DECELERATION AND TRAPPING OF NEUTRAL POLAR MOLECULES

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In this lecture I will give an overview of the various experiments that we have performed over the last years to explore the possibilities of manipulating neutral polar molecules with electric fields. Arrays of time-varying, inhomogeneous electric fields have been used to reduce in a stepwise fashion the forward velocity of molecules in a beam[1]. With this so-called 'Stark-decelerator', the equivalent of a LINear ACcelerator (LINAC) for charged particles, one can transfer the high phase-space density that is present in the moving frame of a pulsed molecular beam to a reference frame at any desired velocity; molecular beams with a computer-controlled (calibrated) velocity and with a narrow velocity distribution, corresponding to sub-mK longitudinal temperatures, can be produced. These decelerated beams offer new possibilities for collision studies, for instance, and enable spectroscopic studies with an improved spectral resolution; first proof-of-principle high-resolution spectroscopic studies have been performed[2]. A Stark-decelerator has recently been used to load OH radicals in an electrostatic trap[3] at a density of (better than) 10^7 mol/cm^3 and at temperatures of around 50 mK. Ground-state ND_3 molecules with a translational temperature of around 1 mK have been trapped in a novel AC electric field trap, slow beams of ND_3 molecules have been injected in an electrostatic storage ring[4], and, using microstructured electrode arrays, a switchable mirror for neutral molecules has been constructed and tested[5]. The possibilities of these deceleration and trapping methods for a variety of molecular physics studies will be detailed, and the approach that we are following to further increase the phase-space density of the trapped molecules will be discussed.

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