Cold molecular hydrogen

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Hydrogen molecule, the simplest neutral chemically bound system, is an ideal benchmark for testing quantum theory. Precise determination of the energy intervals between rovibrational levels allows for testing quantum electrodynamics (QED) for molecules [1] and putting constraints on the strength of beyond-Standard-Model interactions [2]. Compared to other simple calculable species, hydrogen possesses a unique advantage: its ground electronic state harbors hundreds of long-living rovibrational states, setting the ultimate limit for testing quantum theory with this molecule at the level of 10^{-24}. Current experiments remain 14 orders of magnitude above this limit [3].

I will present our ongoing work to explore this gap using cold H_2. In particular, I will discuss the new cavity-enhanced spectrometer fully operating in the deep cryogenic regime (down to 4 K) [4]. Beyond testing QED on molecular hydrogen, the setup enables the realization of primary SI standards for temperature, concentration, and pressure at cryogenic conditions, and allows to explore the H_2 phase diagram below its triple point. Finally, I will outline the progress towards trapping a cold H_2 sample in a 0.2 K-deep optical dipole trap, currently under development in our group.

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