Spectral Analysis of the Constellation Stars of Pegasus (The Winged Horse)

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Abstract

This paper will elucidate the spectral features of the main stars in the constellation Pegasus. The selection of stars was arbitrarily 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 are used to 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. Stellarium was used to define the stars comprising the constellation lines.

Data Processing Details

Most of the spectra obtained for this analysis were collected on the evenings of November 10, 2023 and November 14, 2023 (EST). One star (Lambda Pegasi) was later discovered to be a mistaken capture, so the report was delayed until the following year. The spectrum for Lambda Pegasi was captured on the evening of August 31, 2024 (EDT). Additional specifics for each capture are included with 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 are the exposure length, 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 bias, dark, or flat frames were used for these captures, nor were reference stars captured for individual sessions. The captures must therefore be considered “Quick and Dirty,” and so are unsuitable for professional or purely scientific applications. However, this author believes that they are adequate for general demonstration purposes. Refinements to these results are certainly possible if extra steps were taken to account for camera read noise, image defects in the optical train, and specific atmospheric influences that differ from those encountered when generating the initial response curve (Alpha Lyrae on July 18, 2023). 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.

This constellation is very large against the sky. This made for some lengthy sessions to capture the data needed. Also, a good number of the stars are of lower apparent magnitude, which demanded more care during the capture process. The initial run was conducted on November 10, 2023. The follow-up run on November 14, 2023 was conducted to recapture data for a handful of targets that might have been misidentified during the first run. Comparisons were made between these follow-ups and the initial captures, and the more confident or better quality capture was used for each.

α Pegasi

Alpha Pegasi, also known as Markab, is classified as either a very early A-type star or a very late B-type star[1,2]. As a consequence, we should expect to see strong hydrogen Balmer absorptions in its spectrum and a curve representative of a hotter star.

The processed spectrum is presented below:

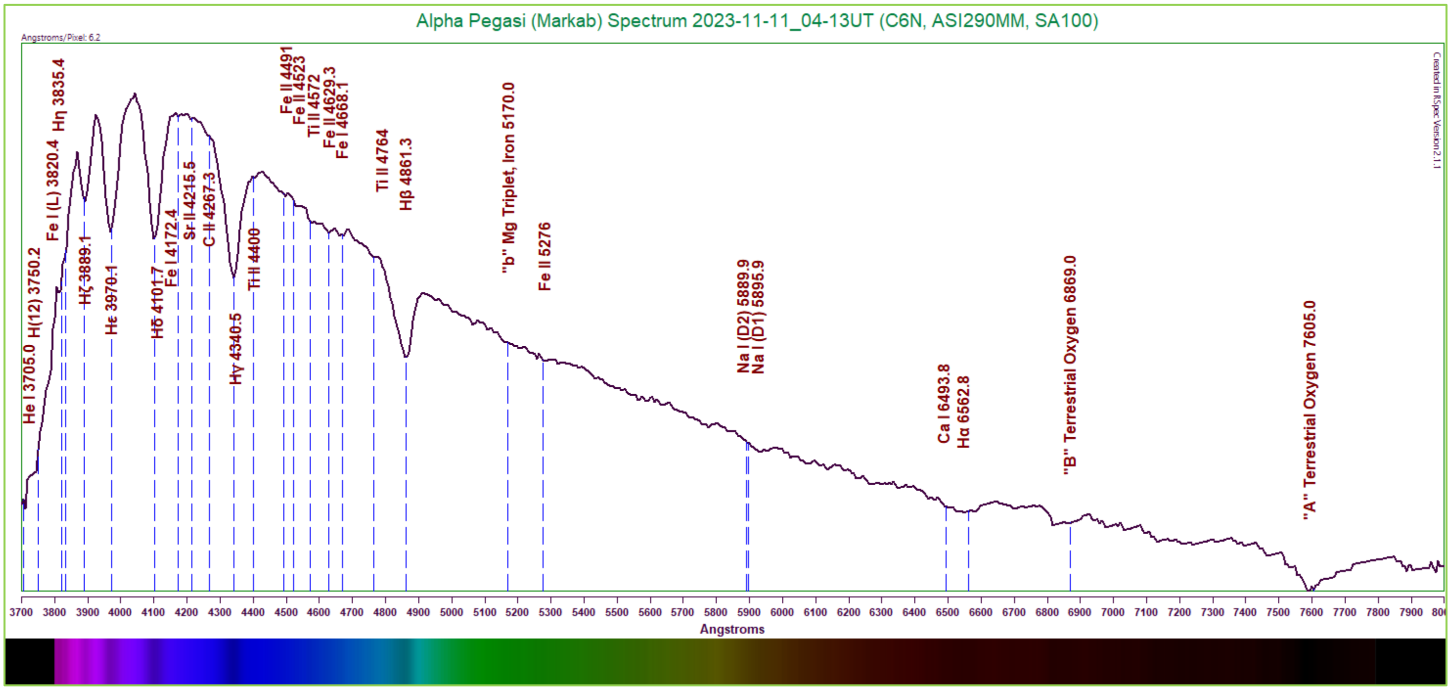

Figure 1: Alpha Pegasi (Markab) Spectrum (6.2 Angstroms/pixel)
Capture Details 1: Exposure 267ms, Gain 65, 45% of 810 frames stacked

This result is in line with our expectations. The curve of the spectrum shows a hotter star, peaking in the low wavelength region. The hydrogen Balmer absorptions are the main features. Their depth is not tremendous, but definitely on the strong side. The Fe (L) line at 3820.4 Angstroms carves out a small but sharp absorption. By contrast, the Hη line above it is only causing a slight bump in the continuum. The magnesium triplet at 5170 Angstroms is very weak, causing only the slightest dip in the continuum—nearly unrecognizable. The sodium doublet at 5890-96 Angstroms is more pronounced, but still not strong. Though mostly very faint, a number of additional metal lines can be seen here, mostly iron. The lack of any helium traces in this one is unexpected.

Employing Wien's Law, we will attempt to ascertain a very rough estimate of the star's temperature. Of course, being an early type star, we can expect our estimate to fall significantly short. Using an estimated peak energy wavelength of 4043 Angstroms, we obtain an effective temperature of about 7167K. The accepted temperature of the star is 10100K[2]. This is not a surprisingly inaccurate comparison.

β Pegasi

Beta Pegasi, or Scheat, is an early M-type star[1]. We should see deep TiO features scattered throughout this one. The spectrum should appear quite different from Markab, above, and reflect a much lower temperature.

The spectrum is presented here:

