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A WAVELENGTH INDEPENDENT SINGLE-MODE FIBRE 3dB BEAMSPLITTER

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ABSTRACT

The fabrication and performance of a wavelength independent single-mode fibre beamsplitter is discussed. The device has a novel configuration based on a tapered Y-junction.

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There have recently been several proposals for wavelength independent and wavelength insensitive single-mode fibre couplers and splitters[1]. Such couplers are desirable because of their reproducible characteristics and should be useful for wavelength multiplexing and spectral measurements.

Our recent understanding of single-mode fibre tapers and tapered couplers [2] allows us to propose a novel structure comprising a tapered Y-junction which exhibits wavelength independent 3dB power splitting.

The fused biconical tapered coupler is now known to be essentially a cladding mode device [3] which relies for its operation on the equal excitation and subsequent interference of the two lowest order LP_{01} and LP_{11} modes in the cladding/air waveguide comprising the coupler waist. Such interference is very wavelength dependent [2].

The beam expansion and the cladding mode behaviour of the simple single-mode fibre taper has recently been exploited in the production of low-loss splices between dissimilar fibres [4] and in the production of a very simple beam expander [5].

WAVELENGTH INDEPENDENT BEAMSPLITTER C.D. Hussey & J.D. Minelly

The characteristics of the taper and tapered coupler are combined in our device. The Y-junction is constructed by:

1. Cleaving a tapered fibre at its waist.
2. Cleaving a tapered coupler at its waist.
3. Fusion splicing the above components together.

The resulting device is shown schematically in Figure 1. The single taper provides the input port and the two fibre fork comprises the output ports.

Care must be taken so that both constituent components have low loss and that the coupler has a waist of circular cross-section with its diameter matched to that of the taper waist. (For standard fibre a taper ratio of 5:1 ensures cladding mode behaviour).

The propagating field now crosses the splice point with little loss since the LP_{01} modal fields on either side of the splice are well matched. The excitation symmetry in a perfect Y-junction ensures no coupling to the LP_{11} mode and hence no wavelength sensitivity.

The adiabatically increasing cores at the fork side of the junction now guide power equally into the two output ports independent of the wavelength.

The wavelength response from 650nm-1000nm of one Y-junction beamsplitter is shown in Figure 2. The fibre had a diameter of 80m and a second mode cutoff wavelength of 650nm.

The residual wavelength response is believed to be caused by a small transverse offset of the input taper. Excess losses in preliminary experiments are typically 1.5dB.

In the above we have considered a three port device where the power in the input port is equally divided between two output ports. However, there is no restriction in principle as to the number of output ports for which equal power splitting will still occur. The input and output fibres will normally be identical although in general the input fibre can be completely different (i.e. different diameter and refractive index).

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WAVELENGTH INDEPENDENT BEAMSPLITTER C.D. Hussey & J.D. Minelly

Figure Captions

Figure 1 Schematic of single mode wavelength independent Y-junction beamsplitter.

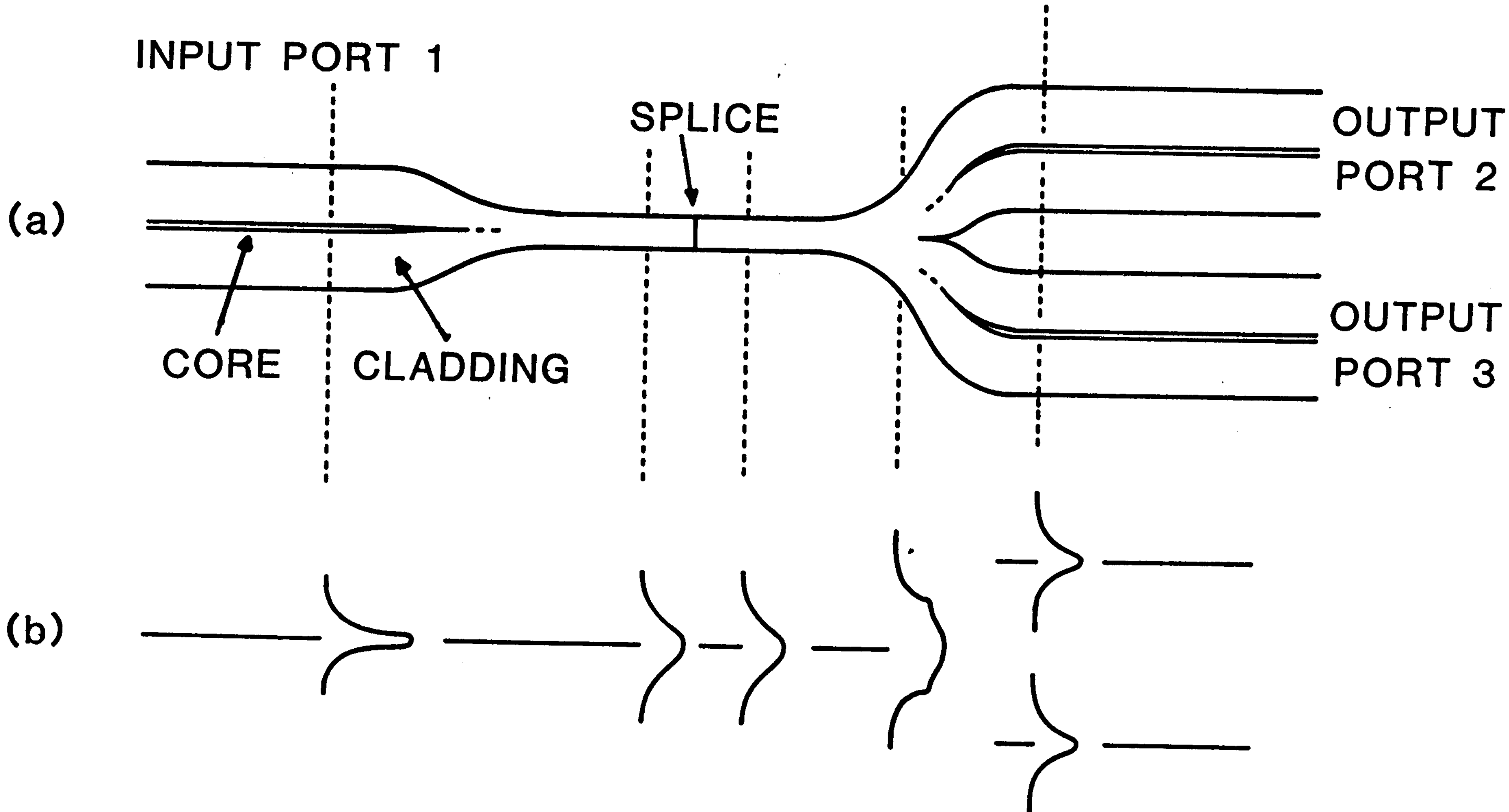
Figure 2 Wavelength response of beamsplitter

