Femtosecond Time-Resolved Imaging of Torsion in a Chiral Molecule using PImMS.

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We show that it is possible to directly image torsion of a chiral molecule, consisting of two benzene rings linked by a carbon-carbon single bond, on its natural femtosecond time-scale. The torsional motion is of special importance because it is the fundamental reaction coordinate linking the left-handed and the right-handed mirror forms of the chiral molecule.

Our experimental strategy relies on three key components: 1) The ability to precisely confine the spatial alignment of the molecule with respect to the laboratory frame, 2) Femtosecond timed Coulomb explosion imaging and 3) Simultaneous detection of all ionic fragments from the Coulomb explosion process.

Initially the molecule is fixed-in-space by laser induced 3-dimensional adiabatic alignment with a 10 nanosecond (ns) long laser pulse. Next, torsion is induced by a femtosecond pump pulse, synchronized to the peak of the ns pulse. The torsion is monitored in real time by Coulomb exploding the molecules with a delayed, intense femtosecond probe pulse and detecting the emission direction of the ionic fragments [1]. In particular, ion species labelling each of the two benzene rings, here F^+ and Br^+ ions, are detected simultaneously by a Pixel Imaging Mass Spectrometry (PImMS) camera [2]. Covariance analysis of the emission distribution of the two ion species yields the dihedral angle between the two benzene rings directly and reveals torsional motion with an amplitude of 2 degrees and a period of 1.3 ps observed for 10 ps. We discuss the prospects for enhancing the amplitude of the torsion by trains of synchronized pump pulses.

References:
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