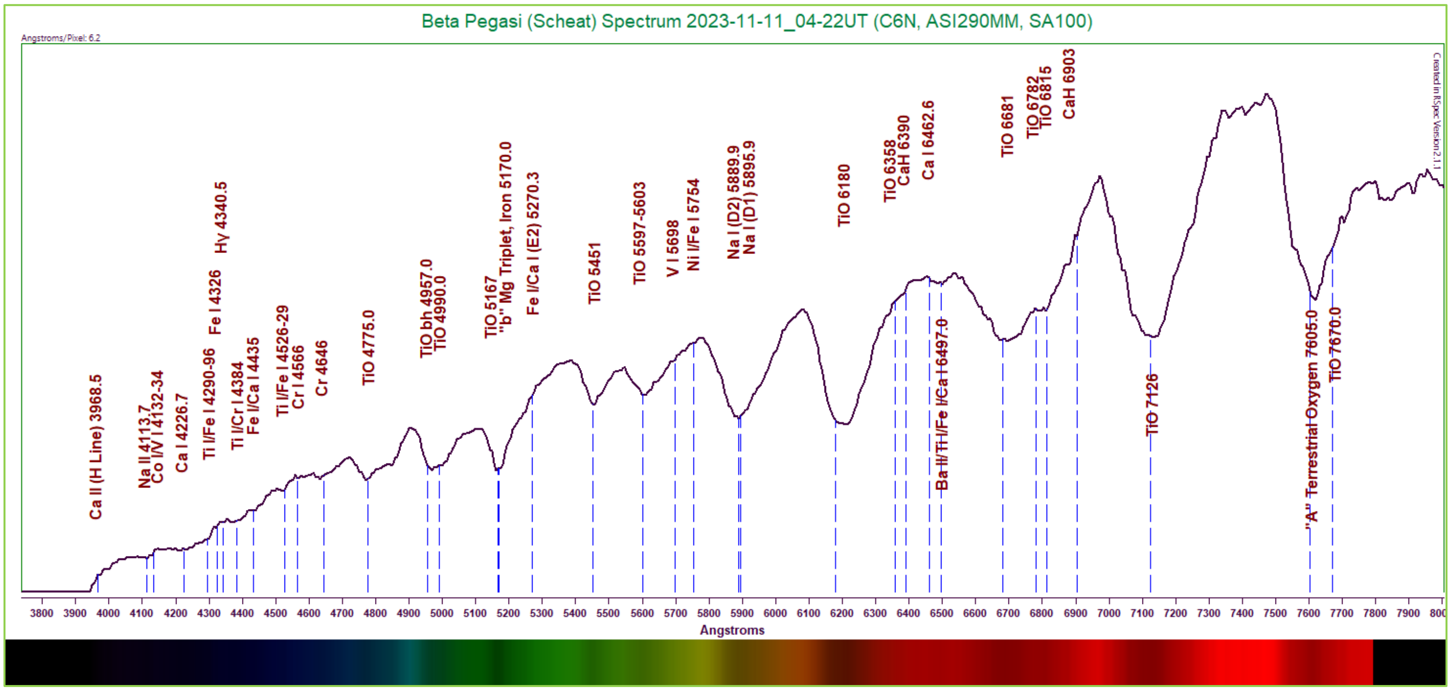

Figure 2: Beta Pegasi (Scheat) Spectrum (6.2 Angstroms/pixel)
Capture Details 2: Exposure 249ms, Gain 68, 50% of 737 frames stacked

As expected, we can clearly see a much different star from Markab. The curve peaks at a much longer wavelength, indicating a greatly lower temperature. None of the hydrogen Balmer series appear here. Instead, we see several deep absorptions from TiO. The magnesium triplet at 5170 Angstroms is visible, being apparently broadened by the adjacent TiO line. The sodium D1 and D2 lines are causing a deep cut, possibly being aided by TiO lines as well, though these could not be positively identified. Some additional faint metal lines are marked; many of these are very faint or are only producing mild bumps in the continuum. These include calcium, sodium, cobalt, titanium, chromium, iron, and CaH.

Using Wien's Law, we will attempt to ascertain an estimate of the star's temperature. Since this is a late-type star, we should expect that our estimate will be much closer to the mark than that of Markab. Using an estimated peak energy wavelength of 7470 Angstroms, we arrive at a temperature estimate of 3879K. The established temperature of the star is listed as 3689K[2]. Our estimate is not too far off.

γ Pegasi

Gamma Pegasi, known as Algenib, is an early B-type star[1]. Some hydrogen Balmer lines may be visible, if weakened, as well as perhaps some helium lines. The curve should also reflect the high temperature of the star.

The spectrum for the star is as follows:

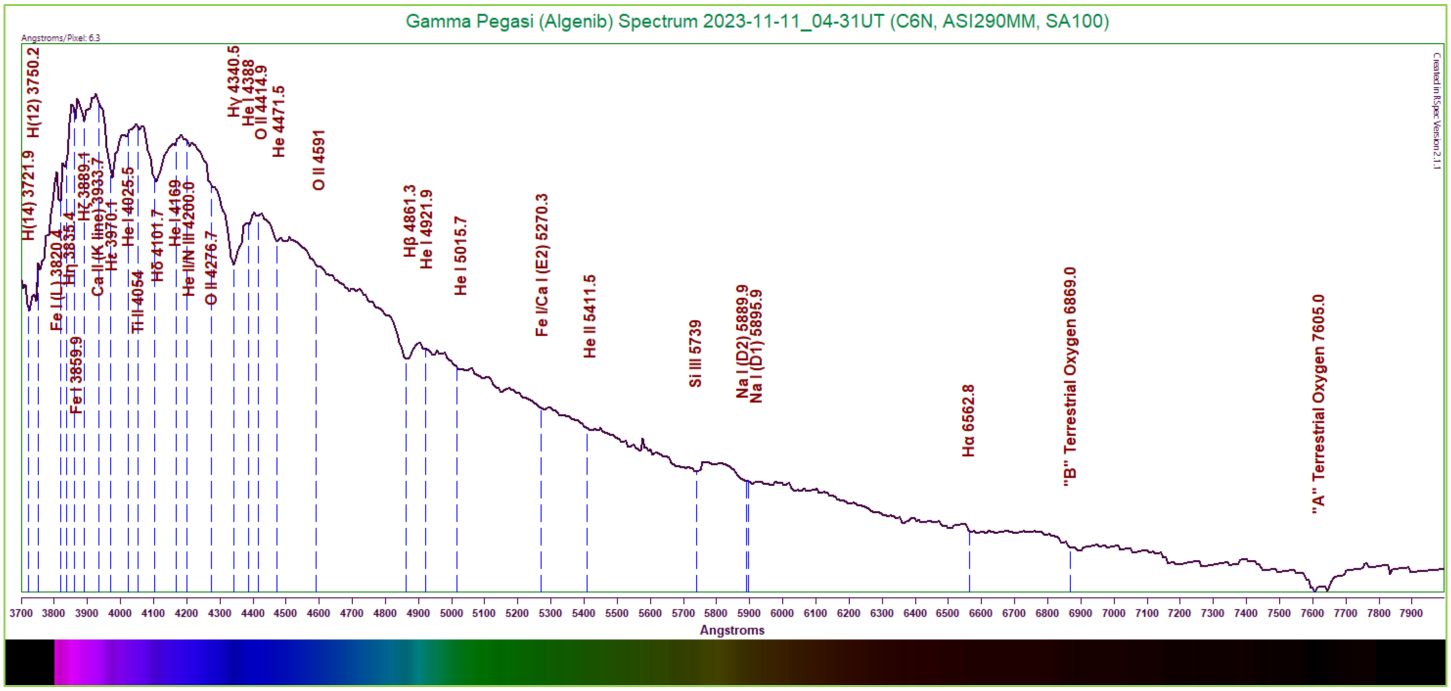

Figure 3: Gamma Pegasi (Algenib) Spectrum (6.3 Angstroms/pixel)
Capture Details 3: Exposure 343ms, Gain 62, 40% of 709 frames stacked

This spectrum presents some characteristics that were expected, such as the noticeable (though weakened) hydrogen Balmer lines. The general curve does indeed reflect a hot star, as it peaks at the lower wavelength end. The Fe (L) line at 3820.4 Angstroms appears unusually deep here, with the Hη line above it also showing its own distinct small cut in the continuum. The calcium K line is just barely detectable as a slight bump on the lower side of the Hε absorption. The magnesium triplet is missing here, but we do see a small absorption for the Fe I/Ca I (E2) line that normally lies above it at 5270.3 Angstroms. The sodium doublet at 5890-96 Angstroms presents a decently recognizable absorption. We can see a number of helium lines present, at 4025.5, 4388, 4471.5, 4921.9, 5015.7, and 5411.5 Angstroms. These are all faint, but marked. Additional metals present include iron, titanium, ionized oxygen, and doubly ionized silicon.

Using Wien's Law, we will attempt to ascertain a very rough estimate of the star's temperature. Again, since it is an early-type star, we can expect our estimate to be grossly short. Using an estimated peak energy wavelength of 3927 Angstroms, we can calculate an effective temperature of 7379K. The accepted temperature for the star, however, is 21179K[2]. That makes our estimate short by a factor of 3!

ε Pegasi

Epsilon Pegasi, widely known as Enif, is listed as an early K-type star[1]. It should display a curve consistent with a lower temperature, showing numerous metal lines spread throughout.

