ATTENUATION MEASUREMENTS IN SCINTILLATING GLASS FIBRES

N.Demagh,C.Fisher,N.Kurtz,P.Pfeiffer (presented by N.KURTZ)

ABSTRACT

Results of tests on Cerium doped scintillating glass fibres produced by SCHOTT are reported.Detailed measurements of attenuation length as a function of wavelength are given. The minimum attenuation length was found to be$\approx$17 cm at 425 nm (close to the peak of Ce^{3+} emission).

INTRODUCTION

In 1983 SCHOTT produced fibres using Cerium doped scintillating glass as core as part of a development program with the Rutherford Appleton laboratory.Single fibres with diameter 50μm,75μm and 150 μm where produced and used in the tests reported here.In addition, prototype targets were produced containing $\approx 4.10^4$ coherent fibres of 15μm and 30μm diameter.In this paper we report on the attenuation length measurements made using the single fibres at the department of optics of the University of Strasbourg.

The general properties of these fibres are:

-refractive index of the core glass n_c= 1.6
-refractive index of the cladding glass n_d= 1.52
-trapping angle from axis ±17.5°i.e. trapping efficiency = 5%
-radiation length 4.2 cm (note that this value is very low
   due to the presence of Barium)
-density = 3.5 gm/cm^3

ATTENUATION MEASUREMENTS

The attenuation length has been measured as a function of the light frequency using a single fibre of 75μm diameter doped with Ce_2O_3. The single fibres had a

circular cross section with a cladding thickness of 5μm.They are shown in Fig.1. The simple experimental set-up is shown in the diagram:
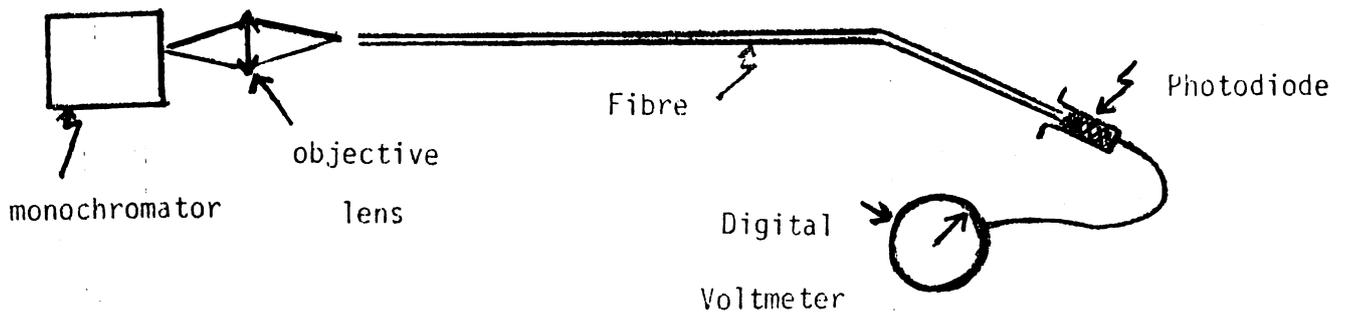
The monochromator selects a wave length with band width≈0.25 nm.The objective lens is used to produce a spot at the end of the fibre.A photodiode detects the light emerging from the fibre and a reading is obtained on a digital voltmeter.Setting up is achieved by varying the position of the lens to maximise the signal recieved at the photodiode. Measurements were made with various fibres lengths i.e. the same fibre carefully cut starting at 115 cm and ending at ≈17 cm.For each length the signal was recorded approximately every 5 nm from 350 nm to 700 nm.The digital voltmeter had an offset of≈0.2 V when the source was off compared with a typical peak signal ≈10 V and a signal in the interesting region of typically 0.5 V.The offset was regularly checked and found to be stable to about 1-2 mV. Each time the fibre is cut there is a new interface between fibre and diode.Each measurement was repeated,including cutting with diamond and microscope check of cut surface. If we assume that the interface is exactly reproducible then we find λatt ≈ 210 cm at 700 nm and λatt ≈ 28 cm at 425 nm (the peak of the Ce_2O_3 emission spectrum).In practice because of the difficulty to make a good coupling we prefer to assume the attenuation is negligible at 700 nm and to use this point for normalisation. Fig.2 shows the transmitted intensity recorded by the diode as a function of wavelength,normalized to 10 at 700 nm,for three different fibre lengths.The actual peak values recorded before normalization were: 7.7 V at 115 cm,10.6 V at 66.0 cm,11.7 V at 46 cm and 12.0 V at 17 cm. The attenuation lengths are derived in the usual way:

$$\lambda att = \frac{L_2 - L_1}{\ln (I_2/I_1)}$$

where I_1 is the intensity recorded at length L_1 and I_2 is the intensity recorded at length L_2.Since $I_1 = I_2 = 10$ by normalization at 700 nm we obviously find (assume)

$$\lambda att = \infty \quad \text{at 700 nm}$$

221

The results are displayed graphically in Fig.2; we also show the emission spectrum from Ce_2O_3 scintillator.

