重庆大学-辛辛那提大学联合学院

学生实验报告

CQU-UC Joint Co-op Institute (JCI)
Student Experiment Report

实验课程名称 Experiment Course Name College Physics Experiment II

开课实验室（学院）Laboratory (School) CQU-UC

学院 School JCI 年级专业班 Student Group 2018 ME01

学生姓名 Student Name 易弘睿 学号 Student Number 20186103

学年 Academic Year 2019——2020 学期 Semester Spring

成绩 Grade	
教师签名 Signature of Instructor	

批改说明 Marking instructions:

指导老师请用红色水笔批改，在扣分处标明所扣分数并给出相应理由，在封面的平时成绩处注明成绩。

Supervisors should mark the report with a **red ink pen**. Please write down **the points deducted** for each section when errors arise and specify the corresponding reasons. Please write down **the total grade** in the table on the cover page.

重庆大学-辛辛那提大学联合学院______________________________实验报告

JCI ____ Experiment Report

学院 School____Chongqing University______年级专业班 Student Group__________2018ME01________
姓名 Name________________易弘睿________________ 学号 Student Number________20186103_______
开课学院、实验室 Academic School/ Laboratory____________________CQU-UC____________________
实验时间 Date of Experiment________2020_________年 Year______5______月 Month_____24_____日 Day
报告时间 Date of Report________2020________年 Year_____5_____月 Month______21______日 Day

课程名称 Course Name	College Physics Experiment II	实验项目名称 Experiment Project	Spectrometer and refractive index of glass prism	实验项目类型 Type of experiment project				
				验证 Verification	演示 Presentation	综合 Comprehensive	设计 Design	其他 Others
指导老师 Supervisor	边立功	成绩 Grade				√		

实验目的 Description/Instruction:

1. To understand the structural feature and the design of spectrometer;
2. To understand and master the requirement and method of adjustment;
3. To learn to use the the minimum deviation method to measure the refractive index of glass prism.

原理和设计 Principle and Design:

1. Principle of the lens

The distance from the object to the lens u, the distance from the lens to the image v, and the focal length f are related by:

$$\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$$

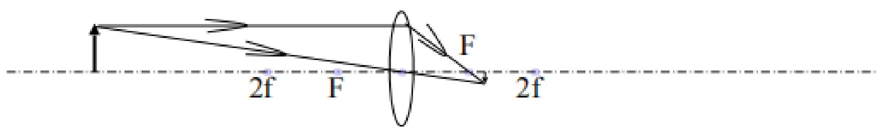


Figure 1: Focus of Lens

Where u > 2f, 2f > v > f, producing inverted, reduced real image.

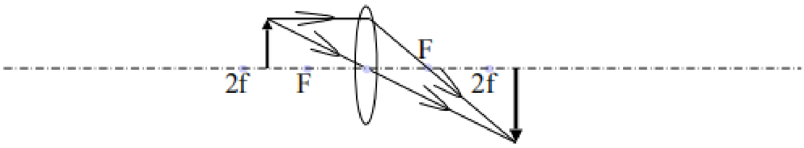


Figure 2: Focus of Lens

Where f < u < 2f, v > 2f, producing inverted, magnified real image.

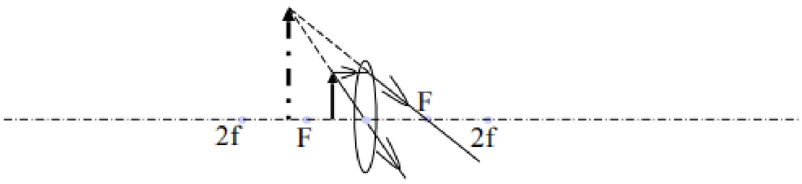


Figure 3: Focus of Lens

Where u < f, v > u, producing erected, magnified virtual image.

