Physics 307L

Spring 2021

Prof. Darcy Barron

Updated Schedule

- Schedule of assignment due dates through the end of the semester is now posted on wiki, and will be in Teams soon
  - https://ghz.unm.edu/juniorlab/index.php?title=Schedule_Spring_2021#Course_Schedule
- **First lab report due date is moved back to Wed, March 31**
  - Please ask if you have questions about completing the analysis for the experiment you write about in Lab Report 1
  - Lab report cannot be on Lab 0
  - https://ghz.unm.edu/education/juniorlab_pdfs/labreportguidelines.pdf
- **All students will give Talk 3** during scheduled during final exam time for this class, Friday, May 14 from 12:30pm – 2:30pm
  - This should not conflict with any other scheduled finals, but please let me know if there is a problem

Grades so far

- Grades are completed for 30% of the class so far
  - Includes Labs 1 – 5, Talk 1
  - Lab reports and talks are 50% of final grade
- Sending out individual emails with feedback from Talk 1, and curved grade so far
  - If you don't think your grade reflects the effort you are putting into this class, or are unsure about how to improve, please email me for a meeting
- Reminders
  - Please look at comments and feedback on graded lab notebooks
  - Please refer to Part I of textbook as a reference for basic error analysis
    - "Part I introduces the basic ideas of error analysis as they are needed in a typical first-year, college physics laboratory"
      - Chapter 1: Preliminary Description of Error Analysis
      - Chapter 2: How to Report and Use Uncertainties
      - Chapter 3: Propagation of Uncertainties
      - Chapter 4: Statistical Analysis of Random Uncertainties
      - Chapter 5: The Normal Distribution

Upcoming Schedule

- Everyone has now completed 7 weeks of labs, including
  - Balmer Series
  - Poisson Statistics
  - Speed of Light
- There are 7 lab sections left, to complete 3 longer, advanced labs on your own before the end of the semester
- Acoustic Impedance Spectroscopy and Charge of Electron will be available in April

Challenging Modern Physics experiments

These require independent problem solving – harder than intro physics labs

10 experiments

0) Intro (RC Circuits, the oscilloscope, Chua's Circuit)

1) Speed of Light
2) Poisson Statistics
3) Balmer Series

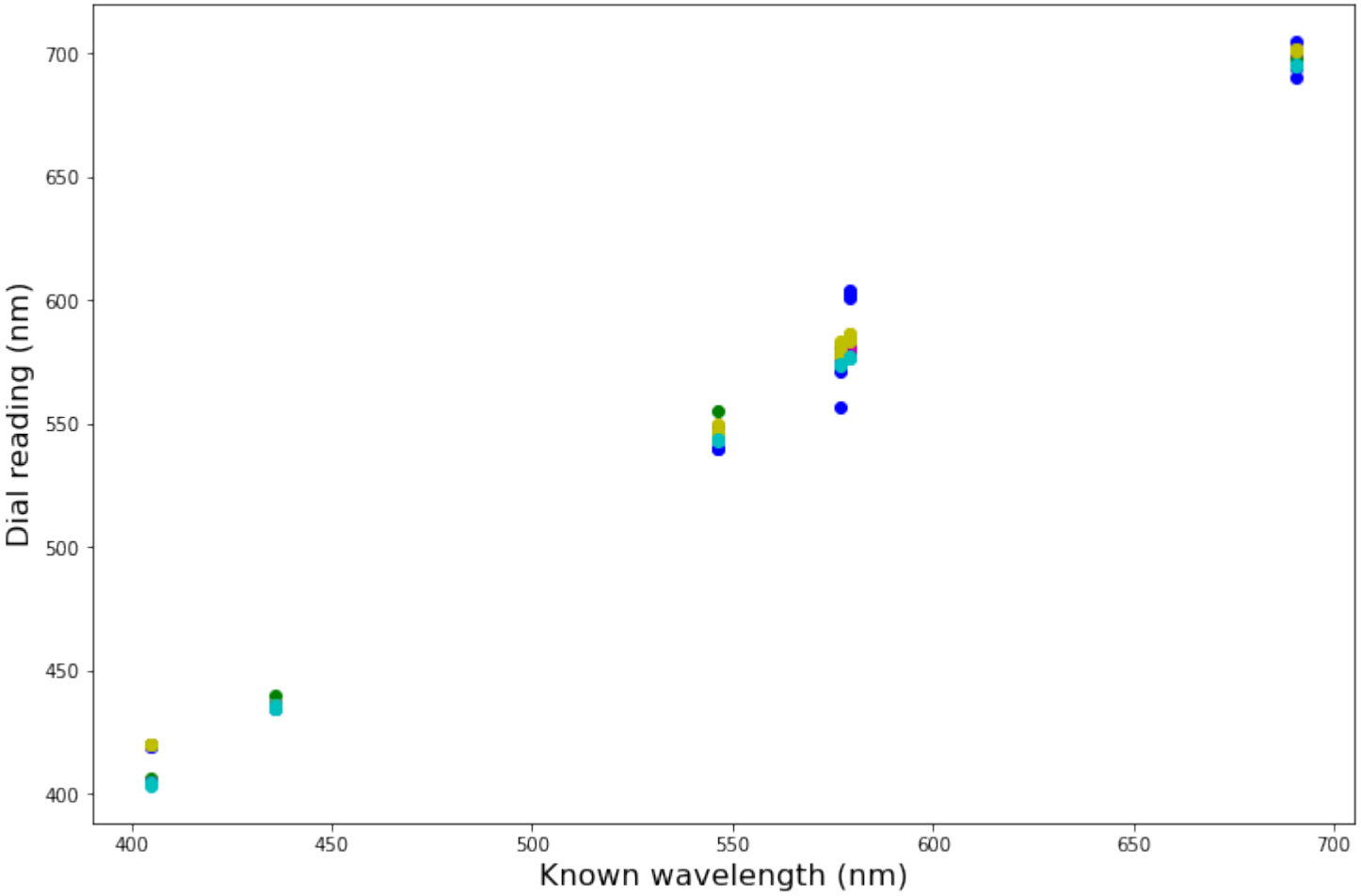
4) Planck's Constant
5) Compton Scattering
6) Electron Diffraction
7) Ratio e/m
8) Franck-Hertz experiment
9) Electron spin resonance
10) Millikan oil drop: electron charge
11) Acoustic Impedance Spectroscopy

