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# Dynamics of Color-Center Induced Nonlinear Transmission in $GeO_2$-$SiO_2$ Fibres

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**ABSTRACT**

We show that the predominant factor limiting high power transmission in the blue/green spectral region in germanosilicate core fibres is the creation of germania-related color-centres via two-photon absorption.

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**SUMMARY**

The use of polarisation-preserving, high birefringence (or Hi-Bi) single-mode optical fibres in laser-doppler velocimetry and holographic interferometry is restricted by strongly intensity-dependent transmission at higher power levels [1] in the blue/green spectral region. This can limit the transmitted power

to just a few hundred milliwatts. We have investigated this effect at 470 nm in germanosilicate-cored single-mode HiBi fibres, and found that the predominant factor limiting power transmission is the creation of colour centres via two-photon absorption (TPA). This is known to occur in borosilicate glasses at 532 nm [2] and in a variety of glasses at UV wavelengths [3], but to our knowledge it has not yet been identified in germanosilicate glasses at blue/green wavelengths.

We launched high-intensity pulses (470 nm, 6 ns FWHM, 30 Hz repetition rate) from a Quantronix dye-laser (pumped by a frequency-tripled Nd-YAG laser) into 5 metre lengths of fibre. The induced loss at 470 nm was measured at regular time intervals (with the laser light blocked) using a chopped white-light measurement system incorporating a monochromator and a photomultiplier in conjunction with a lock-in amplifier. The experimental points in Figure 1 represent the loss immediately after switching off the laser light together with the loss measured in the same fibre one day later. This suggests the creation of at least two types (say I and II) of color-center, with a spontaneous decay from type I to II, type II having the larger loss cross-section. We have developed, and fitted to our data, a detailed mathematical model describing the dynamics of these color-center populations, including the effect of axial variations along the fibre (essential because of the long interaction lengths involved). A fit of this model (which will be presented in detail elsewhere) to the data in Figure 1 shows good agreement. In Figure 2 the full dynamics of the induced loss are presented as a function of time for a 5 m length of fibre exposed in two 10 minute stages to pulses of 44 W and 4.4 W peak powers. The data is plotted on the same time axis for ease of comparison. During the 44 W stage the loss rises to 4.7 dB. Interestingly the 4.4 W stage leads to an initial rise in loss before it begins gradually to bleach out. This is because the stimulated bleaching rate at this lower power level is so slow that the decay of colour-centres from type I to II initially dominates, causing the loss to increase. Once again our model provides a good fit to the data. If a higher second-stage power level is chosen (keeping it always less than 44 W) the initial dominance of the spontaneous decay diminishes.

We have found that the saturated absorption level induced at a given peak power density scales linearly with the germania concentration in the core, indicating that the absorption is attributable to germania-related defect centres.

**REFERENCES**

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[2] W.T.White III, M.A.Henesian and M.J.Weber, J. Opt. Soc. Am. B2 (1402-1408) 1985.

[3] W.L.Smith, C.L.Vercimak and W.E.Warren, J. Opt. Soc. Am. 72 (1782) (A) 1982.

## FIGURE CAPTIONS

1: Saturated loss in 5m of fibre measured immediately after exposure (compared with a theoretical fit), together with the increased loss measured one day later.

2: Dynamics of the induced loss: Curve A shows the increase in loss with time for 5m of fibre exposed to 44W at 470nm. Curve B shows the subsequent evolution of the induced loss when the power is reduced to 4.4W.

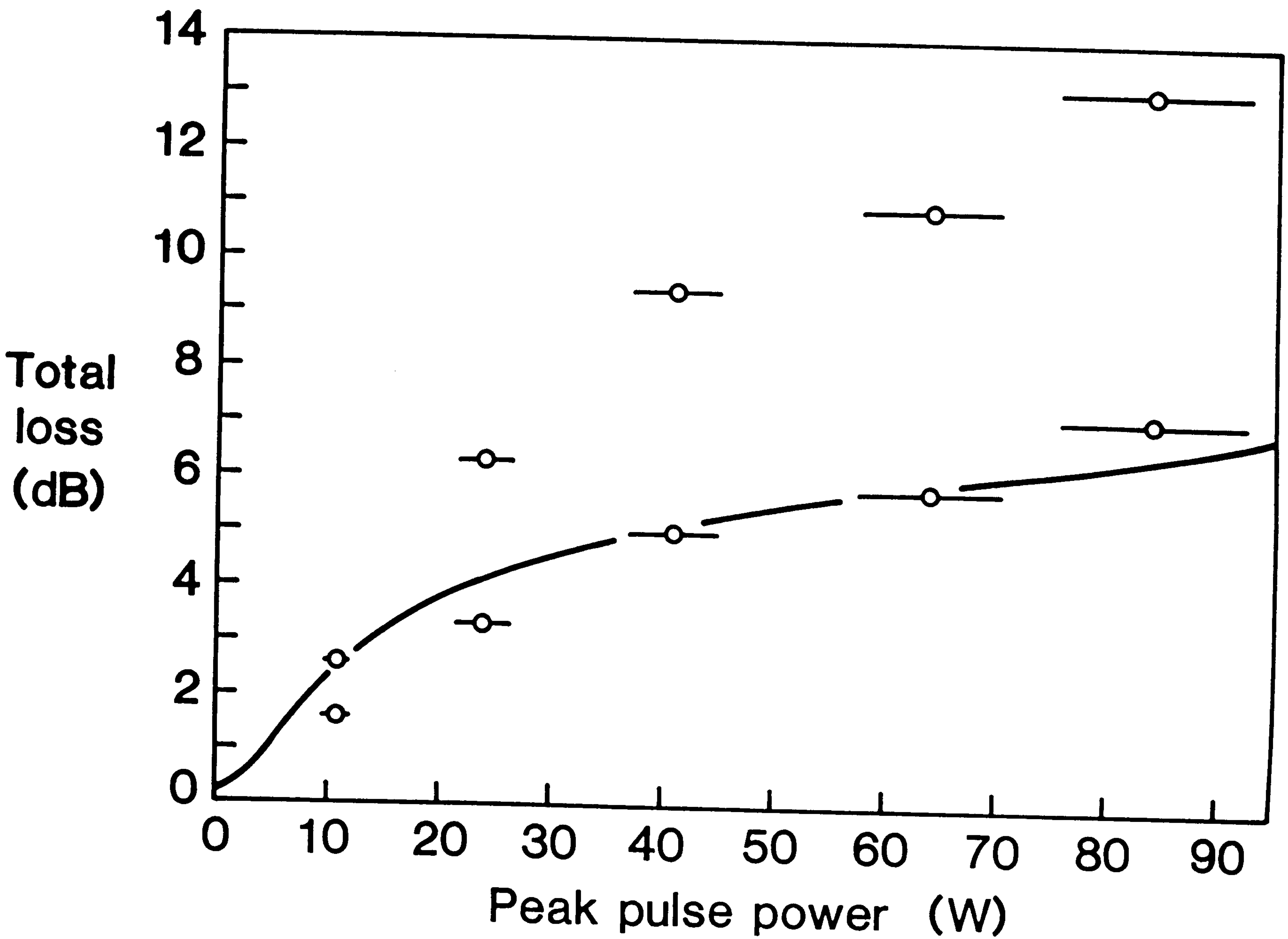
Total loss (dB)
0
2
4
6
8
10
12
14
0
10
20
30
40
50
60
70
80
90
Peak pulse power (W)

