4.1x Solitonic Self-Spectral Compression of Fraction of Supercontinuum Spectrum

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The effect of solitonic self-spectral compression (self-SC) has been recently experimentally demonstrated and analyzed in details [1], as a spectral analogue of soliton-effect compression [2–7]. The self-SC has been observed in a hollow core fiber under combined impact of negative group velocity dispersion (GVD) at 800 nm wavelength and self-phase modulation (SPM). Both the soliton-effect compression and self-SC demand the negative GVD, which can be archived by the use of hollow core photonic crystal fibers, or in common single-mode fibers for radiation with wavelengths higher than 1300 nm. The solitonic self-SC requires strong GVD and weak SPM [1], while for solitonic pulse compression weak GVD and strong SPM are required [2]. Analogically, an effective adiabatic soliton self-SC in a dispersion increasing fiber for pre-chirped pulses, the spectral analogue of adiabatic soliton compression, has been reported [8].

We report the self-SC of noisy supercontinum radiation in a standard single-mode fiber. To reach the wavelength range above 1300 nm, where silica has negative GVD, we generated supercontinuum and cut the spectrum with a longpass filter at 1300 nm. We used laser with amplifier at 1030 nm with 400-fs pulse duration and 1 kHz repetition rate. We generated the supercontinuum in YAG crystal for effective output at infrared part of spectrum. After cutting the spectrum, we coupled the radiation into a 600-m long standard single-mode telecom fiber. We optimized the self-SC process by controlling the power with a neutral density filter, resulting in 4.1x self-SC of noisy supercontinuum.

We also carried out numerical studies of the process, based on the solution of the nonlinear Schrodinger equation. We examined pulses with spectrum similar in shape with one from experiment. As the supercontinuum has noisy nature, we numerically examined propagation of randomly modulated pulses in a medium with negative GVD and nonlinearity, using the "signal + noise" model for the pulses. Our studies show that self-SC occurs even for pulses with noisy nature. Moreover, the process of self-SC suppresses the noise, resulting in more coherent radiation at the output. This process has periodic nature, which is associated with high order solitons.

In conclusion, we have experimentally demonstrated 4.1x self-SC of a fraction of noisy supercontinuum spectrum in a 600-m single-mode fiber. Detailed numerical modeling of self-SC for randomly modulated pulses shows that, according to its solitonic character, the process suppresses the noise, resulting in more coherent radiation.

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