EXAMINE THE SPECTRAL CLASSIFICATION OF EARLY TYPE STAR SAO 36620 AND LATE TYPE STAR 74164

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Abstract

In this investigation, we observe the spectra of one early type star SAO 36620 with spectra type B5III and one late type star SAO 74164 with spectra type G7III using Colby College's Young Telescope. We convert the 2-dimensional images of dispersed spectra into a 1-dimensional spectrum and label the absorption lines that can be identified with comparison to the known elemental transitions. From the features of absorption lines and the comparison of the two spectrums, we deduce the spectra types for both stars and compare them with the published values. We conclude that star SAO 36620 has spectra type B due to the HI absorption line features and star SAO 74164 has spectra type G due to the metal absorption line features.

Introduction

To demonstrate that a CCD camera and a spectrograph mounted on a small telescope can be used for spectral classification of bright stars, we chose to observe the spectra of two bright stars and compare them with each other as well as their previously published spectral types. The spectra we generated from the observation can determine the spectral classification as the absorption lines of the spectra have distinctive features due to different surface temperatures.

In this investigation, we chose one early type star SAO 36620 with spectra type B5III (Ducati et al. 2002) and one late type star SAO 74164 with spectra type G7III (Keenan et al. 1989). The spectra of SAO 36620 should have strong HI line and the spectra of SAO 74164 should have strong neutral metal lines and CaII lines considering their published spectral classification[1].

Observation and Data Reduction

Observation

The observation was operated at 10:30 pm 16th November 2019. The weather is non-photometric. Necessary information of our target stars is listed in Table 1.

Table 1. The information of both stars. The spectra type for SAO 36620 is B5III, the V magnitude is 4.5, the Right Ascension in epoch 2000.0 is 00°44'43.519'', and the Declination in epoch 2000.0 is +48°17'03.71''. The spectra type for SAO 74164 is G7III, the V magnitude is 4.38, the Right Ascension in epoch 2000.0 is 00°38'33.346'', and the Declination in epoch 2000.0 is +29°18'42.31''

Name	SAO 36620[2]	SAO 74164[3]
Spectra type	B5III	G7III

[1] https://www.cfa.harvard.edu/~pberlind/atlas/htmls/note.html
[2] Values obtained from software SkyX
[3] Values obtained from software SkyX

V magnitude	4.5	4.38
Right Ascension (epoch 2000.0)	00°44’43.519’’	00°38’33.346’’
Declination (epoch 2000.0)	+48°17’03.71’’	+29°18’42.31’’

Data were obtained at Colby College’s Young Telescope, a Planewave 0.7m Corrected DallKirkham design with f/6.5 and 0.7m aperture. The spectrograph is a LISA spectrograph by Shelyak Instruments. We used a 300 line/mm grating with the grating angle set to disperse a wavelength range from about 2700 to 8700 Angstroms and a 23micron slit width which provided a spectral resolution of 2.7505 Angstroms per pixel. The acquisition camera, an Aluma 3200 by Diffraction Limited, is a front-illuminated KAF3200 CCD sensor with 2184 x 1472 pixels at 6.8 microns square.

For each star, we took the spectra with 30s exposure time. We used a guide camera to align stars onto the slit.

Data Reduction

The data reduction process for both stars are identical. To generate the spectra of each star, a mathematical way of producing the final processed image is used and the equation (1) is shown in the following:

$$Final\ image = [(Raw\ image) - (Avg\ dark)] \times \frac{mean\ value\ of\ (Flat - Avg\ dark)}{(Flat - Avg\ dark)} \quad (1)$$

We reduce the images, firstly, by subtracting the average dark with the same exposure time as for the images taken. A dark is an image of the thermal noise from free electrons moving around in the semiconductor of the CCD and the electronic noise related to reading out the detector. The dark is subtracted from both stars and the flat. The flat is taken in 10s and thus, the dark used is 10s to get the normalized flat.

After subtracting the dark, we convert the 2-dimensional images of dispersed spectra into a 1-dimensional spectrum of intensity versus x-pixel position using IRAF task "apextract". To do this task, we defined a rectangular aperture which encloses as much of the light of the spectrum in the y-direction as possible without reaching the background level. The apertures are defined for both stars, the calibration spectra and the flat. We defined a trace which is a function that defines where spectra are located on CCD image. Trace can guide the aperture defined previously to follow the dispersion path of our spectra on the detector and along the trace, the 2-dimensional images are converted to 1-dimensional spectrum.

Afterwards, we divide our 1-dimensional spectra by the normalized flat. Flat frames indicate how the pixels in the detector respond to a uniform light source and can be used to correct for areas of the detector that are less sensitive than other areas, including the vignetted corners and regions where dust grains are present. The dark subtraction was performed on the 2D images, but the flat-fielding was performed on the 1D spectra through use of a smoothed flat that is smoothed using the "continuum" function. The reason why we used a smoothed flat is because we could not get a high enough signal-to-noise flatfield with the quartz lights we use for the internal spectrograph flats, and thus dividing by the flat without smoothing first would have introduced additional noise to the final spectra.

