Search for a drifting proton-to-electron mass ratio from molecular spectra

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General relativity and the standard model of particle physics depend on a number of independent numerical parameters that determine the strengths of the different forces and the relative masses of all known fundamental particles. Although they determine properties of atoms, cells, stars and the whole Universe, there is no theoretical explanation of why they have values they have. Moreover, even if they are commonly reffered to as the fundamental constants of nature, it is also commonly admitted that these constants could vary over cosmological time and space. So far, the constants seem to be constant. But, nobody understand why it is so. The aim to solve the problem is also supported by the fact that the actual values of some of the constants appear to be very finely adjusted to allow for the life we enjoy on our planet.

One way for to probe a possible variation of certain fundamental constants is based on a comparison between wavelengths of astronomical spectral lines as observed at high redshift (λ_{ast}) with wavelengths of the same lines measured at zero redshift in the laboratory (λ_{lab}). For a given transition i it holds

$$\lambda^i_{ast} = \lambda^i_{lab}(1+z)(1+K_i\frac{\Delta\mu}{\mu}),$$

where z is the astronomical redshift of the source of the probed radiation, $K_i = \frac{\mathrm{d}ln\lambda_i}{\mathrm{d}ln\mu}$) is the so-called sensitivity coefficient, $\mu = m_p/m_e$ is the proton-to-electron mass ratio and $\Delta\mu$ is its cosmological drift. Apparently, the effects of the cosmological drift are proportional to the sensitivity coefficients. As a matter of fact, typical magnitudes of these coefficients ($\sim$ 0, -1/2 and -1 for the electronic, vibrational and rotational transitions, respectively) appear to be too small for resolving the constancy problem of the physical constants. Nevertheless, in the case of some near-degeneracy transitions, the sensitivities may be significantly enhanced (e.g., the sensitivity of the inversion or internal rotational transitions), providing thus new hope for more decisive constraining of the probed pron-to-electron mass ratio. So far, despite of impressive progress in this direction, the constancy question still remains unanswered. However, as there is a plethora of the so far unprobed astronomical spectral transitions, it does not appear unthinkable that there exist transitions possessing sensitivity adequate for final answers. Therefore, together with (very few) other 'hunters', we find it worthwhile to continue the search for such promising transitions. To date, we have already found several transitions which are not only anomalously sensitive, but also strong enough for to be detected extragalactically. The story of our search will be detailed in my talk.