Author: Conor M. Larsen

Title: Stellar Peanuts: Binary Analysis of KIC 7766185

Research Summary:

This paper presented an analysis of the contact binary KIC 7766185. Photometric observations were obtained from the Kepler Eclipsing Binary Catalog. A phase-folded light curve was constructed from these data, and outliers were removed using Peranso. TESS data were also acquired to be used in period analysis. In addition, 7 spectra were obtained from KPNO. These spectra were reduced in IRAF, and cosmic rays were removed. From the spectra, the radial velocities of the two stars were measured. The 4^{th} spectrum was used as a reference since it was measured close to primary eclipse where virtually no radial velocities were measured. The 3^{rd} and 7^{th} spectra yielded radial velocities that did not coincide with the other values found, so these results were disregarded. An optimizer was used to fit radial velocity parameters to the results found from the spectra, specifically, the mass ratio and semi-major axis. Then, a model light curve was fit to the Kepler data to determine the inclination, effective temperature ratio, and passband luminosity of the system. Lastly, the TESS data were used to construct an O-C diagram. From this diagram, the period does not appear to be changing, but the residuals are offset from zero, indicating that that the ephemeris reported by Kepler needed to be updated. From the results of the binary analysis, the classification of the contact binary was determined to be A-type W UMa. Also, because no period variations were detected, it was determined that the system is not a red nova candidate.

Recommendation: Accept with minor revision

This paper demonstrates an excellent analysis of the contact binary system. The methodology for the most part seems sound, and the results significantly contribute to science and knowledge in the field. There are some areas where clarification or reorganization is required.

Concerns:

Major points:

- Even though the measurements of spectra 3 and 7 were excluded in analysis, they should still be reported in Table 3. Otherwise, this is an omission of data, and failure to report these values may compromise the integrity of the paper.
- Can the claim really be made that the ephemeris from Kepler is incorrect? All of the error bars of the O-C points contain 0, so there is not enough of a difference between these points and 0 to claim that the ephemeris is incorrect. The ephemeris may need a slight update, but the use of such strong language as “incorrect” is not appropriate in this case.
- In the discussion, it seems that the author is assuming his results are correct and that those report by other papers are incorrect. For example, at the end of paragraph 1 in the discussion, it says, “These results demonstrate the

importance of in-depth studies of contact binaries…to refine the parameters reported in large pipeline studies." The values reported by the author may be more precise but may not be refined if the true value is closer to an older reported value than the value determined by this paper.

- If reported with error bars, could the equivalent radii of the stars be flipped, where, within the uncertainty, the secondary star is the larger star? If so, then the classification of the binary cannot be determined. This issue demonstrates the importance of reporting uncertainties with results. However, not all values in Table 5 or those mentioned in the discussion were reported with uncertainties.

Minor points:

- The author uses "we" and "us" (plural) when there is only one author on the paper.

Abstract:

- All final measurements (stellar parameters, ephemeris) should be given in the abstract.

Introduction:

- "The stars in contact binaries are so close that tidal distortions become present" should be cited.
- "The gravitational and tidal interactions distort the two stars" can be deleted because this is pretty much stated in the previous sentence.
- Figure 3 should not be referenced in the introduction since no results should be mentioned in this section.
- The discussion of B-type stars at the end of paragraph 3 can be moved to paragraph 4.
- In Table 1, instead of "in cgs units" can be moved to the end of the reported value to be consistent with the other values in the table where the unit it attached to the value rather than the parameter name.

Observations:

- The author needs to give more information on the Kepler and TESS observations. He should give the exact dates over which observations were conducted, filters, etc.
- For the outliers removed from the Kepler data, were there any specific criteria that determined if an observation was an outlier?
- Figure 1 is not necessary to show since the light curve with the model is shown later in Figure 4.
- "The spectra were reduced through a pipeline…" What is this pipeline? Are there any details that can be provided about it?
- The citation of personal communication with Orosz can be removed. Instead, if there is a paper listing this information, this should be cited, and Orosz can just be listed in the acknowledgements.

