BZ MONOCEROTIS: AN ECLIPSING BINARY

BRADLEY E. SCHAEFER
6870 S. Elizabeth Circle
Littleton, CO 80122

Abstract

This paper presents a visual light curve, an O-C diagram (from 1900 to present), and estimated color indexes for the BZ Monocerotis system. The period and epoch are $3^{d}.451804$ and J.D. 2,443,192.663 respectively. BZ Mon is most likely composed of B4V and G5III stars, and is near the Mon OB2 association.

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BZ Monocerotis was discovered to be variable by Hoffmeister (1935) as an Algol type eclipsing binary with a photographic magnitude range from 12^{m} to 16^{m}. A finder chart is given by Hoffmeister (1957). Guthnick and Schneller (1943) give a period of $3^{d}.4517021$ with a photographic range of $12^{m}.1$ to $15^{m}.4$. Ahnert (1947) lists five times when BZ Mon was observed not to be at maximum. Kukarkin and Parenago (1969) claim that Ahnert corrected the period to $3^{d}.452002$.

At the suggestion of Marvin Baldwin, I undertook a study of BZ Mon during 1977 and 1978. Approximately a hundred visual magnitude estimates were made with a variety of telescopes, including the University of Denver's 20", the Massachusetts Institute of Technology's 24", and Wellesley College's 24". In addition, I examined over five hundred plates from Harvard College Observatory's plate collection, extending back to 1900.

Three minima were observed well enough for accurate times of minima to be deduced. These minima timings and their estimated errors are:

$$\text{J.D. (min)} = 2{,}443{,}192.663 \pm 0.010$$
$$\text{J.D. (min)} = 2{,}443{,}482.615 \pm 0.020$$
$$\text{J.D. (min)} = 2{,}443{,}544.739 \pm 0.010.$$

These times, along with the magnitude of BZ Mon as found on the Harvard College Observatory plates and as given by Ahnert (1947) can be used to construct an O-C curve. Figure 1 shows the O-C curve for BZ Mon, for a period of $3^{d}.451804$ and an epoch of 2,443,192.663. The accuracy of this period can be estimated by drawing a line of maximum slope on the O-C curve which is still consistent with the data. The period used in constructing the O-C curve cannot be off by more than 0.05 in phase over 20,000 days. This value corresponds to an uncertainty of $0^{d}.00030$ in the period of BZ Mon.

Using this period, my visual magnitude estimates were folded to form a light curve. The resulting light curve (see Figure 2) is typical of a totally eclipsing Algol type binary with no readily observable secondary minimum. The total duration of the eclipse is 300 minutes(D=0.060 in phase)while totality lasts nearly 150 minutes(d=0.030 in phase). A lower limit on the ratio of the radius of the smaller star to the bigger star can be found from equation 3.31 of Kopal(1950):

$$\frac{\text{radius of small star}}{\text{radius of large star}} \gtrsim \frac{D-d}{D+d} = \frac{1}{3}$$

The depth of primary minimum is $2^{m}.2$ in the visual, which implies that the ratio of luminosities of the two components is 6.6 to one. With such a deep primary minimum, it is a safe assumption that the bright totally eclipsed star is the smaller.

By a stroke of luck, both the red and the blue plates of the Palomar Sky Survey were taken during phases of full totality (times of exposures are given in the plate catalogue). I measured the image diameters of BZ Mon and many other stars with known color index (as a check) using a microscope. Image diameters were converted to red and blue magnitudes using the method of Liller and Liller (1975), and then converted to color index (B-V) using the relation of Perek (1958). I find that $B-V=+0^{m}.82 \pm 0^{m}.10$ (roughly spectral type G) for the faint star. Calculations show that the color index of the two stars outside of eclipse is well within the measurement error of the color index of the bright star alone. The difference between the photographic and visual amplitudes ($1^{m}.1$) equals the difference between the color indices at maximum and minimum. So the color index of the bright star is $-0^{m}.28 \pm 0^{m}.15$ (an early B type star).

Taking the information from the last two paragraphs, we see that the small blue star must lie $2^{m}.05$ above the large G type companion on an H-R diagram. All these restrictions are best met by a system composed of a B4V and a G5III star. From the absolute magnitude of a B4V type star($M_B=-1^{m}.9$), the distance modulus is seen to be $14^{m}.0$. This value corresponds to a distance of 1.6 kpc (for an absorption of $1^{m}.9$/kpc due to the interstellar medium - a necessary correction as BZ Mon has a galactic latitude of zero). Sahade and Berón Dávila (1963) and Semeniuk (1962) both noted that BZ Mon is in optical coincidence with the I Mon = Mon II = Mon OB2 association, which lies 1.6 kpc away (Blitz 1979), so it appears likely that BZ Mon is near the Mon OB2 association. The author would like to thank the referee for suggesting a method of estimating the color index of the bright star.

