A measurement of the proton mass by rotational spectroscopy of HD^+ molecular ions

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We have developed an approach that enables Doppler-free rotational spectroscopy of sympathetically cooled molecular ions in ion traps [1]. It makes use of the strong radial spatial confinement of molecular ions when trapped and crystallized in a linear quadrupole trap, providing the Lamb-Dicke regime for rotational transitions. We achieve a line width of 1×10^{-9}, an improvement by ≈ 50 times over previous highest resolution in rotational spectroscopy of ensembles of ions.

We have measured the absolute frequency of the fundamental rotational transition in HD^+, (v = 0, N = 0) → (v = 0, N = 1) (v, N are the vibrational and rotational quantum number, respectively) at 1.3 THz. We compare the value with the result of an *ab initio* calculation for this transition, which is proportional to the combination of fundamental constants $m_e/m_p+m_e/m_d$. Using CODATA2014 values for the deuteron mass and for the electron mass, we derive

$$m_p = 1.007\ 276\ 466\ 9(13)\ \text{u}\ .$$

The presentation will discuss the experimental technique, the result and the potential for further improvement.

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[1] S. Alighanbari, *et al.* Nature Physics, in press (2018); arXiv:1802.03208v1