Spectral Analysis of the Constellation Stars of Aries (The Ram)

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Abstract

This paper will elucidate the spectral features of the main stars in the constellation Aries. 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 captured for this analysis were obtained on the evening of November 18, 2023 (EST). Additional specifics for each capture are 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.

α Arietis

Alpha Arietis, known as Hamal, is regarded as an early K-type star[1]. The spectral curve should show a cooler star with numerous metal lines scattered throughout.

The processed spectrum is as follows:

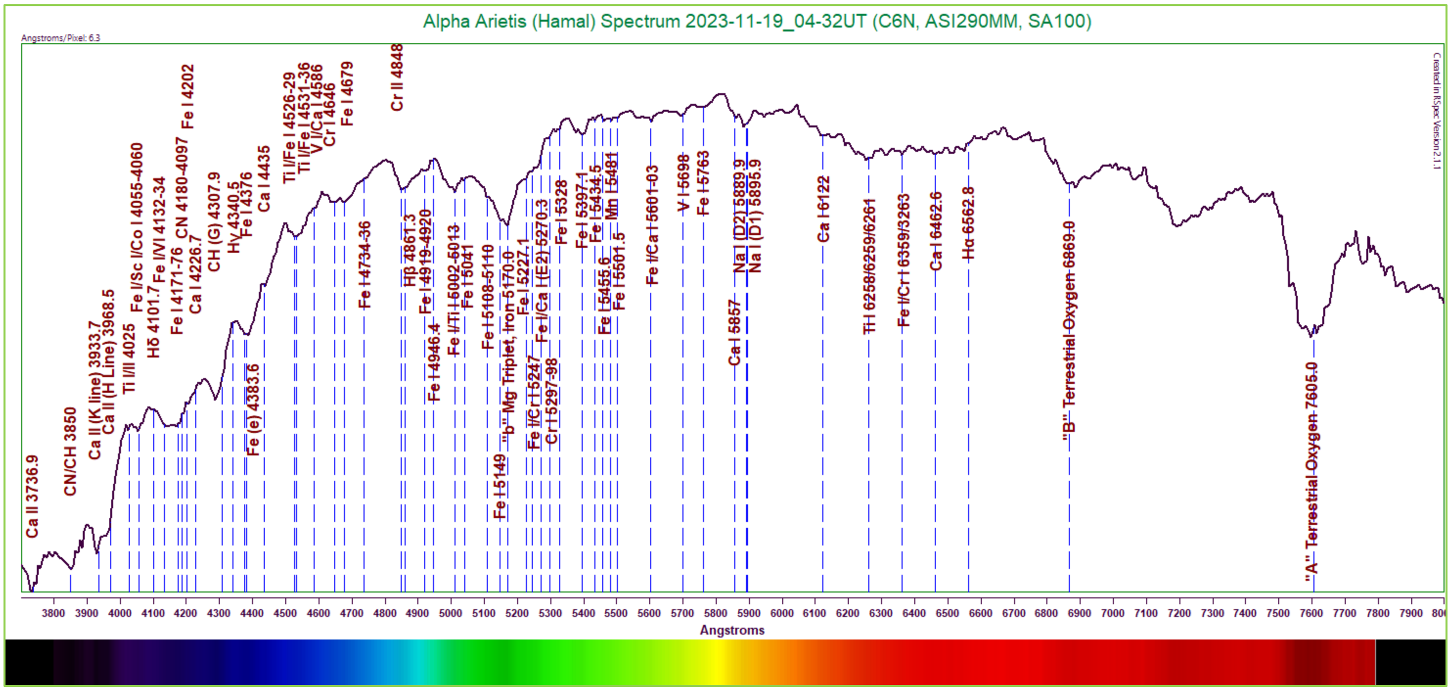

Figure 1: Alpha Arietis (Hamal) Spectrum (6.3 Angstroms/pixel)
Capture Details 1: Exposure 481ms, Gain 21, 50% of 507 frames stacked