In this investigation, we did not flux calibrate the spectra as the final spectra are plotted as relative intensity versus wavelength the intention of this investigation is to identify the spectral lines.

Once we had 1-dimensional calibration spectra, we used IRAF to mark the wavelengths of known spectral features so that we can convert the x-pixel to wavelength. The calibration spectra were from Argon and Neon gas and several bright lines whose wavelengths were known were found. More emission lines were identified automatically after we labelled several known emission lines. The line list gives all known elemental transitions for Ar and Ne that fall within the wavelength range of our spectra. We converted the x-pixel position to wavelength in Angstroms using a cubic spline which allows for a conversion between x-position to wavelength that is not strictly linear.

After we got the wavelength solution from the calibration spectra, we applied it to our stellar spectra which converts our 1-dimensional spectrum that is in units of intensity versus x-pixel to intensity versus wavelength in Angstroms. We then created an array of wavelengths with corresponding intensities and used it to generate a graph of spectrum.

Finally, with the stellar spectrum, we determine the central wavelengths of all absorption lines presented in our stellar spectra. We compared against known elemental transitions to identify the line element and transition.

Results and Discussion

The generated spectrum for early type star SAO 36620 is shown in Figure 1 and the spectrum for the late type star SAO 74164 is shown in Figure 2. On both graphs, we compared against the known elemental transitions (Abt et al. 1968) and identified certain absorption lines which are labelled, and the corresponding observed wavelengths, actual wavelengths, and the percent differences are listed in Table 2 and Table 3.

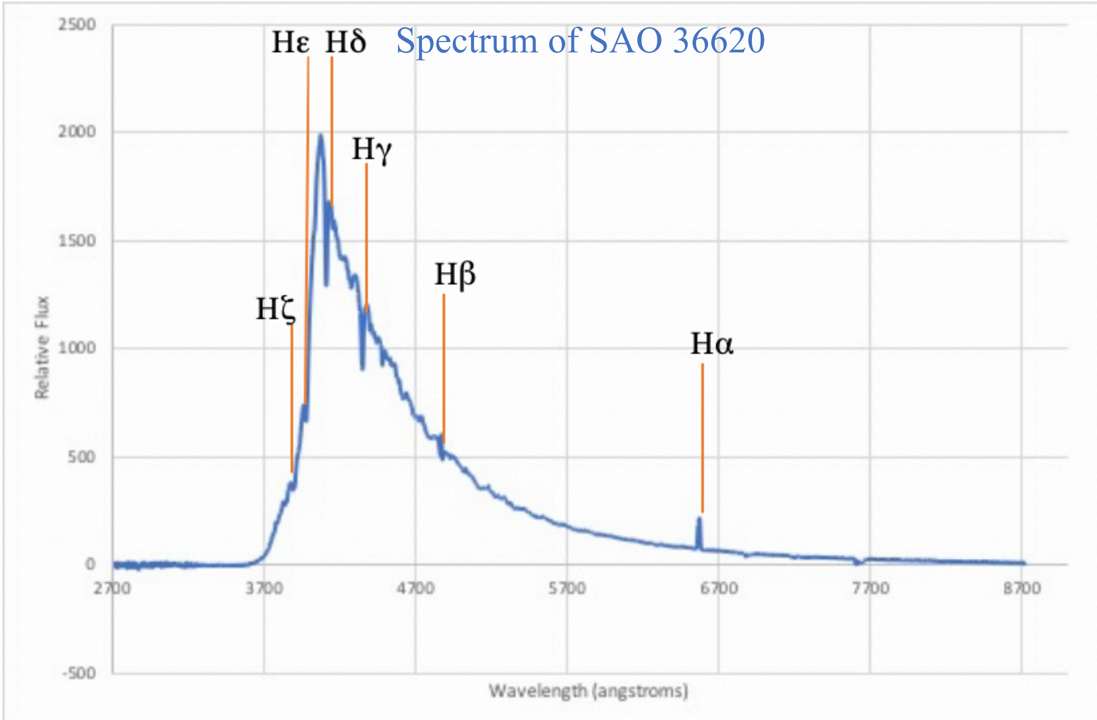

Figure 1. The spectrum of early type star SAO 36620. The absorption lines are labelled whose wavelengths are shown in Table 2. It shows strong features of HI absorption lines which indicates it is an early type star with spectra B.

Table 2. The observed wavelengths in angstroms of each labelled absorption line and the corresponding actual wavelength in angstroms as well as the percent difference for star SAO 36620.

