Exercises Astronomical Observing Techniques, Set 12

Exercise 1

A famous astronomer proposes a Fourier Transform Spectrometer to fly aboard the next Mars mission to take very high resolution spectra of the minerals in the Martian soil. The instrument shall have a spectral resoluton of R = 500,000 and operate around a wavelength of $\lambda = 10\mu$m.
a) Discuss whether or not this is a realistic proposal.

After long negotiations, ESA finally agreed to an FTS with a resolution of R = 100,000 working at $\lambda = 1.0 - 1.1\mu$m.
b) Let k_m be the highest wave number contained in the source spectrum. What step size Δx should be chosen for the moveable mirror so that the interferogram is sufficiently sampled at all wavelengths?

c) While it will take considerable time to get a full $\lambda = 1.0 - 1.1\mu$m spectrum at R = 100,000, the S/N will be substantially higher than with a simple monochromator. How large is the multiplex gain (Fellgett advantage)?

Exercise 2

Compare the angular dispersion of a 600 lines per mm grating at 400 nm and 900 nm. Assume m=1 and an angle of incidence of 25 degrees.

Exercise 3

A very simple spectrograph has a transmission grating with 1000 lines per mm and a detector with 1936×2592 pixels of 1.75 microns and a focal length of 3.85 mm. The angle of incidence is 17.3 degrees and the camera is stuck parallel to the grating.
a) Where does the wavelength range of 400 nm to 650 nm end up on the detector if you want to image the slit as well?

b) We are not using a collimator in this design. What effect does this have on the resolution. Calculate the resolution (delta lambda in nm) this set up if the slit is 0.5 mm wide and at a distance of 73 mm. The entrance aperture is 1.783 mm.