Development of all-optical control techniques using nonlinear fiber effects

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Research Outline

All-optical control techniques using nonlinear optical effects in fibers

In fiber-optic communication, the large-capacity optical networks are required to respond to the increasing of the data traffic. For the next-generation fiber-communication systems, it is necessary to develop ultrafast and wideband optical devices. To use nonlinear optical phenomena in optical fibers are the most effective methods for the all-optical signal control techniques due to the high nonlinearity, ultrafast response speed, wide bandwidth, low loss, and compatibility with the fiber-based systems.

In 2002, the interesting nonlinear fiber phenomena of "pulse trapping and amplification in birefringent fibers" were discovered by N. Nishizawa and T. Goto. The nonlinear fiber phenomena of pulse trapping and amplification in birefringent fibers have been attractive for the ultrafast all-optical control techniques. As shown in Fig.1, an ultrashort control pulse traps ultrashort signal pulse in optical fiber (or twin ultrashort pulses trap each other), and they co-propagate along the fiber. In the propagation along the fiber, the pulse energy is transferred from one to another. Recently, we demonstrated pulse trapping of a continuous wave beam and incoherent light and by ultrashort pulse in birefringent fibers.

The attractive devices using this novel nonlinear fiber phenomena can be developed for the next-generation ultrafast and wideband fiber-optic communication systems, light sources, and so on.

Pulse trapping and amplification phenomena in birefringent fibers

We investigate the mechanism and characteristics of the novel nonlinear fiber phenomena of pulse trapping and amplification in birefringent fibers both experimentally and numerically. Additionally, we developed novel ultrafast all-optical control techniques using pulse trapping and amplification in birefringent fibers.

Using the pulse trapping and amplification phenomena in a standard low-birefringent fiber, a ultrafast all-optical signal regenerator have been developed. When the temporal difference between the two pulses was varied at the fiber input, the initial temporal differences are compensated for and the amplified signal pulse was obtained. The output waveform is a chirp-free, sech^2-shaped, ultrashort pulse. Thus, the regenerator is capable of performing three functions in a single fiber simultaneously: amplification, re-shaping, and re-timing. Since pulse trapping and amplification originates from the ultrafast nonlinear effects of cross-phase modulation, and stimulated Raman scattering, the wideband and ~1 THz ultrafast operation can be achieved.

The performances can be improved using appropriate fibers (highly nonlinear fiber, photonic crystal fiber, etc.). We expect that the techniques would be the key to develop devices applied for a large capacity (next-generation) communication.

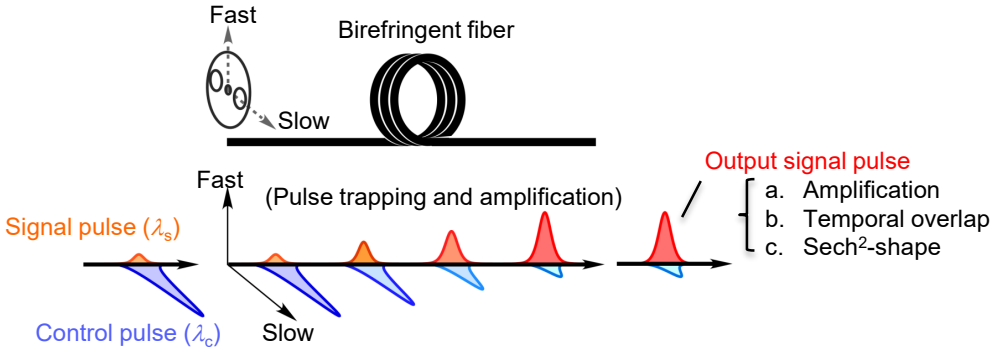

Fig. 1. Scheme of pulse trapping and amplification in birefringent fibers.