# The Classification of BZ Ursa Majoris

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High speed differential photometry is performed on the cataclysmic variable star BZ Ursa Majoris. The data was taken during the first observed superoutburst of this system. This officially classifies BZ UMa as an SU UMa type dwarf nova. Super humps are easily seen in the light curve and the superhump period is approximated at 103 minutes. High frequency modulations were searched for to conclude whether BZ UMa is an intermediate polar or not. The results were inconclusive with two high frequency modulations apparent, but most likely being the harmonics of the orbital period.

## Introduction

BZ UMa is a cataclysmic variable star (CV) with a period of 97.8 minutes (Ringwald et al. 1994). A CV is a binary system consisting of a white dwarf (the "primary" star) and usually a late main sequence ("secondary") star (Warner 1995). Mass is transferred from the secondary via Roche lobe overflow, forming an accretion disk around the white dwarf. The matter is then accreted onto the white dwarf releasing energy. BZ UMa is also a Dwarf Nova (DN), meaning that it has reoccurring outbursts (dwarf novae outbursts or DNO's). These outbursts are typically five to ten days long and the system gets brighter by approximately five magnitudes. BZ UMa also shows signs of being an SU UMa type dwarf nova with its short orbital period (below the period gap) and low mass ratio of $q = 0.2 \pm 0.09$ (Jurcevic et al. 1994). The defining characteristic of SU UMa type stars is the superoutburst, which until now had not been detected in BZ UMa.

BZ UMa may also be an intermediate polar (IP). Intermediate polars are CVs that harbor a magnetic white dwarf that is strong enough to truncate its inner accretion disk. At a certain radius the white dwarf's magnetic field slows the inward motion of the matter, forcing it to follow the field lines from that radius on. There are six observational characteristics of IP's given by Patterson (1994): 1) a stable optical period with $P_{spin} < P_{orb}$; 2) an X-ray period at or near $P_{spin}$; 3) pulsations in HeII emission lines; 4) circular polarization; 5) existence of sideband periods in the optical and/or X-ray, usually on the low frequency side of the main signal; and 6) a very hard X-ray spectrum with low-energy absorption. BZ UMa is a relatively strong X-ray source (Verbunt et al. 1997) and has high excitation HeII lines (Green et al. 1982) which are two of the six criteria. There was also variability discovered in its radial velocity curve that has been unexplained (Ringwald et al. 1994). In order to establish BZ UMa an intermediate polar we searched for criterion 1.

## Observations and Reduction

Observations were taken at California State University Fresno 16" Meade LX200 telescope. Images were taken over four different nights with an exposure time of 5s. The four nights were: April 12, 15, 16 and 18. Image reduction and photometry was done using AIP4Win. The light curve is shown in Fig. 1. The light curve clearly shows superhumps, the defining characteristic of a superoutburst, for the days of April 15, 16, and 18. A superoutburst has long been expected for this system but has failed to be observed in previous outbursts.

