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.

SECTION A

1
Draw and annotate two 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. [3]

In the first diagram, show the path of rays which indicate the focus of the system, and in the other diagram show the rays which show the angular fields. [4]

2
Write down (itemised), with a brief expansion of each, 4 (only) advantages or disadvantages, for each of:

a) refracting telescopes [3]

b) reflecting telescopes [4]

Think in terms of size, cost, quality, practical application in astronomy, etc

3
List (itemised) seven main advantages or disadvantages of a modern Charge-Coupled Device (one point mark for each correct answer) [7]

4
Identify the four main phases of the Interstellar Medium (ISM) and contrast the difference between them using the parameters of temperature, density and the hydrogen ionisation state within each phase. [5]

Quote the percentage (by number) of hydrogen atoms, helium atoms, and heavier elements (metals) in the generic ISM. [2]

5
In which region of the electromagnetic spectrum are many interstellar absorption lines observed? [1]

List two types of bright objects that can be used as background sources to probe interstellar atomic gas in the line-of-sight to the near and distant Universe. [2]

Explain how the equivalent width of an absorption line is calculated. You may illustrate your answer with an annotated diagram. [4]

6
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 observed was that reflected somehow from the nearby stars. [4]

Why are observations at millimetre wavelengths so much more useful in exploring interstellar clouds than observations at visible wavelengths? [3]

SECTION B

7

Draw a sketch of the electromagnetic spectrum and indicate on it the approximate wavelengths associated with the main region of EM radiation, from gamma rays to long radio waves. Also indicate on this sketch the approximate blackbody temperatures of sources at each region and finally plot a curve along the sketch indicating how the atmospheric transparency/opacity changes through the different wavelength regions as a function of altitude. [10]

Describe which telescopes and detectors (and their locations, i.e. ground or space) are used to make studies of objects in each of the main regions of EM radiation. [10]

8

A telescope of 200mm diameter has a focal length of 3000mm.

a) What would be the magnification with a 20mm eyepiece? [2]
b) In that same case, what would be the size of its exit pupil? [5]
c) If the eyepiece has an apparent angular field of 50 degrees, what would be the angular field observed in the sky? [5]
d) What would be the angular and linear resolution of this telescope in arcseconds and in micrometres (respectively) at the focal plane for yellow light at 550nm? [8]

Show your calculations, including definitions of symbols used.

9

Describe in detail four different techniques (ground and space based) used to detect the presence of and/or to image extra solar planets. Include information about present achievements, the challenges and limitations encountered (regarding what they can detect), the advantages, disadvantages and the expected future developments, especially in space observatories.

(Total mark will be out of [20], 5 marks for each technique described.)

10
Describe the dominant heating and cooling mechanisms in a pure ionized hydrogen nebula (H II region), with reference to photoionisation, thermalisation, and recombination. What energy does a photon need to have to photoionise hydrogen? Describe (with the aid of a diagram) how these mechanisms operate in a hydrogen atom. Include in your diagram an indication of how the Lyman, Balmer and Paschen series arise. [8]

What are the dominant sources of heating and cooling in a diffuse cloud where hydrogen is mostly neutral? [3]

Discuss briefly how forbidden lines form and why forbidden lines cannot be observed on Earth. Why are forbidden lines very efficient at cooling gas? [9]

11
Outline the basic approach used to determine gas element abundances from measurements of interstellar absorption lines. [7]

What would be the difference between observing an interstellar cloud with strong forbidden lines and weak forbidden lines? How would this affect the nebula cooling rate? [3]

What is found when the abundances of metals in the ISM are compared to those in the Sun? How does this help in determining the chemical composition of interstellar dust? [2]

At what specific wavelength of the radio region does neutral hydrogen in the ISM emit electromagnetic radiation? In simple terms, explain how this emission process occurs. You may use a diagram to illustrate your answer. [6]

Hydrogen in its molecular form (H_2) is hard to detect. Emission from what molecule is commonly used to trace its existence? On average, in what proportions are H_2 and this molecule found? [2]

12
What is the relationship between Giant Molecular Clouds and H II regions? Indicate a key observational fact that points towards a close relationship. [4]

Outline the process of triggered star formation in molecular clouds. Include references to the effects of OB-type stars and supernovae in this process. [7]

List the four main classes of low- and intermediate-mass protostars corresponding to the various stages of star formation, and outline the basic physical processes characterizing each class. [5]

With the aid of a diagram explain what *proplyd* means and what the term represents (make sure to indicate the UV radiation field and the orientation of the system). [4]

PHAS2521/2010 END OF PAPER