Spectral Analysis of the Constellation Stars of Lacerta (The Lizard)

Anthony S. Harding Jr.
2023-12-03

Abstract

This paper will elucidate the spectral features of the main stars in the constellation Lacerta. The selection of stars was chosen to coincide with those typically used to trace the constellation lines that form the geometric shape of the constellation itself[1]. Though other stars within the boundary of the constellation (as determined by the IAU) may be objects of interest, the analysis is confined to the stars forming the constellation lines.

The stars in the constellation will generally be presented in order of their accepted Bayer designations, using Greek letters to rank them roughly in order of decreasing brightness. Alpha (or α) is usually the brightest star in a constellation. Afterward, Beta (β), Gamma (γ), and so on indicate decreasing apparent magnitude. It is usually the brightest stars that define the constellation lines. Of course, there are deviations from this rule that have been retained for historical consistency.

Equipment Used

All spectra used in this analysis were captured using the following equipment and resources:

Telescope: Celestron Advanced C6-N Newtonian Telescope, with an aperture of 6 inches, and a focal length of 750mm. This makes the focal ratio f/5.

Mount: Meade LX85 German Equatorial Go-To Mount. The mount was aligned using the three-star method.

Camera: ZWO ASI290MM monochrome camera.

Transmission Grating: The SA100 grating was employed to produce the spectra used in this analysis. The grating has 100 lines per millimeter.

Capture Software: The ASI Studio suite of programs was used in the capture process. Following capture, the same suite was used to stack images and export them as TIF files for evaluation and analysis.

Analysis Software: Rspec v2.1.1 by Field Tested Systems, LLC.

Reference Material Used in Analysis: The *Spectral Atlas for Amateur Astronomers* by Richard Walker and *Spectroscopy for Amateur Astronomers* by Marc F. Trypsteen and Richard Walker were both used to assist in identifying specific facets of the resulting spectra, and proved invaluable in this process. Wikipedia and Stellarium were also instrumental in obtaining information regarding the various stars.

Data Processing Details

All of the spectra obtained for this analysis were obtained on the evening of November 14, 2023 (EST). Additional specifics for each capture are included in the header for each star's spectrum in the pages that follow. The times presented there are given in UT, as is desirable for any astronomical work. Also included in this header is the number of frames captured, and the percentage of those frames which were applied to the stacking process. The determination of this percentage was subjectively chosen based on the quality of the footage captured—the accuracy of the tracking, the steadiness of the atmosphere at the time, etc.

The tracking of the Meade LX85 mount used in the capture process has limitations regarding its accuracy. Therefore, some gain was applied during the captures in order to shorten the exposure times. This was kept to a minimum, as excessive use of it does compromise the quality of the exposures. No dark or flat frames were used for these captures. Also, no sharpening or other image modifications were made to the stacked images. Most of the spectra therefore show telluric absorption bands; some of these are labeled, where others are not.

α Lacertae

Alpha Lacertae is classified as an early A-type star[1]. Typical features for stars of this type include extremely prominent hydrogen Balmer absorption lines and a curve peaking near the lower wavelength range, indicating a higher temperature.

The processed spectrum is as follows:

