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Circular Dichrosim in Photoionization of H_2 and D_2

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Synopsis In this work, circular dichroism in H_2 (D_2) photoionization is studied in detail. We have selected several photon energies for a case study: 19 eV for which only direct ionization to the $1s\sigma_g$ ionization channel is present, 27 eV where autoionization of Q_1 $^1\Sigma_u^+$ doubly excited states takes place, and 32.5 eV for which autoionization from Q_1 and doubly excited states and direct ionization to $1s\sigma_g$ and $2p\sigma_u$ channels strongly interfere. The latter case shows clear evidence of different behavior of the photoionization against radiation helicity.

Circular dichroism (CD) measures the different response of a material when exposed to left- or right-handed circularly polarized light. This effect is usually observed in chiral molecules. However, CD can also be observed in oriented achiral molecules and in polarized atoms when the emission direction of photoelectrons is measured [1, 2, 3, 4], and it results from the non-coplanarity of three vectors involved (light propagation axis **k**, electron momentum $\mathbf{k_e}$ and molecular axis **n**). Actually, recent experimental and theoretical studies in photoionization of H_2 show that CD may persist even when the polar angle θ_e of the photoelectron emission direction k_e is not determined [5]. In this work, we have studied circular dichroism in the angular distributions (CDAD) in the ($\mathbf{k_e}$,**n**)-plane perpendicular to **k**, coming from the photoionization of H_2 (D_2) by selecting different photon energies. In doing this, different reaction mechanisms are then involved, showing up their role in the CD effect. Figure 1 shows the measured and calculated CDAD as a function of the polar angle θ_e of the photoelectron direction $\mathbf{k_e}$ for H_2. At photon energies of 19 and 27 eV the CDAD is perfectly antisymmetric with respect to θ_e=90^o. At 32.5 eV this antisymmetry breaks up to yield a non-zero CD after θ_e integration, which results from time delayed autoionization of Q_1 $^1\Sigma_u^+$ and Q_2 $^1\Pi_u$ doubly excited states into ionization channels with opposite inversion symmetry, i.e., $1s\sigma_g$ and $2p\sigma_u$.

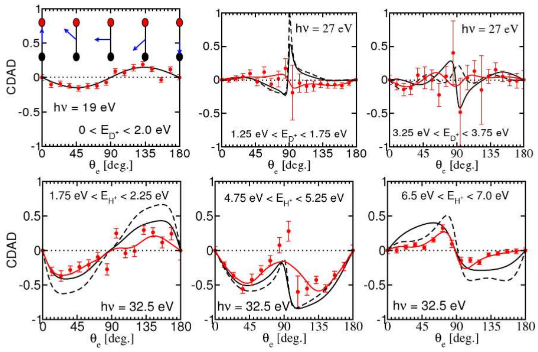

Figure 1. CDAD. Red circles: experimental results, red solid curves: fitting of the experimental results, black solid curves: theoretical results convoluted within the instrumental resolution, black dashed curves: theoretical results. The red balls in the insets denote H^+, and the black ones, H; the blue arrow indicates the electron emission direction. The photon energies and the proton kinetic energies are indicated in each figure.

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