Descriptions here: https://ghz.unm.edu/juniorlab/index.php?title=Main_Page

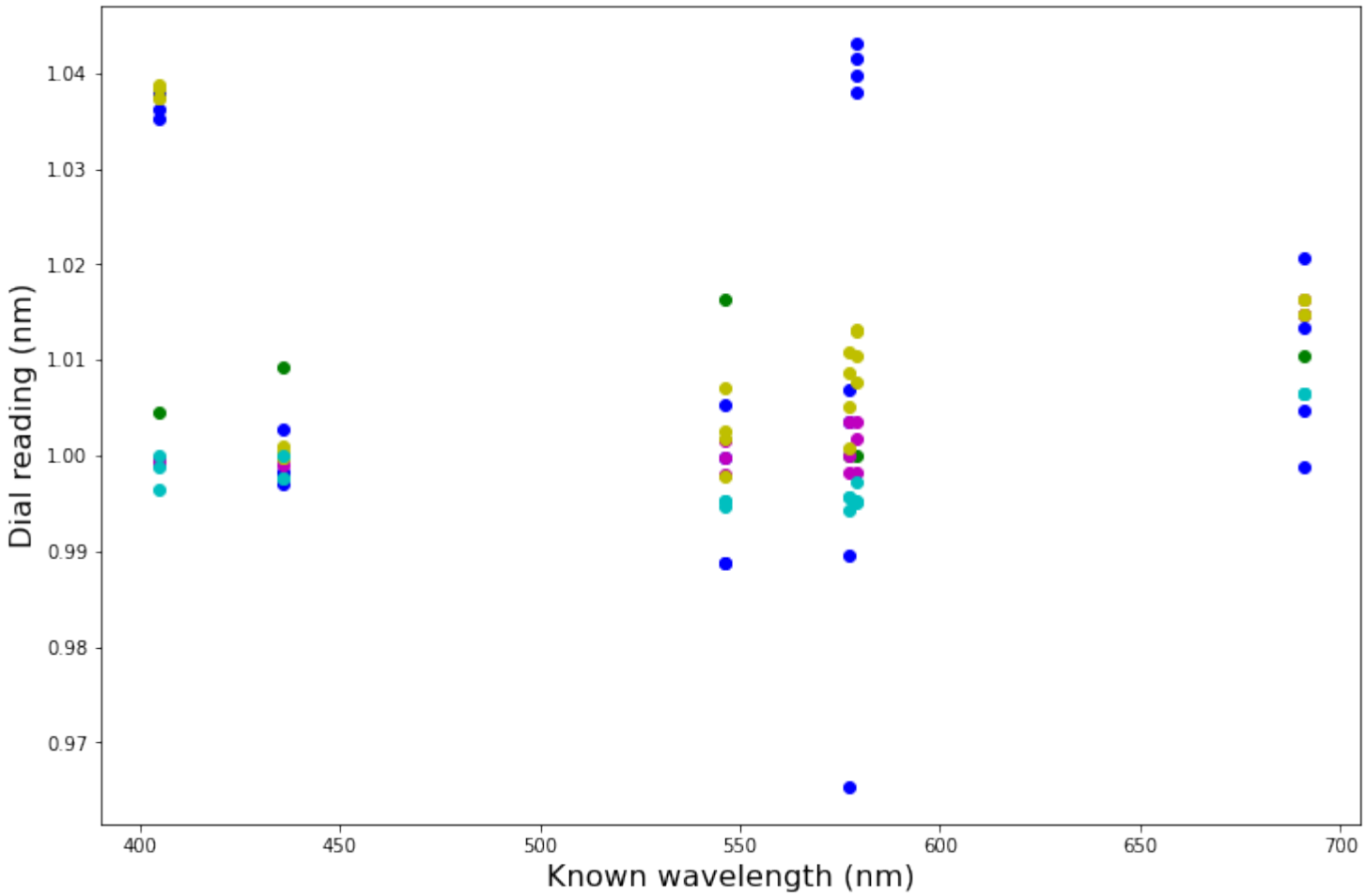
Balmer Series Analysis

- Straightforward steps
  - Estimating uncertainties from equipment
  - Repeating measurements to estimate uncertainty
  - Propagating uncertainties
  - Simple linear fit to data
- More complex steps
  - Rejecting data (Chapter 6 of Taylor)
  - Choosing how to combine separate measurements
  - Least-squares fitting with errors in both dimensions

Rejection of Data



Rejection of Data



Chauvenet's Criterion

- If you make N measurements of a single quantity x, Chauvenet's criterion gives a simple test for deciding whether to reject a 'suspect value'
- $t_{sus} = \frac{|x_{sus} - \bar{x}|}{\sigma_x}$
- $n = N \times Prob(outside\ t_{sus}\sigma)$
  - Use Appendix A to look up values
- If n < 0.5, then it is reasonable to reject x_{sus}

Example

- We make 10 measurements of length, x, and get these results:
  - 46, 48, 44, 38, 45, 47, 58, 44, 45, 43