The spectrum is as follows:

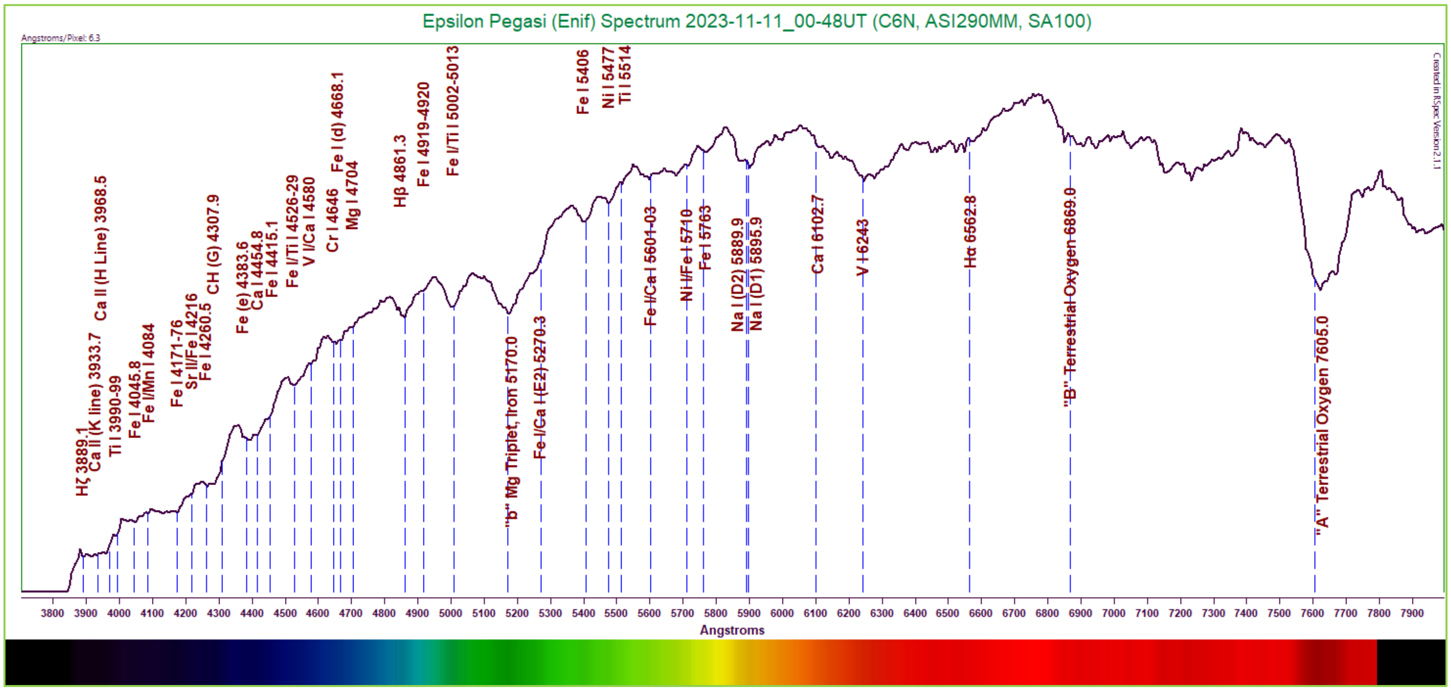

Figure 4: Epsilon Pegasi (Enif) Spectrum (6.3 Angstroms/pixel)
Capture Details 4: Exposure 227ms, Gain 101, 35% of 1074 frames stacked

Indeed we can see features consistent with an early K-type star. The curve reflects a temperature on the low side, and numerous metals are indicated. The hydrogen Balmer lines are definitely weak, but several can be identified. The calcium H and K lines in the lower wavelength area are not terribly strong here, but they do create a notable plateau. The CH (G) absorption is readily identified at 4307.9 Angstroms. The magnesium triplet is displayed gloriously, cutting a deep groove out of the continuum. The sodium D1 and D2 lines at 5890-96 Angstroms are definitely weaker, but are also well shown. There are numerous fainter metal lines present, including a good amount of iron, titanium, strontium, calcium, vanadium, chromium, and nickel. This one turned out very well.

Using Wien's Law, we will attempt to estimate the star's effective temperature. Using an estimated peak energy wavelength of approximately 6756 Angstroms, we arrive at a temperature of 4289K. The established temperature for Enif is around 3964K[2].

ζ Pegasi

Zeta Pegasi, also referred to as Homam, is classified as a late B-type star[1]. We should expect to see somewhat strong hydrogen Balmer lines, and a spectral curve consistent with a hot star.

The processed spectrum follows:

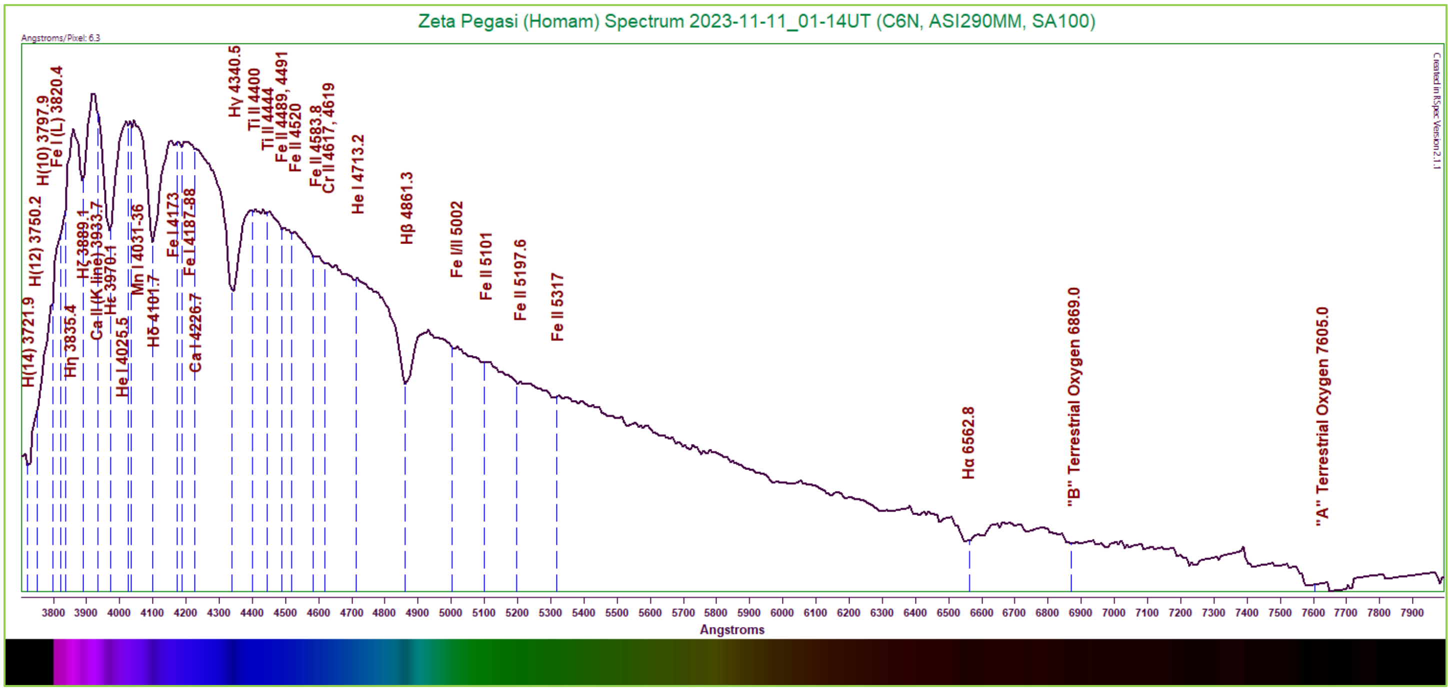

Figure 5: Zeta Pegasi (Homam) Spectrum (6.3 Angstroms/pixel)
Capture Details 5: Exposure 441ms, Gain 95, 40% of 422 frames stacked

This star seems to have produced a very clean-looking spectrum. The hydrogen Balmer lines are pretty clear, though not overly deep. The Fe (L) line and the Hη line appear muted, simply combining to produce a gentle bump in the continuum. The calcium K line is producing a similar effect, though less pronounced, on the lower side of the Hε absorption. Two helium lines appear in the spectrum, at 4025.5 and 4713.2 Angstroms. Some other extremely small and faint metal lines are marked, including a copious amount of iron, with some titanium, manganese, calcium, and chromium. A very interesting result.

Using an estimated peak energy wavelength of 3918 Angstroms, Wien's Law results in an effective temperature of 7396K. Again, since this is an early-type star, we should anticipate that this result is much too low. Indeed, the accepted temperature of Homam is 11190K[2].

η Pegasi

Eta Pegasi is a spectroscopic binary known as Matar. The star is listed as a late G-type star[1]. We should expect to see a star of moderate temperature, with numerous metal lines present.