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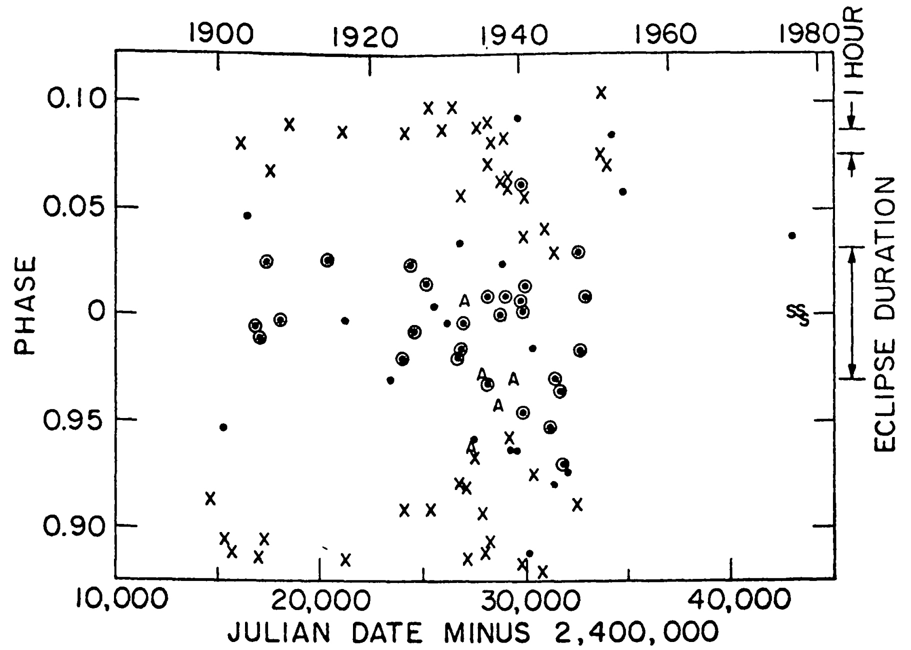

Figure 1. Modified O-C Curve for BZ Mon. This figure shows the approximate magnitude of BZ Mon as a function of phase and Julian Date of observation (much like a standard O-C curve). Each "x" is for a plate from Harvard College Observatory on which BZ Mon appears at maximum light. If the plate showed BZ as being not at maximum light, a "." or a "⊙" is used to indicate whether it is fainter than $13^{m}.0$. Photographic observations from Ahnert(1947) are indicated with an "A". Times of minima reported in this paper are shown by an "S".

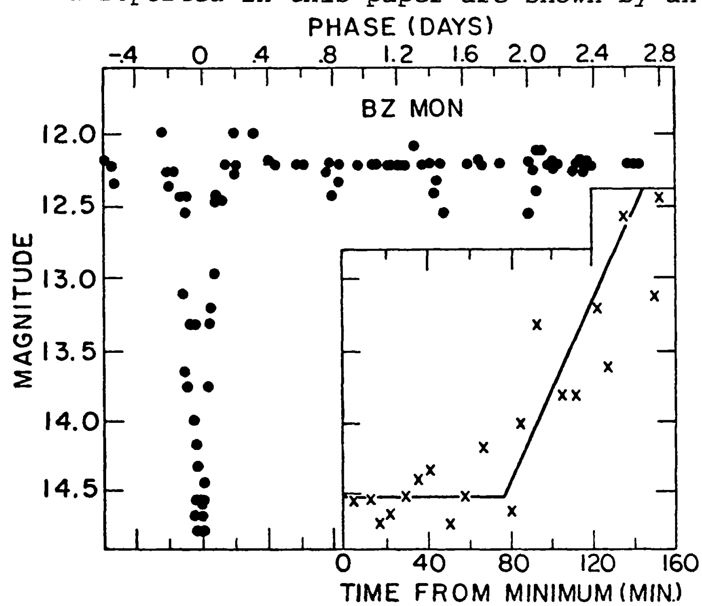

Figure 2. Light curve for BZ Mon. This figure plots the light curve from visual estimates of BZ Mon made by the author during 1977 and 1978. A period of $3^{d}.451804$ and epoch of J.D. 2,443,192.663 are used. The inset diagram shows individual observations near minimum, folded around zero phase. The light curve appears to be totally eclipsing for a time of near 150 minutes. The sketched light curve is the author's best judgment as to its true shape. An individual visual observation is accurate to within $0^{m}.2$.