American Association of Variable Star Observers

Polarimetry and the Long Awaited Superoutburst of BZ UMa

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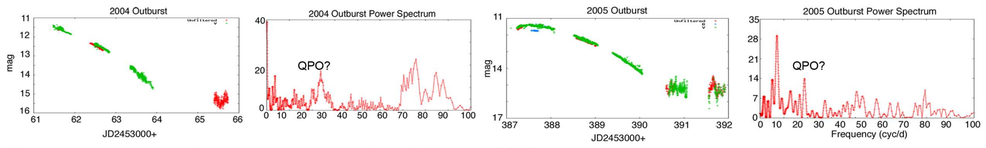
The dwarf novae BZ UMa has perplexed astronomers for decades. Regular outbursts typical of UGSU dwarf novae have been detected. However, despite good coverage, no UGSU type superoutbursts had been detected while peculiar emission lines, intense quiescent flaring and quasiperiodic oscillations during outbursts have all been reported. This has led to speculation that it could be an intermediate polar (IP) or a hybrid between an IP and a UGSU star. We report null polarimetry results and also detection of the long awaited superoutburst. We make the case for BZ UMa as an UGSU-type cataclysmic variable star, but some peculiarities remain to be addressed.

BZ UMa's Identity Problem

BZ UMa is a dwarf nova discovered by Markarian (1968) with nearly annual outbursts that rise from *V*=~16.5 to *V*=~11. Its mass ratio, orbital period and cycle between outbursts place it in the **U Gem type, SU UMa subclass (UGSU)** of dwarf novae. UGSU dwarf novae are also supposed to exhibit superoutbursts in between groups of regular outbursts. Superoutbursts are brighter than normal outbursts and include superhumps (periodicity in the light curve associated with precession of the accretion disc).

However, no superoutbursts had been detected in intense photometric coverage of outbursts in 2003, 2004, 2005, and 2006. Also, 16 outbursts visually monitored from 1968-2002 had the same basic peak brigthness (*V*=~11) and a short decay rate (~4d). Adding to the confusion, between 1976 and 1992 only one outburst was detected, despite relatively good monitoring by amateur astronomers.

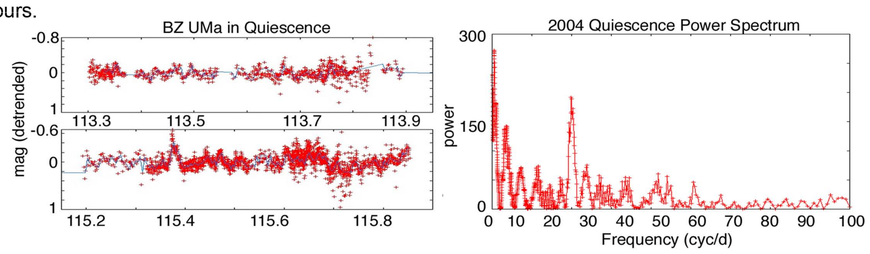
In the 1999 outburst Kato detected quasiperiodic oscillations (QPOs) of ~39m (Kato 1999) . Kato concluded based on this evidence that BZ UMa was likely an **intermediate polar (IP)** dwarf novae that had been incorrectly classified as a UGSU. BZ UMa is a bright X-Ray source in the ROSAT catalog (0.41 +/- 0.04 cnts/s^-1).



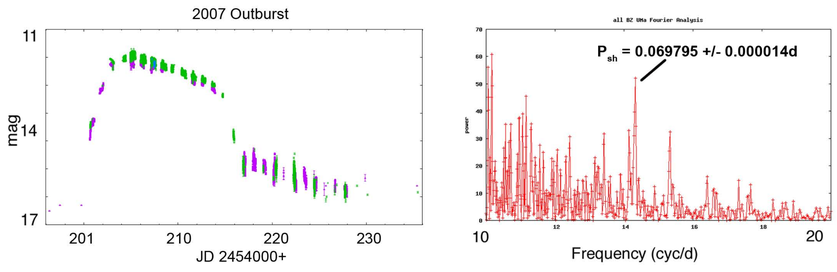
The above plots and Fourier spectrums of the 2004 and 2005 outbursts show no superhumps, but we do see evidence of QPOs. (All data from the AAVSO.)

