Astronomy 3130 – Spring 2017
Pre-lab 5 – Build yourself a spectrograph

On or near the optical table in the infrared lab you will find a continuum light source, a diffraction grating on a stand, two lenses on mounts, and a box to serve as a screen. Track down a TA and under their supervision and advice use these components to build a simple grating spectrograph.

Lay the system out one step at a time beginning with the light source.

1) You first need to produce a collimated beam from the point source (rays impinging on a dispersing element should be parallel).

- As a starting point you should determine the focal length of the lens you will use as the collimator (one of the two lenses is physically bigger than the other, think about which will serve better as the camera lens in particular).

- A point source of light serving as an object one focal length away from a lens will produce an image at infinity and thus collimated light.

- Knowing the focal length of your collimating lens will thus give you an idea of how far the light source needs to be placed from the lens.

- The property of a collimated beam is that it maintains its diameter regardless of distance downstream. In a dark room you can see the size of the beam across the room. Adjust the source lens distance until you get the appropriately sized beam. Make sure the point source is on the optical axis of the lens (and thus on a line perpendicular to it) in order to avoid aberrations.

2) Place the grating: In a dark room the scattered light from the collimated beam is bright enough to be seen on the surface of the grating. Place the grating some distance away from the collimating lens (enough to make room for the camera lens further downstream). Don’t worry about the rotation of the grating for now, but set it so that the grating is roughly perpendicular to the incident collimated beam.

3) Place the camera lens:

- As with the collimator lens, estimate the focal length of the camera lens before setting it in place. The “screen” on which the spectrum gets focused will be about one focal length away from the lens since collimated light mimics light coming from a source infinitely far away.

- The camera lens focuses the reflected light coming from the grating. If the grating were a mirror then the camera lens would simply make an image of the light source. In fact, when changing grating angle you will soon observe the 0\textsuperscript{th} order “spectrum" which is nothing but an image of the source itself because the 0\textsuperscript{th} order is produced by the grating acting as if it were a mirror (all wavelengths reflect at the same angle). Finding 0\textsuperscript{th} order is a good way to find if you have good alignment of the optics because the image should be sharp and not suffer from significant aberration.
• The camera lens should be located near the collimator lens (to minimize the angle of the reflection off of the grating) and should be offset enough so as not to interfere with the beam transmitted through the collimator on its way to the grating.

• As with the collimator the camera lens should be perpendicular to the line between the center of the lens and the collimated spot on the grating.

Focus the screen: Use the white box as a screen, move the screen around until you get a good focus across the spectrum. Rotate the grating in place to find $0^{\text{th}}$ order and $1^{\text{st}}$ and $2^{\text{nd}}$ order on either side of the $0^{\text{th}}$ order image. Which side/order is brighter (the grating “blaze” will preferentially divert light into one or two of the orders)?

What to report

Make a sketch of your spectrometer layout. Label the sketch with distances for each component. Estimate the angle of reflection off of the grating.

Estimate the dispersion in Angstroms/millimeter of the second order spectrum.

For reference, below is an example of a grating spectrograph (with a rather complex camera lens).