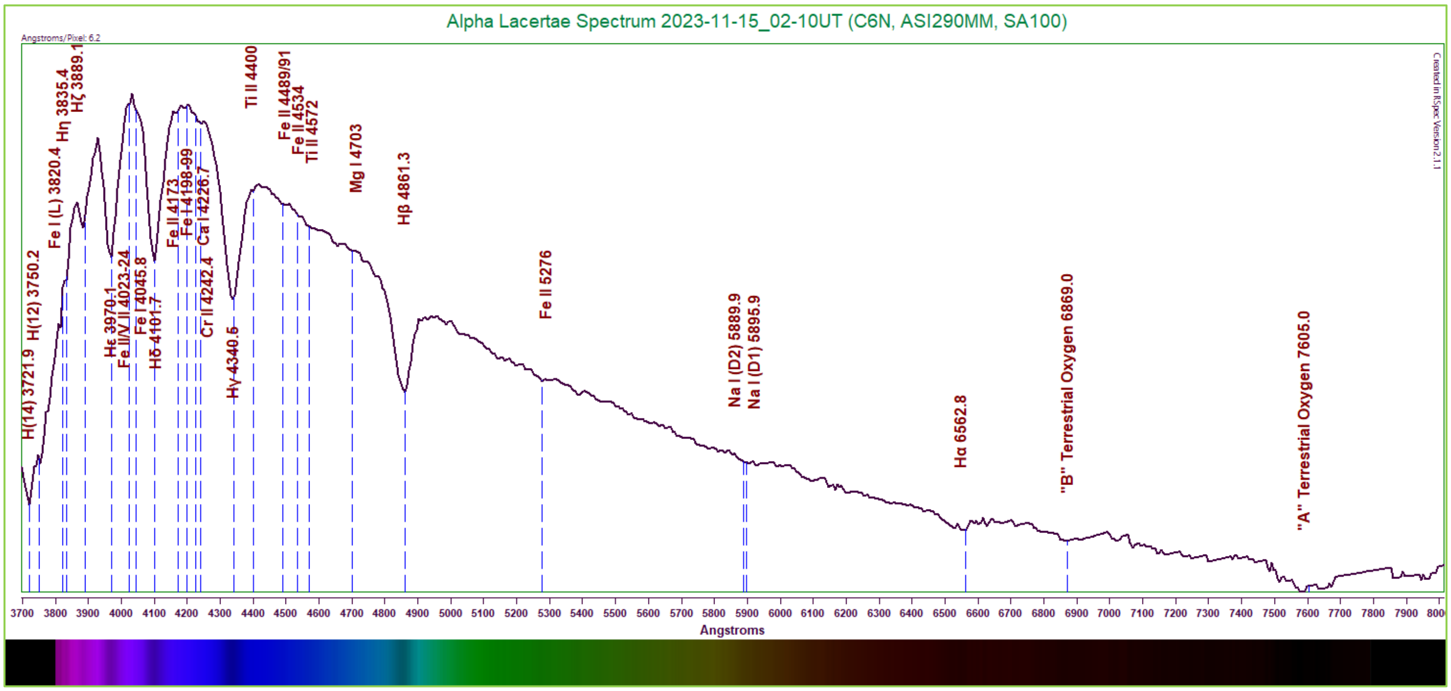

Figure 1: Alpha Lacertae Spectrum (6.2 Angstroms/pixel)
Capture Details 1: 597ms, Gain 92, 50% of 308 frames stacked

As expected, the hydrogen Balmer lines are very clear. The Fe (L) line at 3820.4 Angstroms marks out its characteristic small sharp cut in the continuum. The sodium doublet at 5890-96 Angstroms is visible only as a very subtle dip in the continuum. Several very faint additional metal lines are marked, but all are very close to the noise level in the continuum and are thus potentially suspect. These include iron, calcium, chromium, titanium, and magnesium.

Employing Wien's Law, we will attempt to obtain a rough estimate of the star's effective temperature. However, with this being an early-type star, we can expect our estimate to fall very short of the actual value. Using an estimated peak energy wavelength of 4038 Angstroms, we obtain a result of 7176K. The listed temperature of the star is as 9050K[2].

β Lacertae

Beta Lacertae is a suspected double star whose components may lie very close together[2]. The primary is classified as a very late G-type star[1]. This being the case, we can expect to see a star a bit cooler than our Sun, with some of the features more common in later-type stars becoming emergent.