The processed spectrum follows:

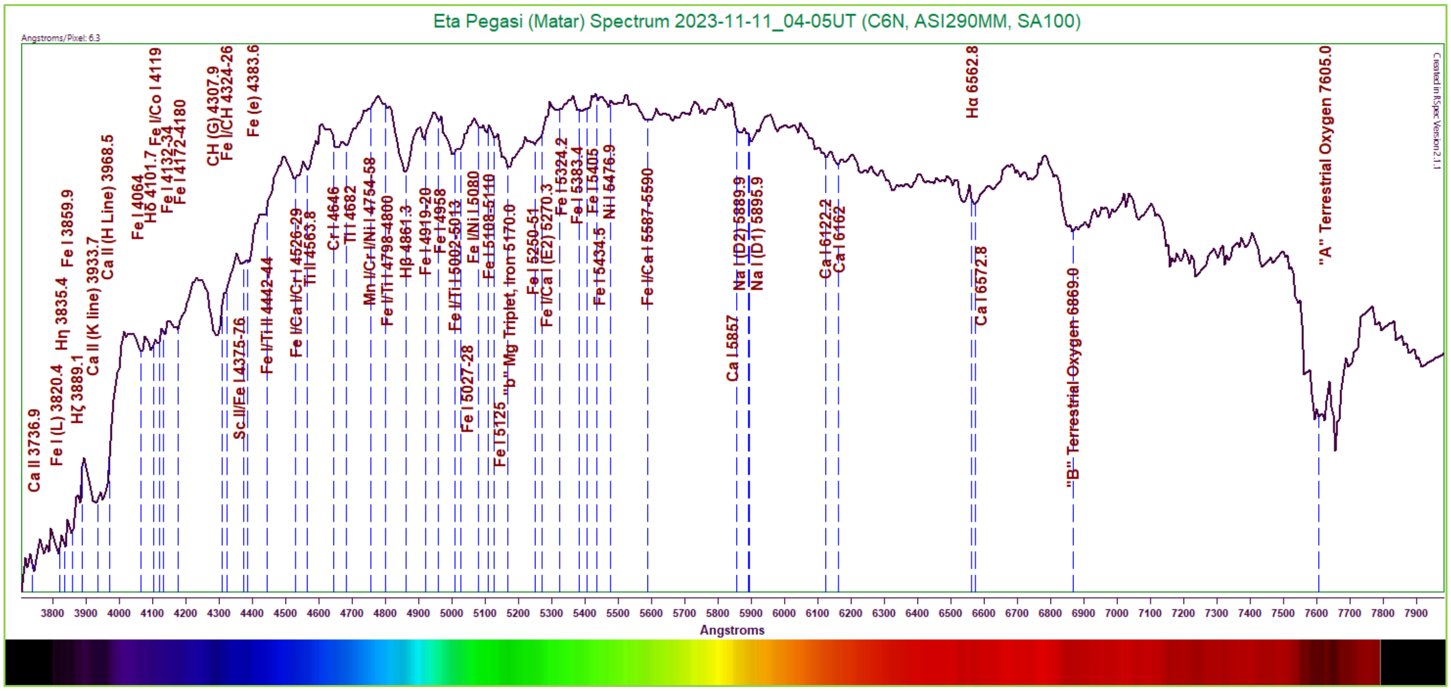

Figure 6: Eta Pegasi (Matar) Spectrum (6.3 Angstroms/pixel)
Capture Details 6: Exposure 361ms, Gain 95, 45% of 409 frames stacked

As expected, we see a spectral curve of a moderately hot star showing a lot of metal lines. Many of the hydrogen Balmer lines are present, though they are somewhat weakened or even missing. Near the lower wavelength range, the calcium H and K absorptions carve out a deep gouge in the continuum. The CH (G) absorption is also cutting deeply into the continuum, though not as severely. The magnesium triplet at 5170 Angstroms is fairly deep here, cutting a good dip into the spectrum together with the nearby iron lines above it. The sodium doublet at 5890-96 Angstroms is not quite as deep, but it is broadened by an adjacent calcium line just below it. A great number of much fainter metal lines can be seen, primarily iron. In addition to this, we can also see traces of calcium, scandium, titanium, chromium, manganese, and nickel. One absorption in particular escaped positive identification, and that is the notable absorption just below the Hα line. The closest match found would seem to indicate ionized magnesium, but it doesn't seem appropriate for this type of star. Very curious. This could simply be a shortcoming in the reference materials used.

We will again employ Wien's Law in an attempt to calculate a rough effective temperature. This particular curve, however, makes estimating its peak energy wavelength very uncertain, as the magnesium triplet is causing a large dip in the curve at its approximate peak. Using a rough visually estimated peak energy wavelength of 5170 Angstroms, we obtain a result of about 5605K. The established temperature of the star is 4970K[2]. Considering the uncertainties involved, it is not surprising that our estimate is off. The spectroscopic companion is also likely contributing to the apparent error.

θ Pegasi

Theta Pegasi is also called Biham, and is listed as an early A-type star[1]. We can expect to find clear hydrogen Balmer absorptions in this one, as well as a curve reflecting a fairly high temperature.

The spectrum of the star is presented below:

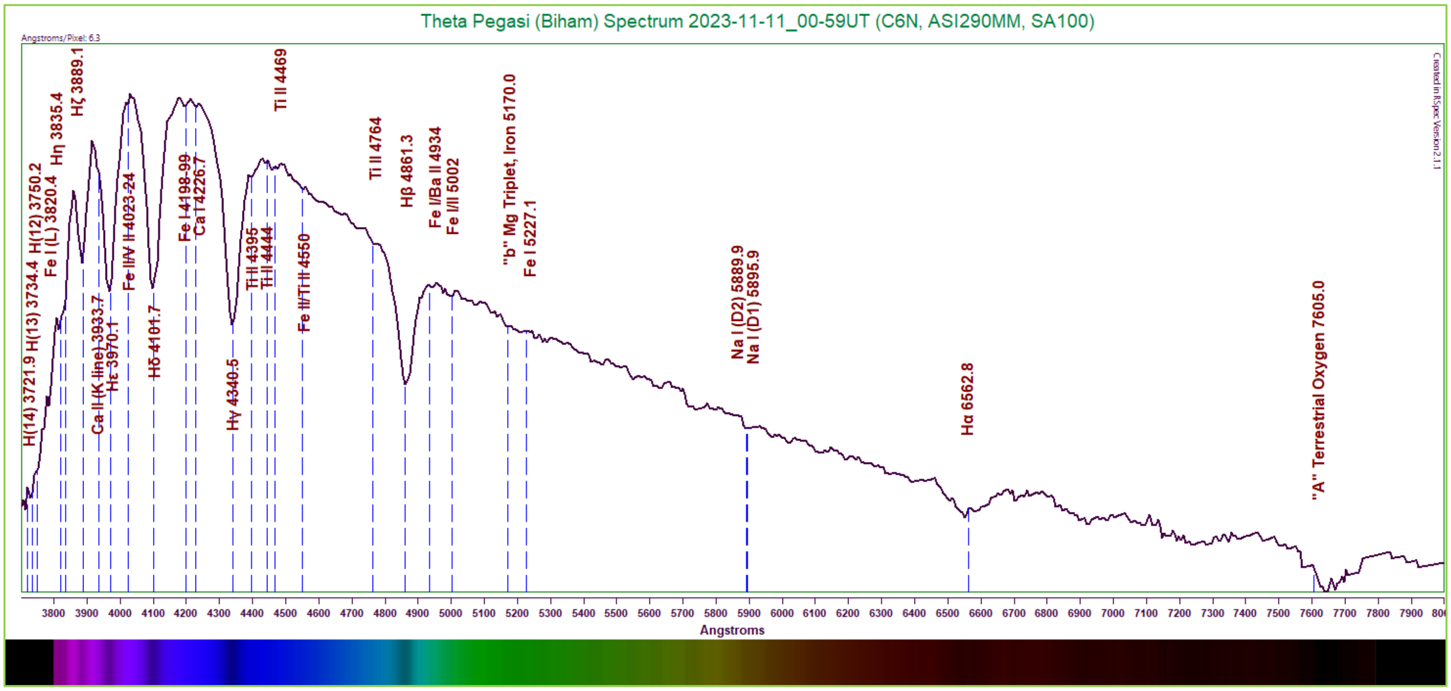

Figure 7: Theta Pegasi (Biham) Spectrum (6.3 Angstroms/pixel)
Capture Details 7: Exposure 456ms, Gain 95, 50% of 335 frames stacked

As expected, we see very strong hydrogen Balmer absorptions present here, and the curve's shape is consistent with an early A-type star. The Fe (L) line at 3820.4 Angstroms is causing a small but sharp cut into the continuum. The Hη line above it is causing a moderate-sized bump just above it. The calcium K line is just beginning to emerge here, causing only a slight disfiguration on the lower side of the Hε line. The magnesium triplet appears quite weak, but together with the Fe I line at 5227.1 Angstroms is causing a small trough in the spectrum. Beyond this, the spectrum becomes quite noisy. The sodium doublet is marked, but this is a suspect identification based on the noise levels in that part of the spectrum. A number of additional, faint metal lines can be seen in the spectrum, including iron, titanium, and calcium.