- In Equation 1, it should be specified that the epoch is reported in days. Also, the ephemeris is T_{obs}, so to show what the ephemeris is, the equation should be rewritten as $T_{obs}=T_0+PE$.

Radial Velocity Measurements:

- Instead of “Spectrum 4 was obtained at a phase of 0.997, during the primary eclipse,” it should say something like “It is best to obtain spectra during an eclipse,” and the 0.997 phase should be mentioned later when it talks about how Spectrum 4 was used as a template.
- What is VHELIO?

Binary Analysis:

- Are the values used as initial values those in Table 1?
- More detail should be given about what the Nelder-Mead optimizer does and how it works.
- Is Table 4 showing the initial values?
- On Figure 6, the axis labels of “asini” and “lnprobability” should be remade so that they are more readable (spaces between “a sin i” for example?) Also, is log probability log 10 or ln? In the text it says “log” implying log 10, but on the y-axis of the plot in Figure 6, it says “ln.”
- The initial value for the passband luminosity should be given in whichever table shows the initial and final values.
- The corner plot in Figure 7 should be bigger.
- Table 5 can be combined with Table 4 to compare the initial values and the results. Also, the eccentricity does not need to be reported in the table if it is an assumed value.
- All values in Table 5 need uncertainties.

Period Study:

- The first few sentences about TRO and AML can be moved to the introduction.
- Is there a reason why TESS data and not Kepler data were used for this analysis?
- It says T_0 is the ephemeris, but in Equation 1, the ephemeris is defined at T_{obs}.

Discussion:

- When comparing the values to Prsa et al. 2011, it might be best to mention what the values from this paper were to facilitate comparisons for the reader.
- All values mentioned in the discussion need to be reported with their uncertainties.
- Red nova candidates should be introduced and explained in the introduction.

Evaluation of Criteria:

Is the length appropriate?

Yes, the length is appropriate.

Are the title and abstract sufficiently informative?

“Stellar Peanuts” seems somewhat random in the title. Yes, this is the shape of a contact binary, but it is not descriptive in this case. It should be mentioned in the abstract that this is the first in-depth photometric and spectroscopic analysis of the binary. This is a big deal! Lastly, the important values found in this study should be stated in the abstract (ephemeris, criterion for classification as an A-type, etc.)

Is the contribution to science significant?

Yes, this is the first analysis of the binary to use both photometric and spectroscopic observations, significantly contributing to the knowledge of this system.

Is level of English adequate?

Yes, the level of English is adequate.

Is the literature properly cited?

There are a couple instances where the literature was not properly cited (see concerns above).

Are the results clearly and accurately presented?

The results are clearly and accurately presented. However, not all results are reported with uncertainties.

Is the topic appropriate for the journal?

Yes, this is appropriate for the journal.

Data Management Plan:

The data is accessible online, and the results are presented in the paper. The methodology could have been slightly more specific or clear in places in order to make the results truly reproducible.

Additional Comment: Excellent work! Your project was cool to read about!

Peer review report

Title: Stellar Peanuts: Binary Analysis of KIC 7766185

Author: Conor M. Larsen

Summary

The study focuses on determining the parameters of the contact binary star KIC 7766185 by PHOEBE. The data of the study come from two sources: the spectroscopic observation from the Kitt Peak National Observatory and the light curve from Kepler mission. Regarding the former, the author uses the FXCOR task of IRAF, a Fourier cross-correlation method, to extract the radial velocity. Among 7 spectra, the author can obtain 4 with reliable measurements, leading to 8 data points for radial velocity in total (4 for each star). This radial velocity curve and the Kepler light curve are used to optimize inclination, mass ratio, fillout factor, temperature ratio, and semi-major axis by the Nelder-Mead method in PHOEBE. Next, the author employ the Markov Chain Monte Carlo (MCMC) to obtain appropriate error ranges on the optimized parameters. The study has two MCMC runs. In the first run, there are 16 walkers for 3000 iterations, and the mass ratio and asin(i) values are obtained. The author also proves that this first run reaches convergence through the corner plot and the log probability plot. However, the second MCMC sampling for other parameters – fillout factor, inclination, temperature ratio, and passband luminosity – has not converged yet. Moreover, the study also evaluates the period change of KIC 7766185 by using the O-C diagram. The study detects no period change between the Kepler data (2013) and the TESS data (2019). Therefore, the author emphasizes that the star is not a red nova candidate. Lastly, the study corrects the ephemeris provided by the Kepler Eclipsing Binary Catalog, specifically from 2454954.554702 to 2454954.55433995 Julian date.

