Spectral Analysis of the Constellation Stars of Camelopardalis (The Giraffe)

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Abstract

This paper will elucidate the spectral features of the main stars in the constellation Camelopardalis. 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

All of the spectra obtained for this analysis were collected on the evening of November 7, 2024 (EST). 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 are 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. The response curve used in this analysis was generated (using Alpha Lyrae) on the evening of August 31, 2024. 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.

The stars of this constellation are relatively dim, the brightest being only magnitude 4.25. This combined with the general condition of my northern sky left some doubt regarding the quality of the resulting data. Still, the decision was made to proceed.

α Camelopardalis

Alpha Camelopardalis is classified as a very late O-type star[1]. Based on this, we can expect an extremely hot star showing reduced hydrogen Balmer lines, with some notable helium absorptions present.

The processed spectrum is presented below:

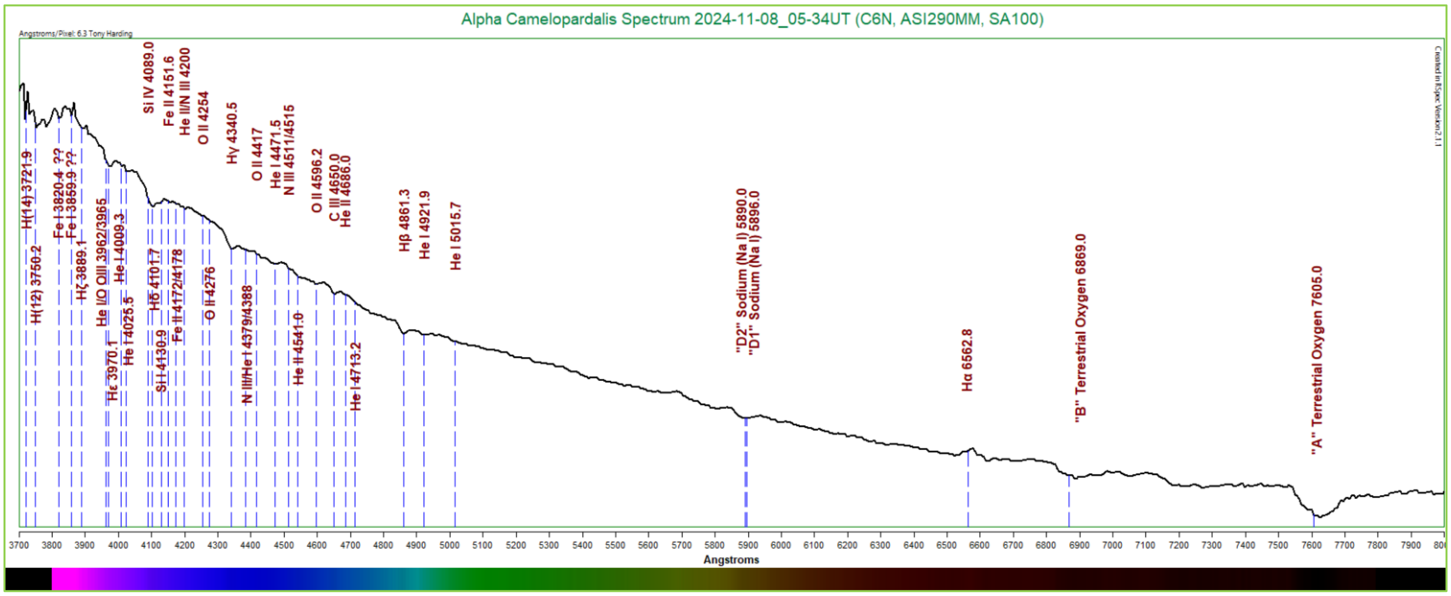

Figure 1: Alpha Camelopardlis Spectrum (6.3 Angstroms/pixel)
Capture Details 1: Exposure 2s, Gain 107, 80% of 172 frames stacked, Integration Time 275s

This specimen provides a very interesting result. Many of the hydrogen Balmer lines are visible, but these are definitely not strong. The Hα feature shows emission; investigation of this revealed that it is due to a strong stellar wind. Numerous helium lines are present, both neutral and ionized, at 3962, 4009.3, 4200, 4471.5, 4541.0, 4686.0, 4713.2, 4921.9, and 5015.7 Angstroms. Two very questionable lines for neutral iron are marked at 3820.4 and 3859.9 Angstroms; these are questionable due to the extremely high temperature of this star, which we would not normally expect to show neutral iron absorptions. The sodium doublet at 5890-96 Angstroms is present, but this is certainly due to interstellar sources. Other metals marked include silicon, ionized iron, oxygen, nitrogen, and carbon.

