Preliminar results of a Cs vapor cell CPT clock using push-pull optical pumping

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We developed an experimental set-up to detect high-contrast CPT resonances in buffer-gas-filled Cs vapor cells using push-pull optical pumping (PPOP) [1]. The laser source of the system is a distributed-feedback (DFB) diode laser tuned on the Cs D_1 line at 894.6 nm. A Mach-Zehnder electro-optic modulator (MZ EOM) is driven by a 4.596 GHz local oscillator to generate two first-order optical sidebands frequency-separated by 9.192 GHz. The dc electrode bias voltage of the MZ EOM is actively controlled using an original microwave synchronous detector technique to stabilize optical carrier rejection (~28dB) at the output of the EOM. A Michelson-like interferometer allows to generate the so-called push-pull interaction scheme [2]. The laser light is transmitted through a Cs vapor cell filled with a buffer gas mixture of N_2 and Ar. The laser power at the output of the cell is detected by a photodiode. The laser can be frequency stabilized onto the Cs-buffer gas cell into the bottom of the absorption line. The local oscillator frequency can be locked to the atomic 0-0 clock transition frequency.

In a first point, the impact of several experimental parameters (laser intensity, cell temperature, RF power, ..) on the clock resonance lineshape parameters was evaluated to find conditions that will optimize the clock short term frequency stability. The clock resonance is about 560 Hz with a contrast of about 22% for an input laser power in the cell of about 700 uW. The clock relative frequency stability is measured to be 4.2 10^{-13} at 1s, in good agreement with the signal to noise ratio limit, that is encouraging compared to state-of-the-art vapor cell atomic clocks based on double-resonance or CPT techniques. Nevertheless, the clock frequency stability performances are currently strongly limited after one or a few seconds, preventing Allan deviation to decrease as expected with a $\tau^{-1/2}$ slope, signature of a white frequency noise.

Investigations are currently in progress in order to understand the origin of this strong limitation. Laser power effects are strongly suspected, including total laser power variations and slight independent fluctuations of sidebands power at the output of the EOM. The sensitivity of the clock resonance frequency to various experimental parameters such as the EOM temperature, the EOM bias point, the EOM RF driving power, the static magnetic field, the optical path difference in the Michelson interferometer and laser variations will be studied with attention.

Progress, first conclusions of these investigations and last frequency stability results will be reported at the conference.

[1] Y. Y. Jau et al., Phys. Rev. Lett. 93, 160802 (2004).

[2] X. Liu et al., Phys. Rev. A 87, 013416 (2013)