2. Principle of the microscope

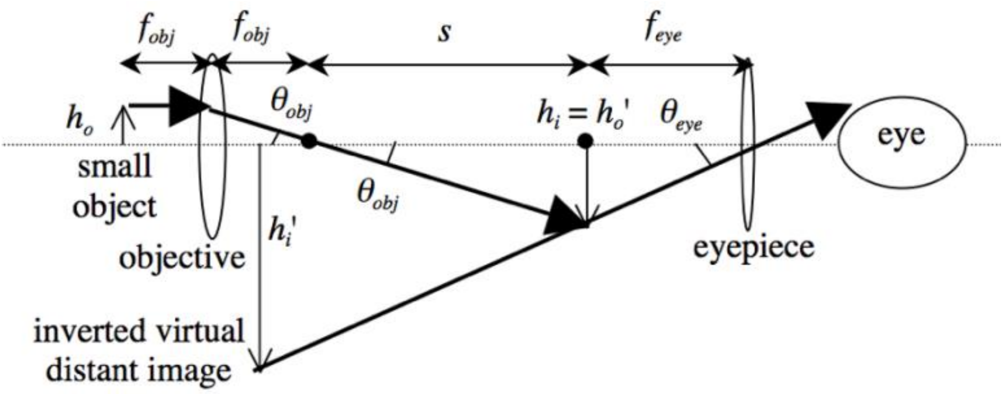


Figure 4: Structure of Microscope

$$M \equiv m_{obj} m_{eye} = \frac{s}{f_{obj}} \frac{n}{f_{eye}} = \frac{(L - f_{obj} - f_{eye})n}{f_{obj} f_{eye}}$$

3. Principle of refraction

When monochromatic light ray crosses from one medium (such as air) to another (such as acrylic), it is refracted. According to Snell's law:

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

The refraction Angle (θ_2) depends on the incident Angle (θ_1) and the refractive index of the two media (n_1 and n_2), as shown in Figure 5. Because the refractive index of light varies with the frequency of light, the white light that enters the material (at an angle other than 0º) will break down into different colors at different bending degrees at each frequency.

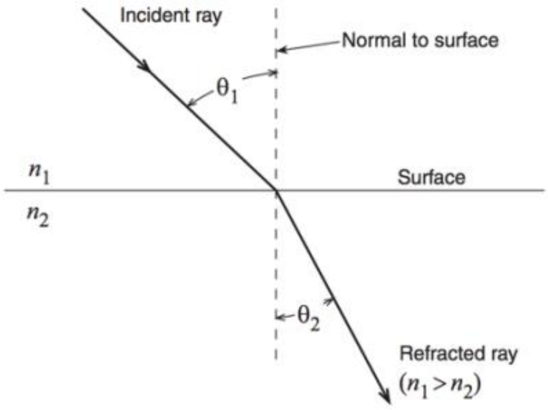


Figure 5: Reflecting of Light

4. Principle of white light and rainbow

White light is made up of all the colors of the rainbow - red, yellow, green, blue, and violet. Different colors correspond to different wavelengths. Human eyes are sensitive to light with wavelengths in the range 390 nm (violet) to 750 nm (red) (1 nm = 10^{-9} m).

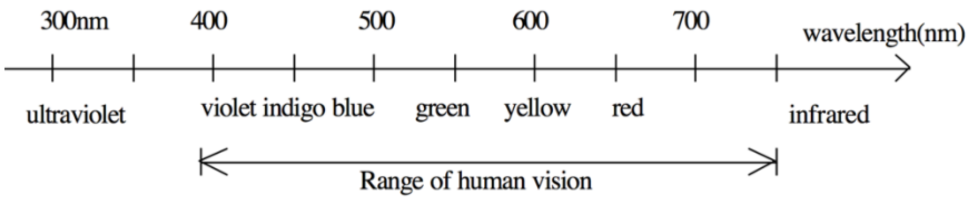


Figure 6: Wavelength of Different Light

5. Principle of prism

Glass has a greater index of refraction at shorter wavelengths, that is, it bends blue light more than red light. So a prism can be used to disperse white light into its component colors.When a ray of light is refracted by a prism, the angle between the incoming and outgoing rays is called the angle of deviation (β). For a given prism and a given wavelength, the value of β depends on the angle between the incoming ray and the surface of the prism. β is minimum when the angles of the incoming and outgoing rays make equal angles with the prism surfaces. In this special symmetric case, the prism's index of refraction (n) is related to β and the apex angle of the prism (α) by the formula:

$$n = \frac{\sin\left(\frac{\alpha + \beta}{2}\right)}{\sin\left(\frac{\alpha}{2}\right)}$$

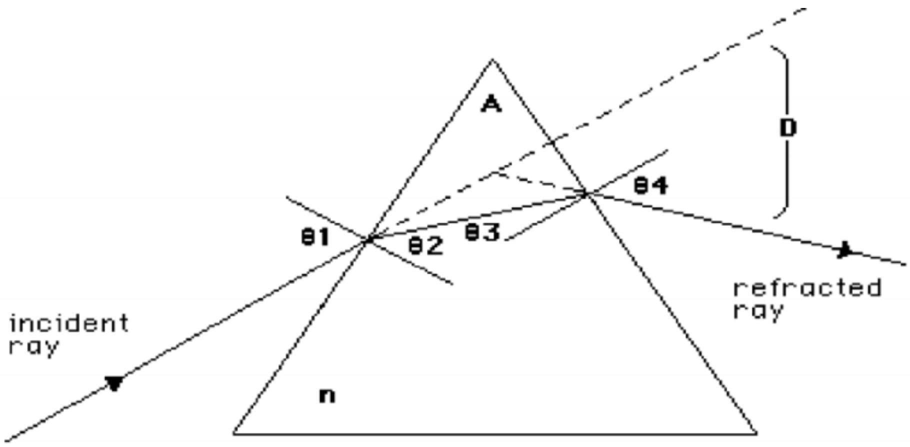


Figure 7: Reflecting of Light in Prism

6. The Cauchy formula

We will use a prism spectrometer to measure the dispersion angle of various wavelengths. From the measurements, we will make a graph of the index of refraction vs. wavelength. The form of the curve of index of refraction as a function of wavelength, known as the Cauchy formula:

$$n = A + {}^{B}/_{\lambda^2} \text{ or } n = A + \left({}^{b}/_{\lambda}\right)^2$$

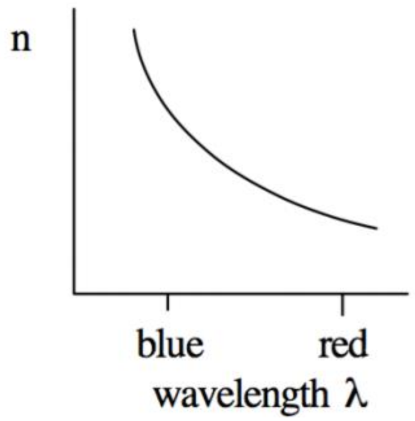


Figure 8: The Cauchy Formula

实验器材 List of instruments and materials:

Spectrometer (with plane mirror and other attachment), prism, sodium lamp, fluorescent lamp.

实验步骤 Implementation:

1. Focusing the eyepiece on the cross-hairs

Pull the eyepiece almost out of the telescope by the ring and insert it slowly until the cross hairs are in focus with the eyes relaxed. In order to avoid eye fatigue the eyepiece should be in focus after the eye has been focused for distance vision.

2. Adjustments of telescope to receive parallel rays

Turn the telescope towards a distant object (e.g. a far off building) and adjust the telescope to see a clear well-defined image of the distant object. If the initial adjustment of the cross hairs was good, the image of the distant object will remain fixed against the image of cross hairs as the eye is moved slightly from side to side.

