Progress on implementation of a cross-polarised wave generation temporal filter for the Gemini laser

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Introduction

Improvement of temporal contrast for chirped pulse amplification (CPA) is of great importance. A technique for temporal cleaning of the pulse by cross-polarised wave (XPW) generation has become a routine tool for CPA systems. Recently a temporal filter based on XPW [1] (XPWTF) has been installed at the front end of the Gemini laser system to provide effective contrast enhancement. Here we describe the progress made to incorporate XPWTF together with additional structural elements into the chain of Gemini laser amplifiers.

Figure 1. Schematic diagram of the temporal cleaning unit which consists of : 1-pulse compressor; 2-XPW stage; 3-stretcher and dispersion control; 4- amplifier.

The design incorporates the XPW as the main part of a temporal cleaning unit, positioned in the amplification chain between the 1 kHz front end amplifier (Femtolasers Compact Pro) and the multi-pass main grating stretcher. The temporal filter unit (Figure 1) includes a pulse compressor, XPW stage, temporal stretcher and amplifier (Figure 1). The first two elements of the temporal filter unit, the compressor and XPW temporal filter, have been described earlier [1]. After the XPW stage the beam enters the stretcher which consists of a dispersive mirror stretcher, a material stretcher and a dispersion control device, which is an acousto-optical programmable dispersion filter (APODF) or "Dazzler" (Fastlite). The dispersive mirror stretcher is made of five matched pairs of mirrors (Ultrafast Innovation) with a nominal positive dispersion +150 fs^2 per bounce. The beam from the XPW stage is reflected twice from each mirror, giving a total of 20 reflections and a positive dispersion of ~ 3000 fs^2. The dispersion of the mirror pairs has been tested in a dispersion-scan [2] configuration with detection of the spectrum at the second harmonic frequency while the second order dispersion was changed at the fundamental frequency using the Dazzler in the source laser. The optimum compression point moved to a lower value of group delay dispersion (GDD), confirming the expected stretch. Figure 2 shows the smooth dependence of the SHG spectrum after 4 bounces off the mirrors and the compensation of the mirror pairs' dispersion irregularities.

The material stretcher is a 150mm long block of SF10 glass used in double pass, which adds a GDD of ~47700 fs^2 at 800 nm. The TeO_2 Dazzler crystal adds a GDD of ~12000 fs^2 due to the material dispersion, and there is an additional GDD of ~9000 fs^2 from the programmable acousto-optic effect. The total GDD in the temporal cleaning unit will be in the range of 73550 fs^2, similar to the normal stretch of the pulse before the grating stretcher. The use of the Dazzler at this point provides flexibility in pulse dispersion management and also reduces the repetition rate of the pulses to 10 Hz before amplification.

The beam size in the stretching part of the system is reduced before the Dazzler with a Galilean lens telescope to match the aperture size of the Dazzler crystal. The beam is demagnified further between the stretcher and amplifier with another positive-negative singlet lens pair.
The amplifier (see fig.3) is built for 4-pass amplification in a 6 mm long Ti:Sapphire crystal with Brewster cut. The amplification path is folded by 6 mirrors. The amplifier is pumped by a frequency-doubled Spectra-Physics INDI laser, whose output is split to pump the crystal from both sides. The pump beams are image-relayed and demagnified to give a pumped region of ~1.5-1.8 mm diameter.

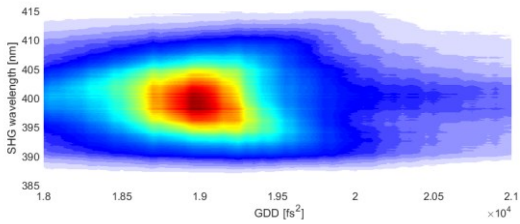

Figure 2. Spectral traces of the frequency doubled infrared pump pulse after 4 reflections from a pair of positively chirped mirrors, as a function of the applied group delay dispersion (GDD step 50 fs^2).

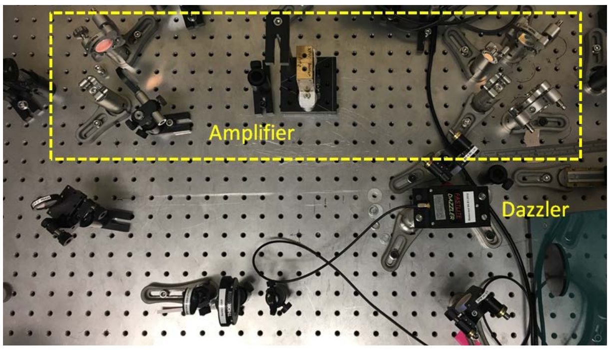

Figure 3. Photo of booster amplifier, consisting of 6 folding mirrors and the Ti:Sapphire crystal in the middle of the amplifier.

Amplification tests with a dummy seed beam showed the expected gain of around 50 at a moderate pump level.

Conclusions

The work on full implementation of the XPW temporal filter is continuing. All the major components have been installed and aligned, and preliminary amplification tests with a dummy seed beam have shown the expected performance.

References

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2. M.Miranda, C. L. Arnold, T. Fordell, F. Silva, B. Alonso, R. Weigand, A. L'Huillier and H. Crespo "Characterization of broadband few-cycle laser pulses with the d-scan technique", Optics Express 20, 18732-18743 (2012)