ALL FIBRE POLARISER USING A NULL COUPLER

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Abstract

We report a new fibre polariser based on a twisted null taper coupler. The best extinction ratio observed so far is 15dB.

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We report a new fiber polariser based on a null coupler. This is a fused taper coupler made from two markedly dissimilar fibres[1]. Each input fibre carries two modes in its core (the two polarisations of the "single" mode), making four modes in all. Along the coupler, each evolves adiabatically into just one mode of the cladding waveguide at the narrow circular coupler waist. The four corresponding modes of the waist are the HE_{11}^{x}, HE_{11}^{y}, TE_{01}, and HE_{21}^{e} hybrid modes[2], Fig. 1. This evolution is reversed at the output taper.

The HE_{21}^{o} mode, which is the degenerate rotated version of the HE_{21}^{e} mode, is not normally excited; any light coupled to it is lost. However, if the coupler is twisted through 45^{o}, the input HE_{21}^{e} mode becomes an HE_{21}^{o} mode relative to the output fibres, while the circularly symmetric TE_{01} mode is unaffected. Hence a twisted null coupler acts as a polariser for light in the narrow fibre.

A null coupler was made by pre-tapering one fibre before elongating the pair[3]. The excess loss was 0.2 dB and the maximum splitting ratio was 1:4000, for 633nm light. The finished coupler

was then twisted through 45^{o}. This had no effect for input light in the fibre that had not been pre-tapered. However, for input light in the pre-tapered fibre, there was an additional polarisation - dependent loss. Anything from no loss to almost total loss resulted from adjusting the input polarisation state, Fig. 2. Thus the twisted coupler acted as an all fibre polariser. The maximum extinction ratio was 15dB. The same behaviour occured for twists at odd multiples of 45^{o}as expected. Lesser extinction ratios resulted from different twist angles, with no extinction at all for zero twist.

Maximum loss corresponds to the HE_{21}^{e} mode being excited in the waist, whereas zero loss corresponds to the TE_{01} mode. The input polarisation was adjusted to give maximum loss, and the coupler waist was then cleaved. The emerging far field had a ring-shaped intensity pattern, becoming two-lobed after passing through a sheet polariser. When the sheet was rotated in one direction, the lobes rotated in the opposite direction, indicating the HE_{21} mode, see Fig.1. In contrast, for the orthogonal input polarisation state, the lobes rotated in the same direction as the sheet, indicating the TE_{01} mode.

The cleaved waist was found to be circular in cross-section with a diameter of 2μm, Fig. 3.

The circularly-fused null coupler acts as an all fibre polariser when twisted through an odd multiple of 45^{o}. The extinction ratio of 15 dB would be improved by making the waist narrower (to make the residual fibre cores less significant) and more perfectly circular.

References

1. T. A. Birks, P. St. J. Russell and C. N. Pannell, to be published in Optics letters.
2. A. W. Snyder and J. D. Love, "Optical Waveguide Theory", Chapman and Hall, 1983.
3. D. B. Mortimore, Electron. Lett., **21**, p. 742. 1985.

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Figure Captions

1. Schematic diagram, not to scale, of the correspondence between core modes in the fibres and cladding modes in the coupler waist.

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Figure Captions

2. Throughput in the pre-tapered fibre in a null coupler twisted through 45^{o}, as a function of the rotation of a half wave plate at the input.