Amateurs on the Spot

In order to look for further evidence of QPOs and the intense flickering associated with IPs, we organized a worldwide network of amateur astronomers to monitor BZ UMa over two days in April, 2004. Since QPOs are short lived, we needed to minimize aliasing from gaps in the data. Amateurs were ideal for the task because of their global distribution and willingness to dedicate two nights of their lives to this project. The light curve (below) of data from ~30 amateurs shows significant flickering and a QPO that lasted about four hours.

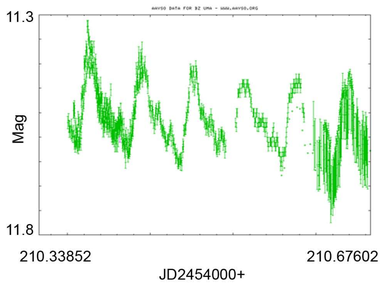


Finally, in April 2007 a long awaited superoutburst was detected (below). The outburst lasted about seven times longer than a typical outburst. Superhumps were detected and QPOs were absent.



To the right is a sample of the 2007 outburst light curve showing the profile of superhumps. Note the dual peaks, which are typical for traditional superhumps. A Fourier+CLEANEST (Foster 1995) analysis reveals P_{sh}=0.069795+/-.000014d, which is a few minutes off from P_{orb}, also as expected with superhumps.

Superhump photometry by AAVSO observers Keith Graham (USA) and David Boyd (U.K-BAAVSS.).



Vital statistics

* Discovered by Markarian (1968)
* Porb: 0.0679 days, (Ringwald et al., 1994)
* q = 0.20, (Jurcevic et al., 1994)
* Secondary: M5.5 +/- 0.5V (Ringwald et al., 1994)
* Previously Measured Circular DC Polarisation: 0.077 +/- 0.17% (Liebert & Stockman, 1980)
* Cycle: 313d
* Range: 11.3 - 16V

The *Original* Case for a UGSU

- Orbital period
- Mass ratio
- Supercycle length
- Evidence of strong accretion disc in spectra

The *Original* Case for an IP

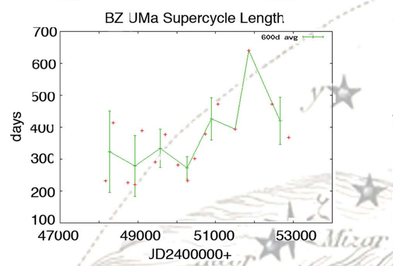
- Bright X-ray source
- Quasi-periodic oscillations in 1999, 2001, 2004 outbursts
- Strong flaring in quiescence
- Peculiar emission profile similar to another IP

The *Updated* Case for a UGSU

- Orbital period
- Mass ratio
- Supercycle length
- Evidence of strong accretion disc in spectra
- Superhumps in 2007 super outburst
- Polarization consistent with UGSU systems

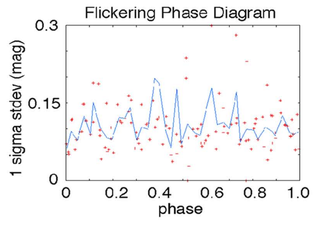
The *Updated* Case for an IP

- ~~Bright X-ray source~~
- Quasi-periodic oscillations (QPOs) in 1999, 2001, 2004 outbursts
- Strong flaring in quiescence
- Peculiar emission profile similar to another IP
- No QPOs in 2007 outbursts



Supercycle Behavior

The AAVSO International Database has 10,820 observations of BZ UMa by 159 observers dating back to November 21, 1968. Analysis reveals 20 outbursts where BZ UMa was brighter than 14.5 visual magnitude and observed by more than one observer. A long period of inactivity occurred between 1976 and 1992 where only 1 outburst was detected and confirmed despite consistent visual monitoring that should have detected an outburst. An average cycle of 312.6 days between outbursts was computed while omitting that gap with a large standard deviation of 114d.



