Boğaziçi University

Introductory Phys Labs

DIFFRACTION GRATING

PHYL 202

THEORY

What is diffraction grating?

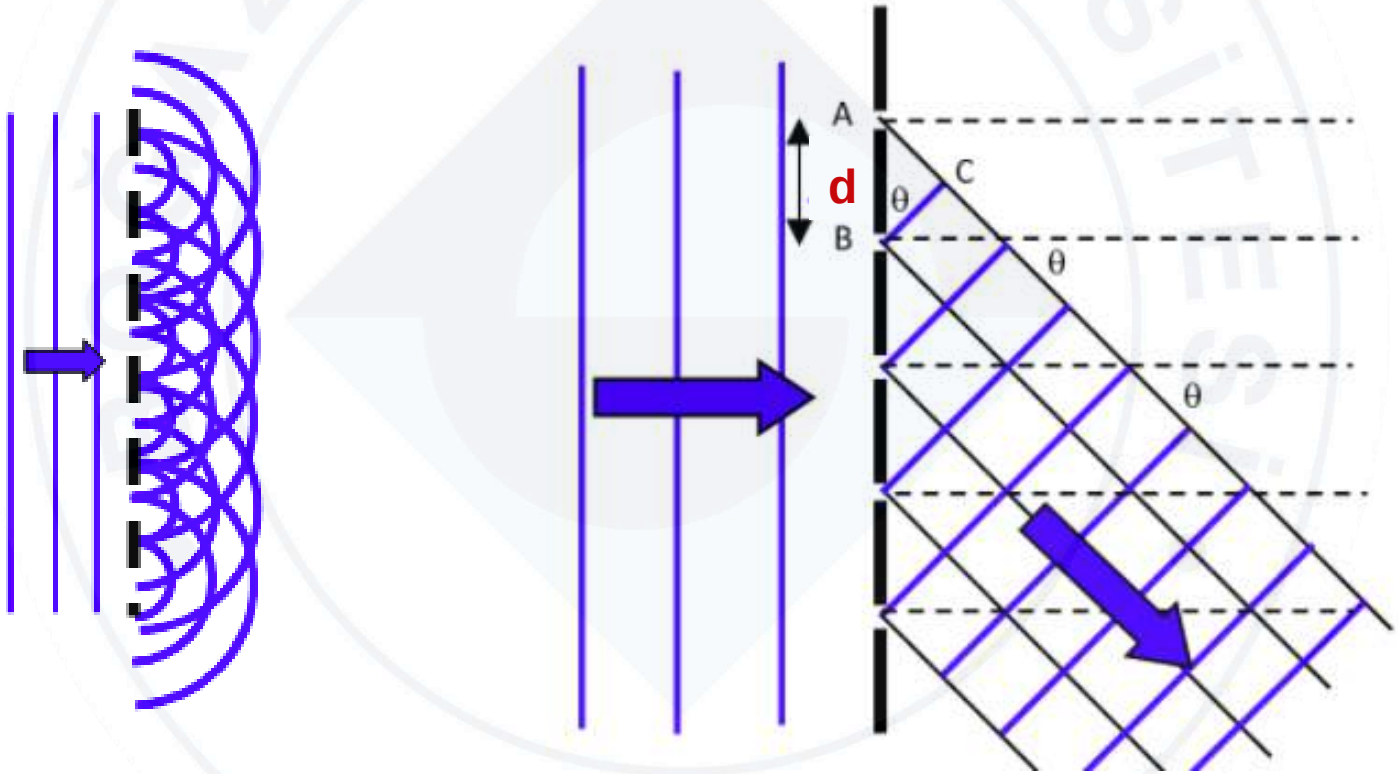
Diffraction grating is an optical device, composed of many equally separated thin slits, that diffracts the incoming light. The angle of diffraction can be determined by the formula