Recommendation: accepted with minor revisions.

Justification

a. Major points

- Binary analysis:
  - *"the semi-major axis of the system was set by visually inspecting the radial velocity curve"*: the author should explain how he inspects the radial velocity curve.
- Discussion
  - *"However, analysis of the O-C diagram reveals no period changes between the Kepler and TESS observations. Therefore, KIC 7766185 is not a red nova candidate"*: The time difference is only 6 years (short compared to the life time of stars), is it too little to conclude if the period actually changes?

b. Minor points

- Abstract:
  - The word "conducted" is overused (3 times).

- Introduction:
  - "*Figure 3 displays the model …*": While I understand the author refer to the shape which can only be shown after the analysis, it is weird to see Figure 3 before Figure 1 and 2. I think in a paper, the first figure listed should be 1. Because this is just introduction, I suggest that the author should remove this part "Figure 3 … shape of W Ums stars."
  - "*W Uma stars have 3 sub-types … above 1000 K"*: this paragraph introduces the types of W Uma stars, but the previous paragraph ("*Due to … more than 1000 K*") already explains one specific type. These two paragraphs should be reversed or arranged differently.
  - "*W Uma stars have 3 sub-types … above 1000 K*": this paragraph does not have any citations for the first and second sentences.

- Observation:
  - *"Several measurements … a phase folded light curve"*: a period of the star should be specified here.
  - *"The Kepler light curve is displayed in Figure 1"*: this is a folded light curve, not just a light curve.
  - *"the outliers were removed using the outlier removal function"*: the author needs to explain what this outlier removal function is or what mechanism it uses to remove outliers.
  - *"The binary analysis was conducted with the Kepler light curve only*. *The TESS measurements were only utilized for the period analysis section."*: the author needs to explain why he used one but not the other for the binary analysis.
  - *"They were reduced in IRAF using the echelle package"*: citations for IRAF and echelle package are needed.
  - *"The deepest lines … telluric interference"*: more explanations or definition of telluric interference should be mentioned.
  - *"The most prominent real absorption lines … 4861 Angstrom"*: I think this sentence moves away from the author's discussion on how to reduce the spectra. I would suggest the author to remove this sentence.
  - *"The phase was calculated … Kepler Eclipsing Binary Catalog"* citation for the catalog should be listed again here.

- Radial velocity measurements
  - "*For each range, the VHELIO measurement…"*: the definition of the VHELIO measurement should be provided.

- Binary analysis
  - *"The values reported in the literature were inputted as initial values"*: the author should refer back to Table 1 here.
  - *"Once the initial values were tweaked to moderately match the data…"*: the author should provide the initial values after being tweaked here.

- *"The Nelder-Mead method of minimization was first proposed…":* the author should briefly mention how this method works.
- *"Since the radial velocity curve only consists … just the radial velocity curve"*: I do not see the connection between these 2 sentences, the author should explain in more details here. For example, why can't the radial velocity parameters be optimized by both the light curve and the radial velocity curve?
- *"While the Nelder-Mead Optimizer can be used to … they are under-estimated"*: citations or explanation are needed.
- *"MCMC (Markov Chain Monte Carlo):* I think it should be Markov Chain Monte Carlo (MCMC). Also, more explanations on how MCMC works should be stated (for example, what is the concept of Monte Carlo? Does it use randomization?).
- *"A set of prior distributions may also be added to the sampler"*: to the knowledge of the reviewer, prior must be added for MCMC to run, not just "may".
- *"PHOEBE utilizes the MCMC sampler emcee developed …"* : the author should explains what are the differences (if any, or what is special about) between *emcee* and other MCMC sampler.
- *"The log probability plots computes the log probability for each walker at each iteration"*: the author should explain what log probability after each walker is.
- *"The first MCMC run returned … for mass ratio of …"*: the author should explain what the errors associated with the values of asin(i) and mass ratio are (for example, are they 1-standard deviation, or are they 16% and 85% quantile values, or are they something else?)
- *"The radial velocity parameters have errors determined from MCMC sampling"*: similar to the previous comment, the author should explain what the errors actually are (standard deviation or quantile range).
- The corner plots should be bigger, the numbers on the plots are hard to read.

