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Search for varying constants and new physics from molecular hydrogen

Tuesday, 13 September 2016 10:00 (1 hour)

The spectroscopy of molecular hydrogen can be used for a search into physics beyond the Standard Model. Differences between the absorption spectra of the Lyman and Werner bands of H_2 as observed at high redshift and those measured in the laboratory can be interpreted in terms of possible variations of the proton-electron mass ratio $\mu = m_p/m_e$ over cosmological history. Investigation of some ten of such absorbers in the redshift range $z = 2.0 - 4.2$ yields a constraint of $|\Delta\mu/\mu| < 5 \times 10^{-6}$ at 3σ, as was recently reported in a review [1]. Observation of H_2 from the photospheres of white dwarf stars inside our Galaxy delivers a constraint of similar magnitude on a dependence of μ on a gravitational potential 10^4 times as strong as on the Earth's surface [2].

While such astronomical studies aim at finding quintessence in an indirect manner, laboratory precision measurements target such additional quantum fields in a direct manner. Laser-based precision measurements of dissociation energies, vibrational splittings and rotational level energies in H_2 molecules and their deuterated isotopomers HD and D_2 produce values for the rovibrational binding energies fully consistent with quantum ab initio calculations including relativistic and quantum electrodynamical (QED) effects [3]. Similarly, precision measurements of high-overtone vibrational transitions of HD^+ ions, also result in transition frequencies fully consistent with calculations including QED corrections [4].
These comprehensive results of laboratory precision measurements on neutral and ionic hydrogen molecules can be interpreted to set bounds on the existence of possible fifth forces [5] and of higher dimensions [6], phenomena describing physics beyond the Standard Model.

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Summary

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