Photometry & Python: Painting a Picture of Planetary Nebula Central Stars

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Abstract

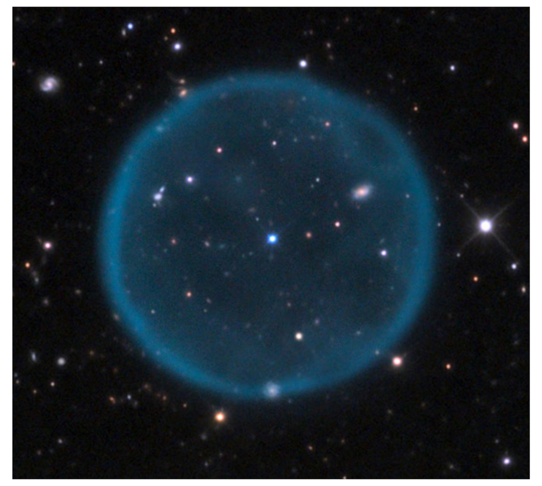
Planetary nebulae (PNe) are some of nature's most beautiful yet most mysterious objects. Many of these PNe have intricate shapes not expected to be produced by a spherical star. We want to further understand how their unique shapes are produced, especially those that do not fall within conventional classifications. Our research aims to study the effects binary star systems have on PNe. To study these objects, we use data collected from the observatories affiliated with the SARA Consortium, of which Valpo is a member institution. We then use photometry, measuring the magnitude of an object, to get better measurements of magnitude, temperature, and distance, among other values. While performing photometry is the main part of our research, we are also working on creating new Python code that more efficiently parses this information into a smaller amount of specific information that we can work with and analyze. The code takes the original images and measures the brightness of each star, allowing us to use these values to arrive at our final brightness measurements. We are improving existing code by adding more efficient Python packages that will further aid in the ease and speed of analyzing the data from these objects.

Background

- PN = second to last phase of a star with 8 times the mass of the sun or less
  - Once the red giant expends the fuel sources in its core, it ejects outer layers
  - Outer layers are full of different ionized elements, mostly hydrogen and helium
- PNe come in many unique shapes
  - Main classifications: spherical, elliptical, and bipolar
    - What causes the shapes?

      ➔Binary star systems?

NGC 2818 (Credit: NASA, ESA, and the Hubble Heritage Team (STScI/AURA)

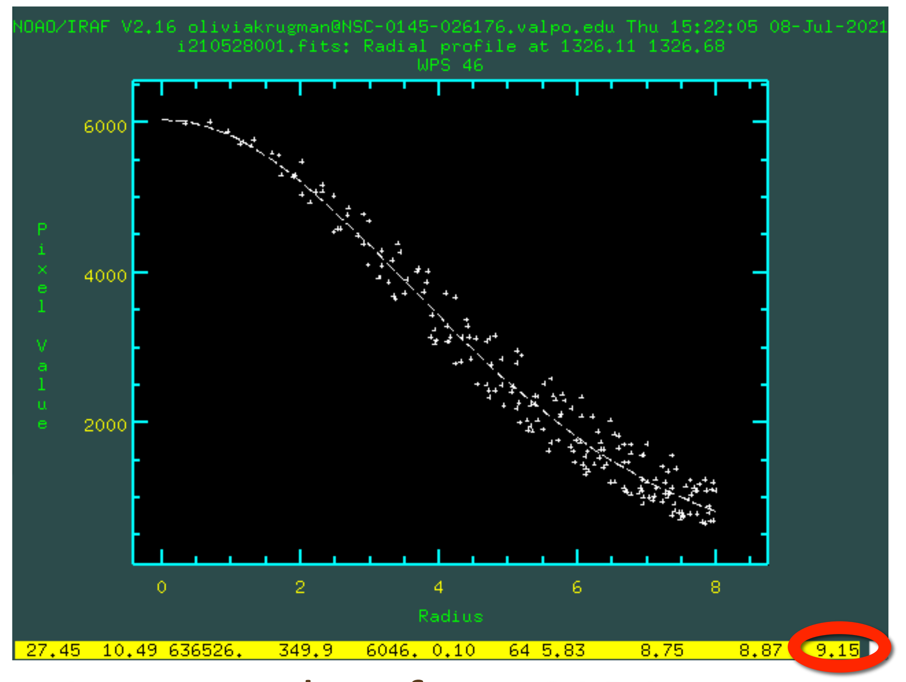


Abell 39 (Credit: Adam Block/Mount Lemmon SkyCenter/University of Arizona)

