WEEK 14

Online Exam Part 1

Personal Identifier	Y362220X
Status	Finished
Started	Sunday, 19 Jan 2025, 15:23
Completed	Sunday, 19 Jan 2025, 18:21
Duration	2 hours 58 mins

Information

Flag question

The questions in this part of the Online Exam are based on Topics 1, 2 and 3 of the module.

The three questions in the first section are based on concepts related to stars across the three topics, and the three questions in the second section are based on concepts related to galaxies across the three topics. There are 15 marks available for each section of questions, or 30 marks in total.

Some questions require numerical answers, some require you to choose the correct response from a drop-down list of options or to select a check-box alongside the correct option(s), whilst other questions may require you to drag-and-drop answers into place or type your answer into free-text entry boxes. Note that numerical answers have a tolerance on the correct answer to allow for small rounding errors in calculations.

Some questions include one or more boxes in which you can "show your working" by either entering text or attaching an image or a file of your written notes. Entering anything into these boxes is entirely *optional* and will not be marked, but may allow the marker to give you partial credit for an otherwise incorrect answer.

The Online Exam allows you to submit **one attempt** for each answer. However, answers are not submitted until you have clicked on **Submit all and finish**. Before you submit your answers, you may change them as many times as you wish. Your last selected answers will be stored. **You must submit within the 3 hour time period after you have started it and by the cut-off date**. There is no grace period after the cut-off for this Online Exam.

While working through the questions, press **Next page** to move on to the next question. Although the questions are presented to you in sequence, it is possible to attempt them in any order. To move to a different question, select the relevant question number from the navigation panel on the left-hand side of the screen.

You are advised not to use the 'Back' function on your web browser.

When you have ***completed*** the Online Exam and are ready to submit it for marking, please remember to select the **Submit all and finish** button. The **Submit all and finish** button is located at the bottom of the summary screen. If you have worked through the questions in order, the summary screen will appear automatically once it is completed. If you have answered the questions out of order then it can be accessed at any time by selecting **Finish attempt...**(on the left-hand side of the screen). If you fail to finish all of the questions within the 3 hour time period your answers will automatically be submitted and your exam will be scored from the answers you have provided.

Question 1 Complete

Marked out of 5.00 | Flag question

The star Epsilon Sagittae has proper motion components of:
$\mu_{\alpha*}$ = 16.38 mas y^{-1} and μ_{δ} = 14.36 mas y^{-1} and an annual parallax of ϖ = 5.61 mas.

a. Calculate the magnitude of its overall proper motion.

μ = 21.78 mas y^{-1} (4 s.f.)

(1 mark)

b. Use the annual parallax to calculate its distance.

d = 178 pc (3 s.f.)

(1 mark)

c. Complete the following sentences to explain how to convert the star's overall proper motion in mas y^{-1} into its transverse velocity in km s^{-1}.

First convert milliarcseconds per year into radians per year then multiply by the distance in parsecs. Next multiply by the number of kilometres in a parsec and divide by the number of seconds in a year.

What is the star's transverse velocity?

v_T = 18.4 km s^{-1} (3 s.f.)

(3 marks)

You may, if you wish, use the box below to show your working for any parts of this question, but this is not essential.

```
\mu= \sqrt{(\mu_{\alpha})^2 + (\mu_{\delta}}^2}
d=\frac{1}{\omega\bar}
1pc=3.0857×10¹³ km
1yr=3.156x10^7s
```

Question 2 Complete

Marked out of 5.00 | Flag question

The star Beta Ceti has a radius of R = 16.8 $R_{\odot}$, a luminosity of L = 139 $L_{\odot}$ and an effective surface temperature of T_{eff} = 4840 K.

a. With reference to the Hertzsprung–Russell diagram, what type of star is this?

- supergiant star
- white dwarf star
- red giant star (selected)
- main sequence star

(1 mark)

b. What would be the likely colour index for this star? (Assume that interstellar reddening is negligible.)

