

Title: Development of new techniques based on optical fiber links for geophysics sensing

Scientific context

Optical fiber links were developed in the last decade to transfer an ultrastable frequency reference over hundreds of km, with a minimal degradation of its stability and accuracy performance. It consists of transmitting an ultrastable laser, whose frequency is controlled with atomic clocks, through an optical fiber to the remote lab, with an active compensation of the phase noise induced by the propagation.

In France REFIMEVE is a national network of optical links which is developed and operated by LPL and LTE laboratories and disseminates time and frequency signals across France. It also has connections to UK, Germany and Italy national metrological institutes to serve for clocks comparisons and tests of fundamental physics beyond the standard model. For more details, see <https://www.refimeve.fr/>

Metrological fiber links are now mature and give rise to a wide range of applications and user cases. The objective of the proposed PhD thesis is to explore different uses of these links mainly aiming at seismic sensing.

Thesis description:

The candidate will first exploit the coherence of the disseminated signal to improve the length of coherent Optical Frequency Domain Reflectometry (C-OFDR) and study its limits in terms of resolution and sensitivity. The candidate will investigate and demonstrate the impact of laser noise on this measurement. The study will be performed for different classes of lasers, including commercial ones, state-of-the-art Hz-linewidth lasers, and lasers distributed by optical fibre. The candidate will participate to in-field seismologic tests. Based on these field measurements, the candidate will adapt and enhance the modulation techniques to improve the sensitivity and/or the localisation capabilities.

A second objective of the thesis will be to explore how the polarization of the optical signal can be used to improve the sensitivity of C-OFDR and acquire deeper knowledge on the seismic events. For that purpose, we propose to analyse the seismic noise on two orthogonal states of polarisation and study the sensitivity to the various types of seismic events.

The PhD work will be mainly based on experimental development and studies using photonics metrology techniques. The PhD candidate will benefit from the experience of the LPL group in optical links and from the equipment developed for the REFIMEVE network.

Techniques/methods in use: fiber optics, optoelectronics, frequency measurements

Applicant skills: Optics – Basis in electronics – Metrology - Data analysis

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