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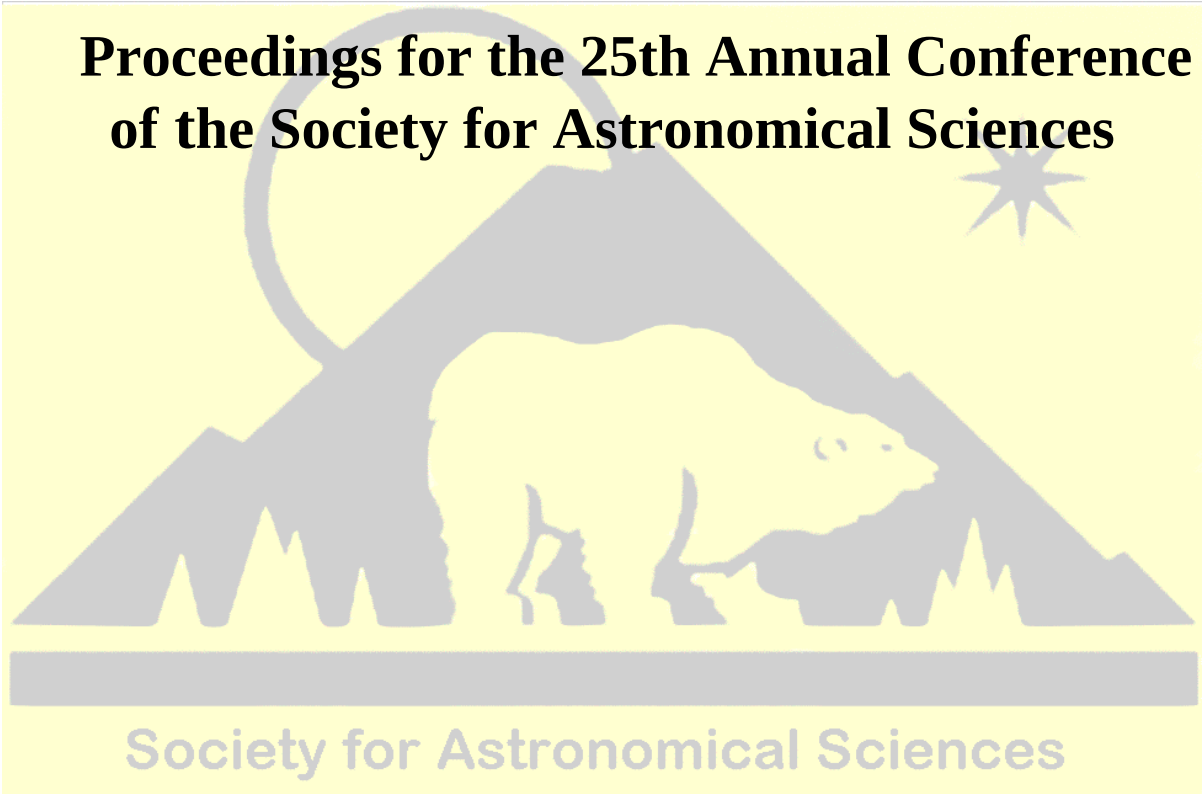


# Symposium on Telescope Science

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# The Discovery and Initial Characterization of a New Eclipsing Binary with Peculiar Properties

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**Abstract**

During the course of a general spectroscopic survey at the Dark Sky Observatory (Appalachian State University), a new eclipsing binary star, HD5501, was found. Photometric observations in the BVRI bands for nearly a year give a period of 7.53 days with a primary eclipse of 0.45 magnitude and a secondary of 0.3 magnitude. The system is constantly varying, suggesting an ellipsoidal variable with the stars in or near contact, perhaps with one or both Roche lobes filled. Spectroscopic examination (1.8A/pixel) of the system at different phases show the Balmer lines (beta, gamma and delta) along with the important shell lines of FeII between 4900 and 5200 Angstroms are stronger in eclipse than at quadrature. This suggests differing orientation of gas around the system. Higher resolution spectra (0.9A/pixel) shows slightly broader metallic lines in quadrature than in eclipse. This suggests the system is an SB2. A spectrum at H-alpha shows a classic wind signature, again suggesting the presence of mass transfer in the system. 

