Manipulation of large molecules

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Large molecules have complex potential-energy surfaces with many local minima. They exhibit multiple stereo-isomers, even at the low temperatures of ~1 K in a molecular beam. We have developed methods to manipulate the motion of large, complex molecules and to select their quantum states. We have exploited this state-selectivity, for example, to spatially separate individual conformers (structural isomers) of complex molecules and to demonstrate unprecedented degrees of laser alignment and mixed-field orientation of these molecules.

Such clean, well-defined samples would strongly benefit or simply allow novel experiments with complex molecules, for instance, femto-second pump-probe measurements, X-ray or electron diffraction in the gas-phase, high-harmonic generation, or tomographic reconstructions of molecular orbitals. These samples would also be very advantageous for metrology applications, such as, for example, matter-wave interferometry or the search for electroweak interactions in chiral molecules. Moreover, they provide an extreme level of control for stereo-dynamically controlled reaction dynamics of complex molecules.

In this presentation, I will describe and compare the manipulation methods employed and our respective results. In addition, I will discuss the prospects of imaging experiments on gas-phase molecules and their dynamics using the upcoming X-ray free-electron lasers.