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Stark and Zeeman deceleration of atoms and molecules

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In the past years considerable efforts have been invested to develop general methods with which to produce cold samples of atoms and molecules that cannot be laser cooled. Methods developed so far include, among others, the photoassociation of ultracold atoms [1], buffer-gas cooling [2] and multistage Stark deceleration [3]. With the aim of performing high-resolution spectroscopic measurements, we have recently contributed to the development of two new methods of producing cold samples of atoms and molecules starting from supersonic beams: Rydberg-Stark deceleration [4] and multistage Zeeman deceleration [5,6]. The talk will provide a description of these two methods. The former method exploits the very large dipole moments (more than 1000 Debye) that can be induced in atomic and molecular Rydberg states by electric fields and was recently used to stop and trap clouds of translationally cold Rydberg atoms and molecules after deceleration in a single-stage device [7,8]. The latter method exploits the Zeeman effect in paramagnetic species and the ability to switch on and off large magnetic fields (>2 Tesla) in about 5 μs. It was used to decelerate an atomic sample initially in a supersonic beam to zero velocity in the laboratory reference frame and subsequently load the atoms into a magnetic trap [9]. The deceleration methods, the diagnostic methods to characterize the velocity distributions of the decelerated species and the trapping methods will be illustrated by experiments conducted on hydrogen atoms and molecules.

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