Austin W.M.
semi-Professional Portfolio

draft 2 as of
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Abstract

A multidisciplinary applied scientist with a focus on leveraging analytical techniques to solve complex, real-world problems. With expertise spanning physics, astronomy, and chemistry, the emphasis has been on data management, programming (primarily in Python), and electronics repair. This portfolio showcases diverse projects, technical skills, and ongoing work, reflecting a commitment to continuous learning and practical applications. Whether developing software solutions or conducting detailed scientific analysis, the goal is always to apply theoretical knowledge to real-world challenges.

Sometimes, academic structures are dogma-ed for a reason. To get a decent grasp of this document will require more than an introductory knowledge of Calculus, Physics 1 & 2, and computer programming in general. The following page contains a table of its contents followed by a verbose introduction. I consider, personally, absolutely none of it to be important.

Table of Contents

(please ignore for now this is mostly a placeholder)

Introduction

ChatGPT wants to call me[1] a ”data analyst and physicist with a deep interest in applying analytical techniques to solve complex problems”. I'd call myself an academic, whose current knowledge and insight lacks what's required to make decent money. I have only a bachelors degree in Physics, but it's something I'm most proud of and hope to continue one day. It's difficulty lived *almost* all the way up to its regard, but I did very well in the program and was particularly adept in astronomy and astrophysics.

Because my education has not yet proved to be a returning bet, I have instead busied myself learning new things that pique my interest. It would be somewhat fair to call myself a physicist, chemist, mathematician, musician, martial artist, hopeful writer, or computer scientist. If you, or someone you know, is a professional in one of those fields then they are probably better than I am... but I could keep up with them. If you pick 2000 people at random, I am likely among the best.

Those are some things I could be paid for, though my skills span much farther. I am pretty solid in web development (I am very good at using Google), I sometimes build and repair electronics, I can be quite the handyman, I perform maintenance and repairs on whatever cars are in my driveway, and *anyone* I've ever worked with in a restaurant for the past 15 years will agree that I am very, very good at my job. There are other things to tell about me but they aren't why this document exists, and I'm skirting my line of humility quite close as it is.

This document is written in LaTeX.[2] The page which follows will contain a table of its contents. This portfolio presents somewhat notable projects, accomplishments, hobbies, or just things I've done. It will contain pictures I've taken. It may contain songs I play. It is definitely *not* the GitHub profile of a software engineer, the resume of an entrepreneur, or the curriculum vitae of an esteemed professor. It is different and worse than those. It is what it is, and also more human.

May death come swiftly to us all,

Austin W. Miller

Astrophysics and Cosmology

Hubble's Law: Cosmological Data Analysis (AST 3930L)

Problem: Determine the relationship between the velocity of distant galaxies and their distance from Earth to confirm the expansion of the universe. The end goal was to calculate the Hubble constant using real observational data.
Solution: Taking data from NASA's online data archive, I used Python to analyze the velocity and distance of galaxies. By applying least-squares fitting, I was able to compute Hubble's constant and verify the universe's expansion as described by Hubble's Law. **this requires some theoretical background as I will show soon!
Skills Highlighted: Python, Data Visualization, Statistical Modeling
Not yet imported: plan to add the theory for this problem and lots of math

Python Code Excerpt:

```
import numpy as np
import matplotlib.pyplot as plt

distance = np.array([...])
velocity = np.array([...])
plt.errorbar(distance, velocity, yerr=velocity_error, fmt='o')
hubble_constant, _ = np.polyfit(distance, velocity, 1)
plt.plot(distance, hubble_constant * distance, label=f'H_0 = {hubble_constant}')
plt.legend()
plt.show()
```

