Towards real-time vibrational noise compensation of a 40 cm long Fabry-Perot cavity at 1542 nm

Mohamed Guessoum[1], Benjamin Pointard[1], Jérôme Lodewyck[1], Rodolphe Le Targat[1]

[1]LNE-SYRTE, Observatoire de Paris – Université PSL, CNRS, Sorbonne Université, Paris

Email: Mohamed.guessoum@obspm.fr

Optical lattice clocks have the potential to reach a fractional resolution better than 10^{-17} in one shot, only limited by the atomic Quantum Projection Noise (QPN). Nevertheless, operational optical clocks are for the time being limited by the so-called Dick effect (sampling of the residual frequency noise of the laser probing the clock transition). In order to interrogate the metrological transitions of the seven operational SYRTE atomic clocks, we are developing an ultrastable laser based on a long Fabry-Perot cavity (~40 cm) equipped with crystalline mirrors at 1542 nm. The theoretical thermal noise of this source is projected to be at the few 10^{-17} level, and therefore compatible with the QPN limit. Its spectral purity will be forwarded by the transfer oscillator technique, via frequency combs, to 265.5 nm/578 nm/698 nm (to probe respectively Hg/Yb/Sr cold atoms optical clocks), and to 6.8 GHz/9.2 GHz (respectively for Rb/Cs cold atoms microwave fountains).

In this paper, we report on the progress of the project over the last few years. We will particularly focus on a method to control the effects of vibrations based on the use of seismometers located next to the cavity in order to measure on-the-fly the instantaneous speed experienced by the resonator. Based on this approach, and on an a priori determination of the sensitivity coefficients of the cavity to accelerations, we are developing a method of feedforward in order to correct the 1542 nm carrier. The transfer itself towards the frequency combs is performed by changing the tuning word of the digital reference of the stabilized fiber bringing the 1542 nm ultrastable light to the combs. We will also discuss the limits of the transfer, notably uncompensated paths, the effect of a Brewster angle cut electro-optic modulator on the control of the residual amplitude modulation, and we will present preliminary results of stability comparison with other SYRTE cavities in the mid 10^{-16}.