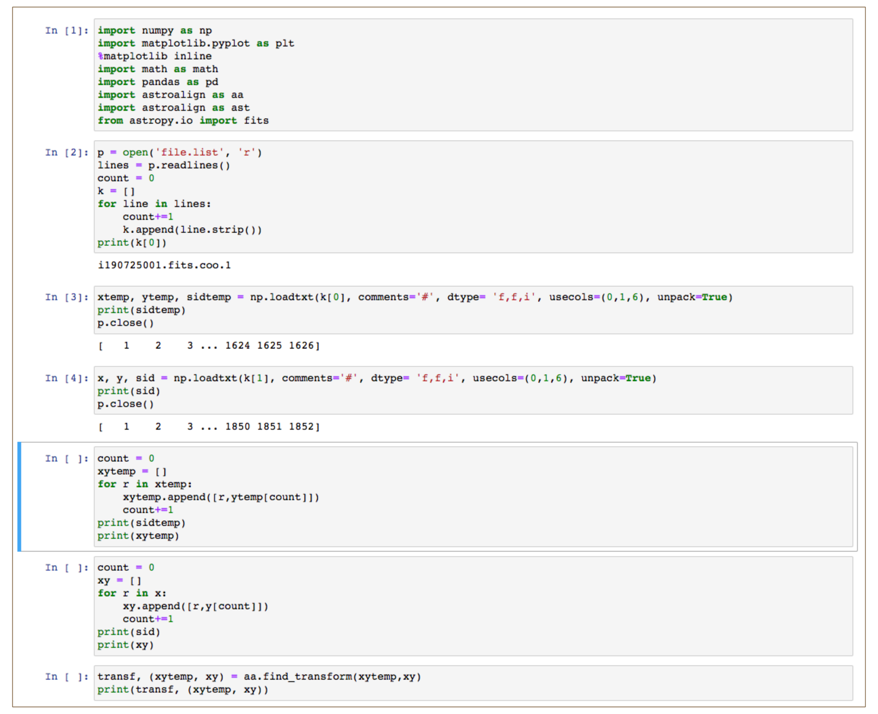
Main Points

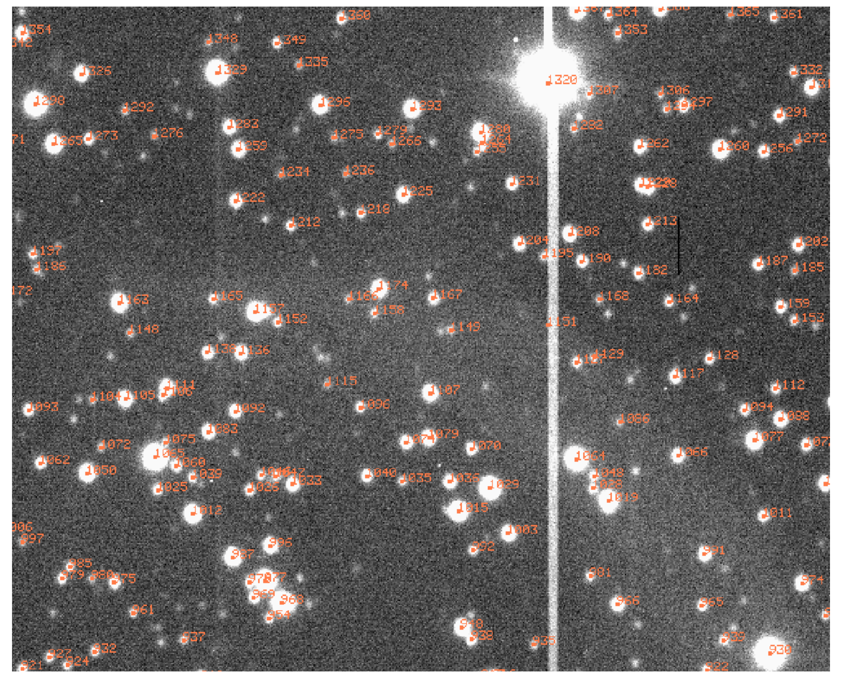
1. Reducing data taken from observations allows us to run photometry.
2. Photometry allows us to find stars in the images and gives us the stars' brightness.
3. Python code allows us to make comparisons with the sources to get a light curve on the central binary systems of PNe.

Data and Analysis



- Images taken from SARA consortium observations processed using IRAF
  - (pictured above) recorded the background counts and then averaged the FWHM for 3 stars to get an average FWHM for the image





- Next, performed photometry on these images using the average FWHMs and background counts
  - Photometric results provide star locations and magnitudes

- Code created in Python to run differential photometry
  - Differential photometry – taking the magnitudes of the target object and several reference objects and subtracting them
- Automating this code to run hundreds of images at once
  - Some PNe have upwards of hundreds of images to process

Conclusions

Due to the nature and time length of my project, we are not yet ready to present specific conclusions. We have the data necessary, but the code to process this data is still in progress. We have interesting photometric data processed using IRAF, and running that data through our Python photometry program will give us our final light curves. We will use those light curves to determine if these systems have a central binary star system, thus contributing to the binary fraction for PNe.

Future Work

- Taking more observations of PNe, both known and newly discovered.
  - Processing these images using the code I plan on finishing by the end of the summer
- Additional work on the code possible
- Once code is fully functional, using already photometrically processed data as input to provide light curves for the central star
  - Allowing us to determine if the central star of the PN is a binary star system

Acknowledgments & References

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