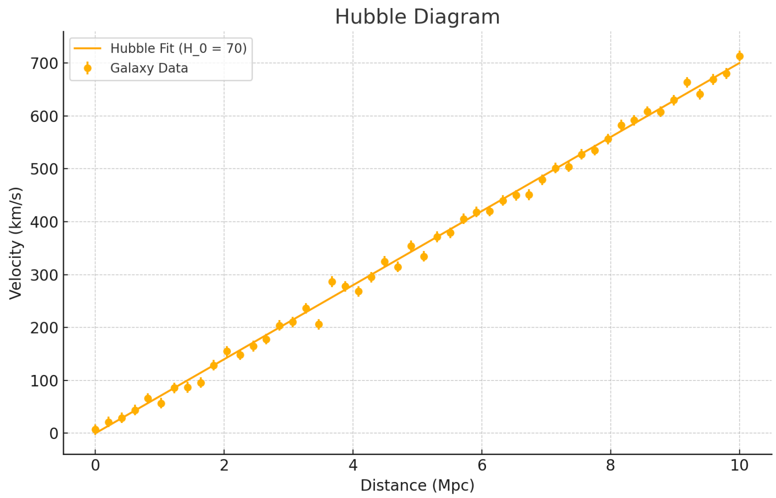


Figure 1: Hubble Diagram showcasing the linear relationship between distance and velocity of galaxies.

Exoplanet Detection Using Kepler Data (AST 3930L)

Problem: Analyze NASA's data of light curves from the Kepler Space Telescope to detect potential exoplanets orbiting distant stars by identifying dips in brightness caused by planetary transits.
Solution: I use Python to manipulate and weed out data points, then analyze the light curve data and detect the characteristic dips associated with exoplanet transits. By applying signal processing techniques, I confirmed the detection of exoplanets using real world observational data.
Skills Highlighted: Data Analysis, Python Programming, Astrophysical Modeling

Python Code Excerpt:

```python
import numpy as np
from scipy.signal import find_peaks

# Sample data from Kepler light curve
light_curve = np.loadtxt('kepler_data.txt')
peaks, _ = find_peaks(-light_curve, prominence=0.1)

plt.plot(light_curve)
plt.plot(peaks, light_curve[peaks], 'x')
plt.xlabel('Time')
plt.ylabel('Flux')
plt.title('Exoplanet Transit Detection in Kepler Light Curve')
plt.show()
```

