Quantum Tests of the Einstein Equivalence Principle on Ground and in Space

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The Einstein equivalence principle is a corner stone of general relativity and therefore challenged with growing precision by experimental tests on ground [1,2] and in space [3]. In the recent past several atom-interferometric experiments were started with the aim to perform precise tests of the universality of free fall with quantum matter displaying unique features such as a long coherence length or pure sin polarisation [9-10]. They aim to reduce the present sensitivity gap between current ground based tests and a future space mission STE-QUEST [11,12], which will allow to improve on the ultimate systematic uncertainties of ground based experiments. A more elaborate version of STE-QUEST is proposed for The ESA M4-mission. It will host a dual species interferometer for testing the universality of free fall as well as enable intercontinental comparisons of state-of-the-art ground clocks for a test of the sun and moon gravitational redshift.

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[1] J. G. Williams, S. G. Turyshev, D. H. Boggs, Phys. Rev. Lett. 93, 261101 (2004).
[2] S. Schlamminger, K.-Y. Choi, T. A. Wagner, J. H. Gundlach, and E. G. Adelberger, Phys. Rev. Lett. 100, 041101 (2008).
[3] P. Touboul, G. Métris, V. Lebat, and A. Robert, Class. Quantum Grav. 29, 184010 (2012).
[4] S. Fray and M. Weitz, Space Sci. Rev. 148, 225 (2009).
[5] A. Bonnin, N. Zahzam, Y. Bidel, and A. Bresson, Phys. Rev. A 88, 043615 (2013)
[6] M. G. Tarallo, T. Mazzoni, N. Poli, D.V. Sutyrin, X. Zhang, and G. M. Tino, Phys. Rev. Lett 113, 023005 (2014)
[7] G. Varoquaux, A. Landragin, R. A. Nyman, R. Geiger, P. Cheinet,and P. Bouyer, New J. Phys. 11, 113010 (2009).
[8] S. M. Dickerson, J. M. Hogan, A. Sugarbaker, D. M. S.Johnson, and M. A. Kasevich, Phys. Rev. Lett. 111, 083001 (2013).
[9] A. Sugarbaker, S. M. Dickerson, J. M. Hogan, D. M. S.Johnson, and M. A. Kasevich, Phys. Rev. Lett. 111,113002 (2013).
[10] H. Müntinga et al., Phys. Rev. Lett. 110, 093602 (2013).
[11] D. N. Aguilera et al., Class. Quantum Grav. 31, 115010 (2014)
[12] G. M. Tino and M. Kasevich (eds) 2013 Precision interferometry with Bose-Einstein condensates (Atom Interferometry vol 188) (Proceedings of the International School of Physics "Enrico Fermi") N. Gaaloul, J. Hartwig, C. Schubert, W. Ertmer, and E. M. Rasel