$$m.\lambda = d.\sin\theta$$

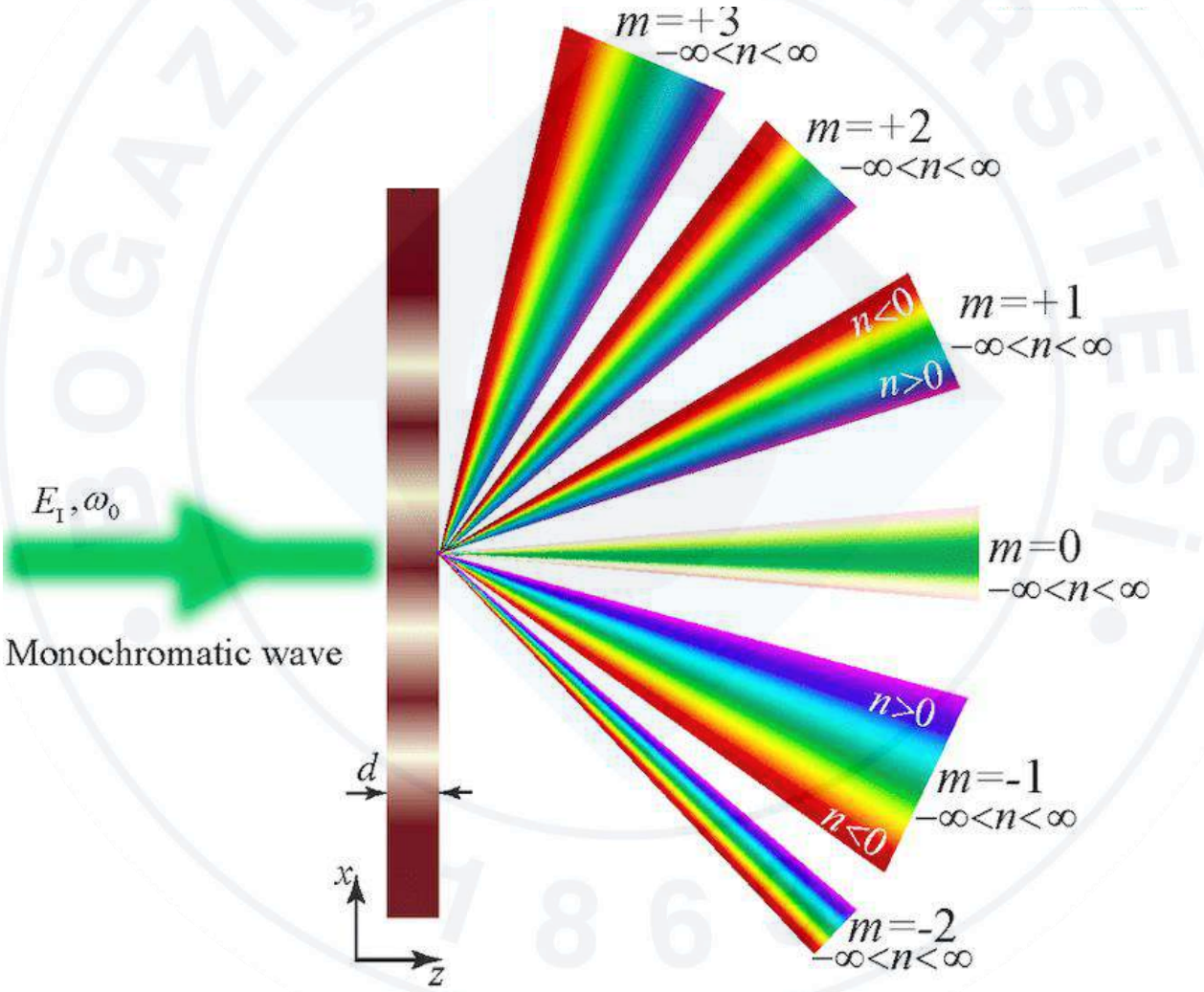
,where

- **d is the separation between successive slits,**
- **λ is the wavelength of incoming light,**
- **m is the order of the spectrum.**

What is diffraction grating?

