2008-exam

University of Cape Town

National Astrophysics and Space Science Programme

B.Sc. (Hons) or M.Sc. June 2008 Examination

Observational Techniques 1 (OT1)

Exam duration 3 hours. Answer SEVEN questions (approximately 25 minutes each; 25 marks each). The marks allocated to each part question are indicated in brackets.

1. SATELLITES

a) List the main systems on a spacecraft and their functions (12)

b) Describe the main features of a survey class astronomy mission and an observatory class astronomy mission. Give an example of each. (8)

c) Describe briefly the various hazards posed by the space environment for a spacecraft. (5)

2. SPECTROSCOPY

a) Explain what is meant by the linear dispersion of a grating or prism and the resolving power of a spectrograph. (4)

b) With the aid of a sketch, derive an equation for the condition of constructive interference for a reflection diffraction grating. (6)

c) Assuming a constant angle of incidence, differentiate the equation obtained in part (b) to obtain an expression for the angular dispersion of a grating. Hence explain how dispersion varies with spectral order and the grating line separation. (6)

d) Briefly explain how a Volume Phase Holographic (VPH) grating works and list three advantages a VPH grating has over a conventional reflection grating. (9)

3. SPECTROSCOPY

a) Sketch the layout of a typical Cassegrain "long slit" spectrograph, labelling the principal components (5)

b) Sketch the layout of a typical echelle spectrograph, describing the key components. Explain how the echelle spectrograph achieves very high dispersion and explain the necessity for a cross-dispersing element. (12)

c) Briefly describe how the Tully-Fisher relation works and list the three underlying assumptions. (8)

4. VARIABLE STARS

a) Using sketches where necessary, explain how the light curve of an eclipsing binary star can be used to determine the relative radii of the component stars. What additional information would be required to enable determination of the actual radii of the stars ? (8)

b) Using sketches where necessary, explain the effects on the light curve of an eclipsing binary system of:

i) heating of one star by the other (reflection effect)
ii) non-spherical stars (geometric effect)

and indicate how the two effects can be separated. (12)

c) Briefly describe three features which help to define the class of R Coronae Borealis (RCB) variable stars. (5)

5. VARIABLE STARS

a) Explain how the kappa-mechanism drives stellar pulsation. (10)

b) Describe three factors which result in the Type I Cepheid variables being so useful to the determination of the distance scale in the Universe. Explain how the early confusion of Type I and Type II Cepheids (W Vir stars) led to an underestimation of the distance scale by a factor of about 2. (10)

c) Briefly explain why crystallization in white dwarf stars could affect determination of the age of the Galaxy. (5)

6. POLARIZATION

a) Describe an example of an astronomical source of polarization. Use a diagram if you wish. Include a description of how the polarized light is produced. Describe appropriate instrumentation for measuring such polarization. (25)

7. POLARIZATION

With the aid of a diagram, explain the function of the main components of a dual beam imaging polarimeter. (25)

8. INFRARED TECHNIQUES

a) Explain why the Earth's atmosphere makes observations at infrared wavelengths more difficult than visual observations. List 3 things that can be done to overcome or reduce these difficulties. (6)

b) Why would you observe at infrared wavelengths if you wanted to know more about the following (there may be several reasons for some of these):

i) very young stars
ii) highly evolved stars
iii) galaxies at low Galactic latitude
iv) the Centre of the Milky Way
v) novae or supernovae (10)

c) Describe in one paragraph an infrared satellite (e.g. Spitzer or IRAS),

highlighting two of its achievements. (4)

d) What characteristics of AGB stars make them useful as distance indicators ? Which element, created in the core of an AGB star, can be dredged to the surface and what techniques would you use to detect this element? (5)

9. SALT INSTRUMENTATION

a) List four parameters which need to be considered when designing optical imagers, noting why each is important. Indicate briefly where they are interrelated and how they need to be optimised to produce an efficient imaging instrument. (8)

b) Using sketches where appropriate, describe how SALTICAM will operate in "frame transfer" and "slot" modes. What important area of research will these modes allow ? (8)

c) Briefly describe the first SALT science achieved with SALTICAM, including the important result obtained. (9)