

Introduction Astronomy

Midterm Practice Exam

Please note

This exam has 30 points in total. There are different types of (sub-) questions: 8 multiple-choice (mostly at the end), 2 essay, 2 sketch, and 3 where you need to calculate properties. For the essay questions, a few lines suffice. Please note that there is a list of constants and conversion factors that might be helpful at the end of this exam. Additionally, you should have received a formula sheet. You can use a simple electronic pocket calculator to solve questions. You are not allowed to use any other material.

1 Getting the distance

a. (1 pt) You want to determine the distance to our neighbouring disk galaxy M31 (the Andromeda galaxy). Your method of choice would be:

- (A) Parallaxes
- (B) Cepheids
- (C) Type Ia supernovae
- (D) Hubble's law

b. (3 pt) For **every** answer you have **not** chosen above, explain why this would not be the best method in 1 or 2 sentences.

2 In the footsteps of Cecilia

You are, for the first time in human history, combining novel quantum theory with stellar absorption line spectra. You realise that the lines with the deep-

est hydrogen absorption in the Balmer series (characterized by the electron transitioning between the energy levels ≥ 3 to the 2nd energy level in an hydrogen atom) occur in A type stars.

(2 pt) Explain why the lines get weaker for a hotter star, and why for a cooler star.

3 A Hertzsprung-Russell diagram

a. (4 pt) Make a sketch of a HR diagram for a stellar cluster with age 10 Gyr. It only needs to be qualitative, but make sure to indicate which direction on your axes goes to larger temperatures, which to redder colours, and which to larger luminosities. The different types of stars can be represented simply by lines or ellipses inside the HR-space, but make sure you label the following populations:

- (A) White dwarfs
- (B) Main sequence stars
- (C) Red giant branch
- (D) Asymptotic giant branch

b. (2 pt) How would this sketch change if you were looking at a 500 Myr old cluster instead? (You are allowed to make another sketch, but you can also explain in words).

4 Gaia and its parallaxes

(3 pt) Gaia expected to have a measurement accuracy in its parallaxes by the end of mission of 7 microarcseconds for brighter stars up to $G \sim 13$ in (Gaia-)magnitude. You are interested in stars that have a certain relative precision in their measured parallax, namely you want their uncertainty to be at most 10% of the measured value. How large is the volume your study can then cover? Your answer should be a number.

5 The night sky

You are looking up in the sky to see a more extended source that turns out to be a stellar cluster. You learn that the cluster is 86 pc away from you and you observe it to have apparent magnitude $m_V = 1.8$.

- a. (4 pt)** What is the luminosity of this cluster in the V-band in terms of solar luminosities in the V-band (ignoring any dust)? Give a number.
- b. (2 pt)** A spectrum of one of the stars reveals a Ca line at 855.2 nm is shifted to 855.3 nm. What is the radial velocity of the cluster? Give a number. Also explicitly state if it is moving towards you, or away from you.
- c. (1 pt)** You want to observe this cluster with a telescope. Its coordinates are: 12h 22.5m right ascension and +25 degrees declination. You use the Gratema telescope in Groningen at 53 degrees latitude. How many degrees do you have to tilt the telescope from the zenith to see the cluster?
- (A) 28 degrees
(B) 62 degrees
(C) That depends on the time of the day
(D) That depends on the time of the year
(E) C and D

6 About two main-sequence stars

We are comparing two main sequence stars, Star1 has a solar-like mass, Star2 is twice as massive.

- a. (2 pt)** How long will they stay on the main-sequence, relatively speaking?
- (A) Star1 2 times longer than Star2
(B) Star2 2 times longer than Star1
(C) Star1 4 times longer than Star2
(D) Star2 4 times longer than Star1
(E) Star1 8 times longer than Star2
(F) Star2 8 times longer than Star1

- b. (1 pt)** What would you expect for their colours?
- (A) Star1 redder than Star2
 - (B) Star2 bluer than Star1
 - (C) Both have the same colour as they are both on the main sequence
 - (D) That depends on how long they are on the main sequence already
- c. (1 pt)** What would you expect for their absolute bolometric magnitudes?
- (A) $M_{Star1} = M_{Star2}$
 - (B) $M_{Star1} < M_{Star2}$
 - (C) $M_{Star1} > M_{Star2}$
 - (D) That depends on their distances to us
- d. (1 pt)** What is the main energy source of Star2?
- (A) p-p chain
 - (B) CNO cycle
 - (C) triple-alpha
- e. (2 pt)** If an Earth-like planet would orbit Star2 at 1AU, its period would be:
- (A) 0.6 years
 - (B) 1.7 years
 - (C) 1.4 years
 - (D) 0.7 years
 - (E) 1 year
- f. (1 pt)** These two stars are in a stable binary pair. You can not resolve them with the 1 m ground-based telescope you are using at 550 nm. What would help to resolve these stars?
- (A) Observe them from space
 - (B) Observe at redder wavelengths
 - (C) Go to an 8m telescope on the ground
 - (D) A and B
 - (E) A and C
 - (F) B and C
 - (G) A, B and C

List of constants and conversion factors that may be useful:

Speed of light: $c \approx 3 \times 10^5 \text{ km s}^{-1}$

Solar luminosity: $L_{\odot} = 3.83 \times 10^{33} \text{ erg s}^{-1}$

Solar absolute V-magnitude: $M_{V,\odot} = 4.83$

Solar B - V: $(B-V)_{\odot} = 0.6$

Solar V - I: $(V-I)_{\odot} = 0.72$

Solar mass: $M_{\odot} = 1.99 \times 10^{30} \text{ kg}$

(Current value of) Hubble constant: $H_0 = 70 \text{ km s}^{-1} \text{ Mpc}^{-1}$

Gravitational constant: $G = 6.7 \times 10^{-8} \text{ cm}^3 \text{ g}^{-1} \text{ s}^{-2}$
or $G = 4.3 \times 10^{-3} \text{ km}^2 \text{ pc } M_{\odot}^{-1} \text{ s}^{-2}$

1 Mpc = $3.086 \times 10^{24} \text{ cm}$

$k_B = 1.38 \times 10^{-23} \text{ J/K}$

mass proton $m_p = 1.67 \times 10^{-27} \text{ kg}$

mass electron $m_e = 9.11 \times 10^{-31} \text{ kg}$

1 radian = 206265 arcsec