- Period study
  - *"Thermal Relaxation Oscillation (TRO) and Angular Momentum Loss (AML)"*: need citations for these two concepts.
  - *"using the Find Extremum function in Peranso"*: citation for Peranso is needed here.

- Discussion
  - *"While the temperature reported by Kepler is not reliable as a primary temperature"*: citations or explanations are needed.

Evaluation

The length of the paper is appropriate and the topic is appropriate for the journal. The author should mention more numerical results in the abstract. Also, as he did the period analysis, the author should include that in the title as well. The contribution to science is significant, especially the author better determine the star's parameters and the star's Kepler ephemeris. The English in the paper is easy to follow, however, a good amount of citations are missing in the paper. Besides the results of the second MCMC run that is yet to finish, the results in the paper

are stated clearly. Regarding the data management plan, the author should explain how he plan to publish the Kitt Peak Observatory spectra data. Other than that, the Kepler and TESS data are already publicly assessable.

All my comments are constructive reviews and sometimes they can come from personal preference or personal experience. Please understand if I misunderstand you in some points.

Congratulation on your work and I enjoy reading the paper. Good luck on the results of the second run.

Note to the Editor – Conor

To the Editor-

I stand by my review of this paper, the editor is free to disclose my identity to the author, should it be requested. I did not find any truly significant issues with this paper. The research was very clearly laid out to the reader and had an impressive flow/narrative. There were a few minor points where I would have appreciated clarification of certain terms or methodologies, but otherwise, I found no fault with it. I would certainly recommend the publication of this paper due to its importance in the study of stellar astrophysics. In the interest of a complete and fair analysis, I would like to make it known that, having done research in the field of eclipsing binary systems, I already have a fair amount of the background knowledge needed to understand the inner workings of this paper. This may have affected my review of the research because I am already partial to the jargon used by this community.

Best regards,

Danielle Mortensen

Conor Review

Summary:

The author conducts a study of the contact binary KIC 7766185. They obtain observational data from both *Kepler* and *TESS* and create lightcurves from which an analysis can begin. Spectroscopic observations were taken from archival data from Kitt Peak National Observatory. From here, radial velocity measurements were obtained through *IRAF*'s FXCOR task. Out of seven spectra obtained, one (with a phase of nearly 1) was used as a template. A binary analysis using *PHOEBE* was then carried out for characterizing KIC 7766185. The optimized values (using MCMC) were inclination, mass ratio, fillout factor, temperature ratio, and semi-major axis. Values for the mass ratio and *asini* were run separately through MCMC first and converged after 3,000 iterations. Separately run were optimizations for fillout factor, inclination, temperature ratio, and passband luminosity. This MCMC run did not converge after around 300 iterations. The author acknowledges that this lack of convergence does not allow for accurate error estimations on the second round of stellar parameters. Finally, the author conducts a period study through which they use *Kepler* and *TESS* data to calculate an O-C curve and determine any change in period of this contact binary over the course of six years. It was determined that there has been no detectible period change, therefore the stars are unlikely, at this point, to have fully decaying orbits and produce a red nova. In addition, the O-C curve indicated that the ephemeris value in KIC are incorrect, and the author provides a more suitable value.

Recommendation:

I would recommend that this paper be **accepted with minor modifications**.

