All Fibre Tunable Source of Picosecond Pulses at 1545 nm

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ABSTRACT

We have developed a tunable source of picosecond pulses at 1545, utilising pulse compression in dispersion decreasing fibre, followed by spectral filtering and amplification.

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In this paper we present a simple method of production of tunable soliton pulses of picosecond duration around 1545 nm. Our system uses solely passive techniques to produce and modify, both temporally and spectrally, a stable stream of soliton pulses, which represents simplifications over previous techniques to produce such pulses[1], which have required implementation of active techniques. This source has potential as a general laboratory tool with a tuning range of >50nm, making it a viable alternative to other sources such as colour centre lasers. The availability of high peak pulse powers also makes it an attractive source for second and third order non-linear effects such as second harmonic generation, cascaded optical non-linearities and optical switching.

The experimental setup is depicted in figure 1.

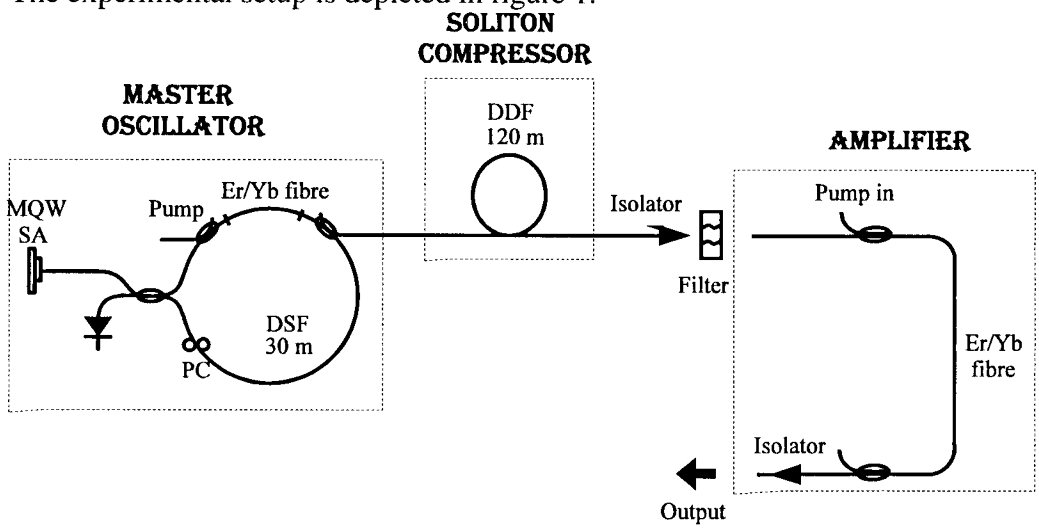


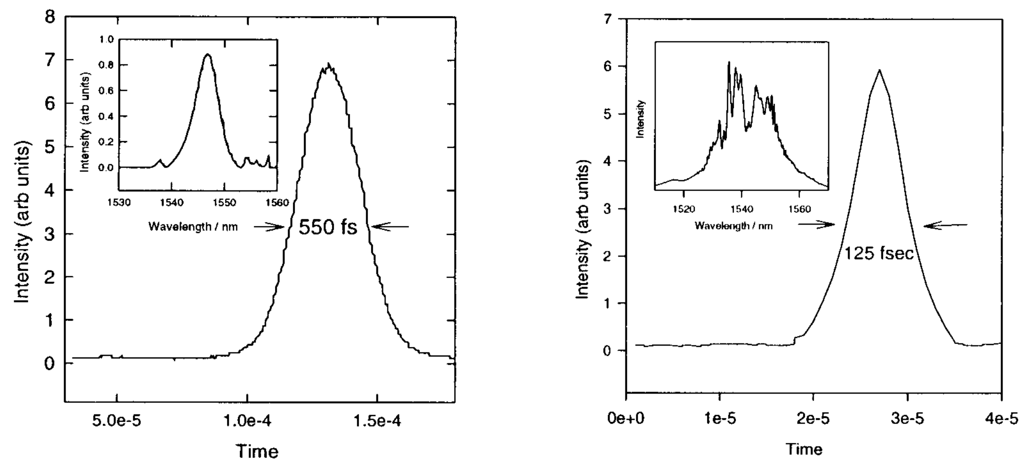
Fig.1 Experimental configuration

The laser is based on non-linear amplifying loop mirror (NALM) used in conjunction with a multi-quantum well (MQW) saturable absorber, and is pumped at 1064 nm by a 400mW mini-YAG laser. The inclusion of the MQW results in easier self-starting of the laser and also acts as a passive phase modulator which stabilises the laser repetition rate compared to conventional NALM lasers[2]. The laser produces bandwidth limited soliton pulses at 1545 nm, with a pulse duration of 550 fsec (fig 2a) and a spectral bandwidth of 5 nm (time bandwidth product of 0.32). The repetition rate of the laser is 200 Mhz with an average output power of 20 mW, resulting in pulses with a peak power of 100W.

