Research on V533 Herculis

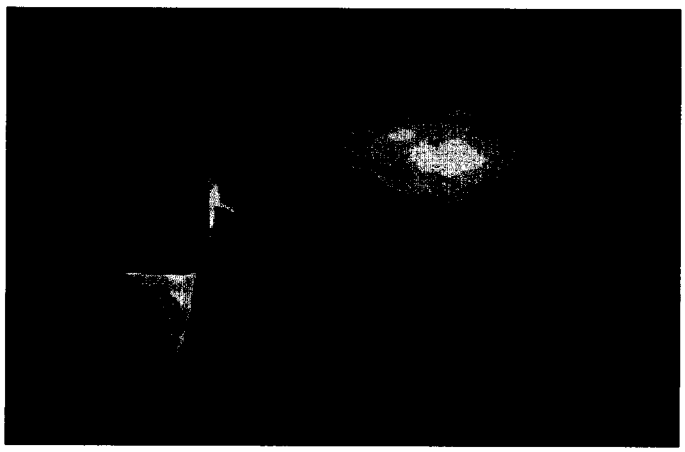
Peter Littlewood, California Polytechnic State University, San Luis Obispo
Advisor: Dr. William Welsh, San Diego State University

This summer, I was to investigate the 63.6 s oscillation found by Patterson (1979) for V533 Herculis, then classified as an intermediate polar cataclysmic variable system. Robinson & Nather (1983) were unable to find the 63.6 s oscillation found by Patterson. My research worked with four data sets, collected on the MLO 40" and 24" telescopes. In the power spectra, we found the low frequency flickering associated with the accretion disk; however we did not detect the 63.6 s oscillation or 31.8 s harmonic signal in any of the four data sets we took.

Introduction

V533 Herculis is classified as a cataclysmic variable star; a pair of stars comprised of a white dwarf as the primary star, and a companion star, usually a red dwarf. Because of the gravitational field of the white dwarf, the companion star fills its Roche lobe (distorting the star into a teardrop shape, as shown below) and begins accreting matter towards the primary star. This matter forms a thin stream moving in towards the primary star, however due to the conservation of angular momentum, will not fall straight onto the primary star, but instead will begin to swirl around it. This forms an accretion disk (a very thin disk spiraling around the primary star), as the matter begins to move inwards. Because of the gravitational pull on the matter, as the matter moves it will grind against other matter, and begin heating. Radiation is emitted from the disk which can be observed as random fluctuations in the magnitude, known as flickering.

In an intermediate polar (as V533 Her was originally classified), a magnetic field from the primary star draws matter in towards the poles, and as the white dwarf rotates an observer can view the blackbody radiation being emitted from the pole. The artistic rendition to the right shows a secondary star accreting matter to a primary star, forming an accretion disk.



Observations and Reduction

Our work consisted of four sets of data: May 16th 2002 on the MLO 40" in the B band from archival data, and three new sets of data taken this year on the MLO 24", by Dr. Welsh, Michael Dulude, and myself. The July 7th data is in the B band, July 9th in V band, and July 10th in I band. These data were reduced using standard IRAF reduction tools, and photometry was performed using the DAOPHOT and PHOTCAL packages.

There were a couple of problems with the data that we obtained. The May 16th data was taken on a CCD that reads out using 2's-complement notation. Simple IRAF code written by Dr. Welsh corrected this problem fairly easily. A surface plot of such a star is shown below.

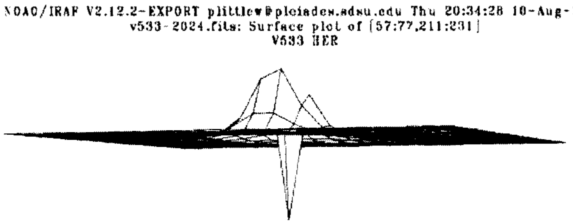


Fig. 2: Example surface brightess profile for star with 2's complement error.

In the July 9th data, Michael Dulude and I were operating the telescope on our own for the first time, and when the pier flip occurred the tracking was not operating quite correctly, and was no longer pointing towards V533 Herculis. There is a gap in the data during this period, however does not appear to have significant effect on our power spectrum. See figures below for light curve and power spectra of July 9th in order to view the gap in data. With the newer FFT algorithmic structures in place, computer analysis by FFT is possible for data with gaps, so computations of the power spectra of our signal comes out reasonable, even with the missing data.

Analysis

For these sets of data, a possible oscillation expected may be around 63.6^{-1} s, or 15.723 mHz. If the signal were present as found in 1979, it would be expected to see a power spike corresponding to approximately 15.7 mHz. Additionally in the light curve and corresponding power spectra, the accretion disk fluctuates in brightness known as flickering. Flickering is a non-periodic signal with power concentrated in the low frequencies, caused by the continual accretion of matter into the accretion disk. As the matter accretes and collides at irregular intervals, the light curve will be seen as a fluctuating magnitude with no apparent pattern. In the power spectra, it is observed by strong signals at the far left of the graphs, following an f^{-1} to f^{-2} noise trend.