Justification:

- *Major Points:*
- *Minor Points:*
    - Abstract: "We report a new value for the ephemeris of KIC 7766185."
        - What is this new value? These results should be present in the abstract.
    - Section 2: Equation (1)
        - The variables "T_0" and "T_obs" are never explicitly explained.
        - It also may be helpful to change these variable names because "T" was previously (in Table 1) used to refer to stellar temperatures rather than times.
        - Same goes for Equation (2).
    - Section 4: "…the semi-major axis of the system was set by visually inspecting the radial velocity curve."
        - Since this one was done by hand, perhaps the author should explain the process of estimating the semi-major axis via the RV curve.
    - Section 5: "…there is no period variations throughout the *TESS* Sector 14 observations and no period change between the *Kepler* measurements…"

        - Would 6 years difference in data have created a significant enough change in period to have noted in the O-C curve? Especially if these objects may have orbital decays of much longer times.
    - Section 6: "The determined value (0.04257) has a percent difference of 126.591%..."
        - The author does not explicitly mention possible cause of this rather large error from literature with which the mass ratio and temperature ratio aligned well with. Is there any reason for why this might be?

Evaluation:

- *Is the paper length appropriate?*
    - Yes. The paper seemed to explain everything in depth but also maintained concise wording.
- *Are the title and abstract sufficiently informative?*
    - Yes! Quirky and informative title and wonderfully written abstract. The abstract gives a detailed description of the research and the results.
- *Is the contribution to science significant?*
    - It may be beneficial to explain the importance of this in-depth study further in the discussion or conclusion. While the research does correct a value in the Kepler Input Catalog and provide parameters for KIC 7766185, it is not immediately clear why this specific contact binary is a special case worth reviewing in the scientific community.
- *Is the level of English adequate?*
    - Yes. Easy to read and understand.
- *Is the work properly grounded in literature?*
    - Yes. Literature was referenced throughout the paper for previous studies and analysis of this particular system along with an in-depth explanation of contact binaries in the introduction section.
- *Are the results clearly and accurately presented?*
    - With the exception of the new ephemeris not reported in the abstract, yes, the results were clearly presented within the paper.
- *Is the topic appropriate for the Journal?*
    - Yes. The author's research is a clear fit for this Journal being on the topic of contact binary analysis.
- *Is the data management plan good?*
    - Yes. The author clearly states every piece of software used for this research and acknowledges that both *Kepler* and *TESS* data (free to the public) were used in this analysis.

Final Comments:

This was an absolute delight to read! The paper was extremely careful in giving full explanations of the circumstances of this research and presenting the results. It was both easy to read and

extremely concise and informative. I hope these comments are accepted as constructive criticisms and the author finds them helpful. My best wishes in their success!

Summary:

This paper details an analysis of the contact binary KIC 7766185. Photometric observations by the *Kepler* space telescope and the *TESS* telescope were utilized along with spectroscopic observations from the Kitt Peak National Observatory. A light curve was generated using the *Kepler* data. Radial velocity measurements were obtained using the Fourier cross-correlation method. Spectrum 4 was used as the template against which to measure the shifts of the other spectra. Using the radial velocity curves, a binary analysis was carried out in *PHOEBE*. A forward model was first built using literature values as initial parameter values. At this point, optimizers were used to best fit the system parameters to the radial velocity curves given. Once a fit was found, the parameters (inclination, mass ratio, fillout factor, temperature ratio, and semi-major axis) could be determined. Error ranges were determined using MCMC sampling. A period study was also conducted using the *TESS* light curve. It was found that the ephemeris reported for the *TESS* data was off and a new value is reported. The paper then discusses the results and compares the values with previously reported values across various literature.