The output from the laser was coupled to a 120 m length of dispersion decreasing fibre (DDF) produced at the Fiber Optics Research Centre of the General Physics Institute in Moscow, with dispersion varying linearly from 10 ps/nm.km at the input to ~ 0.5 ps/nm.km at the output. As long as the rate of dispersion decrease is small compared to the dispersion length the solitons are compressed adiabatically according to

$$\tau_p \propto D / E_s$$

where t_p is the soliton pulse width, D is the dispersion and E_p is the pulse energy.

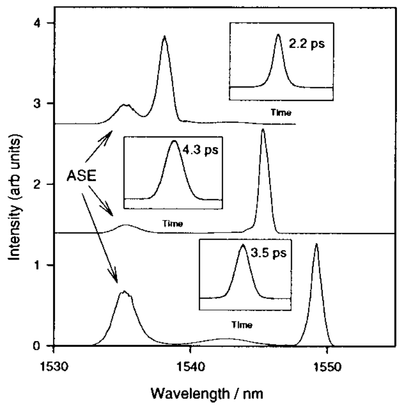


(a) (b)

Fig.2 Autocorrelations and spectra (insets) at the output of the laser (a) and the DDF (b)

The pulses are compressed in the fibre to 125 fsec (fig 2b), and remain transform limited with a spectral bandwidth of 20 nm (inset) and a peak power of 250 W. It is the effect of third order dispersion which limits the compressed pulsewidth to around 125 fsecs. In this fibre the third order dispersion is 0.06 $ps/nm^2.km$, meaning that the dispersion seen by the 125 fsec pulse over it's 20 nm bandwidth varies by 1.2 ps/nm.km. Consequently, for a pulse propagating in a region of zero dispersion at pulse centre, much of the pulse propagates in a regime of positive dispersion, imposing a lower limit on the attainable pulsewidths. Implementation of a fibre with flattened third order dispersion in our system will allow compression of the pulses to less than 50 fsecs[3], resulting in a spectral bandwidth of >50nm.

The output pulses from the DDF were passed through a 1nm wide notch filter centred on 1550 nm, and then amplified in 5m of Er/Yb doped fibre, pumped by Nd:YAG. Rotation of the filter facilitated tuning of the wavelength of the output pulses from 1535 - 1550 nm, the upper limit set by the filter rather than the spectrum of the pulses emerging from the DDF.



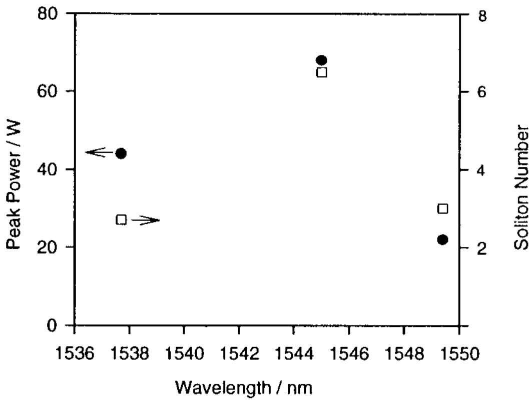


Fig. 3 Spectra and autocorrelations (insets) of amplified pulses at various wavelengths **Fig. 4 Peak power and soliton number**

Figure 3 shows autocorrelation traces and spectra for the output pulses for a range of wavelengths. The peaks due to amplified spontaneous emission (ASE) account for a significant proportion of the output power only at the high wavelength end of the tuning range. The time bandwidth product of the output pulses indicates that they are not transform limited $sech^2$ pulses, although for many applications this is not of great importance. The energy of the output pulses and the soliton order as a function of wavelength are shown in figure 4. The peak power of the pulses may be increased by further optimisation of the system

In conclusion, we have demonstrated a simple and reliable source, which is capable of yielding picosecond pulses tunable over a range of 50 nm around 1545 nm. This is useful as a general spectroscopic tool, and considering the high peak powers available provides a means of investigating non-linear optical effectsefficient second harmonic generation. Preliminary experiments on second harmonic generation in periodically poled Lithium Niobate suggest that conversion efficiencies of 20% will be readily achievable.

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