

A525 - Problem Set # 3

September 29, 2008

Due: October 8, 2008

The homework assignments will be used as part of your final grade. Please work on this problem set by yourself.

1. A grism is a grating and a prism combined. Let the prism have an apex angle, α . The other part of the grism is a transmission grating with line spacing D . Light is incident normal to one face of the prism, goes through the prism and strikes the grating, which is infinitesimally close to the other surface of the prism. Let $n_g(\lambda)$ be the index of refraction of the prism.
 - a) Derive a relation between angular deviation of light as a function of wavelength and order.
 - b) Show that there is a wavelength, λ_c , that which goes through the grism undeviated by finding λ_c in terms of the parameters given above.
2. We wish to design a high resolution echelle spectrograph for a 30 meter telescope which will operate at a spectral resolution of 100,000 at $0.6 \mu\text{m}$ with a $0.5''$ slit, sampled at four points per resolution element. The array detector has $18.5 \mu\text{m}$ pixels. The spectrometer will operate with the $f/10$ secondary (final focal ratio for the telescope), operates from 0.5 to $1.0 \mu\text{m}$, and uses a $\tan \alpha = 2$ echelle.
 - a) What must be the $f/\#$ of the camera which illuminates the detector?
 - b) What must the projected size of the echelle be? Does the spectral purity or chromatic resolution limit the system resolution?
 - c) What is the focal length of the primary for the echelle stage assuming it acts as both the collimator and camera?
 - d) Determine the groove spacing for the echelle and justify it.
 - e) What is the angular range off the disperse light off the echelle (that is, for the longest order)?
 - f) What must the resolution of the predisperser (order sorter) be? If the predisperser is a grating, what size grating is required?
 - g) Assuming the collimator for the predisperser directly collimates the light from the telescope, what is its size and focal length? What is the size of the entrance slit to the predisperser?
 - h) What is the size and focal length of the predisperser camera, assuming it feeds light to the echelle stage? What are the limits to the size of the echelle entrance slit?
 - i) What are the dimensions (in pixels) of the detector needed to cover the spectrum?
 - j) Make a rough sketch of an optical system which satisfies the above criteria. Adjust the spacing of the optical elements to allow the Lyot stop to be at a convenient location for baffling. Indicate where the Lyot stop will be in your sketch. Don't forget to include the entrance slit to the spectrometer and the detector focal plane.