A Michelson interferometer for pulse-train generation on Gemini

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Introduction

An experimental proposal from the Plasma Physics group at the University of Oxford asked for a Michelson interferometer to be included in one of the Gemini beam lines. The purpose of the interferometer was to modulate the envelope of the stretched pulse, by overlapping two copies of the pulse with a small delay between them. After compression, this would result in a highly modulated pulse, in effect a train of pulses, whose spacing could be controlled by adjusting the relative delay in the arms of the interferometer and by changing the phase correction applied with the Dazzler at the front end of the laser. This article describes the design and setup of the interferometer.

Design and location of the interferometer

The beam diameter in the Gemini amplifiers is 50 mm, and 4-inch optics are required to avoid beam clipping at 45 degrees. The preferred location for the interferometer was at the input to the south amplifier, where there is a suitable space free from mirrors and other components. Placing the device there would also allow the 50% energy loss to be made up in the amplifier. However, there were concerns that amplification would change the spectrum of the pulse and distort the modulation and, in any case, the energy needed in the pulse train beam was not very high. The users therefore requested that the interferometer be placed after the final pass of the amplifier.

Michelsons are generally set up so that the arm mirrors retro-reflect the beam, and where the device is being used for spectroscopic applications, this is acceptable. In the beam of a high-power laser, however, back reflections must be avoided, so the interferometer was designed with an angle of incidence of 1.2° on the arm mirrors. This was small enough not to cause any clipping on the interferometer optics, but ensured that the rejected beam was displaced by 100 mm at a point near the Ti:sapphire crystal, where it was absorbed on a beam dump. Figure 1 shows the layout of the device.

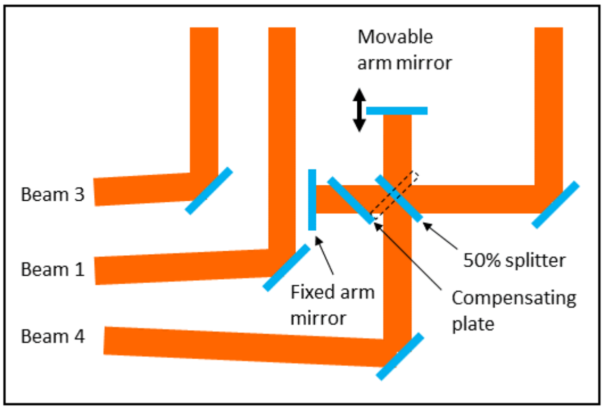

Figure 1. Schematic of the Michelson layout in the south amplifier. The dashed outline shows the position of the mirror that was removed to make space for the interferometer

The space available for the interferometer was very limited, due to the presence of other beam-steering optics and the pipes carrying the pump beams for the amplifier. One beam-steering mirror was removed after marking its position on the table, and the other components installed. Figures 2 and 3 are photographs of the setup in place on the amplifier table.

Figure 2. Top view of the Michelson interferometer

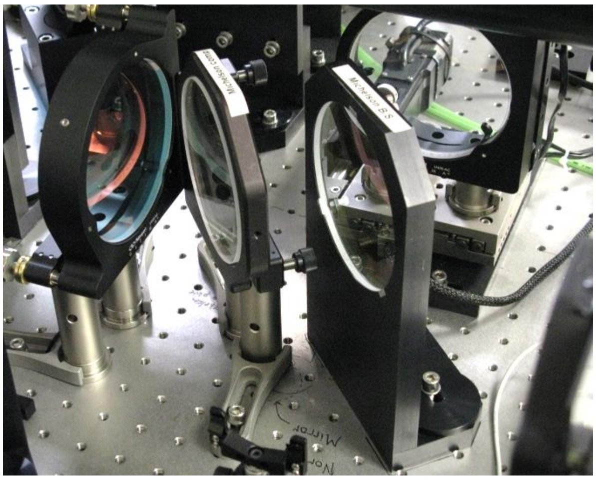

Figure 3. Oblique view showing the motor of the delay stage behind the movable arm mirror at the upper right

The plan view in Figure 2 corresponds more or less to the schematic in Figure 1. The movable arm mirror is mostly hidden by the pump beam pipe at the top of the image.

Setup and alignment

The beamsplitter and the compensator plate were both oriented at 45 degrees by referencing the hole matrix on the table. The 50% coating of the beamsplitter faced the incoming beam, and the compensator plate was positioned in the reflected beam to balance the effect of the extra double-pass by the transmitted beam through the beamsplitter substrate. The compensator is the same thickness as the beamsplitter, and anti-reflection coated on both sides. The fixed and movable arm mirrors were both mounted in high-quality adjustable mounts, so the beams from the two arms could be made parallel. The movable arm mirror was mounted on a delay stage that could be controlled remotely through a PC, and the tilt adjustments on that mirror were fitted with picomotors to allow the experimenters to fine-tune the alignment. The 1.2° angular offset was made by defining the location of the return beam at a point near the Ti:sapphire mount, and aligning the mirror in the movable arm to bring the CW diode beam to that location (Figure 4).