Despite the star's obviously high temperature, we will use Wien's Law to calculate an effective temperature. From the flux curve above, the peak energy wavelength appears to lie at 3714 Angstroms. With this value, we calculate an effective temperature of 7802K. The established temperature for the star is listed as 29000K[2]. As expected, the estimate is very, very short of the mark.

γ Camelopardalis

Gamma Camelopardalis is classified as an early A-type star[1]. From this, we can expect extremely strong hydrogen Balmer absorptions, with a smattering of metals mixed in.

The completed spectrum is presented here:

Ium

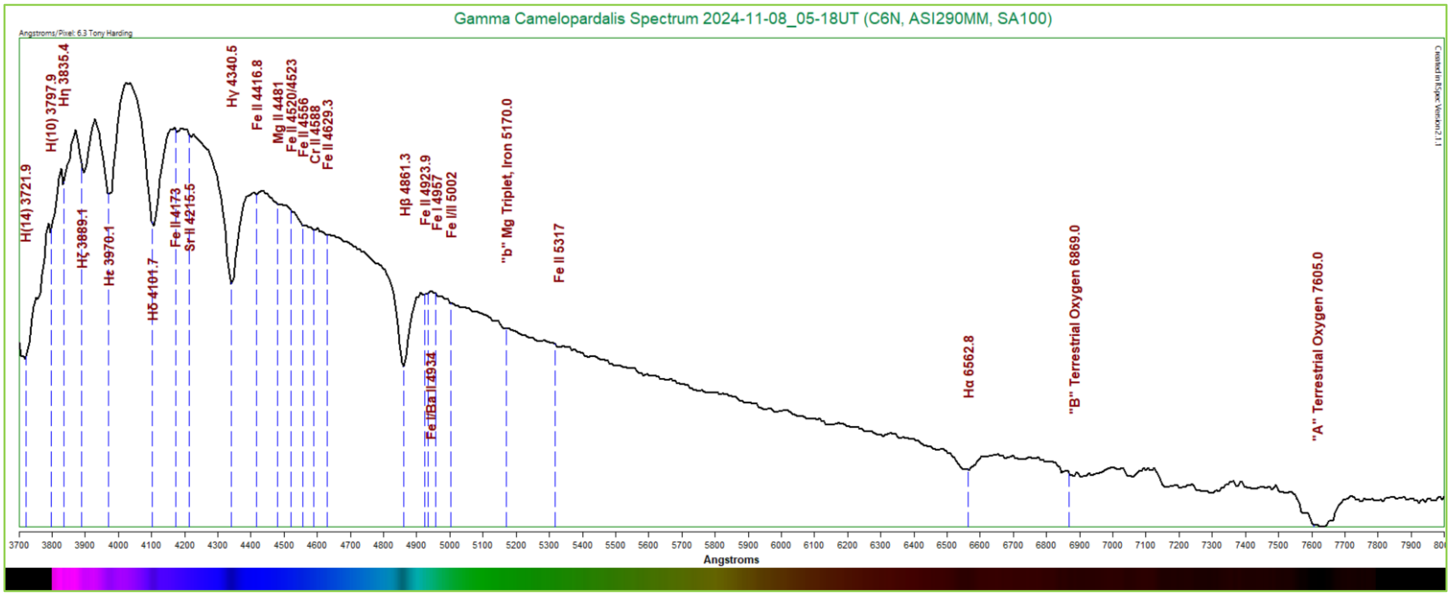

Figure 2: Gamma Camelopardalis Spectrum (6.3 Angstroms/pixel)
Capture Details 2: Exposure 2s, Gain 116, 85% of 172 frames stacked, Integration Time 292s

As expected, the hydrogen Balmer lines are very deep and clear here. Two small but surprisingly crisp absorptions are noted at 4173 Angstroms (ionized iron) and 4215.5 Angstroms (ionized strontium). The magnesium triplet is extremely small but present at 5170 Angstroms. Some other faint or very faint metals are indicated, including neutral and ionized iron, ionized magnesium, and ionized chromium.

Using Wien's Law, we will attempt to calculate an effective temperature. Again, our calculation must be anticipated to be very short of the mark due to the early-type star involved. From the curve above, the peak energy wavelength appears to lie at 4024 Angstroms. Using this value, we calculate a temperature of approximately 7201K. The listed temperature for the star is 8892K[2].

