Spitzer 24um Observations of the Eclipsing M-dwarf Binary GU Boötes

Gerard T. van Belle[1], Kaspar von Braun[1], David Ciardi[1], Donald Hoard[2], Stefanie Wachter[2]

[1]Michelson Science Center, Caltech; [2]Spitzer Science Center, Caltech

Abstract: We present a carefully controlled set of Spitzer 24 μm MIPS time series observations of the newly discovered low mass eclipsing binary star GU Boötes. These observations serve to characterize the MIPS-24 observing techniques of the spacecraft, precisely establishing the photometric repeatability of this instrument at the tens of μJy level. These data serve to substantiate the previously announced GO-1 and upcoming GO-2 observations of extrasolar planet transits at similar levels of precision. The ancillary science return is the first-ever long wavelength characterization of such an object's light curve, allowing for improved characterization of the primary and secondary component linear radii, in addition to other aspects of their surface morphology.

What is GU Boötes?

- GU Boötes is a nearby, low-mass eclipsing binary system, consisting of two M-dwarfs (López-Morales & Ribas 2005)
- The nearly equal mass binary system was only recently discovered in 2005

Why is GU Boötes important?

- Very few (<5 pair) double-lined, detached eclipsing low-mass binaries are known
- Eclipsing binaries can be used to ascertain fundamental stellar properties such as mass, linear radius, and effective temperature
- Over 70% of the stars in the Milky Way are low-mass objects with M< 1 $M_{\odot}$
- Still considerable uncertainty over the mass-radius relation for low-mass stars

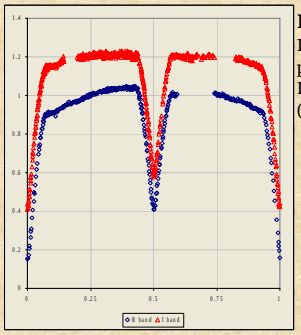

Figure 2a: R-band and I-band differential photometry curves from López-Morales & Ribas (2005).

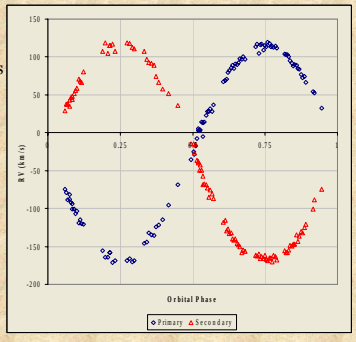

Figure 2b: Radial velocity curve from López-Morales & Ribas (2005).

Table 1: Spitzer MIPS-24 Observations of GU Boötes

Date	MIPS Campaign	AORs	Exposures[a]
2006 Feb 20	29	16103424 16103680 16103936 16104192	860
2006 Feb 21	29	1610448 16104704 16104960	860
2006 Apr 01	30	16105216 16105472	860

[a] 10 seconds per exposure

Looking for the Author?

- He's around here somewhere.
- Talk to him about flying. He loves flying.
- Email me at: gerard@ipac.caltech.edu
- Online at: http://spider.ipac.caltech.edu/staff/gerard

Figure 1: The Spitzer Space Telescope has been in space since 25 Aug 2003. The 0.85-m telescope observes objects between 3 and 180 microns and was the first telescope to directly detect photons from extrasolar planets.

Observations

- 24 μm MIPS data were obtained as described in *Table 1*, below
- Two secondary eclipse events were recorded in MIPS campaign 29, a third was observed during MIPS campaign 30
- Two events within a campaign, along with a second campaign, were selected as a means by which to test MIPS repeatability from event to event, over the short- and long-term
- 24 μm observations were selected as being minimally affected by limb darkening and/or spots for M-dwarfs

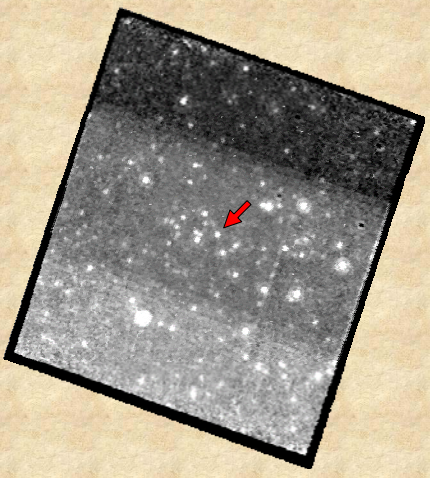

Figure 3: A 2x2 mosaic of MIPS-24 images from Spitzer. At the center of this mosaic is GU Boötes (marked by red arrow). North is up and east is left in the image.

Data Reduction

- The Spitzer *mopex* package was utilized to extract the point-source photometry
- BCD frames were mosaiced together in sets of 17
- *apex* utilized to extract point-source aperture photometry from the mosaiced frames

Table 2: Wavelength-Independent WD98 Input Parameters

Parameter	Value
Orbital Period (*days*) [a]	0.488728 ± 0.000002
Ephemeris (HJD phases 0.0)[a]	2,452,723.9811
Orbital Eccentricity[a]	0.0
Mass Ratio (M_2/M_1) [a]	0.9832 ± 0.0069
Secondary Eclipse duration (*sec*)	5665
Combined 24 μm flux (μJy)	502 ± 30
Secondary eclipse minimum 24 μm flux (μJy)	253 ± 80

[a] From López-Morales & Ribas (2005)

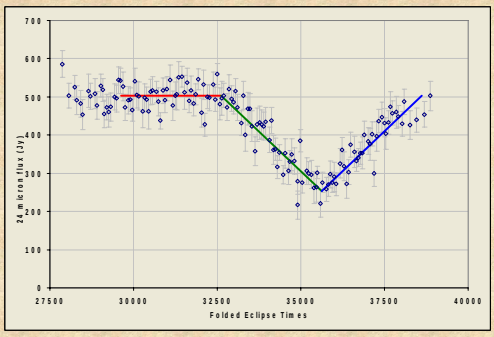

Figure 5: Folded 24 micron light curve for all 3 observed secondary eclipses of GU Boötes. Constant flux level prior to the eclipse is 502±31 μJy; minimum flux level is 253±80 μJy during the eclipse, consistent with a nearly full eclipse of an equally bright secondary star.

Conclusions (thus far)

- Spitzer absolute repeatability from observing campaign to campaign appears to be good at the <10 μJy level. Intra-campaign repeatability levels are even better.
- 24 μm light curves for GU Boötes appear to be uncontaminated by surface morphology compared to their optical counterparts

To-Do List

- Derive more fundamental stellar parameters; in particular, compare diameter indicated at 24μm with R- & I-band values
- Derive individual component 24μm fluxes and compare to SED fits for stars
- Compare point-response fitting photometry provided by *apex* to aperture photometry values

References

- Berger et al., 2006, ApJ 644 475
- López-Morales & Ribas, 2005, ApJ 631 1120
- Torres et al., 2006, ApJ, 640 1018

Figure 4a, b, c: Individual observed secondary eclipse events for of GU Boötes. Constant flux level for (a,b,c) are 506±30, 504±31, 498±30 μJy; ingress egress slopes are 0.094±0.028, 0.074±0.034, 0.077±0.032 μJy/sec; minimum flux during maximum eclipse is 224±72, 282±87, 268±83 μJy. Reduced χ2 for each fit was 1.98, 0.91, 1.62, respectively.