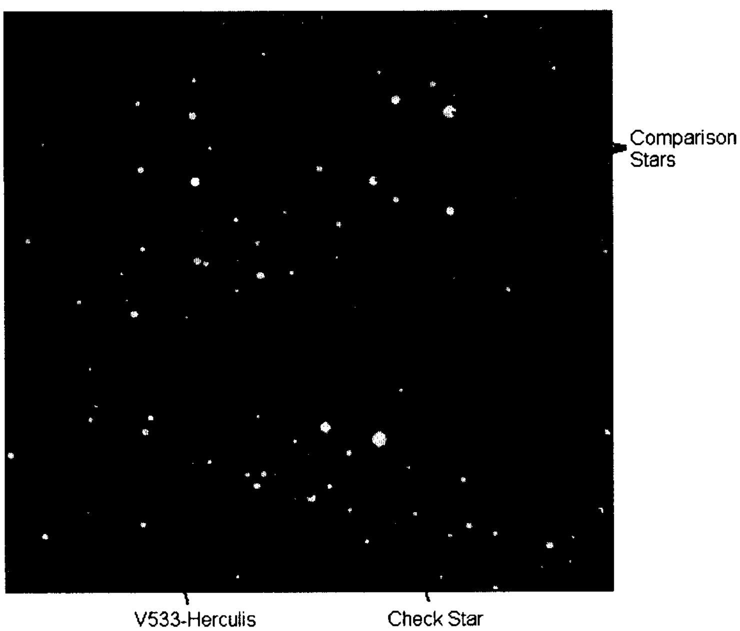


Fig. 2: Combined field image of V533 Herculis (V band)

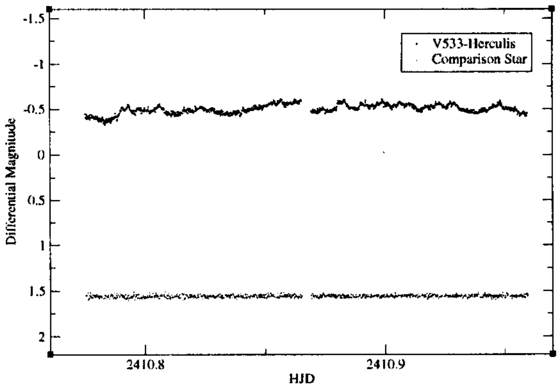


Fig. 3: May 16th 2002 light curve, B band

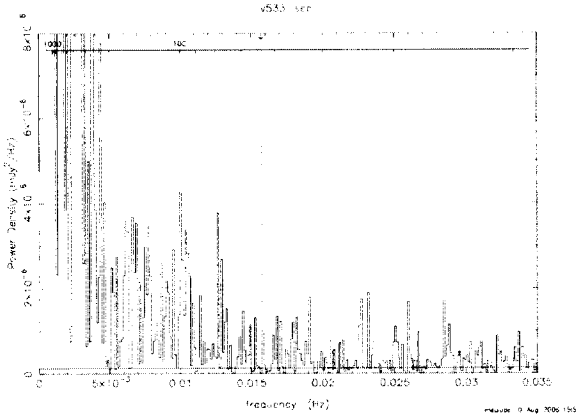


Fig. 4: May 16th 2002 power spectrum
(In all power spectra, y-axis units are in mag^2 / Hz, not mJy^2 / Hz.)

