Investigating the Existence of a Potential Exoplanet in the Star System V808 Aurigae
Isaac Dubash, Marian High School, Mishawaka, IN, USA

Introduction

In 2024, research conducted by the University of Notre Dame suggested that an exoplanet, previously undiscovered, was orbiting around a star system called V808 Aurigae. This system is an eclipsing binary, which means it contains two stars. These stars orbit a common center, and, as the name suggests, periodically eclipse one another. Because of this, measurements of the system's brightness (called magnitude) show regular decreases in light output, which allow us to measure orbital periods. After years of taking these photometric measurements, it was found that the period of the star was changing. Equations suggested that a planet with an eccentric orbit was causing these changes. Whenever the planet's orbit was far from the stars, the stars were unaffected by the planet's gravity. However, when the planet was close to the stars, the stars were affected by the planet, causing the stars' orbit to slow. Research like this is done because it advances our knowledge of planet formation and the search for extraterrestrial life, teaching us about astrophysics and giving us more perspective on our place in the cosmos. By studying systems like V808 Aurigae, more knowledge can be gained about our own solar system and the conditions that affect it. In summation, the goal of my research is to further explore whether or not this star system contains a planet.

Hypothesis

If there is a planet affecting V808 Aurigae, then photometric measurements should follow results shown in Fig. 4 in Leichty et al. (2024), because the planet's gravity would pull on the stars, changing the time it takes for them to orbit.

Procedure

★ Photometric measurements of V808 Aurigae were collected with 3-8 second exposures over a time of up to 3 hours. 6 eclipses of the system were documented with time in units of JD (Julian Date).
★ Exact times of eclipse (called mideclipse) were calculated as the mean of the two times the system's magnitude was half of its normal level.
★ Mideclipse times were converted from JD to BJD (Barycentric Julian Date).
★ Using the system's ephemeris (Equation 1 of Schwope et al. 2015), epoch values were calculated for each eclipse time (E = 0 in January 2009). Values were rounded to the nearest integer.
★ Epoch integers were reinserted into the ephemeris found in Schwope et al. 2015 to return a new BJD value (called "C")
★ C values were subtracted from their respective observed mideclipse times to find O - C values.
★ O - C values were converted to seconds and compared to the O - C value plot found in Figure 4 of Leichty et al. 2024.

Originally, my plan was to, with the help of my mentor, use the Krizmanich Telescope at the University of Notre Dame to collect photometric measurements. However, due to time and weather constraints, that did not end up being possible. Alternatively, I analyzed previous measurements of V808 Aurigae taken by Notre Dame's Dr. Peter Garnavich. Data used was collected in January and March of 2025.

The Krizmanich Telescope, used to take photometric observations, sits atop the University of Notre Dame's Jordan Hall. Photograph by Isaac Dubash.

An inside view of the Krizmanich Telescope at the University of Notre Dame. Photograph by Isaac Dubash.

A visual of the Auriga constellation, which contains V808 Aurigae. The website which contains this image is used to find the star's coordinates. Screenshotted by Isaac Dubash from stellarium-web.org.