The processed spectrum is presented below:

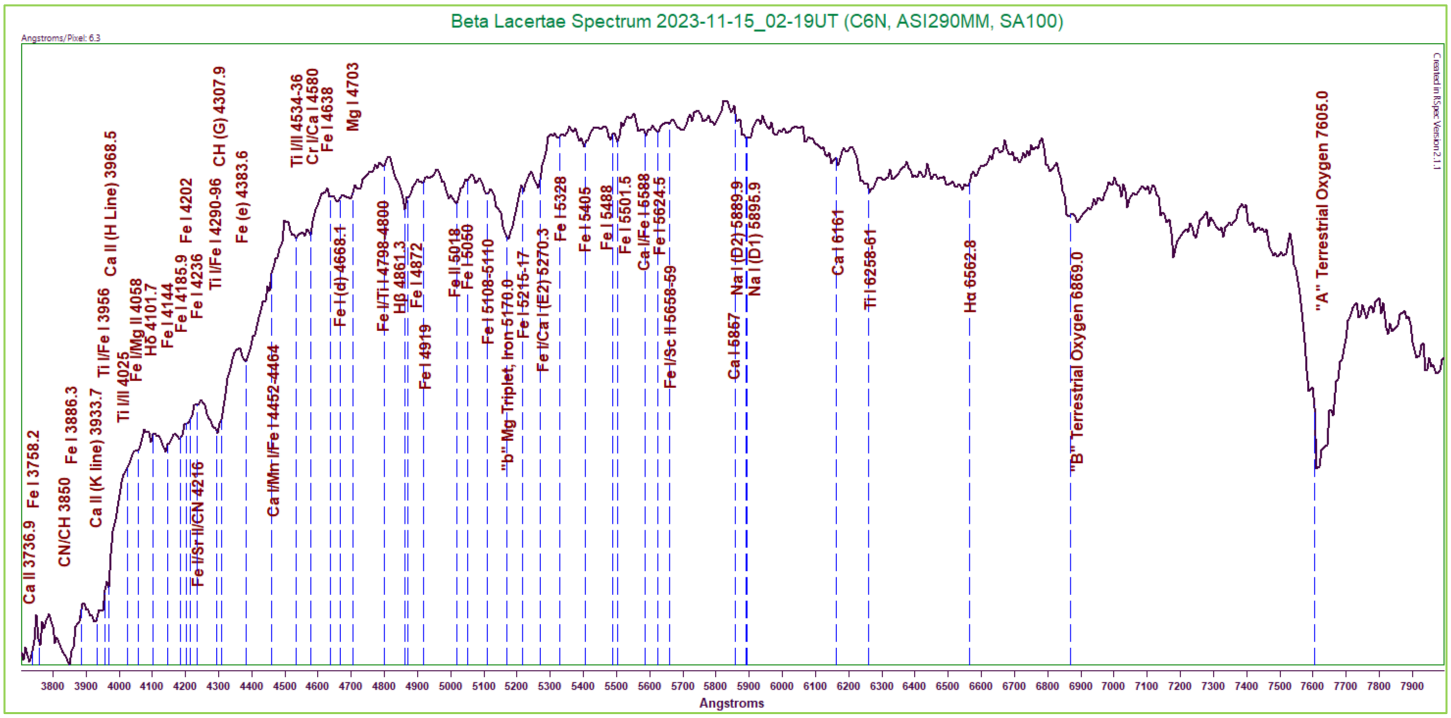

Figure 2: Beta Lacertae Spectrum (6.3 Angstroms/pixel)
Capture Details 2: Exposure

We can see from the general shape of the spectrum a typical G-type curve. Some of the hydrogen Balmer lines are evident, though definitely weak. The CN/CH absorption at 3850 Angstroms is very strong here. The calcium H and K lines are also showing a deep cut into the continuum. The CH (G) absorption at 4307.9 Angstroms is deep and prominent, with the titanium/iron line just below it. The magnesium triplet is easily visible at 5170 Angstroms, along with the surrounding iron lines flanking it. The sodium doublet at 5890-96 Angstroms is much weaker, but still easily identified. A number of fainter additional metal lines can be seen along the curve, including calcium, titanium, lots of iron, chromium, and magnesium.

Employing Wien's Law, we will calculate an estimate of the star's effective temperature. Using an estimated peak energy wavelength of 5822 Angstroms, we calculate a result of 4977K. The accepted temperature of the star is 4803K[2]. In this case, our estimate appears to be fairly close.

