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Measurement of the fine-structure constant as a test of the Standard Model

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Measurements of the fine-structure constant a require methods from across subfields and are thus powerful tests of the consistency of theory and experiment in physics. Using the recoil frequency of cesium-133 atoms in a matter-wave interferometer, we recorded the most accurate measurement of the fine-structure constant to date: a = 1/137.035999046(27) at 2.0 × 10−10 accuracy. Using multiphoton interactions (Bragg diffraction and Bloch oscillations), we demonstrate the largest phase (12 million radians) of any Ramsey-Bordé interferometer and control systematic effects at a level of 0.12 part per billion. Comparison with Penning trap measurements of the electron gyromagnetic anomaly g-2 via the Standard Model of particle physics is now limited by the uncertainty in g-2; a 2.5-sigma tension rejects dark photons as the reason for the unexplained part of the muon's magnetic moment at a 99% confidence level. Implications for dark-sector candidates and electron substructure may be a sign of physics beyond the Standard Model that warrants further investigation.

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