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TUNABLE SOURCE OF 4ps TO 230fs SOLITONS AT REPETITION RATES FROM 60-200 Gbit/s

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Abstract We demonstrate an ultra high-repetition-rate, tunable source of soliton pulses based on the non-linear propagation of a dual-frequency beat-signal from two DFB laser diodes, amplified with an erbium-doped fibre amplifier, through a dispersion-decreasing fibre.

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Abstract We demonstrate an ultra high-repetition-rate, tunable source of soliton pulses based on the non-linear propagation of a dual-frequency beat-signal from two DFB laser diodes, amplified with an erbium-doped fibre amplifier, through a dispersion-decreasing fibre.

Traditionally, active or passive mode-locked lasers are employed as sources of optical pulses. The repetition rate is thus determined by the resonator length and, in the case of the active scheme, additionally by the optoelectronic modulator frequency. An alternative method recently proposed[1-3] produces a continous train of soliton pulses by the non-linear propagation of a high power, cw, dual-frequency (beat) signal in a length of either amplifying or dispersion-tapered (ie decreasing) fibre. In this case the repetition rate of the pulse train is simply determined by the frequency separation of the source lasers. Thus high-quality solitons at repetition rates in the range ~GHz to THz can be generated.

In this paper we report the performance of an ultra high repetition-rate, 60-200 Gbit/s soliton pulse source. We demonstrate extremely wide tuning of repetition rate, pulsewidth and mark-space-ratio (MSR) of the generated pulse trains for the various different regimes of operation of the source.

The experimental configuration is illustrated in Fig.1. Two pig-tailed single-frequency DFB diode lasers emitting at wavelengths around 1.55μm were used to create the beat signal. The laser wavelength separation could be varied between 0 and 2.5 nm by independently varying the diode temperatures. The beat signal was amplified in an Er^{3+}-doped fibre amplifier (EDFA) pumped by a Ti:Sapphire laser at 978nm. Up to 300 mW of amplified signal was available at the EDFA output. The key component in the scheme is a 1.6km length of dispersion-decreasing fibre (DDF) used for compression of the beat signal into a train of soliton pulses. The dispersion of the DDF gradually decreased from 10 ps/nm/km to 0.5 ps/nm/km over its length. To extend the range of tunability of the source, lengths of dispersion-shifted fibre (DSF), either 1km or 2.2km were added before the DDF and resulted in i) a high repetition-rate (60-90 Gbit/s, 1.3-4ps pulsewidth) soliton source, ii) a high repetition-rate (60-80 Gbit/s, 900fs-4ps pulsewidth) soliton source or iii) an ultra high repetition-rate, (75-200 Gbit/s, 230fs-2ps) pulsewidth source, as described below.

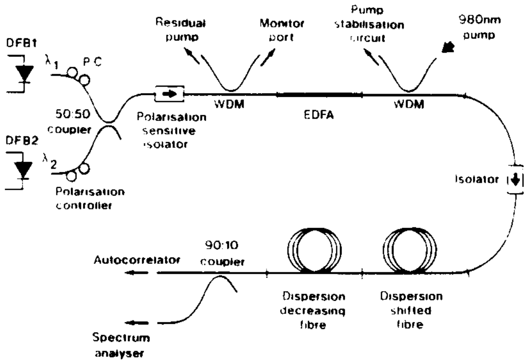

Fig 1. Experimental configuration.

(i) In this case a 1km length of DSF (D <1.5 ps/nm/km) was spliced in-front of the DDF and caused a small spectral enrichment of the beat-signal through four-wave mixing prior to soliton formation in the DDF. The output from the DDF consisted of cw trains of high-purity, pedestal free, fundamental solitons at a repetition rate in the range of 60-90 Gbit/s and duration in the range of 1.3 - 4ps, corresponding to mark-space ratios (MSRs) in the range 1:4 to 1:11. A typical result is illustrated in Fig.2. Tuning was achieved simply by varying the frequency separation between the source DFBs and the amplifier pump power.

