# Using precision oscillators to test fundamental physics

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Cryogenic sapphire oscillators at microwave frequencies have been constructed in the laboratories of the Frequency Standards and Metrology Research Group since 1990, with frequency instabilities of parts in $10^{15}$ [1], and a decade latter with instabilities of parts in $10^{16}$ [2]. Due to this innovation, sapphire oscillators have become important tools for testing some fundamental principles of physics. For example, the technology has been used for highly sensitive transducers for gravitational wave detectors [3], to pump the transitions of atomic frequency standards with improved signal to noise ratio [4,5], and for tests of Lorentz Invariance, such as Kennedy Thorndike and Michelson-Morley experiments, as well as tests in the photon sector of particle physics [6-11].

In this work we present results of a continuously rotating cryogenic microwave oscillator constructed to test Local Lorentz Invariance (LLI). Initial results from this experiment [11] improve limits set by previous non-rotating experiments by more than a factor of 7 with only 3 months of data. Now, with over 12 months of data, we have reduced the noise floor by a factor of 2. Also, we present experiments that are sensitive to the scalar and parity-odd coefficients for Lorentz violation in the photon sector of the Standard Model Extension (SME) of particle physics. We are developing a high precision microwave interferometer experiment [10] with different electromagnetic properties in the two arms. With present technology we estimate that the scalar and parity odd coefficients may be measured at sensitivity better than parts in $10^{11}$ and $10^{15}$ respectively, which represents six orders of magnitude improvement in the former and four orders for the latter.

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