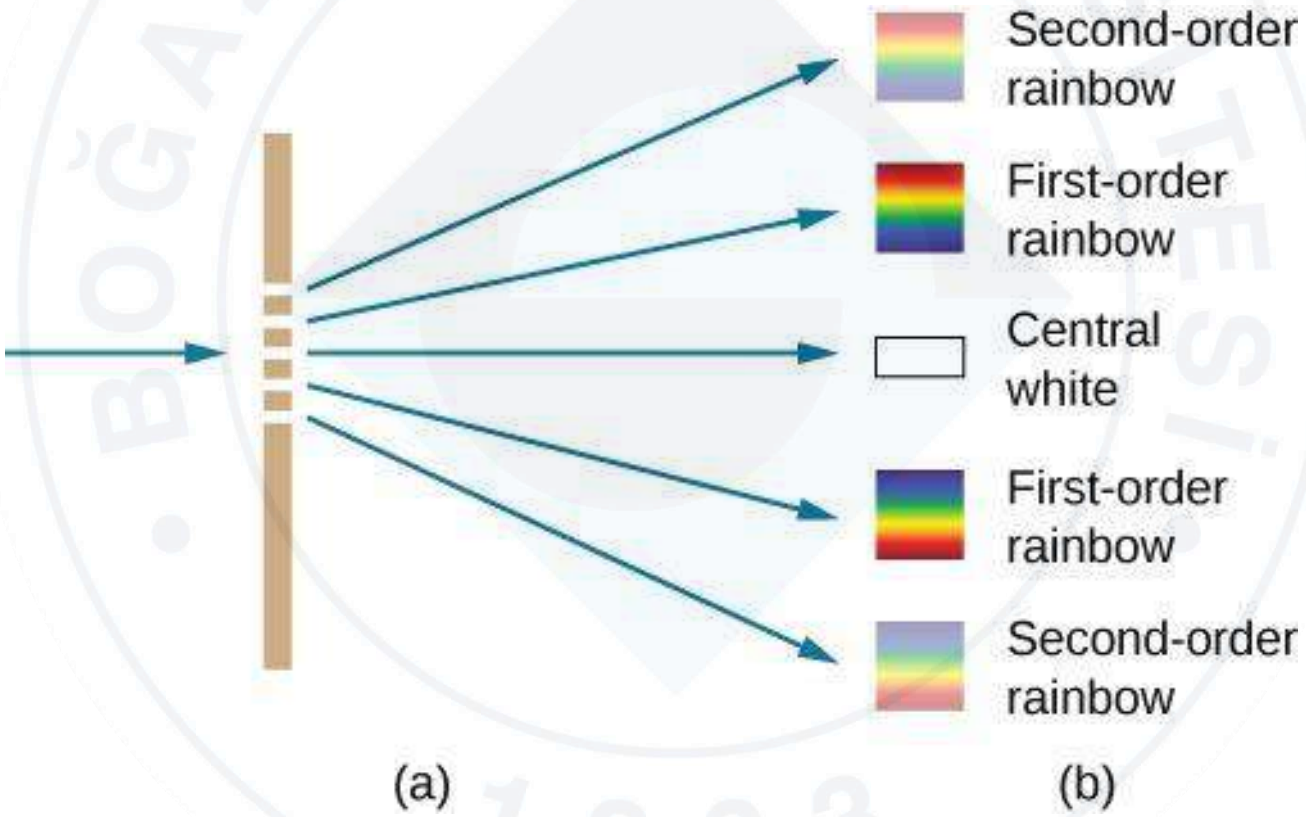


Diffraction of white light:



DIFFRACTION GRATING

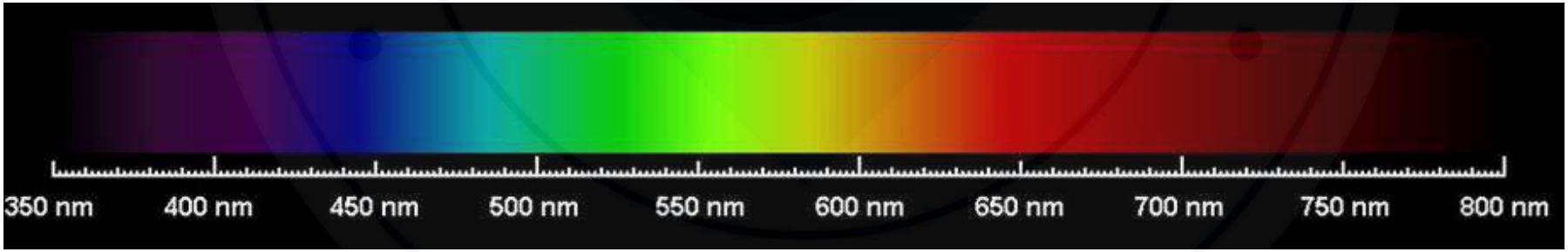
First order (m = 1) diffraction lights are brighter than others. We will use them throughout the experiment.



