Department of Physics

Examination paper for FY3215 – Observational Astrophysics
Date: June 3d 2025
Time: 15:00 - 19:00

Course contact: Manuel Linares Alegret / Jordan Simpson
Present at the exam location: YES (17:00-18:00)

Permitted examination support material: C: Specified printed support material is allowed. A specific basic calculator is allowed.

OTHER INFORMATION

Read the questions carefully and make your own assumptions. In your answers, explain clearly what assumptions you have made and how you have understood or limited the assignment

If there are direct errors or omissions in the assignment set and you cannot make your own assumptions, please refer to the information about complaints regarding formal errors on the NTNU website "Explanation of grades and appeals".

SPECIFIC INFORMATION FOR YOUR COURSE

This exam accounts for 50% of the final grade. Total score: 10 points. Official formula sheet provided. Read carefully. Good luck!

No paper drawings:
This exam does not include hand drawings. If you receive hand drawing sheets, this is by mistake. You will not be able to submit the sheets, and they will not be graded.

File upload:
This exam includes drawing tablets.
15 minutes are added for file upload after the test has ended. The time is included in the time shown at the top left of the test, and the time is reserved for file upload. That means that you cannot work with your assignment during this time.

Withdrawing from the exam:
If you wish to submit a blank test/withdraw from the exam for another reason, go to the menu in the top right-hand corner and click "Submit blank". This cannot be undone, even if the test is still open.

Access to your answers:
After the exam, you can find your answers under previous tests in Inspera. Be aware that it may take a working day until any hand-written material is available in "previous tests".

Students will find the examination results in Studentweb. Please contact the department if you have questions about your results. The Examinations Office will not be able to answer this.

Problem 1 [2 points]. Stars and blackbody radiation.

a. Assuming the Sun is well approximated by a T=5780 K blackbody, at which photon frequency is its surface brightness (or spectral energy flux density at Earth) maximum? To which wavelength does that correspond? [0.5 p]

b. Star 1 is 11.3 times more luminous than star 2. The effective temperature of star 1 is 1.4 times higher than that of star 2. Using Stefan-Boltzmann's law, give the ratio of their radii, R_1/R_2. [0.5 p]

c. Derive the Rayleigh-Jeans limit for low photon frequencies from the blackbody spectrum,

$$B_\nu(T) = \frac{2h\nu^3}{c^2}\frac{1}{e^{\frac{h\nu}{kT}}-1},$$

giving an approximate expression for $B_\nu(T)$. [1 p]

Problem 2 [2 points]. Absolute magnitude, distance modulus, distance and extinction.

a. Define absolute magnitude and parsec. [0.5]

b. Derive the relation between distance modulus and distance (in parsecs), using the inverse square law [0.5 p]

A type Ia supernova occurs when an accreting white dwarf reaches its maximum mass and explodes.

c. At maximum light, the brightest type Ia supernovae are known to have an absolute visual magnitude of M_V= -19.60. A type Ia supernova in the *Kanelbolle* galaxy is measured to have an apparent visual magnitude (at maximum light) of m_V=13.25. Calculate the distance to the *Kanelbolle* galaxy (give your answer in megaparsecs, Mpc). [0.5 p]

d. Recalculate the distance to the *Kanelbolle* galaxy, if the dust in the line of sight absorbs 1.5 magnitudes in the V band. [0.5 p]

Problem 3 [2 points]. A 150-mm telescope with f/5 and perfect optics operates from space.

a. Calculate the angular resolution in arcseconds, according to Rayleigh's criterion, if we are observing in the visible band (5500 Å). [0.5 p]

b. What is the corresponding physical size (half-width at zero intensity, in micrometers) of a point source at the focal plane? [0.5 p]

c. What should be the pixel size of a CCD at the focal plane so that the image is not undersampled? [0.5 p]

d. Discuss and quantify how the angular resolution would change if the same telescope is used from Trondheim. [0.5 p]

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Question 4 [1 point]. Calculate the radial velocity of a star if its observed Balmer H-alpha line is centered at a wavelength of 6552 Å (rest wavelength 6562.87 Å). What is the minimum dimensionless spectral resolution (R) needed to measure this redshift?

Question 5 [1 point]. A CCD has a charge transfer efficiency of "three nines" (0.999), and 2048 pixels on each side.

a. Describe the read-out process. How many charge transfers are needed to move charge across one pixel? [0.5 p]
b. What fraction of the charge stored in the pixel that is most distant from the serial register is read out? [0.5 p]

Question 6 [1 point]. Explain how we can measure photon energy using:

a. an X-ray CCD. [0.5 p]
b. an optical CCD. [0.5 p]

Question 7 [1 point]. Draw and define briefly the following astronomical coordinates (including reference points/planes):

a. Altitude. [0.25 p]
b. Azimuth. [0.25 p]
c. Right Ascension. [0.25 p]
d. Declination. [0.25 p]