Spectroscopic Classification of Evolved Star Candidates

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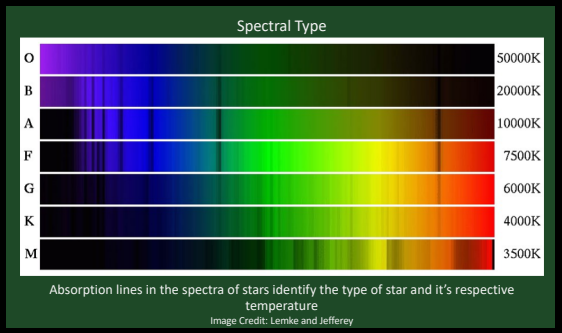
Abstract

Spectroscopy is a tool for determining the composition and physical properties of a material. Because stars have atmospheres composed of atomic or even molecular gas, the light emitted from the star interacts with the gas as it passes through the stellar atmosphere on its way to the Earth. This interaction results in absorption lines in the spectrum of the star. In this project, I analyze the spectra of a specific class of evolved stars called proto-planetary nebulae (PPNe), which are stars that have evolved through the red giant phase and are on their way to becoming white dwarfs. The spectra were taken by Professor Hrivnak at Kitt Peak National Observatory in 1992, 1995, and 2000. These targets were selected based on their strong infrared emissions, indicating circumstellar dust which is a characteristic of evolved stars. However, PPNe are not the only celestial objects that emit in the infrared. This project uses visible spectroscopy to determine whether or not these targets show signatures of an evolved star which will help confirm their identities as PPNe.

Background

Proto-Planetary Nebulae (PPNe)

- Transitional phase in a star's life [has nothing to do with planets!]
- After a star uses up it's hydrogen fuel, the star enters the Red Giant Phase
- Eventually the star ejects it's outer layers creating a Planetary Nebula (PN)
- A Proto-Planetary Nebula is the transitional phase between the Red Giant and a PN



Absorption lines in the spectra of stars identify the type of star and it's respective temperature
Image Credit: Lemke and Jefferey

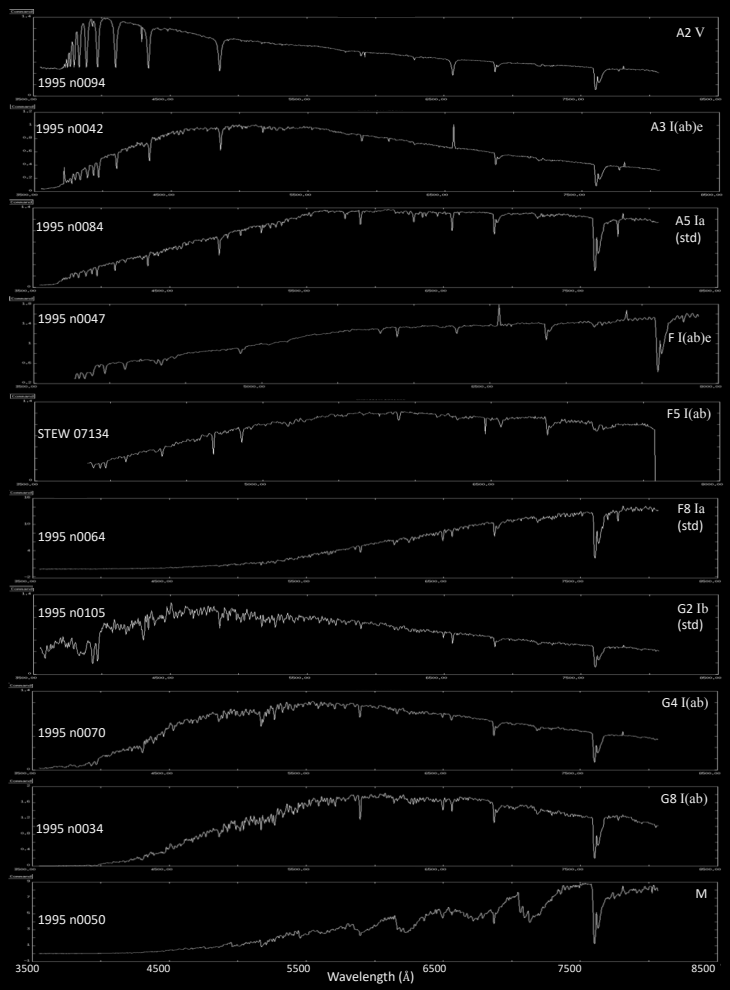
Stellar Classification

- Atoms in the stellar atmosphere absorb or scatter certain wavelengths of light
- These wavelengths do not reach the Earth and create absorption lines in a spectrum
- Absorption lines reveal spectral type and luminosity class

- Spectral Type
  - Type: O B A F G K M
  - Sub-Type: 0 - 9
  - Relates to temperature
  - Based on strengths of absorption lines in spectrum

Luminosity Class	
Ia	Bright Supergiant
Ib	Supergiant
II	Bright Giant
III	Giant
IV	Subgiant
V	Main Sequence

- Luminosity Class
  - Subtleties in spectra relate to size of star: Supergiant (I), Giant (III), normal (V).
  - Proto-Planetary Nebulae have Supergiant signatures (Ia, Ib)



The digital spectra presented here are a sample that have been classified and illustrate some of the significant and subtle differences between spectral types and luminosity classes

Research & Results

- This research project is searching for a spectral type from B to G with a supergiant luminosity class
- All of the spectra for this project are low resolution which allows for the observation of fainter stars and the ability to obtain a wider range of the spectrum at the expense of detail
- Emission (particularly Hα) is evident in some of the hotter stars (B and A)
- We relied on a technique that measured the equivalent width of the O I (7776 Å) line to determine the luminosity class in stars between A and G spectral types
- Initially went through all three datasets determining an initial classification focusing on the spectral type
- Currently working back through the data to reaffirm the spectral type but focus on determining the spectral sub-type and luminosity class

Image	Observatory	Classification	PPN
n40048	KPNO 1995	A0 Ve	No
n40054	KPNO 1995	A0 Ve	No
n40094	KPNO 1995	A2 V	No
n40042	KPNO 1995	A3 I	Yes
n40036	KPNO 1995	F I (metal-poor)	
n40047	KPNO 1992	F Ie(metal-poor)	
07134	STEW 2000	F5	
08359	STEW 2000	G1	
n40030	KPNO 1995	G4 I	Yes
n40070	KPNO 1995	G4 I	Yes
n40034	KPNO 1995	G8 I	Yes
n40040	KPNO 1995	M	No

- This table shows classifications determined from the second analysis of the spectra
- Some targets are determined to be metal-poor, making it difficult to accurately classify
- An "e" notates prominent emission in the spectrum

References

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