- (B – V) < 0 (blue)
- (B – V) > 0.2 (red)
- (B – V) ≈ 0 - 0.2 (white) (selected)

(1 mark)

c. Using Wien's law, calculate the wavelength at which its blackbody spectrum reaches a peak.

λ_{peak} = 599 nm (2 s.f.)

(1 mark)

d. Rearrange the LTR relationship to obtain a proportionality expressing the radius of a star in terms of its luminosity and temperature. Complete the following expression by selecting appropriate values for the powers in the boxes.

$R \propto L$ [+0.5] x T [+2]

(1 mark)

e. In the past, Beta Ceti was less luminous and hotter than it is now, with a luminosity of 72.4 $L_{\odot}$ and an effective temperature of 10700 K. Use the proportionality you have derived above to calculate the ratio of its radius now to its radius in the past.

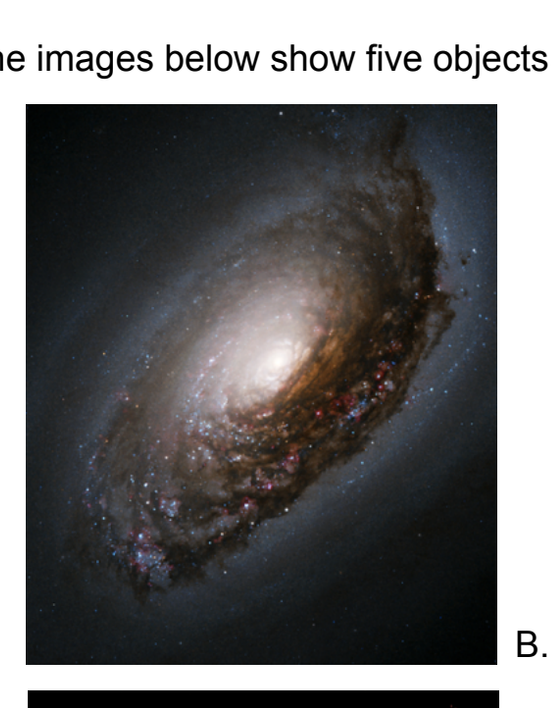
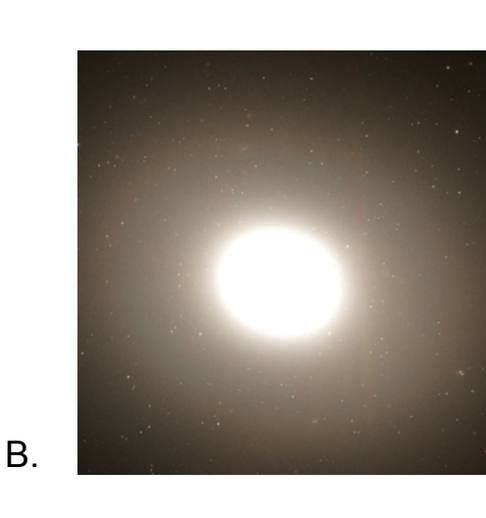
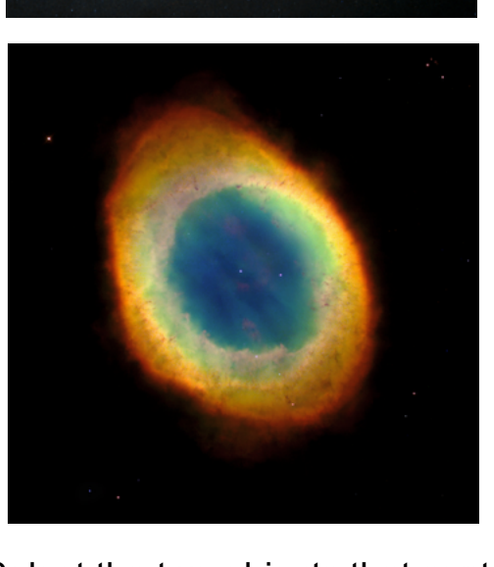
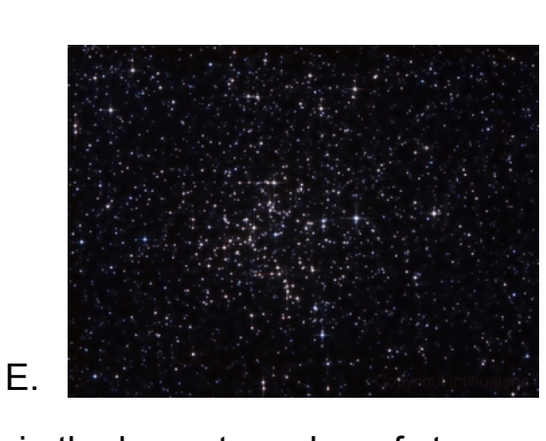
R_{now} / R_{past} = 2.5 (2 s.f.)