(ii) In the next configuration the 1 km DSF fibre was replaced with a 2.2km length of similar DSF and this permitted the generation of cw soliton trains at repetition rates in the range 60-80 Gbit/s and soliton durations in the range 900fs to 4ps, corresponding to MSRs from 1:4 to 1:17. In these cases a small (~ ±mA) 100MHz synchronous modulation of the laser drive currents was employed, to increase the laser linewidth, and to suppress stimulated Brillouin scattering[3]. Fig.3 shows the spectrum and autocorrelation trace for a 64GBit/s train of 900fs pulses corresponding to a MSR of 1:17. In addition, 40-60Gbit/s trains of 1 to 3ps pulses could be generated, although in this case a pedestal remained.

(iii) Finally, the amplified beat-signal was coupled directly to the DDF. Unfortunately, in this case the amplified power was not sufficient to generate a cw train of well-separated pulses in this particular DDF. To overcome this we chopped the DFB lasers with a 100nsec pulsewidth and 300kHz repetition frequency through synchronous modulation of their drive current. As a result the power of the beat signal within the 100ns square pulses increased approximately three times in comparison to the cw power[3]. Repetition rates ranging from 110 to 200Gbit/s and soliton durations from 650fs to 2ps were obtained in this mode. In addition, we have obtained 75-140 Gbit/s trains of optical solitons with durations as short as 230fs through the Raman self-frequency shift, as shown by the spectrum and autocorrelation of Fig.4. The generated spectrum is shifted to the Stokes region and contains approximately 80% of the full signal energy. The physical mechanism in this case is similar to one recently considered theoretically[4].

In conclusion, we believe that this simple, highly-stable and widely-tunable all-fibre soliton source has great potential for application in telecommunication systems and as a tool for the investigation of ultrafast phenomena.

References

1. E.M. Dianov, P.V. Mamyshev, A.M. Prokhorov and S.V. Chernikov, Opt. Lett., **14**, p. 1008, 1989.
2. P.V. Mamyshev, S.V. Chernikov and E.M. Dianov, IEEE Jnl. of Quant. Electr., **27**, p. 2347, 1991.
3. S.V. Chernikov, J.R. Taylor, P.V. Mamyshev and E.M. Dianov, Electr. Lett., **28**, p. 931, 1992.
4. P.V. Mamyshev, S.V. Chernikov and E.M. Dianov, Opt. Lett. **15**, p. 1365, 1990.

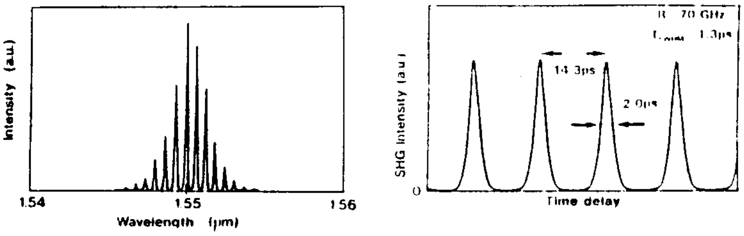

Fig 2. **Spectrum and autocorrelation of 70 Gbit/s repetition rate, 1.3ps pulses after propagation through 1km DSF and DDF.**

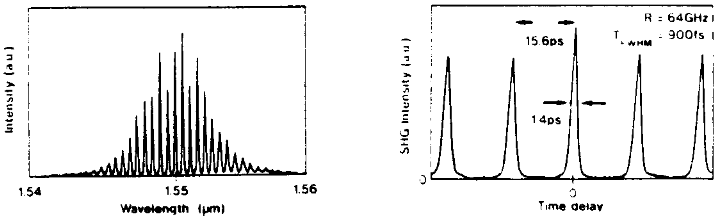

Fig 3. **Spectrum and autocorrelation of 64 Gbit/s repetition rate, 900fs pulses after propagation through 2.2km DSF and DDF.**

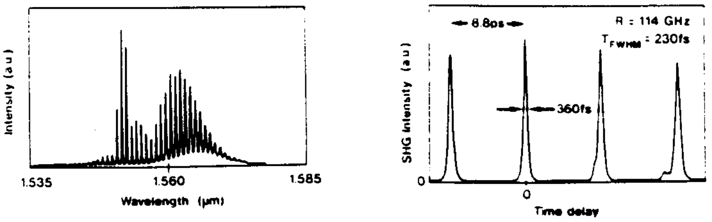

Fig 4. **Spectrum and autocorrelation of 114 Gbit/s repetition rate, 230fs pulses after propagation through DDF.**