Accurate spectroscopy of cold hydrogen molecules

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Due to its simplicity, H_2 constitutes a perfect tool for testing fundamental physics: testing quantum electrodynamics, determining fundamental constants, or searching for new physics beyond the Standard Model. H_2 has a huge advantage over the other simple calculable systems of having a set of a few hundred ultralong living rovibrational states, which implies the ultimate limit for testing fundamental physics with H_2 at a relative accuracy level of 10^{-24}. The present experiments are far from this limit.

I will present our cavity-enhanced spectrometer fully operating in the deep cryogenic regime down to 4 K [1]. We solved several technological challenges that allowed us to uniformly cool not only the sample but also the entire cavity, including the mirrors and cavity length actuator [2], which ensures the thermodynamic equilibrium of a gas sample. I will present our first experimental results on accurate determination of the energy of the 1-0 S(0) transition in H_2 [1]. I will also present our so far results of an ongoing project aimed at trapping cold H_2.

References

[1] K. Stankiewicz, et al., https://arxiv.org/abs/2502.12703 (2025).

[2] M. Słowiński, et al., *Rev. Sci. Instrum.* **93**, 115003 (2022).