SYFC 2: Variations of Fundamental Constants II

Time: Monday 16:30–18:00 Location: A 001

Invited Talk SYFC 2.1 Mo 16:30 A 001

Gravitational and cosmological probes of varying fundamental parameters — •Thomas Dent — Cardiff University

If fundamental parameters of physics such as gauge couplings and particle masses (mass ratios) vary over spacetime then the equivalence principles and framework of general relativity must be altered. As one result, test objects of different composition do not feel the same acceleration: hence local variations can be tested by Eötvös experiments. This provides the strongest bound on variations within the Solar System tracking the gravitational potential.

For physical consistency, an extra degree of freedom is required to exist as a cause of variation. If there is a cosmological time variation such a field will contribute to the expansion of the Universe via its stress-energy. This contribution can be bounded by probes of 'dark energy', putting interesting bounds on the magnitude of time variation in different scenarios.

Invited Talk SYFC 2.2 Mo 17:00 A 001

The astrophysical search for varying fundamental constants — •Nils Prause — Hamburger Sternwarte, Germany

The currently favoured model of an accelerated universe with a cosmological constant gave rise to a number of theories, most of them including a variation of fundamental constants. Next to laboratory measurements, astrophysical observations are of great importance to probe these variations. Using the light of distant background quasars, the evolution of fundamental constants can be traced back to the the early stages of the universe. Molecular rotational and atomic resonance transitions were studied, using high resolution spectroscopy covering a wide wavelength range, to set constraints for the fine structure constant α and the proton to electron mass ratio μ.

SYFC 2.3 Mo 17:30 A 001

Variability of the proton-to-electron mass ratio on cosmological scales - quantification and handling of systematics — •Martin Wendt — Hamburger Sternwarte, Germany

Cosmology contributes a good deal to the investigation of variation of fundamental physical constants. High resolution data is available and allows for detailed analysis over cosmological distances and a multitude of methods were developed. The raised demand for precision requires a deep understanding of the limiting errors involved. The achievable accuracy is under debate and current observing proposals max out the capabilities of todays technology. The question for self-consistency in data analysis and effective techniques to handle unknown systematic errors is of increasing importance. Evidently systematics are not yet under control or fully understood since findings by different groups are partially in disagreement witch each other . We try to emphasize the importance to take these errors, namely i.e. calibration issues, into account and put forward some measures adapted to the problem.

SYFC 2.4 Mo 17:45 A 001

Towards Direct Frequency Comb Spectroscopy of Metal Ions — •Boerge Hemmerling, Daniel Nigg, Ivan V. Sherstov, and Piet O. Schmidt — QUEST Inst. for Experimental Quantum Metrology, PTB Braunschweig & Leibniz University of Hannover, Germany

The possible variation of fundamental constants is a highly debated subject. Laboratory experiments that compare ultra-precise clocks to probe the variation of the fine-structure constant are within their errors compatible with $\dot{\alpha}/\alpha \sim 0$. However, experiments on astronomical time scales that compare quasar absorption spectra with today's spectra of metal ions yield contradictory results reaching from no variation to $\Delta\alpha/\alpha \sim 10^{-5}$. The latter observations are amongst other obstacles limited by inaccurate spectroscopy data on certain transition lines in complex ions such as Ca^{+}, Ti^{+} and Fe^{+} [1].

We plan to investigate these ions by sympathetically cooling them via magnesium ions in a linear Paul trap to the motional ground state. By employing well-developed quantum logic techniques [2], we plan to elude difficulties, such as state preparation and detection in these multi-level systems. Furthermore, a frequency comb will be used as a spectroscopy probe to cover the few 10 nm wide band of interesting transition lines. We will present the latest experimental results of our ground state cooling scheme where we compare pulsed and cw approaches to reach the ground state of the harmonic trap.

[1] J. C. Berengut et al., arXiv:physics/0408017 (2006)
[2] P. O. Schmidt et al., Science 309, 749-752 (2005)