3. Adjustments of the collimator to provide parallel incident rays

Swing the telescope so that it is aligned with the collimator. There are two knobs under the telescope. One of these is to fix the telescope relative to the collimator and the other for fine alignment of the telescope with respect to the collimator. Note that there is another set of knobs for the prism table. One of them is to fix the prism table at any position and the other is used for finer adjustments. The slit side of the collimator should face the light source. Illuminate the collimator slit with the mercury light source. Make the slit width narrow and bring the slit into sharp focus while viewing through the eyepiece side of the telescope and by adjusting the collimator only. Again use the absence of parallax between the slit image and the cross hairs.

4. Measuring the minimum deflection angle

First, move the cursor to drive the platform, and directly find the image of the slit image formed and the refraction light of the eye (if fluorescent lamp is used, the color is from dispersion). Observe the telescope in this direction, you should see an obvious vertical symmetrical vertical spectral bright line. Select the line to test, change the incidence angle of the vernier disk, and reduce the spectral line of the deflection angle. Move the cursor disk in a small direction, and continue to rotate until it is found that there is a moving spectral line of rotation phenomenon in the field of vision of the telescope, that is, when the incident angle changes to a certain position, and then continues to change, the field of vision of the line no longer moves in the original direction. After a brief pause, it began to move in the opposite direction. Hold the rotation pause position and hold the cursor dial. The micro rotating telescope aligns the longitudinal crosshair with the line to be measured at the turning, and records the two vernier readings at the angle position. This position is the position of the minimum deflection angle corresponding to the outgoing light. Remove the prism, then rotate the telescope to align the collimator, align the longitudinal crosshairs with the slit image, and read the angle position of the incident light. Minimum deviation angle of vernier reading.

实验结果和数据处理 Results and Data processing:

Table 1: Measurement of the Vertex Angle of Prism

Vernier	A_o	A_i	$A = 180° - \|A_o - A_i\|$	A
1	90°35′	270°35′	60°	60°
2	30°8′	150°8′	60°	

Table 2: Measurement of the Minimum Deviation Angle

Vernier	ϕ_o	ϕ_i	$\delta_{min} = \|\phi_o - \phi_i\|$	$\bar{\delta}_{min}$

1	275°28′	326°24′	50°56′	50°55′
2	95°30′	146°24′	50°54′	

Then we calculate the refractive index n:

$n = \frac{sin(A+\delta_{min})}{sin\,A/2}=\frac{sin(60°+50.92°)}{\sin(30°)}=1.647$

Error=$\frac{1.652-1.647}{1.652}$=0.3%

实验讨论 Discussions:

1. Errors

Errors may come from two parts: measurement errors and instruments errors.

①Since the experimental instrument used by the experimenter was old, the fine adjustment knob could not be continuously and uniformly adjusted, so that after replacing the double-sided mirror with the triangular prism, the two optical face crosses could not be aligned at the same time. The experimenter can only measure the instrument again and change it again, resulting in an experimental time that is too long and the experiment is not expected to be completed. Therefore, the above data analysis can only assume that the data is described, and there is no real data support.

②When measuring the minimum deflection angle, no instrument tells us where the turning point is, it can only be estimated by ourselves, but the vernier disk is more accurate. This can lead to errors.

③Other errors may come from instruments, such as aging and abrasion.

2. Question

(1) In the adjustment instrument, when our eyes move up and down and left and right, the bright cross image also moves up and down and left and right at the crosshairs above the reticle. This phenomenon is called parallax. The existence of parallax affects the accuracy of the measurement, how to eliminate the parallax?

A: As a self-aligning telescope, the spectrometer should first adjust the eyepiece first. Look at the cross and the crosshairs, then adjust the eyepiece and the crosshair reticle sleeve to see the image of the cross, and the cross, the cross and the crosshair are coplanar. In this way, the purpose of eliminating parallax is achieved. At the same time, the operator pays attention to keeping the eyes in a relaxed state and controlling the eyes to not focus.

(2)When measuring the angle, the telescope is rotated from 330°00' to 0° to 33°15'. What is the actual angle of the telescope?

