

# Eclipse Binary System BB Pegasus

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## Abstract

CCD ground-based photometry of the contact binary system BB Pegasus is presented along with analyses of the light curve. Recent radial velocity data with these obtained light curves were used to compute parameters. These results are compared with published values computed using spectroscopic values. The light curve displays total annular eclipses in the primary. The period is very short, equal to 0.3615015 days. A recent spectroscopic study indicates the existence of a third body. Three times of minimums were gathered for this poster paper and when added to those found in the literature a plotted quadratic ephemeris displays a sine-like variation of the O – C curve indicating a tertiary component to the system. The light curve of this system shows an asymmetry in which the maximum after primary eclipse is higher than the other maximum, O’Connell effect. Two small cool stellar spots on star number 1 were used to make the parameter model fit the light curve data.

## 1. Introduction

BB Pegasus is a contact binary, low temperature of 6250 K, an F8 main sequence binary system. The mass ratio determined photometrically using the acquired light curve, Figure 1, and Binary Maker 3 (Bradstreet 2004) is computed to be 2.778. Following the normal convention the reciprocal of  $2.778 = q = 0.3599$ , which is identical to the spectroscopic  $q$  acquired by Lu (1999). Their radial velocity data was plotted and mass ratio  $q$  of 0.360 computed, Figure 2, which is used to compute the parameters and absolute parameters of this system. See Table 1.

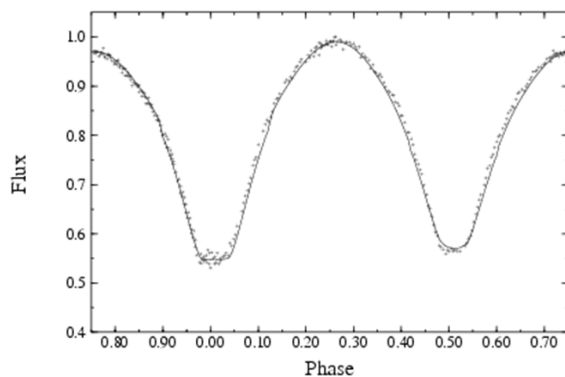


Figure 1. Light curve of BB Peg in R. Solid curve is the theoretical light curve from the parameters in Table 1.

This is a W UMa type contact eclipsing binary with a short period, ellipsoidal shapes because the components being so close are distorted by tidal forces and mass transfer is occurring between the

stars which are also similar in luminosity. Kalomeni (2007) has determined the mass transfer from the less massive to the more massive component is occurring.

D’Angelo (2006) spectroscopic study determined the existence of an M-type dwarf star orbiting about the binary. Time variations and O – C analysis display a sine-like variation which implies a tertiary component orbiting the system.

## 2. Observations

The observations were made on September 15 and 16, 2007 in the R and V filters using a Meade 12” LX200 classic with SBIG ST-9XE yielding a 1920mm (75.6”) focal length and effective field of view of 2.18 arcsec/pixel. Three times of minimum obtained, two primary and one secondary minimum, are the last three minimum shown in Figure 4 along with those published in the literature.

## 3. Discussion and Conclusion

The linear ephemeris (Kreiner 2004) was used to construct the binary’s O – C diagram of Figure 4

$$\begin{aligned} \text{HJD Min.} &= 2,452,500.0335 \quad (6) \\ &+ 0.3615016 \quad (2) \quad E \quad (1) \end{aligned}$$

The equation for the least-squares fitting in Figure 1 was added to equation (1) to obtain the quadratic ephemeris

$$\begin{aligned} \text{HJD Min.} &= 2,452,500.037332 \pm 9.4 \times 10^{-4} \\ &+ 0.361502561 \pm 9.1 \times 10^{-8} \text{ E} \\ &+ 1.49215^{-11} \pm 1.4 \times 10^{-12} \text{ E}^2 \end{aligned}$$

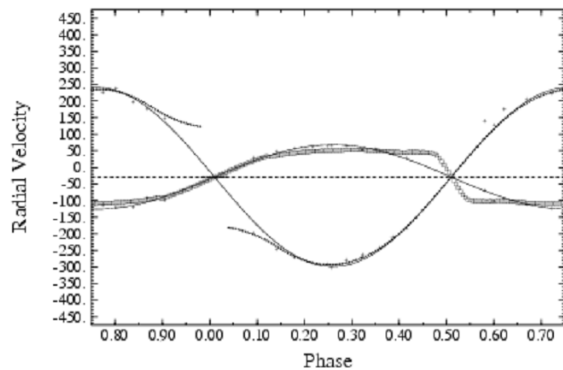


Figure 2. Radial velocities of BB Peg (Lu 1999).

