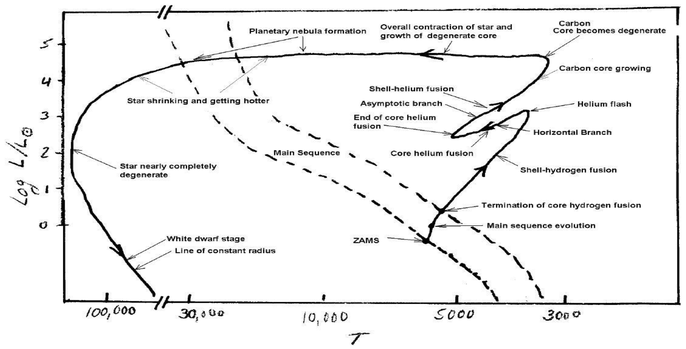
Reduction and Analysis of Photometric Data for 48 PPNe

Matthew Bremer, Mentor: Professor Bruce J. Hrivnak
Department of Physics and Astronomy, Valparaiso University

Abstract

We are carrying out research to determine the pulsation period of low-mass stars' life cycles called Proto-Planetary Nebulae (PPNe). The datasets come from our Valparaiso University Observatory (VUO), as well as the All Sky Automated Survey – All Sky Catalogue (ASAS-ASC), and the All Sky Automated Survey for Supernova (ASAS-SN). These datasets complement each other to ensure that we get high-quality data for our very faint objects over long intervals of time in both hemispheres. Observations for this project have been carried out at VUO for 25 years. The ASAS-ASC and ASAS-SN data recently became open to the public and we are using them in our analysis. We are using these three datasets to search for periodic photometric variability in 48 evolved stars. We do this by using a sophisticated period search program called Period04. Our research has found 18 objects that have one or more significant periods ranging from 37 to 208 days.

Background



- The PPNe stage is the stage between red giants and white dwarfs
- PPNe are wrapped in dust cocoons left over from mass ejected during 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

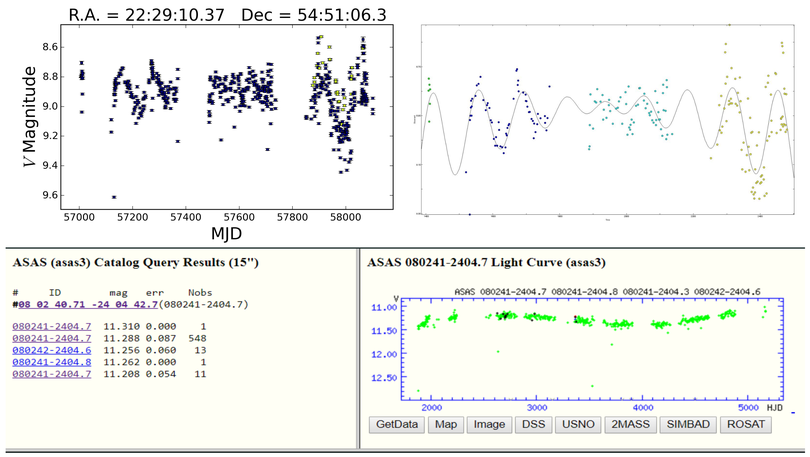
Observations

Valparaiso University Observatory (VUO)
- 0.4 meter Cassegrain telescope
- CCD camera, 2008 – Present
- Red (R), Visual (V), and Blue (B) filters

ASAS-ASC
- 2 telescopes, down to 14th mag faintness
- 2000 – 2009 data
- V filter, lower precision, search for long term trends

ASAS-SN
- 20 telescopes worldwide
- V filter, 2015 – Present, down to 17th mag
- High frequency observations, high precision
- Supplementary to our datasets

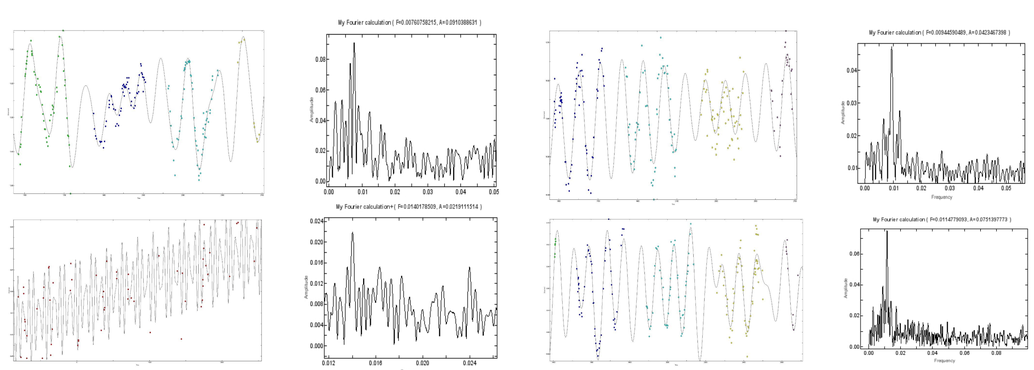
Data Reduction



- Data from ASAS-SN IRAS 22272 (top) and ASAS-ASC IRAS 08005 (bottom) database produce a range of quality
- Extract best quality data for our analysis

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. Uncertainties are calculated by a least-squares method. Our objects have periods between 35 and 200 days. Light curves of IRAS 20000, IRAS 04296, IRAS 19386, and IRAS 22223 and frequency spectrums are shown below as an example.



Results

Some results from the V filter shown in table below.

Object	Periods (Uncertainties) days	P1/P2
IRAS 04296+3429	53.3 (0.1), 71.5 (0.1)	0.75
IRAS 05113+1347	154.3 (0.4), 207.9 (0.4)	0.74
IRAS 07253-2001	73.8 (0.1), 73.3 (0.1)	1.01
IRAS 07430+1115	137.9 (0.5), 116.2 (0.6)	1.19
IRAS 17279-1119	90.22 (0.001), 90.20 (0.001)	1.00
IRAS 18095+2704	103.4 (0.1), 99.0 (0.2)	1.04
IRAS 19386+0155	105.6 (0.2), 116.8 (0.7)	0.90
IRAS 20000+3239	132.9 (0.3), 154.6 (0.6)	0.86
IRAS 20136+1309	146.5 (0.5), 84.4 (0.3)	1.74
IRAS 22223+4327	86.6 (0.1), 91.1 (0.1)	0.95
IRAS 22272+5435	131.6 (0.1), 112.7 (0.2)	1.17
IRAS 23304+6147	81.6 (0.2), 87.4 (0.3)	0.93

- Periods are found and compared to results from other datasets.

Acknowledgements

- Valparaiso University
- Department of Physics and Astronomy
- Professor Hrivnak
- The National Science Foundation
- Indiana Space Grant Consortium

References

1- Kwok, S. (2001). Cosmic butterflies: the colorful mysteries of planetary nebulae. Cambridge: Cambridge Univ Press.
2- Hrivnak, B. J., et al. 2010. Variability Proto-Planetary Nebulae I. Light Curve Studies of 12 Carbon-Rich Objects. Astrophysical Journal, 709, 1042.
3- Hrivnak, B. J., et al. 2013. Studies of Variability in Proto-Planetary Nebulae. II. Light and Velocity Curve Analyses of IRAS 22272+5435 and 22223+4327. The Astrophysical Journal, 766:116 (21pp).