Determination of the fine-structure constant using atom interferometry

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To test the standard model, we need to know the parameters that scale the fundamental interactions. Among them, the fine structure constant α which characterizes the strength of the electromagnetic interaction and thus plays a crucial role in quantum electrodynamics calculations. Using atom interferometry to measure the quotient $\hbar/m_{\mathrm{Rb}}$ of the reduced Planck's constant and the mass of a rubidium-87 atom, we obtained the most accurate determination of the fine structure constant $\alpha = 1/137.035999206(11)$ with a relative accuracy of 81 parts per trillion (ppt) [1]. This value differs by 5.6 σ from the one deduced from the cesium recoil measurement [3].

Combining Ramsey-Bordé interferometer based on Raman diffraction with Bloch oscillations in accelerated optical lattice and using an ultra-stable and robust experimental set-up, we achieved a record sensitivity of 4×10^{-11} to α in 48 h integration time. This enabled us to investigate experimentally several systematic effects, especially those related to wave-front distortions [2].

In this talk, I will present our experiment and I will discuss the impact of the new value of α on the test of the Standard Model based on the comparison between the theoretical and experimental values of the electron anomalous magnetic moment[5, 4]. I will also present some results from our recent work on the atom interferometer based on the diffraction of atoms by a picosecond frequency-comb laser [6]

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