The Challenge of AZ Cas-Part 1

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Abstract

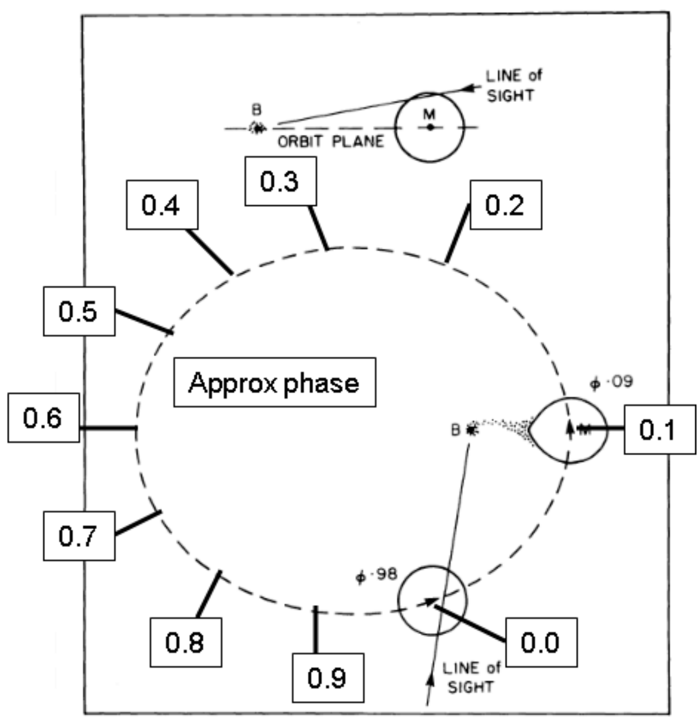
This is an interim report on observations of the spectrum of AZCas taken during 2012-13 and in 2018, and ongoing. Spectra cover approximately 6400-6700A at about 2A resolution. During this time at least two major Ha emission events have occurred, with at least one showing very strong variance over a two hour period. Images of all spectra taken are provided in a PowerPoint ppt file, while sample spectra are discussed in this paper..

Introduction

In this section, all data are taken from the 1977 paper by Cowley, Hutchings, and Popper.

AZCas is an eclipsing binary star in Cassiopia. AZCas is a 9.7mag star, and was discovered to be eclipsing in 1956 with a 9.3 year period (verified using Harvard and other records going back to 1901). Subsequent work showed that the system is composed of a very large diameter cool giant M0 star and a much smaller, hot B0 star in highly elliptical (e=0.55) orbit. The M star appears to have a mass of about 18 (solar masses) while the B star is about 13. The primary eclipse occurs when the M star passes in front of the B star, and lasts for approximately 100 days.

Adjacent is a schematic of the system which is modified from the Cowley paper. Note that the primary eclipse occurs at phase=1.0, while periastron occurs at about phase=0.09 approximately a year later. At periastron, it appears that the M star fills its Roche surface and bleeds mass onto or around the B star, and possibly around the whole system. Given the high eccentricity, it is likely that the two stars are not synchronized in their rotation. Evidence shows that even at maximum separation, there are still evident effects of the stars on one another.



History of my own introduction to AZCas.

My own interest in the star arose from a general interest in Be (ie, class B emission, especially the Ha line) stars, and then the announcement of an impending AZCas eclipse in January 2013. In 2012 I had completed my major observatory building effort in Maryland that included a homebuilt 18inch f3.5 Newtonian, a homebuilt f3.5 Littrow spectrometer of moderate resolution about 2-3000, and using a wide format camera (ST8 equivalent). I had done a number of spectroscopic studies that showed the system able to track wavelength changes as low as 0.1-0.2A (though with much brighter and faster changing stars than AZCas). In any case, I began occasional observations in early August 2012.

On just the second night, Aug 6, 2012 I began automated observation. After about an hour, I went to bed, but unknowing, a band of clouds passed through causing the telescope to lose lock on the guide star. About an hour later, the telescope regained lock on a star and continued for another hour. The result the next morning were two radically different spectra, convincing me that the scope had drifted and locked onto some other even more interesting star.

Although I did take a few more spectra of AZCas, I spent months searching databases and the sky for the second star, without success. I then moved on to other projects (including spectropolarization studies). In early 2018, I decided to review all my AZCas data from earlier years. Ironically, I quickly concluded that the "second star' in fact had still been AZCas, accidentally caught in a surprisingly radical and rapid event. Thus, in 2018 I began a new series of observations which I expect will continue until after the next eclipse in May 2022. To improve the odds of capturing transient events, observation has been done on every weather-acceptable night. Unfortunately, adverse weather has caused interruptions of as much as two weeks in the records: the average frequency of observation has been only 2 per week.