  - What is the mean of the dataset?
  - What is the standard deviation?
  - What is the suspicious value?
  - What is probability that such an outlier would appear from random chance?

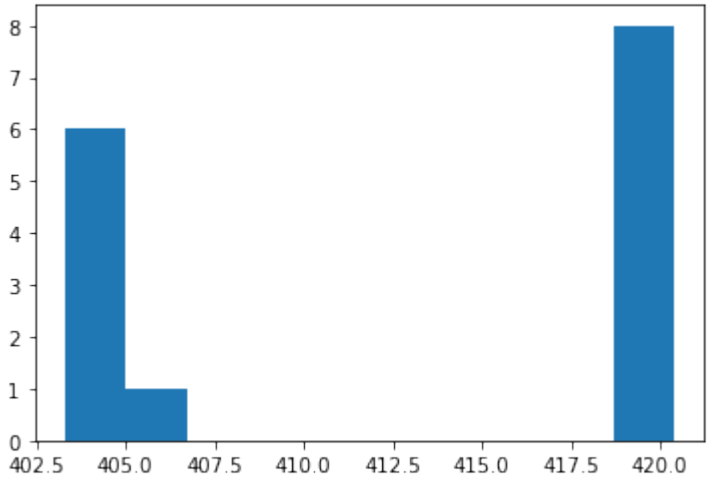
  - https://forms.office.com/Pages/ResponsePage.aspx?id=MJiqJfngK0iJfho7PlVeXAdTM2p7tzFHrUgTnPHg3QZUNFlQWURRNjJHVllRMTBBVFdXTVlSWjJaOS4u

Example 2

- Multiple measurements of second shortest wavelength line of mercury emission
- `[437, 435.0, 435, 434.5, 439.8, 435.4, 435.6, 435.7, 436.2, 435.7, 436.0, 435.7, 435.8, 434.8, 434.8]`
- What is mean? What is standard deviation?
- What value is suspect?
- Should it be thrown out and why?
- https://forms.office.com/Pages/ResponsePage.aspx?id=MJiqJfngK0iJfho7PIVeXAdTM2p7tzFHrUgTnPHg3QZUNlNRNVRNTVlyU0JDRkNSRkNKRUpMSVVKMC4u

Example 3

- We have multiple measurements of the shortest wavelength mercury line
- `[420, 419.4, 420, 419.0, 406.5, 404.5, 404.5, 404.4, 419.8, 420.2, 420.4, 419.8, 404.7, 403.3, 404.2]`