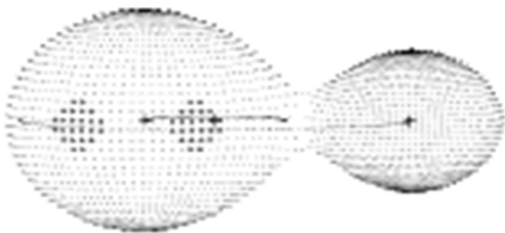


Figure 3. BB Peg shown in spherical coordinates geometry with two stellar spots on star 1.

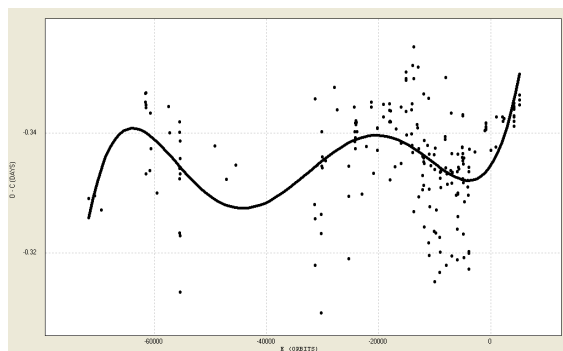


Figure 4. O-C, in days, plotted against orbits of BB Peg.

When the residuals from equation (2) were plotted it shows a sine curve, Figure 4. This sinusoid would suggest a triple system interpreted that the timing residuals are caused by the light-travel time differences as the eclipsing system moves about the barycentre of the triple. D’Angelo (2006) did a spectroscopic study of the system and determined an orbital period for the third body = 29.7 years while Kalmomi computed a period = 27.9 years. Using measurements and data computations of Figure 4 this pa-

per computes a period for the tertiary component of  $35.522 \pm 1.121$  years. When analyzing data sets and radial-velocity studies to determine teriaries in systems it is not an exact science so the above three different measurements to come within  $\pm 21\%$  is accepted.

There appears to be a gain in the angular momentum of the system ( $dP/dt$ ) since September 1998. The data computes this gain =  $2.578^{-6}$  seconds each cycle or  $2.605^{-3}$  seconds each year. This is average angular momentum change for a W UMa type system.

Figure 1 shows an asymmetry in which the maximum after primary eclipse is higher than the maximum after the secondary minimum, O’Connell effect. Two small cool stellar spots, Figure 3, on star number 1 were used to make the parameter model fit the light curve data rendered in Figure 1. Table 1 displays the spot parameters and it should be noticed the spots were only 10% cooler than the surrounding areas on star 1.

mass ratio input	= 2.778000
mass ratio < 1	= 0.359971
Fillout 1	= 0.300000
Fillout 2	= 0.300000
Normalization Factor	= 0.98500
inclination	= 87.000
wavelength	= 5500.00
temperature 1	= 6250.00
temperature 2	= 6600.00
gravity coefficient 1	= 0.320
gravity coefficient 2	= 0.320
limb darkening 1	= 0.547
limb darkening 2	= 0.573
reflection 1	= 0.500
reflection 2	= 0.500
Third light	= 0.000
Period	= 0.36150100
K1	= 97.200000
K2	= 270.200000
Kg	= -28.9

Absolute Parameters

Mass 1 =	1.376664 solar masses
Mass 2 =	0.495232 solar masses
Semi-major axis =	1.828719 million km
Semi-major axis =	2.627470 solar radii

Spot Parameters

Star	Co-Lat	Long	Spot Radius	Temp Factor
1	90.000	242.620	12.110	0.90
1	90.000	296.920	12.110	0.90

Table 1. Parameter solutions BB Peg.

#### **4. Acknowledgements**

This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France.

#### **5. References**

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