This paper will summarize the observations to date. By including it on our web site (above) it will become available to others working on this star as they search for fellow observers and additional data.

Observation Methods

In general, the observations are conducted as follows. After locating the star with the telescope (almost always under remote control) the spectrometer/telescope focus is checked on a nearby bright star. The telescope is then moved to the nearby (5 a-min East) star SAO11931 which is a B7 6.3mag star with a strong absorption line at Ha which is used as a wavelength calibration. Automated observing (CCD Commander software) then begins, usually taking an SAO11931 spectrum, then nine successive AZCas spectra, all 300 s exposures. The series is then repeated nine times for a total of about 3 hours yielding good S/N. The next day, using a Visual Basic routine working with MaximDL (my imaging software) the spectra are corrected using dark, flat, rotate, and mirror operations. The same routine then analyzes the spectrum, removes sky background, combines the spectra, and compiles a text file of the (generally averaged) intensity vs. X-pixel. Reducing a night of data takes about ten minutes.

The text file is then inserted into an Excel spreadsheet which normalizes the spectrum to a value of about 1.0 in the 6480 region. The spreadsheet also performs an initial wavelength calibration by aligning the absorption feature at 6495 A with a reference spectrum. Final wavelength calibration is later accomplished by fitting Gaussian curves to selected absorption lines and comparing to the SAO11931 spectrum from the same night (results not shown in this paper).

The resulting wavelength precision is within about +/-0.2A over many months. Because the resolution of the spectrometer is only about 2A, care is necessary when searching for small Doppler movements of lines.

Observations-General

There are two groups of observations of AZCas. The first group covers 2012-13, while the second group includes those in 2018 and later (no spectra were taken in the years between). The reader will see that there are several "events" (Ha related changes) in the first group, while the second group began with an "event", which resolved into an unchanging spectrum.

During this time, the major change in the instrumentation was the failure of the ST1602 camera (spring 2018) and replacing it with an STF-8300M. The former had 9u pixels which was the basis of the spectrometer design, while the replacement camera has 5.4u pixels. The second camera is operated at binning=x2, so that the wavelength calibration changed from approximately 0.33A/pixel to 0.45A/pixel. The spectrometer has a calculated resolution of R=2-3000, or about 2A at the Ha 6563A line.

There have also been observational and analytic/software changes. However, all spectral images shown here, from the earliest to the latest, have all been analyzed (or reanalyzed) using the most recent methods.

The data have not been uploaded to other databases on the web. The only one that might be plausible is the BSS Be spectrum website in France. However, because AZCas is not listed as a recognized Be star, this resource is not available. The AAVSO does have limited photometric data for AZCas; however, AAVSO does not accept spectral data. For the foreseeable future, these AZCas data will remain available through personal request.

The spectra are shown in this paper as a series of JPGs copied from the spreadsheets thus allowing a quick review of all the data. Each spectrum has three curves as identified by the legend:

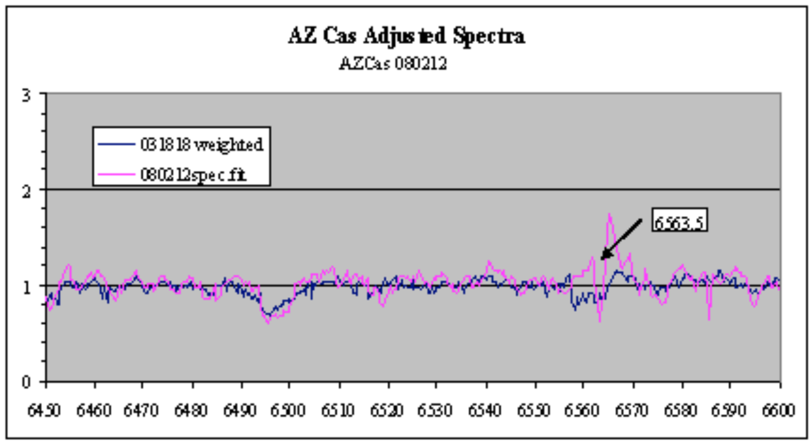
- The black curve is an average of several early 2018 spectra. This is used as a handy, unchanging reference

- The yellow curve is in most cases the spectrum of the reference star SAO11931. This was normally taken the same night as the target AZCas spectrum as shown in the legend.
- The red curve is AZCas, with date identified in the legend.

