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Astro 98 Final Project Report
Flux Changes in Primary and Secondary Depth Stellar Eclipsing

Objective
The objective for this project evolved from my original proposal in a few different ways. Originally, I had the objective of using databases that provided information such as luminosity values and radius' for different stars and simply classifying whether at those values they were going through primary or secondary eclipsing. As I researched through various databases, I found one that gave information more specifically on light curves and provided more detailed information such as the eclipse depth and widths, therefore challenging myself to use the relationship of flux to depth and compare determine its changes in primary and secondary eclipsing.

Python Libraries Used:
1. Pandas: Helped to filter the data needed to calculate flux values without having other unnecessary data that could make the process confusing and overly complicated. This included TESS IDs, signal ID, ra, pmdec, pmra, and empty values.
2. Numpy: Helped generate randomized data to assure methods used to calculate flux changes were accurate
3. Matplotlib: Helped plot the data for the randomized data, the TESS database, flux change patterns, and error bars
4. Scikit-learn: Helped with using linear regression, the mean square error, and error bars to assure accuracy

Data Base Used: hlsp_tess-ebs_tess_lcf-ffi_s0001-s0026_tess_v1.0_cat.csv **from the Transiting Exoplanet Survey Satellite**

Scientific Concepts Used:
- <u>Mag-flux eq. Derivation</u>
  $M_a - M_b = -2.5 \log_{10} (F_1/F_2)$ → Flux change = 10^(-0.4*eclipsing depth)
  Eclipsing depth= either primary or secondary
- Primary eclipsing experiences greater depth values due to the brighter star being blocked, playing a significant role in how much flux there is since it will emit more than a dimmer star.

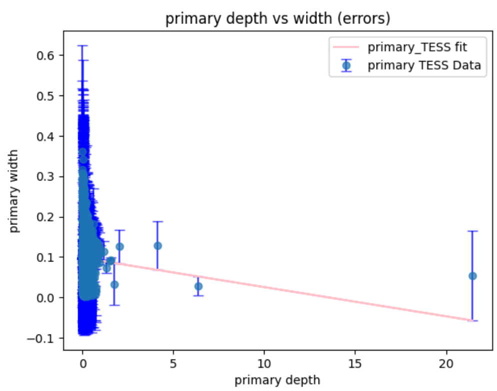
Methods Used
Since there was no luminosity or radius provided, I specifically focused on calculating the flux using the flux to magnitude equation and deriving it into an equation only depending on eclipsing depth. With the formula, I calculated the flux changes of various stars in the TESS database and plotted the flux changes for primary and secondary and checked if the flux changes overall had different gaps and connected with certain concepts. For example, primary eclipsing occurs when the brighter star is blocked by the dimmer star and secondary eclipsing is when the dimmer star gets blocked by the brighter star. In primary, therefore the flux should, according to fundamental concepts of astrophysics, have a larger change in flux than in secondary.

Error Checking Methods Used:

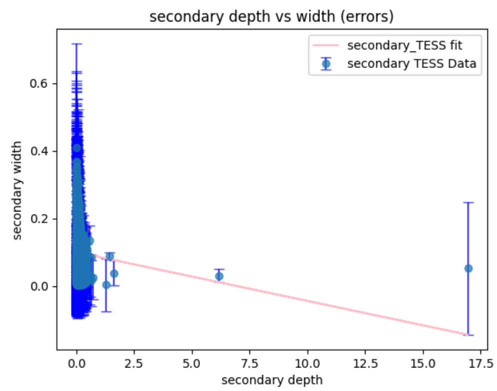
To check if using the depth of the primary and secondary eclipses were accurate variables to use to calculate flux changes, linear regression was used between eclipse depth and the eclipse width. Despite the eclipse width not necessarily being used in calculating the flux changes, it was a good variable from the TESS database because it provided a way to connect depth with to other aspects of the eclipse and showing its relevance to the eclipsing and therefore validating the depth to be used to find the flux.Later the MSE was used, which was a method to check the validity of both the random data generated and the TESS database and its use in finding the flux changes. The MSE provided me a way to check the linear regression eclipsing widths and the ones provided in the randomized and TESS data set.

Results

My plot results for the flux changes correlated in the inverse relationship between depth and flux, in the primary eclipsing the depth was greater and the flux was therefore smaller and for secondary eclipsing, the smaller depth values produced larger flux values. By checking for errors and error bars, errors were overall minimal and the most minimal for the randomized data which would correlate with the fact that real-life databases contain more variabilities, inconsistencies, and their own errors in calculation.



Graph 1.



Graph 2.

Graph 3 and 4 are the fluxes calculated by filtering the data and using just the eclipse depth and Graph 5 shows both flux values combined showing their differences that are proven correct by astronomical concepts.

Learning

At the start of this project I was primarily just focused on luminosity, radius, and magnitudes, which could have worked out in comparing which values correspond to primary or secondary eclipsing but doing research on different variables seen on different databases and not just what I had planned allowed me to see different relationships that could led me to understand other aspects of binary eclipsing.

Learning the relationships of such things like the eclipsing width and eclipsing depth allowed us to do better error-checking methods such as line regression and then MSE. Learning about flux changes and using depth and width allowed me to learn that there are many other relationships that can be seen through coding equations and plotting those relationships.

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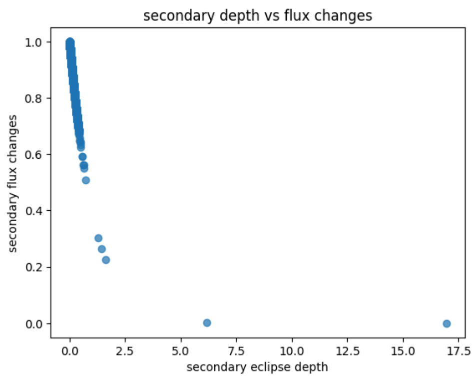
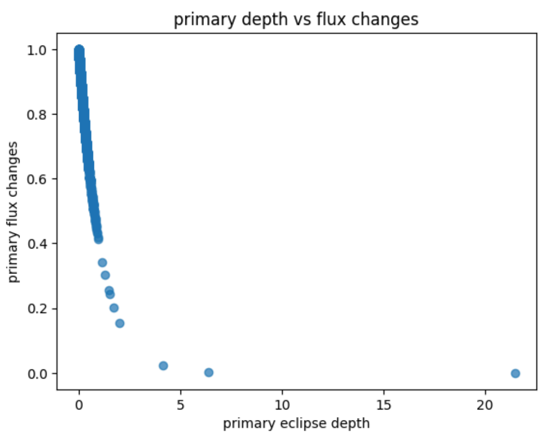
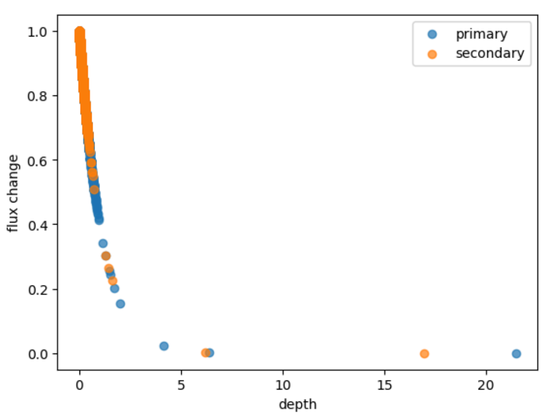


Graph 3. Primary Eclipsing flux



Graph 4. Secondary Eclipses flux



Graph 5. Both flux values combined to show a difference in flux values.