

Exercises Astronomical Observing Techniques, Set 11

14 November 2012

Exercise 1

- a) WYFFOS is the multi-object, wide-field, fibre spectrograph working at the Prime focus of the 4.2m WHT telescope. At a wavelength of 500 nm the resolving power is (R) is 2200. Calculate the spectral resolution element ($\Delta\lambda$) for this instrument.
- b) How many pixels should be used (along the spectral axis) to properly sample this spectrum from 450 to 550 nm?

Exercise 2

- a) A square grating of 5 cm has 40 grooves per mm. Calculate the maximum resolving power obtainable at a wavelength of 500 nm, using the second order ($m=2$).
- b) Calculate the wavelengths for constructive interference, using an incidence (i) and diffraction (i') angle of 30° and -30° respectively.
- c) In order to increase the efficiency at a specific order a blazed grating is used (having the same properties described above, except those mentioned below). The angle of incidence and diffraction (i and i'), are both 30° which is also equal to the blaze angle (θ_B). Calculate the blaze wavelength (λ_b) associated with the order $m = 50$.

Exercise 3

Spectroscopy can be used to detect molecular gas lines.

- a) How can you determine the strength of an emission line?
- b) What kind of information can you derive from these lines? Name at least three different kinds.
- c) Why would we want high resolution (small velocity resolution elements) for low signal spectra? How do you improve the S/N?
- d) When is a line a significant detection?

Exercise 4

TU Bootis is a binary with a period of 8 hours. You want to measure the absolute radial velocities by spectroscopy. The masses of the two stars are 1.1 and 0.44 M_{sun} respectively.

- a) Rewrite the Doppler equation (for small velocities) $\Delta\nu = \nu_0 \frac{v}{c}$ to a wavelength equation.
- b) With Kepler's laws, the velocities and masses of a binary system are related by:

$$\frac{m_1}{m_2} = \frac{v_2}{v_1} \quad (1)$$

$$m_1 + m_2 = \frac{P}{2\pi G}(v_1 + v_2)^3 \quad (2)$$

Calculate the radial velocities of the two stars.

- c) What is the minimal resolving power necessary to measure the velocities of the binary?
- d) The Intermediate Dispersion Spectrograph (IDS) at the Isaac Newton Telescope has a dispersion of $0.31 \cdot 10^{-10}$ m per pixel at 460 nm. Is this sufficient for this binary?
- e) How would you plan this project? What observations do you need and how would you analyze them? Describe in 5-10 lines.