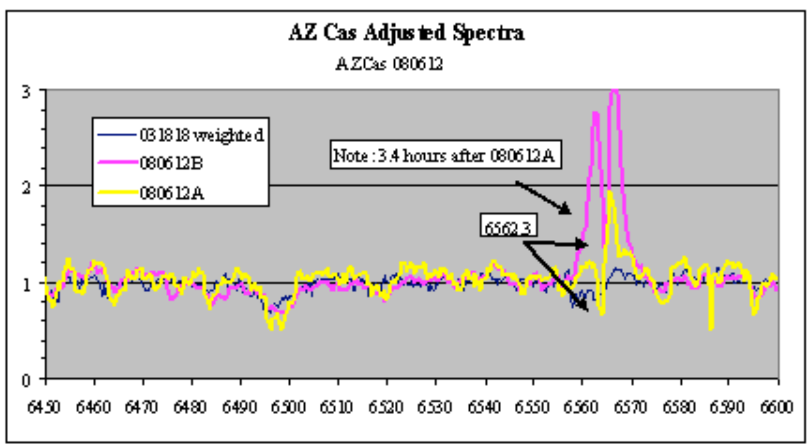
The wavelength calibration in each graph is good to about +/-1A (done by matching the 6495 features of the black and red spectra). Later analysis allows evaluation of possible wavelength shifts to a precision of about 0.1-0.2A as noted above.

First Observation Group

Selected images will now be described. AZCas observations began on August 2, 2012 phase=.96, with the second observation on August 6. The August 2 observation was not unusual, and indeed, was similar to the large majority of spectra taken later nt2018. Note the line group at 6495 used for rough calibration. The low, flat absorption feature at around 6560 is from early 2018 spectra.

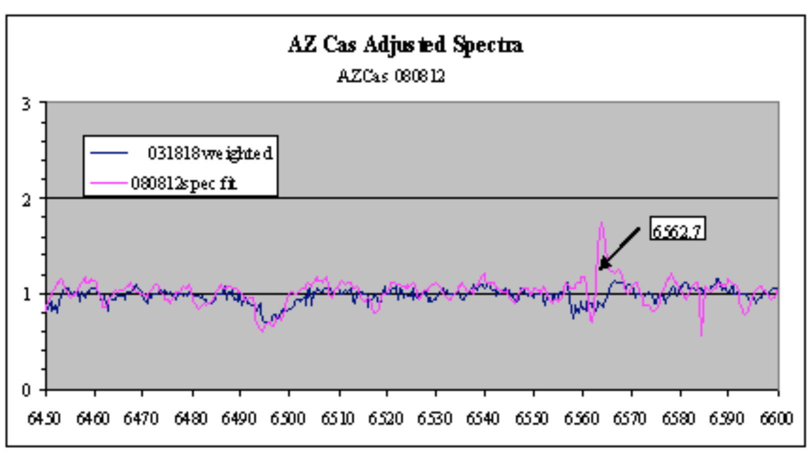


The second night of observation, as noted above, was interrupted by clouds before and after which the spectrum was radically different, as shown in the next slide. In this case, the yellow spectrum was taken before the cloud interruption, while the red spectrum came after.



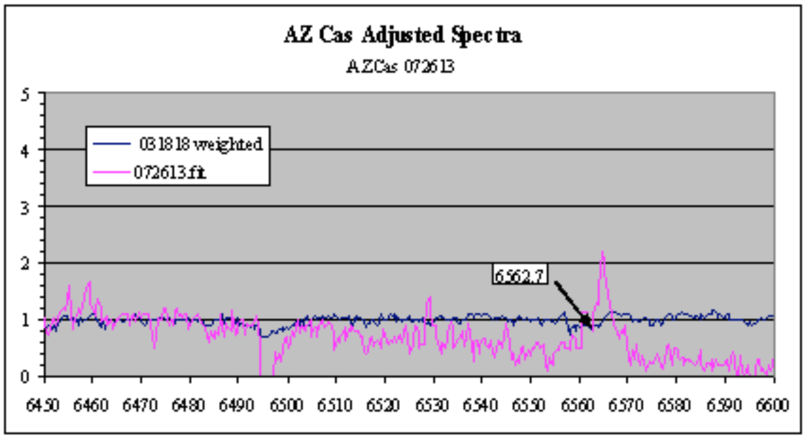
The next night of observation was August 8, as shown. The star had returned to the previous line shape.

