Extremely Flexible and Accurate Chirp-Compensation for 75-MHz Repetitive Glass-Fiber Output of a More-Than 100-THz Bandwidth -- Generation of a-Few-Optical-Cycle Transform-Limited Pulses --

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Abstract. 92-fs, 75-MHz-repetitive pulses from a simple laser-oscillator glass-fiber system were compressed to 7.1-fs transform-limitedly by a chirp compensator consisting of a prism-pair and a spatial-phase-modulating pulse shaper that *in-situ*-adjusts independently and accurately any order dispersions.

Recently, optical pulses in the 4-5 fs regime have been generated by external pulse compression [1] with an amplifier at the repetition rate of 1 kHz, and directly from Ti:sapphire lasers at the repetition rate of 100 MHz [2]. For their chirp compensations, the combinations of prism-pairs, grating-pairs and chirped mirrors have been employed [1,2]. However, the inter-dependence among the group-delay dispersion (GDD), the third-order dispersion (TOD) and the higher-order dispersions as well as the bandwidth limitation of these techniques make it difficult to generate a-few-optical-cycle *transform-limited* pulses. To overcome these problems, we have developed a 4.9-fs, 1-kHz-repetition pulse compressor based on a novel hybrid chirp compensation of a prism pair and a spatial-light-modulating pulse shaper [3]. In this paper, we demonstrate for the first time that this compensation technique is applied to compression to 7.1-fs transform-limited pulses at a 75-MHz repetition rate from a fused-silica fiber in a simple, non-amplified optical source. Furthermore, *in-situ* accurate measurements of the TOD dependence of interferometric autocorrelation traces with keeping GDD constant are demonstrated without realignment of any optics.

In our experimetal setup, the 12-fs, 10-nJ pulses at the center wavelength of 800 nm were generated from a mode-locked Ti:sapphire laser. The 12-fs pulses were coupled into a 2.5-mm silica fiber by a 36x reflective objective which introduced no additional GDD and TOD. A single-mode fused silica fiber with a core diameter of 2.7 μm was used. The output from the 2.5-mm fiber was collimated

In conclusion, we performed compression to 7.1-fs transform-limited pulses at the 75-MHz repetitive rate using a prism pair and a 256-pixel SLM in a pulse-shaping configuration. The accurate TOD characteristic of interferometric autocorrelation traces of more-than 100-THz bandwidth pulses was measured while keeping GDD constant.

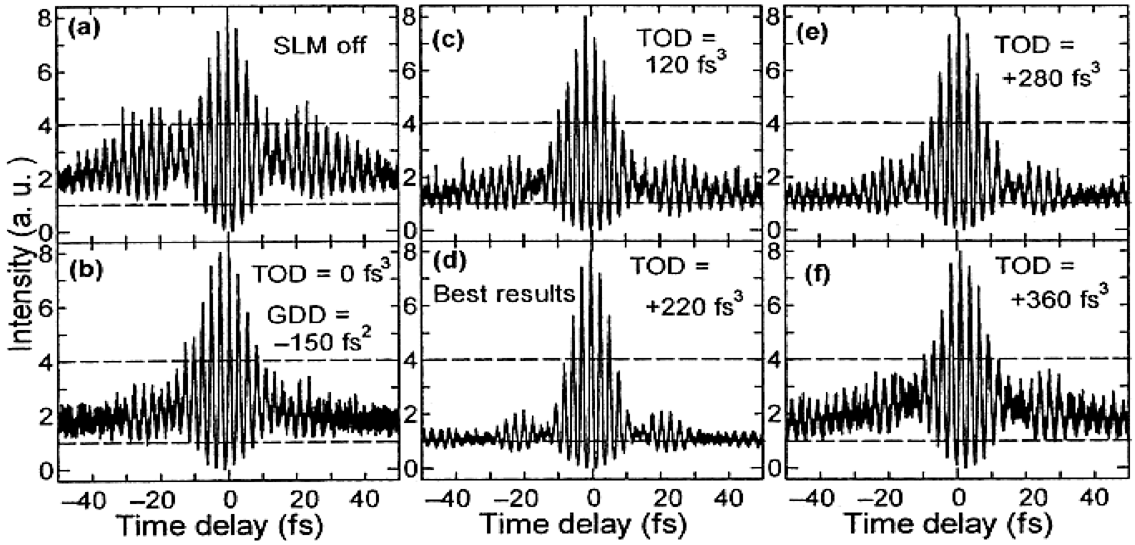

Fig. 2. TOD dependence of measured interferometric autocorrelation traces while keeping GDD = -150 fs^2 constant.

