PHOTOMETRIC STUDY OF BZ ERIDANI

R. K. SRIVASTAVA and WAHAB UDDIN
Uttar Pradesh State Observatory, Naini Tal, India

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Abstract. The 1980–1981 *U*, *B*, and *V* observations of the eclipsing binary BZ Eridani have been presented. A new period of BZ Eri comes out to be $0^d_.6641703$. The colour curves of the system show appreciable variations, and are indicative of intrinsic variability. The secondary minimum falls nearly at phase 0.5. Some interesting features are given. The features of BZ Eri are changing. Some light variations are visible around the phase of the secondary minimum. The discussion reveals that BZ Eri is a complicated system.

1. Introduction

The eclipsing binary system BZ Eridani (= $-06°841$ = 272.1934) was discovered to be a variable by Hoffmeister (1934) from photographic observations. Kippenhahn (1955), Götz and Wenzel (1961), and Meinunger (1966) confirmed its eclipsing type variability from their subsequent photographic observations.

The eclipsing binary system BZ Eri remained neglected photoelectrically for nearly forty years since its discovery, and its first photoelectric observations were secured by the first author in 1975–1976 observing season. First photoelectric light curves in *U*, *B*, and *V* filters, and some results were published (cf. Srivastava and Sinha, 1981). First geometrical elements based on these observations have been obtained (cf. Srivastava and Uddin, 1985a). In order to confirm its feature presented earlier by Srivastava and Sinha (1981), fresh photometry was attempted by the first author, and some individual minima alongwith some comments were presented (cf. Srivastava and Uddin, 1985b). Srivastava (1985a) presented the first period study of the system, which was lacking in the literature.

TABLE I

Particulars of the variable, the comparison, and the check stars of BE Eri

Stars	α_{1855}	δ_{1855}	m_v	Average standard deviation of the individual observations in *U*, *B*, and *V* filters
BZ Eri (= BD − 6°841)	$04^h05^m05^s_.7$	$-06°24'_.2$	$9^m_.1$	–
Comparison star (= BD − 6°840)	04 04 24.1	−06 20.8	9.0	$\pm 0^m_.030$ (*U*) $\pm 0^m_.023$ (*B*) $\pm 0^m_.016$ (*V*)
Check star (= BD − 6°839)	04 03 50.0	−06 14.8	9.4	–

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2. Observations

Due to the reasons stated above new photoelectric observations of the system BZ Eri in *U*, *B*, *V* filters have been secured in the 1980–1981 observing season through the 38-cm reflector of the Uttar Pradesh State Observatory employing a 1P21 photomultiplier thermo-electrically cooled to $-20\ ^\circ$C, the *U*, *B*, and *V* filters of the Johnson and Morgan system, and d.c. techniques.

A total of six nights of observations have been secured using BD $-6°840$ and BD $-6°839$ as the comparison and the check stars, respectively. The instrumental magnitudes of the system BZ Eri have been converted to the standard magnitudes with the help of standard stars. The particulars of the variable, the comparison and the check star are given in Table I. The average standard deviations of an individual observation derived on four nights are given in the last column of Table I. Present standard deviations of an individual observation in *U*, *B*, and *V* filters are, respectively, $\pm 0\overset{m}{.}030$, $\pm 0\overset{m}{.}023$, and $\pm 0\overset{m}{.}016$, which are slightly less than those obtained in the earlier photometry, i.e., $\pm 0\overset{m}{.}035$, $\pm 0\overset{m}{.}032$, and $\pm 0\overset{m}{.}024$, respectively. The standard *U*, *B*, and *V* observations of BZ Eri have been listed in Tables VII, VII, and IX, respectively. The light and the colour curves are shown in Figure 1, in which the solid circles represent the observed points and open circles indicate some reflected points.

3. Epoch and Period

The times of the primary minima of BZ Eri are given by Kippenhahn (1955), Götz and Wenzel (1961), Meinunger (1966), Srivastava and Sinha (1981), Srivastava and Uddin (1985a, b). The period of the system was presented by Meinunger (1966) as $0\overset{d}{.}6641704$. Srivastava and Sinha (1981) gave an improved period of BZ Eri as $0\overset{d}{.}6641701$. New times of minima in individual filters have been given by Srivastava and Uddin (1985b), and a new period of $0\overset{d}{.}664170$ was also given based on Srivastava and Sinha's (1981) epoch. Srivastava (1985) was the first to initiate the period study of BZ Eri, which showed that large period variations were present in the system.

During the course of our observations, two primary and three secondary minima have been secured, whose details have been presented by Srivastava and Uddin (1985b) alongwith other photoelectric minima, and they are presented here in Table II as the mean of *U*, *B*, and *V* filters. Out of these, the time of one minimum (J.D. 2444581) has been derived graphically, while the times of remaining minima have been obtained using Kwee and van Woerden (1956) method.

