UNIVERSITY COLLEGE LONDON

EXAMINATION FOR INTERNAL STUDENTS

MODULE CODE : **PHAS1102**

ASSESSMENT PATTERN : **PHAS1102A**

MODULE NAME : **Physics of the Universe**

DATE : **27-May-09**

TIME : **10:00**

TIME ALLOWED : **2 Hours 30 Minutes**

2008/09-PHAS1102A-001-EXAM-119

TURN OVER

Answer ALL SIX questions from Section A and any THREE questions from Section B

Numbers in square brackets in the right-hand margin indicate a provisional allocation of maximum possible marks for different parts of each question.

The following may be assumed if required:

Planck constant	h	6.63×10^{-34} J s
Speed of light	c	3.0×10^{8} m s^{-1}
Stefan-Boltzmann constant	σ	5.7×10^{-8} W m^{-2} K^{-4}
Gravitational constant	G	6.7×10^{-11} N m^2 kg^{-2}
Solar radius	$R_\odot$	7.0×10^{8} m
Solar bolometric luminosity	$L_\odot$	3.8×10^{26} W
Solar mass	$M_\odot$	2.0×10^{30} kg
1 parsec	pc	3.1×10^{16} m
1 AU		1.5×10^{8} km
1 eV		1.6×10^{-19} J

Section A

(Answer ALL SIX questions from this section)

1. Describe, in a few sentences, what is meant by the 'solar neutrino problem'. (Complete answers will include an explanation of the basic properties of neutrinos, of how the problem arose, which technical advances allowed it to be solved, and how neutrino physics had to be modified to resolve it.) [7]

2. What are the end points of stellar evolution? Distinguish the different types, and state on what the ultimate fate of a star depends. [3]
   What are Gamma Ray Bursts, and which astrophysical phenomena are believed to lead to them? Distinguish the cases of short and long bursts. [3]

3. Define what is meant by the *apparent*, *absolute* and *bolometric magnitudes* of a star. Explain what the *bolometric correction* is. [4]
   What is the UBV Johnson system, and why was it introduced? [3]

4. List, without elaboration, the principal ingredients of the 'Standard Model' of Particle Physics. [7]

5. Name three methods by which the masses of clusters of galaxies may be determined. [3]
   Briefly outline the principles behind any *one* of those methods. [4]

6. State Hubble's Law. [2]
   List any two items of observational evidence in favour of the 'Big Bang' model (in addition to the expansion of the Universe), and any two problems with that model. [2] [2]

Section B

(Answer THREE questions from this Section)

7. Explain what are meant by the *proper motion* and the *radial velocity* of a celestial object. [4]

Show that if an object has an observed proper motion of μ arcsecond per year, and lies at a distance d parsec from the observer, the tangential component of its velocity (i.e., the component perpendicular to our line-of-sight) is given by [7]

$$v_t = 4.74\,\mu\,d \text{ km s}^{-1}$$

A nova shell is observed to be expanding away from the location of the nova with a proper motion of 1 arcsec per year. Spectroscopic observations of the hydrogen Hα line emitted by the front of the shell (i.e., that part closest to the observer) show an observed wavelength of $\lambda = 654.2$ nm. Determine the expansion velocity of the shell in km s^{-1}, and use this, together with the observed proper motion, to determine the distance to the nova. [7]

[You may assume that the nova is not moving relative to the Sun, and that the rest wavelength of Hα is $\lambda_0 = 656.3$ nm.]

What is the corresponding parallax of this object? In deriving the distance, what key assumption have you had to make? [2]

8. Briefly explain how the brightness of stars is expressed in terms of magnitudes, the reason behind the system of stellar magnitudes, and the relation between magnitude and flux. [4]

What are the effects of interstellar material on the magnitudes and colours of stars observed through such material? By which parameter are the effects on the colours measured? [3]

The Sun has an apparent visual magnitude $V = -26.7$. Calculate its absolute magnitude M_V. What is its V magnitude as seen from α Cen (which is 1.3 parsecs distant) if the amount of interstellar material between the two stars is negligible? What would the Sun's V magnitude be if $E(B-V) = 0.3$? [8]

When viewed through a telescope the components of a double star are found to have $V = 4.0, (B-V) = 0.5$, and $V = 3.0, (B-V) = 0.3$, respectively. Calculate the intensity ratio of the two stars at V and at B, and then estimate the V and B magnitudes, and the $(B-V)$ colour, of the combined system. [5]

9. Explain what is meant by the term 'black-body radiation' and give three examples of such emission. [4]

For a given temperature, sketch the variation of the intensity (per unit frequency range) of black-body radiation as a function of frequency, according to quantum physics, taking care in labelling the axes. How would the graph change if the temperature increased? [4]

State the Stefan-Boltzmann law (including units) and explain (without any calculation) how it is derived. How is it possible to calculate the luminosity of a star only knowing its radius and temperature? [3]

If a blue supergiant star with a surface temperature of 25,000 K evolves into a red supergiant with the same luminosity and a temperature of 5,000 K, by what factor does the radius change? [2]

Briefly explain what is meant by hydrostatic equilibrium in a star, and how stars remain stable unless this equilibrium is severely disturbed. [3]

The Sun is a G2 V star, while the bright star Rigel is a B8 Ia star: Explain what is meant by these classifications (your answer should include a list of the full sequence of Harvard types). [4]

10. Describe the evidence for a black hole at the centre of our Galaxy. (A complete answer will mention the observational difficulties associated with obtaining this evidence.) [7]

Outline the key observational properties of Active Galactic Nuclei, and details of the physical mechanisms underpinning those properties. [5] [8]

11. Explain the Tully-Fisher relationship, its calibration, and why it is useful for determing the distances to remote galaxies. [5]

Why are some supernovae useful 'standard candles', and others not? [3]
Relate the sequence of events that gives rise to a Type Ia supernova. [8]

What major result has emerged in recent years from the study of Type Ia supernovae at cosmological distances? Why is the result surprising? [4]

END OF PAPER