A compact Ti:sapphire laser oscillator: generation and characterization of 10-femtosecond optical pulses

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A compact Ti:sapphire laser oscillator implementing mirror-dispersion-control and Kerr-lens mode-locking is designed and constructed. The oscillator routinely generates 10-fs pulses with good stability.

A schematic of the constructed laser oscillator is shown in Fig. 1. Z-folded linear cavity has a round-trip cavity length of about 2.1 m. The oscillator consists of a gain medium - highly doped, 2-mm-thick Ti:sapphire crystal, a pair of GDD-oscillation- compensated, double chirped mirrors - M_2 and M_3 ($f_1 = f_2 = 2.5$ cm), a high reflectivity end mirror - M_1, and an output coupler - OC. A frequency-doubled, diode-pumped Nd:YVO_4 laser, (Spectra-Physics Millennia V) is used as a pumping source.

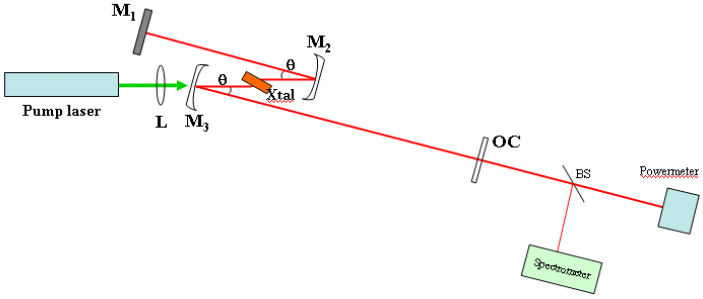


Fig. 1: Schematic diagram of the mirror dispersion controlled sub-10-fs oscillator (Xtal: Brewster oriented, Ti:sapphire crystal, M_1: high reflectivity end mirror, M_2, M_3: GDD-oscillation-compensated double chirped mirror pair, OC: output coupler, L: focusing lens for the pump laser, θ: beam folding angle for astigmatism compensation)

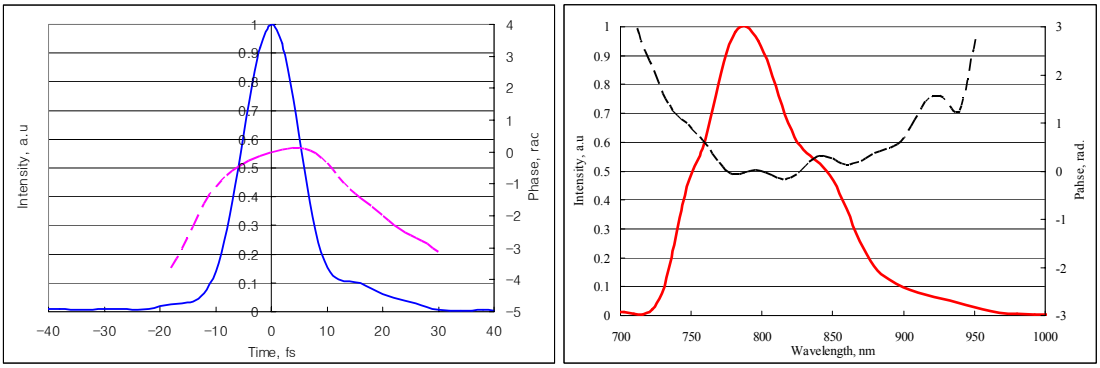
The lengths of the cavity arms confined by M_1-M_2 and M_3-OC have been set equal to d_1=30 cm and d_2=70 cm, respectively.

At the optimized cavity condition, the oscillator generates Kerr-lens mode locked pulses with a sufficiently broad spectrum and a short duration. The output power is 200-400 mW when use 3-4.5 W pumping.

The generated pulse's amplitude and phase are fully characterized by combining FROG (frequency-resolved optical gating) technique and crystal dithering technique[3,4]. The crystal

dithering is necessary because the bandwidth of the optical pulses far exceeds the phase matching bandwidth of the second harmonic generation crystal used in FROG.

In Fig. 2, we have shown the pulse characteristics which were determined by the FROG technique.



(a) (b)

Fig. 2: Reconstructed pulse characteristics.
(a) Temporal intensity (solid) and phase (dashed) profiles of 11.9 fs pulse (FWHM)
(b) Spectrum (solid) and spectral phase (dashed) profiles (spectral width is 95 nm at FWHM)

The temporal length of the pulse was obtained as 11.9 fs at FWHM. The spectral bandwidth of the retrieved pulse is 95 nm at FWHM. The low amplitude oscillations observed in the spectral phase may be explained by GDD oscillations in DCMs and the output coupler.

Temporal and spectral domain consistency checks of the reconstructed pulse have been done by comparing the independently measured data and the agreements were fairly good.

References

1. L. Xu, G. Tempia, A. Poppe, M. Lenzner, Ch. Spielman, F. Krausz, A. Stingl, K. Ferencz, High power sub-10-fs Ti:sapphire oscillators, Appl. Phys. B 65, 151-159 (1997)
2. Y. S. Lim, H. S. Jeon, Y. C. Noh, K. J. Yee, D. S. Kim, J. H. Lee, J. S. Chang, J. D. Park, Generation of sub-10-fs pulses from a Kerr-lens mode-locked Ti:sapphire laser using double-chirped mirrors with flat group delay dispersion, J. Korean Phys. Soc. 40, 837-843 (2002)
3. R. Trebino, K. W. DeLong,D. N. Fittinghoff, J. Sweetser, M. A. Krumbugel, B. Richman, "Measuring ultrashort laser pulses in the time-frequency domain using frequency resolved optical gating," *Rev. Sci. Instrum. 68, 1 (1997).*
4. Baltuska, M. S. Pshenichnikov, D. A. Wiersma, "Second-Harmonic Generation Frequency-Resolved Optical Gating in the Single-Cycle Regime," *IEEE J. Quantum Electron 35, 459 (1999).*