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Nonlinear propagation in long fibre Bragg gratings

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Abstract

Nonlinear propagation in long (40 cm) fibre Bragg gratings is examined. We observe clear evidence of soliton formation and associated pulse reshaping. This is the first time such long gratings have been used in nonlinear experiments.

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In nonlinear fibre Bragg gratings many novel effects are predicted to occur [1] and it is only recently that the first experimental reports have appeared in the literature [2]. In these initial experiments short gratings were used which makes it hard to distinguish between propagation effects and effects associated with the formation of gap solitons. It is thus important to use long gratings in nonlinear experiments as they allow one to distinguish between the various effects.

To this end we fabricated a 40cm long grating with a bandwidth of ~ 0.05 nm which was apodised over the first 4cm to enhance the formation of solitons at the front of the grating. Its reflectivity was $\sim 95\%$ and was slightly asymmetric. Into the grating we launched 2ns near transformed limited pulses with a peak power of 20kW. The pulse's frequency could be tuned across the bandwidth of the grating.

Initially the pulse was tuned to the short wavelength edge of the bandgap where the reflectivity was still high. The pulse transmission was then measured as a function of the input peak power and the results are shown in Fig. 1. At high powers the pulse shape has changed markedly with the formation of a narrow pulse approximately 1.5ns after the front of the pulse. This secondary peak which has a width of 200ps is the result of the formation of a gap soliton which then propagated through the structure at approximately 90% of the speed of light. Such slow propagation is a clear indication of nonlinear behaviour.

We then tuned the pulse to lie just outside the short wavelength side of the grating where we observed modulational instability as expected. Fig. 2 shows the transmitted pulse shapes for three different powers. It can be clearly seen that the input pulse breaks up into two and then three pulses as the power increases. Similarly when we tuned to the long wavelength side of the grating pulse broadening was observed.

In conclusion we have performed the first nonlinear experiments in long fibre Bragg gratings. We have observed gap soliton propagation at frequencies inside the bandgap and multiple soliton formation due to modulational instability outside the band gap. These results are clearly than earlier experimental results due to the increased length of the grating.