An illustration of a binary star system, which, like V808 Aurigae, contains a red giant and white dwarf star. Illustration by Dr. Mark A. Garlick, aavso.org.
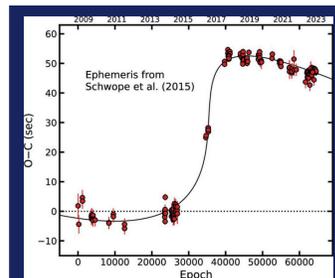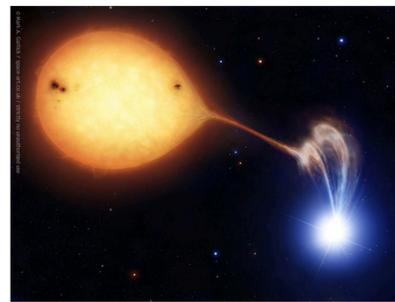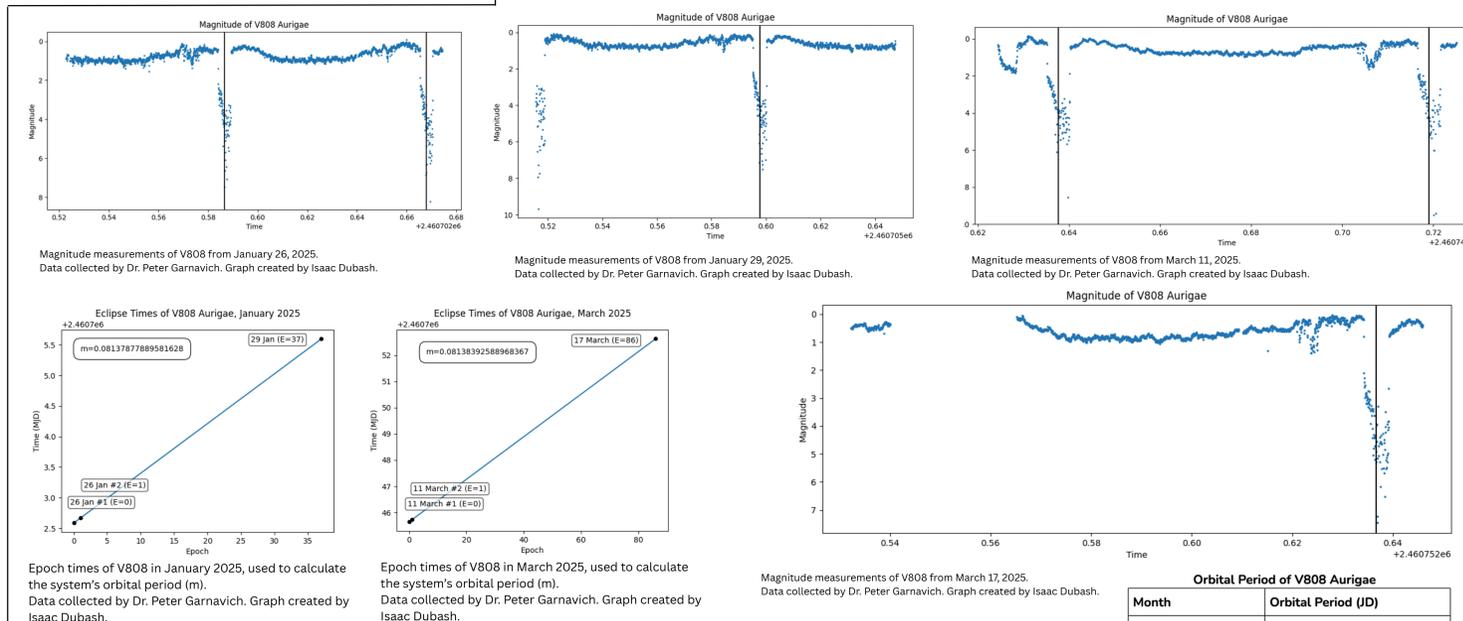

Figure 4 of Leichty et al. (2024), which analyzes 14 years' worth of data on V808 Aurigae. This graph contains a polynomial of best fit which is used for general analysis.
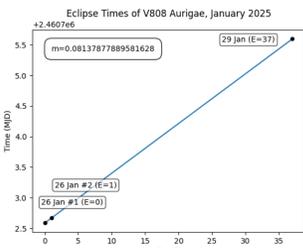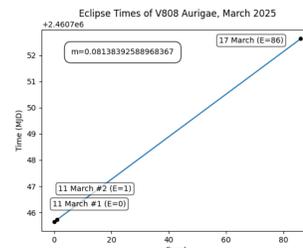
Data

Magnitude measurements of V808 from January 26, 2025. Data collected by Dr. Peter Garnavich. Graph created by Isaac Dubash.

