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Low-energy inelastic collisions with Stark decelerated molecular beams

Over the last years methods have been developed to get improved control over the absolute velocity and over the velocity spread of molecules in a molecular beam. These methods rely on the quantum state specific force that polar molecules experience in inhomogeneous electric fields. This force is rather weak, but nevertheless suffices to achieve complete control over the molecular motion, using techniques akin to those used for the control of charged particles [1]. With the Stark decelerator, a part of a molecular beam can be selected and transferred to any arbitrary velocity, producing bunches of state-selected molecules with a computer-controlled velocity and with longitudinal temperatures as low as a few mK.

These tamed molecular beams are ideally suited formolecular scattering experiments, and offer the capability to study inelastic and reactive scattering processes as a function of the continuously variable collision energy, from low to high collision energies, and with a high intrinsic energy resolution. The packets of molecules that emerge from the decelerator have a quantum state purity that approaches 100 %, allowing the background free detection of scattering products. Recently, we have performed the first scattering experiment using a Stark decelerated beam of polar molecules. A beam of ground-state OH ($X^2\pi_{3/2}$, v = 0, J = 3/2, f) radicals was scattered with a beam of Xenon under 90 degrees, and the behavior of the cross-sections for inelastic scattering near the energetic thresholds was accurately measured [2].

Recently, a new Stark decelerator molecular beam machine has become operational in our laboratory that is dedicated to crossed beam scattering experiments [3]. I will discuss the inelastic scattering of fully state selected OH radicals with He, Ar, and D2 as a function of the collision energy [4,5], as well as the inelastic scattering between Stark-decelerated OH ($X^2\pi_{3/2}$, J = 3/2, f) radicals and hexapole state-selected NO ($X^2\pi_{1/2}$, J = 1/2, f) radicals. The future prospects for measuring quantum interference effects, product pair correlations, and scattering resonances will be discussed.

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