A Sub-10-Femtosecond Terawatt-Scale Ti:sapphire Laser System

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Summary. A three-stage, 1-kHz amplifier system has been developed delivering sub-10-fs pulses with a peak power of 0.3 TW. Passive and active spectral amplitude and phase control allow preserving a bandwidth of 120 nm (FWHM) up to multimillijoule energy levels and temporal compression of the broadband pulses close to their Fourier limit. Future improvements to increase the peak power beyond 1 TW will be discussed.

1 Introduction

Development of high-peak-power laser systems based on the chirp pulse amplification (CPA) concept [1] has opened the way to generate coherent x-ray radiation and attosecond pulses by the technique of high-order harmonic generation (HHG). The ultrashort duration of such pulses benefits both the conversion efficiency [2] and the confinement of the emission into an isolated sub-femtosecond pulse [3]. For Ti:sapphire based amplifier systems a repetition rate of 1 kHz is a good compromise between pulse energy and repetition rate [4-13] and the bandwidth of the amplifier material can support sub-10-fs pulses. We describe an amplifier system producing multi-millijoule sub-10-fs pulses for the first time.

2 Description of the amplifier system

The laser system (Fig. 1) contains three, multi-pass Ti:sapphire amplifier stages and is seeded by a Ti:sapphire oscillator (Femtosource Compact Pro, Femtolasers GmbH). The first stage implements 9 passes and is pumped by 10-mJ pulses after splitting the output of a Q-switched, frequency-doubled Nd:YLF Laser (Thomson CSF 621D) at a 1-kHz repetition rate. The other half of the output is used for pumping the second stage. The first stage delivers pulses with an energy of 1 mJ and gain narrowing is partially compensated [9,13] by thin film dielectric filter inserted into the first eight passes.
After amplification the pulses have a bandwidth of 60 nm. With combination of an LAK16A double prism compressor [13] and specially designed chirped mirrors we were able to recompress the pulses close to their Fourier limit of about 20 fs.

In order to provide sufficient bandwidth for generating sub-10-fs pulses, the pulses are launched into a hollow-core fiber [17]. The direction of the laser beam is monitored at two different positions with a CCD camera (Fig. 1). Deviations of the ideal beam direction are corrected with a pair of mo-