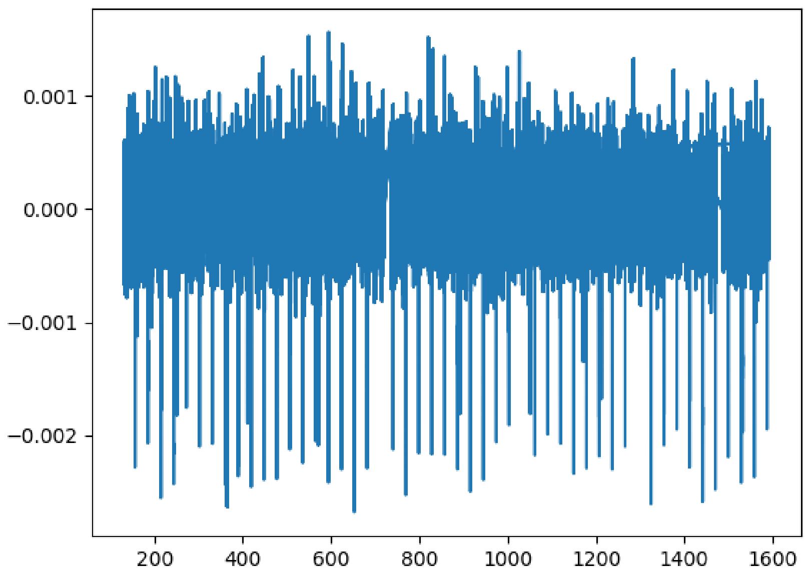


Figure 2: Raw data plot

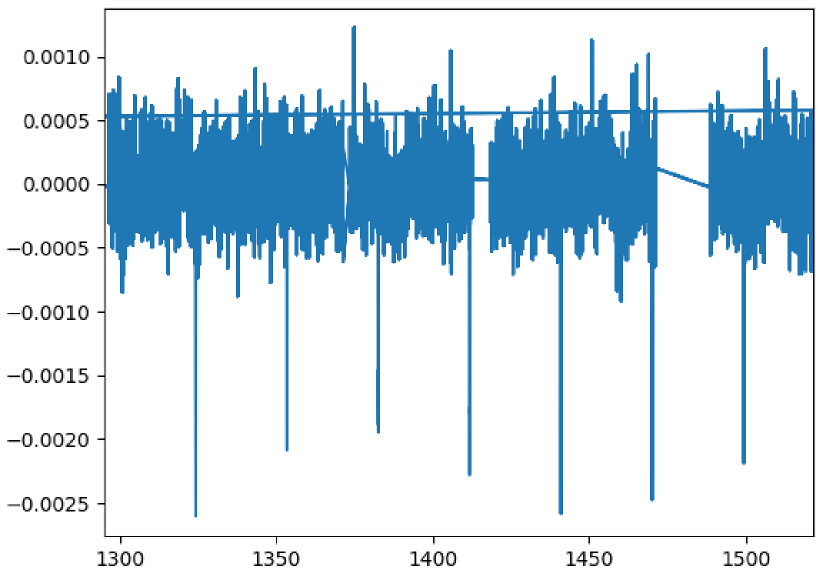


Figure 3: data plot after analysis showing evidence of exoplanet 1

Galactic Rotation Curves (AST 3930)

In this project, I studied the rotational velocities of galaxies to understand their mass distributions. Using radio observations, I created rotation curves and applied Newtonian dynamics to infer the presence of dark matter. Python was used to process the radio data and plot the results.
Skills Highlighted: Data Analysis, Python, Astrophysics

```
# Load radio data and plot rotation curve
import numpy as np
import matplotlib.pyplot as plt

radii = np.array([...])  # Radii from galaxy center
velocities = np.array([...])  # Corresponding velocities

plt.plot(radii, velocities, label='Rotation Curve')
plt.xlabel('Distance from Center (kpc)')
plt.ylabel('Velocity (km/s)')
plt.title('Galactic Rotation Curve')
plt.show()
```

