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Soliton self-frequency shift in the air-clad tapered fiber

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We report the first observation of self-frequency-shifted solitons in the silica/air-clad tapered fiber. Femtosecond tunable soliton generation with a spectral shift of wavelength up to 1127 nm has been demonstrated for 55-fs pump pulses at 805 nm.

The continuous downward shift of a carrier frequency of ultrashort pulses in fibers, known as the soliton self-frequency shift, enables tunable-redshifted solitons to be obtained in a wide spectral range by varying the pump power [1-3]. During the last 1-2 years this effect was observed in different photonic crystal fibers. In this work, we report for the first time on a soliton self-frequency shift in the silica/air-clad tapered fiber.

The diameter of the silica/air-clad tapered fiber waist is 2.3 μm with the waist length of 12 cm, the lengths of the intermediate regions (between the 2.3-μm waist and 125-μm initial SMF-28 fiber) are 3 cm. The tapered fiber was pumped by pulses of a modelocked Ti:sapphire laser operating at 805 nm. Pulses of the laser had a duration of 50 fs (FWHM time-bandwidth product of 0.44) and the pulse repetition rate was 82 MHz. After the pulses were passed through optical isolation elements and a microobjective, their duration increased up to 80 fs. Using these positive-chirped pulses for the tapered fiber pump resulted in supercontinuum generation. To compensate the positive chirp of pump pulses we applied a dispersion prism delay line in a double-pass configuration.

When using chirp compensated pulses the output spectrum showed qualitative changes. We observed a solitary redshifted spectral component and its wavelength depended on the pump power. In Fig. 1, the output spectra from the fiber for different average powers of fiber-output radiation are presented (maximum average launched pump power was 110 mW for the upper spectrum).

The prisms of the chirp compensator were initially spaced to compensate for positively chirped pulses and then experimentally adjusted by varying the spacing between the prisms and intraprism path length to produce the maximal redshift of spectral components. Fig. 1 shows the power dependence of output spectra at optimal adjustment of the prism compressor.

When the fiber-output powers were more than 10 mW supercontinuum generation was observed in the blue-band of the spectrum simultaneously with the self-frequency soliton forming, but the power of this supercontinuum generation was comparatively not large. For the spectrum from Fig. 1 (16 mW of the fiber-output), the self-frequency shifted soliton energy was about 44% (peak at 1007 nm) of the overall output radiation energy. While increasing the pump power one can observe two distinct redshifted spectral peaks at 1014 nm and at 1127 nm (upper spectrum on Fig. 1). The average powers of radiation of these spectral components were 7 mW and 10 mW, respectively, for 43 mW fiber-output power.

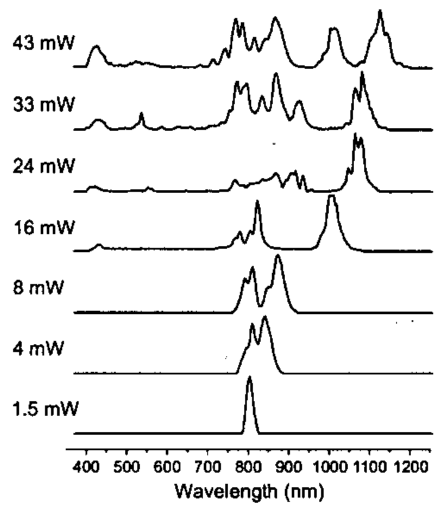

Fig. 1. Output spectra from a 2.3 μm tapered fiber for different average powers of fiber-output radiation (Y axis: normalized intensity).

In summary, we have demonstrated a femtosecond soliton self-frequency shift in silica/air-clad tapered fiber. The 55-fs pump pulses were launched in the anomalous dispersion region of the fiber near a zero-dispersion wavelength. Tunable soliton generation with a spectral shift of wavelength up to 1127 nm was achieved at 805-nm pump in the relatively short (12-cm length) 2.3-μm tapered fiber.

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