## 1. Introduction

HD 5501 (= BD+59 154 = BSD 8-397) is a 9th magnitude star in the constellation of Cassiopeia in the field of the Cas OB1 association, which has attracted almost no attention in the astronomical literature. It has been observed once in the UBV system (Bigay & Lunel, 1965) and once in the Stromgren uvbyBeta system (Perry & Johnston, L. 1982). It was observed by Fehrenbach (1961) and by Barbier (1968) using objective prisms to measure its radial velocity (–46±20 km/s). We do not have a parallax for the star. Spectral types given by Hardorp et al (1959) and Fehrenbach et al (1961), both based on objective prism plates, indicate an early, luminous, A-type star, not an unusual find in a rich Milky Way field. However, after these efforts, the literature is silent on the star.

On November 7/8 2004, one of us (ROG) obtained a slit spectrum of HD 5501 as part of a campaign to discover new A-type shell stars in Kapteyn selected region #8. When the spectrum was reduced a few days later, it was noted that this star showed the spectra characteristics of an A-type shell star, in particular, enhanced absorption in the Fe II multiplet 42 lines at 4924, 5018 and 5169A. Hence, another follow-up spectrum was obtained later that month (Nov 28/29 2004), and it was noticed that the strength of the shell lines had changed! We then checked the photometry in the TASS (The Amateur Sky Survey) database, and found that this star displayed photometric variability with an amplitude of nearly 0.5 magnitude. Analysis of the TASS data indicated a rough period of about 7.5 days, with a lightcurve that appeared to be that of an ellipsoidal eclipsing binary. We began obtaining photometry at the Dark Sky Observatory, but since ongoing programs did not permit a concentrated photometric study of this star with the phase coverage required to obtain a definitive light curve, ROG asked Dale Mais for help.

## 2. Methodology

Photometry was conducted with an Astrophysics 5.1-inch f/6 refractor using an ST-10XME camera, 2x2 binned pixels, and the Johnson BVR and I filters. Images were obtained in duplicate for each band and two reference stars used per variable star for analysis. Image reduction was carried out with CCDSOFT image reduction groups and specially written scripts for magnitude determinations, which allowed for rapid, nearly real time magnitudes to be found. Spectroscopy was carried out with a slit spectrometer and the 0.8m DFM reflector at Appalachian State University. Light curve analysis was carried out using Peranso software (Vanmunster, 2005).

## 3. Results and Discussion

Figure 1 shows the unanalyzed results of magnitude determination spanning greater than a 100 day observing session in the V-Band. The determinations have been controlled using 2 standard stars in the field. The B, R and I band results are very similar (data not shown).

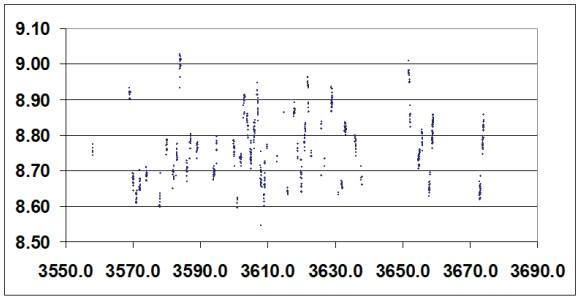


**Figure 1. Corrected magnitudes in the V-band during a >100 day observing period. Multiple determinations were carried out during each evening of observing. Magnitude is indicated along the y-axis with Julian day number along the x-axis.**

Clearly there is variation in this star that appears to span approximately 0.4-0.5 magnitude in the V-band. These results were imported into the software package Peranso for period determination and creation of a phase diagram. The period determination routine used within Peranso was the ANOVA method. Shown in Figure 2 is the phase diagram generated from analysis of the observations from Figure 1. The results favor a period of 7.53 days with a primary drop in magnitude of approximately 0.45 and a secondary drop of 0.3 magnitude. The result of the period determination is shown in Figure 3.

