Preliminary measurements of buffer gas collisional clock frequency shifts in Cs vapor cells in presence of Xe and He

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FEMTO-ST developed an original technology for filling and fabrication of Cs vapor microfabricated cells filled with buffer gas [1]. A great originality of this method is that Cs vapor is generated after the complete sealing of the cell by laser activation of a Cs dispenser developed by SAES Getters. Additionally, we pointed out the possibility to cancel the temperature-dependence of the Cs clock frequency at a temperature inversion of about 80°C using a single Ne buffer gas [2]. In this single gas configuration, the main advantage is that the so-called inversion temperature where the Cs clock will typically operate does not depend on the buffer gas pressure. At the opposite, this single-gas cell configuration prevents the clock to operate at high ambient temperature (typically above 100°C) without the use of a power-consuming Peltier element to cool down the cell. This can be an issue for the development for low-power consumption chip scale atomic clocks devoted to be used in applications with stringent and severe environmental conditions. Moreover, we observed that N_2 buffer gas can not be used with our cell technology because this gas reacts and is absorbed by zirconium compound of the Cs dispenser. This prevents the use of a N2-Ar buffer gas mixture. In that sense, we decided to investigate Cs clock frequency shift measurements in presence of other buffer gas, mainly Xe and He.

We implemented a laboratory-prototype Cs cell clock based on coherent population trapping. The laser source is a 1 MHz-linewidth distributed-feedback (DFB) diode laser tuned on the Cs D_1 line at 894.6 nm The laser can be frequency stabilized onto Cs resonance by saturated absorption spectroscopy technique. A pigtailed phase electro-optic modulator (EOM), driven at 9.192 GHz, is used to generate 9.192 GHz frequency-splitted optical lines and realize CPT spectroscopy. We bought cm-scale commercially-available Cs cells filled with buffer gas (Xe and/or He). The cell is inserted in a physics package to be temperature-controlled and surrounded by a static magnetic field. The ensemble is inserted into a double-layer mu-metal magnetic shield.

In a first step, we measured the actual buffer gas pressure in sealed cells through optical red shift measurements following the procedure described in [3]. For this purpose, the laser output is split in two directions. In the first one, the laser beam is sent through a Cs reference cell without buffer gas. In the second direction, the laser beam is sent through the buffer gas-filled Cs cell to be tested. Low laser intensities (< 10 uW/cm^2) are used. Optical absorption spectra from both cells are recorded with a photodiode and fitted by a sum of Voigt profiles. After correct calibration of the frequency axis, the optical frequency shift between both cells is extracted to estimate the actual buffer gas pressure in the buffer-gas-cell using coefficients reported in [4]. We measured the temperature-dependence of the optical frequency shift coefficient for He and Xe.

We started measurements of the temperature-dependent Cs clock collisional frequency shift measurements in presence of Xe and He. The methodology is similar to the one described in [5]. Preliminary results will be reported at the conference for several cells.

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