Field-deployable interferometric fiber link terminals reaching fractional instabilities below 10^{-20}

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Long distance optical frequency dissemination via interferometric fiber links (IFLs) enable a wide range of high precision application such as comparison of atomic clocks[1], chronometric leveling, tests of fundamental physics[2] or searches for Dark Matter[3]. IFLs reach fractional instabilities and uncertainties of 10^{-19} and below[4] however, conventional IFL topologies generally involve paths like the reference arm of the interferometer that need to be passively stable.

We designed and built a novel optical IFL topology for operation outside of temperature-controlled labs. This topology, based on standard fiber components, is free of uncompensated optical paths between the user outputs. The setup consists of two terminals for locations A and B, each supporting one short IFL for the local user, and one long IFL between the terminals.

For testing the performance, we connect the two terminals with 75 km fiber spools and used the short IFLs to generate an out of loop beat (see Fig. 1a). An additional long IFL between the terminals serves as an integrity check. Furthermore, we put the optics and the electronics of terminal B in a climate chamber and ramped the temperature between 15°C and 30°C. The setup achieves a relative instability (modified Allan deviation) below 10^{-20} at an averaging time of 10^3 seconds and approaching 10^{-21} at 10^4 seconds (see Fig. 1c). We observe long-term phase changes over 100 h below 0.25 rad, and the highest phase drift over 1 h was below 0.1 rad[5].

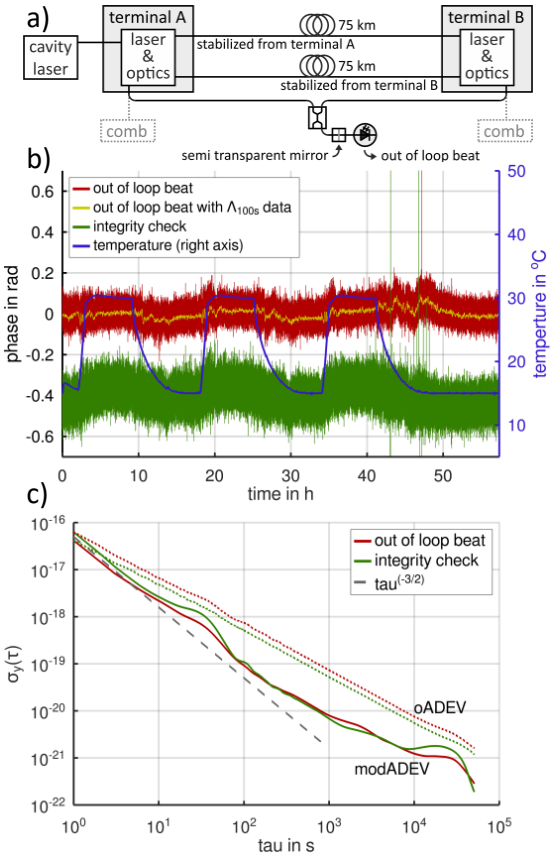

Fig. 1: a) Simplified scheme of the setup. b) Phase and temperature as function of time. c) Corresponding Allan deviations.

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