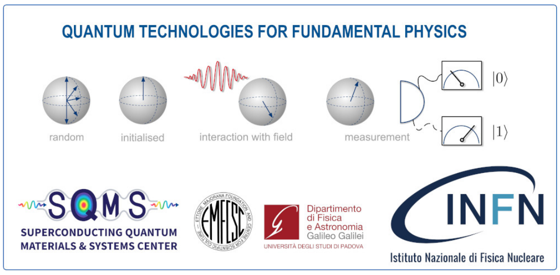

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Towards tests of causal nonlinear quantum mechanics using light-pulse atom interferometry

Tuesday, 5 September 2023 09:25 (25 minutes)

Long-baseline light-pulse atom interferometry (LPAI) is a powerful tool for performing tests of fundamental physics (see [1] and reference therein). Using state-of-the-art technology for coherent manipulation of ultra-cold (picoKelvin) atoms, LPAI is capable of creating quantum superpositions over tens of meters. Moreover, due to acceleration sensitivities close to 10-14 m/s2, using (say) a 100 meter tall LPAI, gravitational phenomena can be studied in conjunction with quantum mechanics (QM). In this talk, I'll discuss our efforts in the construction of two such LPAIs at the Fermi National Accelerator Laboratory (Fermilab) and Northwestern University.

Following recent theoretical investigation of implications of causal nonlinear QM [2], experimental bounds were set on the nonlinear parameter, ε, of said theory using nuclear spins and ions [3,4]. I will discuss proposed tests of this theory using LPAI. Such a measurement involves sensing gravity from well-controlled terrestrial source masses placed at different positions relative to the LPAI. According to the Everett many-worlds interpretation of QM, LPAI can infer a nonlinear coupling, ε, between different branches of the universal wave function with the source mass in different locations. I will discuss measurement schemes for setting new bounds on ε using LPAI.

[1] Abe et al. (2021). Quantum Sci. Technol. 6, 044003.
[2] Kaplan and Rajendran. (2022). Phys. Rev. D 105, 055002
[3] Polkovnikov et al. (2023). Phys. Rev. Lett. 130, 040202
[4] Broz et al. (2023) . Phys. Rev. Lett. 130, 200201

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