

Dynamic chirality and structure of Ar and He tetramers studied by Coulomb explosion imaging

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Chirality related phenomena such as parity violation, circular dichroism, homochirality [1, 2] have attracted much attention in recent decades. Besides “normal” or “static” chirality one distinguishes also instantaneous or “dynamic” chirality, which, for instance, can be induced by zero-point vibrations in systems that are in average achiral and symmetric [3].

The question that has been raised in the current study is whether a circular dichroism can be observed in ionization of a dynamically chiral system, where chirality is only encoded in the bond lengths. In order to answer this question we have chosen two van-der-Vaals-bounded systems: Ar and He tetramers. Instantaneous structures of these clusters have been probed on a single molecule level by Coulomb explosion imaging using the COLd Target Recoil Ion Momentum Spectroscopy (COLTRIMS) [4].

Two enantiomeric structures of Ar and He tetramers were identified. Our experiments with left- and right-handed circularly polarized femtosecond laser fields have revealed no circular dichroism in quadruple ionization of these two enantiomeric forms (Figure 1a). Furthermore, we haven't observed any circular dichroism in electrons emitted in the direction of the laser pulse propagation (Figure 1b).

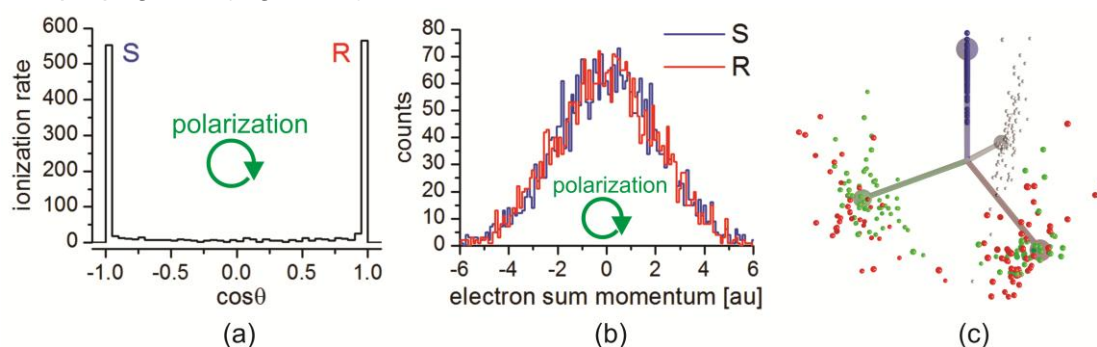


Figure 1. (a) – ionization rate of the left-handed (S) and right-handed (R) dynamic enantiomers of Ar_4 in circularly polarized light, (b) – total photo-electron momentum distribution in the direction of the laser pulse propagation for ionization of Ar_4 in a circularly polarized light, (c) – Ar_4 structures reconstructed from the ion momenta acquired during Coulomb explosion.

In addition the structures of Ar (Figure 1c) and He tetramers were reconstructed from the ion momenta acquired during Coulomb explosion. The combination of Coulomb explosion imaging technique with the structure reconstruction algorithm can be generally applied for characterization of chiral molecular systems on a single molecule level.

References:

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