The phases of the observations have been calculated using Meinunger's (1966) epoch and period, viz.:

$$\text{Primary Minimum} = \text{J.D. } 2425558.445 + 0\overset{d}{.}6641704E\,.$$

The O–C values given in the last column of Table II suggest that both the primary and the secondary minima are shifted earlier and their average shift is $-0\overset{d}{.}0045$. This amount of phase shift has been incorporated in the observed phases to obtain the correct

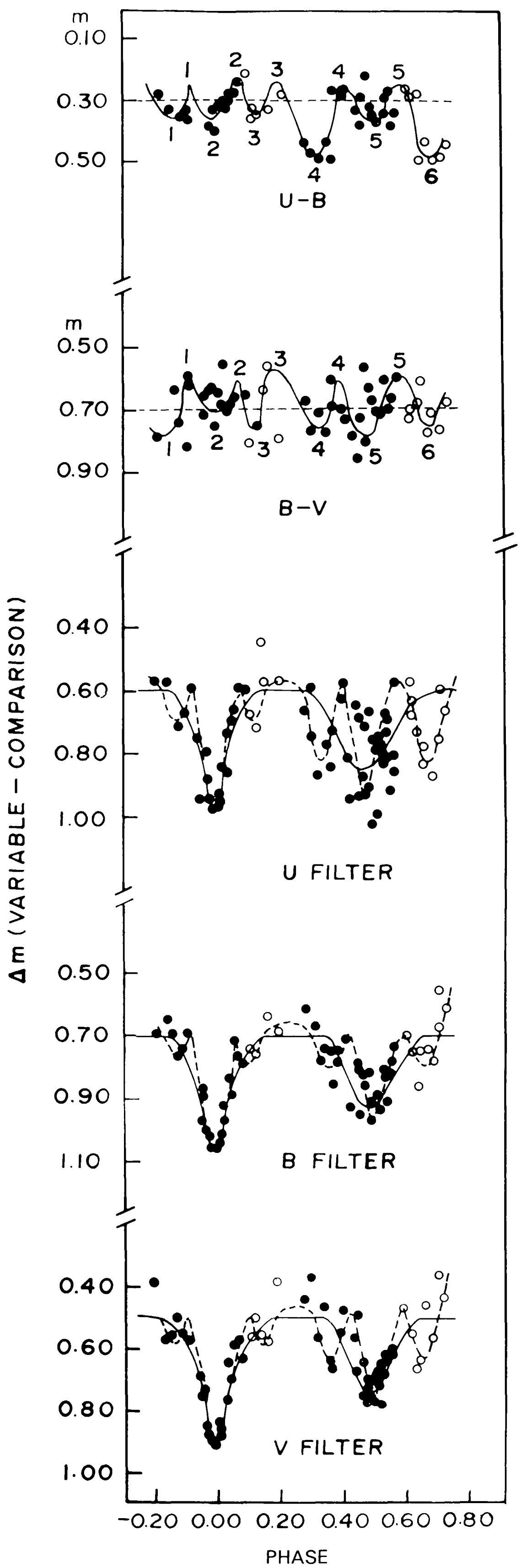

Fig. 1. Light and colour curves of BZ Eri. Solid and open circles represent the observed and some reflected points, respectively. The solid lines represent the smoothened light curves through all the points and dashed lines indicate some interesting features. The dashed lines in the colour curves represent the colour levels at maximum.

TABLE II

Minima of BZ Eri

Sl. No.	Epoch of minima J.D. (Hel.)	Period	O–C based on Meinunger's (1966) epoch and period
	Primary minima		
1	2444590.2449 (±0.0005)	$0^d.6641703$	$-0^d.0029$
2	2444604.1888 (±0.0005)	$0^d.6641702$	$-0^d.0065$
	Mean	$0^d.6641703$	$-0^d.0031$
	Secondary minima		
1	2444581.2972 (±0.0007)	$0^d.6641709$	$+0^d.0157$
2	2.444591.2166 (±0.0018)	$0^d.6641694$	$-0^d.0274$
3	2.444605.1857 (±0.0028)	$0^d.6641702$	$-0^d.0059$
	Mean	$0^d.6641702$	$-0^d.0059$

TABLE III

Epochs and periods of BZ Eri

Sl. No.	Author	Epoch	Period (days)
1	Kippenhahn (1955)	J.D. 2425558.456	–
2	Götz and Wenzel (1961)	J.D. 2437312.444(?)	–
3	Meinunger (1966)	J.D. 2425558.445	0.6641704
4	Srivastava and Sinha (1981)	J.D. 2425558.445	0.6641701
5	Srivastava and Uddin (1985b)	J.D. 2442836.1605	0.6641700
6	Srivastava and Uddin (present work)	J.D. 2425558.445	0.6641703

