INTENSITY DEPENDENT POLARISATION FREQUENCY SPLITTING IN AN Er^{3+}-DOPED FIBRE LASER

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ABSTRACT

An intensity dependent polarisation frequency splitting phenomenon in an Er^{3+}-doped fibre laser operating at 1.55μm has been observed for the first time. The frequency splitting is significant and 530GHz has been measured.

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Single-mode fibre lasers [1,2] have particular characteristics which differ from bulk lasers. One important characteristic is the intra-cavity birefringence which is inevitably present in a single-mode fibre and which induces the polarisation effects in fibre lasers reported recently [3,4]. We have shown that the polarisation effects have an influence over the spectral properties of fibre lasers and report here the first observation of the phenomenon of polarisation frequency-splitting.

The experimental set-up for investigating the polarised spectral properties of a fibre laser is shown in Fig.1. An Er^{3+}-doped fibre with 300ppm concentration was cleaved and butted to the input mirror M1 and output mirror M2 to form the laser cavity. The fibre used was 1.4 metres long and had

an elliptical core which defined the birefringent axes. The input mirror had a transmission at the pump wavelength of >80% and >99% reflectivity at the lasing wavelength of 1.55μm, while the output mirror had a reflectivity of 27% at 1.55μm. A CW DCM dye laser operating at 650nm was used as the pump source and was launched into the fibre longitudinally. The output polarisation from the fibre laser was selected by using a rotatable polariser having an extinction ratio of 50dB and a monochromator with 0.5nm resolution was used to measure the output spectrum.

It was found that the two orthogonal x- and y-polarised eigenmodes in the fibre laser cavity [3,4], had the same centre wavelength when pumped just above the threshold. With increased pump power, however, a significant polarisation frequency-splitting was observed as evidenced by the different wavelength output for each polarisation. At a pump power 6 times above threshold, a frequency splitting of 530GHz (or 4.3nm) was measured, corresponding to approximately four times the spectral width of each polarisation mode. A typical spectrum, measured independently for each polarisation state at a pump power ratio of 4, is shown in Fig.2. The dependence of polarisation frequency splitting on the pump power has also been determined and the results are plotted in Fig.3. It can be seen that the polarisation frequency splitting of fibre lasers is an intensity dependent phenomenon.

It is possible that the polarisation frequency splitting is caused both by the polarisation effects in fibre lasers and the particular spectral properties of the rare-earth dopant ions in the glass matrix [5]. Since two independent polarisation modes exist in a fibre laser, the wide fluorescence spectrum provides a possibility to force the secondary mode to lase at another frequency if the dominant or preliminary mode sufficiently depletes the inverted population. From this point of view, it can be understood why the polarisation frequency splitting is an intensity-dependent phenomenon.

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Figure Captions

Fig.1. Experimental configuration employed to observe polarisation frequency splitting.

Fig.2. Output spectrum of the fibre laser showing polarisation frequency splitting.

Fig.3. The dependence of polarisation frequency splitting on pump power.

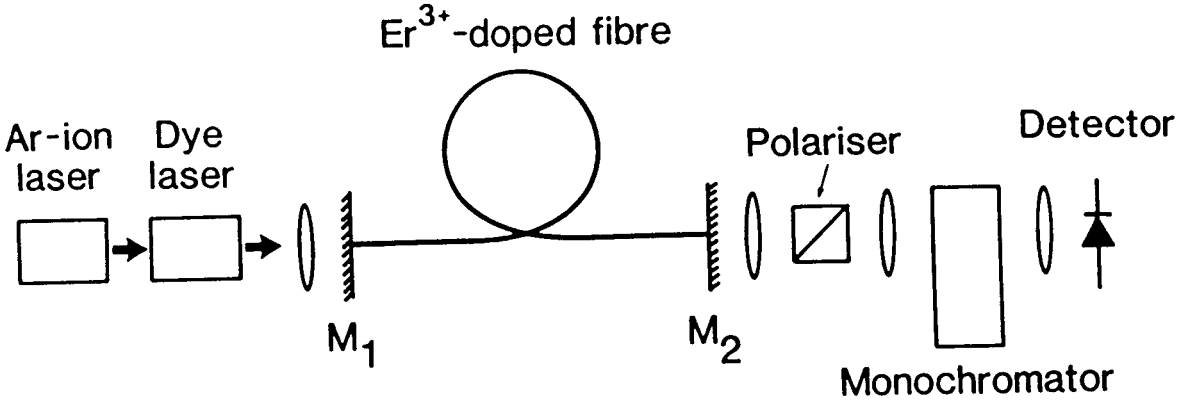
Er3+-doped fibre
Ar-ion laser
Dye laser
Polariser
Detector
M1
M2
Monochromator