Using Wien's Law, we will estimate the star's effective temperature. Again, since this is an early A-type star, we should expect our estimate to fall far short of the actual value. Using an estimated peak energy wavelength of 4030 Angstroms, we obtain an estimate of 7191K. The established temperature is 7872K[1]. This is remarkably close to our estimate, considering how far off these usually are for A-type stars.

ι Pegasi

Iota Pegasi is a spectroscopic binary, whose main component is designated as a middle F-type star[1,2]. We can expect to see a curve representative of a star of middling temperature, but still showing some of the hydrogen Balmer features of its hotter cousins, plus more metal lines throughout.

The processed spectrum follows:

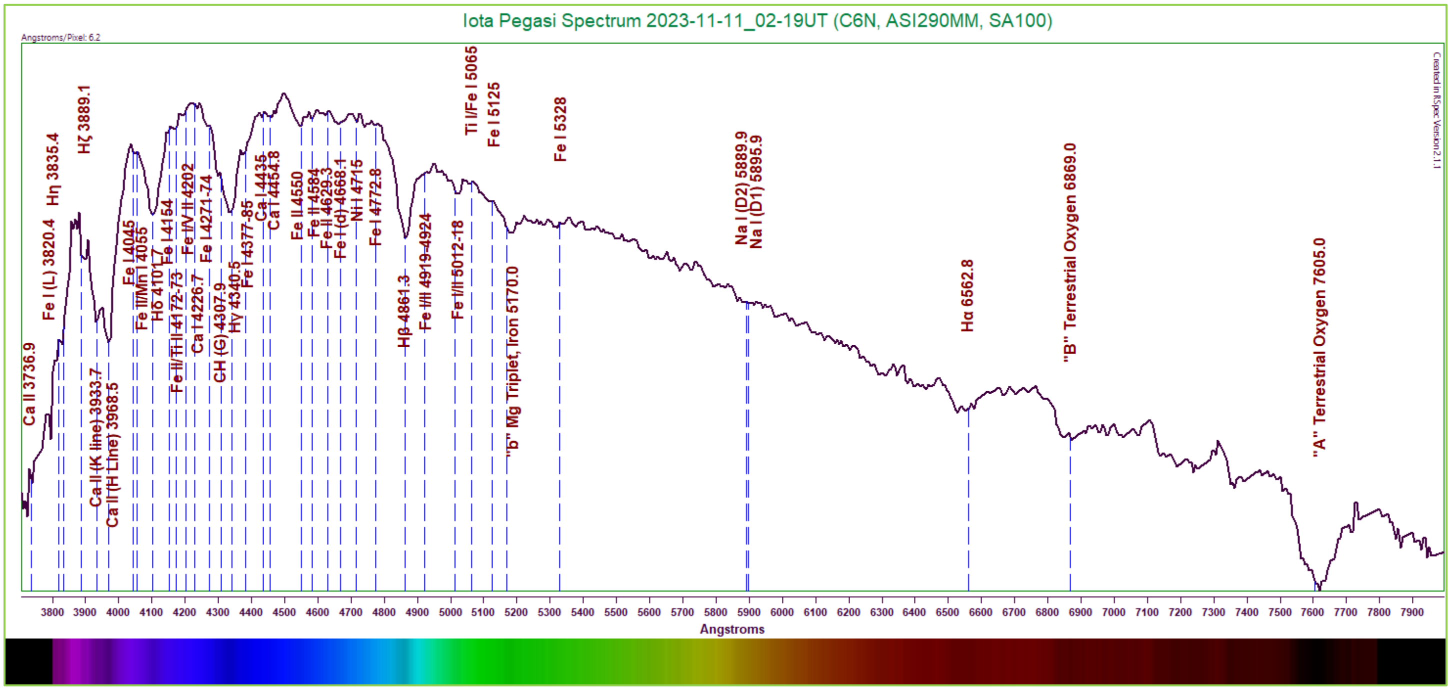

Figure 8: Iota Pegasi Spectrum (6.2 Angstroms/pixel)
Capture Details 8: Exposure 815ms, Gain 113, 50% of 307 frames stacked

Based on the star's reported type, this spectrum is indicative of our expectations. We can see fairly strong hydrogen Balmer lines present, and the curve of the star is appropriate for its type. The Fe (L) line at 3820.4 Angstroms is causing a slight bump in the continuum right below the Hη line. The CH (G) absorption is also present, causing a small feature on the lower side of the Hγ line. The magnesium triplet can be seen, though it is not very strong. Beyond this point, the continuum noise increases, making identification of features difficult. The sodium doublet is marked due to an apparent subtle dip in the continuum, but this could be disputed. A good number of additional, fainter metal lines are marked, mostly iron (both neutral and ionized). We can also see some fainter calcium and titanium present.

We will estimate the star's effective temperature using Wien's Law. Using a visually estimated peak energy wavelength of 4499 Angstroms, this provides a result of 6441K. The established temperature of the star is 6580K[2]. Our estimate is only about 140K off.

κ Pegasi

Kappa Pegasi is a multiple star system, with the primary being a middle F-type star[1]. We should expect to see features similar to those of Iota Pegasi above.

The processed spectrum is presented here:

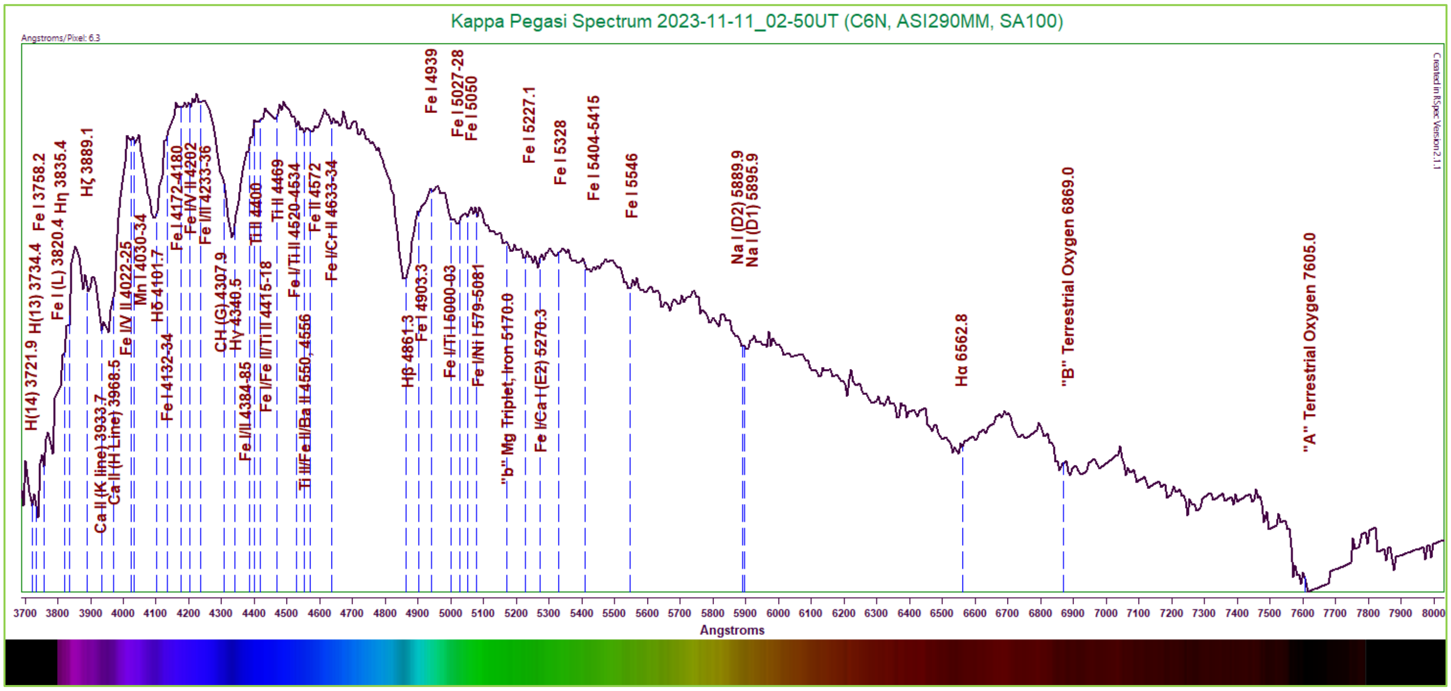

Figure 9: Kappa Pegasi Spectrum (6.3 Angstroms/pixel)
Capture Details 9: Exposure 1s, Gain 190, 60% of 242 frames stacked

The general shape of this spectral curve is indeed similar to that of Iota Pegasi. The curve is noisier due to the lower apparent magnitude of the star, which required higher gain to capture with the equipment used. Again, the hydrogen Balmer lines are evident. The calcium H and K lines are strong, cutting deeply into the continuum. The magnesium triplet and the two iron lines above it are carving out a shallow, broad depression. The sodium doublet at 5890-96 Angstroms is much easier to recognize here. A large number of very faint iron lines are spread throughout the spectrum, some of them seemingly packed very tightly together. In addition to these, we can also see some manganese and titanium.