1 Lacertae

1 Lacertae is classified as an early K-type star[1]. We can expect a curve representing a star slightly cooler than Beta Lacertae above, again with lots of metal lines present.

The processed spectrum follows:

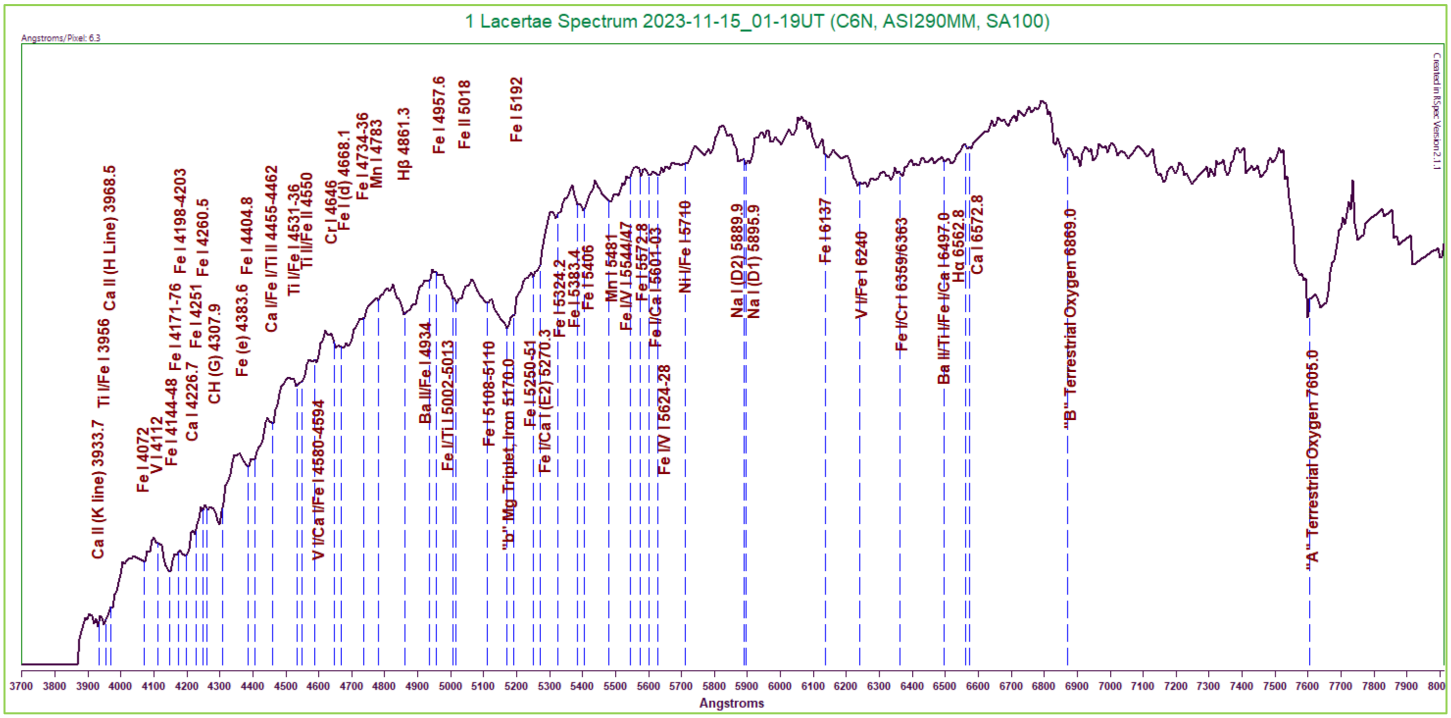

Figure 3: 1 Lacertae Spectrum (6.3 Angstroms/pixel)
Capture Details 3: Exposure 829ms, Gain 101, 35% of 297 frames stacked

