Collecting Data on Brightness Variations in the Central Stars of Planetary Nebulae Using Sky Surveys

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Abstract

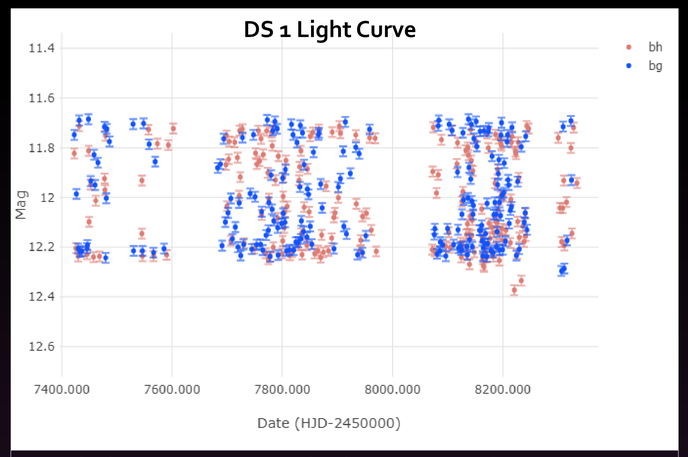
Research on planetary nebulae is shifting from the source of their fascinating shapes to details on how those shapes are created. The overall goal of this project is to measure the fraction of planetary nebulae that have binary central stars. In order to do this, a large amount of data is required. So, we took the list of planetary nebula targets identified in *Gaia* data and a list of nearby, known planetary nebulae and ran them through available online databases. These databases provide data on the brightness of these stars over time. For over 2,000 objects from the *Gaia* list, the Catalina Sky Survey (CSS) had data on 35 of them. 16 objects exhibited possible variability. Using the Palomar Transient Facility (PTF) and the Zwicky Transient Facility (ZTF) databases, only 4 of those appeared in the PTF and 6 in the ZTF. We narrowed the initial *Gaia* list to only objects with magnitudes from V = 14-16 and ran them through the All-Sky Automated Survey for Supernovae (ASAS-SN). Out of 123 objects, we found data for 96. We ran the entire list of nearby objects through ASAS-SN and found data for 113 objects out of 167. We ran period searches on the data found from ASAS-SN using Period04. 14 of the objects from Gaia and 28 of the objects from the nearby objects list looked potentially variable. We present here results on some of the detected variables, preliminary statistics and a discussion of the search process.

Sky Surveys

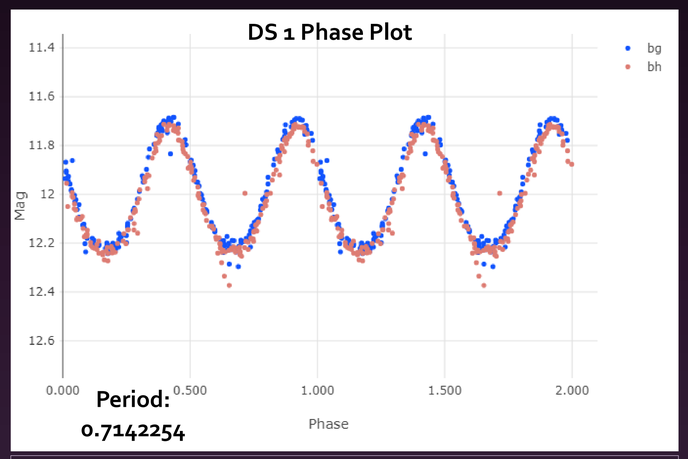
- We created a list of PNe identified in the *Gaia* catalog (Chornay & Walton 2020) resulting 2118 objects.
- These objects were run through the Catalina Sky Survey (CSS) *orphancat* catalog.
- Only 35 objects had data, of these 16 were potentially variable.
- Of those 16 objects, 4 appeared in the Palomar Transient Facility (PTF) and 6 appeared in the Zwicky Transient Facility (ZTF).
- We used the *Simbad* database to perform a background literature search on the 16 potentially variable objects from CSS.
- We sorted the *Gaia* list by magnitude (V= 14-16) and ran those objects through the All-Sky Automated Survey for Supernovae (ASAS-SN).
- We also ran the entire nearby object list through ASAS-SN the results are below.
- Since ASAS-SN does not have a bulk search option, these lists were run manually.

ASAS-SN Results	*Gaia* (V= 14-16)	Nearby Objects
Number of Objects	93	146
Number of Potential Variables	14	28
Number of Known Variables	10	27
Number of Periodic Variables	20	40

51 objects were excluded from the total number of objects because they required further in-depth analysis.

