Measurement of the Fine Structure Constant with a statistical uncertainty below 10^{-10}

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The comparison between determinations of the Fine Structure Constant α based on atomic interferometry and that derived from the measurement of the electron's gyromagnetic anomaly a_e provides a stringent test of the standard model.

On Fig. 1, left, we have plotted the most precise determinations of α. The value $\alpha(a_e)$ is obtained by combining the measurement of a_e made by the group of Gabrielse at Harvard university[1] with the last quantum electrodynamics calculations performed by Riken group[2]. Concerning the values deduced from the measurement of atomic recoil by atom interferometry, the group of H. Müller at Berkeley published recently a new value of α with an uncertainty of 2.0×10^{-10} (systematics: 1.2×10^{-10}, statistics: 1.6×10^{-10})[3]. This value is consistent with our previous measurement (with an uncertainty of 6.6×10^{-10})[4] and shows a discrepancy of 2.5σ with the value $\alpha(a_e)$. This discrepancy needs to be confirmed by other independent measurements with similar or better accuracy.

Last year we have exerted an intense experimental work on our new experimental setup, which now reaches a statistical uncertainty of 6×10^{-11} per 24 hours of integration (see Fig 1, right). This sensitivity allows us to investigate experimentally many systematic effects. In particular, we have been able to tackle a previously undetected effect: velocity dependent phase shift with Raman transitions, which we have used to perform a reduction of the systematic effect induced by light shifts. We are currently finalizing the error budget. In my presentation, I will present the latest results of our experiment.

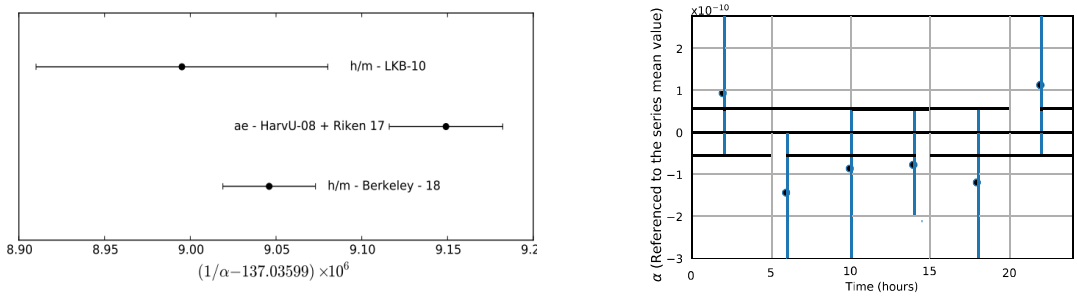

Figure 1: Left: most recent values of α. Right: typical set of data taken continuously during 24 hours. Each point corresponds to 4 hours of integration. The series statistical uncertainty is $5.6\ 10^{-11}$.

[1] D. Hanneke, S. Fogwell, G. Gabrielse, *New Measurement of the Electron Magnetic Moment and the Fine Structure Constant*, Phys. Rev. Lett. **100**, 120801 (2008)

[2] T. Aoyama, M. Hayakawa, T. Kinoshita, M. Nio, *Tenth-order electron anomalous magnetic moment: Contribution of diagrams without closed lepton loops,* Phys. Rev. D **96**, 019901 (2017).

[3] R. H. Parker, C. Yu, W. Zhong, B. Estey, and H. Müller, *Measurement of the Fine-Structure Constant as a Test of the Standard Model*, Science **360**, 6385 191-95 (2018)

[4] R. Bouchendira, P. Cladé, S. Guellati-Khélifa, F. Nez, F. Biraben, *New Determination of the Fine Structure Constant and Test of the Quantum Electrodynamics*, Phys. Rev. Lett. **106**, 080801 (2011)