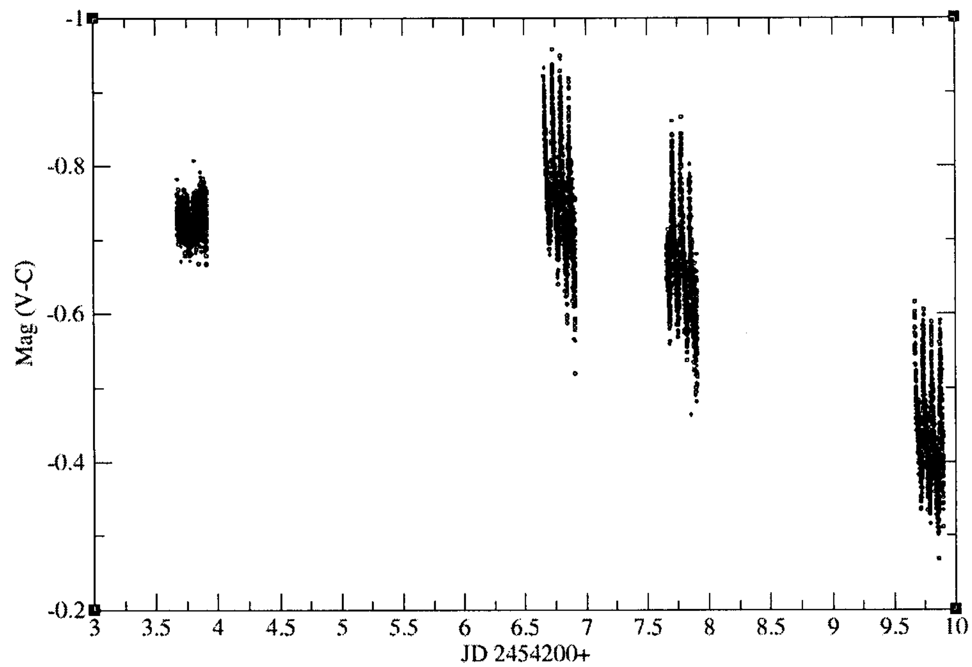


**Figure 1:** The light curve for all four nights of data.

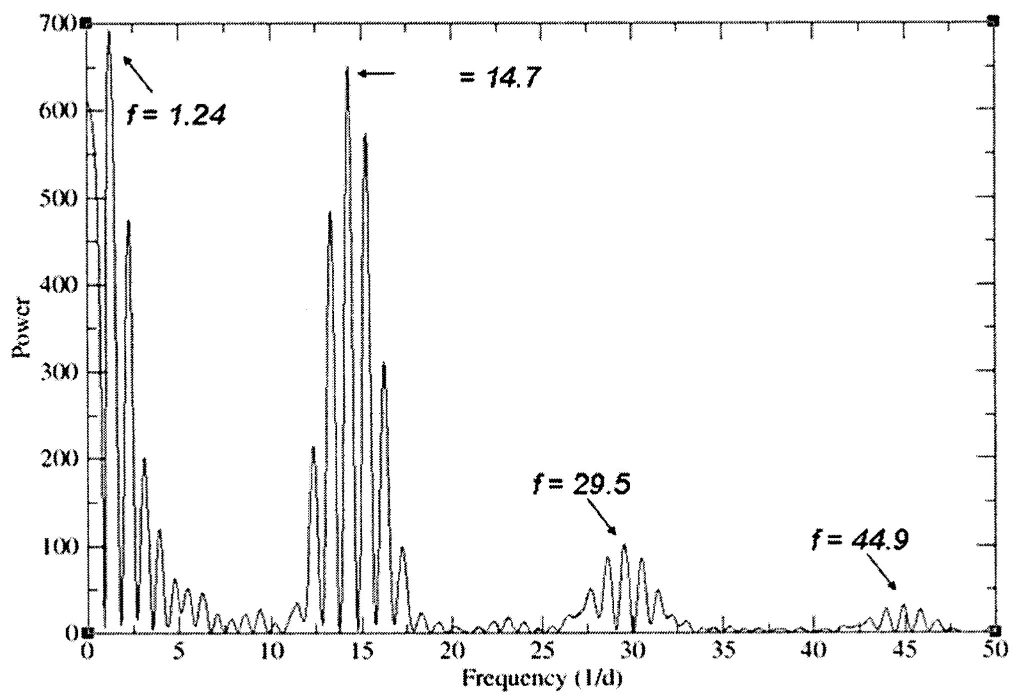


**Figure 2:** The periodogram from the data taken from the nights of April 15 and 16

## Analysis

*I. BZ UMa as an Intermediate Polar*

Since matter is accreted via the magnetic field lines in IP's, a bright spot near the magnetic poles of the white dwarf is expected. If the spin and magnetic axes are not aligned then a modulation should be apparent in the light curve. The white dwarf spin moves the magnetic poles in and out of the field of view, causing this modulation. In order to search for these high frequency modulations, the data was put into a Lomb-Scargle periodgram. The data set for each individual day was put into the periodogram separately, as well as different combinations of days. The periodograms of each individual night were relatively similar. The combinations of nights had much better resolution as well as stronger signals. The periodogram from the nights of April 15 and 16 is shown in Fig.2.

The 14.67 cycles/day frequency is near enough to the 14.7 cycles/day orbital period to label $P_{orb}$. There were also peaks in the periodogram corresponding to 44.9 cycles/day, 29.5 cycles/day and 1.24 cycles/day. The 44.9 and 29.5 cycles/day frequencies are most likely the 1:3 and 1:2 harmonics of $P_{orb}$ respectively. There is also the possibility that one or both of these frequencies are not the harmonics but more analysis and/or data are needed in order to be sure of this. The modulation corresponding to 1.24 cycles/day (19.4 hours) may be from the night-to-night gap between data sets. There is also the possibility that this frequency is not from the night-to-night gaps. This frequency is related the variability found in the radial velocity curve seen by Ringwald et al. (period 17.8 hours).

*II. BZ UMa as an SU UMa Type*

SU UMa type DN's have the defining characteristic of superoutbursts. Superoutbursts are similar to DNO's but last longer, are usually brighter and show superhumps in the light curve. Superhumps are humps in the light curve that usually have about a 0.2 to 0.3 magnitude change. They are the defining characteristic of a superoutburst. Superhumps are thought to be caused by elliptical disk precession. For more information see Hellier (2001). Superoutbursts are also less reoccurring than DNO's, which is most likely why they have yet to be detected in BZ UMa until now. The superhumps have a period that is usually a few percent longer than the orbital period. The light curve for the night of April 15 is shown in Fig. 3.

