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Variation of fundamental constants: theory

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Theories unifying gravity with other interactions suggest temporal and spatial variation of the fundamental "constants" in expanding Universe. There are some hints for the variation of different fundamental constants in quasar absorption spectra and Big Bang nucleosynthesis data. A large number of publications (including atomic clocks) report limits on the variations. We want to study the variation of the main dimensionless parameters of the Standard Model: 1. Fine structure constant alpha (combination of speed of light, electron charge and Plank constant). 2. Ratio of the strong interaction scale (Lambda$_{QCD}$) to a fundamental mass like electron mass or quark mass which are proportional to Higgs vacuum expectation value. The proton mass is propotional to Lambda$_{QCD}$, therefore, the proton-to-electron mass ratio comes into this second category. We performed necessary atomic, nuclear and QCD calculations needed to study variation of the fundamental constants using the Big Bang Nucleosynthsis, quasar spectra, Oklo natural nuclear reactor and atomic clock data. The relative effects of the variation may be enhanced in transitions between narrow close levels in atoms, molecules and nuclei. If one will study an enhanced effect, the relative value of systematic effects (which are not enhanced) may be much smaller. Note also that the absolute magnitude of the variation effects in nuclei (e.g. in very narrow 7 eV transition in 229Th) may be 5 orders of magnitude larger than in atoms. A different possibility of enhancement comes from the inversion transitions in molecules where splitting between the levels is due to the quantum tunneling amplitude which has strong, exponential dependence on the electron to proton mass ratio. Our study of NH_3 quasar spectra has already given the best limit on the variation of electron to proton mass ratio.