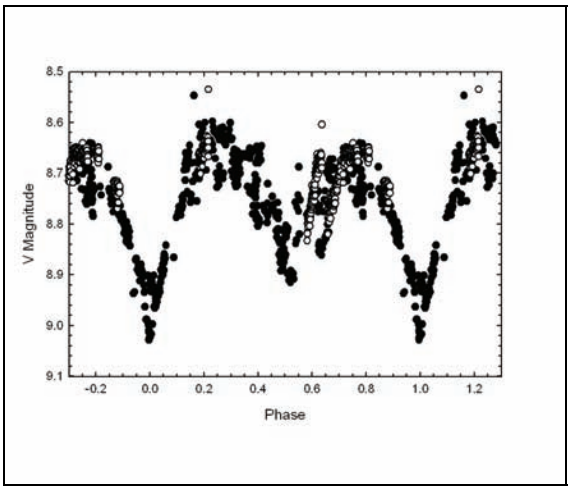


**Figure 2.**

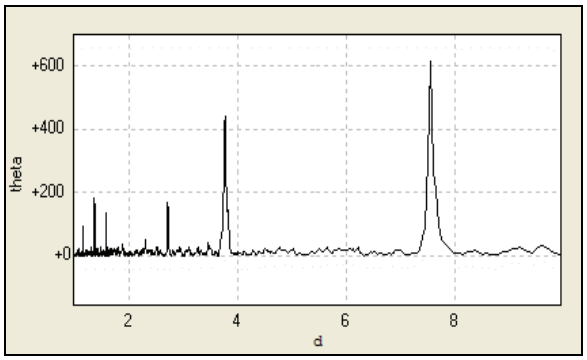


**Figure 3.**

While the period determination favors the 7.53 days as indicated by its greater theta value (a measure of the likelihood this is the correct period), a period corresponding to exactly half this value also has a reasonable theta value.

The fact that a "smoother" phase diagram is not produced would appear to indicate that HD5501 is a more complex system than a simple eclipsing binary. During the descent into the primary eclipse the curve appears better behaved but between primary and during secondary there seems to be a lot of flickering activity observed in the data.

At the same time that photometric observations were being carried out, the spectrum of the system was being determined. Figure 4 shows the spectrum obtained at different light curve phases in the blue part of the spectrum. The Balmer lines (beta, gamma and delta) along with the important shell lines of FeII between 4900 and 5200 Angstroms are stronger in eclipse than outside eclipse.