Emission Spectra

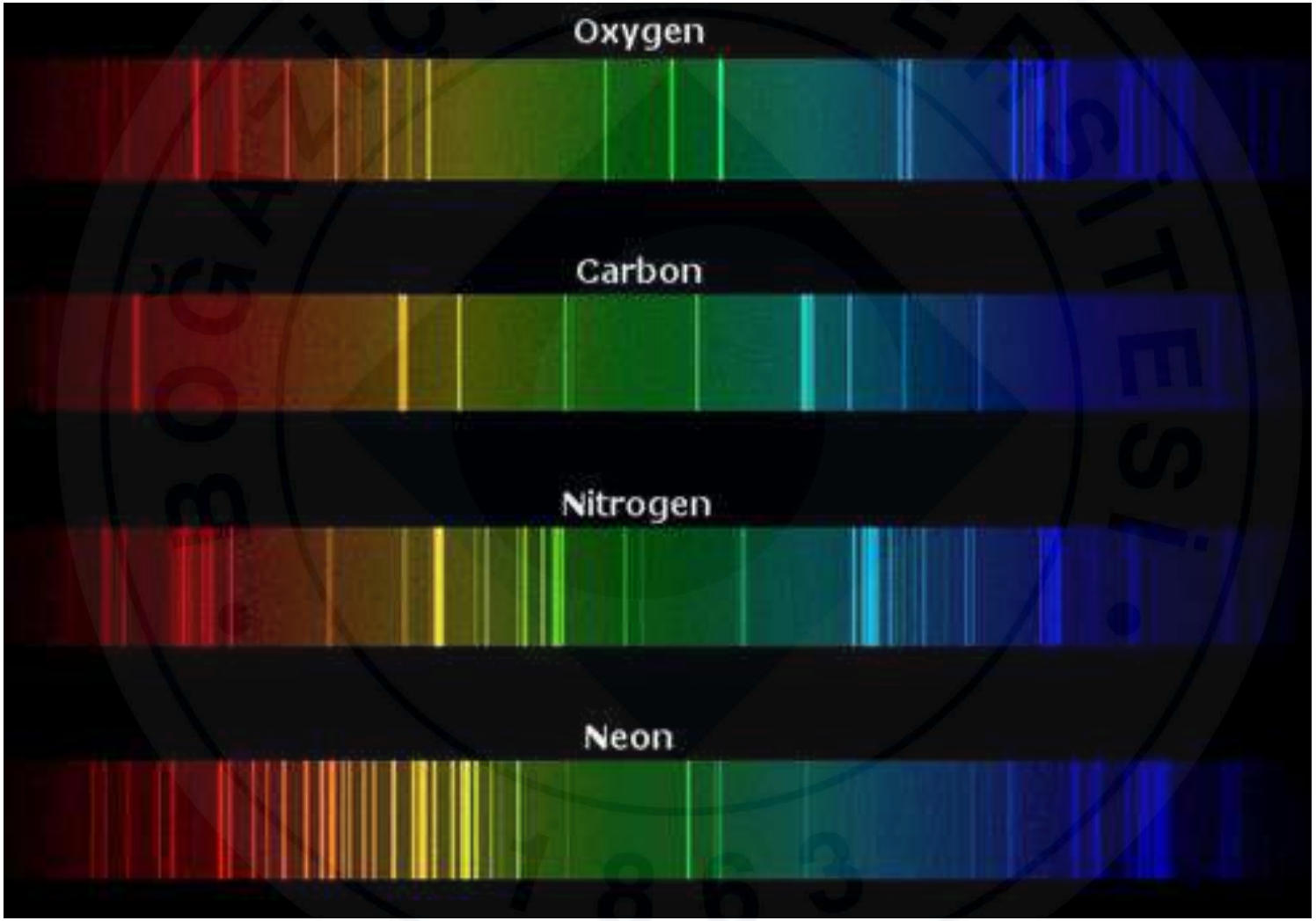
Unlike the continuous spectra of the white light, the emission spectra of atoms have distinct characteristics depending of the atomic structure.

The composition of an object, e.g. a fluorescent lamp or a stellar object, may be determined by observing its emission spectra.



Visible continuous spectrum

Emission spectra of different atoms:

