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Creating Cold Molecules

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The techniques of laser cooling and trapping have transformed atomic physics. The ease of obtaining ultracold atomic samples with these methods has led to new experimentally realizable quantum systems, including the dilute gas Bose-Einstein condensate and the degenerate Fermi gas. After several decades of rapid growth in the field of atom cooling and trapping, the obvious next step is to extend these studies to cold molecules. Molecules have a rich internal energy structure, creating new research opportunities in quantum chemistry, novel collision studies, and collective quantum effects. Cold molecular packets are produced by supersonic expansion coupled with Stark deceleration. First the molecules undergo the expansion process, which cools both the external and internal degrees of freedom. The resulting molecular beam is then slowed to rest by the method of Stark deceleration. Stark deceleration uses the molecules' interactions with inhomogenous electric fields to decelerate the beam. The molecules are then trapped electrostatically, where their collisions can be studied.