Recommendation:

Accept with minor revision

Points of Consideration:

Major:

None

Minor:

State new ephemeris value in abstract

§2.1 author could explain how we know the stars are late type as this is an important trait here

§2.1 author could state why binary analysis only used *Kepler* data while *TESS* was only used for period analysis

§2.2 a brief explanation on telluric interference would be helpful

Mark the H_α and H_β lines on Fig 2 for clarity

Figure 4: blue overlaid on black is hard to see

Paper would benefit from an additional proofread

Evaluation:

Length:

Length is appropriate

Title and Abstract Sufficiency:

Both title and abstract sufficiently describe the research conducted

Contribution to Science:

The paper provides an additional conclusive analysis on KIC 7766185 as well as provides validity to the power of binary analysis using *PHOEBE*

Level of English:

Paper is easy to read, and language used is understandable

Literary Citations:

All credit is given where due. Introduction and values used are all properly cited

Clarity and Accuracy of Presentation:

Results and process are clearly worked out step by step with all determined properties clearly listed and labeled

Topic Appropriate for Journal:

The topic of this paper is appropriate for this Journal

Data Management Plan:

All data is publicly accessible as well as software used. Process is repeatable

Additional Comments:

This paper is extremely well constructed. The presentation of necessary background information as well as the process by which the analysis was carried out is clearly described. In the hope that the author accepts these comments, I accept the author's work and compliment them on their hard work and results. My highest compliments to the author.

Title: Stellar Peanuts: Binary Analysis of KIC 7766185

Author: Conor M. Larsen

Summary: The author first presents background information on the contact binaries known as W UMa type stars. Despite various studies on W UMa stars, there remains many open-ended questions in the field, such as their origin and evolution and the mechanisms for angular momentum loss. The study conducts a binary analysis the contact binary KIC 7766185. The target has photometric observations from the *Kepler Space Telescope* and the *Transiting Exoplanet Survey Satellite* as well as spectroscopic observations from Kitt Peak. He obtains radial velocity measurements using *IRAF* and optimizes the parameters (inclination, mass ratio, fillout factor, effective temperature ratio, and semi-major axis) using *PHOEBE*. He then begins to determine error ranges on the system parameters by conducting MCMC sampling. The system parameters generally align with literature values except for the fillout factor, which has the largest percent difference. In addition to a binary analysis, the study includes a period analysis of KIC 7766185 by creating an O-C diagram. He concludes that no period variations exist amongst the data, but the *Kepler Eclipsing Binary Catalog* value for ephemeris is incorrect. Finally, he uses the study to determine the subtype classification for KIC 7766185 as an A-Type W UMa star by looking at the effective temperature ratio.

Recommendation: Accept after minor revisions.

Justification of Recommendation:

Minor points:

- The fourth paragraph in the introduction section discusses how stars in W UMa systems typically have the same temperature. The next paragraph then describes three sub-types that all consist of two stars with different temperatures. The author should clarify that A-type and W-type systems are the ones previously discussed with low temperature differences to avoid this confusion.
- Section 2.1 classifies KIC 7766185 as a W UMa system because of the equal depth eclipses and the late type stars. However, the author does not state how he knows that the stars are late type stars.

- The large empty space between the end of Table 2 and the beginning of section 3 should be deleted. The same formatting issue happens again after Table 3 and before Table 4.
- Section 4 references values from literature that the author put into his *PHOEBE* code as initial values. He should state the inputs *PHOEBE* takes for initial values, so the reader knows what parameters he took from literature.
- The blue line in Figure 4 is hard to see compared to the light curve data in black. It might help to change the model light curve to a light/ brighter color.
- The author states that the Nelder-Mead Optimizer underestimates error ranges on the system parameters. If there is a specific reason for the underestimation, then the author should include this as justification for switching to MCMC for error ranges.
- The term "fillout factor" should be quickly defined because it is brought up multiple times throughout the paper.

Major points:

- The author needs to complete the second run of the MCMC sampling to obtain error bars for the light curve parameters.