REFERENCES

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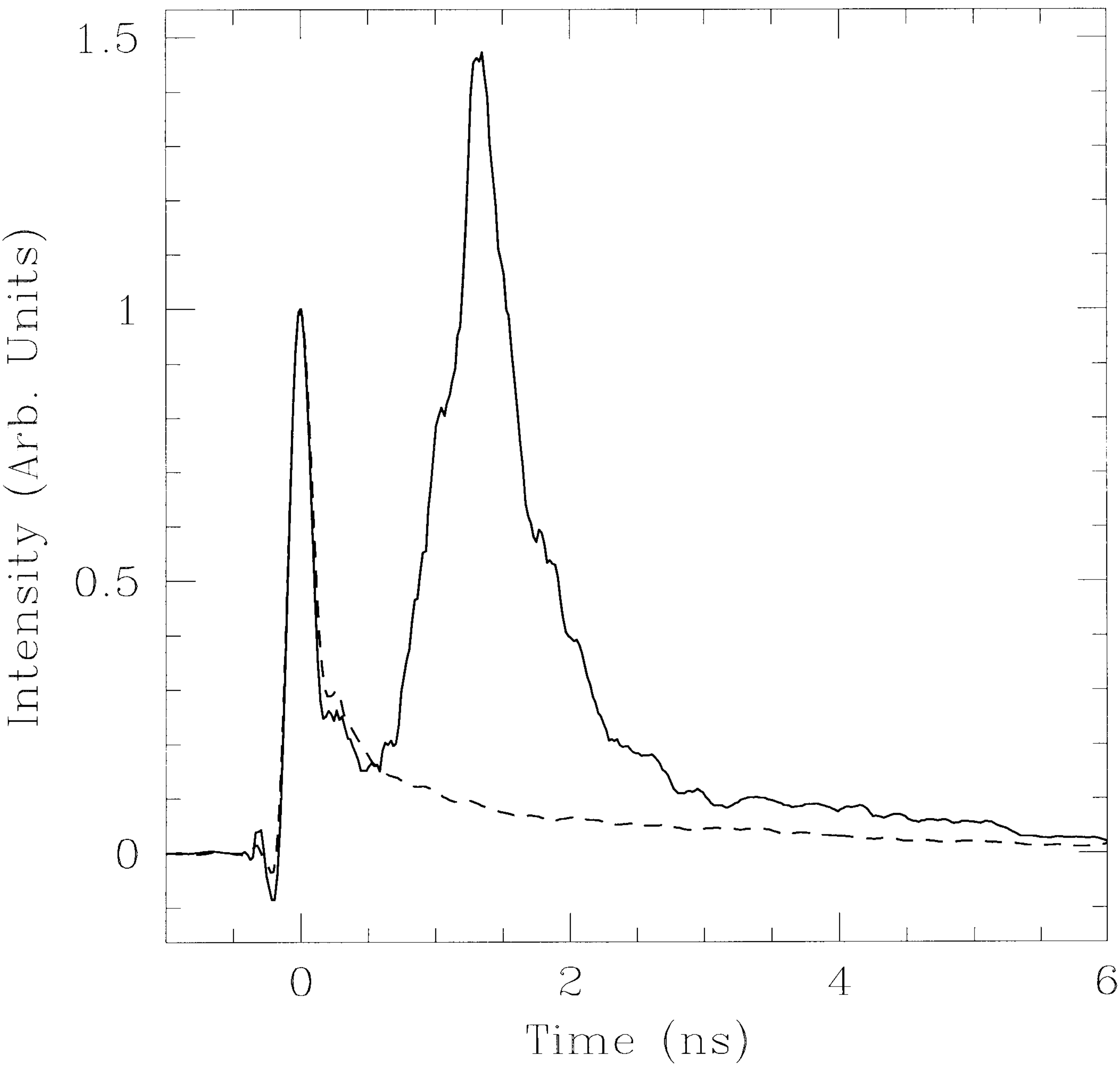
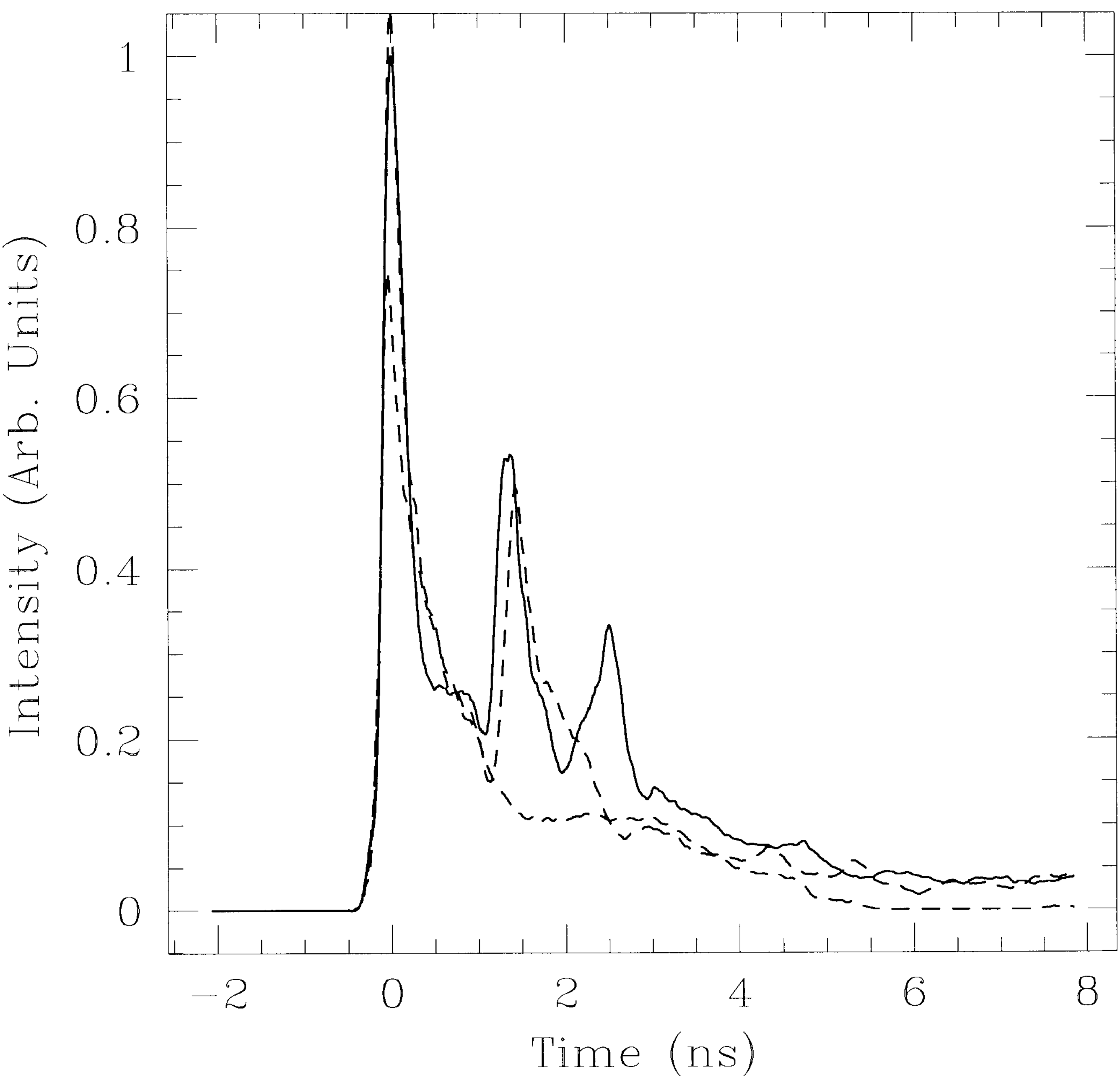
FIGURES

FIG. 1. Transmitted pulse shapes at high (solid line) and low (dashed line). The amplitude in each case has been normalised so that the front peak has an amplitude of 1. The incident peaks powers are 19kW and 3kW respectively.

FIG. 2. Transmitted pulse shapes at incident peak powers of 11kW (solid line) 9kW (long dashed) and 5kW (short dashed). Note that due to modulational instability the input pulse breaks up into multiple pulses.



1.5
1
0.5
0
Intensity (Arb. Units)
0
2
4
6
Time (ns)


Intensity (Arb. Units)
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0.8
0.6
0.4
0.2
0
−2
0
2
4
6
8
Time (ns)