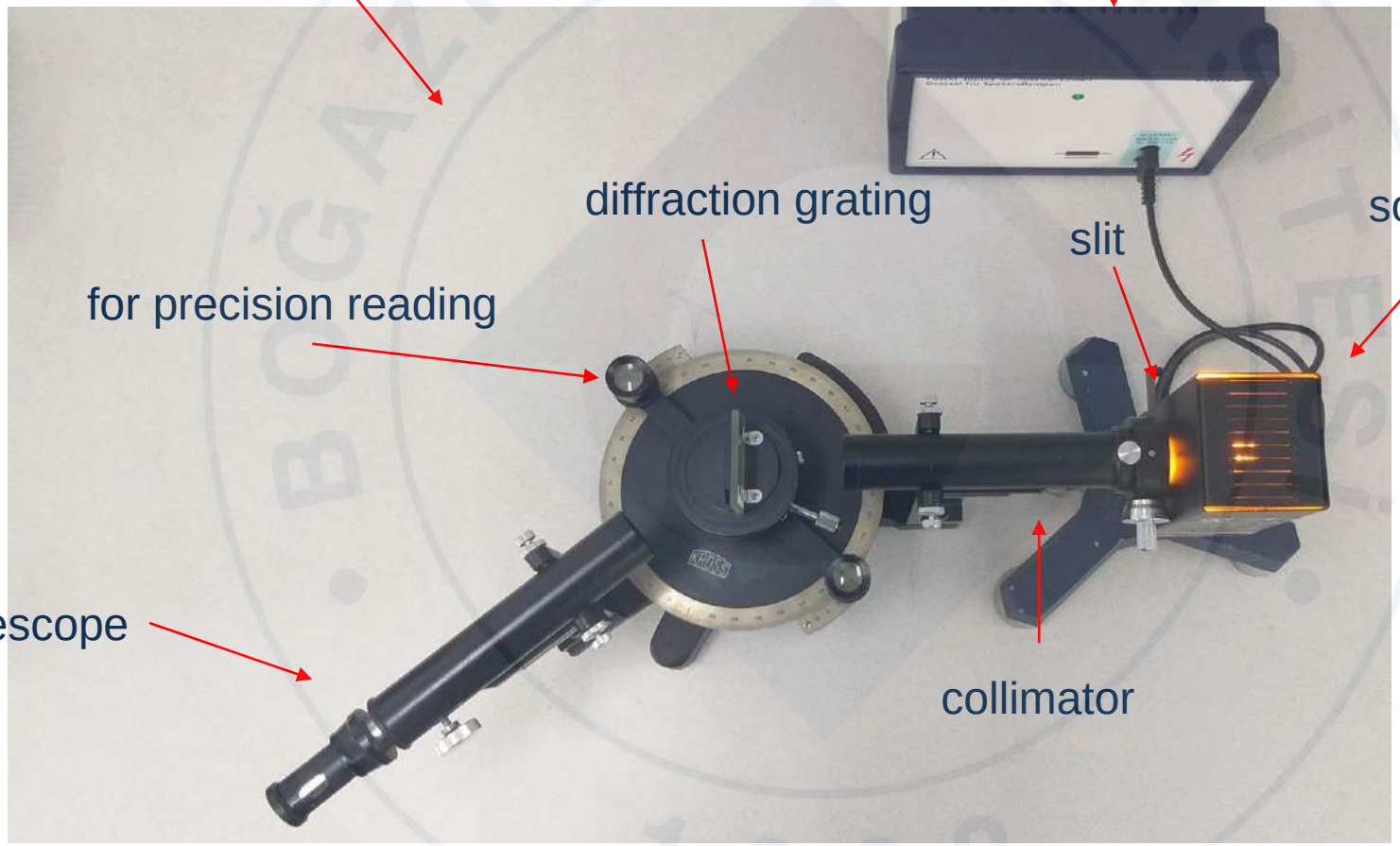


APPARATUS

Spectrometer

Spectrometer is a scientific instrument that measures the spectral components of a physical phenomenon. In this lab, we are using Optical Spectrometers.

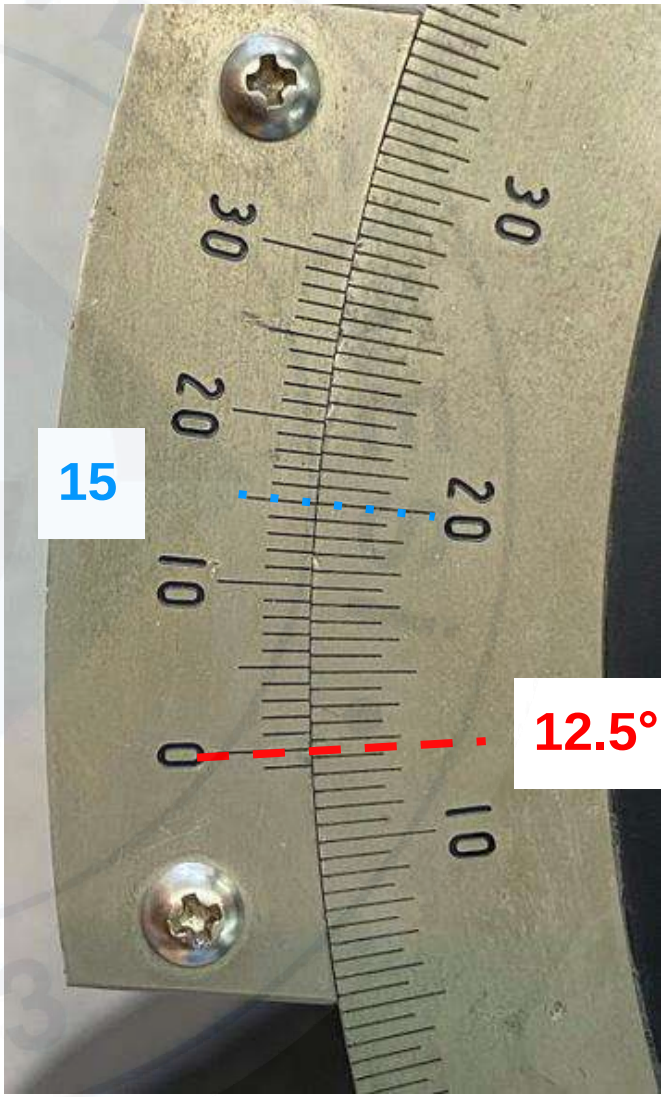
DIFFRACTION GRATING



Reading the Angle:

