

Variation of fundamental constants from Big Bang to atomic clocks: theory and observations.

Victor Flambaum

*School of Physics, The University of New South Wales Sydney 2052 NSW, Australia,
flambaum@phys.unsw.edu.au*

Abstract. Theories unifying gravity with other interactions suggest temporal and spatial variation of the fundamental “constants” in expanding Universe. The spatial variation can explain fine tuning of the fundamental constants which allows humans (and any life) to appear. We appeared in the area of the Universe where the values of the fundamental constants are consistent with our existence.

I present a review of works devoted to the variation of the fine structure constant α , strong interaction and fundamental masses (Higgs vacuum). There are some hints for the variation in quasar absorption spectra and Big Bang nucleosynthesis data.

A very promising method to search for the variation consists in comparison of different atomic clocks. Huge enhancement of the variation effects happens in transitions between very close atomic, nuclear and molecular energy levels. Large enhancement also happens in nuclear, atomic and molecular collisions near resonances.

How changing physical constants may occur? Light scalar fields very naturally appear in modern cosmological models, affecting parameters of the Standard Model (e.g. α). Cosmological variations of these scalar fields should occur because of drastic changes of matter composition in Universe: the latest such event is rather recent (about 5 billion years ago), from matter to dark energy domination. Massive bodies can also affect physical constants. The strongest limits are obtained from the measurements of dependence of atomic frequencies on the distance from Sun (the distance varies due to the ellipticity of the Earth’s orbit).

Keywords: fundamental constants, quasar absorption spectra, atomic clocks