Simple Similaritonic Technique for Measurement of the Bell-Shaped, Two-Peak and Compressed Pulse Duration in Femtosecond Domain

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Abstract: We present the studies targeted to development of a new simple technique of femtosecond pulse duration determination, based on generation of nonlinear-dispersive similariton, and allowing to retrieve the duration of pulse under test by coupling it into a single-mode passive fiber and measuring its energy and spectrum or duration at the fiber output.

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The nonlinear-dispersive (NL-D) similariton, generated in fibers without gain under the combined impact of Kerr nonlinearity and second order of dispersion, has bell-shaped spectral and temporal profiles and parabolic phase (linear chirp) independent of the input pulse characteristics [1]. The spectral width of an NL-D similariton depends on the square root of the seed pulse duration: $\Delta\lambda_{sim} \sim \sqrt{E/\Delta t_{in}}$, where $\Delta\lambda_{sim}$ is the similariton spectral width, Δt_{in} is the input pulse duration and E is the pulse energy coupled in the fiber.

Experimentally, we demonstrated the technique for positively and negatively chirped bell-shaped laser pulses, as well as for two-peak and compressed pulses. We used Coherent Mira 900F laser system with 100fs pulse duration and ~10nm spectral width at FWHM. We chirped the pulses both positively and negatively in a dispersive delay line (DDL) and coupled the radiation into a single mode optical fiber to generate the NL-D similariton. Afterwards, we registered the spectrum of the similariton and measured the radiation average power $\bar{p}$ (alternatively to pulse energy). Additionally, we used a 600m long single mode fiber for generation of the similariton. For these fiber lengths, the second order dispersion stretches the pulses up to nanosecond durations. Thereafter, we measured these stretched nanosecond pulses by an electronic oscilloscope and a photodetector. As the duration of stretched pulse is linearly proportional to the dispersive medium length and spectral width [1], its measurement can be alternatively used instead of the spectral measurement, to determine the duration of pulse under test. The results of the experiment for both spectral and temporal measurements are in a good agreement with the measurements performed by an autocorrelator (fig. 1).

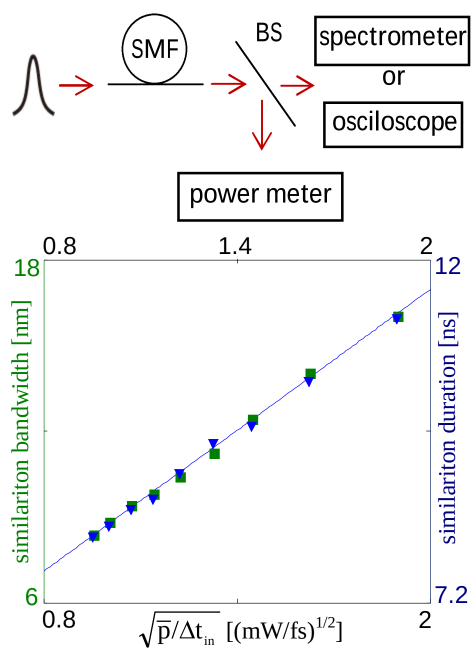

Fig. 1. Experimental results of duration measurements for chirped laser pulses. The similariton bandwidth (green squares, left axis) and similariton duration (blue triangles, right axis) versus $\sqrt{\bar{p}/\Delta t_{in}}$.

Additionally, we have tested the similaritonic method for compressed femtosecond pulses. The results of both the numerical and experimental study show that the method can be used to optimize the pulse compression process. For this, the compressed pulses should be coupled into a single mode fiber, and the DDL should be tuned so that the spectrum at the output of the second fiber is maximally broadened, which corresponds to the point of maximal ratio of pulse compression.

Concluding, we have performed tests of similaritonic technique of pulse duration determination, which resulted in additional option of measurement of similariton duration instead of spectral width. Also, we have proposed an application of the technique, which can be used for pulse optimal compression.

[1] Zeytunyan A., Yesayan G., Mouradian L., Kockaert P., Emplit P., Louradour F., Barthelemy A. J. Europ. Opt. Soc. Rap. Public. 09009, 2009, v.4.