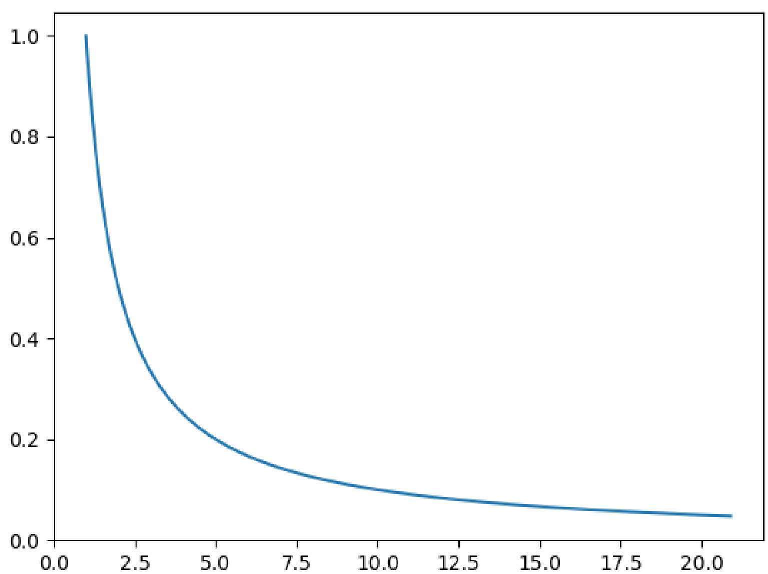


Figure 4: basic Newtonian prediction

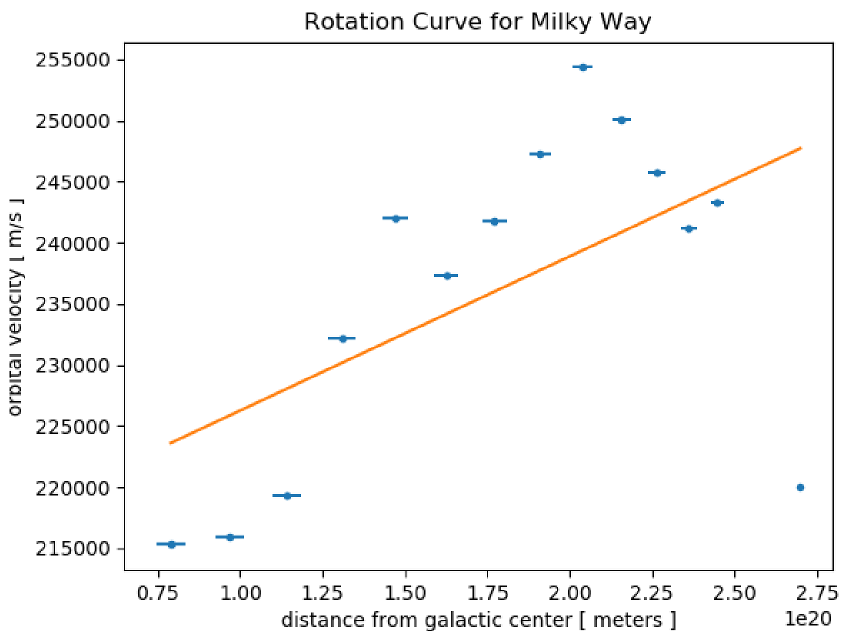


Figure 5: real data

Electron Diffraction (PHY 4823L)

This experiment involved using electron diffraction to study the crystalline structure of graphite. We applied Bragg's Law to analyze the diffraction pattern and calculated the lattice spacing of the graphite sample. Data was processed using MATLAB for data analysis, error propagation, and statistical validation.
Skills Highlighted: Data Collection, Materials Physics, Experimental Physics, MATLAB
Acknowledgment: This lab was performed in tandem with my lab partner, Mercy Adeshola

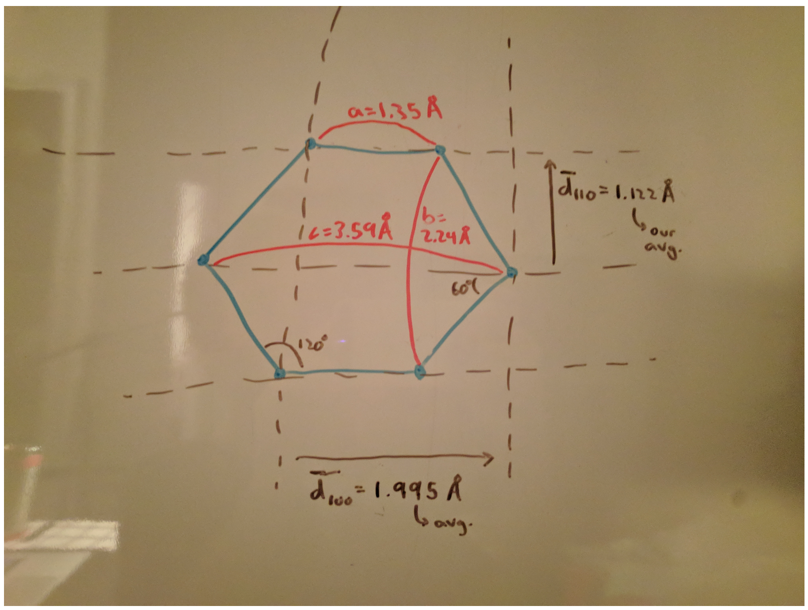
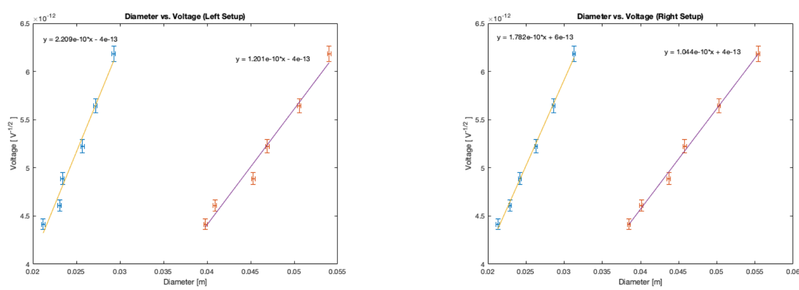