Figure 1

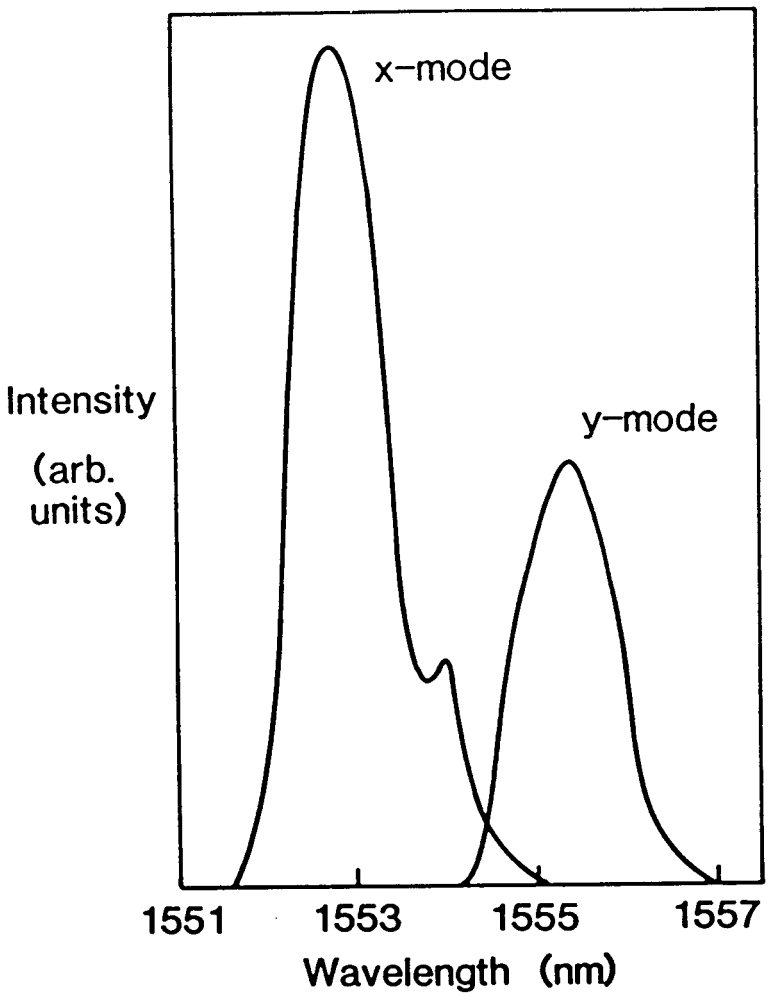
x-mode
y-mode
Intensity
(arb.
units)
1551
1553
1555
1557
Wavelength (nm)

Figure 2

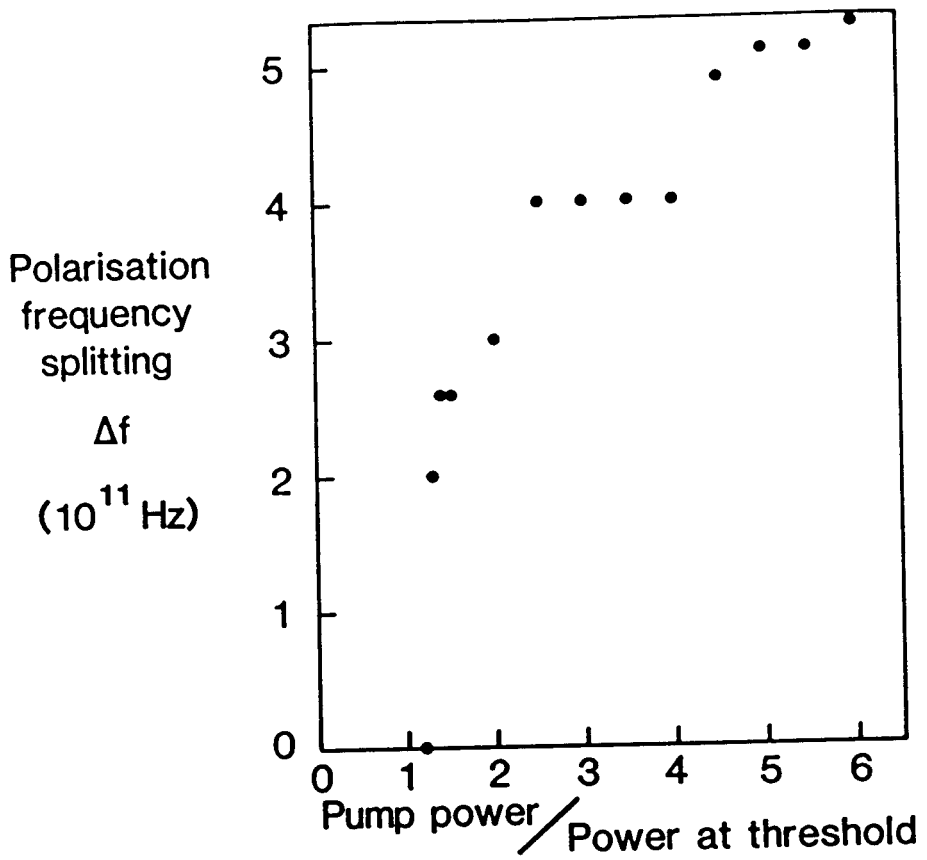
Polarisation
frequency
splitting
Δf
(10^11 Hz)
5
4
3
2
1
0
0
1
2
3
4
5
6
Pump power / Power at threshold

Figure 3