Frequency dissemination with 2×10^{-18} fractional-frequency instability over 120 km of commercial fiber infrastructure

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Frequency dissemination[1] is an essential architecture in optical-frequency metrology enabling the spread of highly stable lasers sources to different users, in the fields of atomic timekeeping, geodesy and fundamental physics. These highly stable lasers facilitate high precision measurements, and atomic-clock comparisons between remote locations.

This work comprises a frequency dissemination with fractional-frequency instability of 2×10^{-18} @ 100 seconds interrogation time on a Single-Mode Fiber communication infrastructure as seen in Fig. 1. The system consists of a Michelson Interferometer[2] over 120 km of optical fiber connecting two academic facilities, the Weizmann Institute of science and Tel Aviv University. We use Optical Add-Drop Multiplexers to incorporate our interferometer into an active communication infrastructure. The Michelson interferometer is used to detect the phase noise accumulated on the fiber channel and a Phase-Locked Loop controlling an Acoustic optic Modulator is used to correct it. This allows distributing phase-stable frequency at the remote station.

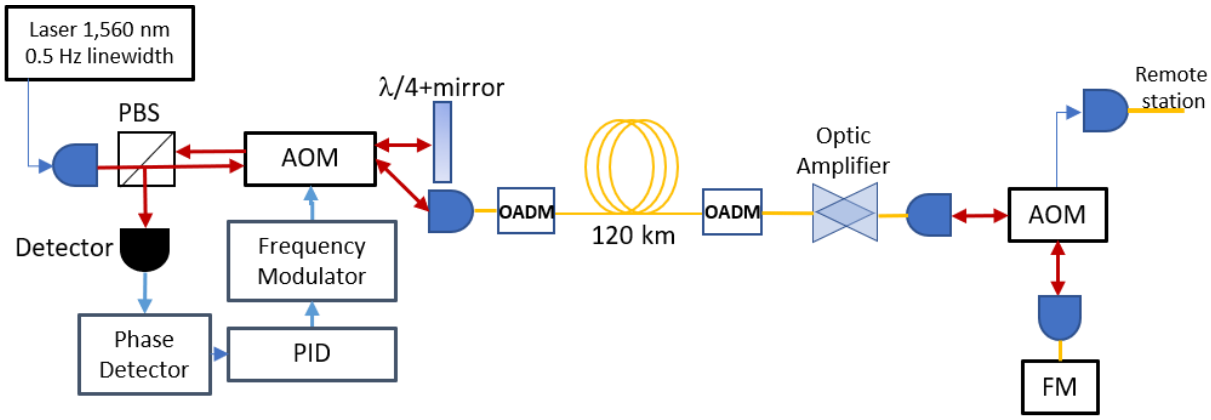

Fig. 1: Frequency dissemination system of a 0.5Hz linewidth laser transferred to a remote station. FM: Faraday Mirror, PID: Proportional Integral Derivative, OADM: Optical Add Drop Multiplexer, AOM: Acoustic Optic Modulator, PBS: Polarized Beam Splitter. Fiber to air (blue shape), detector (black shape).

[1] M. Schioppo, "Comprising ultra-stable lasers at 7×10^{-17} fractional frequency instability through a 2220 Km optical fiber network", Nature Communications, vol. 13, p. 1-11, 2022.

[2] P. A. Williams et al, "High Stability transfer of an optical frequency over long fiber-optic links", J. Optica, vol. 25, p. 1284-1293, 2008.