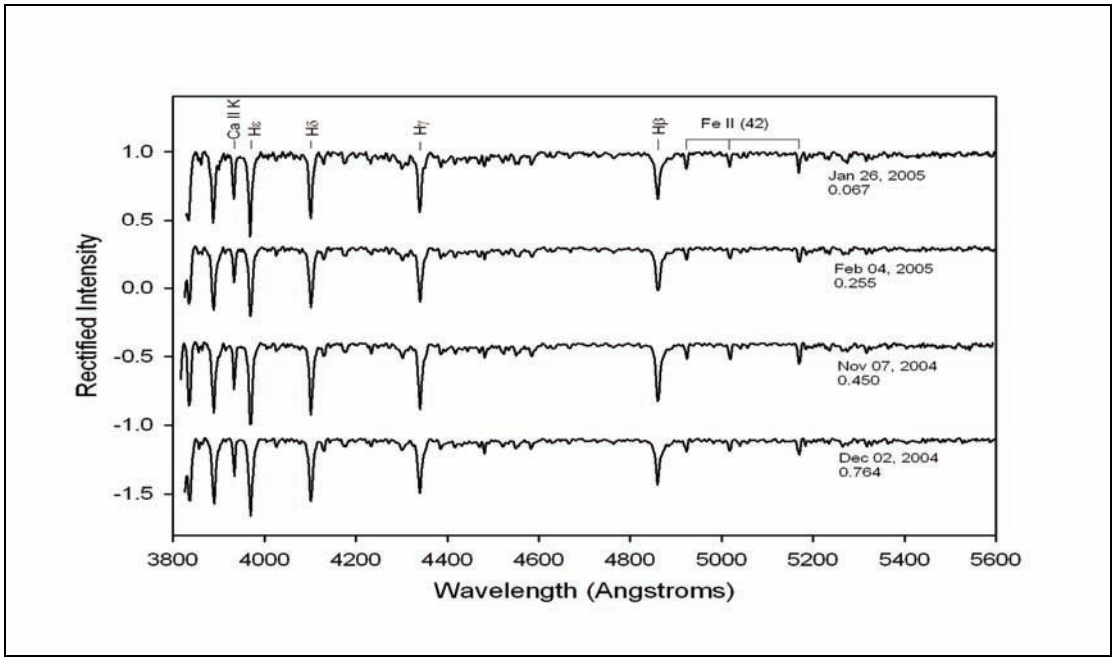


**Figure 4 (above) shows the spectrum obtained at a resolution of 1.8 Angstroms per pixel in the blue region of the spectrum.**

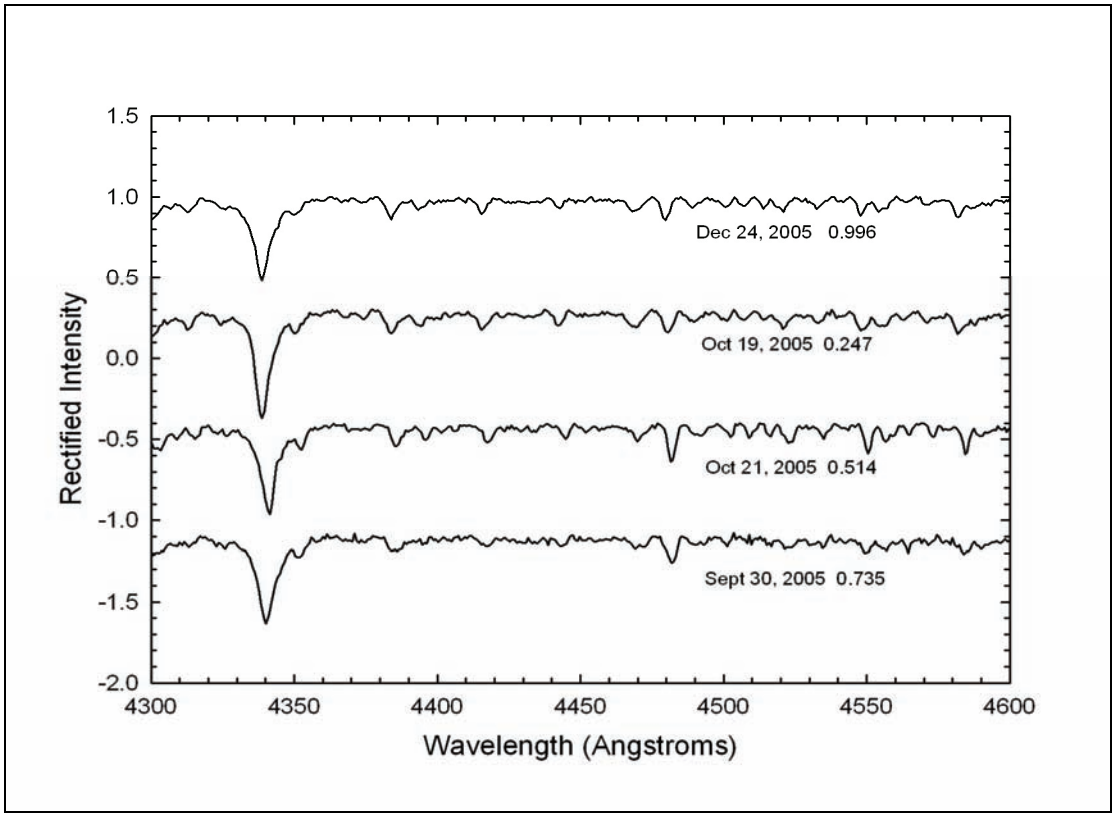


**Figure 5 (above) shows the spectrum obtained at a resolution of 0.9 Angstroms per pixel. The strong line at approximately 4340 A is hydrogen-gamma**

This can be seen by comparing the Fe and Hydrogen lines at phase 0.067 and 0.45 to the lines at phases 0.256 and 0.764. Indeed, the calcium K line exhibits the same behavior. In the higher resolution spectrum in Figure 5, various metal lines such as those at approximately 4480, 4550 and 4580 Å are broader at quadrature than during eclipse. In addition, spectra obtained in the hydrogen alpha region shows this line to have emission on top of the absorption line (data not shown).