(1 mark)

Question 3 Complete

Marked out of 5.00 | Flag question

The images below show five objects from the Messier catalogue.

A. 
B. 
C. 
D. 
E. 

a. Select the two objects that contain the largest number of stars.

A (checked) B (checked) C D E

Select the two objects that contain typically $10^3 - 10^6$ stars.

A B C (checked) D E (checked)

Select the object that is not composed primarily of a collection of stars.

A B C D (selected) E

Select the object that represents the most common type of star cluster in our Galaxy.

A B C (selected) D E

(Note: *If you select more than the correct number of options, your lowest scoring options will be counted.*)

(2 marks)

b. Image C is 800 × 800 pixels in size and has an image scale of 0.27 arcsec per pixel. What is the angular size of the image in arcminutes?

Angular size = 3.6 arcmin (2 s.f.)

The object is about 4.4 kpc away and fills the image frame. Calculate the linear size of the object in parsecs.

Linear size = 4.6 parsec (2.s.f.)

(2 marks)

c. Complete the following sentence concerning the stars in images C and E.

The red stars in image C are cooler than and older than the blue stars in image E.

(1 mark)

Question 4 Complete

Marked out of 5.00 | Flag question

A Cepheid variable star in the spiral galaxy NGC1003 is observed to have a pulsation period of 36.5 d and a V-band apparent magnitude of m = 23.88. The V-band extinction to the galaxy is A = 0.19.

a. Use the pulsation period to calculate the absolute magnitude (M) of the Cepheid variable star.

M = 21.1 (3 s.f.)

Complete the expression for the logarithm of the distance to the galaxy in parsec.

$\log_{10}(d/\mathrm{pc}) = ($ [m] $-$ [M] [+] 5 [–] $A)/5$

Hence determine the distance to the galaxy in megaparsec.

d = 0.005 Mpc (3 s.f.)

(3 marks)

b. Complete the expression for the logarithm of the ratio of the luminosity of the star (L_1) to that of delta Cephei itself (L_2) in terms of the absolute magnitude of the star (M_1) and the absolute magnitude of delta Cephei (M_2).

$\log_{10}\left(\frac{L_1}{L_2}\right) = ($ [M1] [–] [M2] $)/$ [2.5]

Now calculate the luminosity ratio given that the V-band absolute magnitude of delta Cephei is M_2 = –3.47.

L_1/L_2 = 24.3 (3 s.f.)

(2 marks)

You may, if you wish, use the box below to show your working for any parts of this question, but this is not essential.

```
lnd=m-M+5-A/5
m=23.88, M=21.1, A=0.19
d=e^(lnd)

log_10(L_1/L_2)=(M1-M2)/2.5
M_1=1
M_2=-3.47
10^((M1-M2)/2.5)
```

Question 5 Complete

Marked out of 5.00 | Flag question

The image below shows a spectral map of the lenticular galaxy NGC3998 obtained using an integral field spectrograph. Each hexagonal pixel is colour-coded according to the *relative* radial velocity measured from the spectrum at that location. The maximum redshift measured is +200 km s^{-1} (in the lower left part of the image) and the maximum blueshift measured is –200 km s^{-1} (in the upper right part of the image), both relative to the overall motion of the galaxy which is receding from us at a speed of +1090 km s^{-1}. Zero relative redshift is coloured yellow/green across the middle of the image from upper left to lower right. The white ellipses are contours representing the brightness of the galaxy.