Name	Observed Wavelength(angstroms)	Actual Wavelength(angstroms)	Percent difference
Hζ	3881.7	3889.1	0.19
Hε	3959.3	3970.1	0.27
Hδ	4092.5	4101.8	0.23
Hγ	4336.7	4340.5	0.09
Hβ	4858.3	4861.3	0.06
Hα	6556.3	6562.8	0.10

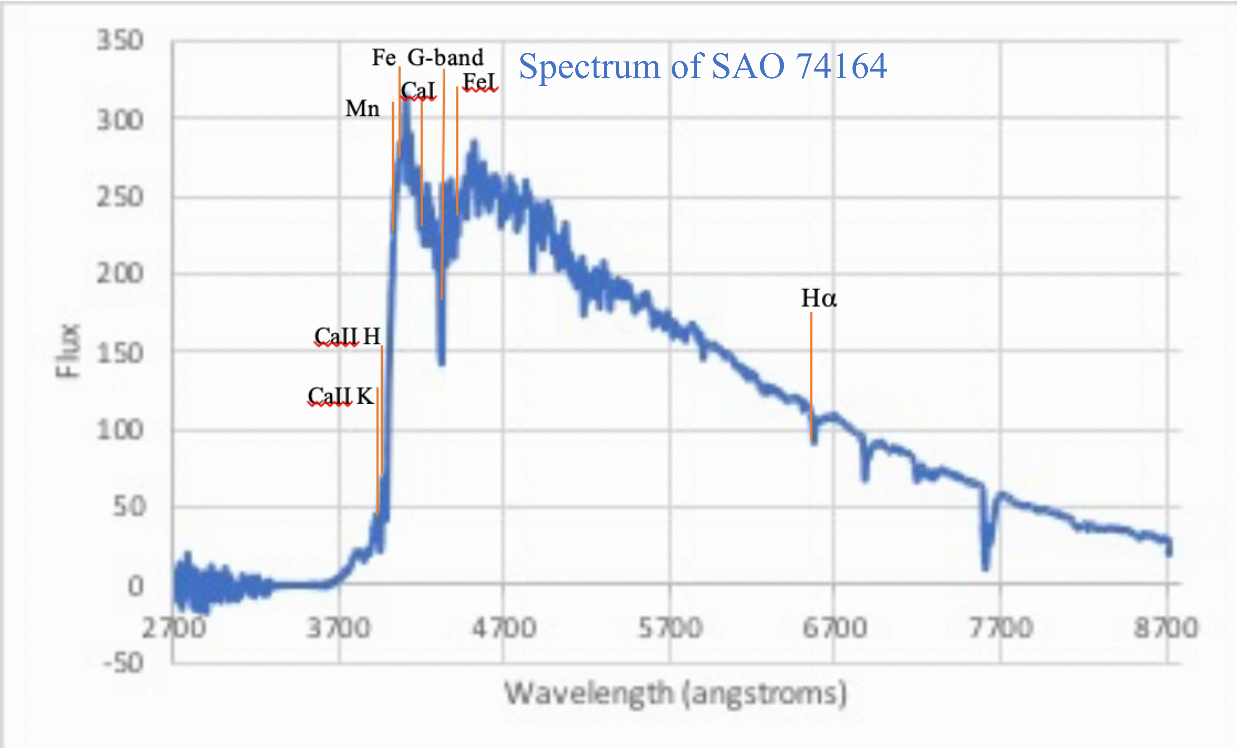

Figure 2. The spectrum of early type star SAO 74164. The absorption lines are labelled whose wavelengths are shown in Table 2. It shows strong features of metal absorption lines which indicates it is a late type star with spectra G.

Table 3. The observed wavelengths in angstroms of each labelled absorption line and the corresponding actual wavelength in angstroms as well as the percent difference for star SAO 74164.

Name	Observed Wavelength(angstroms)	Actual Wavelength(angstroms)	Percent difference
CaII K	3934.423	3933.7	0.02
CaII H	3959.46	3968.5	0.23
Mn	4034.6	4030	0.11
Fe	4047.1	4045	0.05
CaI	4222.35	4226	0.09
G-band	4309.99	4306	0.09
FeI	4385.1	4383	0.04
Hα	6556.3	6562.8	0.10

According to Figure 1, the spectrum of star SAO 36620 shows clear absorption lines of HI. Comparing the observed wavelengths of the absorption lines with the actual wavelengths, the average percent difference is 0.16%. However, the Hα line reveals an emission nature. It may be because that the star is formed in a gas cloud. Since it is an early star, the surrounding hydrogen may still remain and thus is ionized by the star and causes the emission line. Besides the HI absorption lines, there are little other features in the spectrum of SAO 36620. This indicates the star is an early type star and may have spectra B. In comparison, the spectrum of star SAO 74164 shows more features of heavier elements. It has clear absorption lines of mental and very strong CaII lines as well as G-band. Comparing the observed wavelengths of the absorption lines with the actual wavelengths, the average percent difference is 0.08%. Comparing to the spectrum of SAO 36620, it is much less clean which indicates it is a late type star. According to the features, it may be a G type star. The result of our observation meets the expectation we had and the published values for both stars.

However, it is hard to determine more specific classification. We can only deduce which one has early type spectra and which one has late type spectra by comparing the two spectrums and estimate which spectra it may have according to the features. More information and more detailed observation may be needed to give more specific and certain classification. This is limited by our instrument. In addition, we used a guide camera to align stars onto the slit. During the process, the guilder was loose and out of focus. The telescope is not properly focused and thus the light from the star is not completely captured by the slide. The spectra are not as bright as it should be which affects the final result and gives a lot of noise.

Reference

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Keenan P.C., McNeil R.C. 1989, *Astrophys. J., Suppl. Ser.,* 71, 245

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