Astronomical Observing Techniques 2013: Spectrographs (Due on 26 November 2013 at 11:15)

November 19, 2013

1 Multi-Object Spectrograph

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 ($\Delta\lambda$) in nm for this instrument.

b) How many pixels should be used (along the spectral axis) to properly sample this spectrum from 450 to 550 nm?

2 Grating Performance

a) A square grating of 5 cm has 40 groves per mm. Calculate the maximum resolving power obtainable at 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. Hint: use the grating equation.

c) In order to increase the efficiency at a specific order a blazed grating is used (having the same properties described above, except for 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 $m = 50$.

3 Radial Velocity Measurements

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) $\Delta\nu = \nu_0 \frac{v}{c}$ in terms of wavelength.
b) With Kepler's laws, the velocities and masses of a binary system are related by:

$$\frac{m_1}{m_2} = \frac{v_2}{v_1} \tag{1}$$

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

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.