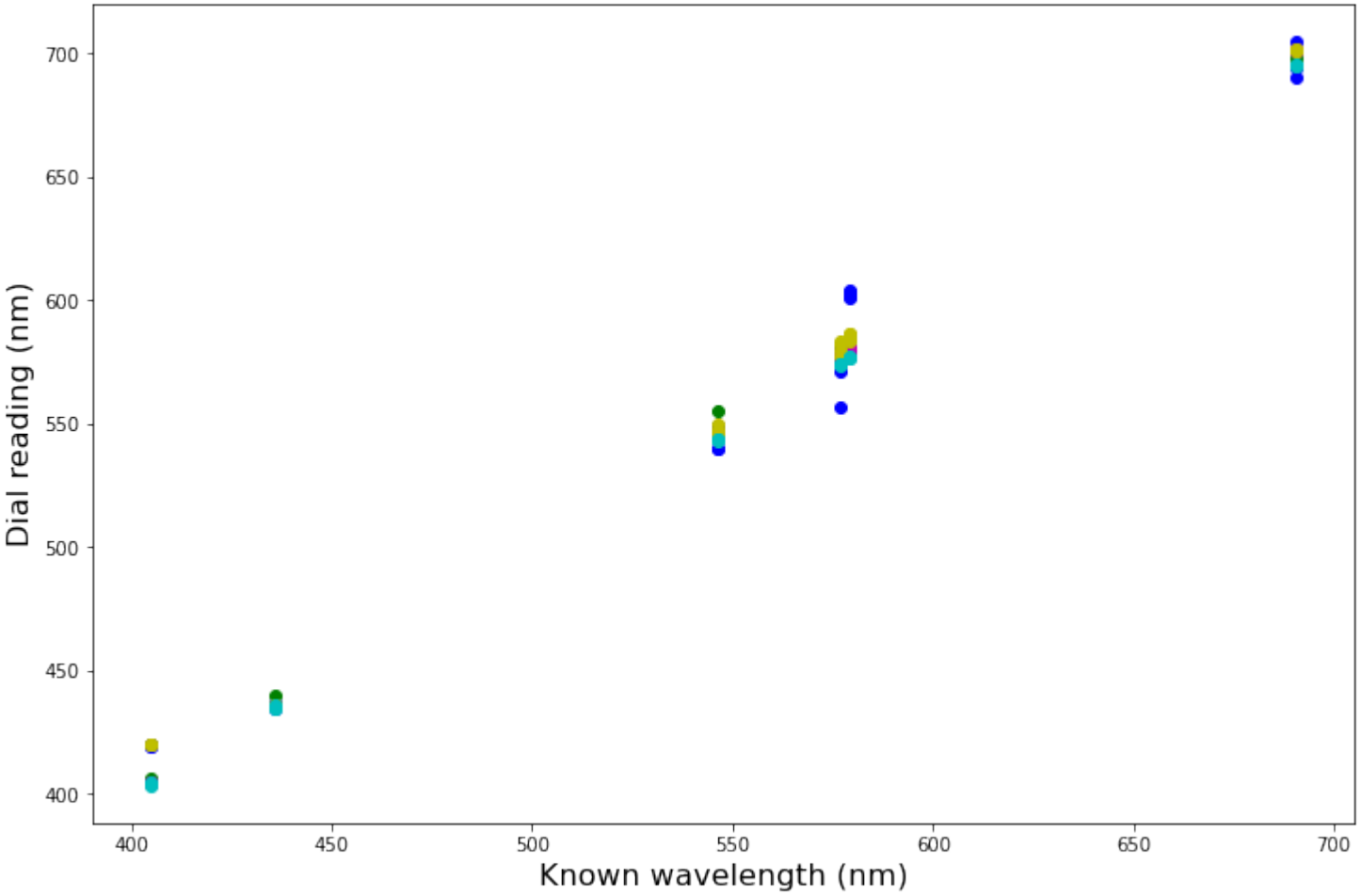


https://forms.office.com/Pages/ResponsePage.aspx?id=MJiqJfngK0iJfho7PIVeXAdTM2p7tzFHrUgTnPHg3QZUOEFUSElLUkdZTVdPNTRFQ09WWUtSWEtTMC4u

