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CW Raman Amplifier For Soliton Transmission

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ABSTRACT

We demonstrate the use of Raman gain for loss compensation in a 35 km fibre span. Computer simulations based on experimental results indicate that the deployment of Raman amplifiers allows the transmission of a 100 GHz stream of solitons over 1000 km.

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The Raman amplifier has the attraction that the transmission fibre is its own amplifier and the first experiments with soliton transmission had produced encouraging results [1], but the lack of inexpensive and reliable pump sources and the appearance of more efficient erbium-doped fibre amplifiers put the Raman amplifier into the shadow. However the development of highly efficient fibre lasers with output power up to 1 W [2] could have a significant impact on the application of the imaginary part of fibre nonlinearity (Raman gain) when and where the real part (the Kerr effect) is already in use and in this paper we demonstrate that the advances of modern fibre optics might result in a re-examination of the Raman amplifiers role in ultra-high bit rate transmission systems.

In the experiment a 35 km length of commercially available dispersion shifted fibre (zero dispersion wavelength is 1542 nm) was pumped by a narrow-band fibre laser based on a co-doped Er/Yb fibre. The laser cavity was formed by a fibre grating with 100% reflectivity at 1535 nm and a fibre loop mirror with 10% reflectivity. With 1.5 W pump power from a Nd:YLF laser the fibre laser produces 250 mW at 1535 nm within less then 0.1 nm spectral bandwidth. As a signal we have employed a broad-band source based on Er/Yb co-doped fibre.

Fig.1 shows the spectral dependence of the Raman gain in the counter-propagation scheme. The experimental results indicate that for 250 mW of pump power the fibre loss is compensated for wavelengths longer than 1600 nm. The maximum gain of 8 dB occurs at 1635 nm corresponding to frequency shift of ~440 cm^{-1} which is in good agreement with the Raman gain curve in silica glass [3].

The most attractive feature of Raman amplifiers is that, being essentially distributed, they offer much more uniform gain along the transmission system than conventional erbium-doped fibre amplifiers. This is a very important issue for soliton-based transmission systems where distributed loss and lumped gain impose strong limitations on the solitons pulsewidth and the amplifier spacing. To demonstrate advantages of the use of Raman amplifiers in soliton transmission systems we have modelled a transmission system with a 35 km spacing and 8 dB loss between amplifier pump units. The fibre dispersion is 1 ps/nm·km and a pulsewidth of 2 ps make the amplifier spacing equal to 27 dispersion lengths. The bi-directional Raman gain is provided by two pump sources giving 11 dB gain each (or 3 dB of net gain, including the fibre loss). The pump power loss includes 8 dB of intrinsic fibre loss and 2 dB loss due to pump depletion. Fig.2 shows the dynamics of pulse propagation over 650 dispersion lengths, the inset demonstrates variations of the pulse intensity and the pulsewidth along the system which indicate reasonable pulse stability.

From the presented results one can conclude that the use of Raman amplifiers makes possible transmission of a 100 Gb/s stream of solitons over at least 1000 km. The further improvement of the pump source such as the shift of pump wavelength towards 1520 nm and optimization of the laser cavity could make the Raman amplifier a real challenger to the erbium-doped fibre amplifier in soliton transmission systems.

References

1. L.F.Mollenauer, J.P.Gordon and M.N.Islam, IEEE J. Quantum. El., 22, 157, (1986)

2. S.Grubb, Proc. OFC'95, (San Diego, USA), Paper TuJ1

3. R.Stolen and E.Ippen, Appl. Phys. Lett., 22, 276, (1973)

Figure Captions

Fig.1 Spectral dependence of the net gain in a 35 km span of fibre

Fig.2 Pulse dynamics in a system with Raman gain. The inset shows the pulse intensity and the pulsewidth variations along the link.

