Spectroscopy

This grating spectrometer is classic in design and still in wide use today. The spectrometer consists of a *collimator* on the left, a telescope on the right, and a diffraction grating mounted on a rotating table called a *goniometer* (see Figure 1).
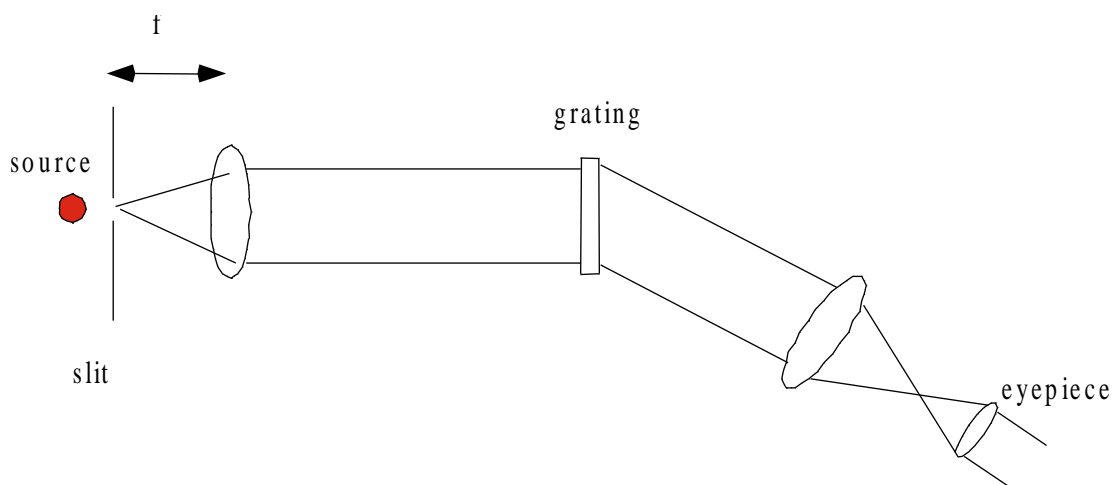

Figure 1. Schematic of the spectrometer, showing the collimator, the telescope, and the grating.

The angle of diffraction is described by the grating equation,

$$\sin\theta_{inc} + \sin\theta_{diff} = \frac{m\lambda}{d} \quad,$$

(1)

where *m* is an integer called the *order*, *d* is the line spacing (or *pitch*) of the grating, λ is the wavelength, and   are angles of incidence and diffraction, measured from the normal to the grating.

Study the instrument carefully and see how it works. In particular, note how the slit opens and closes, and see if you can figure out how to use the *vernier* scale on the divided circle; this scale allows you to interpolate accurately between ticks on the main scale. To focus the collimator and the telescope, twist the 2 lenses. Adjust the collimator so that the slit is focused to infinity; in practice, twist the collimating lens so that it is as far out as possible. Focus the eyepiece on the crosshairs and then focus the telescope on the slit. Devise a method for aligning the grating perpendicular to the incident light beam.

We have 2 sources: helium and sodium. The sodium lamp, in particular, takes a long time to warm up, so turn it on immediately.

Suggestions:

1.Explain the formation of the line images that you see in the telescope.

2.Measure as many different spectral lines as possible, calculate the wavelengths, and compare with known wavelengths. Estimate the standard uncertainty of a typical measurement. Does it depend on the order of diffraction? Estimate the standard uncertainty that results when the diffraction grating is not installed perfectly perpendicularly to the collimated beam. Can you devise a scheme to align the grating correctly?

3.Look at the sodium yellow line with the slit very nearly closed. (If the slit is dirty, fold a piece of paper and insert it into the slit, close the slit, and slide the paper up and down. Then open the slit and remove the paper.) You should resolve a doublet.   How does the resolution of the system vary with slit width?

4.Measure the wavelengths with an order higher than 1. Compare the calculated wavelengths with those measured in first order. Compare the standard uncertainties.

5.Devise other experiments, such as checking for repeatability.