A 8’000-kilometer-long optical frequency network: present status of the REFIMEVE infrastructure

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Frequency and time transfer through optical fibers offers unrivalled performances and has therefore become an essential tool of today's physics. This has led to major breakthroughs, especially in precision measurements in physics, and opened up new perspectives in other fields as Earth sciences[1]. New applications have thus emerged, using for instance stabilized fiber networks as large-scale sensors where the high level of stability allows unprecedented measures of the deformation of the fiber induced by its environment, for example from seismic waves. Thanks to the Multibranch Laser Stations (MLS)[2], the interferometers forming the several links of the network are now aligned in phase, allowing to keep a zero phase differentiation over time between any link of the network. In such a network the measurement of fundamental effects at large scale in a correlated manner will become a reality.

We have realized such a network. REFIMEVE covers France and combines long-distance transfer and state-of-the-art performances[3]. This allows a frequency transfer with stability and accuracy better than 10^{-19} in all the network. A unique feature of REFIMEVE is the ability to perform multi-arm interferometry where interferometers are phase-coherent. The network currently disseminates the frequency and time references of the French national metrological institute LNE-SYRTE to more than 20 French laboratories simultaneously, with an uptime above 80% over months. Beyond the comparison of clocks between France, Germany, UK[4] and Italy during the last 10 years, REFIMEVE is a unique instrument able to deliver reliable services to a broad range of the scientific community.

We will here show the latest performances of REFIMEVE and a study of the noise processes involved in each branch of the network. We will also discuss the architecture of the network, and focus on the integration of regional subnetworks, preparing actively the mechanisms of integration of REFIMEVE into the European landscape of infrastructure. We will finally give perspectives on how to improve transfer performance of the network down to the 10^{-21} level and the future extensions with more than 30 laboratories and reach 10,000 km network size. One major application of such a continuously operating European network could be the realization of optical time scales, steering algorithms and lead to a very robust and reliable realization of UTC in Europe.

[1] Donadello et al, arXiv:2307.06203, 2023.

[2] https://www.exail-technologies.com/fr/

[3] Cantin et al, New J. Phys. 23 053027, 2021.

[4] Schioppo et al, Nature Communications vol. 13, 212, 2022.