A: Going to 30°15' via 0° is equivalent to turning to 360° +30°15' = 390°15', so the angle that the telescope actually turns is:360°+30°15'-330°00' = 60°15'.

(3)Briefly describe the characteristics of the prism spectrum

A: The spectrum obtained by the white light passing through the prism is a colored light band, which is red orange, yellow, green, blue and purple from the top to the bottom, which means that the red light has the smallest refractive index and the bottom side has the least deflection.

(4)Which screws should be adjusted for the telescope to enable parallel light to emit parallel light? How to judge whether the collimator has emitted parallel light?
A: Adjust the pitch knob of the collimator to see the slit image. Adjust the focal length of the

物理实验 原始实验数据记录

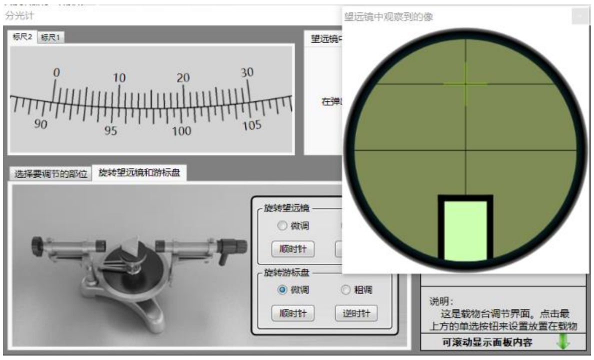
Experiment Data

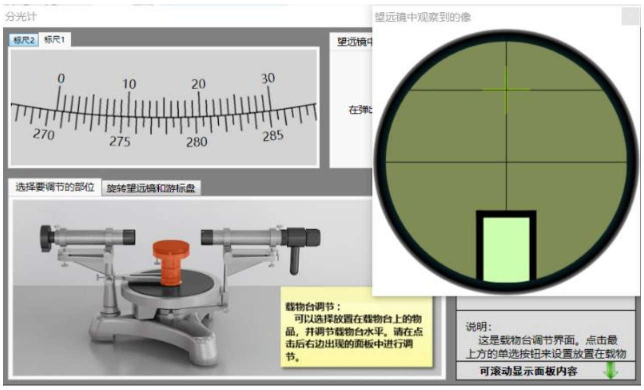
姓名 Name_____易弘睿_____学号 Student Number______20186103______实验时间_2020.5.7_

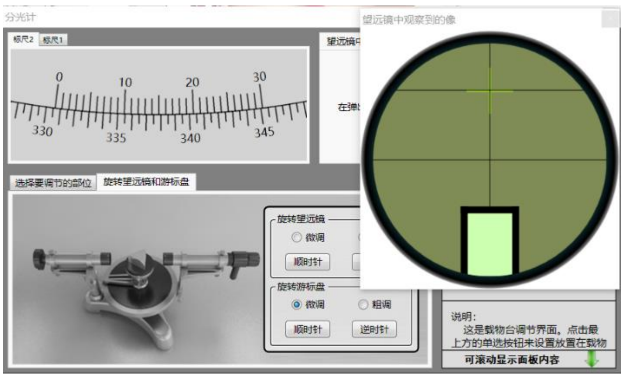
实验名称 Name of experiment: Spectrometer and refractive index of glass prism

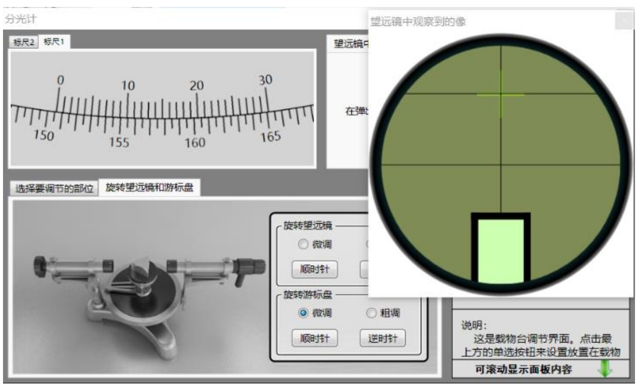
仪器名称	量程	最小量	估读误差	仪器误差	零位误差
Spectrometer	0~360°	1'	1'	1'	
Prism					
Natrium lamp					
Fluorescent Lamp					