Using a visually estimated peak energy wavelength of 4233 Angstroms, we can employ Wien's Law to arrive at a rough guess of the star's effective temperature. The calculation results in a value of 6846K. The established temperature is 6579K[2]. It appears that our estimate in this case is again very close.

λ Pegasi

Lambda Pegasi is classified as a late G-type star[1]. We should expect to see a spectrum of a star just a bit cooler than the Sun, with plenty of metal lines apparent.

The spectrum is below:

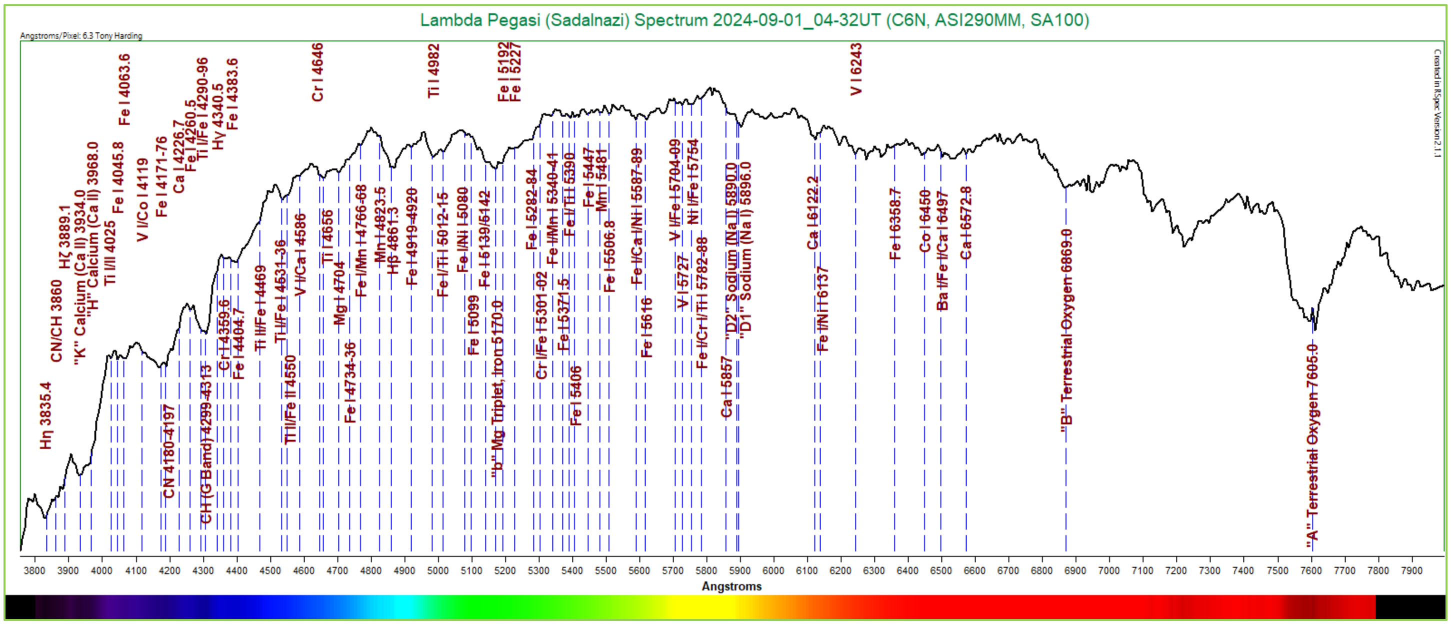

Figure 10: Lambda Pegasi (Sadalnazi) Spectrum (6.3 Angstroms/pixel)
Capture Details 10: Exposure 227ms, Gain 200, 20% of 1074 frames stacked

We can immediately see from the spectrum's shape that we are indeed dealing with a later G-type star. The hydrogen Balmer lines are reduced or missing here, with the Hβ absorption being the strongest. The calcium K and H lines at 3934 and 3968 Angstroms appear distinguishable. The CN molecular absorption at 4299-4313 Angstroms is quite strong and is being aided by the iron absorption just below it. The magnesium triplet at 5170 Angstroms is the deepest apparent absorption here, and is being attended by flanking iron lines. The sodium doublet is visible at 5890-96 Angstroms, as well. Just below it can be seen the calcium absorption at 5857 Angstroms, which shows up amazingly well. Other fainter absorptions include the CN/CH molecular absorption at 3860 Angstroms, as well as titanium, iron, vanadium, calcium, chromium, magnesium, manganese, cobalt, and barium.

Employing Wien's Law, we will calculate an effective temperature estimate for the star. From the spectrum presented above, the peak energy wavelength appears to lie at 5810 Angstroms. Using this value, we calculate a temperature of 4988K. The established temperature for the star is listed as 4933K[2]. Our estimate is extremely close, only falling 55K from the mark!

μ Pegasi

Mu Pegasi, known as Sadalbari, is another late G-type star[1]. We should expect results similar to that for Lambda Pegasi above—a star a bit cooler than our own Sun with lots of metal lines.

The processed spectrum for the star is present below:

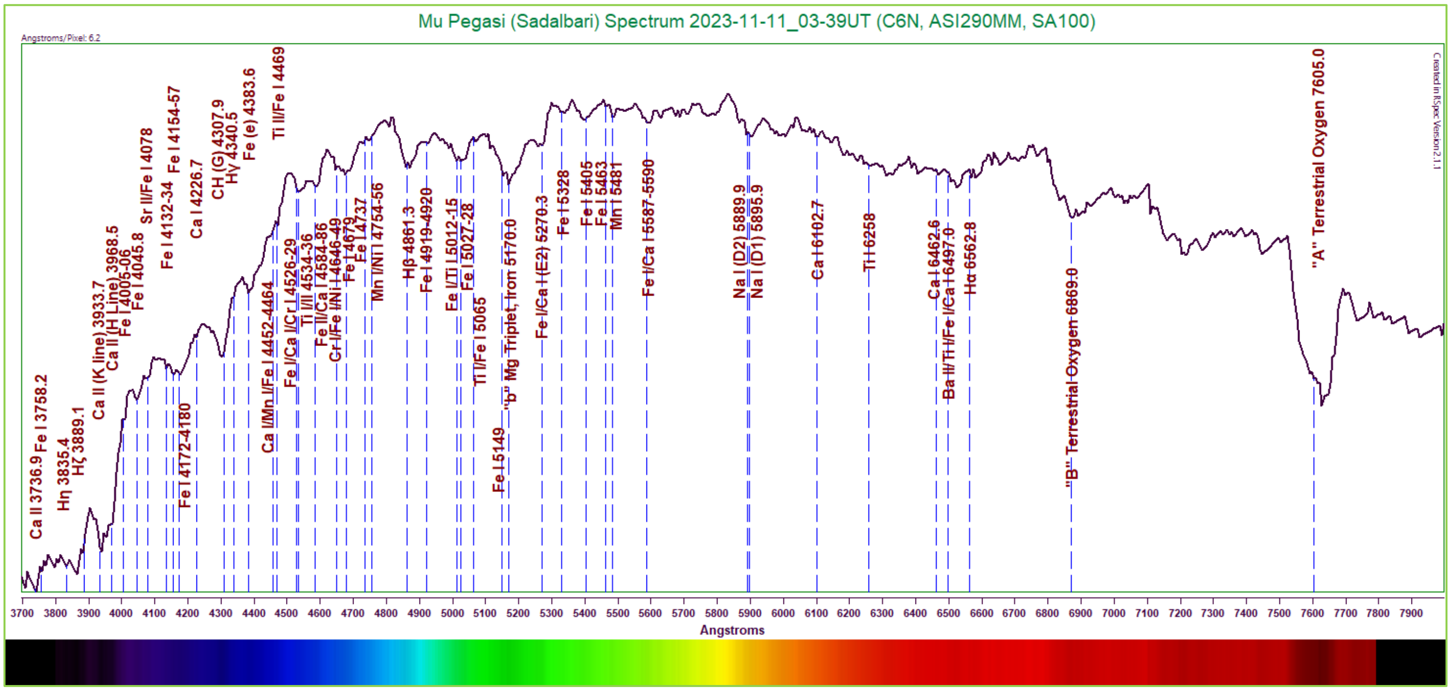

Figure 11: Mu Pegasi (Sadalbari) Spectrum (6.2 Angstroms/pixel)
Capture Details 11: Exposure 589.919ms, Gain 98, 60% of 311 frames stacked