Fig 1

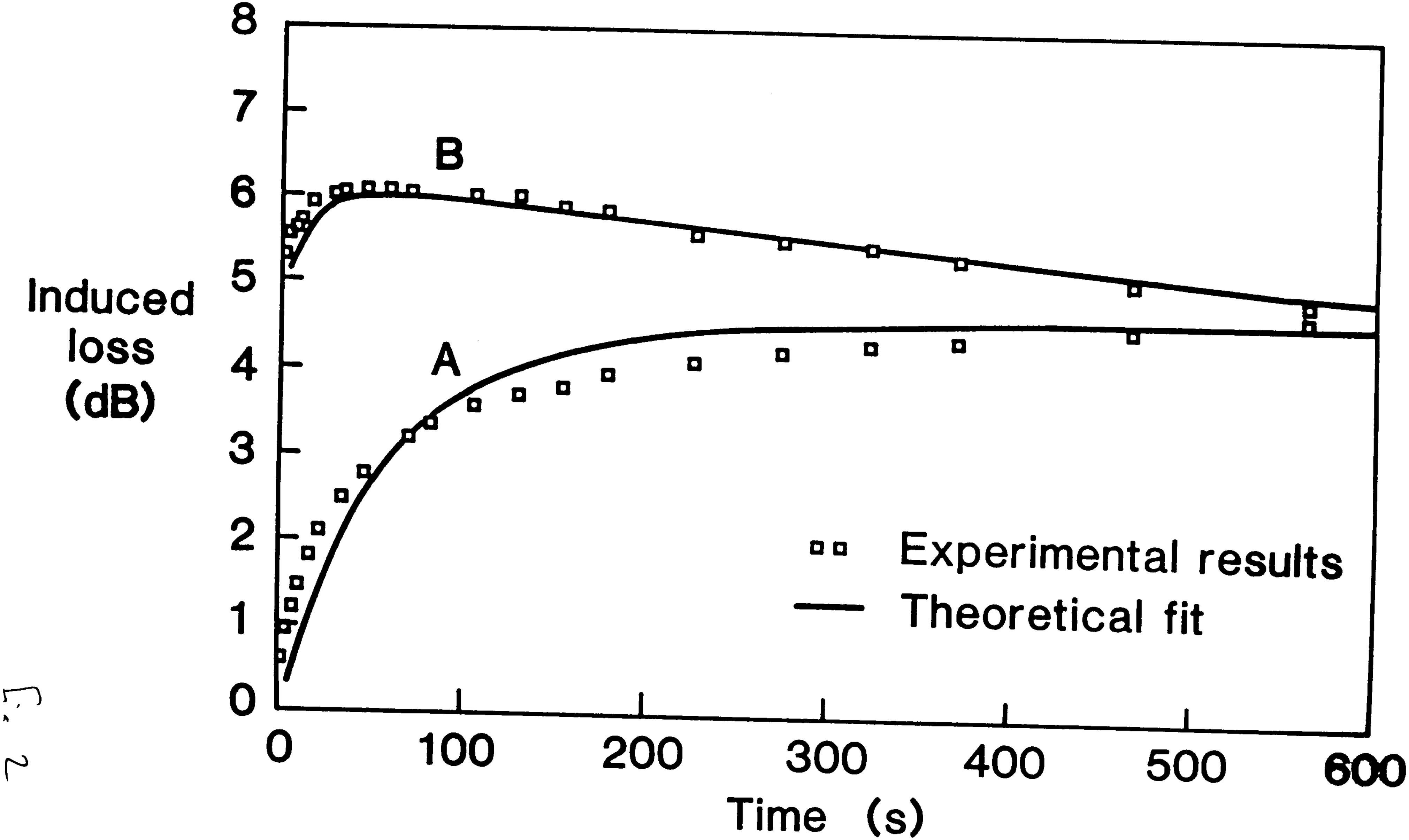
Induced loss (dB)
0
1
2
3
4
5
6
7
8
B
A
Experimental results
Theoretical fit
0
100
200
300
400
500
600
Time (s)

Fig. 2