<u>Evaluation:</u>

1. Is the length appropriate?
    a. Yes – the length is appropriate, but some parts could use a more in-depth explanation (see justifications above).
2. Are the title and abstract sufficiently informative?
    a. Yes – the title and abstract are sufficiently informative. It might be worthwhile to consider adding "period analysis" to the title because the author conducts both a period and binary analysis. This is not an essential change.
3. Is the contribution to science significant?
    a. Yes – the project conducts an in-depth study that has not been done before on the contact binary KIC 7766185.
4. Is the level of English adequate?
    a. Yes – the level of English is adequate.
5. Is the literature properly cited?

    a. Yes – the author sufficiently cites necessary resources.
6. Are the results clearly and accurately presently?
    a. Yes – the results are presented clearly and accurately.
7. Is the topic appropriate for this journal?
    a. Yes – the topic is appropriate for this journal.
8. Data management plan?
    a. If the study is published, then it will provide a list of absolute parameters for KIC 7766185.

Additional Comments: Kudos to the author for delving into a complicated binary and period analysis in such a short (and busy) time frame. The author has clearly become a mini-expert in his research topic.

Author: Conor Larsen

Title: Stellar Peanuts: Binary Analysis of KIC 7766185

Summary:

The author provides an overview of contact binaries and of their respective classifications, detailing the properties that fall under each one. Gathering information from the latest Gaia data release (EDR3), the target has not yet been the subject of independent analysis, but only through a pipeline project. The target KIC 7766185 will be analyzed in-depth and the following parameters will be determined: radial velocity measurements, binary analysis, and a period study to determine if any variation is detected. Photometric observations were made by both *Kepler* and *TESS*. Spectroscopic observations were made by the telescope at Kitt Peak National Observatory in Arizona. The parameters for the observations are also stated. The epoch is calculated for each spectra and the phase is also determined from this. The radial velocity was calculated through FXCOR, a tool within the software *IRAF*. One spectrum is used as a template and helps determine the shift of the other spectra. Of the 7 spectra, 3 and 7 were too inconsistent to include and 4 was not included. The binary analysis was completed through *PHOEBE* and a model was made in which initial values were derived from previous literature. Optimizers were also utilized to refine the initial values. The optimized parameters were: inclination, mass ratio, fillout factor, temperature ratio, and the semi-major axis. With these optimized parameters, plots such as a mesh plot, radial velocity curve and others were created. Some of the priors are still in the process of being retrieved. For the period study, the author's objective was to uncover whether or not there's deviations in the target's *o-c* values. However, no deviations were found but the fact the fit was below the x-axis signifies that the ephemeris is incorrect.

Recommendation: Accept with minor revisions.

Justification

Major Points:

- There are a couple of instances throughout the paper in which the author mentions concepts/methods utilized within the study, but does not expand on it which stirs some confusion.

Minor Points:

- The order in which the figures are mentioned in the paper are out of order (*Figure 3* is the first figure mentioned in-text and not *Figure 1*). The author could make it so that they appear in the appropriate order.

Evaluation:

1. Appropriate Length
    a. Yes, the length of the paper is appropriate.
2. Title and Abstract
    a. Yes, both the title and abstract are very informative to the nature of the project and efficiently provides a brief summary on what the study is along with the results.
3. Scientific Contribution
    a. Yes, the contribution to science is significant and the author makes a point of specifically mentioning the importance of following up on objects that are a part of pipeline projects.
4. English Level
    a. Yes, the level of English is adequate.
5. Literature Citation
    a. Yes, the literature is properly cited in text.
6. Results Presentation
    a. Yes, the author does present the results in an organized manner, so far as to create a table that includes them. The author is still waiting on some of the results as well and will include them on the final version of this paper.
7. Topic
    a. Yes, the topic is appropriate for this journal.
8. Data Management Plan
    a. The author makes note that the data utilized in the study will be made for public release.

Additional Comments: Reading this paper, it is becoming more and more impressive how the author was able to pull it all off, especially within such a short period of time. Good job!

Summary

The author first starts out by describing what contact binaries are and introducing the category W UMa, which the star in question KIC 7766185 falls under. The author uses data obtained from Kepler to complete the binary analysis, Tess to complete the period analysis, and Kitt Peak to produce spectra. He calculated the phase using the ephemeris and period from the Kepler Eclipsing Binary Catalog for each spectrum taken and then obtained the radial velocities for 4/7 of the spectra. Then, he conducted a binary analysis which produced the parameters of inclination, mass ratio, fillout factor, effective temperature ratio, and semi-major axis by using optimizers. Finally, to obtain error estimates, the author used MCMC sampling. The next part involved creating an O-C diagram to observe period changes of the system over time. The author found that there are no period variations, indicating that this system is not a red nova candidate. He also verified that this is an A-type W UMa star.