Σ 385

Struve 385, also known by the designations CS Camelopardalis and HD 21291, is a variable binary system. The primary component is classified as a very late B-type star[1,2]. The unresolved companion star is much dimmer, and currently classified as an early B-type star[2]. However, the secondary probably will not contribute to our low-resolution results. We can therefore expect a spectrum reflective of another hot star, with pronounced hydrogen Balmer lines. We might also be able to pick out a neutral helium line or two.

The spectrum is found below:

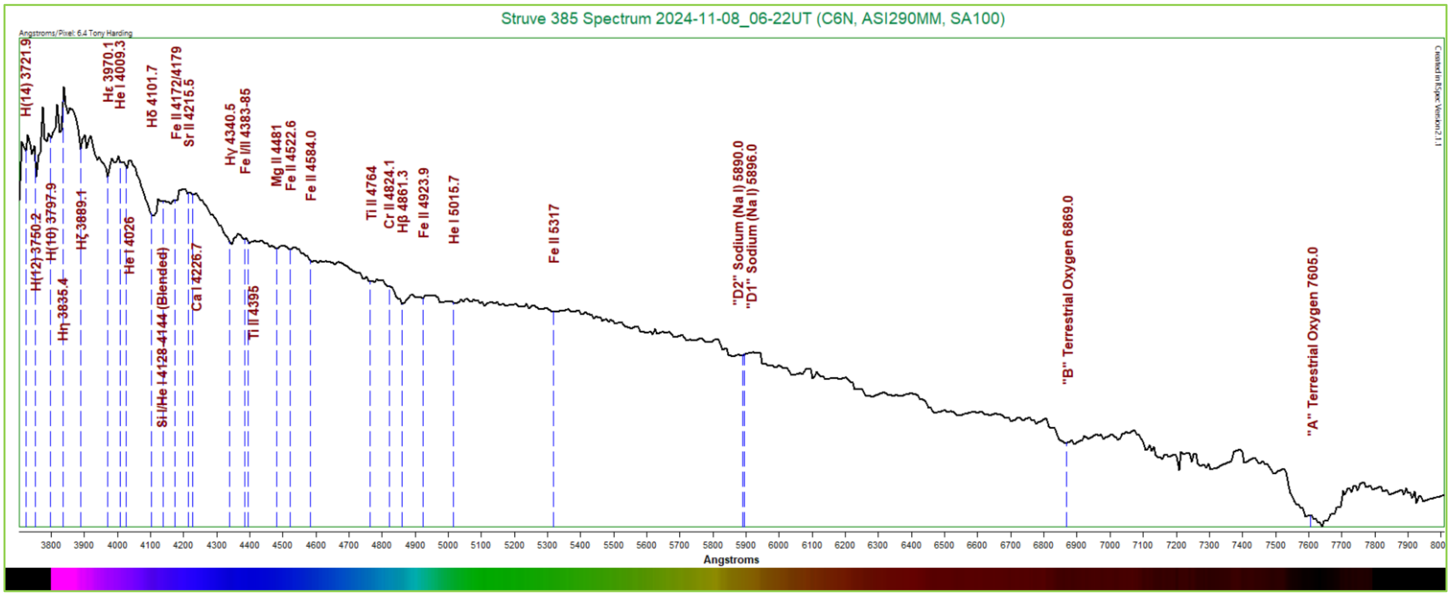

Figure 3: Struve 385 Spectrum (6.4 Angstroms/pixel)
Capture Details 3: Exposure 2s, Gain 53, 79% of 172 frames stacked, Integration Time 271s

This target's result turned out rather noisy, but many of the main features can still be identified. The hydrogen Balmer lines are mostly present, but appear weaker than anticipated. (Some additional checking revealed that the star is a supergiant, which is likely contributing to the reduced appearance of the lines.) Despite the noise, several neutral helium lines are identifiable, at 4009.3, 4026, 4128-4144 (Blended with silicon), and 5015.7 Angstroms. The sodium D2 and D1 absorption is present at 5890-96 Angstroms, likely appearing slightly heightened from interstellar contributions. Some other metals are labeled, including iron, strontium, calcium, magnesium, titanium, and chromium.

We will once more employ Wien's Law to calculate an effective temperature. And—again—the estimate will surely be far too low (given the type of star involved). From the flux curve, the apparent peak energy wavelength seems to lie at 3837 Angstroms. With this value, we calculate a temperature of only 7552K. The professionally derived temperature is listed as 10800K[2].

HIP 18505

HIP 18505, also known by the designation HD 24479, is a single star of the very late B-type. Based on this, we can expect to see many features in common with Struve 385 previously—hydrogen Balmer lines visible, with perhaps some neutral helium present.

