Dual-comb ranging system combined with pseudo-random phase modulation for multi-target detection

Xiaoyang Guo, Jiawen Zhi, Hanzhong Wu, Panpan Wang, Chenggang Shao

MOE Key Laboratory of Fundamental Physical Quantities Measurement, Hubei Key Laboratory of Gravitation and Quantum Physics, National Precise Gravity Measurement Facility, School of Physics, Huazhong University of Science and Technology, Wuhan 430074, China

Email: cgshao@hust.edu.cn

Multi-heterodyne interferometry with optical frequency combs (OFC) enables distance measurement with high-precision and fast acquisition rate on account of OFC's characteristics of ultra-short pulses in the time domain and equally spaced longitudinal modes in the frequency domain. However, in the case of multi-target detection, the phases corresponding to different targets will be aliased, making the synthetic wavelength interferometry not available. Here, we describe a simple approach to overcome this problem.

The experimental setup is shown in Fig. 1. We develop a dual electro-optic comb source, and the difference between the repetition frequencies is 8 MHz. In the signal source, an additional EOM is involved, by which a pseudo-random noise (PRN) sequence is phase-modulated onto the signal beam with a modulation depth of π. Consequently, each returned signal reflected by the target carries a unique time-delayed PRN[1]. In particular, the non-ambiguity range can be greatly expanded, and the distances can be coarsely determined by the cross-correlation of the signals. Subsequently, the beat notes will be demodulated by multiplying the time-delayed PRN, and the residual noises can be suppressed by averaging the signals in the different code chips. The data processing is shown in Fig. 2. In the experiments, we involve three target mirrors in the measurement path. The experimental results indicate that the phases can be recovered, and therefore the distances can be measured with the uncertainty below 1 μm. Our approach can greatly extend the non-ambiguity range in dual-comb ranging and has the potential to provide more authentic 3D imaging with the presence of transparent objects.

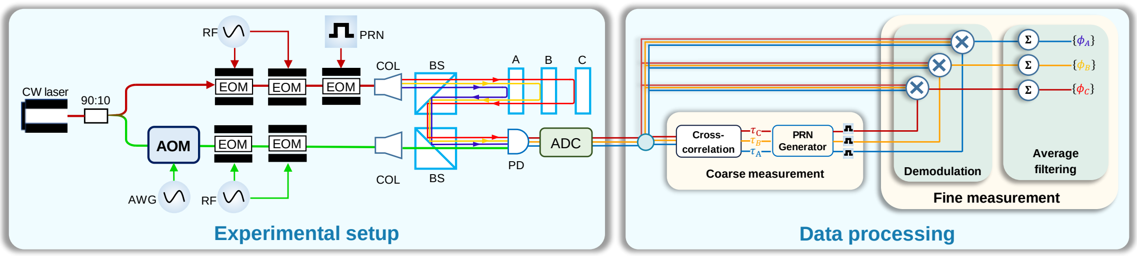

Fig. 1: Experimental setup. AOM: acousto-optic modulator; EOM: electro-optic modulator; AWG: arbitrary waveform generator; RF: radio frequency source; COL: collimator; BS: beam splitter; PD: photodetector.

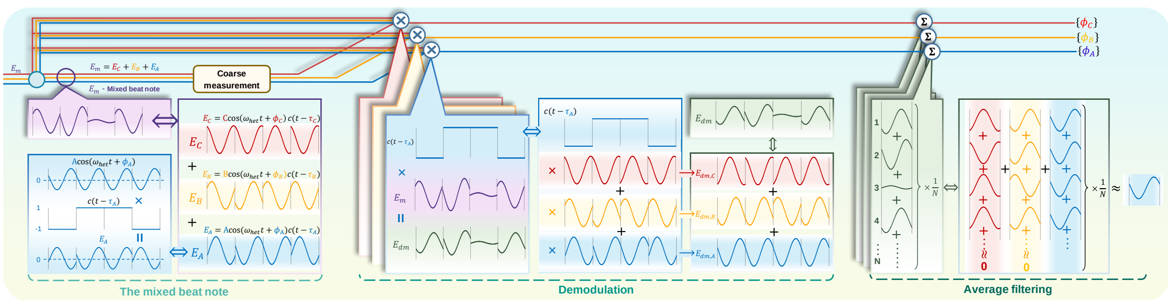

Fig. 2: Principle of data processing

[1] Shaddock D A, "Digitally enhanced heterodyne interferometry", Opt. Lett., vol. 32, p. 3355-3357, 2007.