Magnitude measurements of V808 from January 29, 2025. Data collected by Dr. Peter Garnavich. Graph created by Isaac Dubash.

Magnitude measurements of V808 from March 11, 2025. Data collected by Dr. Peter Garnavich. Graph created by Isaac Dubash.

Epoch times of V808 in January 2025, used to calculate the system's orbital period (m). Data collected by Dr. Peter Garnavich. Graph created by Isaac Dubash.

Epoch times of V808 in March 2025, used to calculate the system's orbital period (m). Data collected by Dr. Peter Garnavich. Graph created by Isaac Dubash.

Magnitude measurements of V808 from March 17, 2025. Data collected by Dr. Peter Garnavich. Graph created by Isaac Dubash.
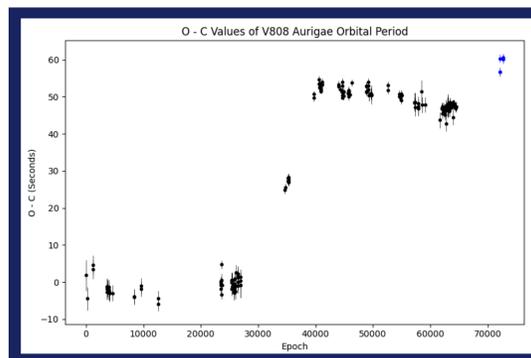

O - C values calculated using the ephemeris found in Schwope et al. (2015). Data in black is from Leichty et al.(2024) and data in blue was collected by Dr. Peter Garnavich of Notre Dame. Error for data in blue was calculated by finding the root-mean-square of the scatter around the line of best fit for eclipse timings. Graph created by Isaac Dubash.

O - C Values of V808 Aurigae Orbital Period

Eclipse	O - C Value (BJD)	O - C Value (seconds)
January 26 (1)	0.0006977082230150	60.281990468502045
January 26 (2)	0.0006555384024977684	56.6385179758071
January 29	0.0006566108204424381	56.73117488622665
March 11 (1)	0.0006950660608708858	60.053707065924454
March 11 (2)	0.0006981985645056	60.32435595989227
March 17	0.0007014260627329	60.60321182012558
Mean	0.0006840913556 51617	59.10549312829971
Median	0.000696387141942 9779	60.16784906387329
Range	4.588766023516655 x 10⁻⁵	3.96469384431839
Standard Deviation	1.989899322203851 x 10⁻⁵	1.7192730143841273

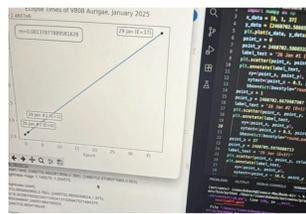Data collected by Dr. Peter Garnavich. Calculations and table by Isaac Dubash.

Results

Photometric data collected showed 6 eclipses in total. Three of these occurred in January 2025, and three in March 2025. Orbital periods were calculated as the slope of the line of best fit for graphs of number of epochs per time: 0.08137877889581628 JD and 0.08138392588968367 JD for January and March, respectively. These orbital period values have a mean of 0.08138135239274998 JD and a standard deviation of 2.573496933694353 x 10-6 JD. Eclipse timings have a statistical uncertainty of 0.046987031504486625 JD for January and 0.00002381013328686395 for March. O - C values were calculated using the ephemeris found in Schwope et al. 2015, Equation 1. O - C values have a mean of 0.0006840913556 51617 BJD (59.10549312829971 sec) , a median of 0.0006963871419429779 BJD (60.16784906387329 sec), and a standard deviation of 1.989899322203851 x 10-5 BJD (1.7192730143841273 sec).
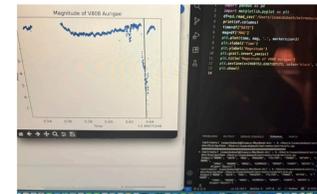
Visual representations of V808 Aurigae's orbital period were created using Python. Photograph by Isaac Dubash.

