The Mercury Spectrum

Introduction

A spectrometer is an instrument used for studying electromagnetic emissions. In this experiment a spectrometer equipped with a diffraction grating is used to identify specific wavelengths from the emission spectrum of mercury, to measure these wavelengths precisely, and to compare them to accepted values.

Procedure

Adjust the diffraction grating so that the normal to its plane makes a small angle α to the incident beam of light. This is shown schematically in Fig. 1. Since $\alpha \approxeq 0$, the angles between the first and zeroth order intensity maxima on either side, θ and θ' respectively, are related to the wavelength λ of the incident light according to [1]

$$\lambda = d\sin(\phi)\ , \tag{1}$$

accurate to first order in α. Here, d is the separation between the slits of the grating, and

$$\phi = \frac{\theta' + \theta}{2} \tag{2}$$

Four visible spectral lines of mercury are depicted in Fig. 2. The accepted values of their wavelengths and color associations are summarized in Table 1. To determine the wavelengths of these spectral lines proceed as follows.

1. Turn on the power supply to which is attached the mecury discharge tube.

Color	Wavelength [nm]
Violet	435.8
green	546.1
yellow–1	577.0
yellow–2	579.1

Table 1: A summary of wavelengths and color associations of the visible spectral lines of mercury, as depicted in Fig. 2.

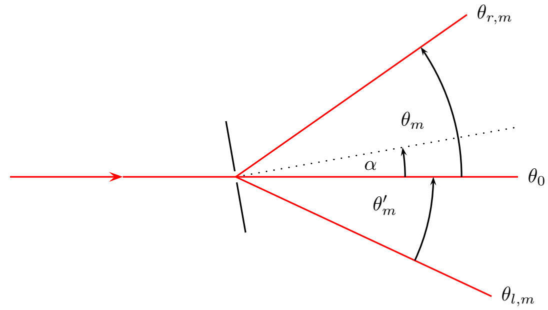

Figure 1: A depiction of the m–th maximum for monochromatic light being dispersed by a diffraction grating. The angle α is the angle the normal to the diffraction grating makes with respect to the incident beam of light. The quantity θ_0 is the angular coordinate of the zeroth order maximum. The quantities $\theta_{l,m}$ and $\theta_{r,m}$ are the angular coordinates of the m–th order maxima to the left and right of the zeroth order maximum.

2. Align the telescope so that the cross hairs in the eyepiece are centered on the light emerging from the collimator tube. Adjust the platform on which the diffraction grating is placed so that the $0°$ marking on the vernier aligns with an angular marking on the scale between the $35°$ and $325°$.[1]

3. Attach the diffraction grating to the platform on the spectrometer.

4. Attach the diffraction grating to the platform on the spectrometer. The normal to the plane of the grating should be aligned with the direction of the beam, i.e. α should be close to zero. If the diffraction grating is positioned properly, the angles θ_m and θ'_m are approximately equal, i.e. they should not differ by more than a degree.

5. Identify the first order maxima of the four visible spectral lines to the left of the collimating tube.

6. Measure the angles of the violet, green, and yellow–2 lines. Report them as θ_l in Table 2. Note: Because of the vernier scale angles can be measured to an accuracy of $.1°$.

7. Perform the corresponding measurements for the first order maxima to the right of the collimating tube and report their values as θ_r.

[1] For some spectrometers, this may not be possible.

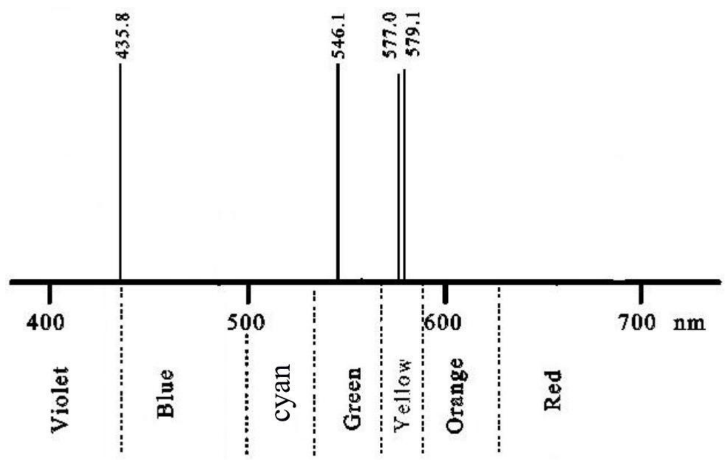

Figure 2: The visible lines of the mercury spectrum are depicted. These lines are denoted, from left to right, violet , green, yellow–1, and yellow–2.

8. Calculate ϕ for each spectral line. According to Fig. 1 one can re-express Eq. 2 as

$$\phi = \frac{|\theta_l - \theta_r|}{2} \, . \tag{3}$$

   Report their values in Table 2.

9. Using Eq. 1 with $d = 1.6667 \times 10^3$ nm, calculate the experimental value of each wavelength and report them in Table 2.

10. Calculate the fractional deviation of each wavelength and report the values in Table 2. The fractional deviation F is defined as

$$F = \frac{|\lambda_{\text{exp}} - \lambda_{\text{accepted}}|}{\lambda_{\text{accepted}}} \, . \tag{4}$$

References

[1] Using the spectrometer.
`http://people.uncw.edu/olszewski/phy102lab/laboratory/spectrometer.pdf`.

	$\theta_{l,1}$ [deg]	$\theta_{r,1}$ [deg]	ϕ_1 [deg]	λ_{exp} [nm]	$\lambda_{\text{accepted}}$ [nm]	F
Violet						
Green						
Yellow–2						

Table 2: Data and Calculations