Constructive polarization modulation for coherent population trapping clock

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A passive coherent population trapping (CPT) clock based on lin⊥lin configuration shows a promising fractional frequency stability of 3.2×10^{-13} at one second[1]. This CPT clock can also be implemented with a push-pull optical pumping scheme[2] (PPOP) using a Michelson interferometer-like phase delay set-up. PPOP simplifies the experimental laser apparatus and provides a realistic candidate for future onboard clocks.

Here we propose another scheme based on polarization modulation which avoids the Michelson-like set-up, while maintaining the high contrast CPT signal. In our scheme, the polarization of a bichromatic laser beam is modulated between two opposite circular polarizations. When the polarization modulation frequency increases, Huang and Camparo[3] have shown that the CPT peak splits in two peaks. We show that if an appropriate phase modulation between the two optical components of the bichromatic laser is applied synchronously, the two CPT dark states, produced successively by the alternate polarizations, add constructively. Fig. 1 shows the CPT signals recorded without (two peaks) and with (one peak) phase modulation. With phase modulation the two dark states are decoupled from the laser all the time. Since the atoms are not accumulated in the extreme Zeeman states of ground hyperfine states by optical pumping, a high contrast CPT signal of clock transition is expected.

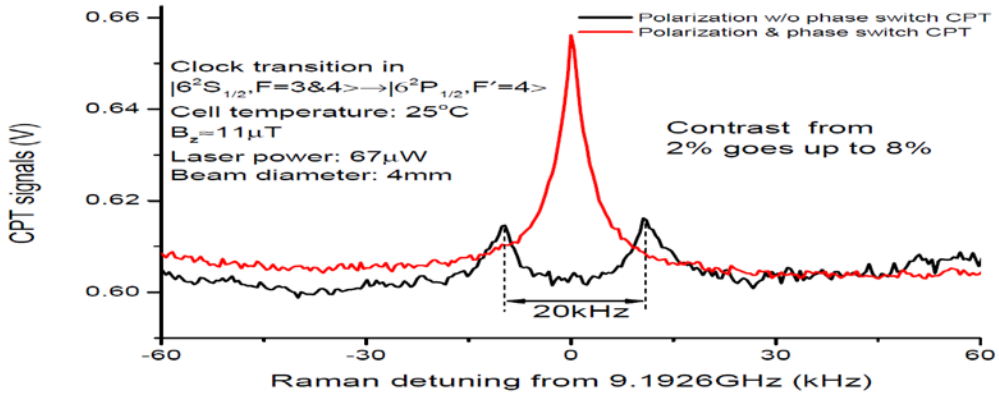

Fig. 1: CPT spectra obtained by constructive and destructive polarization modulation (10 kHz).

The preliminary results show that the observed contrast is at least 4 times higher than that of the conventional CPT scheme using circularly polarized beams, or a destructive polarization modulation scheme. It shows the potential of polarization modulation to construct a high performance CPT clock. The latest achievements and results will be presented at the conference.

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[1]J.-M. Danet, M. Lours, P. Yun, S. Guérandel, E. de Clercq, "Frequency Instability Investigations on a Cs Cell Clock Based on Pulsed Coherent Population Trapping", 2013 Joint UFFC, EFTF and PFM Symposium, p. 586-589, 2013.

[2]Y.-Y. Jau, E. Miron, A. B. Post, N. N. Kuzma, and W. Happer, "Push-Pull Optical Pumping of Pure Superposition States", Phys. Rev. Lett., vol. 93, p. 160802-1-4, 2004.

[3]M. Huang and J. C. Camparo, "Coherent population trapping under periodic polarization modulation: Appearance of the CPT doublet", Phys. Rev. A, vol. 85, p. 012509-1-10, 2012.