New Approaches to Light Shift Suppression in Microwave Atomic Clocks Based on CW Coherent-Population-Trapping Resonances

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Microwave frequency standards (atomic clocks) based on coherent population trapping (CPT) in alkali-metal vapor cells are a rapidly developing quantum technology. High frequency stability of these clocks goes hand in hand with low power consumption and small size. Many efforts are nowadays put into increasing a long-term stability of these clocks by suppressing the light shift of the reference CPT resonance.

Here we examine new approaches that could help to mitigate influence of light field fluctuations on the frequency of CPT resonance. We use a $5 \times 5 \times 5$ mm^3 Cs vapor cell with a buffer gas. The first approach implies using two light beams with orthogonal circular polarizations ($\sigma^+\sigma^-$ configuration). It has already been known that this configuration provides a high-contrast CPT resonance, increasing short-term frequency stability. We show that, under certain conditions, there is one more brilliant feature, consisting in a very low sensitivity of the resonance frequency to the light power fluctuations (see Fig.1).

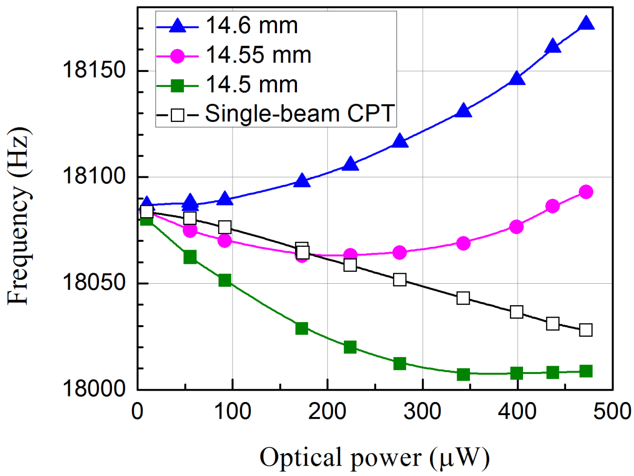

Figure 1: Frequency of an error signal in CPT clock versus light power for different microwave (Raman) phases between the waves. This phase can be adjusted, for instance, by moving a mirror in our scheme (its position is written in the plot)

Another approach is based on a standard scheme where a VCSEL is used to generate a multi-frequency circularly polarized light beam for excitation of the CPT resonance. We additionally use a Mach–Zehnder electro-optic modulator to manipulate the light spectrum. This way can also help to increase stability of the resonance frequency.

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