TABLE IV

Eclipse parameters

Results	Depths of minima		Duration of eclipses		Duration of totality
	Pr.	s	Pr.	s	(during s)
Previous photometry (cf. Srivastava and Sinha, 1981)	$0^m.44$	$0^m.21$	$0^p.38$	$0^p.42$	$0^p.07$
Present photometry	$0^m.37$	$0^m.25$	$0^p.29$	$0^p.29$	$0^p.08$

phases. Based on these minima, an improved period of BZ Eri has been deduced to be $0^d.6641703$, which is not significantly different from that of Meinunger (1966), but this period of the system shows slight increase in comparison to the earlier one (cf. Srivastava and Sinha, 1981). The epochs and the period of BZ Eri, given by various authors, have been listed in Table III.

4. Light Curves

The *U*, *B*, and *V* light curves of the eclipsing binary system BZ Eri have been fairly covered. The results of the earlier and the present photometries have been given in Table V.

The average depths and the durations of the primary and the secondary eclipses alongwith the durations of the totality (during secondary minimum) are given in Table IV. The magnitudes of maximum in *U* and *B* filters have remained almost the same within error, while it has differed (brightened) by $0\overset{m}{.}05$ in the *V* filter.

Slight asymmetry is seen in the branches of both minima, which is comparatively more visible in the secondary minimum. Descending branches of both minima appear shallower than the ascending branches, when the branches are smoothened through all the points, but when the points around the dips of both sides of minima are not considered, this asymmetry washes out. In addition, neglecting the superposed variations (which are shown in Figure 1 as dashed lines), the light between minima shows no continuous variation; hence, it may be expected that either the ellipticity of

TABLE V

Features of BZ Eri

Features	Srivastava and Sinha (1981)	Present work
Maxima magnitude	$0\overset{m}{.}590$ (*U*), $0\overset{m}{.}690$ (*B*), $0\overset{m}{.}550$ (*V*)	$0\overset{m}{.}600$ (*U*), $0\overset{m}{.}700$ (*B*), $0\overset{m}{.}500$ (*V*)
Depth of primary minimum	$0\overset{m}{.}415$ (*U*), $0\overset{m}{.}475$ (*B*), $0\overset{m}{.}435$ (*V*)	$0\overset{m}{.}380$ (*U*), $0\overset{m}{.}330$ (*B*), $0\overset{m}{.}405$ (*V*)
Depth of secondary minimum	$0\overset{m}{.}200$ (*U*), $0\overset{m}{.}210$ (*B*), $0\overset{m}{.}230$ (*V*)	$0\overset{m}{.}220$ (*U*), $0\overset{m}{.}240$ (*B*), $0\overset{m}{.}280$ (*V*)
Period	$0\overset{d}{.}6641701$	$0\overset{d}{.}6641703$
Duration of primary eclipse	$0\overset{p}{.}45$ (*U*), $0\overset{p}{.}35$ (*B*), $0\overset{p}{.}35$ (*V*)	$0\overset{p}{.}25$ (*U*), $0\overset{p}{.}27$ (*B*), $0\overset{p}{.}34$ (*V*)
Duration of secondary eclipse	$0\overset{p}{.}45$ (*U*), $0\overset{p}{.}43$ (*B*), $0\overset{p}{.}37$ (*V*)	$0\overset{p}{.}34$ (*U*), $0\overset{p}{.}28$ (*B*), $0\overset{p}{.}26$ (*V*)
Duration of totality (during secondary minimum)	$0\overset{p}{.}10$ (*U*), $0\overset{p}{.}05$ (*B*), $0\overset{p}{.}07$ (*V*)	$0\overset{p}{.}09$ (*U*), $0\overset{p}{.}07$ (*B*), $0\overset{p}{.}07$ (*V*)
Spectral type of maximum	G1III	G0–G1III
Spectral type of primary component	G0III	G0III
Spectral type of secondary component	G2III	G2III
Spectral type of comparison star (BD – 6°840)	F6I	F7I
Nature of primary eclipse	Total, annular	Total, annular
Nature of secondary eclipse	Total, occultation	Total, occultation
Apparent type of the system	Algol	Algol

the components is very small or it is masked by the observational scatter and systemic complications. Some points around phase 0.7 appear higher than those at phase 0.2.

One important feature seen in the present photometry (which was not present in the earlier one), is the varying duration of the primary and the secondary eclipses in *U*, *B*, and *V* filters. The duration of the primary eclipse is smallest in the *U* filter, and is largest in the *V* filter, while the duration of the secondary eclipse is largest in the *U* filter, and smallest in the *V* filter. On the other hand, the duration of both the eclipses in the *B* filter are nearly the same. Also, the duration of the totality has slightly decreased in the *U* filter, while it has increased in *B* and *V* filters, as compared to earlier results.