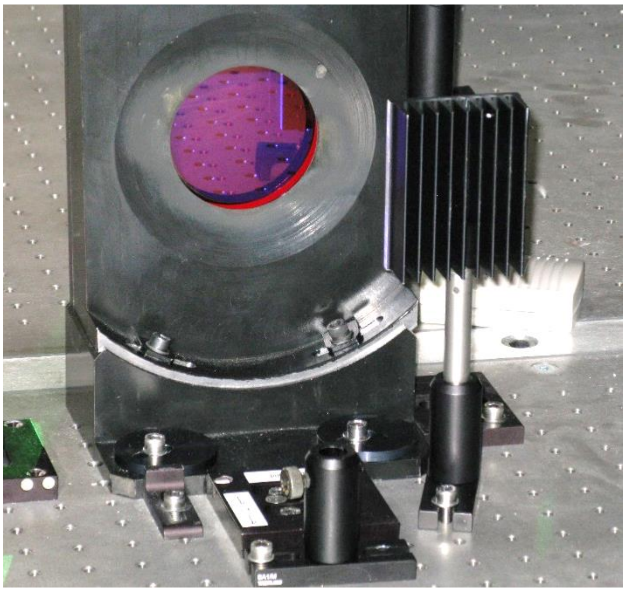

Figure 4. The south amplifier Ti:sapphire crystal & the beam dump for the rejected beam from the Michelson interferometer

The fixed arm mirror was then aligned using an infra-red viewer to observe the output beams. Once the beams were made to fully overlap downstream, fringes became visible in the near-field and the arm mirrors could be brought into parallelism. It was not possible to set the delay of the movable arm using the CW diode beam, because the coherence length of the laser was too long and the fringes were visible over several centimetres of movement. The mirror position was set initially using a ruler, and fine adjustment was made later, using the pulsed beam and timing diagnostics in the target area.

Performance of the interferometer

The interferometer was intended to generate a modulated spectrum, which after compression would yield a temporally-modulated pulse. To achieve this the compressor length was set 1.75 mm longer than required, in order to give a pulse of around 1 ps FWHM duration. Figures 5, 6 and 7 show measurements of the output recorded during the experiment. The spectrum of the pulse is deeply modulated, and the compressed output pulse also shows a deep modulation, in effect a series of pulses with a constant spacing. The sub-pulse spacing could be varied within the time envelope by adjusting the movable arm of the interferometer.

Conclusions

The interferometer was used successfully during the recent experiment by the Oxford group. The setup has since been dismantled, but the positions of the optics were marked on the table so it can easily be restored if needed for use in future experiments.

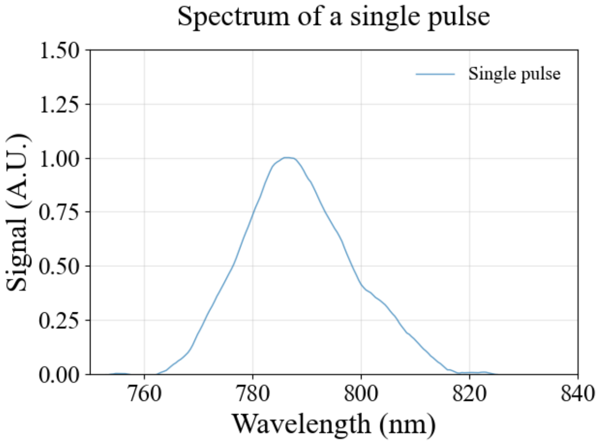

Figure 5. Spectrum of the unmodulated Gemini output pulse

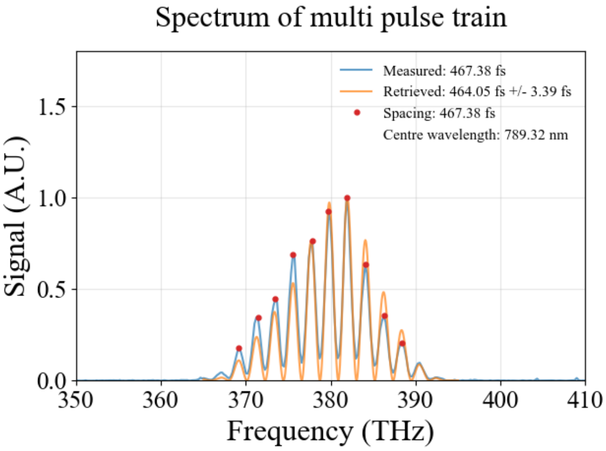

Figure 6. Spectral modulation generated by the interferometer

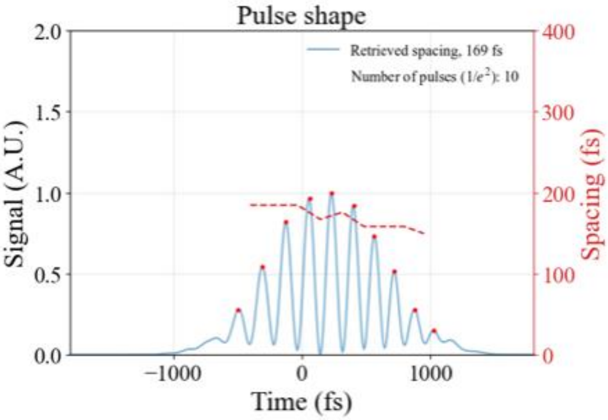

Figure 7. Shape of the output pulse train retrieved from a single-shot autocorrelation measurement, showing the temporal modulation

Acknowledgements

Thanks are due to the Oxford Plasma Physics group for supplying the plots of the interferometer performance.