The processed spectrum is presented below:

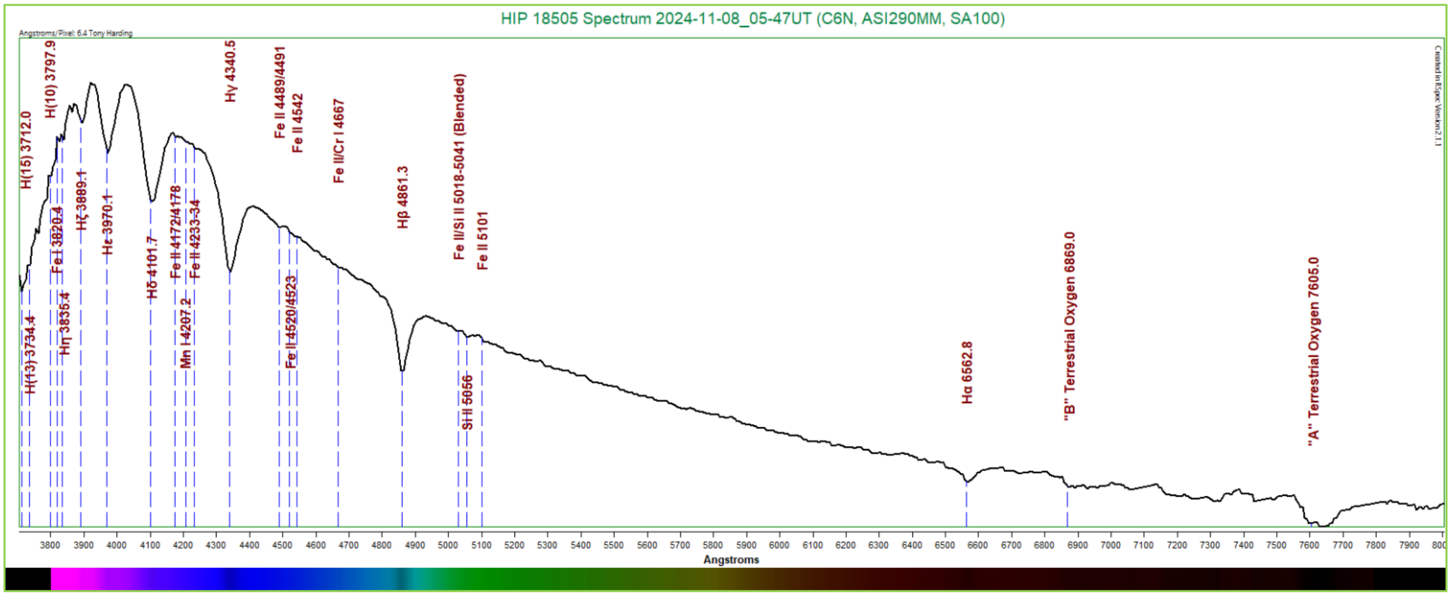

Figure 4: HIP 18505 Spectrum (6.4 Angstroms/pixel)
Capture Details 4: Exposure 2s, Gain 125, 100% of 171 frames stacked, Integration Time 342s

This specimen produced a relatively clean-looking spectral curve. The hydrogen Balmer lines are well represented here. Contrary to our expectations, though, no neutral helium lines are distinctly visible. The magnesium triplet and sodium doublet are also absent here. What we do see, however, is a good number of ionized iron lines—at 4172/4178, 4233-34, 4489/4491, 4520/4523, 4542, 4667, 5018, and 5101 Angstroms. Only a couple other metals are distinguishable here, namely one neutral iron line, one manganese absorption (extremely faint), and some ionized silicon.

Using Wien's Law, we will calculate an effective temperature for the star. Since this is an early-type star, our estimate will certainly fall far short of the actual value, but we will conduct the exercise as a means of demonstration. From the flux curve above, the peak energy wavelength appears to lie at 3922 Angstroms. With this value, we obtain a temperature estimate of approximately 7389K. The professionally determined temperature for the star is listed as 10520K[2]. As anticipated, our estimate is much too low.

Σ 634

Struve 634, also known as HD 33564, is a star of the late F-type[1]. Based on this we can expect to see a spectrum reflective of a star that is a bit hotter than our own sun, with moderate hydrogen Balmer lines and plenty of metals present.