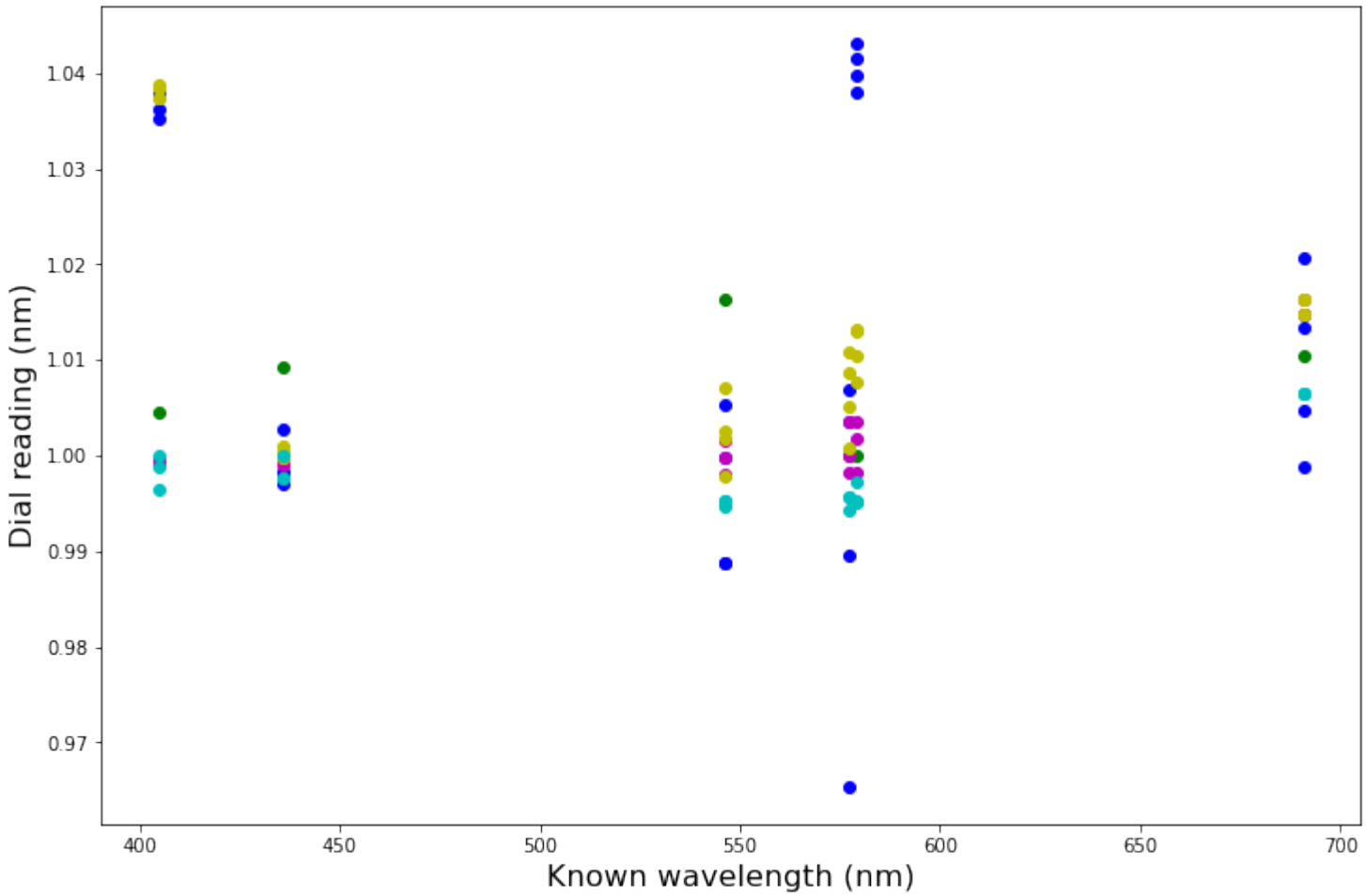
Rejection of Data – Balmer Series

- Is the best measurement combining all data taken?
- What are all the possible ways that we should ‘clean’ the data to get the best result?

Rejection of Data



Rejection of Data



Data

* For λ_2, I realized I was reading the wrong value on the knob for this wavelength. This is why values change. *

- Calibration of Spectrometer using Hg.

