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Finding Variability in Proto-Planetary Nebulae

Avery M. Jackson
Valparaiso University, avery.jackson@valpo.edu

Matthew T. Bremer
Valparaiso University, matthew.bremer@valpo.edu

David M. Vogl
Valparaiso University, david.vogl@valpo.edu

Finding Variability in Proto-Planetary Nebulae

Matthew Bremer, Avery Jackson, David Vogl, and Bruce Hrivnak
Department of Physics and Astronomy, Valparaiso University

Abstract

We observed 44 evolved stars that are in the phase between red giants and white dwarfs. This stage is called proto-planetary nebulae (PPNe). We observed these objects on 33 clear nights this summer. Nearby comparison stars are also observed along with the PPNe each night. We then reduce these images to get quantitative measurements of the brightness of the PPNe in relation to the comparison stars. The measurements are then plotted as light curves to show the variation of brightness over time. This variation in light is due to pulsation of the PPNe. For our project, we combined our data with observations made since 2008. We then analyzed the variation of light in a subset of 12 PPNe. We found periods of variation that range from 40 to 160 days.

Background

- The PPNe stage is the stage between red giants and white dwarfs
- PPNe are wrapped in dust cocoons left over from the AGB phase[1]
- PPNe pulsates due to gravitational instability, causing the star to vary in brightness
- Light variation is on the range of 35 to 140 days[2]
- PPNe stage lasts for about 1000 years

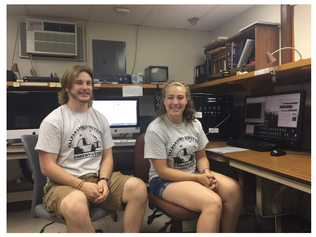
Observations

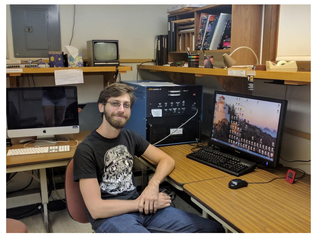
Valparaiso University Observatory (VUO)
- 0.4 meter Cassegrain telescope
- CCD camera
- Red (R), Visual (V), and Blue(B) filters

We have a list of 44 PPNe that we image at the VUO. We observed these objects on 33 clear nights. Each night we set an observing plan based on the sky conditions and observing priority of each object. For each PPN, we observe the object and three comparison stars. We take exposures ranging from 1 to 2700 seconds based on the brightness of the object.

Image of the VUO

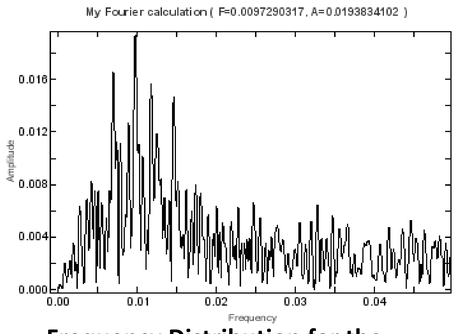
Image of finding chart for IRAS 22223+4327



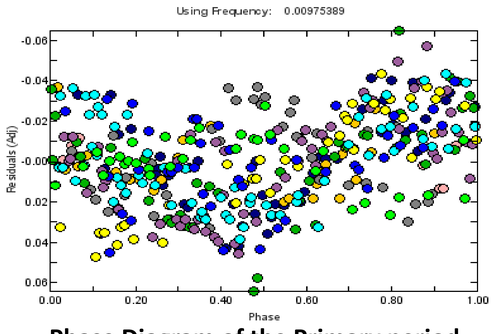


Period Analysis

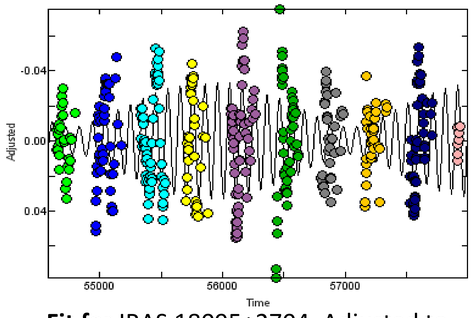
To analyze the data that we have taken, we use a program called Period04 (P04). P04 is a program designed to fit data sets with multiple sine functions simultaneously. Using a Fourier calculation method, it can superimpose multiple functions to complex light curves. It gives periods and their significance compared to background noise. Errors are calculated by a least-squares method. Our objects have periods between 40 and 160 days. Objects IRAS 18095+2704 and IRAS 22223+4327 are shown below.



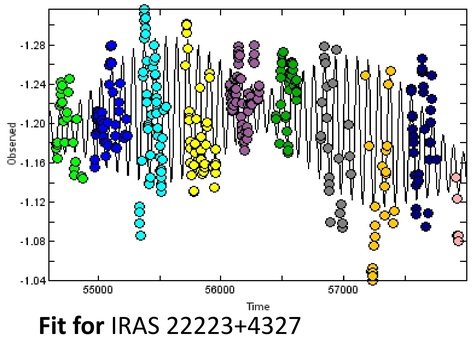
Frequency Distribution for the primary period of IRAS 18095+2704



Phase Diagram of the Primary period of IRAS 18095+2704



Fit for IRAS 18095+2704. Adjusted to account for monotonic increase in brightness.



Fit for IRAS 22223+4327

Results

Results in the V filter are shown below

Object	Period (Days)
IRAS 17436+5003	42.35 ± 0.02, 50.06 ± 0.04
IRAS 18075-0924	82.99 ± 0.21
IRAS 18095+2704	102.8 ± 0.1, 98.3 ± 0.2
IRAS 19039+1232	No significant period
IRAS 19207+2023	95.5 ± 0.1, 92.9 ± 0.2
IRAS 19306+1407	No significant period
IRAS 19475+3119	No significant period
IRAS 19500-1709	No significant period
IRAS 20136+1309	No significant period
IRAS 22223+4327	86.51 ± 0.06, 91.27 ± 0.13
IRAS 22272+5435	131.99 ± 0.09, 119.92 ± 0.07
IRAS 23304+6147	83.8 ± 0.2

Future Work

- Observations throughout the school year
- Further period analysis

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References

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2- Hrivnak, B. J., & Lu, W. (1997).Varibility Proto-Planetary Nebulae 1. Light Curve Studies of 12 Carbon-Rich Objects. Astrophysical Journal, 709, 1042.