PHYSICS AND ASTRONOMY

COLLOQUIUM

Dr. Holger Mueller

University of California/ Berkeley

"Matter-Wave Clocks"

Abstract

De Broglie's matter wave hypothesis describes particles as oscillators at the Compton frequency mc^2/h, where m is the particle's mass, c the speed of light, and h the Planck constant [1]. We illustrate the physical significance of these oscillations through a series of atom-interferometry experiments that employ particles as Compton-frequency clocks: (i) A test of the gravitational redshift at an accuracy of 7 parts per billion [2] and its interpretation in the framework of the standard model extension [3]; (ii) A proposed gravitational Aharonov-Bohm experiment, which will reveal the gravitational redshift of the Compton frequency even in absence of a gravitational force [4]; (iii) A matter-wave clock, in which the Compton frequency of a Cs atom (~3x10^25 Hz) is divided into a conveniently measurable frequency range, based on a combination of an atom-interferometer and an optical frequency comb. The clock achieves an accuracy of 4 parts per billion and can serve as a time standard based on mass or vice versa [5]. Particles are clocks.

[1] L. de Broglie, Ph. D. thesis (Univ. Paris, 1924).

[2] H. Müller, A. Peters, and S. Chu. Nature 463, 926 (2010).

[3] M. A. Hohensee, S. Chu, A. Peters, and H. Müller, Phys. Rev. Lett. 106, 151102 (2011).

[4] M. A. Hohensee, B. Estey, P. Hamilton, A. Zeilinger, and H. Müller. Phys. Rev. Lett. 108, 230404 (2012).

[5] S.-Y. Lan, P.-C. Kuan, B. Estey, D. English, J. M. Brown, M. A. Hohensee, and H. Müller, submitted (2012)

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Bob Wright Centre

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