Compact Fabry-Perot ULE cavity

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Cavity stabilized lasers are promising devices that could overcome the fractional frequency stability limits of current secondary frequency references. Some ultra-stable lasers already display fractional frequency stabilities in the range of 10^{-16} at short term for cavity lengths superior or equal to 10 cm[1,2] and for cryogenic cavities[3]. This very good performance is obtained at the expense of a total set-up volume around 1 m^3.

Our project purpose is to use the high frequency stability offered by this technology in order to build a compact and transportable ultra-stable laser with lesser performances. The goal is to develop a frequency source with a relative frequency stability that overcomes the current performances of the best quartz crystal oscillators. For that purpose we have designed a compact ULE cavity with 2.5 cm length. The cavity will fit in a setup with a total volume of 1.1L. Mechanical and thermal simulation led to a new spacer geometry with acceleration sensitivity smaller than $10^{-12}/(m.s^{-2})$ in all directions and a thermal expansion coefficient annulation around 11°C. The thermal noise of this cavity has been calculated to be 1.5 x 10^{-15}, which would make it a valuable challenger for the current most stable quartz oscillator.

We will present the cavity design and the latest results obtained.

1. Swallows, M. D. *et al.,* "Operating a ^{87}Sr optical lattice clock with high precision and at high density" *IEEE Trans. Ultrason. Ferroelectr. Freq. Control* **59,** 416 –425 (2012).
2. McFerran, J. J. *et al.,* "Laser locking to the ^{199}Hg $^1S_0$ –$^3P_0$ clock transition with $5.4 \times 10^{-15}/\sqrt{\tau}$ fractional frequency instability" *Opt. Lett.* **37,** 3477–3479 (2012).
3. Kessler, T. *et al.,* "A sub-40-mHz-linewidth laser based on a silicon single-crystal optical cavity" *Nat. Photonics* **6,** 687–692 (2012).