The spectrum is found here:

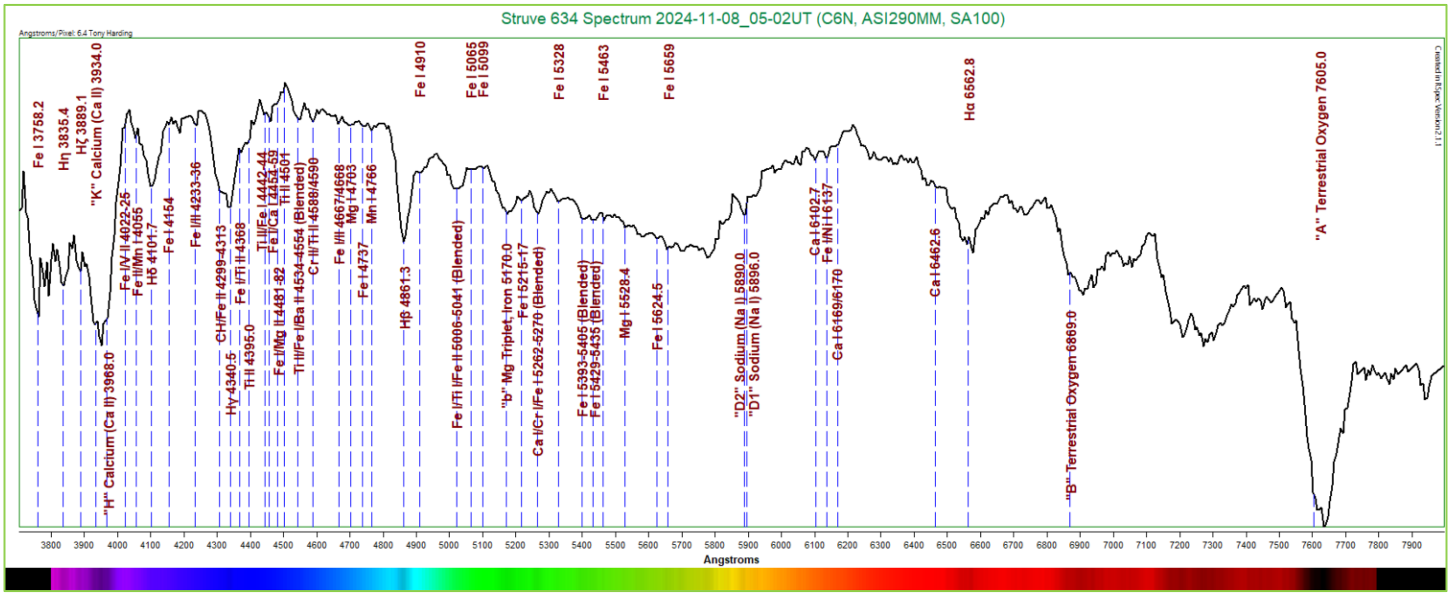

Figure 5: Struve 634 Spectrum (6.4 Angstroms/pixel)
Capture Details 5: Exposure 3s, Gain 117, 90% of 117 frames stacked, Integration Time 315s

The resulting spectrum for this star is fraught with anomalies and considerable noise. The overall shape of the flux curve is anything but smooth; this could perhaps be due to some very thin, high-level cloud cover or pollution that was not noticed at the time the data was captured. The most notable anomaly is seen near 5777 Angstroms, where a very broad, pronounced, and unexplained dip in the continuum occurs. This resembles severe line blanketing in appearance. Despite this, some notable characteristics are still identifiable in the spectrum. Several hydrogen Balmer lines are evident, some strongly. The H and K ionized calcium lines are certainly visible at 3934 and 3968 Angstroms. The molecular CH absorption at 4299-4313 Angstroms is visible just below the stronger Hγ line. The magnesium triplet at 5170 Angstroms is producing a moderate dip in the curve, as is the sodium doublet at 5890-96 Angstroms. Some fainter metals are labeled, but these must all be treated dubiously due to the overall roughness of the results. These include iron, titanium, chromium, magnesium, manganese, and calcium.

Using Wien's Law, we will attempt to calculate an effective temperature. The roughness of the resulting spectrum, however, makes the determination of the peak energy wavelength somewhat uncertain. From the flux curve above, the peak appears to lie at 4505 Angstroms. Using this value, we calculate a temperature of 6432K. The listed temperature of the star is 6396K[2]. Considering the roughness of our flux curve, this is definitely closer to the mark than expected!

Conclusion

Overall, the results turned out to be acceptable. The most glaring exception is Struve 634, whose spectrum indicated notable anomalies and noise. Also, data for another star (Struve 384) was captured, but the results were entirely erroneous and were discarded.

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