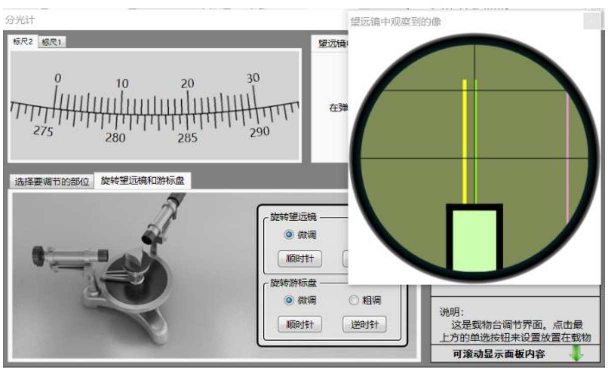
实验数据 Experiment Data （表格自拟）

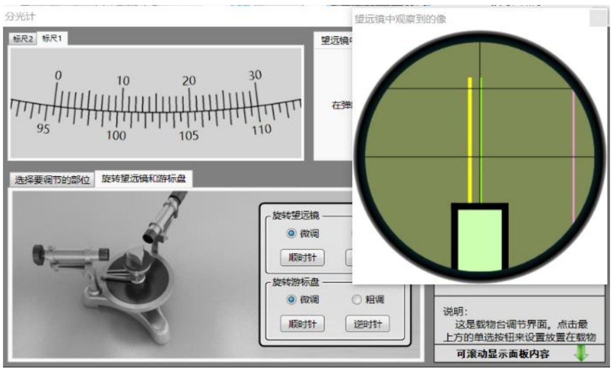


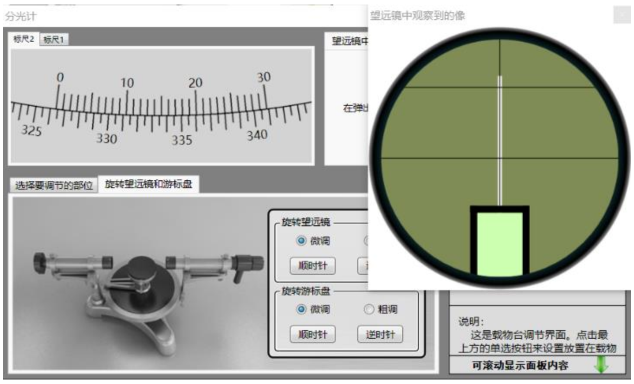


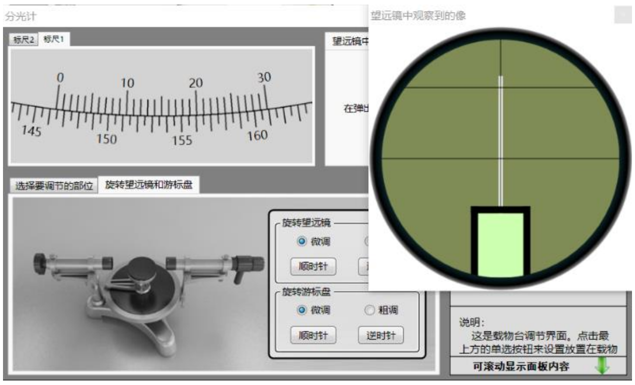












测量三棱镜的顶角及最小偏向角，并计算折射率

测量的三棱镜顶角大小为（单位：度） ____60____

测量的三棱镜最小偏向角大小为（单位: 度） ____50.92____

计算得到三棱镜的折射率为 ____1.647____

指导教师：边立功