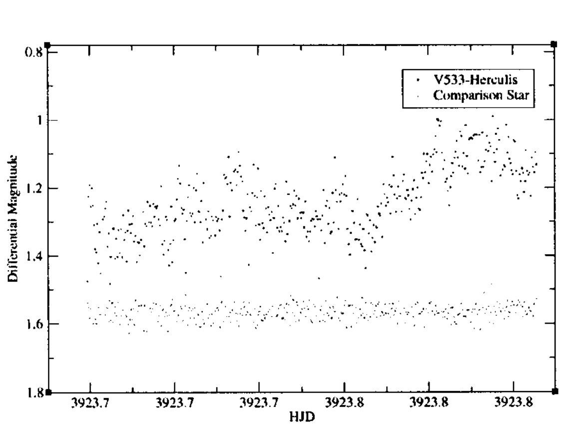


Fig. 5: June 7th 2006 light curve, B band

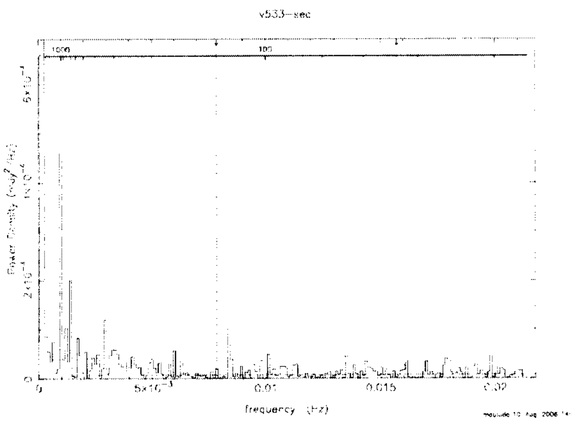


Fig. 6: June 7th 2006 power spectrum, B band

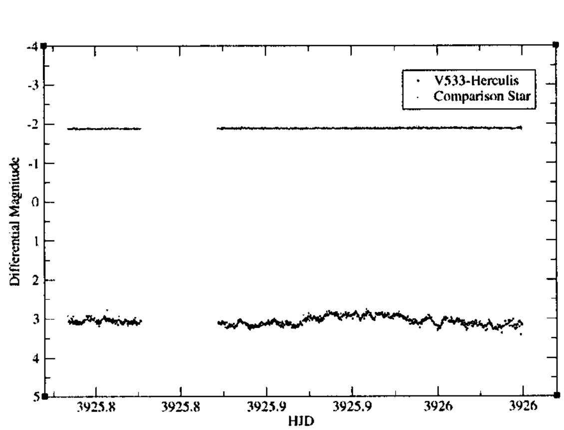


Fig. 7: June 9th 2006 light curve, V band

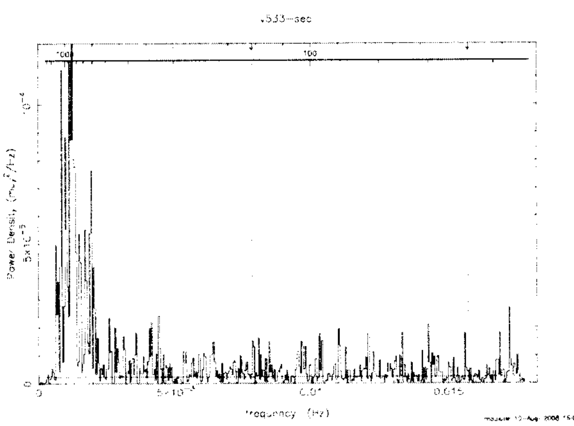


Fig. 8: June 9th 2006 power spectrum

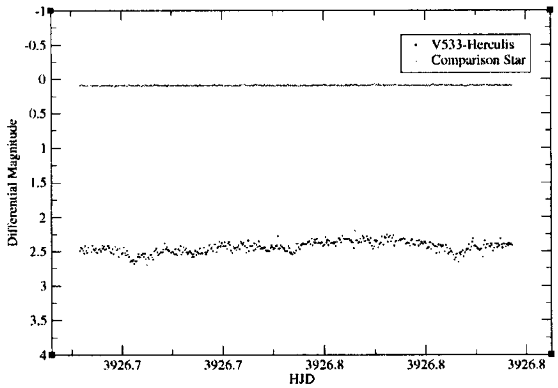


Fig. 9: June 10th 2006 light curve, I band

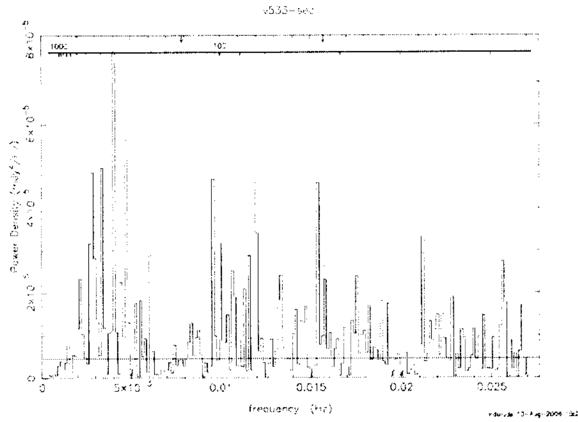


Fig. 10: June 10th 2006 power spectrum

As can be seen from the above power spectra, we observe a high power low frequency grouping. This is consistent with the expected low frequency flickering of cataclysmic variables, in all four power spectra. Marked on the power spectra graphs are the 63.6 s and first harmonic signals, and there is no obvious signal present at the fundamental or the harmonics, only low-power noise. This finding indicates that V533 Herculis is a cataclysmic variable due to the low-frequency power at the frequencies corresponding to random flickering, however the data obtained is not consistent with V533 Herculis being classified as an intermediate polar.

Conclusions

From the analysis done, we conclude that (1) V533 Herculis has no detected periodic signal at 63.6 s or close harmonics. (2) V33 Herculis was at one point an intermediate polar cataclysmic variable, but is not currently exhibiting any coherent oscillations and is uncertain for status as an intermediate polar.

Acknowledgements

SDSU Faculty and Staff
Michael Dulude (SDSU)

References:

Patterson, J. 1979, ApJ, 233, L13
Robinson, E. L. & Nather, R. E. 1983, AJ, 273, 255