For analysis, photometric data and mideclipses were plotted using Python. Photograph by Isaac Dubash.

Magnitude measurements of V808 from March 17, 2025. Data collected by Dr. Peter Garnavich. Graph created by Isaac Dubash.

Orbital Period of V808 Aurigae

Month	Orbital Period (JD)
January	0.08137877889581628
March	0.08138392588968367
Mean	0.08138135239274998
Range	5.146993867388705 x 10⁻⁶
Standard Deviation	2.573496933694353 x 10⁻⁶

Data collected by Dr. Peter Garnavich. Table created by Isaac Dubash.

Statistical Analysis

Statistical Uncertainty (Root-mean-square) of Mideclipse Timings

Month	Root-mean-square (seconds)
January	0.1442961343371284
March	2.0571955159850455
Mean	1.1007458251610869

Table and calculations by Isaac Dubash.

Discussion

My hypothesis states that if a planet is orbiting V808 Aurigae, then photometric measurements should follow the results in Fig. 4 of Leichty et al. 2024. This is because the planet's gravity would affect the stars' motion as it moves closer to them, changing the time it takes for them to orbit. Based on my graph "O - C Values of V808 Aurigae Orbital Period", I would argue that my results support my hypothesis. Data in the graph shows that O - C values collected after about 35,000 epochs are consistently between 40 and 60 seconds. Although a definitive claim is not possible based solely on my data, it is reasonable to conclude that the V808 Aurigae star system contains a planet. Projects like this which study exoplanets are worthwhile because they provide significant information about the life cycles of solar systems, the potential for extraterrestrial life, and the mechanics of celestial bodies.

Conclusion

My study went smoothly overall. I was given a diverse sample of photometric data from the last year to analyze and compare to prior collections. Information gathered from this project could be used primarily to continue searching for the cause for the fluctuations in V808 Aurigae's movement. However, generally this research is applicable for learning about solar systems' life cycles, the workings of physics in outer space, and the continuation of astronomy's search for extraterrestrial life. If I had the chance to repeat this procedure, I would have spent more time planning the collection of photometric data so that I could use more recent data and perform more in-depth error assessments using uncertainty metrics from the telescope. These changes would give me more accurate results and more clarity in my analysis.

Bibliography

Cooney, Walt. "AAVSO Cataclysmic Variables Section | Aavso." AAVSO, https://www.aavso.org/cataclysmic-variables.

Kazmierczak, Jeanette, and Nasa Universe Web Team. "Stars - NASA Science." NASA Science, 2 May 2025, science.nasa.gov/universe/stars.

Leichty, McKenna, et al. "An Eccentric Planet Orbiting the Polar V808 Aurigae." The Astrophysical Journal, vol. 967, no. 2, May 2024, p. 81. https://doi.org/10.3847/1538-4357/ad3bac.

O-C Diagrams. jjherm.es/research/omc.html.

Practical Astrophotography Staff. "A Brief Guide to Calibration Frames: Bias, Dark, Flats and Dark Flats." Practical Astrophotography, 28 June 2015, practicalastrophotography.com/a-brief-guide-to-calibration-frames.

Schlehuber, Madeline. "Undergraduate McKenna Leichty Discovers Probable Planet With Help From Krizmanich Telescope Atop Jordan Hall." College of Science, 22 Apr. 2024, science.nd.edu/news-and-media/news/undergraduate-mckenna-leichty-discovers-probable-planet-with-help-from-krizmanich-telescope-atop-jordan-hall.

Schwope, A. D., et al. "Multi-Epoch Time-Resolved Photometry of the Eclipsing Polar CSS081231:071126+440405." Astronomische Nachrichten, vol. 336, no. 2, Feb. 2015, p. 115. ui.adsabs.harvard.edu, https://doi.org/10.1002/asna.201412151.