Find the intersection point of zero value of the outer scale and inner scale. Then, pick the value on the inner scale that intersection point passes. Note this angle value up to 1 significant figure after the decimal point. In this figure the value is 12.5°.

Then, find the line on the outer scale that exactly matches with the line in the inner scale. Read the value from outer scale. In this figure, 15 of the outer scale is the exact match.



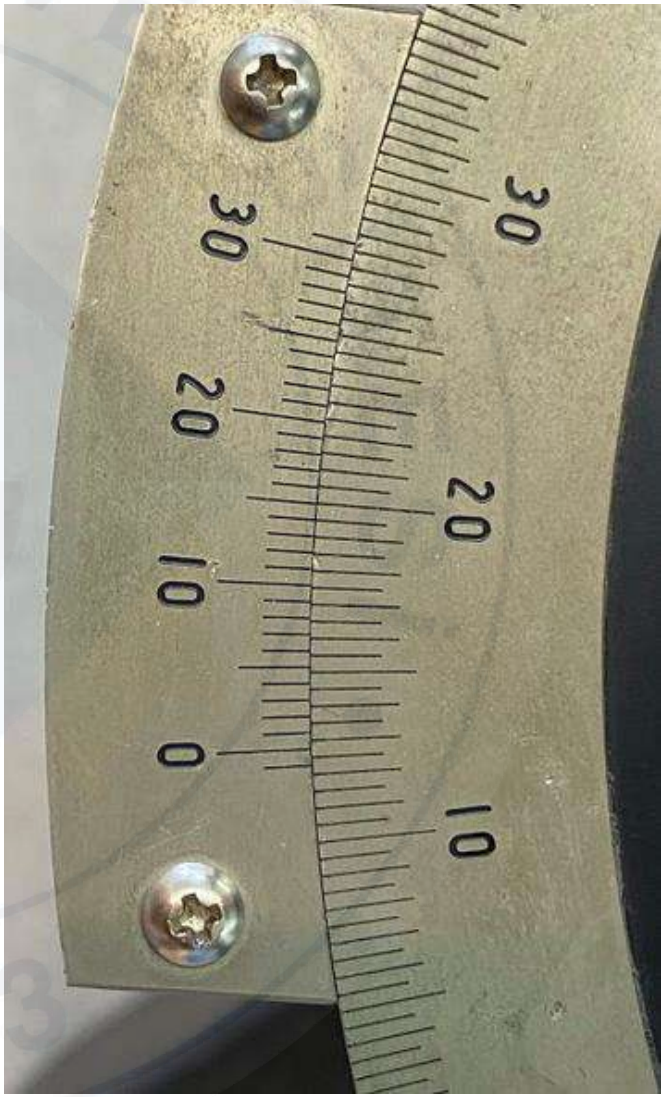
Reading the Angle:

Note this values as 12.5°(15).

The outer scale divides 0.5° to 30 (or 1° to 60). So any reading x from outer scale means x/60 degree angle.

The final reading for this image is

$$12.5° + \frac{15}{60} = 12.75°$$



Angular Dispersion

The angular dispersion is the amount of change of diffraction angle per unit change of the wavelength. It is a measure of the angular separation between beams of adjacent wavelengths.

An expression for the angular dispersion can be derived from the grating equation by differentiating, keeping the angle fixed.

