THE DIFFRACTION GRATING SPECTROMETER

Purpose:

1. To become familiar with the use of a diffraction grating spectrometer
2. To measure the wavelengths of certain lines in the spectrum of the mercury arc lamp.

Apparatus: Spectrometer, grating and holder, mercury arc lamp, sodium lamp (optional), various discharge tubes and accessories.

References:

Discussion: The use of the grating equation

$$N \lambda = d \sin \theta \qquad (1)$$

implies the following experimental conditions:

(i) the spectrometer is in proper adjustment, as specified in Part I
(ii) the grating rulings are parallel to the slit, i.e. , vertical
(iii) the plane of the grating is perpendicular to the axis of the collimator

Angular measurements on the circle must be made with respect to the stationary zero point. A single zero line would enable us to read only to the nearest one-half degree and estimate to a smaller fraction thereof. By means of a vernier, however, it is possible to read with precision to a small fraction of a subdivision on a circle. With the vernier on your instrument , it is possible to read the position of the telescope to the nearest minute. There is, however, the possibility of a slight eccentricity existing between the center of the circle and the center of the vernier scale. This eccentricity error may be made negligible by reading the circle by means of two verniers 180° apart and determining the average reading. The reading of verniers is facilitated by means of two magnifiers attached to a plate covering the circle for the purpose of keeping dust from the engraved scales.

Procedure:

Inspect the spectrometer and identify its parts.
Arrange your data sheet as shown on page 52.

Part I. Adjustment of the Spectrometer

(1) Adjust the grating to satisfy the condition of the grating equation. This is done by placing the telescope in such a position that the image of the slit illuminated by

mercury light is located at the intersection of the cross hairs. Then put the grating into the grating holder so that the grating faces the collimator objective and is as nearly perpendicular to the optical axis as possible.

(2) Adjust the telescope as follows: Place the telescope so that it is in line with the collimator. Focus the eyepiece on the cross hairs, illuminated by the light from the slit, by sliding the eyepiece lens in and out until the cross hairs appear sharpest. Slide the eyepiece back and forth past the best position a number of times, until you are sure that you know what the sharpest image looks like. Next, the *whole eyepiece tube* is moved in and out by rotating the knurled collar until the image of the collimator slit is in focus, i.e., appears clear and sharp. When the adjustments are completely satisfactory there should be no parallax, or relative motion of the cross hairs and slit image as the eye is moved *slightly* to and fro across the eyepiece lens. If there is parallax for small motions of the eye, touch up the last adjustment until parallax disappears. Finally, narrow down the slit as much as possible and set the telescope so that the point of intersection of the cross hairs is symmetrically placed within this very narrow slit image. Record the readings of *both* verniers (A and B) with the telescope in this position. Use the sample data sheet. Now shift the telescope slightly, and again bring back the intersection of the cross hairs to the center of the slit image, and record a second set of vernier readings.

Part II. Wavelengths of the Mercury Lines.

(1) Turn the telescope (approximately 19°) until the bright green mercury line of the first order appears on the cross hairs. Make two independent settings on this line and record your results on the data sheet, always reading both verniers.

(2) Repeat (1) with the first order on the other side of the central image.

(3) Repeat (1) and (2) for all other visible mercury lines, taking only one setting on each side of the central image.

(4) Repeat (1) and (2) for the second order bright green mercury line.

(5) Check for any visible lines in the third order.

Part III. Spectra of Various Elements.

As time permits, examine the spectra of various discharge tubes, including sodium and hydrogen, and record your qualitative observations. Do not measure the wavelengths.

Calculations:

Express all wavelengths in Ångstrom units (1 Å = 10^{-8} cm = 10^{-10} m).

Part II -

From the data of procedures (1), (2) and (3), obtain average values of θ for each of the mercury lines observed in first order.

Using θ as obtained above and the value of the grating spacing obtained from the number of rulings per mm stated on the grating (it should be about 600 rulings/mm), use equation (1) to determine the wavelengths of each of the lines observed in the mercury spectrum.

From the data of procedure (4), again determine the wavelength of the bright green mercury line, now based on the second-order observation.

Compare your results with the accepted wavelengths of mercury lines given below. Tabulate your results along with the accepted values.

Questions to Be Answered in the Report:

1. Compute the longest wavelength for which your grating will form a third-order image.

2. You made two determinations of the wavelength of the bright green mercury line, one based on the first order interference and the other based on the second order interference. Which one do you think is more precise? Explain why.

Wavelengths of Spectral Lines

Mercury

λ(Å)	Color	Intensity
4047	Violet	Very Bright
4078	Violet	Weak
4358	Blue-Violet	Bright
4916	Blue-Green	Weak
5461	Green	Very-Bright
5770	Yellow	Bright
5791	Yellow	Bright

Experiment # 12

Hydrogen

4861	Blue-Green (H_β)	Weak
6563	Red (H_α)	Bright

Sodium

5890	Yellow (D_2)	Bright
5892	Yellow (D_1)	Bright

DATA SHEET

Central Image

Vernier A   Vernier B

________   ________

________   ________

________ Mean ________

1st Order - Hg Green, Right Side

Vernier A   Vernier B

________   ________

________   ________

________ Mean ________

1st Order - Hg Green, Left Side

Vernier A   Vernier B

________   ________

________   ________

________ Mean ________

2nd Order - Hg Green, Right Side

Vernier A   Vernier B

________   ________

________   ________

________ Mean ________

ETC.