University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualifications

Astronomy PHAS2521: Techniques in Astronomy and Interstellar Astronomy

UNIT VALUE:

DATE:

TIME:

TIME ALLOWED:

Answer THREE questions from Section A and THREE questions from Section B.

You are advised to spend no more than 10 minutes on each Section A answer and about 30 minutes on each Section B answer.

The numbers in square brackets indicate the provisional allocation of maximum marks for sub–sections of the question.

Assume:
Speed of light = 300 000 km/s
One parsec = 3.086 x 10^{16} m

SECTION A

1
Draw and annotate two identical diagrams of a simplified optical layout of a refracting telescope with a single biconvex lens eyepiece. Indicate the focal lengths of the lenses and diameters of the entrance and exit pupils. Then:

a) In the first diagram, show the path of rays which indicate the focus of the system. [3]

b) In the second diagram show the rays which show the real and apparent angular fields, annotating these angles. [4]

2
a) Describe in a one or two sentences what visible light is. [3]
b) Calculate the energy (in ergs) of a red photon of 630nm. Assume the Planck constant to be 6.626×10^{-27} erg-s [4]

3
Define briefly the following optical phenomena. Use diagrams to help explain your answers:

a) diffraction [2]
b) angular dispersion [2]
c) reflection [3]

4

a) In one or two sentences, describe the physical process through which ionised hydrogen produces emission lines. Series of these lines are named; give the name of a series, and the region of the electromagnetic (EM) spectrum at which this series of lines is predominantly seen. [3]

b) Atomic hydrogen produces emission lines in the radio regime through a process which does not involve electron bound-bound transitions. In one or two sentences, describe how these emission lines arise, and give the wavelength of the emission. [2]

c) Molecular hydrogen is usually observed by means of a tracer molecule. Give a widely-used example of such a molecule and the region of the EM spectrum at which its emission is usually seen. [2]

5

a) Give a typical density and temperature for each of the following regions:

i) HII regions [1]
ii) Diffuse interstellar clouds [1]
iii) Dark interstellar clouds. [1]

b) If you looked at the spectrum of a reflection nebula, would you see absorption lines, emission lines, both, or no lines? Explain your answer. As part of your explanation, describe how the spectrum demonstrates that the light was reflected from nearby stars. [4]

6

a) In one or two sentences, describe each of the four main classes of young stars. [4]

b) What are sources of the two principal components of the spectral energy distribution (SED) of a young star? [1]

c) At which stage of evolution is a star first seen at optical wavelengths? Give a named example of this type of young star. [2]

SECTION B

7

Relating to detection of light in astronomy:

a) State in a sentence the function of a detector. [2]

b) Describe quantum efficiency of a detector. [3]

c) Define signal, noise and signal to noise ratio in data collection. [4]

d) Calculate the signal to noise ratio for a signal level of 144 photons [5]

d) What does CCD mean? [1]

e) Describe in simple terms how a CCD works. [5]

8

A Cassegrain telescope of 750mm diameter has a focal length of 7000mm and a central obstruction of 100mm diameter.

a) What would be the magnification with a 25mm eyepiece? [2]
b) What would be its light gathering power compared with a human pupil of 5mm diameter? [5]
c) If the eyepiece has an apparent angular field of 50 degrees, what would be the angular field observed in the sky in arc minutes? [5]
d) What would be the angular and linear resolution of this telescope in arcseconds and in micrometres (respectively) at the focal plane for light at 550nm? ([4] for each correct answer) [4x2]

Show your calculations, including definitions of symbols used.

9

Name and describe in detail with the help of diagrams four different techniques to detect extra solar planets. [5] for each technique. [4x5]

10

a) Give the average elemental composition of the interstellar medium (ISM). [1]

b) Define what is meant by the terms:

1) "column density" of an absorbing species [2]
2) "Equivalent Width" of an absorption line, and [2]
3) a "Curve of Growth" for an interstellar absorption line [2]

c) Some heavy elements are depleted in the ISM. Explain the process through which fractional abundances of metals are derived from observations of absorption lines. What is the implication of this depletion? [8]

c) Draw the interstellar extinction curve, titling the axes and noting three of the main features of the curve. [5]

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a) What is the ionisation potential of atomic hydrogen, and to which wavelength of light does this correspond? What type of stars produce this wavelength of photon in large quantities, and approximately how many ionising photons do they produce per second? [4]

b) Give the definition of a Strömgren Sphere, and using a recombination rate of 2×10^{-19} m^3 s^{-1} and a nebular density of 10^8 m^{-3}, calculate the Strömgren Radius for a pure H nebula. Give the final answer in parsecs. [7]

c) List three factors which would increase the size of the Strömgren Sphere. [3]

d) Briefly describe the heating and cooling mechanisms of an HII region. [6]

12

a) Describe the star formation process up until the formation of an embedded protostar. Use and explain terms such as "hydrostatic equilibrium", "Jeans' Mass" and "fragmentation". Which regions of the interstellar medium are most suited to star formation? Explain why. [8]

b) Given a molecular cloud of 1 million solar masses, approximately how much of this mass would be incorporated into stars? [1]

c) Explain the term Initial Mass Function (IMF). Approximately which mass of star is most populous according to most modern IMFs? [3]

d) Compare the length of time necessary for a star of 1 solar mass to reach the Main Sequence with one of 15 solar masses. [2]

e) Star formation can be triggered by external processes; give three examples of such triggering mechanisms. [3]

f) What is the main observational signpost indicating that protostars lose mass? Briefly explain how this phenomenon occurs. [3]

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