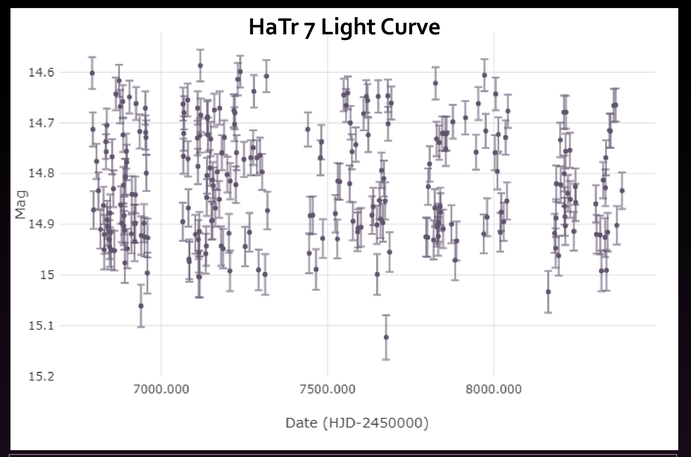


Credit: https://asas-sn.osu.edu/photometry/e8cd31c8-e279-5a95-b273-39e39f40b229



Credit: https://asas-sn.osu.edu/variables/3f881824-8773-5edc-b132-53fb50284aab

Image: DS 1 in the H alpha filter
Parker, Q. A., Phillipps, S., Pierce, M. J., et al. 2005, *MNRAS*, 362, 689.



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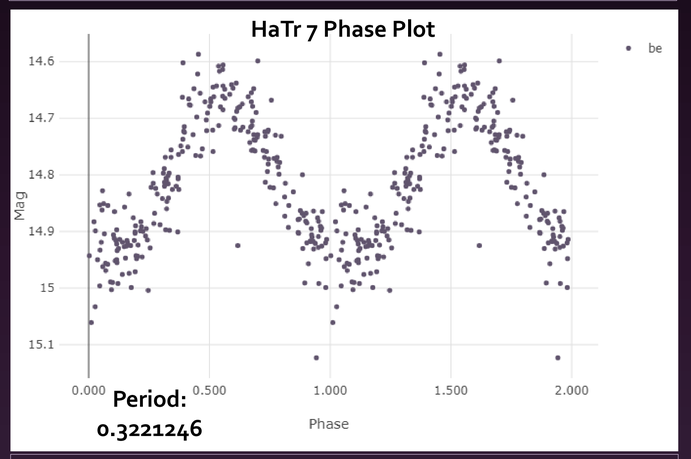

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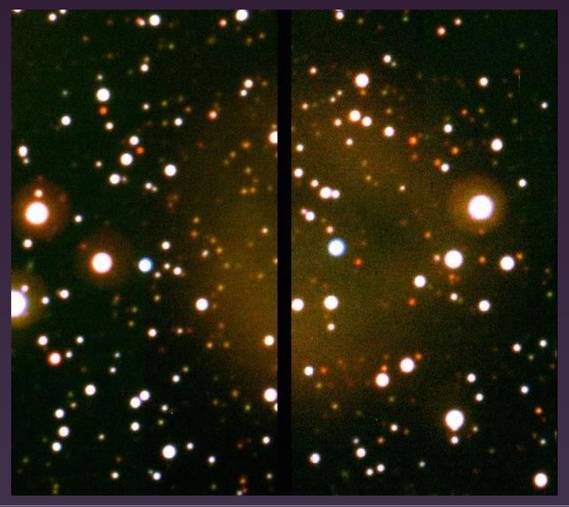

Image: HaTr 7; composite of the B, V, R filters
Hillwig, T., Frew, D., Reindl, N., et al. 2017, *AJ*, 153, 24.

Results

- Potential Variables/ Number of Objects
  - (14/93)*100= 15.054%
  - (28/146)*100= 19.178%
- Known Variables/ Number of Objects
  - (10/93)*100= 10.753%
  - (27/146)*100= 18.493%
- Periodic Variables/ Number of Objects
  - (20/93)*100= 21.505%
  - (40/146)*100= 27.397%
- Preliminary Binary Fraction
  - (60/ 239)*100= 25.104%

A recent paper (Jacoby et al. 2021) showed a binary fraction of 20-25%. Our preliminary binary fraction falls nicely near that calculated binary fraction.

References

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