Title of Project : GHz Mode-locked Pulse Laser with Simultaneously Stabilized Optical Frequency and Repetition Rate and its Applications

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Research Area : Applied Physics and Engineering Fundamentals

Keyword : Laser, quantum electronics, nonlinear optics, optical measurement, optical control

【Purpose and Background of the Research】

A short optical pulse with 10~40 GHz repetition rate has been widely used in many applications such as ultrahigh-speed optical communication, optical signal processing, and optical metrology. For its applications to optical frequency standard, optical measurement, and coherent optical communication, simultaneous stabilization of the optical frequency and the repetition rate plays a very important role. In this project, we aim to realize a mode-locked laser whose repetition rate and optical frequency are simultaneously stabilized to Cs resonance (9.1926 GHz) and C_2H_2 absorption line (1538 nm), respectively. We apply this laser to the delivery of an optical standard signal through optical fiber networks and to coherent optical communication.

【Research Methods】

Two types of pulse generation technique that we develop in this project are schematically shown in Fig. 1. In Type 1, we stabilize the optical frequency of the Cs repetition-rate-stabilized pulse laser (Cs optical atomic clock) by extracting a longitudinal mode from the optical spectrum and lock its frequency to an C_2H_2 absorption line. In Type 2, the C_2H_2 frequency-stabilized CW laser output is carved into an ultrashort pulse with an ultrahigh-speed optical modulator driven by an ultra-stable Cs synthesizer. We demonstrate their performance through long-haul pulse transmission experiments and clarify their applicability to optical metrology and advanced coherent optical transmission.

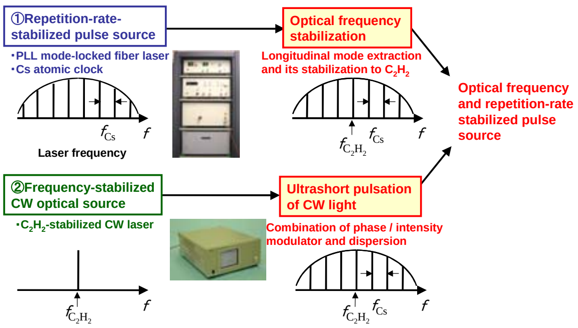

Figure 1 Two types of stable optical pulse source that we develop in this project.

【Expected Research Achievements and Scientific Significance】

Highly precise frequency control of ultrahigh-speed optical pulses enables us to obtain a standard signal from a single optical pulse source, whose long-term stability reaches the same level as that of the Cs time-standard and the C_2H_2 optical frequency-standard. This opens up a new possibility in the field of metrology, where a remote transfer of such a highly stable standard signal throughout the world can be realized by means of optical pulse transmission through optical fibers. In terms of the application to optical communication, an innovative coherent optical transmission such as QAM (quadrature amplitude modulation) and OFDM (orthogonal frequency division multiplexing) is expected. These new possibilities are outlined in Fig. 2.

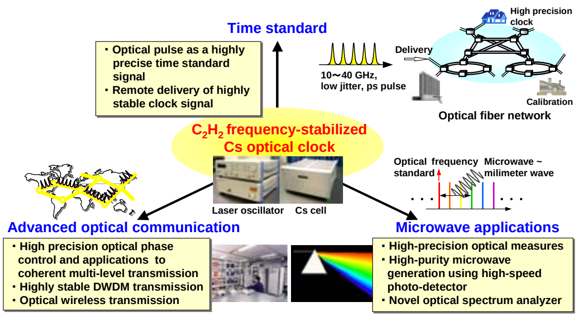

Figure 2 Applications and impact of the time and frequency-stabilized pulse source.

【Publications Relevant to the Project】

[1] M. Nakazawa and K. Suzuki, "Cesium optical atomic clock: an optical pulse that tells the time," Opt. Lett., vol. 26, pp. 635-637, 2001.
[2] M. Nakazawa, K. Kasai, and M. Yoshida, "C_2H_2 absolutely optical frequency-stabilized and 40 GHz repetition-rate-stabilized, regeneratively mode-locked picosecond erbium fiber laser at 1.53 μm," Opt. Lett., vol. 33, pp. 2641-2643, 2008.

【Term of Project】 FY2009-2013

【Budget Allocation】 141,500 Thousand Yen

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