A Nod Approach for the Development of Flywheel Oscillators for Atomic Clocks

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We present theoretical and experimental results for a novel oscillator that converts continuous light energy into stable and spectrally pure microwave signals. This Opto-electronic Oscillator (OEO), can generate ultra-stable, spectrally pure microwave reference frequencies up to 75 GHz with a phase noise lower than -140 dBc/Hz at 10 KHz.

The advent of the trapped ion and laser cooled atomic frequency standards with potential for stability beyond $10^{-13}/\sqrt{\tau}$ has created the need for high performance local oscillators. This is because these new atomic standards operate as frequency discriminators which periodically steer the frequency of a flywheel. The period of time required to perform this function can be as short as a second, and as long as many tens of seconds. During the intervals between each frequency comparison steps to steer the flywheel with the atomic line, the flywheel is free-running. Thus the performance of the flywheel for the duration of period between comparison steps determines the ultimate performance that may be obtained with the atomic standard. At the present time, conventional voltage controlled oscillators (VCO) based on quartz crystals significantly degrade the stability which the trapped ion standards are capable to produce.

We report hereon a novel oscillator that converts continuous light energy into stable and spectrally pure microwave signals. [1] The OEO consists of a pump laser and a feedback circuit including an intensity modulator, an optical fiber delay line, a photodetector, an amplifier, and a filter. This device holds the promise for the development of a flywheel suitable for the new class of ultra-stable atomic standards.