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Molecular collision studies with Stark-decelerated beams

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Molecular scattering behaviour has generally proven difficult to study at low collision energies. We formed a molecular beam of OH radicals with a narrow velocity distribution and a tunable velocity by passing the beam through a Stark decelerator [1]. The transition probabilities for inelastic scattering of the OH radicals with Xe atoms were measured as a function of the collision energy in the range of 50 to 400 wavenumbers. The behaviour of the cross-sections for inelastic scattering near the energetic thresholds was accurately measured, and excellent agreement was obtained with cross-sections derived from coupled- channel calculations on ab initio computed potential energy surfaces [2]. For collision studies at lower energies, the decelerated beams of molecules can be loaded into a variety of traps. In these traps, electric fields are used to keep the molecules confined in a region of space where they can be studied in complete isolation from the (hot) environment. Typically, 10^5 state- selected molecules can be trapped for times up to several seconds at a density of 10^7 mol/cm^3 and at a temperature of several tens of mK [3]. The long interaction time afforded by the trap has been exploited to measure the infrared radiative lifetime of vibrationally excited OH radicals, for instance, as well as to study the far-infrared optical pumping of these polar molecules due to blackbody radiation [4]. As an alternative to these traps, we have demonstrated an electrostatic storage ring for neutral molecules. In its simplest form, a storage ring is a trap in which the molecules - rather than having a minimum potential energy at a single location in space - have a minimum potential energy on a circle. To fully exploit the possibilities offered by a ring structure, it is imperative that the molecules remain in a bunch as they revolve around the ring. This ensures a high density of stored molecules, moreover, this makes it possible to inject multiple - either co-linear or counter propagating - packets into the ring without affecting the packet(s) already stored. We have recently demonstrated a prototype molecular synchrotron, which will be used as a low-energy collider for neutral molecules in the future [5].

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