Dark resonance in wall-coated cell for Rb clocks

E. Breschi[(1)], G. Mileti[(1)]

[(1)] Laboratoire Temps-Fréquence (LTF), Université de Neuchâtel,
Avenue de Bellevaux 51, 2000 Neuchâtel Switzerland
evelina.breschi@unine.ch, gaetano.mileti@unine.ch

This work aims at evaluating the potential of anti-spin-relaxation wall-coated cells for the development of an atomic clock based on coherent population trapping effect. We measure stability of $3 \cdot 10^{-12}$ at 1 s and of about $1 \cdot 10^{-11}$ at 10^4 s. These values seem limited by the detection noise level and the frequency drift induced by the coating, respectively.

We report on the advancement in our evaluation of the potential of a Coherent Population Trapping (CPT-) clock [1] realized using paraffin wall-coated cells [2]. The interaction scheme and the experimental apparatus are described in detail in our previous communications [3-6]. In particular, the two-colour laser source is made of a DFB laser diode and an EOM driven at 6.8 GHz. In our past works we discussed the characterization of the Zeeman and hyperfine relaxation rate of the wall-coated cell measured DRAM- [7] and CPT-spectroscopy, respectively. We optimized the figure-of-merit (e.g., the signal contrast-to-line-width ratio) of the dark resonance prepared in lin||lin configuration depending on the laser parameters, the microwave modulation, the magnetic field and the temperature of the cell [3]. We analysed separately the effect of the temperature of the coating material and of the atom source on the signal strength, line-width and central frequency [4]. In this communication, we report on our first clock stability measurements. Two main changes were made in the experimental set-up as compared to our previous communications. First, the laser system was replaced by a compact and frequency-stabilised laser head ensuring a reduced contribution of the light-shift effect [8]. Second, the laboratory microwave source driving the EOM was replaced by a low-noise frequency synthesizer (Spectradynamics) that could be locked to the CPT transition. We measured a short-term stability of $3 \cdot 10^{-12}$ at 1 s consistent with the signal-to-noise ratio prediction, Fig. 1(a).

Work is in progress to reduce the detection noise level and approach the intrinsic limit which is approximately 10 times better. We also studied the frequency shift depending on the laser intensity and detuning (light shift), the microwave modulation and the cell temperature (Table 1); with the aim of characterizing the medium- and long- term stability of our CPT-clock. An analysis of the frequency drift was also started. In Fig. 1(b) the clock signal recorded for 10 days is represented. The clock frequency is affected by a drift of about $2 \cdot 10^{-10}$/day. According to our analysis the recorded clock drift seems induced by the paraffin. Very preliminary retrace measurements show that the coating drift depends on the temperature "history" of the cell. However when the temperature of the cell is stabilized (it can take several days) the value of the drift seems stabilized. Further analyses are in progress.

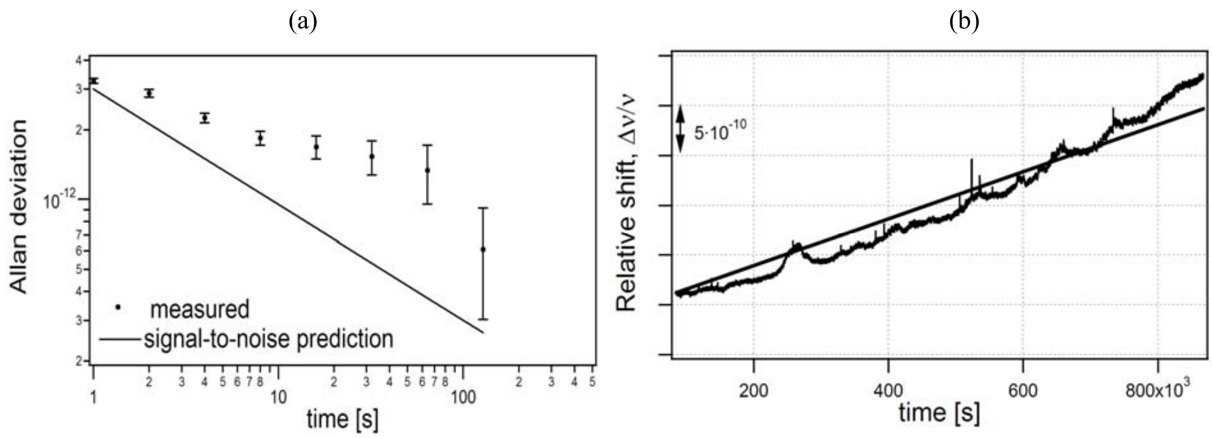

Fig.1 (a) The short term stability measured (dots) and calculed with $\sigma_y(\tau) \sim 0.2/(Q\ S/N)\tau^{-1/2}$ [9]. Where *Q* is the resonance quality factor and *S/N* the signal-to-noise ratio. (b) Frequency drift over 10 days.

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Table 1: Instability budget

Parameter	Coefficient
Coating temperature	$2 \cdot 10^{-10}$/°K
Laser intensity	$-1 \cdot 10^{-9}/(\text{mW}^{-1}\ \text{cm}^2)$
Laser detuning	$4 \cdot 10^{-11}$/MHz
Microwave intensity	$1 \cdot 10^{-11}$/W

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