Figure 6: Hand drawn diagram of concluded inter-atmoic spacings

	d_{100} $[nm]$	d_{110} $[nm]$	ratio
Left Setup	0.221 ± 0.045	0.120 ± 0.024	1.84 ± 0.53
Right Setup	$0.178 \pm 0..14$	0.1044 ± 0.0087	1.70 ± 0.19

Table 1: Summary of Plots and Calculations



(a) left setup

(b) right setup

Figure 7: MATLAB fitlines to experimental data

Magneto-Optic Kerr Effect (PHY 4823L)

I analyzed the magneto-optic Kerr effect (MOKE) to measure magnetic properties such as coercivity and remanence. This experiment required modeling hysteresis loops and analyzing magnetic materials under varying magnetic fields. Python was used to generate plots for visualizing key magnetic characteristics.
Skills Highlighted: Data Processing, Materials Physics, Python, Magnetic properties
Acknowledgment: This lab was performed in tandem with my lab partner, Mercy Adeshola

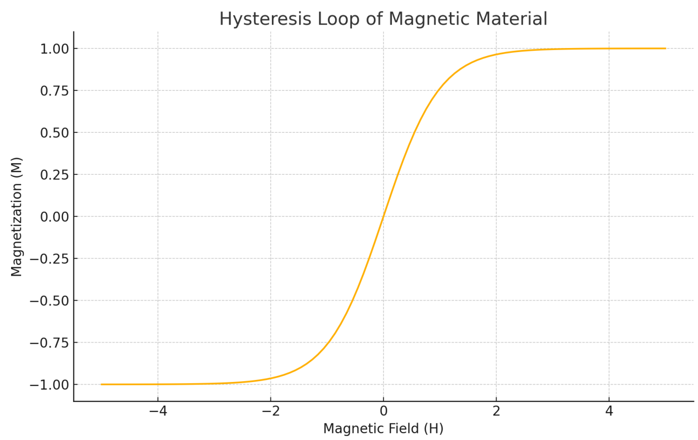


Figure 8: Theoretical hysteresis loop

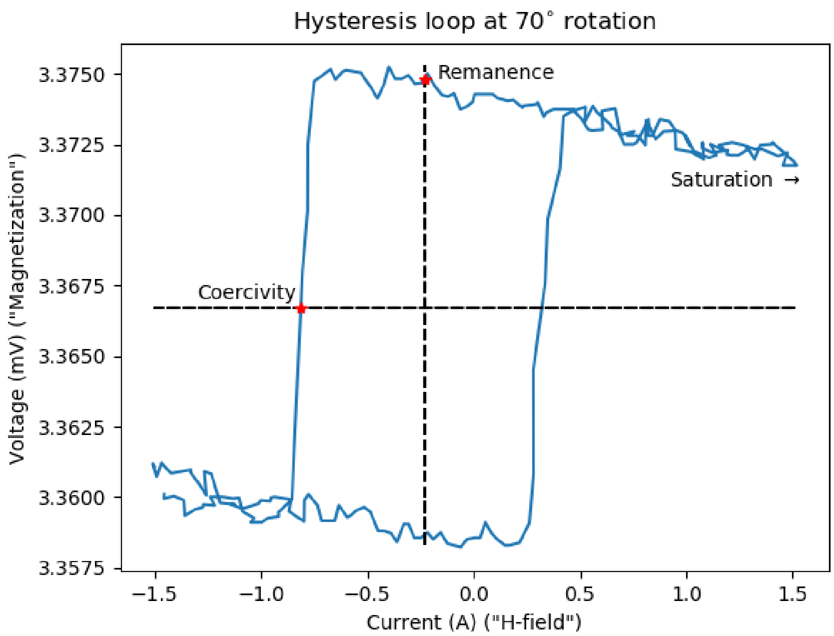
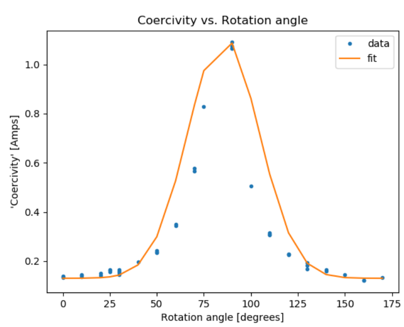
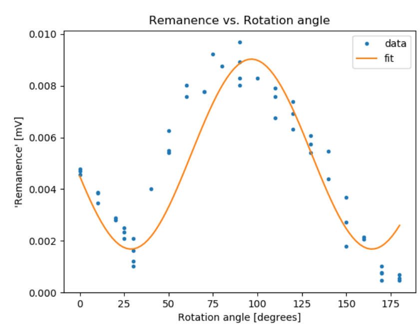


