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**Long distance measurement with a femtosecond laser based frequency comb.**

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Recent advances in the field of ultra-short pulse lasers have led to the development of reliable sources of carrier envelope phase stabilized femtosecond pulses. The pulse train generated by such a source has a frequency spectrum that consists of discrete, regularly spaced lines known as a frequency comb. In this case both the frequency repetition and the carrier-envelope-offset frequency are referenced to a frequency standard, like an atomic clock. As a result the accuracy of the frequency standard is transferred to the optical domain, with the frequency comb as transfer oscillator. These unique properties allow the frequency comb to be applied as a versatile tool, not only for time and frequency metrology, but also in fundamental physics, high-precision spectroscopy, and laser noise characterization. The pulse-to-pulse phase relationship of the light emitted by the frequency comb has opened up new directions for long range highly accurate distance measurement.
For the case of distance metrology a frequency comb can also be viewed as a ruler, which is based on the fact that the vacuum distance between subsequent pulses is known with the accuracy of the used time standard. We have recently demonstrated absolute distance measurements using a frequency comb laser applying a cross-correlation technique, which was supported by a theoretical and a numerical study on the formation of cross-correlation in dispersive media. We have also studied a distance measurement scheme based on dispersive (spectral) interferometry using the frequency comb. For the measurements of distances up to 50 meter, we achieve accuracy of 1µm.
In this work we will present two experimental schemes to demonstrate distance measurements of up to 50 metres in air. The first experiment is done by analyzing the cross correlations measured between pulses emitted from a stabilized frequency comb source which are fed into a Michelson interferometer. To understand our results we implemented a model of pulse propagation in air to account for the effect of dispersion due to air on the measured cross-correlation functions. The measurement results obtained with the frequency comb and a conventional counting laser interferometer are compared. In a following experiment we apply frequency-comb based dispersive interferometry for measuring the distance of 50 m (100 m propagation) in air. During both the measurements, the temperature, the pressure, and the humidity have been monitored. The variation and the uncertainty on the measurement of these environmental parameters limit the accuracy in measuring the absolute distances. The measured distances in air agree with reference measurements to within 1µm.
The frequency comb has the advantage of a large non-ambiguity range and depending on the line width of the particular comb source, coherence lengths of kilometers or more are feasible. Therefore making this technique a good candidate for measuring very long distances, especially in space where the dispersion of air is absent. One promising application is absolute distance metrology between satellites or for formation flying in space.

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