

Astron 98 Final Project: Replicating Bean et al, 2023 figure 1 to find correlation between atmospheric metal enrichment and CO2 absorption

1.Introduction

In this project proposal, I outline the steps I took to replicate figure 1 in Bean et al, 2023 paper to find the correlation between atmospheric metal enrichment and CO2 absorption.

2.Chosen Phenomenon and Data Source:

For this project I will be replicating Figure 1 from a paper published by Bean et al, 2023. To replicate this, I will be using the dataset that Bean uses in his paper using the NIRCcam instrument of JWST. This dataset has the wavelengths, depths, and errors for the Saturn mass exoplanet HD 149026b. The dataset can be accessed at [MAST – Mikulski Archive for Space Telescopes]

(<https://mast.stsci.edu/portal/Mashup/Clients/Mast/Portal.html>)

3.Equation to Fit Data

The equation chosen depends on the trend of the data. Since there's multiple available equation that we can use to fit the data, here are some that I picked for the data that I have.

Log Model

$$y = a + b \cdot \ln(x)$$

I tried fitting the data to a log model and unfortunately the resulting $R^2 = 0.9418$ due to this, I ended up changing the equation to a polynomial to the order of 4

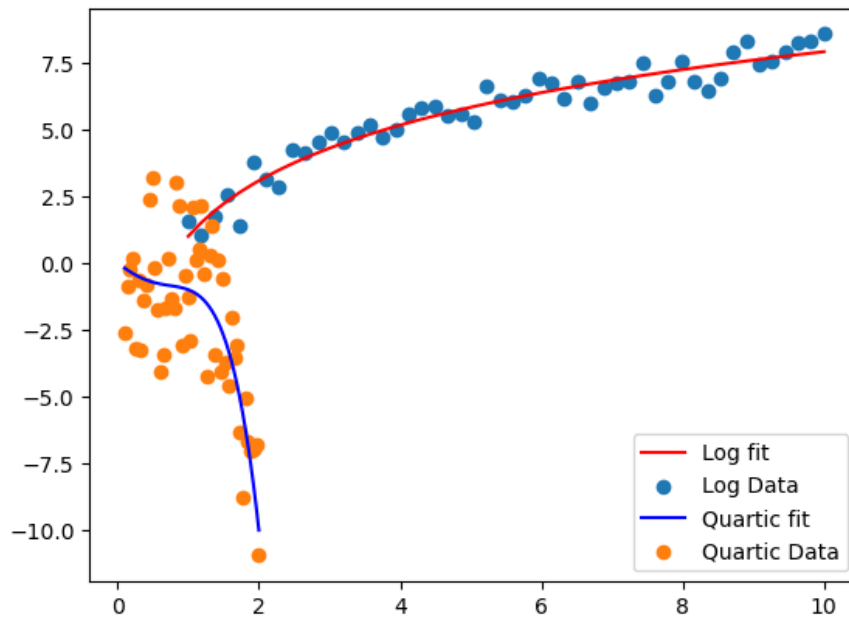
Polynomial Model (order of 4)

$$y = ax^4 + bx^3 + cx^2 + dx + e$$

The resulting R^2 value from this model is around 0.9912.

4.Data Generation for Testing

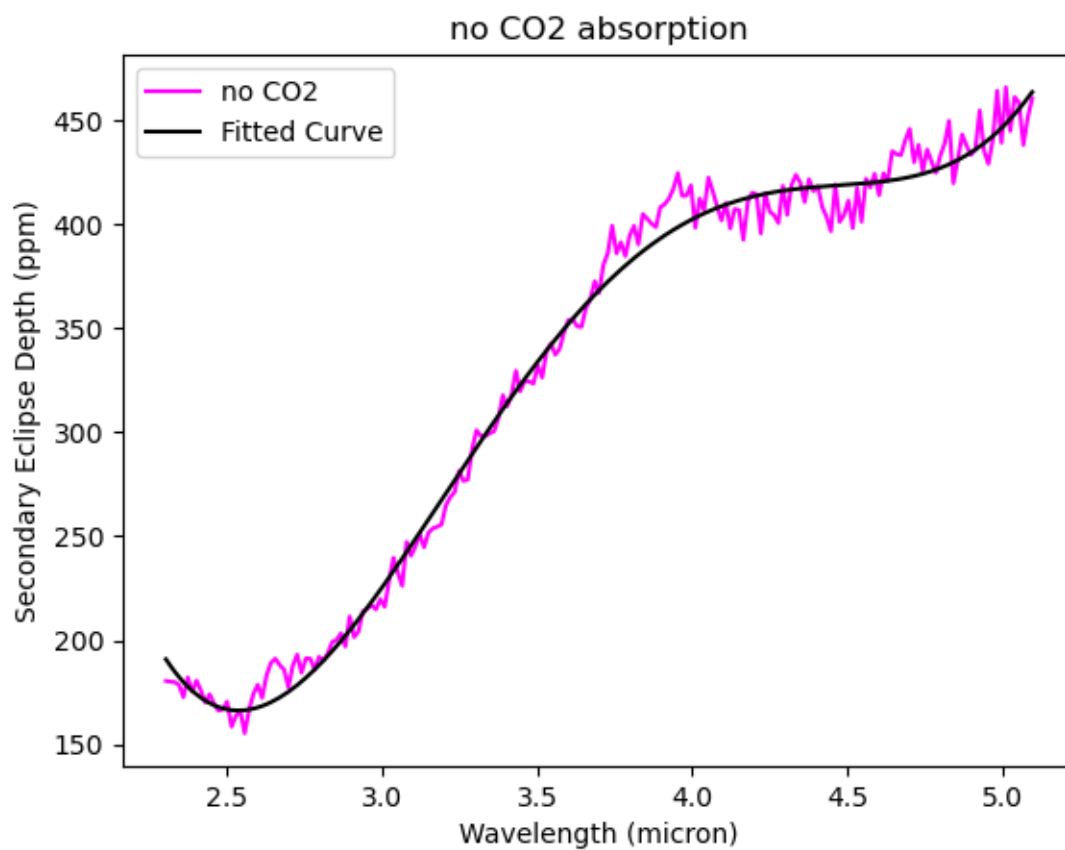
I struggled with generating the data but the curves produced by the polynomial data is closer to the data source.



5.Data Filtering

The x values range of the data source is around 1 – 5 microns and for the y values 150 – 450. So in order to fit the model to the data, the data filtering process would be adjusting the x and y ranges in the model and the parameters of the constants in the equation.

6.Data Fitting



The resulting R^2 value from the fitted curve above is around 0.9912 which I think means its pretty accurate for the data that we have.

7.Explanations for Model Fit

After replicating the figure and fitting it to the model, I believe that the polynomial model (to the order of 4) represents the data best (R^2 value closest to 1)

8.Conclusion and Reference

The polynomial model provides the closest replicate to the data from the paper which shows the correlation between adsorption of CO₂ and atmospheric metal enrichment.

Bean, J. L., “High atmospheric metal enrichment for a Saturn-mass planet”, Nature, vol. 618, no. 7963, pp. 43–46, 2023. doi:10.1038/s41586-023-05984-y.

([High atmospheric metal enrichment for a Saturn-mass planet | Nature](#))