We can see from the shape of the curve that this is a cooler star. The hydrogen Balmer lines that are visible are mostly of moderate strength. The Hβ line appears slightly broadened due to the adjacent chromium line at 4848 Angstroms. Near the lower wavelength range, the CN/Ch absorption at 3850 Angstroms appears quite well. The calcium H and K lines are visible above it, appearing moderately strong. A plateau in the spectrum appears in the 4132-4176 Angstroms range due to a combination of iron lines. The CH (G) line is very deep and sharp. The magnesium triplet is clearly shown, the groove in the continuum appearing very broad due to the iron lines flanking it. The sodium doublet at 5890-96 Angstroms is evident, though weak. Just below it, the calcium line at 5857 Angstroms is vivid. Numerous faint metal lines are evident throughout the spectrum, including calcium, titanium, vanadium, and chromium.

Using Wien's Law, we will obtain an estimate of the star's temperature. Accepting a peak energy wavelength of 5825 Angstroms, our resulting temperature works out to 4975K. The accepted temperature of the star is listed as 4480K[2]. In this case, our estimate is a bit high.

β Arietis

Beta Arietis, or Sheratan, is a spectroscopic binary whose primary is a middle A-type star[1,2]. Such being the case, we can expect to see strong hydrogen Balmer lines present, and a curve representing a hotter star than Alpha Arietis above. We can also expect far fewer metal lines to be visible here.

The spectrum is presented here:

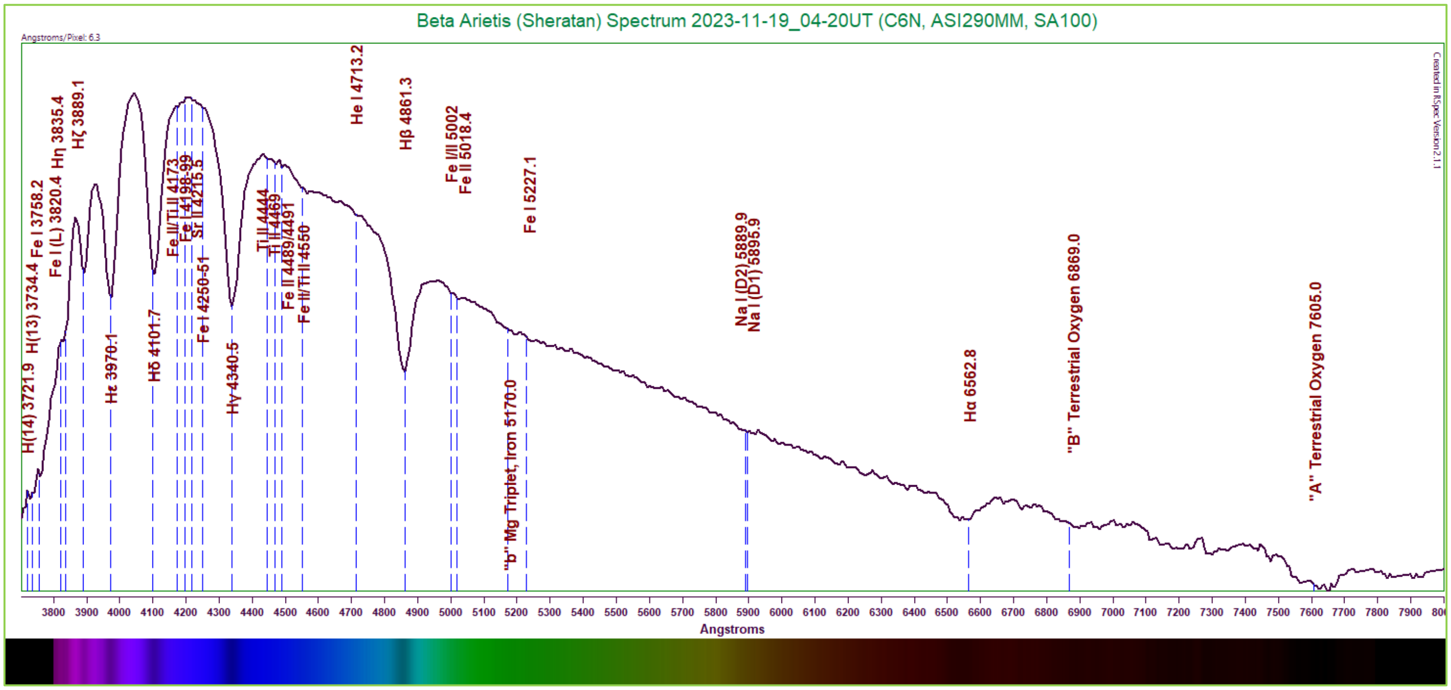

Figure 2: Beta Arietis (Sheratan) Spectrum (6.3 Angstroms/pixel)
Capture Details 2: Exposure 561ms, Gain 68, 30% of 436 frames stacked

Ah, here we see quite a different spectrum from that of Hamal. The hydrogen Balmer lines are very strong here, showing strong, deep absorptions. A small plateau at Hη can be seen, with a contribution from the adjacent iron line. A single helium line—very faint—can be seen at 4713.2 Angstroms. The magnesium triplet is shown only by a minor dip in the continuum level. The sodium doublet is even weaker, evident only by a very subtle dip. Additional very faint metal lines are marked, including iron, strontium, and titanium.

We can employ Wien's Law to obtain a temperature estimate for the stars. However, being an early-type star, we should expect our estimate to be too low. Using a peak energy wavelength of 4044 Angstroms, Wien's Law yields an effective temperature of 7166K. The listed temperature is 9000K[2]. Our estimate is definitely too low, as expected.

γ-2 Arietis

Gamma Arietis, or Mesarthim is a close double star. The equipment used was just able to separate the two components, so we will evaluate each individually.

Gamma-2 Arietis, the slightly brighter member of the binary, is assigned different classifications. It can be found listed as either a very early A-type star or an early A-type star[1,2]. We can therefore expect strong hydrogen Balmer lines here, and a spectrum curve not unlike that of Sheratan above.

The processed spectrum follows:

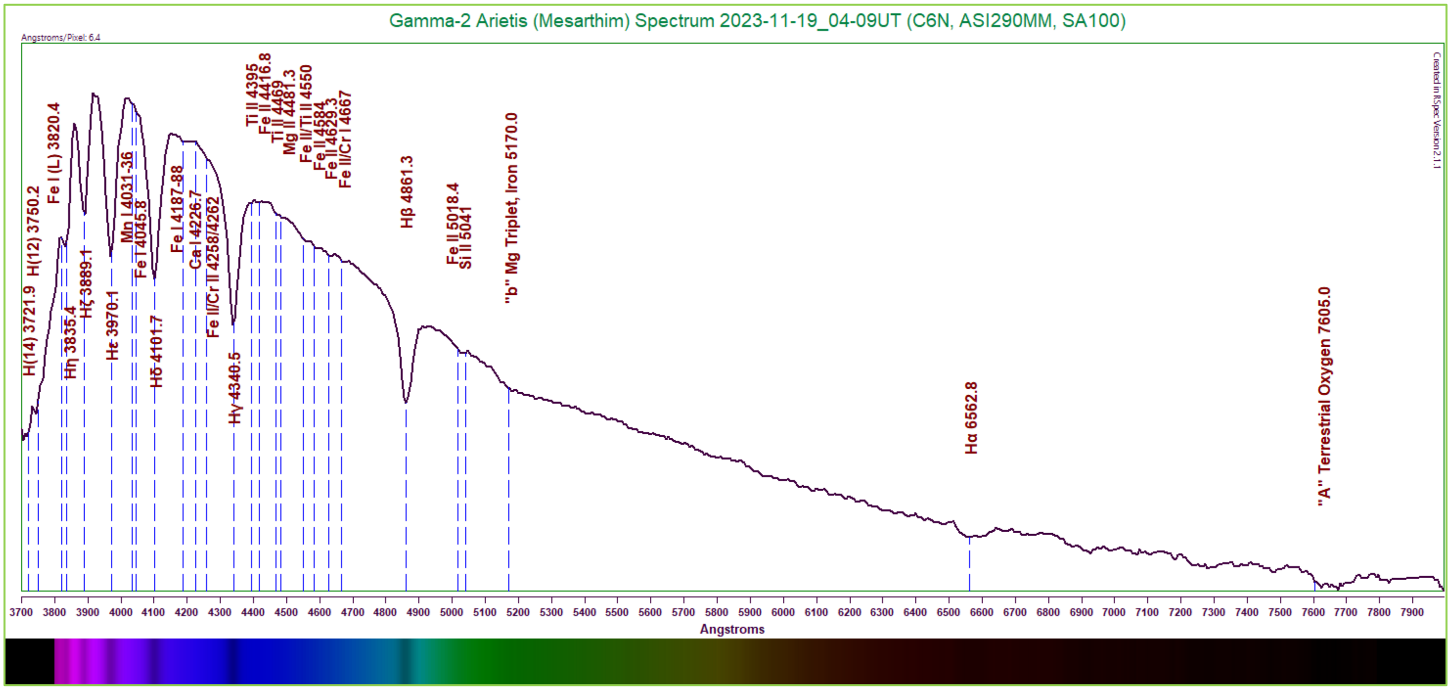

Figure 3: Gamma-2 Arietis (Mesarthim) Spectrum (6.4 Angstroms/pixel)
Capture Details 3: Exposure 888ms, Gain 181, 50% of 281 frames stacked

We can see here a curve representative of a hot star, similar to the result obtained for Sheratan. The hydrogen Balmer lines are pronounced and clear. Even the Hα line is clearly represented. Near the lower wavelength range, we can see the Hη and Fe I (L) lines causing a step in the continuum. The magnesium triplet at 5170 is evident, but shows up as just a conspicuous if small dip in the spectrum. A number of faint to very faint metals are indicated, including manganese, iron, calcium, titanium, magnesium, and silicon.

Employing Wien's Law again, we will ascertain a temperature estimate. Being an early-type star, however, means that our estimate will fall far short of the mark. Using a peak energy wavelength of 3917 Angstroms results in a temperature estimate of 7398K. The established temperature is 10512K[2]. Our estimate is definitely too low!

γ-1 Arietis

Gamma-1 Arietis is the marginally dimmer of the two stars, and also can be found classified in different ways. It can be classified as either a very late B-type star or a very early A-type star[1,2]. In either case, we should see another star with bold hydrogen Balmer lines and a high temperature, similar to the previous two targets analyzed.

The processed spectrum is below:

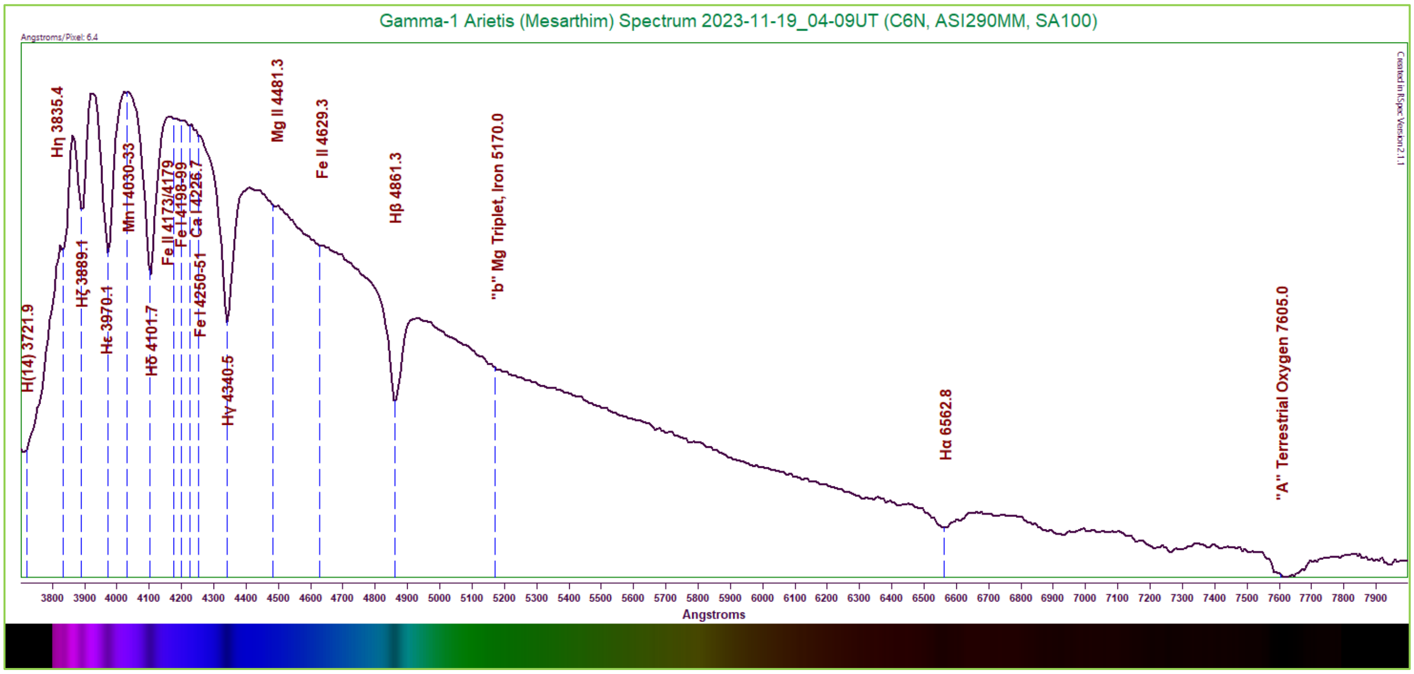

Figure 4: Gamma-1 Arietis (Mesartmhim) Spectrum (6.4 Angstroms/pixel)
Capture Details 4: Exposure 888ms, Gain 181, 50% of 281 frames stacked

This spectrum looks incredibly similar to that of Gamma-2 Arietis, but smoother and with fewer features. The hydrogen Balmer lines are very strong and clear. The magnesium triplet at 5170 Angstroms is weaker, with it only causing the slightest reduction in the continuum line. Only a handful of extremely faint metal lines can be seen, but these include manganese, iron, calcium, and magnesium.

Using Wien's Law will allow us to ascertain a temperature estimate for the star. Again, our estimate will be too low since this is an early-type star. The peak of the curve is not clearly defined here. It appears to fall amid the Hε absorption. Taking the median value between the adjacent peaks, we arrive at a value of 3971 Angstroms. Using this value, Wien's Law provides a temperature estimate of 7297K. The accepted value for the temperature is 10356K[2].

41 Arietis

This star, also designated as c Arietis, is a multiple-star system designated as late B-type[1,2]. Once again, we can expect strong hydrogen Balmer lines and a curve representing a high temperature.

The processed spectrum follows:

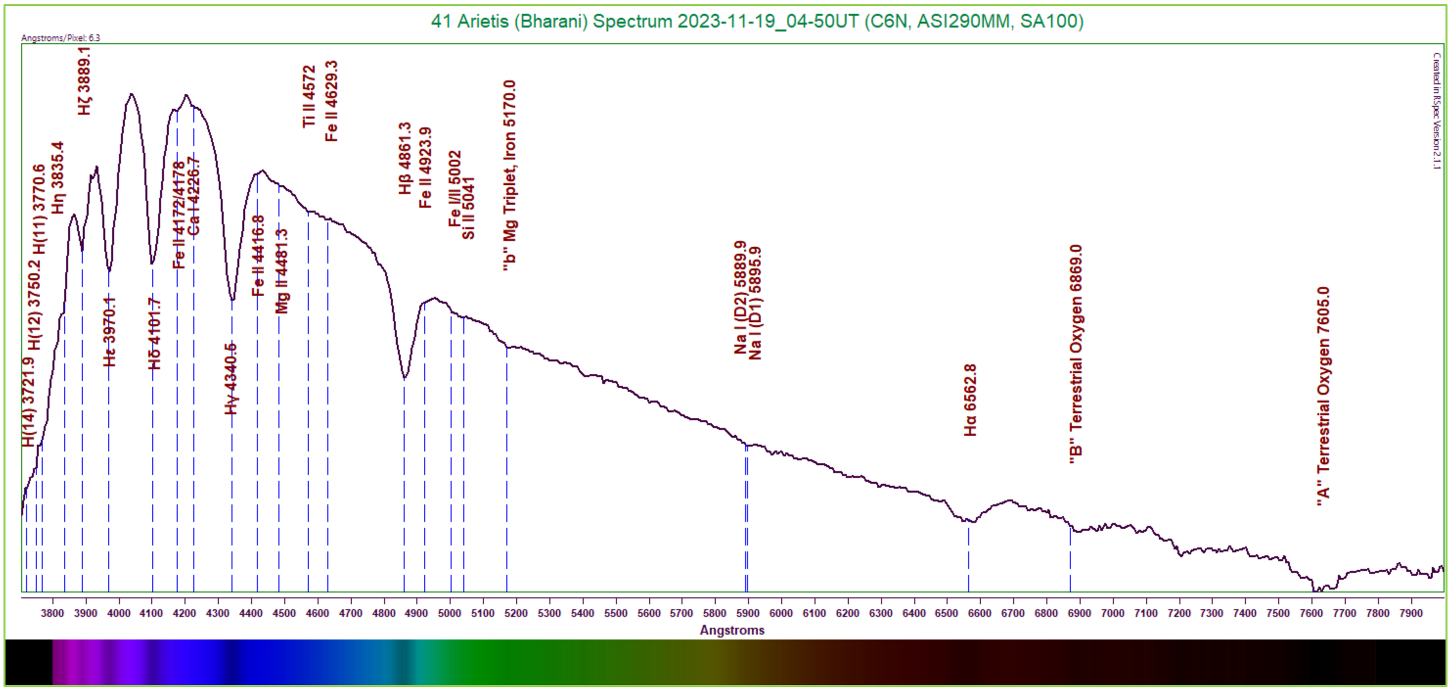

Figure 5: 41 Arietis (Bharani) Spectrum (6.3 Angstroms/pixel)
Capture Details 5: Exposure 1s, Gain 187, 80% of 245 frames stacked

This spectrum definitely reflects the properties of another hot target. The hydrogen Balmer lines are bold here, but are just slightly shallower than the previous target. Two iron and calcium lines between the Hβ and Hγ absorptions are also evident, creating small dips on either side of the peak. The magnesium triplet is represented only by a subtle dip in the continuum. The sodium D1 and D2 lines are also marked, but are only causing a very small absorption. A few additional very faint metals can be seen along the length of the spectrum, including iron, magnesium, titanium, and silicon.

Using Wien's Law, we will once more obtain a rough temperature estimate. As before with early-type stars, we can expect the estimate to fall far short of the mark. Using a peak energy wavelength of 4036 Angstroms, we arrive at a value of 7180K. The accepted temperature of the stars is 11900K[2]. Yeah, our estimate is again very short.

Conclusion

The acquisition of the targets in Aries went smoothly. No misidentifications or other problems were encountered. I had skipped this small constellation earlier in favor of others, but was glad to be able to gather data for it before having to wait until the next year. The processing of these spectra proved to be a bit problematic, especially for the stars of Gamma Arietis. However, them results were acceptable.

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