SELF-MIXING LASER DIODE VIBROMETER FOR VERY LOW FREQUENCY APPLICATIONS

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Introduction - Optical vibrometer based on Laser Diode Self-Mix Interferometry (SMI) is the elective choice in non-invasive vibration monitoring. We present an instrument aimed at measurement of small amplitude (10nm<s<1um) vibrations at very low frequency, below 10^{-3} Hz. Intended application is *in situ* vibration monitoring of artwork, e.g. during 3D surface topography aimed at indentification of the original piece to counteract forgery of the artwork, or to prevent or detect theft during transportation before/after an exhibition. In the intended application, long term stability and glitch-free operation are required. The proposed vibrometer exploits the fringe-lock configuration, and the advantages offered by the presence of the feedback loop. In previous design with AC feedback only, glitches were observed because of fringe lock loss due to wavelength fluctuation induced by temperature fluctuation, even with TEC control of the Laser Diode temperature.

Instrument description and results – Basically, in SMI[1] a returned field $E_R\exp(j\phi(t))$ is added to unperturbed cavity field E_0, generates amplitude (AM) and frequency (FM) modulation of the lasing field. Intensity modulation is easily read by the power monitor photodiode as a interferometric signal $I=I_0(1+F(\phi(t)))$, where the actual form of $F(\phi(t))$ depends on physical parameters of the LD and on the ratio E_R/E_0, i.e. the injection level. At low injection level, $F(\phi(t))$ is the usual cosine and become distorted at higher injection level. In a proper regime of injection, $F(\phi(t))$ becomes sawtooth, allowing development of the fringe-lock vibrometer[2]. Usually, a AC coupled feedback loop is employed. Our improved design uses, in addition to the usual AC coupled loop for signal extraction, a separate DC loop to improve long-term stability of the system. Long term measurements of a rigid set-up on top of a vibration isolation honeycomb table are shown in Fig.1. The glitches seen with open DC loop arises from the wavelength drift due to temperature fluctuation ($d\lambda/dT$=0.65nm/K), and vanishes when DC loop is closed, allowing long term acquisition lasting up to 10 minutes and longer.

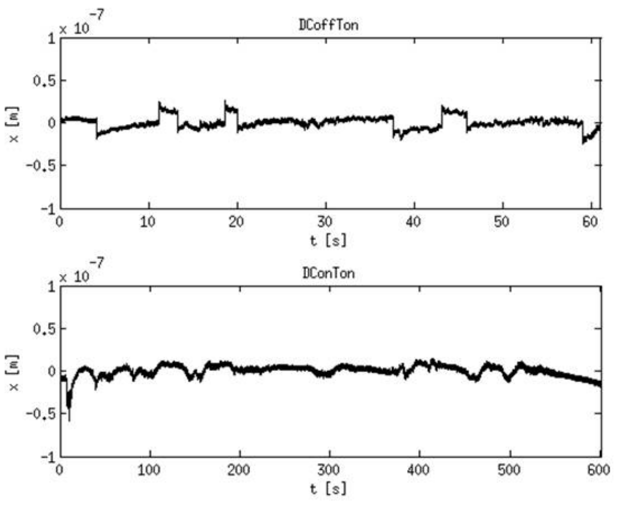

Fig. Typical signal with AC feedback only (upper) and with DC loop added (lower); LD temperature is controlled by TEC in both cases.

References:
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2. G. Giuliani, S. Bozzi-Pietra, S. Donati, "Self-mixing laser diode vibrometer", 2003 Meas. Sci. Technol. **14** pp. 24-32, doi:10.1088/0957-0233/14/1/304