UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For the following qualifications :-

B.Sc. *M.Sci.*

Astronomy 2B15: Techniques in Modern Astronomy

COURSE CODE	:	**ASTR2B15**
UNIT VALUE	:	**0.50**
DATE	:	**15-MAY-02**
TIME	:	**10.00**
TIME ALLOWED	:	**2 hours 30 minutes**

02-C0079-3-40

TURN OVER

Answer SIX questions from Section A and THREE questions from Section B.
The numbers in square brackets in the right hand margin indicate the provisional allocation of maximum marks per subsection of a question

Constants and formulae.

$\pi = 3.14159$

π radians $= 180^{o}$

$h = 6.626 \times 10^{-34}$ J s

$c = 2.998 \times 10^{8}$ m s^{-1}

1 arcsecond $= 4.84 \times 10^{-6}$ rad

1ev $= 1.6 \times 10^{-19}$ J

SECTION A

[Part marks]

1. Describe briefly the technique of photometry. [3]

   If in a certain time period the number of counts due to a source alone is given by N_0 and the number of counts due to the background in the same time period is N_B. Show that the formula for the signal to noise ratio is given by [4]

$$\frac{S}{N} = \frac{N_0}{\sqrt{2N_B + N_0}}$$

   (Assume Poisson Statistics)

2. Give a description, including a diagram clearly labelling each component, of an optical astronomical imaging camera system. [4]

   If the diameter of the telescope is 3.6m and the f-ratio of the beam at the telescope focus is 16, what is the image scale in arcseconds per millimetre at the telescope focal plane? (consider the telescope a simple lens) If the detector in the camera has pixels of size 16μm by 16μm and the size of the detector array is 2048 by 2048 pixels. What should the magnification of the camera optics be to give a field of view on the detector with a diameter of 6 arcminutes? [3]

3. What is the photoelectric effect? [3]

   Describe, with aid of a diagram an Indium Antimonide (InSb) infra-red detector pixel. What are the major problems with these devices and how can they be minimised? [4]

4. In radio astronomy what is the technique of aperture synthesis? Why is this technique easier to implement in the radio regime than in the optical? [4]

The Very Large Telescope Array is made up of many circular 26m diameter dish telescopes. The maximum separation that can be achieved between telescopes in the array is 27 kilometres. At a wavelength of 10cm, what is the achievable resolution of a single telescope in the array and what is the smallest achievable resolution of the whole array? [3]

5. What is a) a birefringent material and b) a polarizer? Give a description of a Wollaston prism polarizer including a sketch. [4]

What is a half wave plate? If half-wave plate is made of quartz that has a degree of birefringence J of 0.008, how thick must the quartz be to act as a half wave plate at a wavelength of 650nm? [3]

6. Give a description of a microchannel plate and how it produces an amplified signal? [3]

Describe, with the aid of a diagram, the design of an image intensified CCD detector that uses microchannel plates in the intensifier stage. [4]

7. Give three advantages of putting an astronomical instrument in space? [3]

Give short explanations of four design considerations that must be made when building space instrumentation. [4]

8. Explain, with a sketch, the problem of spectral degeneracy in a visible wavelength high resolution grating spectrograph and how it is solved. [4]

Consider a reflection grating with line spacing of 100 lines per millimetre. If a collimated beam is incident onto the grating at an angle of 60 degrees to the grating normal at what angle is a wavelength of 600nm dispersed in the 30^{th} order. What wavelengths will be at this same angle in the 29^{th} and 31^{st} orders? [3]

SECTION B

9. What is a multi-object spectrograph? Explain in your answer the difference between a multi-slit and multi-fibre system. [10]

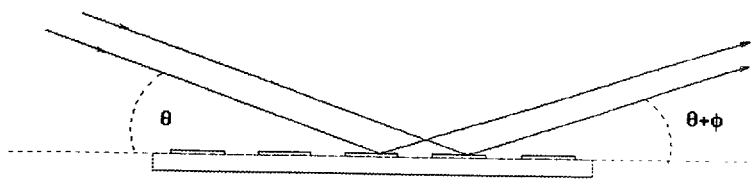
What is an integral field unit? Give a description of the three main types. [10]

10. Describe fully, including labelled ray diagrams, the optical aberrations given below and the effect they have on the image shape?

i) Chromatic Aberration [5]
ii) Spherical Aberration [5]
iii) Coma [5]
iv) Astigmatism [5]

11. Give a detailed description, with sketches, of the following X-ray detectors.

i) Scintillation Detector. [7]
ii) Solid State Proportional Detector. [7]



In the above X-ray reflection grating the condition for constructive interference is given by [6]

$$\phi = \pm\left(\frac{2m\lambda}{a} + \theta^2\right)^{\frac{1}{2}} - \theta$$

where a is the grating spacing, λ is the wavelength and m is the order. Give the formula for the angular dispersion with wavelength of the grating.

If the grating has 80 lines/mm, what is the angular dispersion of the grating in the first order at a wavelength of 1nm?

12. Explain the following adaptive optics terms [6]

i) Guide star
iii) Coherence length
iv) Isoplanatic patch

How is an artificial laser beacon produced? With the aid of diagrams give a description of a laser beacon launch system and describe some of the problems associated with using a laser beacon. [10]

If in a certain seeing condition an adaptive optics system has an effective actuator spacing mapped back onto the primary of 20cm and can achieve a certain Strehl ratio at a wavelength of 500nm. What is the maximum effective actuator spacing mapped back on the primary that could be used to produce an image with the same Strehl ratio at a wavelength of 2200nm in the same seeing conditions? [4]

13. Outline, including sketches, the physical processes by which VHE gamma rays can be produced. [8]

Describe in detail the following systems, including in your descriptions how spurious detections are avoided and the process by which the Cerenkov light that is used in each system is created. [12]

i) A ground based very high energy gamma ray telescope
ii) A heavy water/water neutrino detector

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