Effects of Turbulence on the Femtosecond pulses for Free-space Optical Transfer Link

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Abstract:

With the continued improvements in quantum frequency standards, there has been a brisk demand for free-space optical links for time and frequency transfer [1], towards the goal of future free-space networks for applications ranging from global positioning and timing to fundamental science.

To cancel out the variations in the time-of-flight of the optical links across turbulent air, the reciprocity of the optical bidirectional is used as a dominant approach. Recent free-space optical two-way time-frequency transfer based on optical frequency combs has verified the levels of 100 as in time rely on this reciprocity [2,3]. However, in future realizations of satellite-to-ground or inter-satellite networks, these links will extend over long distances and will cover the moving platforms. In these applications, the spatial variations of the atmospheric turbulence will destroy the reciprocity, and the effects of turbulence on the comb pulses need to be further clarified.

In this work, we explore the effects of turbulence on the comb pulses with theoretical analysis. These effects are difficult to measure directly, so we simulate the dual-comb asynchronous sampling process and map the effects to the changes in the dual-comb interference signals. A comb-based free-space optical transfer link is used for verifying the simulation with the use of a reciprocal optical terminal. Preliminary experiment indicates that atmospheric turbulence does aggravate the relative linewidth and phase noise of the dual-comb interference signals as shown below.

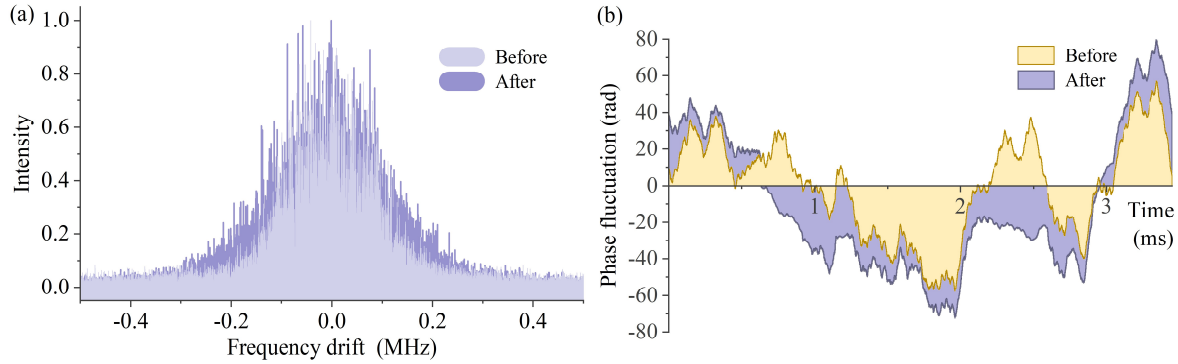

Fig. 1 Verification of the turbulence-induced influence on the femtosecond pulses of the comb. Comparison of the results before and after passing through the free-space optical transfer link. (a) Relative linewidth of the dual-comb teeth; (b) phase fluctuation of the dual-comb interference signal.

References

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