COLD ION-MOLECULE CHEMISTRY WITH A STARK DECELERATOR BEAMLINE

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We describe an experimental method for studying ion-molecule reactive collisions at very low energies. Building on our previous work using an electrostatic quadrupole guide as a source of cold neutral molecules, we discuss a proof of principle study of the charge-exchange reaction between cold xenon ions and Stark decelerated ammonia molecules.

Ammonia molecules from a pulsed supersonic expansion are produced at low velocities using the Stark deceleration technique of Meijer and co-workers. The decelerated molecules are focussed using pulsed electrostatic hexapoles into the centre of a radiofrequency ion trap where they collide with cold xenon ions. A fast-opening vacuum-compatible mechanical shutter installed in the beamline is used to prevent transmission of the undecelerated molecules and carrier gas into the ion trap chamber.

To prepare the target ions, the ion trap is loaded with calcium ions, which are Doppler laser cooled to form a low-temperature ordered "Coulomb crystal" phase. Xenon ions formed by resonant multiphoton ionisation are subsequently loaded and sympathetically cooled through their Coulomb interaction with the laser-cooled ions. The spatial distribution of fluorescence emitted by the laser-cooled ions in the multicomponent crystal is imaged; reactive collisions of Xe^+ with ND_3 are observed and quantified through changes in this distribution. By varying the high voltage switching sequence applied to the decelerator, the velocity of the ammonia molecules can be tuned from around 250 m/s to 35 m/s. For collisions with trapped xenon ions, this corresponds to collision energies (expressed in temperature units) from 65 K down to close to 1 K.