Trial #	λ_1 (~690.75nm)	λ_3 (~579.0nm)	λ_3 (~577.0nm)	λ_4 (546.1nm)	λ_5 (435.8nm)	λ_6 (404.7nm)
1	702	~~602.5~~	577.4	547.5	436.2	419.8
2	701	~~608.5~~	583.2	544.9	435.7	420.2
3	701	~~618~~ 585	579.9	547.1	~~486~~ 436	420.4
4	702	583.5	582	550	435.7	419.8

586.5 (Trial 2)
586.6 (Trial 1)

Experiment:

Spectrum Device – Constant-deviation spectrometer

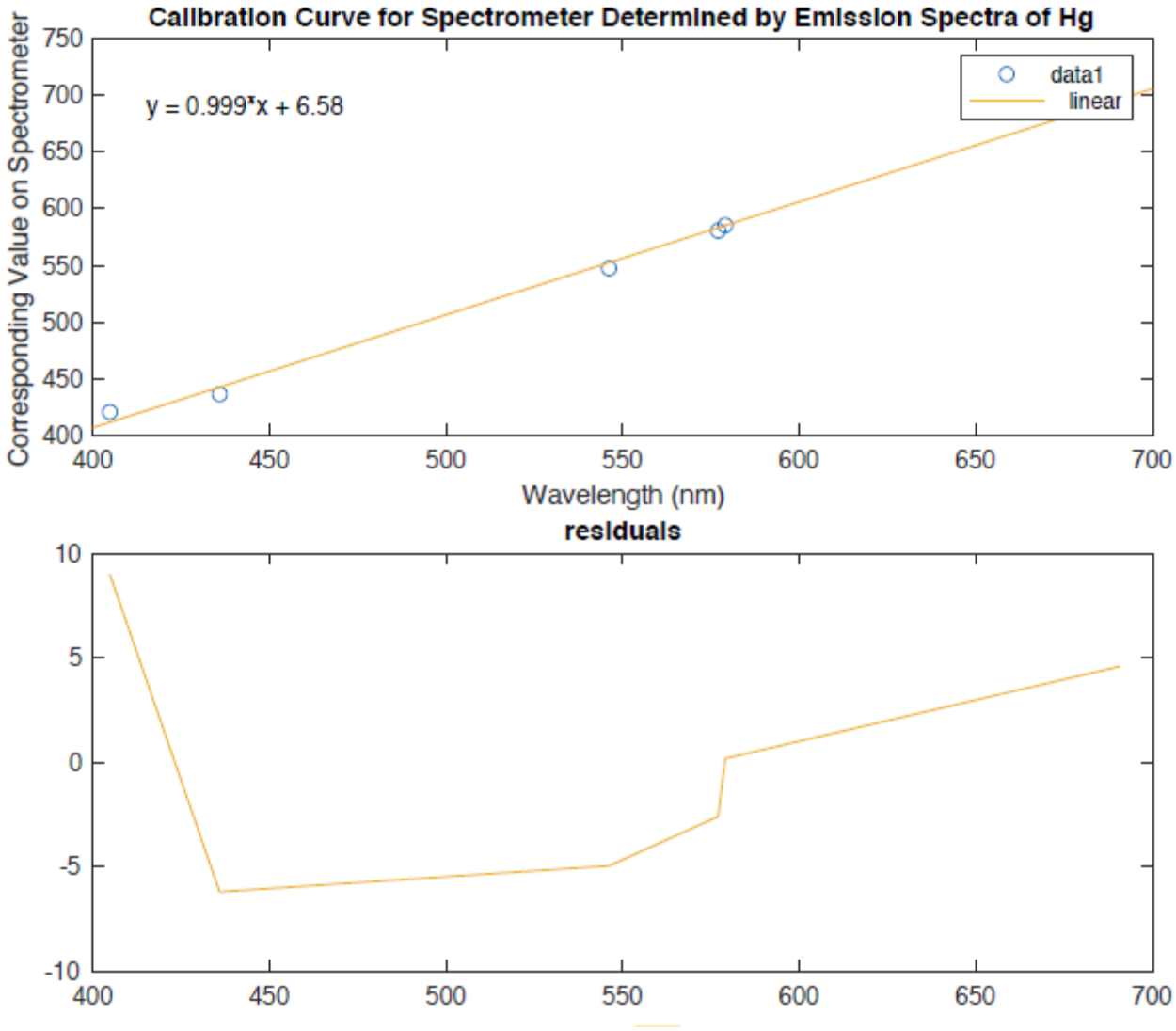
First I started with the mercury lamp who's wavelengths are known. I will use this to calibrate my measurements by creating a calibration curve of wavelength vs dial settings.

First I adjusted the cross-hair focus, slit focus, and slit width adjust to measure the light's location as precisely as possible.

