Cold collisions of decelerated molecules and laser-cooled ions

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As temperatures are lowered below 1K, gas phase chemical processes enter a new physical regime, as they start to undergo a transition from a classical collision picture to one dominated by quantum (wave-like) behaviour. The deBroglie wavelength for translational motion gets progressively longer, becoming greater than the range of molecular interactions. Thermal averaging is lessened and thus the opportunities for precise control of chemical processes are enhanced. We aim to explore this novel physical regime for chemistry taking advantage of recently developed technology for producing cold atoms and molecules. Laser-cooled atomic ions, and sympathetically cooled molecular ions provide ideal targets for studying reactive collisions at very low temperatures when combined with sources of cold neutral atoms and molecules. We have commissioned several cold neutral sources including a Stark decelerator and buffer-gas cooled quadrupole guide, both suitable for use with dipolar molecules such as ammonia, and a Zeeman decelerator and a photodissociation source, suitable for paramagnetic species. Progress in developing these sources and combining them with trapped ions for studying the dynamics and kinetics of chemical processes at ultralow temperatures will be presented.