

Hydrogen molecular ions, fundamental constants, and new physics

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In recent years, the accuracy of rotational and vibrational spectroscopy of HD^+ was improved by nearly three orders of magnitude by use of techniques for Doppler-free excitation [1, 2, 3]. Meanwhile, the precision of theoretical transition frequencies was improved to below the level of 10 parts per trillion (ppt), so that it is now mainly limited by the uncertainty of the 2018 CODATA value of m_p/m_e [4].

We present a global analysis of existing data [5], using the theoretical hyperfine structure to extract the values of spin-averaged transition frequencies through a global linear least-squares adjustment. Using the obtained frequencies, we then assess the potential contribution of HD^+ spectroscopy to the determination of fundamental constants. Our analysis shows that the HD^+ data may significantly improve the values of m_p/m_e and of the electron relative atomic mass, in particular if combined with recent high-precision measurements performed in Penning traps.

High-precision spectroscopic data, including HD^+ , can be used to constrain hypothetical interactions beyond the standard model, which is usually done by comparing experimental results with predictions from the standard model that use CODATA recommended values of fundamental constants. However, it should be realized that the determination of fundamental constants itself would be affected by the new physics being tested. In a second part, we show how this issue can be solved by simultaneously determining both standard-model and new-physics parameters in a consistent way from a global fit [6]. At present, the data show tensions partly related to the proton charge radius, which can be alleviated by including contributions from a light scalar with flavor non-universal couplings.

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