Here we see a curve typical of G-type stars. The lower temperature is indicated by the general shape of the curve. Many of the hydrogen Balmer lines are still evident, though not all of them. Near the lower end of the wavelength scale, we see the calcium H and K lines carving out a very deep groove. In the 4132-4180 Angstroms range, we see three neutral iron lines cutting fairly deeply into the spectrum. The CH (G) line is also notable here at 4307.9 Angstroms. The magnesium triplet at 5170 Angstroms is very plain. We can even clearly see the Fe I line at 5149 Angstroms just below it. The Fe I/Ca I (E2) line above it is very pronounced. The sodium D1 and D2 lines at 5890-96 Angstroms are evident here as well, though not as strong as the magnesium triplet. A variety of fainter metal lines are spread throughout this spectrum, including calcium, lots of iron, strontium, titanium, chromium, manganese, and barium.

We will employ Wien's Law to ascertain a rough estimate of the star's temperature. Using an estimated peak energy wavelength of 5833 Angstroms, the calculation reveals a result of 4968K. The accepted temperature of the star is 4950K[2].Ours is a pleasingly accurate estimate!

ξ Pegasi

Xi Pegasi, or Suudalnujum, is a double star whose primary is middle F-type star[1]. Its companion is a dim, M-type star, and so shouldn't contribute much (if anything) to our spectrum. Based on the star's type, we should still see notable hydrogen Balmer lines on this one, with a decent number of fainter metals emerging.

The processed spectrum is as follows:

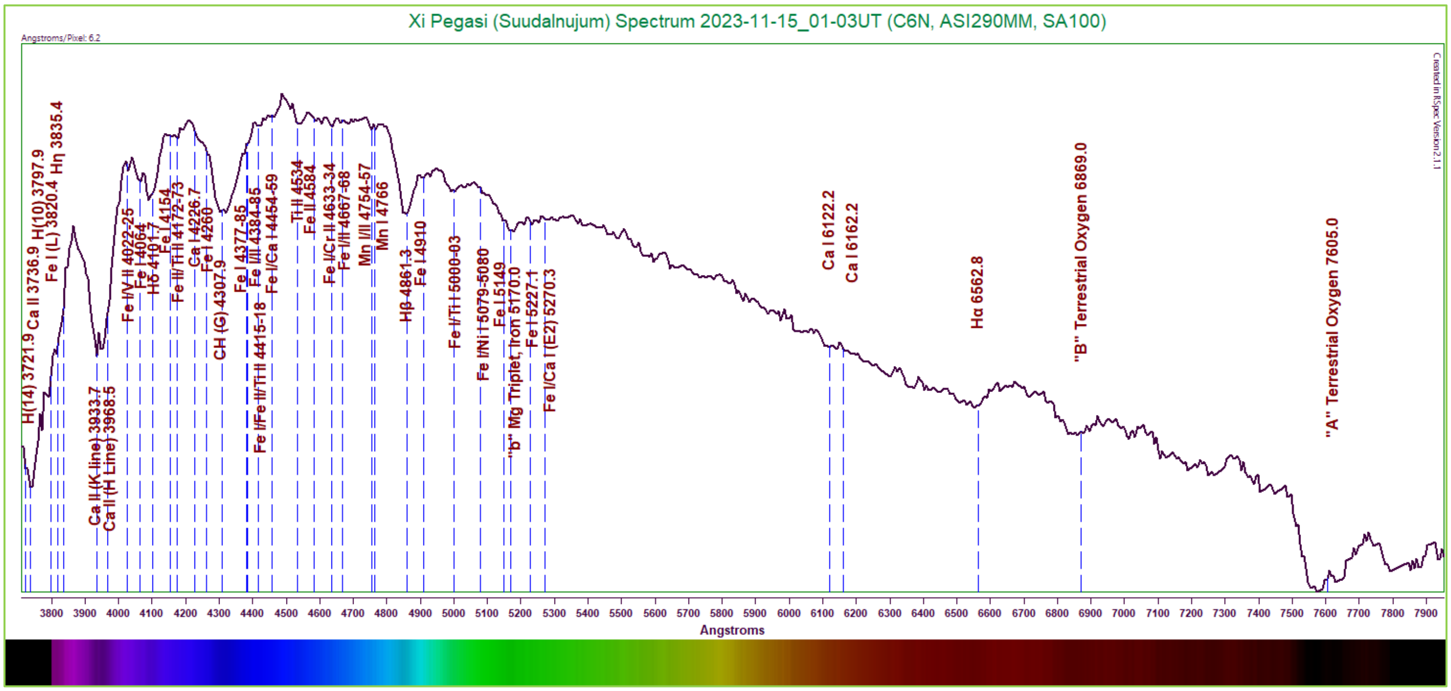

Figure 12: Xi Pegasi (Suudalnujum) Spectrum (6.2 Angstroms/pixel)
Capture Details 12: Exposure 1s, Gain 119, 65% of 252 frames stacked

This curve does resemble our expectations for an F-type star. The hydrogen Balmer lines are still quite prominent, except for the Hε line. The noise levels on this spectrum are a bit higher due to the dimmer apparent magnitude of the star, but the main features can still be easily spotted. The calcium H and K lines are very strong, providing the deepest absorption in the spectrum. The CH (G) absorption is also strong and deep. The magnesium triplet is comparatively weak, but still manages to cut out a shallow groove in the continuum. Above that, the spectrum becomes increasingly noisy. There is no obvious trace of the sodium doublet here. A number of additional fainter lines are marked, including calcium, lots of iron, titanium, and manganese.

Using Wien's Law, we will estimate the star's temperature. Using an estimated peak energy wavelength of 4490 Angstroms, we obtain a result of 6455K. The established temperature of the star is 6178K[2]. Not a terribly bad estimate.

π-1 Pegasi

Pi Pegasi is a double star whose components are widely spread and can be analyzed individually. We will first consider Pi-1 Pegasi.

Pi-1 Pegasi is a middle G-type star[1]. With that in mind, we should expect results not entirely dissimilar from Saadalbari above—lots of metals evident in a star just a little bit cooler than the Sun.