Figure 9: Collected hysteresis data



(a) coercivity under $\Delta\vec{\mathcal{H}}$



(b) remanence under $\Delta\vec{\mathcal{H}}$

Figure 10: Processed data showing particular magnetic properties

Stellar Structure: Numerical Modeling (AST 3930)

I solved the Lane-Emden equation via Runge-Kutta algorithm to model hydrostatic equilibrium of stars with polytropic indices $n = 1.5$ and $n = 3.5$. This project involved using numerical methods in Python to analyze the structure and density profiles of stars.
Skills Highlighted: Numerical Methods, Python, Astrophysical Modeling, Theoretical Physics,

Python Code Excerpt:

```
from scipy.integrate import odeint
import numpy as np
import matplotlib.pyplot as plt

def lane_emden(theta, xi):
    return -2/xi * np.gradient(theta) - theta**n

solution = odeint(lane_emden, initial_conditions, xi_range)
plt.plot(xi_range, solution)
```

Physics Excerpt:

1. ...

Beginning with a power series expansion of $\theta(\xi)$,

$$\theta(\xi) = C_0 + C_2\ \xi^2 + C_4\ \xi^4 + ...\ , \tag{1}$$

applying some natural boundary conditions allows the calculation of some of the constants. First, ρ/ρ_c must equal one at $r = 0$. This means that $\theta = 1$ when $\xi = 0$. Applying this boundary condition shows

$$\theta(0) = C_0 = 1\ , \tag{2}$$

and now

$$\theta(\xi) = 1 + C_2\ \xi^2 + C_4\ \xi^4 + ... \tag{3}$$

Next, taking the derivative and plugging into the Lane-Emden equation allows the calculation of C_2:

$$\frac{1}{\xi^2}\frac{d}{d\xi}\Big(\xi^2(0 + 2C_2\ \xi + 4C_4\ \xi^3 + ...)\Big) = -\theta^n \tag{4}$$

$$\frac{1}{\xi^2}\frac{d}{d\xi}\Big(2C_2\ \xi^3 + 4C_4\ \xi^5 + ...)\Big) = -\theta^n \tag{5}$$

$$\frac{1}{\xi^2}\Big(6C_2\ \xi^2 + 20C_4\ \xi^4 + ...)\Big) = -\theta^n \tag{6}$$

$$6C_2 + 20C_4\ \xi^2 + ... = -\theta^n\ . \tag{7}$$

Reapplying the first boundary condition, $\theta = 1$ when $\xi = 0$, gives

$$6C_2 + 0 = -1^n \quad \Longrightarrow \quad C_2 = -\frac{1}{6} \tag{8}$$

...

2. ...