Here is definitely a curve for a star approaching the later types. The spectrum peaks above the middle wavelength region, indicating the correct approximate temperature. The Hβ line is the only clearly defined hydrogen Balmer line visible; the Hα line is marked, but the noisy continuum in that area makes this a dubious identification. The calcium H and K lines, along with the titanium/iron line at 3958 Angstroms, are carving a nice scoop out of the curve in the lower wavelength region. The CH (G) line is not quite as strong, but still identifiable. The magnesium triplet at 5170 Angstroms, along with the iron lines flanking it, produces the most profound absorption in the spectrum—a nice, sharp "V" cut out of the curve. The sodium doublet at 5890-96 Angstroms is not nearly as deep, but it is easily seen. It appears to be getting broadened, but no positive identification could be made regarding this. Spread throughout the spectrum are numerous faint metal lines, including copious amounts of iron, vanadium, calcium, titanium, chromium, manganese, barium, and nickel.

Using Wien's Law, we will estimate the star's temperature. Using a visually estimated peak energy wavelength of 6783 Angstroms, we calculate a result of 4272K. The accepted temperature of the star is listed as 4288K[2]. Being a late-type star, our estimate is actually extremely close!

4 Lacertae

4 Lacertae is listed as a very early A-type star[1]. That being the case, we can expect to see a clear curve with obvious and deep hydrogen Balmer lines present. Any metal absorptions poking through will certainly be very weak.

The processed spectrum follows:

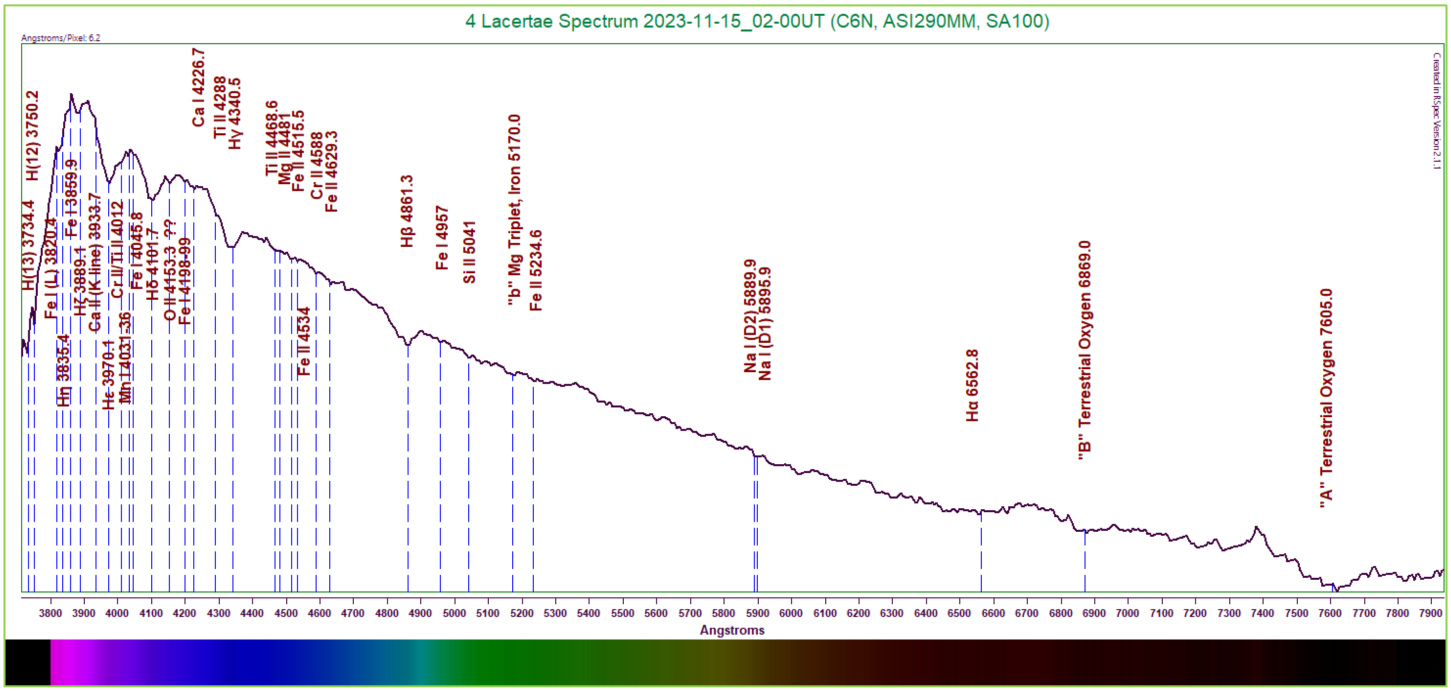

Figure 4: 4 Lacertae Spectrum (6.2 Angstroms/pixel)
Capture Details 4: Exposure 663ms, Gain 157, 30% of 369 frames stacked

The general shape of the curve is indicative of an early A-type star with a high temperature. However, the hydrogen Balmer absorptions are less pronounced than expected, particularly the extremely weak Hα dip, which only shows up as a broad, gentle swoop in the continuum. (This has been explained by the fact that the star is a supergiant, which causes the hydrogen Balmer lines to appear considerably weakened.) The Fe I (L) line at 3820.4, along with the Hη line, cuts out a small groove in the continuum near the lower wavelength range. The calcium K line is just barely beginning to present itself, showing up as a very small bump on the lower side of the Hε absorption. The magnesium triplet and sodium doublet are marked, but both are extremely weak and difficult to separate from the noise of the continuum. Both of these—particularly the sodium doublet—should be regarded dubiously. Throughout the continuum, a series of extremely faint metal lines are marked, including iron, manganese, chromium, calcium, titanium, magnesium, and silicon. One feature in particular appears out of place, and that is the possible oxygen line at 4153.3 Angstroms (marked with "??"). A search through the reference materials used did not reveal any other possibilities, but this identification is certainly questionable.

We will again employ Wien's Law to ascertain a temperature estimate. This will certainly be much too low, as has been the case for nearly all A-type stars. Using an estimated peak energy wavelength of 3870Angstroms, we obtain a result of 7488K. The accepted temperature of the star is listed as 11800K[2]. As anticipated, our estimate is extremely low.

5 Lacertae

5 Lacertae is a variable double star consisting of a very late K-type primary and an early B-type secondary[1]. The two are extremely close together so our spectrum will be a combination of the two, but we can expect the much brighter primary to dominate the results. Being a very late K-type star, we should be able to identify TiO absorptions in the spectrum.

The finished spectrum is presented below:

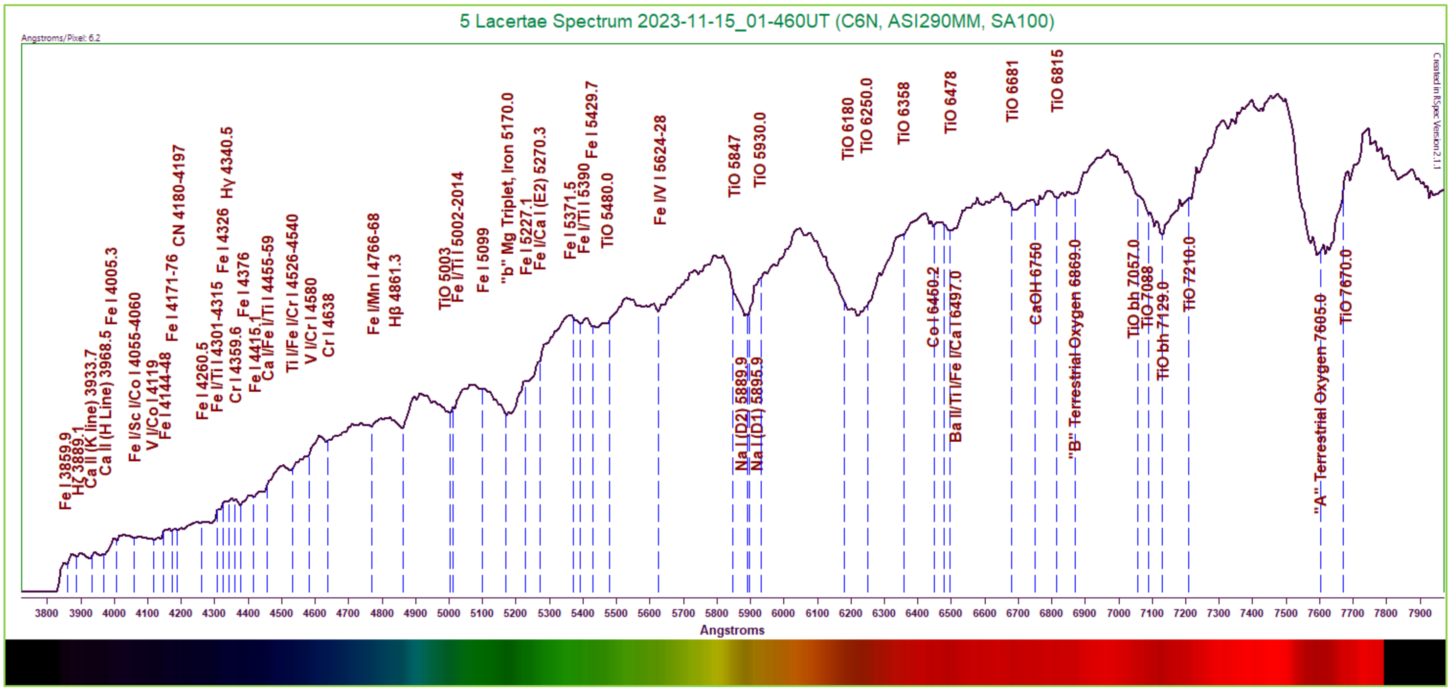

Figure 5: 5 Lacertae Spectrum (6.2 Angstroms/pixel)
Capture Details 5: Exposure 797ms, Gain 101, 70% of 309 frames stacked

This curve strongly suggests a star of the appropriate type—a very late K-type or very early M-type star. The B-type companion does not seem to be contributing to the result, as expected. Only three hydrogen Balmer lines are marked—Hζ, Hγ, and Hβ. These are extremely weak by comparison to the lines in other, earlier stars. The calcium H and K lines are causing only small scoops near the extreme low wavelength range. The magnesium triplet at 5170 Angstroms is making a fine showing, causing a broad cut in the continuum along with its adjacent iron lines. The sodium doublet at 5890-96 Angstroms appears a bit sharper, and seems broadened by two TiO lines, one on either side. A good number of TiO lines are labeled starting at 5003 Angstroms upward on the curve. These range from very weak to obvious in strength. Some additional extremely weak metal lines are also visible, primarily on the lower half of the wavelength scale. These include a considerable amount of iron, some vanadium, CN, chromium, calcium, cobalt, barium, and CaOH.

Using Wien's Law, we will estimate the star's temperature. Using an estimated peak energy wavelength of 7492 Angstroms gives us a result of 3868K. The accepted temperature of the star is listed as 3713K[2].

6 Lacertae

6 Lacertae is an early B-type star[1]. Given such, we should expect the characteristics of a hot star, including some recognizable but weakened hydrogen Balmer lines, and perhaps even a hint or two of helium.

The processed spectrum is presented here:

