Using atoms and molecules to search for variation of fundamental constants

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Frequencies of atomic and molecular transitions depend on the values of the fine structure constant $\alpha = \frac{e^2}{\hbar c}$ and electron to proton mass ratio $\mu = \frac{m_e}{m_p}$. High precision spectroscopy for narrow optical transitions in atoms and molecules put very stringent limits on the time variation of α and μ on the time scale of few years. Astrophysical high redshift observations constrain space-time variations on the cosmological scale on the order of 10 billion years.

In the talk I will discuss several examples of the transitions with high sensitivity to the fundamental constants in molecules and in highly charged ions. In particular, I will focus on the transitions between quasi degenerate levels. Quasi degeneracy can be caused either by some approximate symmetry, or by the accidental cancellation between different contributions to the energy of the atomic system. The latter case is particularly important for the laboratory experiments, where the absolute sensitivity to the variation of the fundamental constants is as important as the relative sensitivity. For the astrophysical observations, where the lines are Doppler broadened, the relative sensitivity plays the main role [1].

Molecular physics gives us many examples of the quasi degeneracy of both types, which leads to the high relative sensitivity of the molecular microwave transitions to the variation of the fundamental constants. Such transitions are particularly interesting to the astrophysics. Recently it was pointed out that one can observe very narrow optical transitions in the highly charged ions [2]. These transitions appear when there is level crossing between different atomic shells in the isoelectronic sequences of ions. On the energy scale typical to ions such crossings can be considered as an accidental degeneracy. Corresponding optical transitions can be used as very sensitive probes to the variation of the fine structure constant α in the laboratory tests [2,3].

References

[1] M. G. Kozlov & S. A. Levshakov Annalen der Physik **525**, 452-471 (2013)
[2] J. C. Berengut, V. A. Dzuba, and V. V. Flambaum, Phys. Rev. Lett. **105**, 120801 (2010)
[3] M. S. Safronova *et al.* Phys. Rev. Lett. **113**, 030801 (2014)