Study on long-term stability of asymmetric optical fiber radio frequency transmission system

Jiahui Cheng, Hao Gao, Yaojun Qiao, Sen Zhang, Bin Luo, Song Yu

State Key Laboratory of Information Photonics and Optical Communications, Beijing University of Posts and Telecommunications, Beijing, China

Email: luobin@bupt.edu.cn

Many advanced scientific and industrial fields rely on high-precision optical fiber radio frequency (RF) synchronization technology, such as atomic clock comparison, navigation and positioning, and fundamental physics research. However, the long-term stability of the RF transmission system is limited by the optical path asymmetry, violating the assumption of equality between the forward and backward paths. In this paper, we experimentally investigate the effects of wavelength asymmetry and fiber length asymmetry on the long-term stability of the RF transmission system. The phase fluctuations introduced by these asymmetries are measured using a 600 km dual-wavelength RF transmission system and a dual-branch RF transmission system, respectively. The experimental results demonstrate that wavelength asymmetry has a minimal effect on the long-term stability, deteriorating by about 0.05 orders of magnitude for every 0.8 nm increase in the wavelength difference. Conversely, fiber length asymmetry exerts a more significant impact, with the long-term stability deteriorating rapidly by half an order of magnitude when the fiber length difference reaches 2 m.

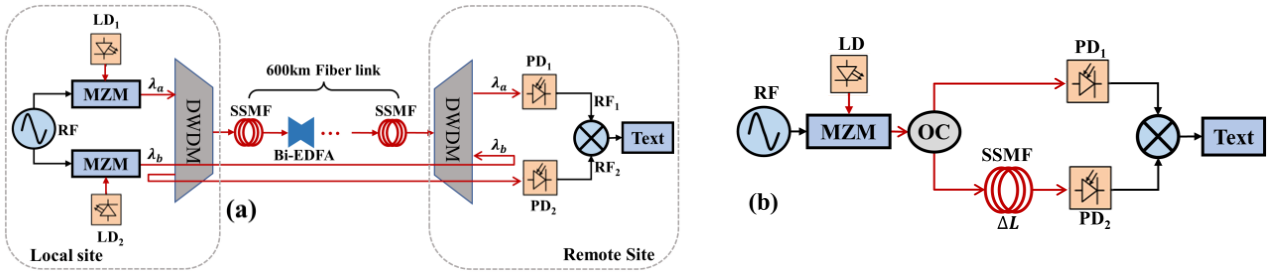

Fig. 1: (a) The 600 km dual-wavelength RF transmission system. (b) The dual-branch RF transmission system. LD: laser diode. MZM: Mach-Zehnder modulator. SSMF: standard single-mode fiber. Bi-EDFA: bidirectional erbium-doped fiber amplifier. PD: photo-detector. λ_a/λ_b: forward/backward light wavelength.

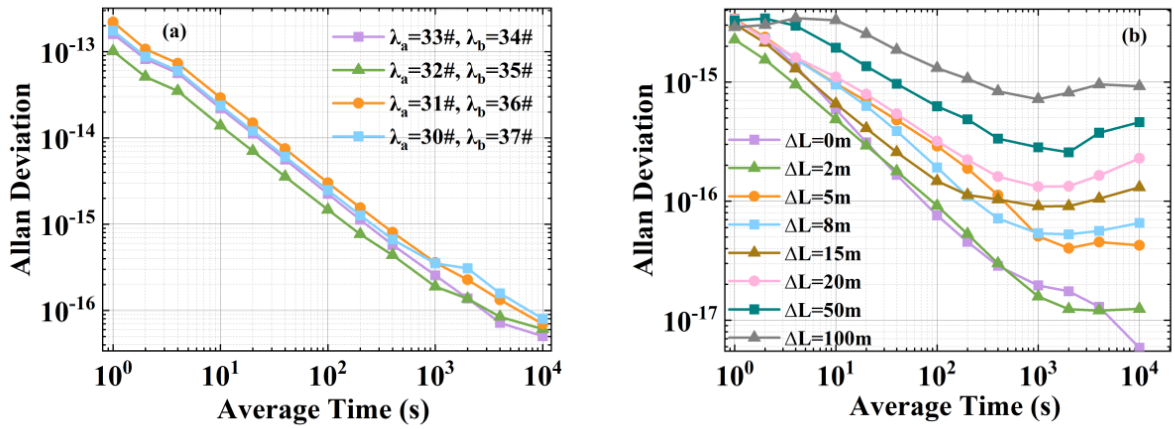

Fig. 2: The ADEV of the system (a) at different wavelength differences and (b) at different fiber length differences