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Taming polar molecules for quantum experiments

Polar molecules offer fascinating opportunities for quantum experiments at cold (<1K) and ultracold (<1mK) temperatures. For example, chemistry at low temperatures features new possibilities such as controlling chemical reactions via electric and magnetic fields or observing reactions based on tunnelling through a reaction barrier. Precision measurements on molecules provide insight into fundamental physics, allowing investigation of physics beyond the standard model. Attaining sufficient control over molecules provides opportunities for quantum simulations and quantum information processing.

In the past, much of our effort has been focused on developing techniques to generate the required ensembles of molecules at very low temperatures. Our cryofuge technique, the combination of cryogenic buffer-gas cooling and centrifuge deceleration, generates record-high continuous fluxes of molecules at a temperature below 1K. Optoelectrical Sisyphus cooling has allowed us cool polyatomic molecules to temperatures as low as 400uK.

Building on this success, we are increasingly aiming at various applications of cold and ultracold molecules. In my talk, I will focus on one specific possibility, combining polar molecules with Rydberg atoms. This hybrid system offers possibilities such as nondestructive molecule detection, matter-based precision spectroscopy, and quantum information processing.