First, by definition

$$\rho \equiv \rho_c \theta^n \quad \Longrightarrow \quad \rho \propto \theta^n \tag{9}$$

Next, $P(\theta)$ is found by plugging $\rho(\theta)$ into the polytropic equation of state given by

$$P = K\rho^{\frac{n+1}{n}}\ , \tag{10}$$

where K is a constant. Doing this substitution gives

$$P(\theta) = K(\rho_c\theta^n)^{\frac{n+1}{n}} = K\rho_c^{\frac{n+1}{n}}\theta^{n+1} \quad \Longrightarrow \quad P \propto \theta^{n+1}. \tag{11}$$

Finally, $T(\theta)$ can be found easily under the assumption that stars approximate an ideal gas. This means that the ideal gas equations must hold. The relation most relevant here is given:

$$P = \frac{k\rho T}{\mu m_H}, \tag{12}$$

where k is Boltzmann's constant, μ is the mean atomic mass of stellar material (assuming it is constant), and m_H is the atomic mass unit. Solving for T,

$$T = \frac{\mu m_H}{k}\frac{P}{\rho}\ , \tag{13}$$

and plugging in the derived expressions for $\rho(\theta)$ and $P(\theta)$ gives

$$T(\theta) = \frac{\mu m_H}{k}\frac{K\rho_c^{\frac{n+1}{n}}\theta^{n+1}}{\rho_c\theta^n} = \frac{\mu m_H K\rho_c^{1/n}}{k}\ \theta \quad \Longrightarrow \quad T \propto \theta. \tag{14}$$

...

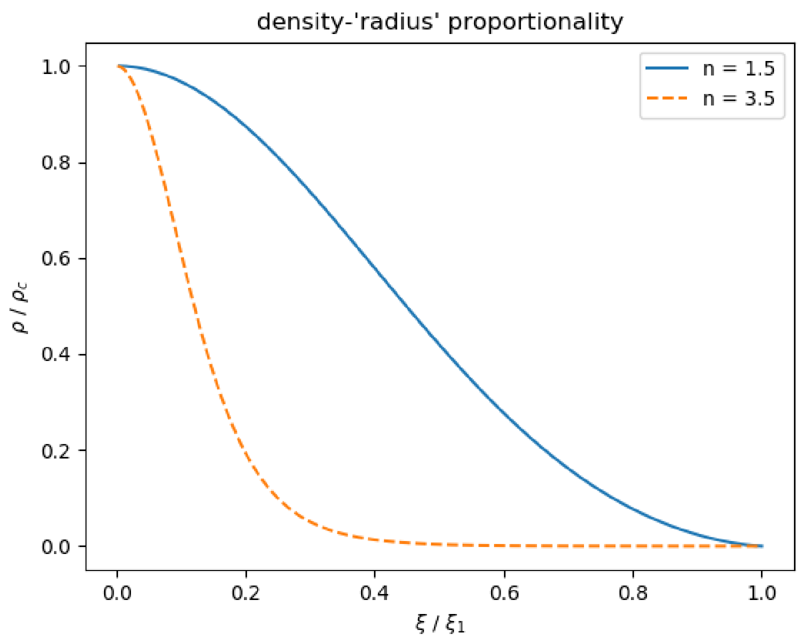


Figure 11: density

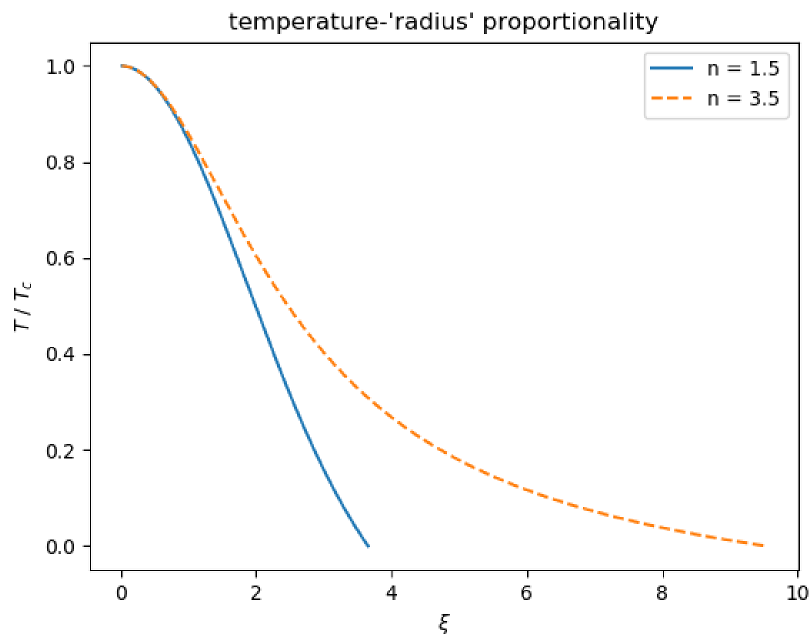


Figure 12: temperature

Research Projects

Chemical Literature Analysis (CHM 4060)

ChatGPT seems to really believe in the addition of this course to my portfolio. I don't consider it especially relevant, to be honest, and all I can think to do is describe what we did, and post some sample questions from the course.