Recommendation

Accept with minor revision.

Justification of Recommendation

Major points:

1. There were no major points that compromise the integrity of the paper or methods used.

Minor points:

1. In the abstract, I think it would be beneficial if the author gave a sentence or two of background about contact binaries and their importance so the reader has a better idea of what is going on right away.
2. In the abstract, the author says that the ephemeris from a past study done on this system is “incorrect.” I do not think that this is the correct way of denouncing another study, especially in the abstract. It is a very bold claim and immediately made me suspicious when I read it. I think it would be better to say something like “a different ephemeris was reported” or something along those lines, rather than just outright saying a published value from a well-known study is wrong.
3. I think the entire introduction section is a little wordy and disorganized. Things can definitely be more concise, and I am not sure about the overall language used. It does not seem extremely professional and geared to people in the field. It seems like the author is talking to an audience of ameteur astronomers.
4. In the introduction, the author refers to figure 3, which is part of the results. It would make more sense to first refer to a figure 1, and not to a figure from the results this early on in the paper.
5. In Table 1, the author lists “sini” as an element, but I am not sure what “i” stands for. I think it should be labeled. Similarly, the author lists “asini” also, but I do not know what that is. Lastly, in Table 4, Rsun is listed, but maybe it would be important to know a value for that.
6. The author uses the phrase “in-depth” study to describe what he is doing, however he does not exactly specify what an in-depth study entails and how it is different from studies done in the past (in the intro).

7. Figure 2 is an example spectra, but I think that it would be good to see all of the spectra in an image appendix.
8. This sentence is in section 3: “By using one of the obtained spectra as a template, the systemic velocity cannot be determined, however, this information is not important for determining system parameters through binary analysis.” What is the point of this sentence if the information is not important anyways?
9. Section 3 is a little disorganized and wordy. This sentence is towards the end of the paragraph: “Spectrum 4 was used as a template and thus could not be used to obtain measurements.” This is the second time that the author mentioned Spectrum 4 was a template, and I don’t think it was necessary to repeat.
10. Why are the parameters from the Nelder-Mead Optimizer under-estimated?
11. What is convergence? I am not sure if that is something which should be explained or if it is something that I should have already been aware of. Based on the rather basic language used in the rest of the paper, it seems like something which should be explained.
12. The author mentions again about the *Kepler* study being incorrect, but I think there needs to be more information about why it is incorrect if he wants to keep such a bold statement.
13. Why is the temperature reported by *Kepler* not reliable as a primary temperature?
14. There are 3 or 4 instances where there should be something cited. For example, the author states “A-Type systems occur when the hotter star is the larger star.” Where did this come from?

<u>Evaluation</u>

1. Paper length
    a. I think the paper is a little too wordy and can be slightly shortened by tightening some things up and being more concise.
2. Title & abstract
    a. The title very much depicts what the paper is about. Aside from needing a sentence or two of background information, the abstract does as well describe the paper.
3. Contribution to science
    a. This is definitely a significant contribution to science and will be meritorious to the journal.
4. Level of English
    a. Some places are not extremely professional, but for the most part it is a well-written paper.
5. Literature
    a. There are a few instances where I would have liked to see an additional reference on some open-ended claims.
6. Presentation of results
    a. The results are clearly stated in Tables with errors and they are within reason of the methodology.
7. Topic appropriateness

a. This topic is appropriate for the journal.

Data Management

I do think that the results are reusable. I think that others can likely redo the analysis to corroborate the results.

Additional Comments

It seems like the author did a ridiculous amount of work on this in such a short amount of time, which is very commendable. It is a great topic and I think it has a lot of publishing-potential, so congratulations to him on a great work.