

Deceleration and trapping of neutral polar molecules

Gerard Meijer

*Fritz-Haber-Institut der Max-Planck-Gesellschaft
Faradayweg 4-6, D-14195 Berlin, Germany
e-mail: meijer@fhi-berlin.mpg.de*

Getting full control over both the internal and external degrees of freedom of molecules has been an important goal in molecular physics during the last decades [1]. In this presentation I will detail the experimental approach that we have developed to produce samples of trapped neutral molecules. Arrays of time-varying, inhomogeneous electric fields are used to reduce in a stepwise fashion the forward velocity of molecules in a beam. With this so-called 'Stark decelerator' 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 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 experiments have been performed. These decelerated beams have also been used to load ND₃ molecules and OH radicals in an electrostatic trap at a density of 10⁷ mol/cm³ and at temperatures of around 50 mK. Optical pumping of trapped neutral molecules due to blackbody radiation has been investigated, and trapping of molecules in vibrationally or electronically excited metastable states has been used to directly measure their radiative lifetimes. Ground-state molecules have been trapped in AC electric field traps, decelerated molecular beams have been injected in a prototype molecular synchrotron, and, using micro-structured electrode arrays, a “decelerator on a chip” has been constructed and tested.

[1] S.Y.T. van de Meerakker, H.L. Bethlem, and G. Meijer, *Taming molecular beams*, Nature Physics 4 (2008) 595-602.