Version TDW/3

EGT3
ENGINEERING TRIPOS PART IIB

Monday 20 April 2015 9.30 to 11

Module 4B11

PHOTONIC SYSTEMS

*Answer not more than **three** questions.*

All questions carry the same number of marks.

*The **approximate** percentage of marks allocated to each part of a question is indicated in the right margin.*

*Write your candidate number **not** your name on the cover sheet.*

STATIONERY REQUIREMENTS
Single-sided script paper

SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM
CUED approved calculator allowed
Engineering Data Book

10 minutes reading time is allowed for this paper

You may not start to read the questions printed on the subsequent pages of this question paper until instructed to do so.

1 (a) Using the principle of Huygens wavelets, describe how light can propagate as plane waves. Show using a simple sketch, what happens to these plane waves when they are incident upon an aperture. State any assumptions made. [30%]

(b) Given the aperture *A(x,y)* shown in Fig. 1, use Huygens principle of wavelets to calculate the far field diffraction pattern of the aperture. Dimensions *(x,y)* are in the aperture plane and *(α,β)* are the far field plane. *R* is the distance from the centre of the aperture and optical axis to the observation point P and *r* is the distance from the wavelet dS to the observation point P, *z* is the direction of propagation. State any assumptions or approximations made. [50%]

(c) Briefly describe what happens in the regions between the aperture and the far field. Are these regions useful for optical applications? [20%]

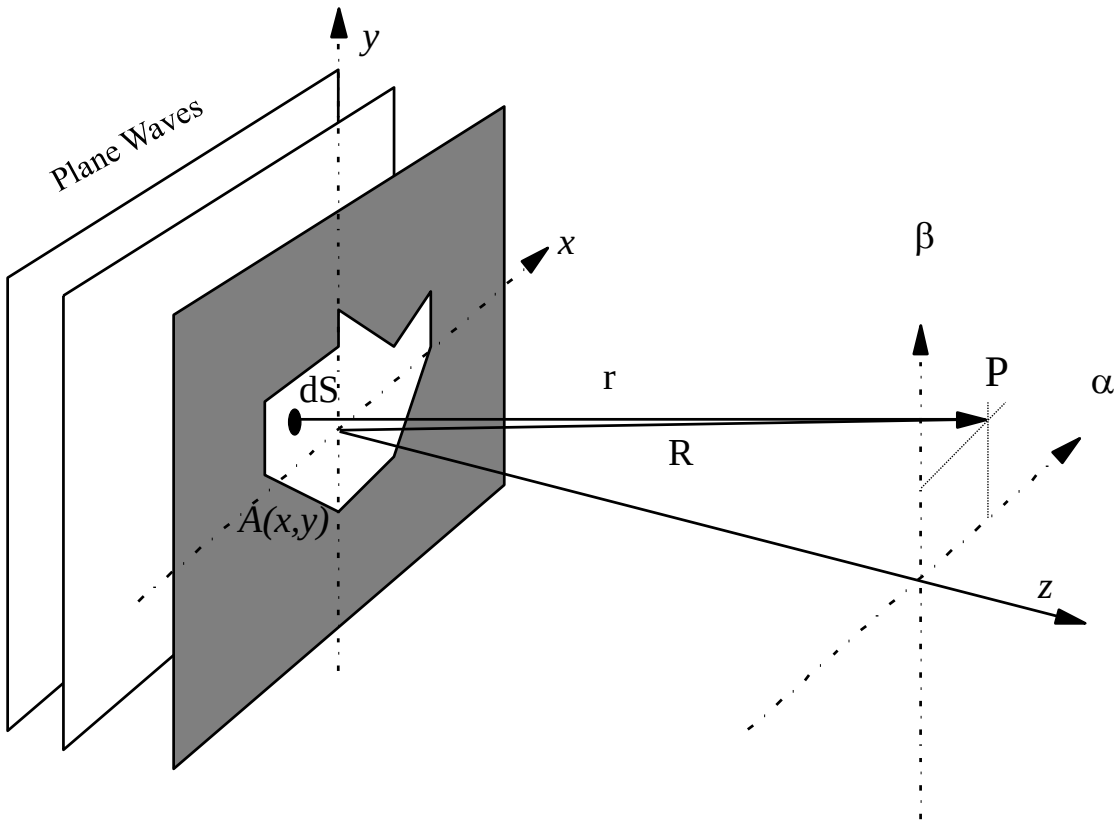

Fig. 1

2 (a) Explain what is meant by optical retardance. Show how a birefringent material can be used to retard an optical wave and derive a simple relationship for the optical retardance. What is the main limitation of this relationship? [25%]