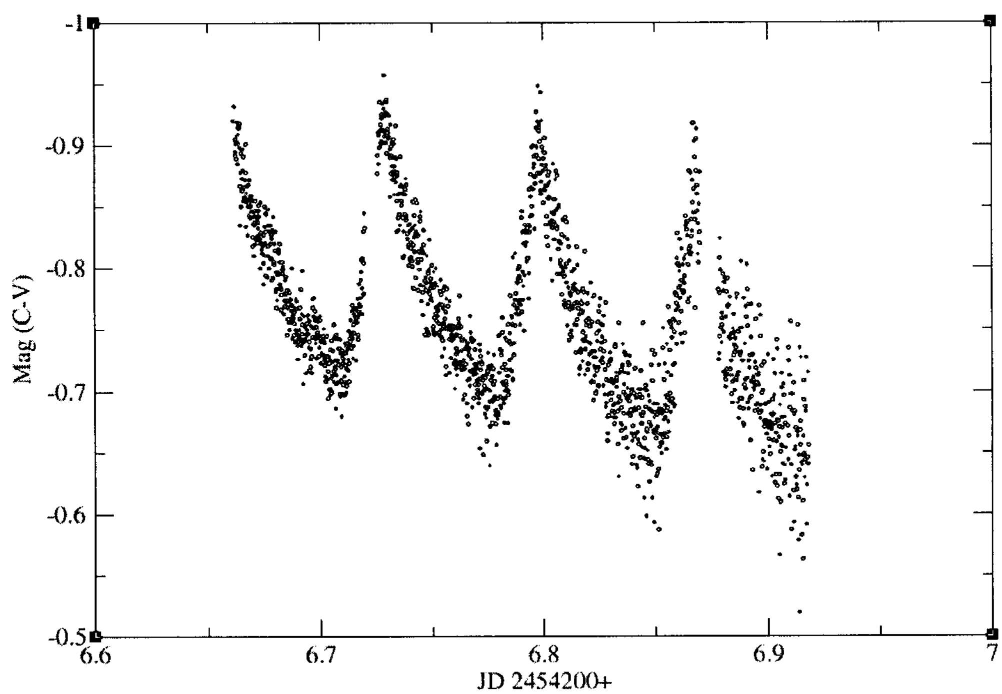


**Figure 3**: The light curve for the night of April 15 is shown. Superhumps are easily visible.

In order to get a period of the superhumps I used the *pdm* (phase dispersion minimization) task in IRAF. There were six complete superhumps in the light curve so I calculated the period of each one. I then took an average of the six periods to deduce a 103 minute superhump period. This is about 5.2% greater than the orbital period of 97.8 minutes and is expected. The approximate magnitude changes of the superhumps were about 0.3 magnitudes, which is also normal for superhumps.

A superoutburst has been expected in BZ UMa for some time. All well observed dwarf novae that have an orbital period less than 2.1 hours (below the period gap) are of the SU UMa type (Warner 1995). The existence of superhumps during this outburst reveals that BZ UMa is in fact an SU UMa type star. This adds to the conclusion of Warner.

## Conclusions

BZ UMa can now be labeled an SU UMa type DN. The light curve shown in fig.1 confirms that the photometry was taken during the first observed superoutburst of BZ UMa. Superhumnps are easily visible in the light curve and have a superhump period of aproximatley 103 minutes. A conclusion for BZ UMa being an IP is still uncertain. The high frequency peaks in the periodograms could be harmonics, but there is still the possibility that they are real periodicities in the light curve. More high speed differential photometry should be done on BZ UMa in order to search for these high frequency modulations.

## Acknowledgements

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## References:

Ringwald, F. A., Thortensen, J. R, & Hamwey R. M. 1994, MNRAS, 271, 323
Patterson, J. 1994, PASP, 106, 209
Warner, B. 1995, Ap&SS, 226, 187
Green, R. F., Ferguson, D. H., Liebert, J., & Schmidt, M. 1982, PASP, 94, 560
Verbunt, F., Bunk, W. H., Ritter, H., & Pfeffermann, E. 1997, A&A, 327, 602
Jurcevic, J. S., Honeycutt, R. K., Schlegel, E. M., Webbink, R. F. 1994, PASP, 106, 481
Hellier C. 2001, *Cataclysmic Variable Stars: How and Why They Vary.* Praxis Publishing Ltd, Chichester UK, chapter 6