Clearly this is a complex system. The spectrum of the system is indicative of an early A type star. This would suggest a temperature of the "system" to be ~9200 K. However, temperatures determined from the B-V photometry give temperatures which are relatively constant between 6800-7200K. (See Figure 6). Thus the system is significantly reddened. Coupling the early A type spectrum to the rather dim apparent magnitude suggests that this star is at a great distance.

In addition, this star is within the galactic plane, so there is most likely significant reddening due to dust. Utilizing previous Stromgren photometry and temperature calibrations, we calculate, after dereddening, a temperature for the system at 9220K (Gray, R., 1992).

Temperatures aside, clearly this star system is peculiar and warrants more work. Both the photometric and spectral we have thus far suggests that the system is constantly varying and may be an ellipsoidal variable with the stars in or near contact, perhaps with one or both Roche lobes filled.

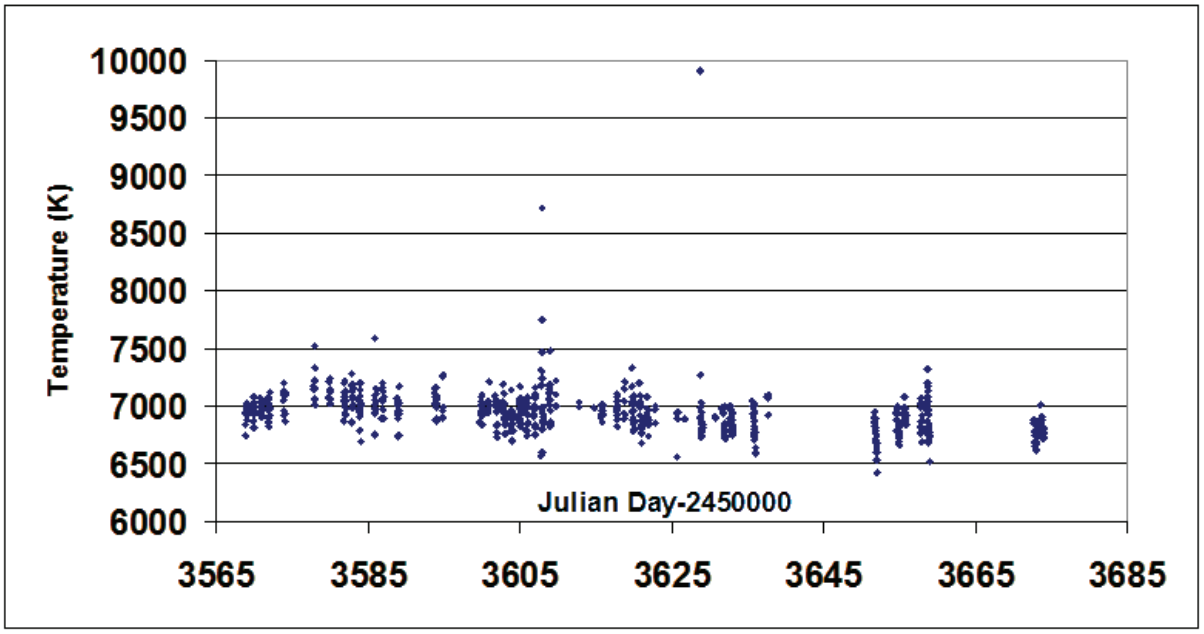


**Figure 6. The B and V determined magnitudes were used to obtain B-V which was then converted to a first approximation temperature. Analysis of this data or the B-V vs. julian day data in Peranso produced no period. So the temperature of the system is independent of the light curve.**

## 4. Conclusions

A new and unusual eclipsing binary system is described along with some of its initial photometric and spectroscopic characteristics. The system is clearly complex with a changing light curve noted. Further efforts will be directed towards refining the light curve and more detailed spectroscopic observations in an effort to better define this unusual system.

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