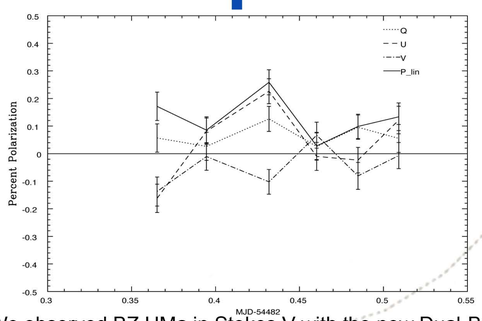
Flickering

The system exhibits significant, high amplitude flaring that is not phased with the orbital period suggesting it is not associated with any particular location on the accretion disc. It also does not diminish during outburst (as expected in UGSUs) and shows up as significant red noise in the power spectra.

Nagging Spectral Problems

We finally have a superoutburst and have detected superhumps. But unanswered questions still exist in the literature. Balmer emission and N(V)/C(IV) emission flux ratios are unusually strong. (Gansicke 2004) Similar abnormal N(V)/C(IV) lines have been found in the IP TX Col. Neustroev et al. (2004) have detected five different peaks in the Ha emission line. Their Doppler maps point to spots in the accretion disc far from the hot spot. The broad lines with multiple, shallow peaks suggest a high inclination system with structure in the accretion disc, yet we haven't detected any full eclipses. The presense of Balmer lines along with He I and Ca emission lines suggest the presence of a dominant accretion disc, something not expected in an IP.

Optical Polarimetry



IPs are expected to have circular polarization rates of between zero and a few percent. Detection of strong circular polarization would confirm the object as an IP (polarization of a few percent and an X-Ray spin period are considered the hallmarks of IPs) (Patterson 1994). However, non-detection alone would not rule out an IP classification. On March 17 1980, (Liebert & Stockman 1980) measured circular polarization of BZ UMa with a 24 min exposure and a ~3200-8600 angstrom detector on the Kitt Peak 2.3m. They effectively detected a null result below their detection limit: 0.077 +-.17%.

We observed BZ UMa in Stokes V with the new Dual-Beam Imaging Polarimeter (DBIP) on the University of Hawaii's 88-inch telescope (2.2m) on Mauna Kea (Masiero, Hodapp, Harrington and Lin 2007) with an angle of 127.57 +/- 4.03 (wrt North). We obtained six full Stokes polarization measurements of BZUMa on the night of 01/17/08 (UT), each consisting of six images taken over a half hour. We detected **an upper limit of <0.2% circular polarization polarization**. Systematic errors were found to be no more than 0.1%.

Conclusion

With the superoutburst and superhumps, the current 40-year light curve of BZ UMa nows resembles that of a UGSU. Polarimetry measurements that would have confirmed its nature as an IP were negative. **We feel that based on current knowledge this system can be classified as a UGSU dwarf nova**. However, considering that in reality star system organization constitutes a continuum, and not neatly defined categories, BZ UMa is likely a hybrid with more UGSU than IP features. As a result, its evolution will prove interesting to watch. Perhaps with an additional 40 years of data we'll know more.

Next Steps

In a dream scenario, we'd like X-ray observations of BZ UMa over the course of around 6 hours to look for a spin period. It is possible that the beat frequency between the spin and orbital periods exists in the optical light curve. So ultra-high precision, high resolution *U* or *B* band photometry would also be helpful. Further polarization measurements, preferably at red to infra-red wavelengths and over many nights, could help confirm the polarization of the light and look for variability (which can be used to describe the system's geometry). Finally, amateur astronomers need to keep a close eye on the system and continue high precision photometry during each outburst so we can look for more QPOs and/or superoutbursts.

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An author (Masiero) and his instrument (DBIP)

Another author (Price) and his instrument (amateur astronomers)

All photometry can be downloaded from http://www.aavso.org/data/download/