$$D = \frac{d\Theta}{d\lambda} = \frac{\tan\Theta}{\lambda}$$

Angular Dispersion

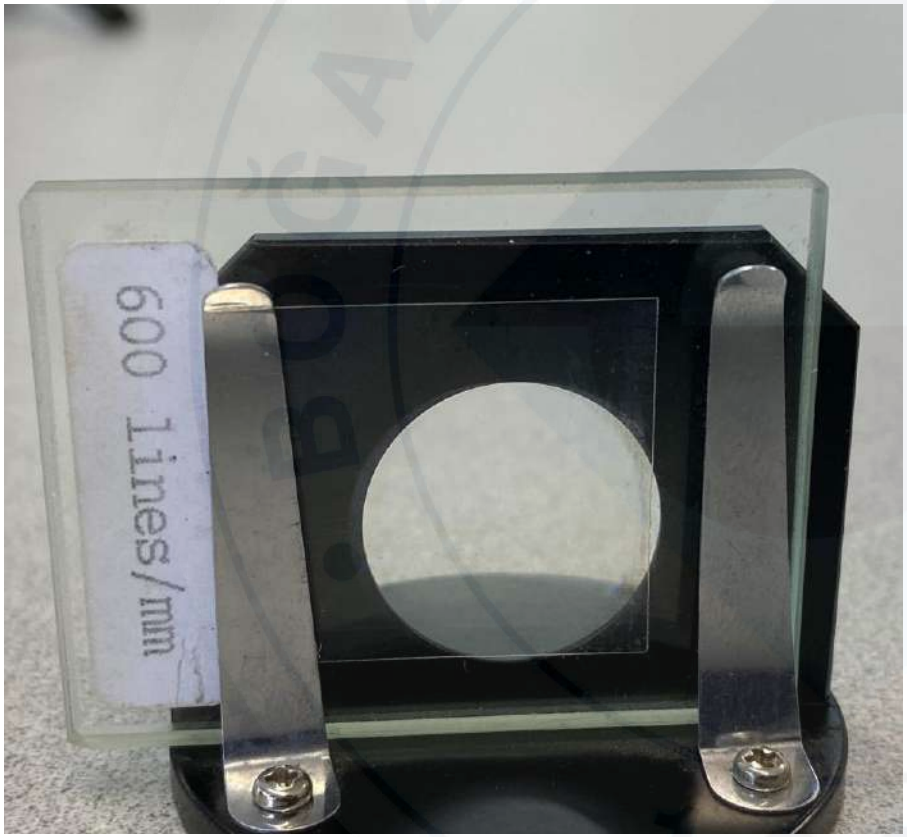
Consider two lines that are nearly equal with wavelengths λ_1 and λ_2 , measured at angles Θ_1 and Θ_2.

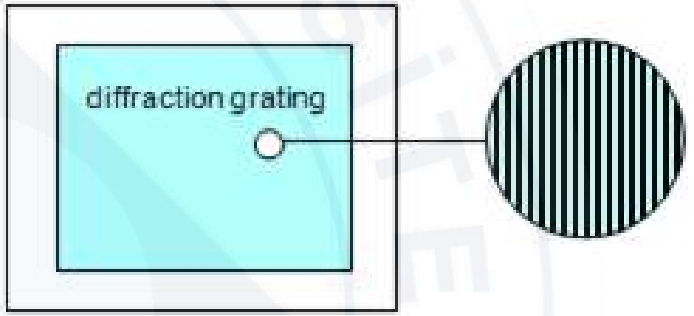
$$\theta_{ave} = \frac{\theta_1 + \theta_2}{2} \qquad \lambda_{ave} = \frac{\lambda_1 + \lambda_2}{2}$$

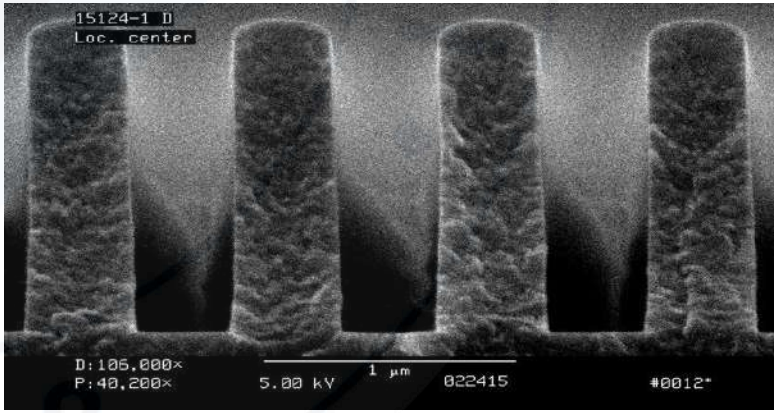
The angular dispersion of the spectrometer can be calculated as

$$D = \frac{\tan\theta_{ave}}{\lambda_{ave}}$$

Diffraction Grating







White Light Source and Sodium Lamp

Unknown Lamps

Setup

White Light Spectrum

View of the white light spectrum from the telescope of the spectrometer.