After I felt satisfied, I recorded the dial settings for each wavelength. I did this for all 8 wavelengths that I could see, then repeated these measurements 3 more times for a total of 4 data sets:

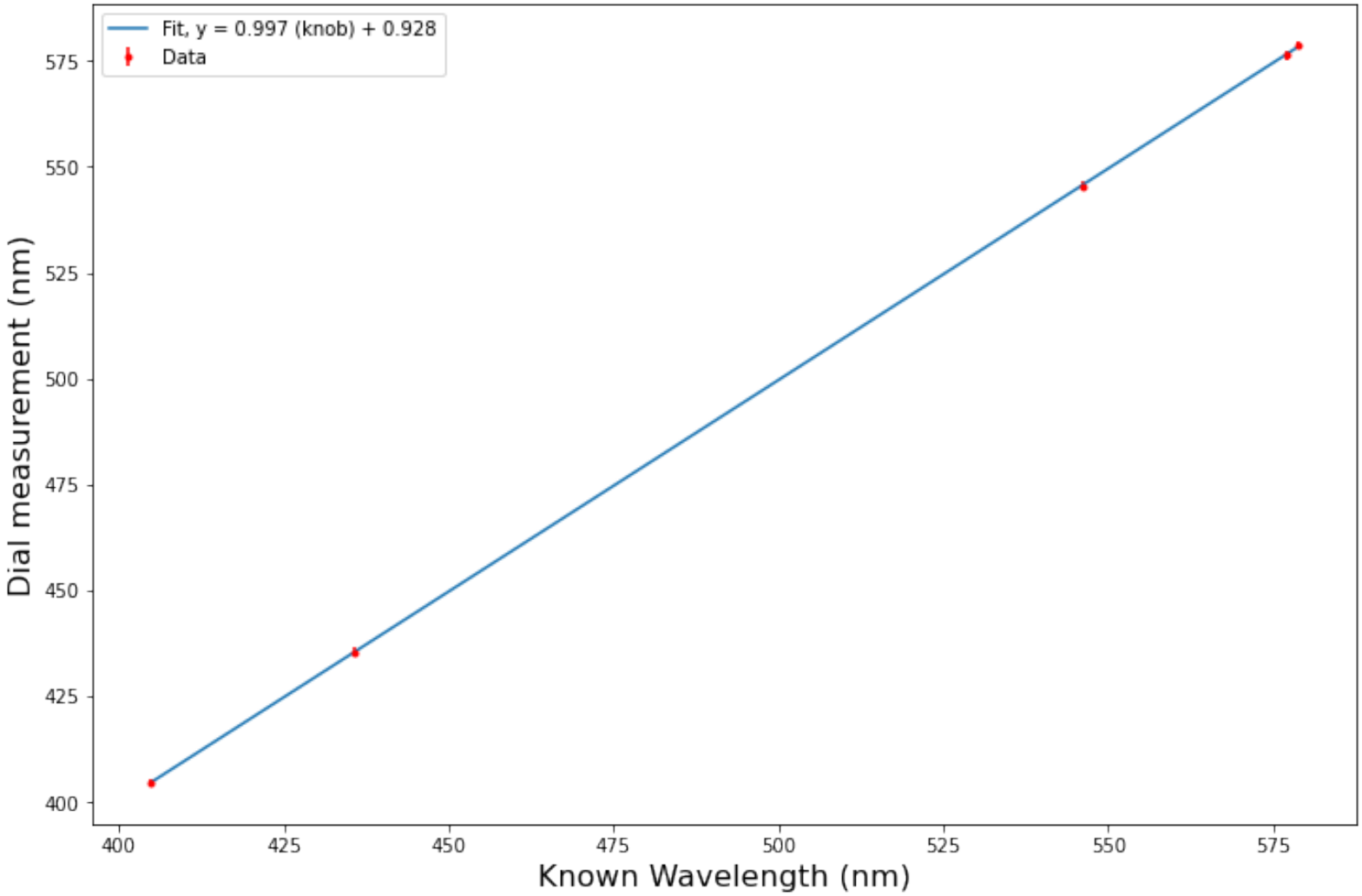
	Dial settings			
Color	Trial 1	Trial 2	Trial 3	Trial 4
Red				(Red not visible)
Yellow 1	57.87±0.05	57.91±0.05	58.04±0.05	58.04±0.05
Yellow 2	57.63±0.05	57.70±0.05	57.70±0.05	57.80±0.05
Green	54.55±0.05	54.69±0.05	54.61±0.05	54.60±0.05
Purple	435.5±0.5	435.3±0.5	435.7±0.5	435.6±0.5
Deep Purple	404.7±0.5	404.8±0.5	404.7±0.5	404.6±0.5

I used the most precise measurements on the dial (second from the back). I couldn't resolve the color red at all. The uncertainty of each measurement is limited by dial resolution at that point.

