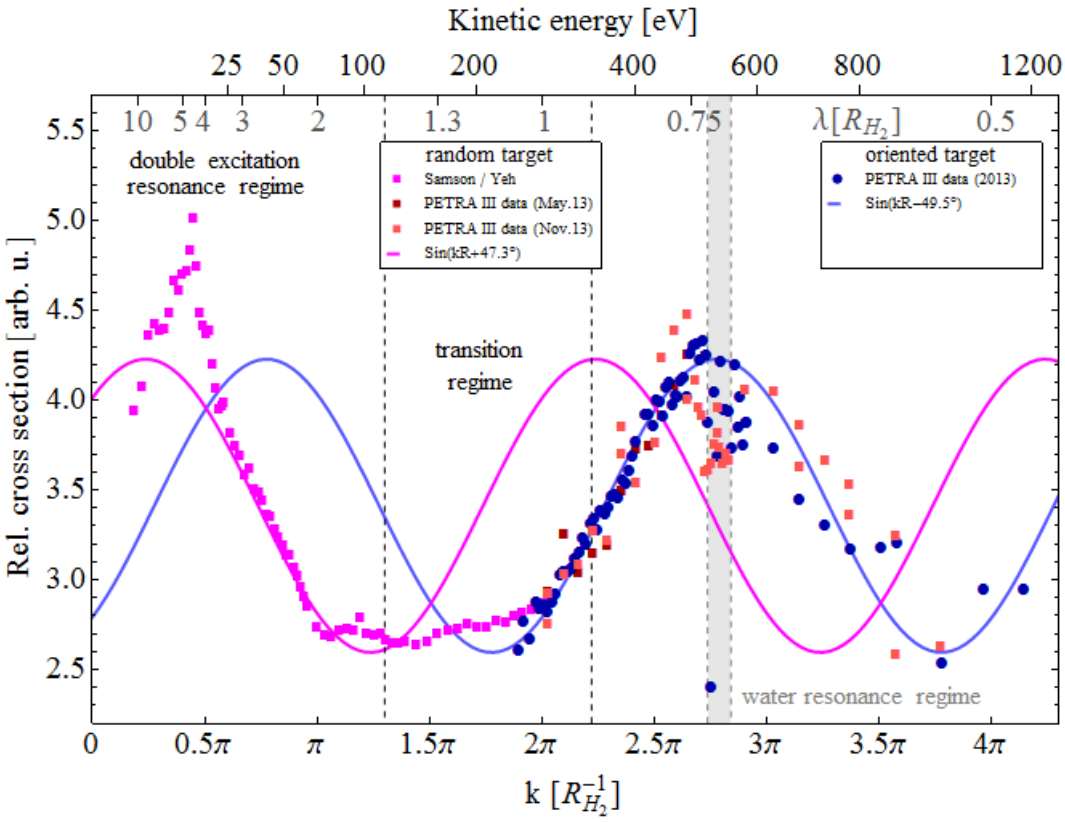

Figure 1: Relative cross section oscillations in the hydrogen molecule; when the de Broglie wave length of the outgoing photoelectron resolves the internuclear distance a transition from random to oriented target properties is observed. This is caused by a preferred orientation of the molecular axis to the polarization vector at higher photon energies and described by the β_m parameter. Low energy data from [6] is normalized to [7].

References

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