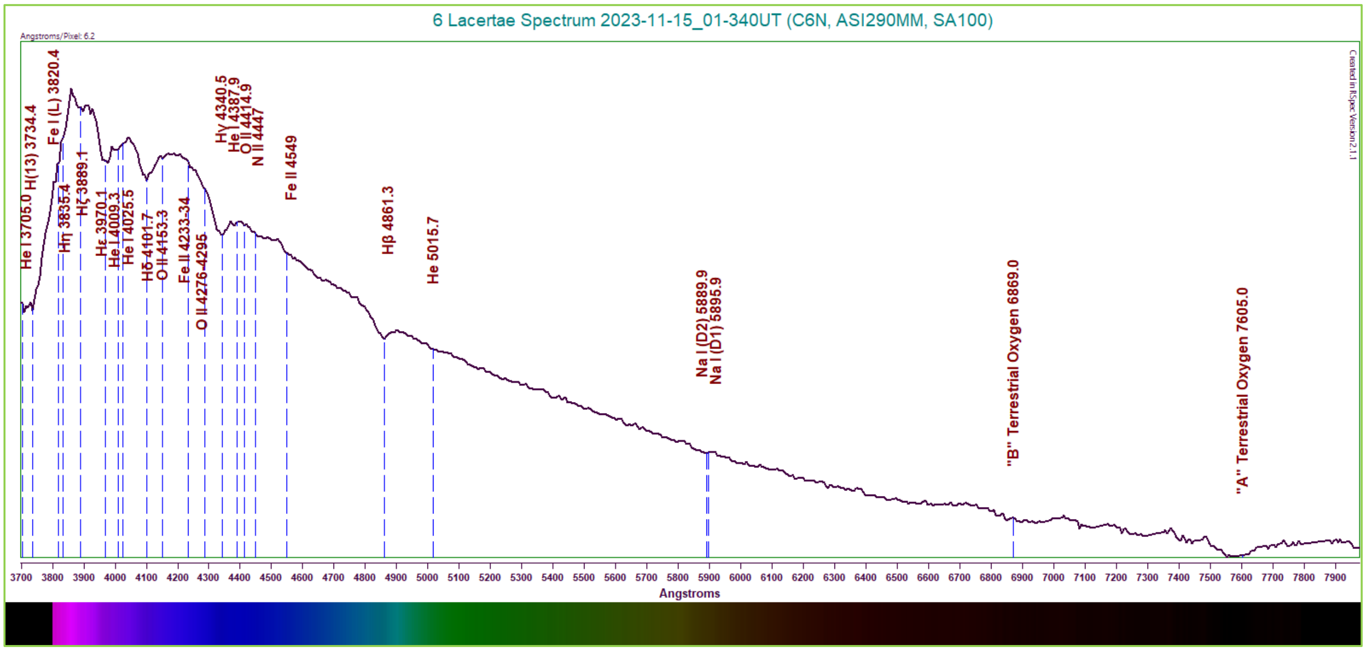

Figure 6: 6 Lacertae Spectrum (6.2 Angstroms/pixel)
Capture Details 6: Exposure 786ms, Gain 146, 30% of 314 frames stacked

This clean-looking curve indeed shows reduced hydrogen Balmer lines, as we anticipated. In fact, the Hα line is missing completely, subsumed into the continuum. The Hη line is only evidenced by a tiny bump in the curve at 3835.4 Angstroms. The sodium doublet is marked and showing only the slightest reduction in the continuum level. Several helium lines are marked—at 3705, 4009.3, 4025.5, 4387.9, and 5015.7 Angstroms. Most of these are extraordinarily weak, except the combination of lines at 4009-4025 Angstroms where two lines combine to create a little scoop out of the curve. A few other extremely faint lines are marked, most causing only very subtle disturbances in the curve. We can see neutral and ionized iron, ionized oxygen, and one ionized nitrogen line.

Wien's Law can again be employed to obtain a temperature estimate. However, this is an extremely hot star, and we can expect our estimate to be exceedingly low. Using an estimated peak energy wavelength of 3863 Angstroms, we obtain a result of 7501K. The listed temperature for the star is indeed high, at 21150K[2].

Conclusion

This small constellation has no very bright stars. Despite this, I was able to capture data for them all on the first run. No unusual problems were encountered.

Contact

Any comments, questions, criticisms, etc. can be directed to anthonyspectro@gmail.com.

References

[1]: As determined using Stellarium v1.1. (Of course, not all sources agree as to the exact stars used in forming the shapes of the constellations. Alternate designations are also applied to most stars.)
[2]: As indicated by Wikipedia.
[3]: *Spectral Atlas for Amateur Astronomers* by Richard Walker
[4]: *Spectroscopy for Amateur Astronomers* by Marc F. Trypsteen and Richard Walker