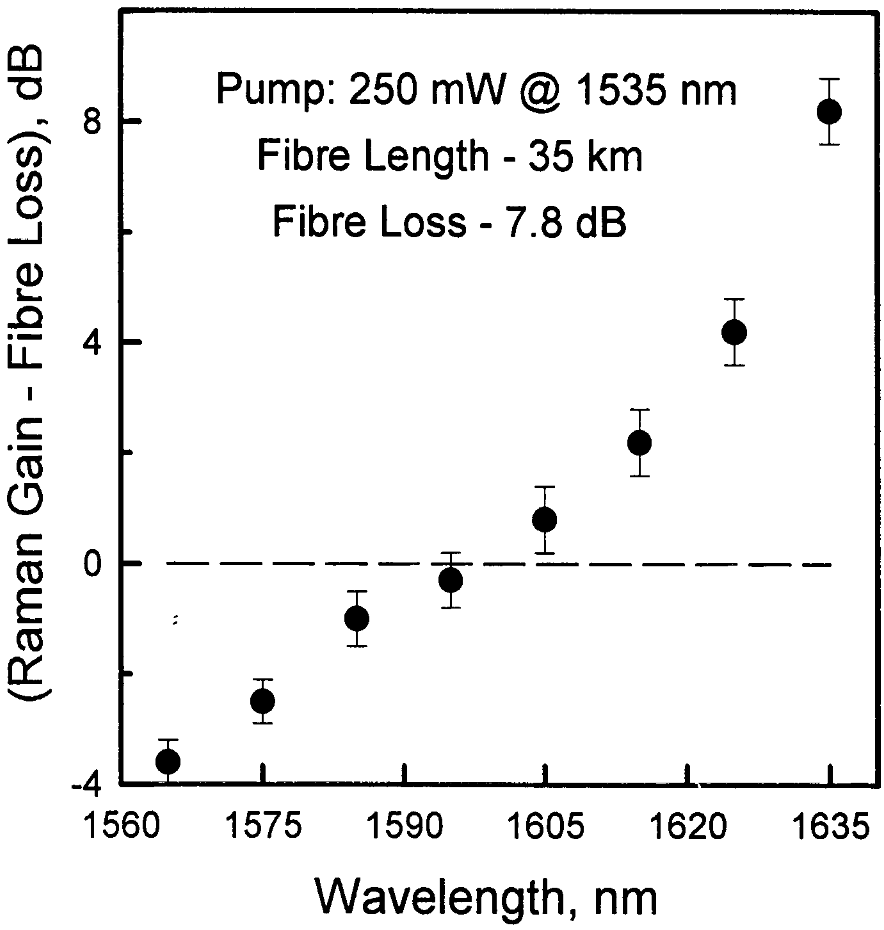

Fig 1

A. B Grudinin and S Gray, „CW Raman Amplifie...

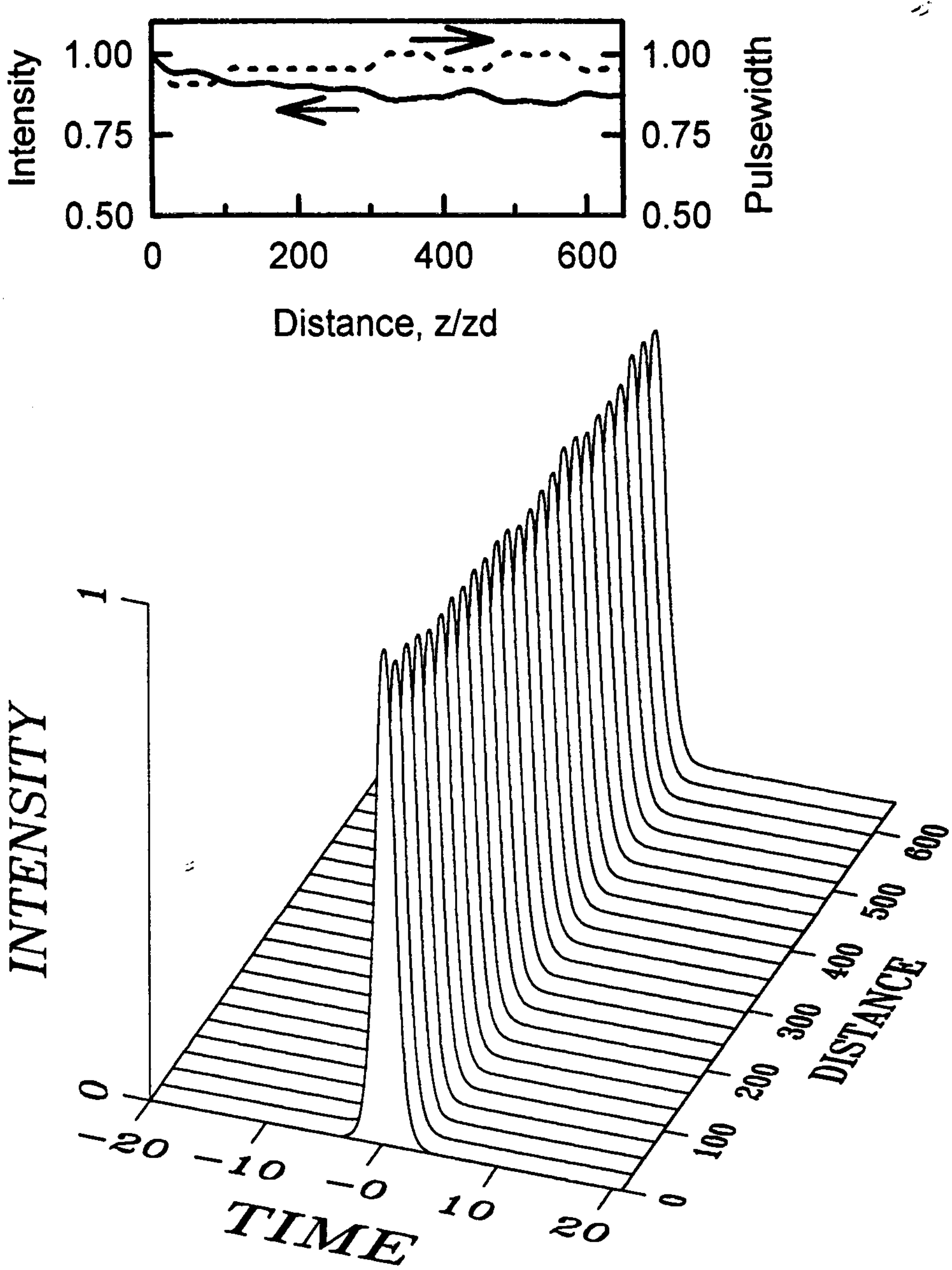

Fig 2

A. B. Grudinin and S Gray, CW Raman Amp ..