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Figure Captions

3. SEM of the cleaved coupler waist.

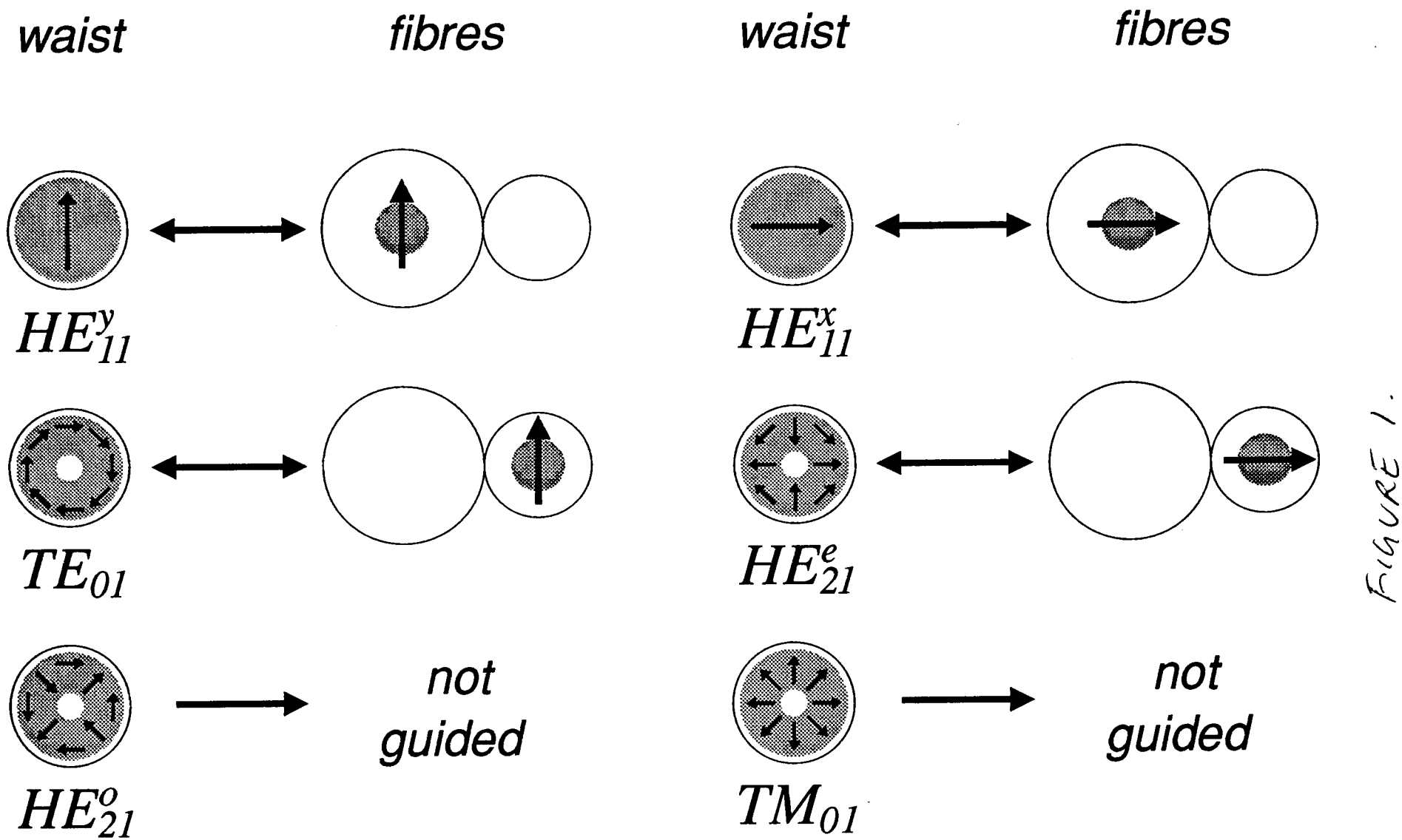
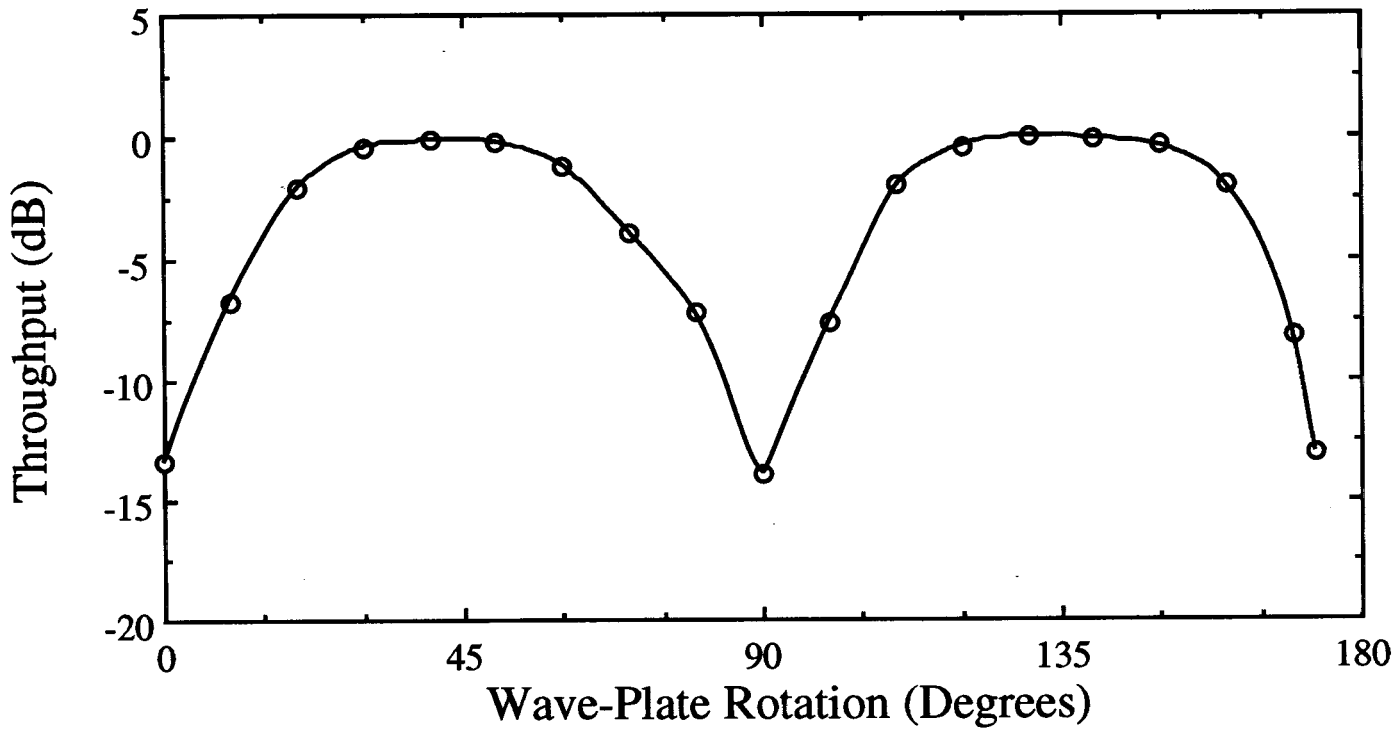

