

Stark deceleration and trapping of OH radicals

Sebastiaan Y.T. van de Meerakker

Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195, Berlin, Germany

Over the last years our group has been developing methods 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. This has been explicitly demonstrated by the construction of two types of linear accelerators/decelerators [1,2], a buncher [3], two types of traps [4,5], and a storage ring for neutral polar molecules [6]. 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.

We will report on the deceleration and electrostatic trapping of ground state OH radicals, a chemically highly relevant species. Depending on details of the trap loading sequence, typically 10^5 OH $X^2\Pi_{3/2}, v = 0, J = 3/2$ radicals are trapped for times up to 1 second at a density of $10^7 - 10^8 \text{ cm}^{-3}$ and at a temperature in the 50-500 mK range [7]. The long interaction time afforded by the trap is exploited to measure the radiative lifetime of long-lived first vibrationally excited state of the OH radical [8]. The trap loading has been optimized using evolutionary strategies, resulting in an increase of the number of trapped molecules by 40 %.

When Stark decelerated beams are used in molecular beam scattering experiments, (in)elastic cross sections can be measured as a function of the continuously changeable collision energy and with an unprecedented energy resolution. Recently, we have performed the first scattering experiments 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 is decelerated or accelerated, and scattered with a beam of Xenon under 90 degrees, allowing to measure the energy dependence of the cross-section for inelastic scattering to higher rotational states around the energetic threshold.

- [1] H.L. Bethlem et al., Phys. Rev. Lett. 83, 1558 (1999).
- [2] H.L. Bethlem et al., Phys. Rev. Lett. 88, 133003 (2002).
- [3] F.M.H. Crompvoets et al., Phys. Rev. Lett. 89, 093004 (2002).
- [4] H.L. Bethlem et al., Nature 406, 491 (2000).
- [5] J. van Veldhoven et al., Phys. Rev. Lett. 94, 083001 (2005).
- [6] F.M.H. Crompvoets et al., Nature 411, 174 (2001).
- [7] S.Y.T. van de Meerakker et al., Phys. Rev. Lett. 94, 23004 (2005).
- [8] S.Y.T. van de Meerakker et al., Phys. Rev. Lett. 95, 013003 (2005).