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Low frequency noise fiber delay stabilized laser with reduced sensitivity to acceleration

B. Argence, C. Clivati[†], J. L. Dournaux[+], D. Holleville, B. Faure*, P. Lemonde and G. Santarelli

LNE-SYRTE, Observatoire de Paris, CNRS, UPMC, 61, Av. de l'Observatoire, Paris, France
[†]Instituto Nazionale di Ricerca Metrologica (INRIM),Torino, Italy
[+]GEPI, Observatoire de Paris, CNRS, Meudon, France
*CNES, Centre National d'Etudes Spatiales, 99 Av. E. Belin, Toulouse, France.

Corresponding author: Berengere.Argence@obspm.fr

Lasers with sub-hertz line-width and fractional frequency instability around $1x10^{-15}$ for 0.1 s to 10 s averaging time are currently realized by locking onto an ultra-stable Fabry-Perot cavity using the Pound-Drever-Hall method. This powerful method requires tight alignment of free space optical components, precise polarization adjustment and spatial mode matching. To circumvent these issues, we use an all-fiber Michelson interferometer with a long fiber spool as a frequency reference and a heterodyne detection technique with a fibered acousto optical modulator (AOM)[1]. At low Fourier frequencies, the frequency noise of our system is mainly limited by mechanical vibrations, an issue that has already been explored in the field of optoelectronic oscillators.[2,3,4]

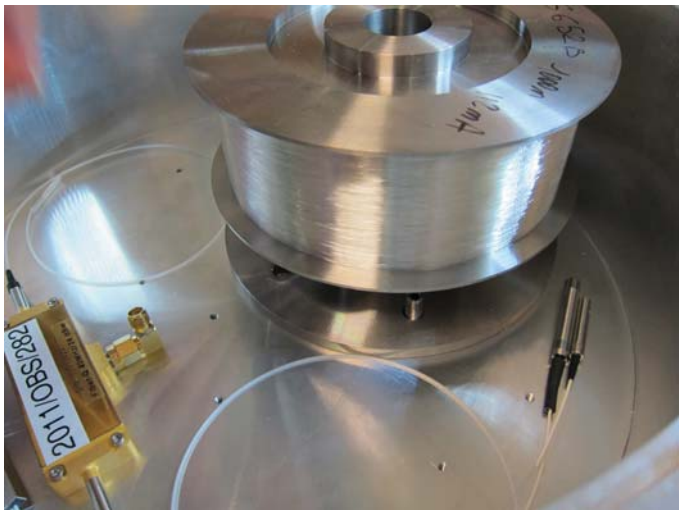

Fig. 1: Low vibration sensitivity spool set up

After extensive study of the spools with Finite Element Modeling (FEM), we realize and test a novel spool design (Fig. 1) which is optimized for low vibration sensitivity along all spatial directions and insensitive to the way it is held. We measure a sensitivity of about $10^{-11}/ms^{-2}$ in all direction for the complete oscillator of 2 km fiber length, limited by the out of spool elements (AOM, coupler, Faraday mirrors). The composed interferometers spool of two symmetrically mounted shows a sensitivity of about $5\text{-}8x10^{-12}/ms^{-2}$. At the conference we will also show frequency noise measurements and the prototype of a simplified oscillator aiming to realize a robust and cost effective very low noise agile laser with acceleration sensitivity below $3x10^{-11}/ms^{-2}$ in all spatial directions.

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