waist
fibres
HE_{11}^{y}
TE_{01}
HE_{21}^{o}
not guided
waist
fibres
HE_{11}^{x}
HE_{21}^{e}
TM_{01}
not guided

FIGURE 1.


5
0
-5
-10
-15
-20
Throughput (dB)
0
45
90
135
180
Wave-Plate Rotation (Degrees)

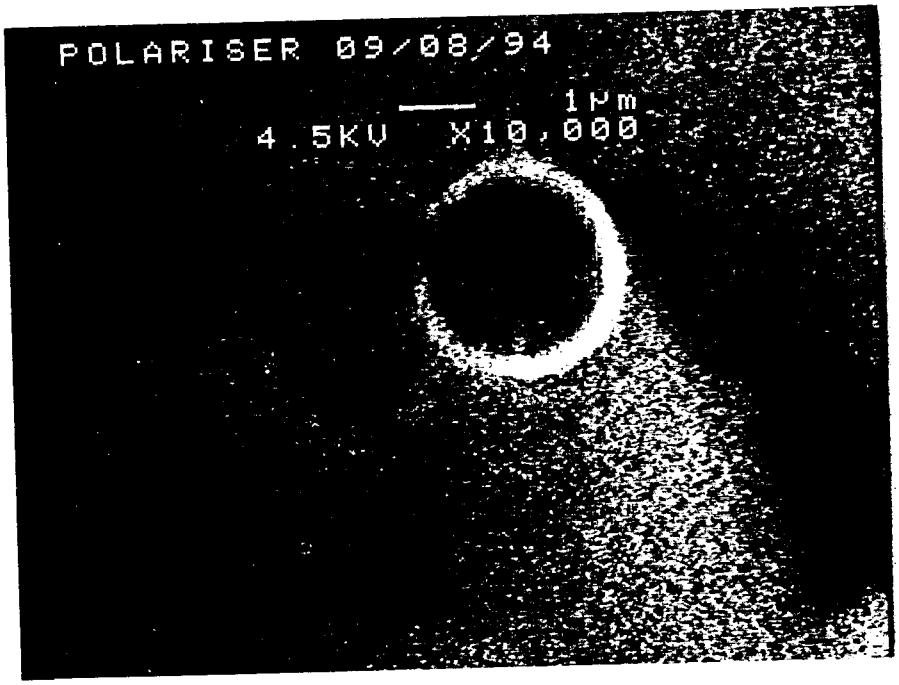


FIGURE 3.