King's College London

UNIVERSITY OF LONDON

This paper is part of an examination of the College counting towards the award of a degree. Examinations are governed by the College Regulations under the authority of the Academic Board.

B.Sc. EXAMINATION

CP/2620   Astrophysics

Summer 1998

Time allowed: THREE Hours

Candidates should answer SIX parts of SECTION A, and TWO questions from SECTION B.

Separate answer books must be used for each Section of the paper.

The approximate mark for each part of a question is indicated in square brackets.

You must not use your own calculator for this paper.
Where necessary, a College calculator will have been supplied.

TURN OVER WHEN INSTRUCTED

$$\text{gravitational constant G} = 6.673 \times 10^{-11} \text{Nm}^2 \text{ kg}^{-2}.$$
$$\text{mass of the Sun } M_\odot = 1.989 \times 10^{30} \text{ kg.}$$
$$\text{radius of the Sun } R_\odot = 6.96 \times 10^8 \text{ m.}$$
$$\text{one parsec} = 3.085 \times 10^{16} \text{ m.}$$
$$\text{speed of light } c = 2.997 \times 10^8 \text{ m s}^{-1}.$$
$$\text{elementary charge } e = 1.602 \times 10^{-19} \text{ C}$$
$$\text{electron mass } m_e = 9.109 \times 10^{-31} \text{ kg}.$$
$$\text{Planck constant } h = 6.626 \times 10^{-34} \text{ J s}.$$

SECTION A – Answer SIX parts of this section

1.1) Define apparent magnitude, absolute magnitude, bolometric magnitude and luminosity.

[7 marks]

1.2) Describe one method for finding the distance of a star in our Galaxy that does not depend on an auxiliary calibration of an astronomical scale. (The astronomical unit is assumed known.)

[7 marks]

1.3) What are gamma-ray bursters? Discuss why are they of great interest in astrophysics? Show that an absorption feature at 20 keV which is due to cyclotron resonance, implies a magnetic field of about 2×10^8 Tesla.

[7 marks]

1.4) What observations have made the existence reasonably certain of black holes of mass $\approx$ 2 - 8 $M_\odot$ in our Galaxy?

[7 marks]

1.5) Give reasons why astronomers think that Cepheid variable stars are stars with mass 5 to 10 $M_\odot$ at a late stage in their lives.

[7 marks]

1.6) Why are pulsars believed to be rotating neutron stars?

[7 marks]

1.7) Suggest a reason why the solar neutrinos that are detected on the Earth's surface are less than the number which is predicted by the Standard Solar Model.

[7 marks]

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1.8) Discuss whether the time between the core collapse of a massive star and its explosion as a type II supernova can be estimated from observation. Can this time be predicted from theory?

[7 marks]

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SECTION B – Answer TWO questions

2) What may be deduced from the observation of (a) visual binaries, (b) spectroscopic binaries and (c) eclipsing binaries?

[18 marks]

Two objects whose masses are M_1 and M_2 are in binary orbit. Assuming circular orbits and Newtonian gravity, show that

$$\omega^2 = \frac{G(M_1 + M_2)}{(a_1 + a_2)^3}$$

where a_1 and a_2 are the radii of the orbits about the centre of mass and ω is the angular velocity.

The first object is observed spectroscopically and has an apparent velocity V with respect to the centre of mass. The angle between the plane of the orbit and the plane of the sky is i. From this and $M_1 a_1 = M_2 a_2$ deduce that

$$\frac{(M_2/M_1)^3 (\sin i)^3}{(1 + M_2/M_1)^2} = \frac{\omega^2 (V/\omega)^3}{G M_1}$$

An x-ray source has an orbiting star whose period is 4.10 days and sinusoidal orbital velocity about 120 km/sec with respect to the centre of mass. Spectroscopic data suggest the star is a B0 supergiant whose mass, by comparison with other such stars, is estimated to be $\approx 9 M_\odot$. The light is not eclipsed. The light from the other object is a blue glow with no absorption lines visible. What can be deduced about the mass and nature of this other object?

[12 marks]

3) Describe the evolution of a star of mass $\approx 5 M_\odot$ according to current theories from its first appearance on the main sequence to its final state.

[30 marks]

4) Describe the observed properties of Cepheid variable stars. Explain how they are used as distance indicators. State the advantages and limitations of this method.

[30 marks]

5) Why do some stars at the end of their lives, explode as supernovas? What is known about supernovas from observation?

[30 marks]

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