As part of the Chemical Literature course, I conducted in-depth research and literature reviews, focusing on modern techniques in chemical and academic research. This was a course required for the Chemistry minor. If nothing else it shows my ability to source and decipher complex scientific papers. I may delete this once I add better samples of my writings and physics research.
Skills Highlighted: Research, Technical Writing, Chemical Analysis
Acknowledgment: None of the words in the following section are mine. They are select questions from problem sets in the course CHM4060, taught in 2019 at USF by Dr. M. Johnston

Sample Excerpts:

> Do a library catalog search on a topic of your choice. Be sure that it a chemistry topic!
>
> In at least one sentence or more, please explain if you be able to would be to retrieve an article in this journal through USF and how difficult it would be to do this. . . i.e. what is the time period you could find article's for and what would the method be you could use to obtain the article.
>
> Can you find a way to access foreign patents? If so, pick a country (e.g., the UK, Switzerland, France, etc.) and report a patent for any chemical or pharmaceutical product or process.
>
> There is a lot of speculation currently about the element thorium as a way of producing nuclear energy at a much cheaper and safer level than can be done with uranium. Below are a few questions regarding this element ...
>
> Again, your main grade will be determined by your content. But at least 10% of the grade will also be assessed on the appearance of your final submission.

Skills Summary

- **Programming:** Python, MATLAB, LaTeX, HTML, Unix Systems
- **Data Science Tools:** NumPy, Pandas, Matplotlib,
- **Cloud Computing:** AWS, Server Management
- **Experimental Techniques:** Electron Diffraction, Stellar Modeling, Numerical Modeling

- **Technical Writing:** Academic Reports, Research Summaries, Scientific Research, Patent verification

Website Development: Personal Portfolio

Project: Personal Website Development
URL: austinmiller.net
Description: I built and maintain my personal website as a professional portfolio and a way to showcase my work and skills. The website is hosted on GitHub Pages and built using HTML, CSS, and Git for version control. The website also showcases some of my astrophysics work, projects, and a dedicated section for my experience managing technology like AWS.

Technologies Used:

- GitHub Pages: For hosting the website and managing version control.
- HTML/CSS: Front-end development for designing the portfolio and presenting my projects.
- AWS: Used for hosting backend components and testing cloud hosting for scaling.
- Git: Version control to manage updates and changes to the site.

Skills Highlighted:

- Web Development
- Cloud Hosting (AWS)
- Version Control (Git)

Server Management: Remote Hosting

Project: Remote Minecraft Server Management
Description: I run a Minecraft server remotely from my MacBook Air, managing everything from server uptime to performance optimizations. The server hosts multiple players and is configured for custom mods. This project has developed my cloud hosting skills, network management, and troubleshooting.

Technologies Used:

- Minecraft Server: Managed remotely for multiple users, with uptime monitoring and mod support.
- MacBook Air: Used as a host server with customized scripts for performance improvements.
- Networking: Configuring ports, managing player access, and resolving connectivity issues.

Skills Highlighted:

- Server Administration
- Cloud Hosting and Networking
- Troubleshooting and Scripting

Contact Information

For additional information or project details, feel free to contact me via email or visit my website.

Footnotes & Errata; References & Sources

1. According to the current iteration of this document as of October 25, 2024.

2. It continues to baffle me that more people don't use it. It is so much better than Microsoft Word (not hating). It is both the easiest, and most useful computer language I have learned of (for people who don't program computers for work, of course).