Manipulating molecules

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In this presentation I will give an overview of last years progress of the Stark-deceleration method for creating cold samples of molecules. Progress includes:

1) Improved trap-loading: the efficiency of loading the electrostatic trap has been significantly improved, increasing the number density of trapped molecules with about two orders of magnitude to about $10^8$/cm$^3$. The temperature of the trapped sample of molecules could be obtained directly from the spatial distribution inside the trap, and is close to 30 mK. In addition, it was demonstrated that it is straightforward to extend the deceleration and trapping scheme to simultaneously store different isotopes, in this case $^{14}\text{ND}_3$ and $^{15}\text{ND}_3$, under comparable conditions.

2) Bunching. We have demonstrated a (re-)bunching element that can be used to manipulate the velocity distribution of the package of molecules leaving the Stark-decelerator. It is effectively a lens for the packages of molecules in the longitudinal direction (i.e. along the molecular beam axis), allowing the preparation of a 'parallel' beam (strongly reduced width of the velocity distribution), as well as a converging beam (i.e. re-bunching of the molecules at a specific position downstream). Mounting the bunching element in between the decelerator and the storage ring will make it possible to detect many more round trips in the very near future.

3) High-field seeking molecules. All experiments reported so far are performed on molecules in low-field seeking states. Molecules that are most suitable for confinement schemes, i.e. molecules residing in their lowest energy level, however, are always high-field seekers. For that reason we have explored two different schemes to extend the deceleration method to molecules residing in high-field seeking states as well:

a) deceleration of high-field seekers using electrostatic dipole lenses in the alternate gradient configuration. With this setup a pulsed beam of metastable CO in high-field seeking states is accelerated from 275 m/s to 289 m/s as well as decelerated from 275 m/s to 260 m/s.

b) RF-transformation of low- to high-field seeker. The transfer efficiency is determined for deuterated ammonia, and, in addition, sensitive RF-spectroscopy of the inversion doublets of $^{14}\text{ND}_3$ and $^{15}\text{ND}_3$ is performed, revealing the detailed hyperfine structure of both ammonia isotopes.