Stars and Galaxies

Observational Techniques Workshop 4

1) The Sun has an apparent visual magnitude of -26.75. *(i)* Calculate its absolute visual magnitude; *(ii)* Calculate its magnitude at the distance of Alpha Centauri (1.3 pc); *(iii)* The Palomar Sky Survey is complete to magnitudes as faint as $V = 19$. How far away, in parsecs, would a star identical to the Sun have to be in order to be just detected on this data?

2) A nearby star is 5^{th} magnitude, but undergoes an outburst where it (instantly) increases in brightness by a factor of 20. What is its peak magnitude? It then fades by 0.3 magnitudes per day. How bright it is after 2 days?

3) Give two reasons why most modern telescopes are reflectors rather than refractors.

4) Name three types of telescope focus and give an advantage of each.

5) You are trying to detect the doppler shift of a star caused by an Earth-like planet. This requires a very stable spectrohraph and extremely high spectral resolution. At which telescope focus would you recommend putting the instrument, and why?

6) Write down four reasons why optical and infrared astronomical observatories are often located at remote, high altitude sites.

7) The Cassegrain focus of the 4.2m William Hershel Telescope on La Palma has a focal ratio of f/11. What is the field of view of the telescope if the detector size is 5×5 cm? What is the plate scale in arcsecs/pixel if the detector has 4096×4096 pixels?

8) Calculate the focal ratio of a 8.00 m telescope which has a plate scale of 2.34 arcsec mm^{-1}.

9) For a 2.5 m telescope with an f-ratio of f/10, what is the effective focal length? Determine the plate scale in arcseconds per millimetre for this telescope?

10) What type of observations is a Schmidt telescope used for? How are its optics different from a conventional telescope?

11) Show that the aparant magnitude of an object, m_{corr} is related to the observed magnitude, m_{obs} via $m_{\text{corr}} = m_{\text{obs}} - A_\lambda(z = 0)\sec(z)$ where z is the zenith distance, $\text{A}_\lambda(z = 0)$ is the absorption coefficient at wavelength λ and at a zenith distance $z = 0$ the airmass is unity.

12) Give four ways that noise in an astronomical CCD image can be minimised.

13) Explain how the dark current, sky background and variations in the sensitivity of a CCD from pixel to pixel (flat fielding) are measured and corrected for in an astronomical image.

14) A 10^{th} magnitude calibration star gives a count rate of 100 photons/second (after corrections for the various noise sources). What is the zero-point magnitude?

15) Using the zero point magnitude and count rate from Q.14, find the ratio of the signal-to-noise ratios for these two stars for the following cases: (a) photon noise limited and (b) sky background limited.

16) Briefly describe the functions of the entrance slit and collimator in a simple transmission grating spectrograph.

17) The condition for constructive interference is $n\lambda = d\sin\theta$. Define the terms in this expression. Derive an expression for the reciprocal linear dispersion, $d\lambda \,/\, dx$.

18) A spectrograph mounted on a 8-meter telescope uses a reflection grating with 600 lines / mm. Due to mechanical constraints, the mimimum angle between the camera and the collimator is 30° (i.e. the sum of the incident and reflected angles is 30°). If a first order spectrum is observed, what is the maximum wavelength that can be observed?

19) What is the absolute magnitude of a star measured to have apparent magnitude, $m = 9.5$, and an annual parallax of $p = 0.5$ arcsec?

20) Why must a radio telescope be much larger than optical telescopes to achieve moderate angular resolution on the sky? Calculate the angular resolution of a radio telescope of diameter 26 m (a single dish on the VLA) working at a wavelength of 6 cm.

21) What is the advantage of combining radio signals from two well separated radio telescopes observing the same source at the same time?

22) Explain the term "aperture synthesis"

23) Why do X-ray telescopes have very long focal lengths? Why do the images of galaxies appear different in X-rays compared to those at UV, optical, infrared and radio wavelengths?

24) In a telescope system, how is radiation detected in the sub-mm regime? For blackbody radiation, what temperature are observations at 500μm sensitive to?

25) Define the terms coherence length, coherent time and isoplanatic patch as they relate to the atmosphere.

26) Discuss two ways that observations can be made to be diffraction limited.

27) The European Extremely Large Telescope (E-ELT) will have a primary mirror that is 39 m across. Show that the effective power of a telescope operating at the diffraction limit scales at D^4. Discuss one science goal that E-ELT will address that is not possible with current technology.