

## Contrast enhancement using gating techniques

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### Introduction

As part of the Astra facility development it is important to investigate contrast enhancement techniques to ensure high temporal contrast pulses are delivered to target. With the impending Gemini upgrade it is especially important to ensure a high ( $10^9:1$ ) contrast ratio to prevent any pre-pedestal generating a pre-plasma and adversely affecting the laser interaction. In the last annual report a contrast cleaning technique based on Kerr gating in  $CS_2$  was reported. This work has been followed up to investigate saturable absorber and solid state Kerr media.

### Experimental details

The Kerr gating was tested in Astra using a 2 mm PbBiGa glass<sup>1,2</sup> sample and the original carbon disulphide ( $CS_2$ ) for comparison. The beam was split to give 90% of the energy for the gating pulse and 10% to be gated, Figure 1.

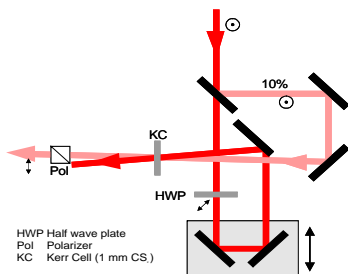


Figure 1. Experimental layout for self-gating experiments.

The polarizer was set to fully extinguish the gated pulse when the gating pulse was blocked. The polarization of the gating pulse was rotated through  $45^\circ$  by a half-wave plate. Both pulses enter the Kerr cell. The more intense gating pulse is slightly ahead and causes a birefringence in the media which then rotates the polarization of the weaker gated pulse allowing it pass through the polarizer.

The saturable absorber gating was tested using the same setup with the waveplate and polarizer removed. A dye, IR140, and glass filter RG850 were chosen for their saturable absorber properties at 800nm. A 2mm cell of 30mg IR140 in 100cc of ethanol was used. The gating pulse fluence was set to saturate the absorber before the second pulse arrived.

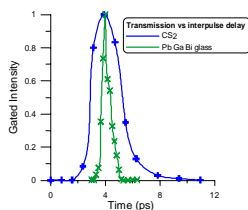


Figure 2 SA response.

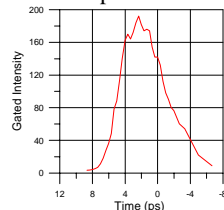


Figure 3 Kerr response.

### Results

The gated signal vs. the relative pulse delay was plotted to assess the response time of the two gating techniques Figures 2 and 3. The glass showed a very sharp response with a gate time of 300 fs. A gating pulse intensity of  $70 \text{ GWcm}^{-2}$  was required to give 57% gated efficiency. In comparison the IR140 started saturating at  $10 \mu\text{J}/\text{mm}^2$  ( $\sim 10$  less intensity).

For the tests the gating pulse was set to  $42 \mu\text{J}/\text{mm}^2$  to ensure some saturation before the second pulse arrived. The dye had a slower response time and a fwhm of 6 ps, closer to that of Central Laser Facility Annual Report 2004/2005

the  $CS_2$  tested before. The RG850 filter tested was found to be closer to an RG840 and had too little absorption at 800 nm to show any appreciable gating and could not be used for the tests.

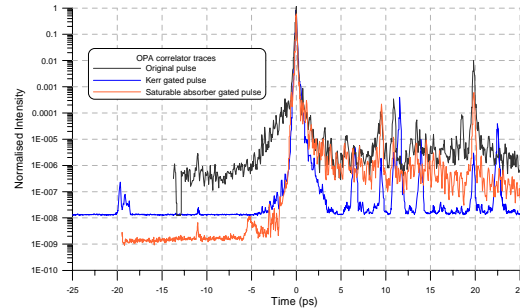


Figure 4. Correlation scans.

When the beam profile of the gated pulses was viewed it was apparent that beam non-uniformities in the Kerr gating pulse were being imprinted on the gated pulse. This was not observed with the absorber gating.

A high dynamic range correlation scan of the different techniques is shown in Figure 4. The grey trace shows the original laser pulses with a  $\sim 10^6:1$  pulse contrast and a slow, 7 ps, rising edge.  $CS_2$  Kerr gating is shown on the blue trace. The measurement was limited by the correlator sensitivity as signified by the lack of noise on the low-level trace. However the contrast has been improved by at least two orders of magnitude and the rising edge is significantly sharpened. Further measurements showed that was limited by the polarizers and could be improved by using higher quality optics. It was not possible to take a scan with the Kerr glass due to its lower transmission and poor optical quality. The orange trace shows the results achieved with the IR140 saturable absorber. Again it was slightly limited by the correlator, but shows a considerable reduction of the pre-pedestal ( $\sim 3$  orders of magnitude) and sharpening of the rising edge. After the main pulse a much longer and slower relaxation is evident, a longer range scan showed a decay time of  $\sim 100\text{ps}$ .

Autocorrelation traces of the ungated and Kerr gated pulses showed no measurable stretching in the gate. SPIDER measurements of the saturable absorber gated pulse showed 0.2 radians phase error, within the noise level of the instrument.

By adjusting the energy split the total efficiency of the  $CS_2$  Kerr cleaning was increased to 10%. The saturable absorber cleaning was nearer 4% although no attempt was made to optimize this.

### Conclusion

Two methods of pulse cleaning have successfully been demonstrated, giving up to 1000 times improvement in pulse contrast. The saturable absorber gave the best results with no measurable temporal or spatial effects. Since IR140 is unpleasant to work with we will continue by investigating solid state saturable absorbers like V: YAG and other glasses.

### References

1. "Femtosecond optical Kerr shutter using lead-bismuth-gallium glass Optics" Comms 215 (2003) 407-411
2. Sample made by:-The Technical Glass Company, Suffolk CB9 7BN UK