The processed spectrum is presented below:

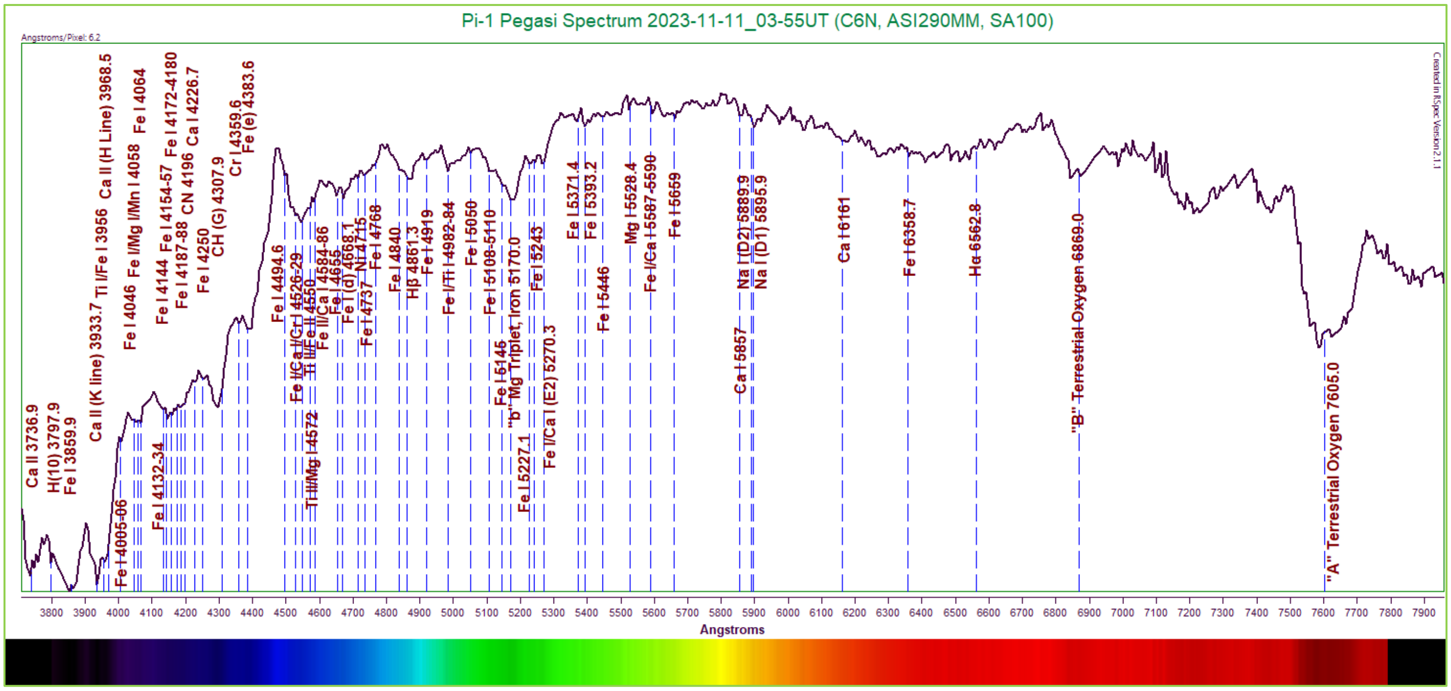

Figure 13: Pi-1 Pegasi Spectrum (6.2 Angstroms/pixel)
Capture Details 13: Exposure 3s, Gain 101, 100% of 60 frames stacked

The general shape of the spectrum curve for this star does indeed look correct for a G-type star. The quality of this capture seems higher than most of the others, and features are practically jammed on top of each other. (It was challenging to try and line up the labels with the absorption lines, so exercise great caution when zeroing in on any single line.) Only a few of the hydrogen Balmer lines are visible here, and those are considerably weak. At the extreme low wavelength region, the Ca II line at 3736.9 Angstroms is quite deep. The Fe I line at 3859.9, though, is even deeper. The calcium H and K lines are profoundly deep, with a very faint titanium absorption between them. The CH (G) line at 4307.9 Angstroms is easily recognized. The magnesium triplet at 5170 Angstroms is notable, with several very small iron absorptions flanking it. The sodium doublet at 5890-96 Angstroms is quite small, and a fairly strong neutral calcium line is identifiable just below it. Other, fainter metal lines appear here, including tons of iron, CN, calcium, titanium, and magnesium. An anomalous spike in the continuum appears near 4474 Angstroms, but it is likely an artifact of the capture—perhaps a dim background star not detected during the capture process.

Estimating a peak energy wavelength of 5815 Angstroms, we can employ Wien's Law to obtain a rough estimate of the star's effective temperature. The calculation results in a figure of 4983K. The established temperature of the star is 4898K[2]. Another fairly close estimate!

π-2 Pegasi

Pi-2 Pegasi is classified as a middle F-type star[1]. Such being the case, we should expect a curve similar to that of Suudalnujum presented earlier, with healthy hydrogen Balmer lines and a respectable presence of metals.

The processed spectrum of the target is presented below:

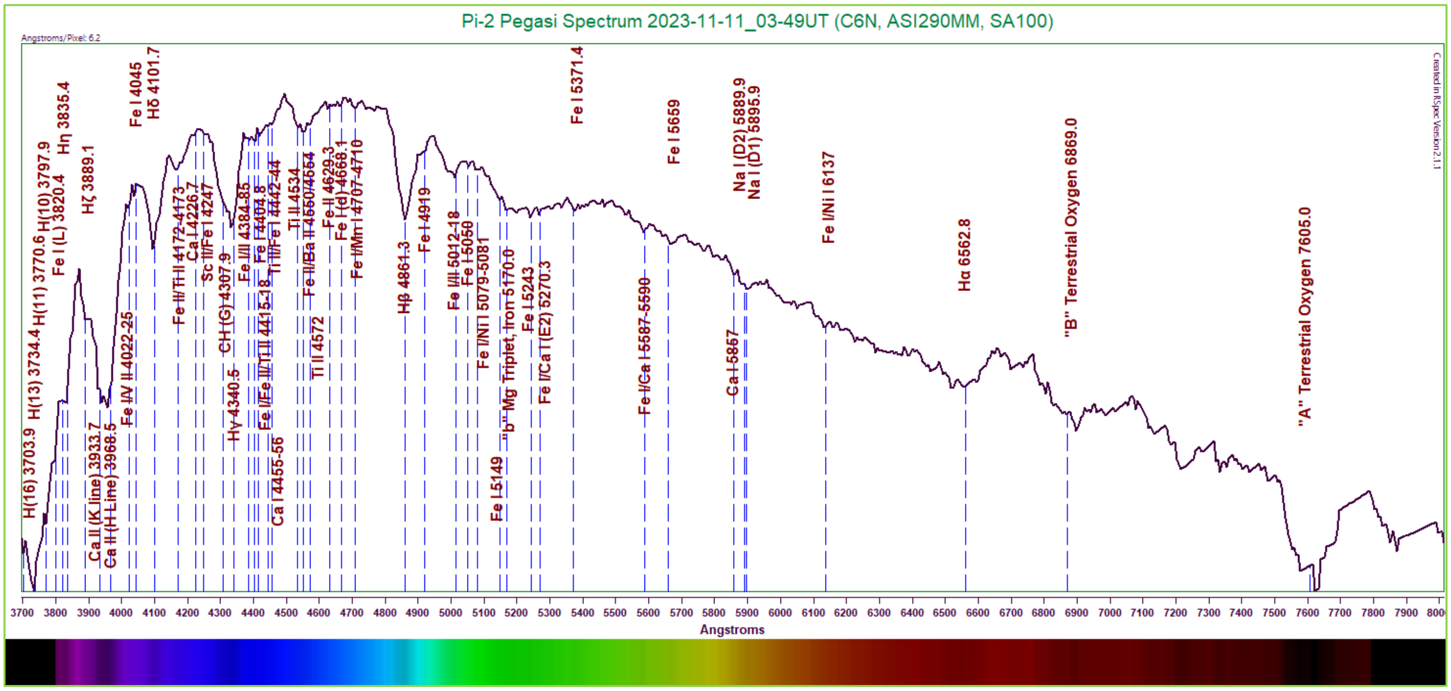

Figure 14: Pi-2 Pegasi Spectrum (6.2 Angstroms/pixel)
Capture Details 14: Exposure 1s, Gain 107, 65% of 183 frames stacked

This one turned out quite well. The general shape of the curve appears consistent with this class of star. The hydrogen Balmer lines are present, except where overlayed by more powerful absorptions (such as the calcium H and K lines). The Fe (L) line and Hη line are causing a respectable stair-step in the continuum at 3820-3889 Angstroms. The calcium H and K lines are displaying a deep cut. The CH (G) line (on the lower side of the Hγ absorption) is displaying a noticeable bump. The magnesium triplet at 5170 Angstroms has carved a large scoop out of the continuum together with the adjacent iron lines. The sodium D1 and D2 lines are visible, but much less pronounced. A calcium line at 5857 Angstroms just below them can be seen. Numerous additional, fainter metal lines are noted, including iron, calcium, scandium, and titanium.

Using Wien's Law, we will attempt to obtain an estimate of the star's temperature. Using an estimated peak energy wavelength of 4496 Angstroms, our result is 6445K. The established temperature of the star is 6300K[2]. Not a shabby estimate!

Conclusion

Capturing the dimmer stars in Pegasus did prove challenging. Of the three stars revisited on the 14th, none were found to be in error, though one (Xi Pegasi) was a clearer capture than the initial one, so that one was used. The recapture of Lambda Pegasi went without a hitch, but it did delay the report significantly.

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