EXPERIMENT

PART 1

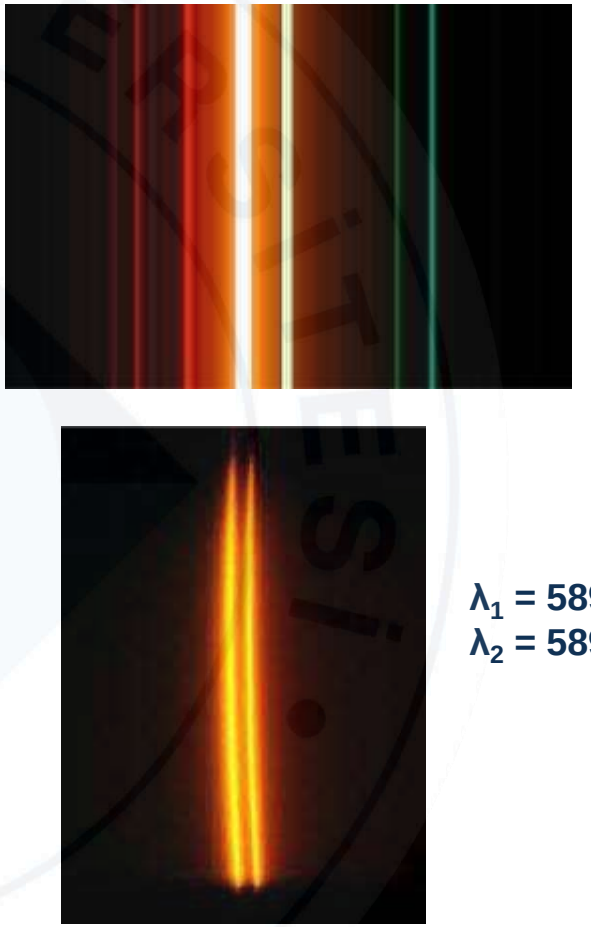
Determination of Diffraction Grating Constant d

THE BALMER LINES OF HYDROGEN

To determine the diffraction grating constant, we need a known wavelength λ and a diffraction angle θ. Sodium lamp is used for this purpose.

Sodium spectrum has two adjacent bright yellow lines with given wavelengths. Use the average. The order of the spectrum is 1. Read left and right angles and take their average.

Using average θ and λ, find the diffraction grating constant d.



λ_1 = 5890 Å
λ_2 = 5895 Å

Sodium emission spectrum doublet

PART I: DETERMINATION OF DIFFRACTION GRATING CONSTANT, *d*

Wavelength of sodium doublet	λ	=	5890 Å and 5895 Å average 5893 Å
Order of the spectrum	m	=	.....
Angle of spectrum line *(Uncalibrated)*	θ_{left}	=	.....
Angle of spectrum line *(Uncalibrated)*	θ_{right}	=	.....
Average angle	θ_{ave}	=	.....
Diffraction Separation	d	=	.....

PART 2

Unknown Discharge Tube

PART II: UNKNOWN DISCHARGE TUBE

Discharge Tube Number : .....

Color	θ_{left} *(uncalibrated)*	θ_{right} *(uncalibrated)*	$\theta_{average}$	λ ( )

For the Part 2, note all emission lines color and (both left and right) angles. Calculate the λ using diffraction constant d from Part 1 and the average angle.

Gas in the Discharge Tube is (*check the appropriate box*) **:**

☐ **Argon**	☐ **Krypton**	☐ **Hydrogen**
☐ **Helium**	☐ **Mercury**	☐ **Neon**

Using the emission spectra of given elements (from the Appendix of Phys 202 Lab Book), determine the type of the fluorescent lamp used in this experiment.

PART 3

Dispersion Measurement

PART III: DISPERSION MEASUREMENT

COLOUR	θ_{left} *(uncalibrated)*	θ_{right} *(uncalibrated)*	$\bar{\theta}$	λ ( )
		AVERAGE		

Take two adjacent lines from Part 2, copy the table with their angles and wavelengths.

DIFFRACTION GRATING

Dispersion of the spectrometer:

$$D = \tan\bar{\theta}_{ave} / \lambda_{ave} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Calculate the angular dispersion of the diffraction grating using average angle and wavelength.

PART 4

White Light Spectrum

PART IV: WHITE LIGHT SPECTRUM

COLOUR	θ_{left} *(uncalibrated)*	θ_{right} *(uncalibrated)*	$\theta_{average}$	λ ( )
Red End				
Violet End				

For the Part 4, read the angles of red/violet ends of white light spectrum from both left and right sides. Then using the average θ and diffraction constant d, calculate the wavelengths.

Limits of the visible range :

..... $< \lambda (\quad) <$ .....

Write the wavelength limits of visible spectrum. Please do not forget the write the unit.

After you finished, select a question from page 105 and answer.