



HAL
open science

Noise of spectral transfer of laser frequency by locking to the direct difference of fiber interferometer signals

Stéphanie Grabielle, Fabien Kéfélian, Debanjan Show, Jean-Pierre Coulon

► To cite this version:

Stéphanie Grabielle, Fabien Kéfélian, Debanjan Show, Jean-Pierre Coulon. Noise of spectral transfer of laser frequency by locking to the direct difference of fiber interferometer signals. European Frequency and Time Forum (EFTF), Jun 2024, Neuchâtel (CH), Switzerland. hal-04632384

HAL Id: hal-04632384

<https://hal.science/hal-04632384>

Submitted on 3 Jul 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Noise of spectral transfer of laser frequency by locking to the direct difference of fiber interferometer signals

Stéphanie Grabielle, Debanjan Show, Jean-Pierre Coulon, Fabien Kéfélian

ARTEMIS, Université Côte d'Azur & Observatoire de la Côte d'Azur & CNRS, Nice, France

Email: stephanie.grabielle@oca.eu

Femtosecond laser frequency comb can achieve transfer of frequency stability between two lasers of different wavelength with a residual instability compatible with the most advanced optical clocks. Due to cost issue or reduced performance requirement, alternative techniques have been also developed such as the transfer cavity, either with bulk Fabry-Perot cavity or even fiber-based resonator¹. Here we consider another technique introduced in ref [2] using a difference of interferometric signals provided by a fiber-based Mach-Zehnder interferometer. The setup is presented on

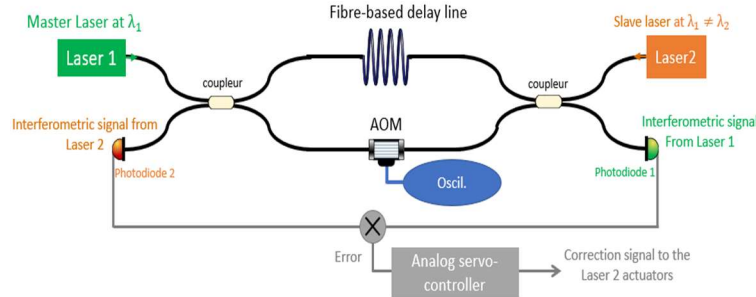


Fig.1: Experimental scheme of the spectral transfer

Fig.1. The two lasers propagate in the opposite direction in the interferometer. The delay line is realized with a 500 m SMF-28 fiber on one arm and an acousto-optic modulator (AOM) is inserted in the other arm. The error signal to lock laser 2 on laser 1 is obtained by mixing the two heterodyne signals. An analog servo system is used to apply the correction to the slave laser.

To investigate the noise limit of the technique, contrary to ref. [2] we used a direct subtraction of the interferometric signal with the mixer and a fully analogic servo system, as well as a smaller wavelength difference. Two RIO diode lasers were used, one at 1560 nm as reference and another at 1542 nm as the slave. A second interferometer is setup with the same reference laser and a second 1542 nm diode laser as slave. We measured the frequency of the beat note between the two slave lasers. As shown on Fig. 2, we demonstrated a transfer frequency noise below $1 \text{ Hz}/\sqrt{\text{Hz}}$ over the [100 Hz – 17 kHz] range with a promising minimum level of $0.2 \text{ Hz}/\sqrt{\text{Hz}}$, 14 dB below ref. [2]. We have investigated the different possible contributions to the residual noise including laser noise crosstalk and fiber noise coupling due to wavelength difference or polarization asymmetry.

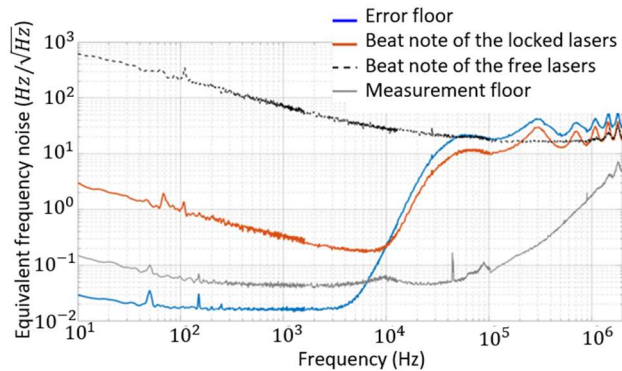


Fig.2: frequency noise characterization

¹ T. Steshchenko, K. Manamanni, H. Mouhamad, V. Roncin, and F. Du-Burck, "Limitations of frequency stability transfer in the near infrared using a fiber-based ring cavity", *Opt. Lett.*, vol. 47, p. 5465-5468, 2022.

² N. Bourbeau Hébert, A.P. Hilton, P.S. Light, A.N. Luiten, "Hertz-level frequency comparisons between diverse color lasers without a frequency comb", *Opt. Lett.*, vol. 45(15), p. 4196-4199, 2020