(b) A Ferroelectric Liquid Crystal (FLC) is a very important modulation technology for applications such as optical holography and correlation. Explain the basic molecular and optical features that differentiate a FLC from a nematic liquid crystal. [25%]

(c) Explain why a FLC material is not suitable for phase modulation when in a bulk cell structure. Why does surface stabilisation alleviate this? List two penalties that occur when using a surface stabilised FLC device. [25%]

(d) Show how a FLC material can be used to create a pixel in a simple optical shutter array. What sort of applications might use this type of device? [25%]

3 (a) Sketch the basic architecture of the *1/f* Joint Transform Correlator (JTC) and describe the process of how it operates. What are the main advantages of a 1/f JTC over the more traditional optical non-linearity approach? [40%]

(b) Explain why edge enhancement is a very effective type of algorithm when processing the joint power spectrum of a JTC. Use the example of a binary phase only *1/f* JTC to demonstrate one such advantage of the edge enhancement process. Give an example of a suitable edge enhancement algorithm that might be implemented. [30%]

(c) Explain why a *1/f* JTC is a better architecture for applications such as inspecting frames in a video sequence for object motion, than the matched filter? How might the sequence of correlations also form part of the inspection process? [30%]

4 (a) Describe with the aid of a diagram, the basic operation of a Shack Hartmann wavefront sensor. What are the main limitations of this type of wavefront sensor? [30%]

(b) Fig. 2 shows a single row scan from a plane wave that has been distorted by an optical aberration. Sketch what the output from the corresponding row of a 10 zone per row Shack Hartmann wavefront sensor might look like when illuminated by the wavefront in Fig. 2. Explain any assumptions made in your analysis. [20%]

(c) The aberration detected in part (b) has been detected within the optics of a holographic projector. The projector is based on a binary phase hologram calculated by the direct binary search algorithm. Explain how this algorithm works and then show how the algorithm can be modified to include and correct for the optical aberration. [30%]

(d) Explain how a binary phase hologram might be used to perform the same task as the Shack Hartmann wavefront sensor? [20%]

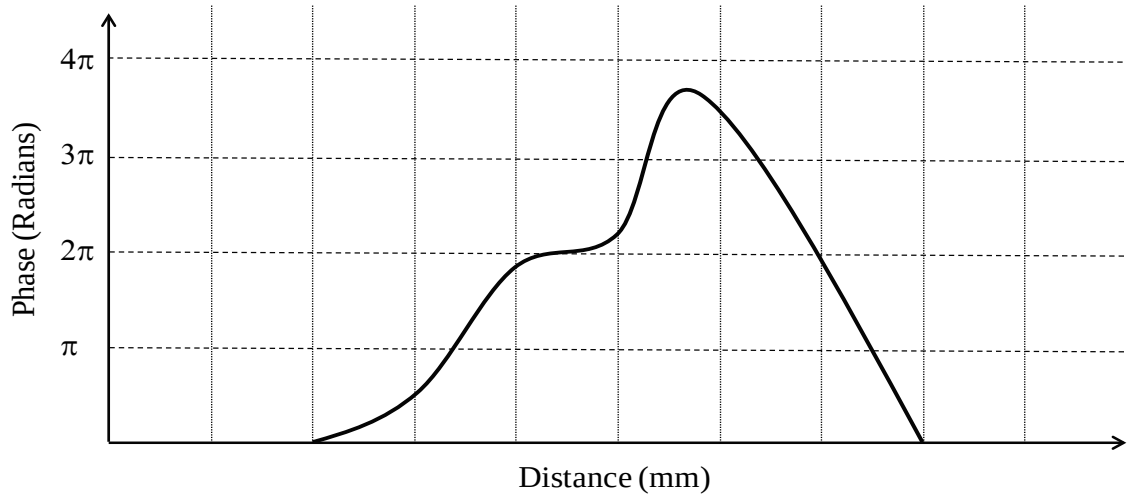

Fig. 2

END OF PAPER

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