Development of an Optical Carrier Hybrid Transfer System

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Phase-stabilized optical fiber links[1, 2] have permitted ultra-stable frequency comparisons between distant optical clocks. At NMIJ, we have measured a frequency of the Sr optical lattice clock at the University of Tokyo via a 120 km fiber link over a physical distance of 50 km[3]. The transferred optical signal was phase-locked to a fiber comb to convert the microwave signal of the hydrogen maser in NMIJ which was calibrated using a Cs fountain clock and a frequency link to the international atomic time. We are currently developing an optical carrier hybrid transfer system for transferring optical carrier signals of Yb and Sr optical lattice clocks[4, 5] at NMIJ.

The optical carrier hybrid transfer system consists of phase stabilization systems to stabilize the phase fluctuations of an optical carrier, bidirectional optical amplifiers, and regenerators, as shown in Fig. 1. The phase stabilization system employs the method demonstrated by Ma et al[6]. Two acousto-optic modulators (AOMs) with frequency shifts of +100 MHz and +55 MHz were installed at the transmitting side and the receiving side, respectively. A faraday rotator mirror (FRM) was used at the receiving side to reflect part of the optical carrier back towards the transmitting side. The AOM at the receiving side was used to distinguish the reflected optical carrier from the FRM from other intermediate reflections. To stabilize phase fluctuations of the optical carrier at the receiving side, the round-trip light was phase-locked to the optical carrier at the transmitting side. All the optical components were connected with optical fibers. We installed the systems at the transmitting side and the receiving side in the same laboratory to evaluate the transferred signal. A narrow linewidth fiber laser at 1551 nm was used for the light source. Using a spooled fiber of 90 km, the measured fractional frequency stability of the transferred light with phase stabilization was a fractional frequency stability of 4×10^{-15} at an averaging time of 1 s and 6×10^{-18} at 1000 s, measured with a phase measurement system. We are working on the development of the regenerator to further extend the distance and planning to apply our optical carrier transfer system to a spooled fiber of 300 km. In the presentation, we report on the latest results on our optical carrier hybrid transfer system.

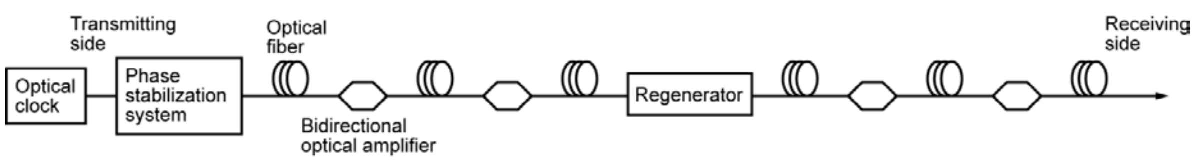

Fig. 1: Schematic of the optical carrier hybrid transfer system

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