BOARD OF STUDIES
NEW SOUTH WALES

2003

HIGHER SCHOOL CERTIFICATE EXAMINATION

Cosmology

Distinction Course

Modules 1, 2 and 3 (including Residential 1)

General Instructions

- Reading time – 5 minutes
- Working time – 1 hour
- Write using black or blue pen
- Board-approved calculators may be used
- A data sheet is provided at the back of this paper

Total marks – 60

Section I Page 2

8 marks

- Attempt FOUR questions from Questions 1–6
- Allow about 8 minutes for this section

Section II Page 3

12 marks

- Attempt Questions 7–8
- Allow about 12 minutes for this section

Section III Page 4

40 marks

- Attempt Questions 9–10
- Allow about 40 minutes for this section

Section I

8 marks
Attempt FOUR questions from Questions 1–6
Allow about 8 minutes for this section

Answer all questions in the writing booklet provided. Extra writing booklets are available.

Question 1 (2 marks)

State and explain briefly the containment principle in cosmology.

Question 2 (2 marks)

Describe the characteristics of a galaxy.

Question 3 (2 marks)

Why does a radio telescope such as MOPRA have a liquid helium cooling system within its receiver?

Question 4 (2 marks)

The GAIA astrometric satellite is designed to make a 'stellar census of our galaxy', observing out to stars with parallax of 40 microarcseconds.

To what distance does this correspond?

Question 5 (2 marks)

A supernova in a nearby galaxy was observed at maximum brightness with magnitude 12.3.

Given that the peak absolute magnitude for these supernovae is $M = -19.4$, calculate the distance to the galaxy.

Question 6 (2 marks)

Explain how the perfect cosmological principle led to the development of the Steady State theory of the universe.

Section II

12 marks
Attempt Questions 7–8
Allow about 12 minutes for this section

Answer each question in the writing booklet provided. Extra writing booklets are available.

Question 7 (6 marks)

Outline the theoretical concepts on which the Big Bang model of the universe is based.

Question 8 (6 marks)

The photo shows an Australian astronomical telescope.

(a) What wavelengths of electromagnetic radiation does this telescope observe? (1 mark)

(b) What is the benefit of having an array of separate antennas spaced along a baseline? (5 marks)

Please turn over

Section III

40 marks
Attempt Questions 9–10
Allow about 40 minutes for this section

Answer each question in the writing booklet provided. Extra writing booklets are available.

Question 9 (20 marks)

The scale of the universe is based on the measured distance between Earth and Sun.

Describe some of the techniques used to extend this unit distance to the nearer stars, galaxies and beyond.

Question 10 (20 marks)

Although the Ptolemaic model of the universe has been discarded, it did last 1500 years without serious challenge.

Discuss some reasons for the longevity of this model.

End of paper

Cosmology

Data Sheet

Physical Constants and Conversion Factors

Recommended values

Abstracted from the consistent set of constants in CODATA Bull. No. 63 (1986) by the Royal Society, the Institute of Physics, and the Royal Society of Chemistry.

The number in parenthesis after each value is the estimated uncertainty (standard deviation) of the last digit quoted.

speed of light in a vacuum	c	$2.997\,924\,58 \times 10^{8}$ m s^{-1} (exact)
permeability of a vacuum	μ_0	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of a vacuum, $\left[\mu_0 c^2\right]^{-1}$	ϵ_0	$8.854\,187\,817\ldots \times 10^{-12}$ F m^{-1}
elementary charge (of proton)	e	$1.602\,177\,33(49) \times 10^{-19}$ C
gravitational constant	G	$6.672\,59(85) \times 10^{-11}$ N m^2 kg^{-2}
Planck constant	h	$6.626\,0755(40) \times 10^{-34}$ J s
Avogadro constant	N_A	$6.022\,1367(36) \times 10^{23}$ mol^{-1}
molar gas constant	R	$8.314\,510(70)$ J K^{-1} mol^{-1}
Boltzmann constant	k	$1.380\,658(12) \times 10^{-23}$ J K^{-1}
unified atomic mass constant	m_u	$1.660\,5402(10) \times 10^{-27}$ kg
rest mass of electron	m_e	$9.109\,3897(54) \times 10^{-31}$ kg

SI secondary units

astronomical unit	AU	$1.495\,978 \times 10^{11}$ m
parsec	pc	3.0856×10^{16} m = 3.262 ly
Gregorian calendar year	y	365.2425 days = 31 556 952 s
jansky	Jy	10^{-26} W m^{-2} Hz^{-1}

Indicative values

earth mass	5.977×10^{24} kg
solar mass, $M_\odot$	1.989×10^{30} kg
galaxy mass	$10^{11}\ M_\odot$
Hubble constant, H_0	$100\ h$ km s^{-1} Mpc^{-1} (typically h ranges from 1 to 0.5)

Conversion factors

distance (light-year)	ly	9.460×10^{15} m = 63 240 AU
energy (erg)	erg	10^{-7} J
magnetic field (gauss)	G	10^{-4} T
wavelength (angstrom)	Å	10^{-10} m

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