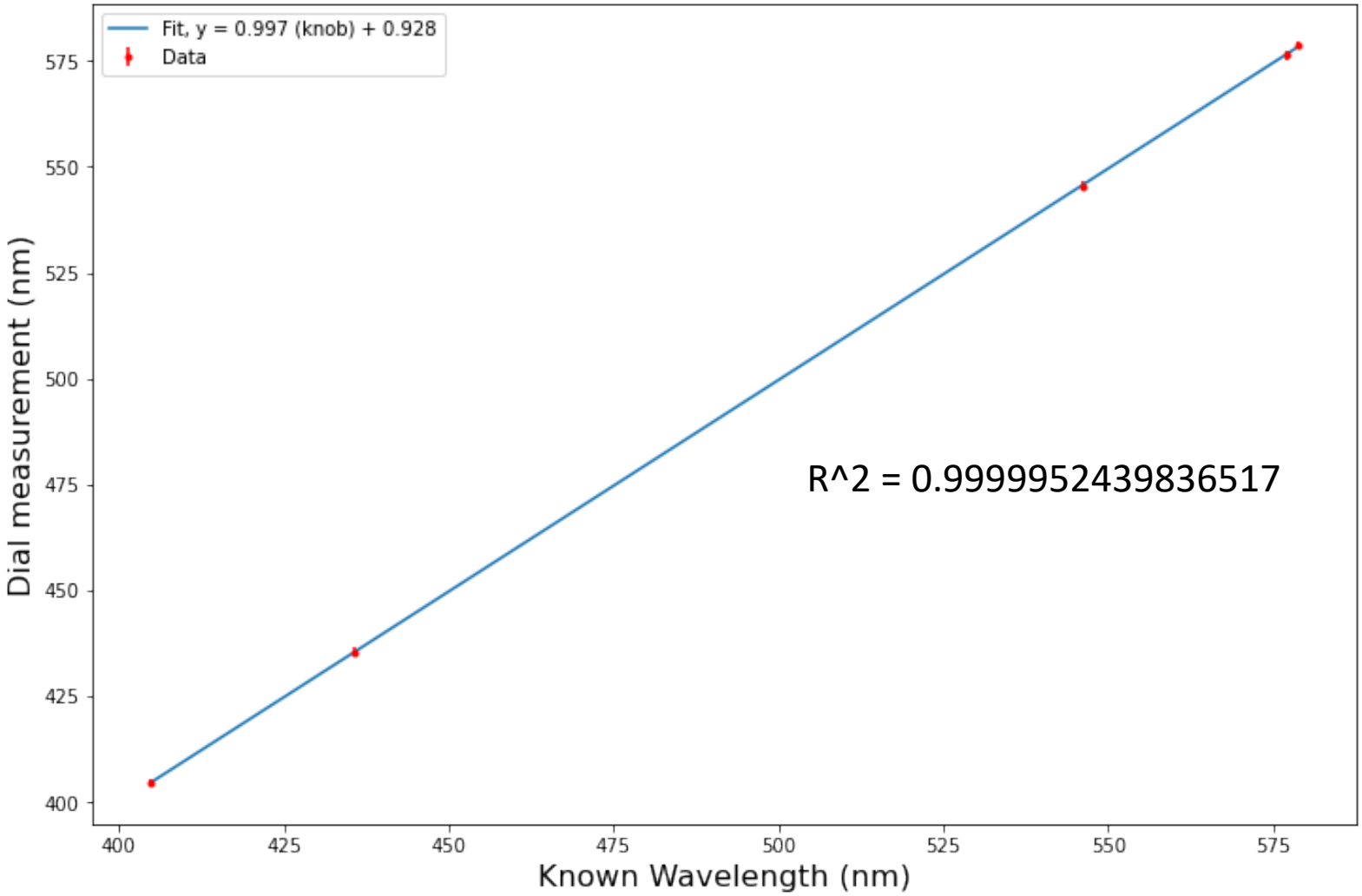

Calibration Curve for Spectrometer Determined by Emission Spectra of Hg
y = 0.999*x + 6.58
data1
linear
Corresponding Value on Spectrometer
Wavelength (nm)
750
700
650
600
550
500
450
400
400
450
500
550
600
650
700
residuals
10
5
0
-5
-10
400
450
500
550
600
650
700

Emission lines of Mercury

690.75 nm (red)
579.0 nm (yellow)
577.0 nm (yellow)
546.1 nm (green)
435.8 nm (purple)
404.7 nm (deep purple)



The slope = 0.997427327412303 8, with uncertainty 0.0012558490265354887 The intercept = 0.928255469079249 7, with uncertainty 0.6452914621011211



The slope = 0.997427327412303 8, with uncertainty 0.0012558490265354887 The intercept = 0.928255469079249 7, with uncertainty 0.6452914621011211