Classifying Infrared Emission Line Stars Using Optical Spectroscopy

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Introduction

- About 30% of B-type (massive) main sequence stars show emission line features in their spectra, indicating they have gaseous material surrounding them.
- 20% of these, called Be stars, have material that obeys typical Keplerian orbital motion.
- The remaining 10%, denoted as Bp stars for their peculiar spectra, have large-scale stable, magnetic fields, which traps the material in orbit, forcing it to co-rotate with the star.

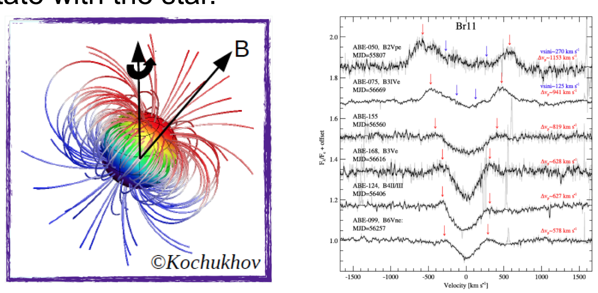

Figure 1: (Left) Model Bp star with magnetic field. (Right) IR Emission Lines of target stars from Chojnowski et al. (2015)

- A study by Chojnowski et al. 2015 analyzed infrared spectra of a large survey of B-type stars.
- By observing the broadening of the peaks within the line profile, due to the doppler shift, this spectra tells us how fast the material orbiting the star is moving.
- $\triangle V_{Peak}$ = the value for the velocity of the material orbiting the stars.
- Nine of Chojnowski's stars had emission features associated with either Be or Bp stars with large separation between emission peaks. These are the stars we used in our study.

Motivation

The purpose of this study is to distinguish the Bp from Be stars for a particular sample of stars. We need to recognize differences in the two orbital velocity scenarios, as the emission from their chemical makeup can appear similar. By identifying more Bp stars, we can better understand their behavior and properties.

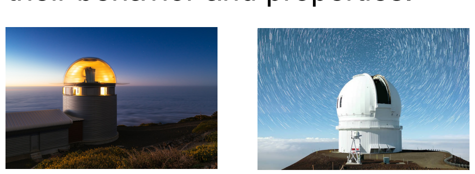

Figure 2: (Left) Mercator Telescope, Canary Islands. (Right) CFHT Telescope, Mauna Kea Observatory.

Method

- To classify whether these stars are Be or Bp, we compared the velocity of the material orbiting the star, $\triangle V_{Peak}$, to the star's line of sight projected rotational velocity, vsini, using these two criteria:

For Be stars- $\triangle V_{Peak} < 2$ vsini

For Bp stars- $\triangle V_{Peak} > 2$ vsini

- These relations indicate that without a magnetic field trapping the material rotating around the star, the material will orbit the star slower than the star is rotating, which follows typical orbital mechanics.
- We cannot measure the rotation of the star in the infrared since the stars are hot (~20,000 K) and emit very little light in the infrared.
- To measure an accurate stellar rotational velocity, we needed optical spectra, which did not exist for any of our target stars. We therefore obtained optical spectra from both the Mercator telescope in the Canary Islands and the CFHT telescope in Hawaii.
- To use the optical spectra to measure the star's rotational velocity, we wrote a program using Python to plot the raw data as a spectrum, and another program to add and average multiple observations to reduce the noise. We then wrote one last code to compare the line profile of the absorption line He I 4388 Å, to a grid of rotationally broadened synthetic spectra to find the Doppler broadening due to the star's rotation.

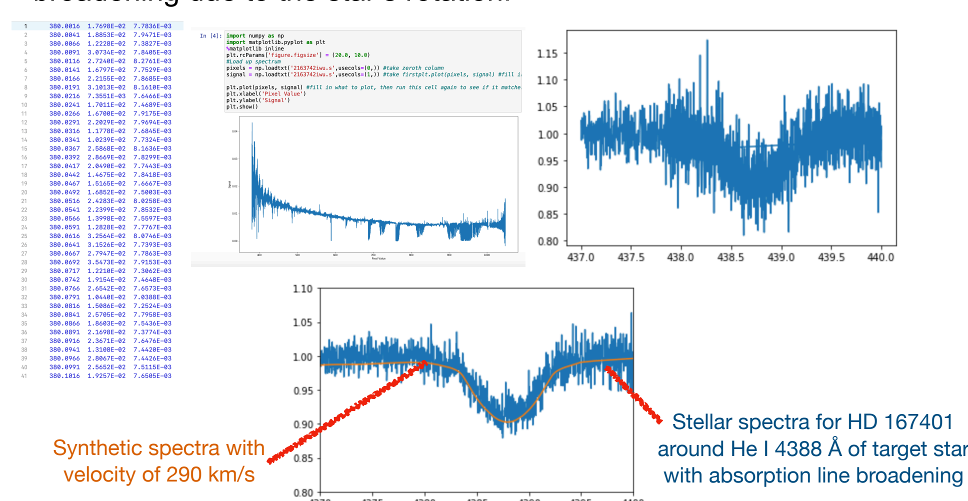

Figure 3: (Top Left) Raw spectral data for HD 167401 from telescope. (Top Middle) Complete graph of optical spectra for HD 167401. (Top Right) Normalized graph of area around He I 4388 Å for HD 167401. (Bottom) Vsini fitted line for HD 167401 absorption line He I 4388 Å.

- Comparing with a synthetically broadened line profile gives an estimate for the projected velocity, our vsini, where the "sini" indicates that the inclination of the system affects our ability to accurately measure rotational velocity.

Results

Name	vsini	$\triangle V_{Peak}$	Stellar Type
TYC 3692-67-1	360 km/s	819 km/s	Be
HD 167401	290 km/s	627 km/s	Bp
HD 280849	320 km/s	522 km/s	Be
HD 51477	210 km/s	628 km/s	Bp
MWC 1085	240 km/s	551 km/s	Be
HD 33656	320 km/s	551 km/s	Be

Figure 4: Stellar-type classification based off Vsini results. Vsini has a +/- 10 km/s error bar. TYC 3692-67-1 showed spectral features unique to Be stars.

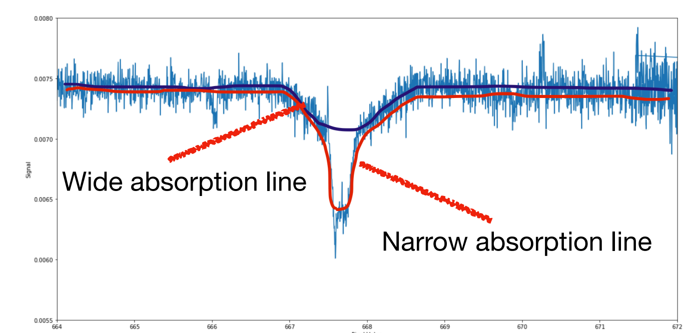

Figure 5: From an initial look at the absorption lines, it appears that the star SS 453 is actually part of a binary star system, meaning two stars orbiting each other. This binarity is shown by the narrow absorption line within the wider absorption line.

Conclusion

- From this study we have identified two good candidate Bp stars to follow up with magnetic confirmation
- We still have much to learn about Bp and Be stars, but we know they play an important role in the evolution of their host galaxies, from their momentum to the chemicals they release through supernovae.
- Through finding a few candidate Bp stars, our research hopes to give the massive-star community more targets to study these important astronomical bodies, leading to a clearer picture of how our galaxy came to be and how it will continue to evolve in the future.

References and Acknowledgments

- Chojnowski et al., 2015, Astronomical Journal, 149, 7.

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