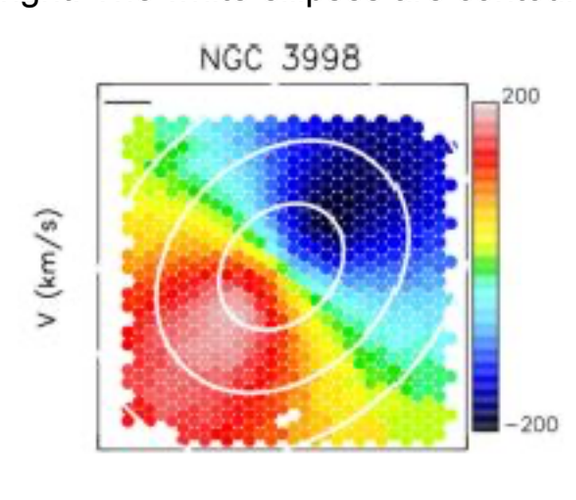


Figure: A radial velocity map of the galaxy NGC3998. (Boardman et al., 2017, MNRAS, 471, 4005)

a. What is the projected orientation on the plane of the sky of the rotation axis of the galaxy?

→ ↑ ↖ (selected) ↗

(1 mark)

b. What would the map of *relative* radial velocities look like if the rotation axis of the galaxy was pointed directly towards us?

- the map would be red in the centre and blue around the edges
- the map would be uniformly yellow/green (selected)
- the map would be uniformly red
- the map would be blue in the centre and red around the edges
- the map would be uniformly blue

(1 mark)

c. The [OIII] spectral line has a rest wavelength of 500.7 nm. What wavelength would be measured for this line from the part of this galaxy that is rotating towards us the fastest? (*Hint*: remember to account for the rotation *and* the recession of the galaxy.)?

Measured wavelength of [OIII] line =

502.2 nm | 500.4 nm | 502.9 nm | 501.0 nm | 502.5 nm (selected)

(1 mark)

d. If the spectrum of the galaxy is observed using a telescope with a lower spatial resolution, so that only a *single* spectrum is obtained from the entire galaxy, what would be the velocity dispersion of the resulting spectrum and what would be the overall width of the [OIII] spectral line?

velocity dispersion = 170 km s^{-1}

overall line width = 0.67 nm

(2 marks)

Question 6 Complete

Marked out of 5.00 | Flag question

A supernova is observed in the galaxy NGC2424 at a distance of 51 Mpc away. In order to spatially resolve the supernova from the centre of the galaxy, an astronomer needs to measure the position of the supernova within the galaxy to a precision of 400 pc. To achieve this, they are using a ground-based telescope with a primary mirror diameter of 12 cm and a broadband filter centred on a wavelength of 1.2 μm. The seeing at the observatory site is 0.75 arcsec.

a. What is the angular precision required to locate the supernova?

Angular precision required = 1.62 arcsec (2 s.f.)

(1 mark)

b. What is the limiting angular resolution of the telescope?

Limiting angular resolution = 2.51 arcsec (2.s.f.)

(1 mark)

c. What is the reason that the supernova *cannot* be located to the angular precision required ?

Select the appropriate reason:

The angular resolution of the telescope is smaller than the seeing

(1 mark)

d. Which of the following changes (applied on its own) could allow the supernova to be located to the angular precision required? (Select all those that apply. If you select more than the expected number of options, incorrect choices will incur negative marks.)

- [ ] Use a broadband filter in the optical part of the spectrum
- [x] Use an adaptive optics system on the telescope
- [ ] Use a broadband filter in the far ultraviolet part of the spectrum
- [x] Increase the diameter of the telescope primary mirror
- [ ] Decrease the diameter of the telescope primary mirror
- [x] Relocate the telescope above the Earth's atmosphere

(2 marks)

Finish review