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by another reflective objective and measured by a spectrometer. At the input pulse power of 127 kW, the spectrum was broadened owing to the dispersive self-phase modulation effect and the broad-spectral pulses had the duration of 92 fs. This chirped pulse was first pre-compressed by a pair of fused silica prisms with a separation length of 59 cm. The output pulse from the prism-pair was coupled into a pulse-shaping apparatus [4], which consisted of a pair of 300 lines/mm gratings and a pair of concave 200-mm focal-length spherical silver mirrors. A programmable 256-pixel spatial-light-modulator (SLM) with the total effective width of 27 mm was placed on the Fourier plane.

The 92-fs chirped pulses from the 2.5-mm fiber were compressed to the Fourier transform limited pulses by compensating for GDD and TOD. The GDD and TOD of a silica fiber output were measured to be 342 fs^2 and 187 fs^3 at 800 nm, respectively, by the second-harmonic generation frequency-resolved optical gating. The GDD by the fiber was canceled by using the prism pair, whose GDD and TOD are -342 fs^2 and -479 fs^3 respectively. Considering the SLM's material dispersion (GDD = 165 fs^2 and TOD=125 fs^3), we applied the GDD of -150 fs^2 and TOD of +220 fs^3 to the SLM, which gave the total GDD to be 15 fs^2 and TOD to be 53 fs^3.

The shortest pulse width after complete phase control corresponded to the 7.1-fs pulse duration calculated by the inverse Fourier transform (IFT) of the broad-spectrum from 670 to 930 nm as shown in Fig.1. We confirmed that the dispersion evaluation is correct by measuring the interferometric autocorrelation traces as a function of TOD under the constant GDD = -150 fs^2 as shown in Fig. 2. It shows that GDD = -150 fs^2 and TOD = +220 fs^3 are optimum, and even the small change in TOD greatly affects the temporal pulse profile.

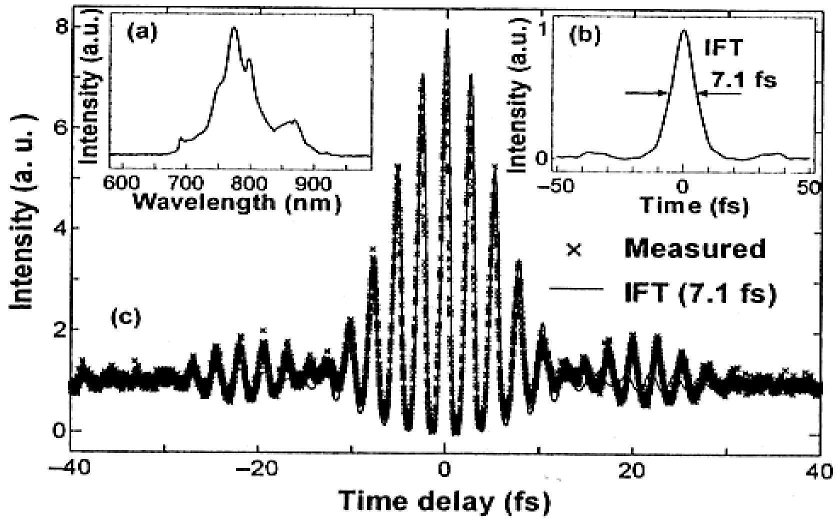

Fig. 1. Measured interferometric autocorrelation trace of the Fourier-transform-limited pulse (×). The solid curve is a fit of calculation from IFT of the pulse spectrum (inset (a)) with FWHM of 7.1 fs (inset (b)).