There are some differences among the three spectra besides the obvious Ha related feature which led me to assume that



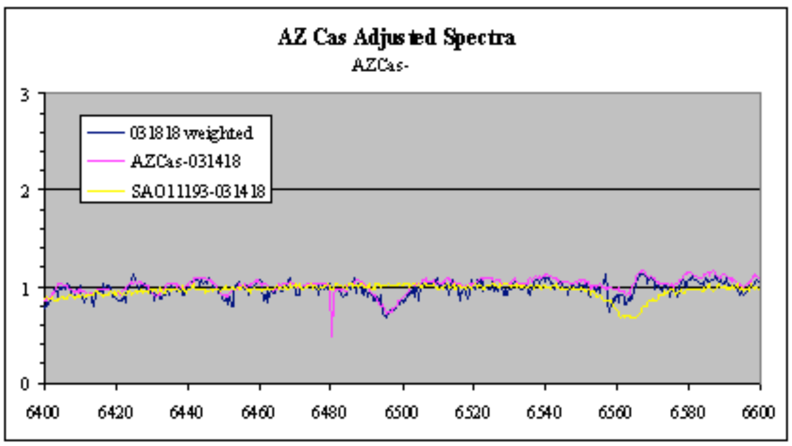
the event was actually a different star. As mentioned, using several different methods, I conducted an intensive search in the area and found no star with a spectrum like the event. It should also be noted that the Aug 6 observing sessions for each curve were truncated by clouds, so the statistics on the data are not as good as most other sessions.

Although there were few observations during the following 11 months, the spectrum appeared unchanged until July 26, 2013 phase=0.06 when AZCas, even in a spectrum of poor S/N, was clearly in emission. AZCas was still in emission on Aug 16 nearly a month later.

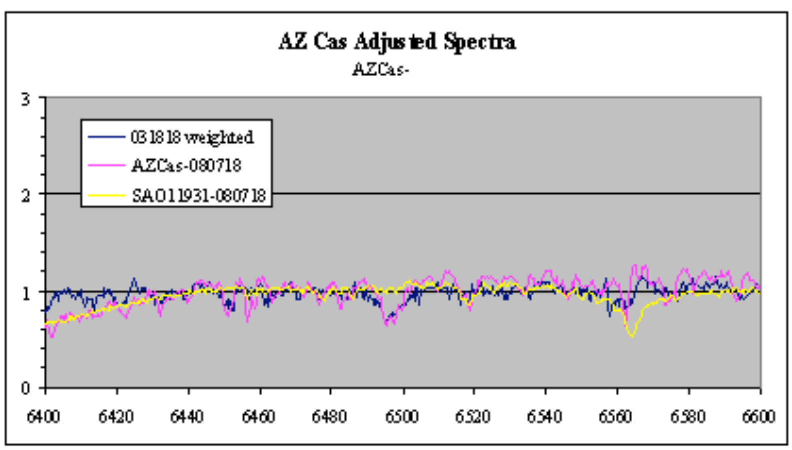


Second Observation Group

The second observation group began on March 14, 2018 phase=0.52. Obviously, given the prior spectra, the lack of structure near Ha was surprising. However, observations in the following weeks showed a return of absorption and emission features, presumably indicating that some emission event had occurred prior to March 14.



By early April, features were returning to the Ha region, and by the end of April, the spectrum had taken the shape that has remained for the next four months through September 2018 phase=0.6.



It is certainly possible that during the weather interruptions of the observing that additional events could have occurred, but there is no clear sign of this having happened.

A search for periodicities or smooth drifts in wavelength of major spectral features have so far shown none, with a sensitivity of about 0.2A.

Conclusion

There are obviously interesting transient behaviors of this star that occur not only near periastron but also in other parts of the star orbit. There is no sign (so far) of periodicities in the wavelength of features, though the greater number of features in the spectrum are from the M star. Continuing observations are planned.

References

The Masses of Cool Supergiants: the Interacting System of AZ Cassiopeiae. Cowley, Hutchings, Popper. Astronomical Society of the Pacific. Aug. 5, 1977

Menkescientific.com. Web site of John Menke, includes papers describing the N18 telescope, the spectrometer used here, and several papers describing results of using the instruments.