Precision spectroscopy of HD at 1.4 μm

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The weak infrared spectrum of the heteronuclear diatomic molecule HD originates from the existence of a small electric dipole moment ($\sim 10^{-5}$ D), due to the inversion symmetry breaking in conjunction to the breakdown of the Born-Oppenheimer approximation. Since the HD has only two nuclei and two electrons, representing one of the simplest molecular systems existing in nature, it is possible to perform highly-accurate *ab-initio* quantum-mechanical calculations of its energy dipole transition levels and moments which take into account the violation of Born-Oppenheimer approximation by means of adiabatic and non-adiabatic corrections [1]. A quantum test system for fundamental physics can be obtained comparing HD precision measurements with advanced QED calculations which in turn puts constraints on a fifth force for a certain effective range [2].

In this work, a precision measurement of the HD electric-dipole first overtone band transition R(1) line-center frequency has been carried out implementing a new concept of frequency-stabilized cavity ring-down spectroscopy. It is based on the use of a pair of phase-locked extended-cavity diode lasers (ECDL) emitting in the wavelength range between 1.38 and 1.41 μm [3]. One of these acts as reference oscillator, being locked to a high-finesse cavity by means of the Pound-Drever-Hall (PHD) technique which in turn is locked to a self-referenced erbium-doped fiber-laser based Optical Frequency Comb Synthesizer (OFCS). The frequency of the probe laser is accurately scanned across the HD vibration-rotation transition, while an intrinsically stable high-finesse optical cavity tracks the laser frequency. Observing several repeated cavity ring-down events, absorption spectra have been recorded with high resolution, precision and fidelity. The cavity finesse determined under vacuum conditions is about 160000, which enables to get an optical path of 43.8 km. The measurements have been performed on a 97% ^{2}H-enriched hydrogen sample, at a pressure ranging between 1 e 15 Torr. As a result of a global fitting procedure of a manifold of spectra across the pressure range, the line center frequency has been determined to be 7241.849351(2) cm^{-1}, that is (217105181.75 $\pm$ 0.07) MHz. It agrees with the theoretical value 217105180 (2) MHz reported in [1].

Further measurements of the HD first overtone band absolute frequency lines will be attempted in the near future.

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