Splitting ratio is defined as

$R = 10 \log_{10} (P_2/P_3)$

where P_2 = power in port 2

P_3 = power in port 3.



(a) STRUCTURE

(b) LP_{01} FIELD EVOLUTION

Fig 1 Hussey & Kinally

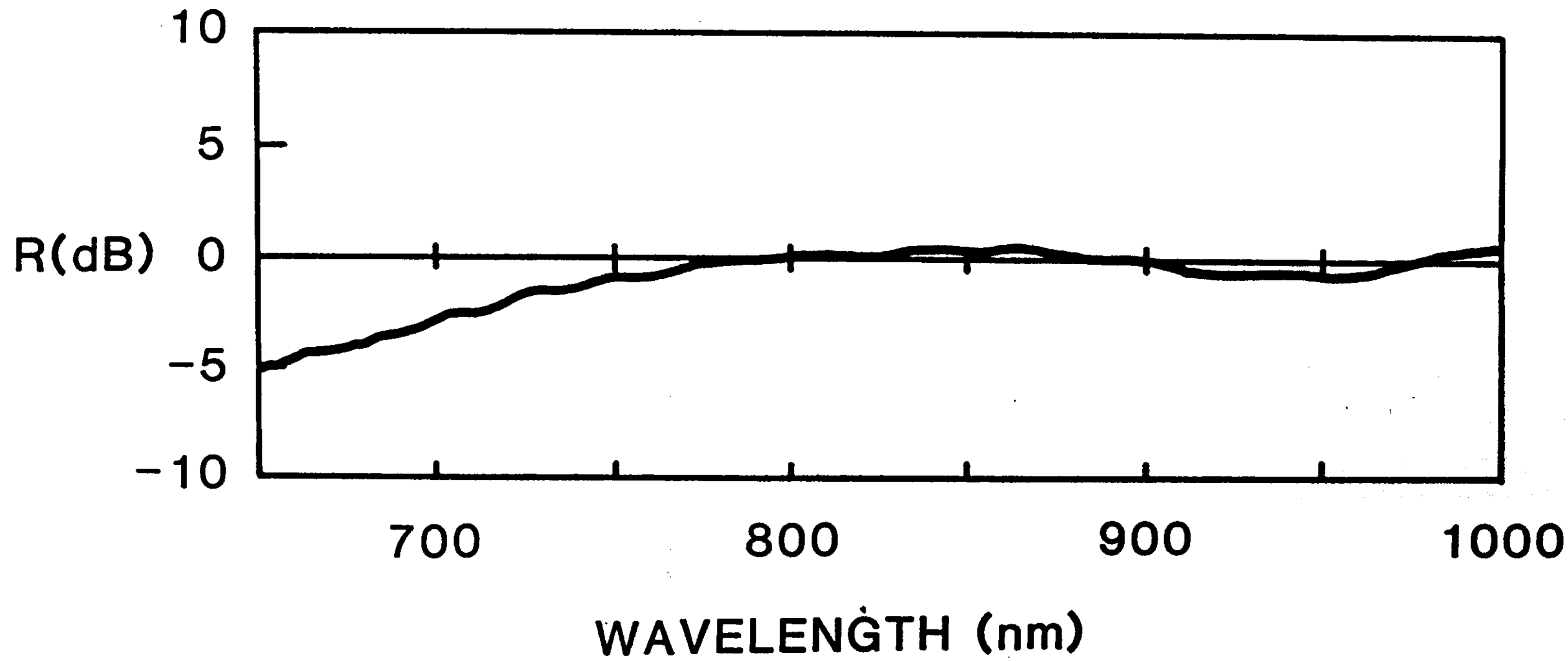


Fig 2 Hussey & Minelly