There is an apparent variation of the curve with fibre length a short attenuation length for short fibres and a long attenuation for long fibres.This effect has been reported by others -for example with plastic fibres.In the following paper by Phil Hughes it is show that this effect is probably spurious and that the family of curves can be explained by a universal attenuation length $\approx$ 17 cm at 400 nm independant of length over the range studied.This correspond to a bulk attenuation of $\approx$ 20cm.
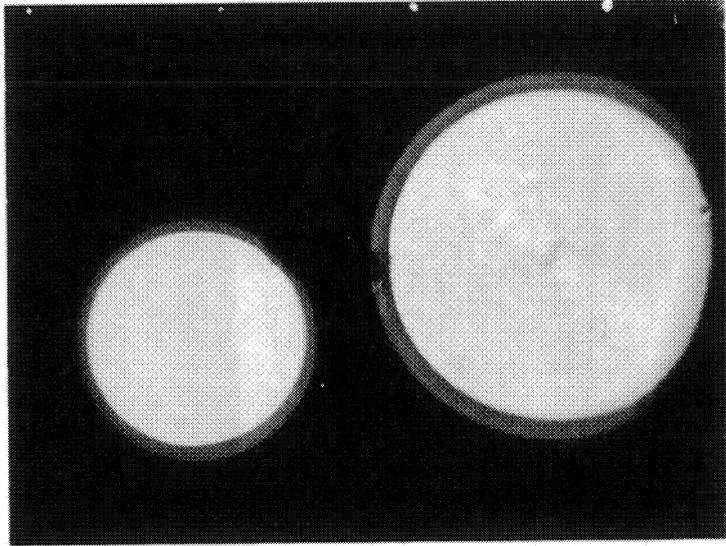
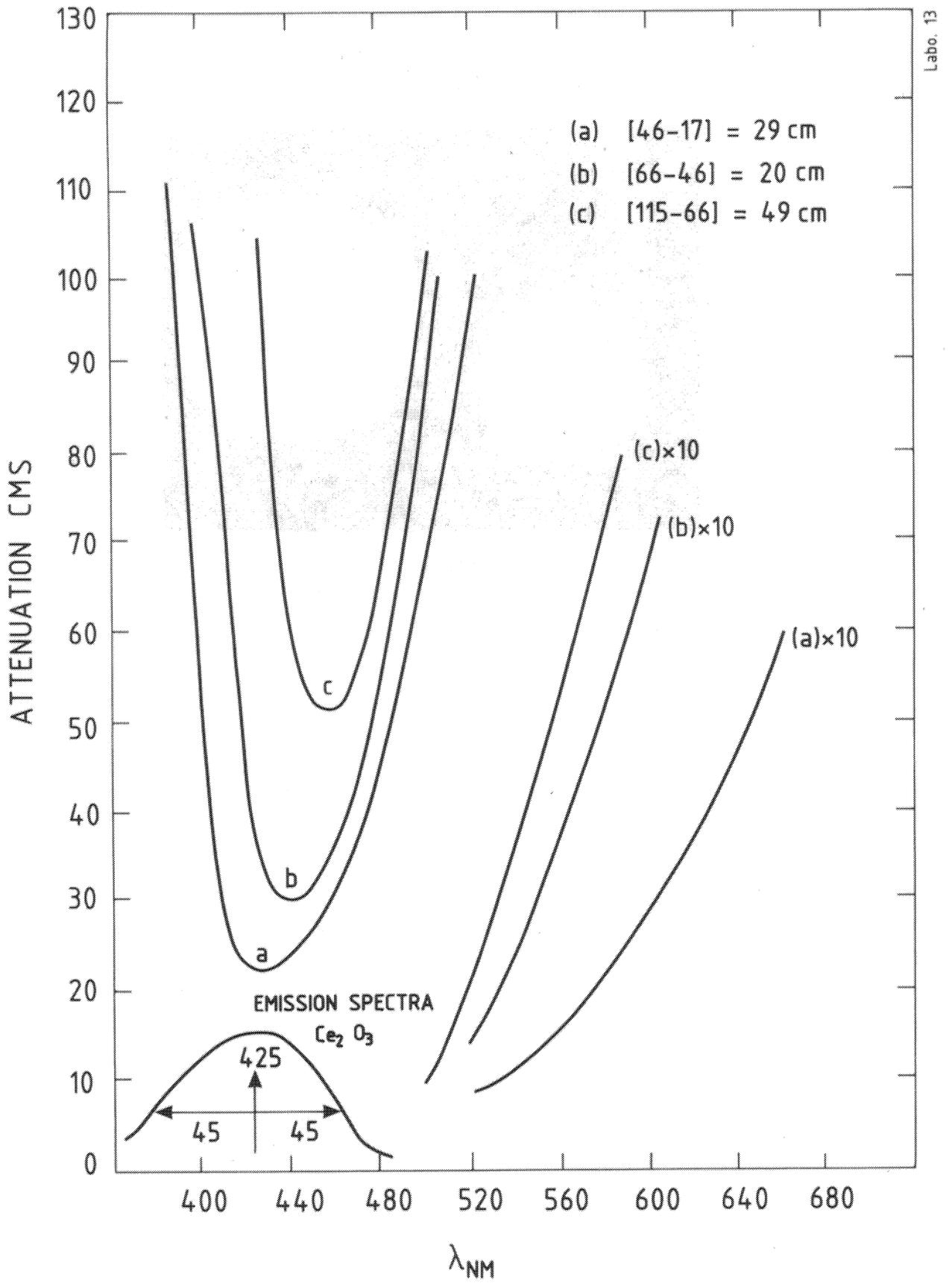Reference: P.Hughes,following paper in this report

Fig. 1

Fig. 2