The average χ-values for the primary and the secondary eclipses turn out to be approximately 0.269 and 0.416, which confirm our earlier findings that the secondary eclipse is an occultation, while the primary eclipse is a transit one.

Like in earlier photometry, the distortions of the light are seen around the phase of the secondary minimum. These are larger as compared to earlier ones. The dips before and after the primary minimum are almost of the same magnitude in the *B* filter, but are of larger magnitudes in *U* and *V* filters as compared to earlier photometry. Likewise, the dips before and after the secondary minimum are also of larger magnitudes.

In the earlier photometry (cf. Srivastava and Uddin, 1985a), the light distortions were more conspicuous in the phase interval 0.300 to 0.700, while in the present photometry, these were seen in the phase interval 0.280 to 0.710. Thus, both the photometries reveal that the light distortions around the secondary minimum are found nearly in the same phase interval. A definite dip of about $0^m.04$ is found at $0^p.301$, which when reflected is also seen on the right-hand side of the secondary eclipse. Likewise, a dip of nearly $0^m.05$ at $-0^p.155$ is seen before primary eclipse, which when reflected, is not found on the other side of the eclipse. In the present photometry, a dip of $0^m.15$ is seen at $0^p.380$, which when reflected is apparent at $0^p.625$. Likewise a dip of $0^m.08$ is centered at $-0^m.133$, which is when reflected is found to be centered at $0^p.110$. Thus, it is apparent that the dips are centered on the average at $-0^p.14$ and $0^p.34$ in both the photometries. In the present photometry, the dip, falling before the secondary minimum, has shifted later by nearly $0^p.08$, while the dip, falling before the primary minimum, has shifted slightly earlier by $0^p.02$. The dips are indicative of shell features around both the components of BZ Eri.

5. Colour and Luminosity Classification

The colours of the comparison star have been obtained on four nights, the average colours being $B - V = 0^m.498$ and $U - B = 0^m.399$. These values agree fairly well with the F7I colour sequence of Arp (1958). The earlier photometry revealed its spectral luminosity class as F6I. The colour of the primary component has been derived by reading $\Delta(B - V)$ and $\Delta(U - B)$ values at the tip of the secondary minimum, as the secondary eclipse is a total occultation. By incorporating the colours of the comparison star to these differential colours, the colours of the primary component turn out to be $B - V = 0^m.658$ and $U - B = 0^m.279$. These place the primary component in G0–G1III

TABLE VI

Colour indices of BZ Eri

Phase	$B - V$	$U - B$	Sp.
Maximum (combined colour of both components)	$+0^m.698$	$+0^m.299$	G1III
Primary component (at the tip of the secondary minimum)	$+0^m.658$	$+0^m.279$	G0–G1III
Secondary component	$+0^m.708$	$+0^m.409$	G2III
Comparison star	$+0^m.498$	$+0^m.399$	F7I

spectral-luminosity class see Arp (1958). From the branches of the secondary eclipse, we have obtained the differential colours of the secondary component, and adding to these the colours of the comparison star, we obtained the colours of the secondary component as $B - V = 0^m.708$ and $U - B = 0^m.409$. These indicate that the secondary

TABLE VII

Standard U observations of BZ Eridani

J.D. (Hel.)	Phase	ΔU	J.D. (Hel.)	Phase	ΔU
2444581.1426	0.2975	$0^m.593$	2444591.2142	0.4620	0.879
.1899	0.3689	0.737	.2272	0.4815	0.913
.2028	0.3883	0.629	.2348	0.4930	1.033
.2124	0.4026	0.578	.2460	0.5097	0.996
.2345	0.4359	0.640	.2563	0.5253	0.829
.2462	0.4537	0.691	.2660	0.5399	0.819
.2592	0.4732	0.933	.2765	0.5558	0.807
.2831	0.5091	0.750			
.3010	0.5360	0.746	604.1505	−0.0607	0.757
.3111	0.5512	0.917	.1652	−0.0385	0.794
.3213	0.5666	0.860	.1709	−0.0299	0.887
			.1788	−0.0180	0.957
590.1154	−0.1942	0.576	.1851	−0.0084	0.980
.1379	−0.1603	0.582	.1916	+0.0012	0.978
.1509	−0.1408	0.440	.1991	0.0125	0.952
.1629	−0.1227	0.721	.2060	0.0229	0.650
.1752	−0.1043	0.678	.2157	0.0375	0.739
.1875	−0.0856	0.590	.2263	0.0536	0.665
.2519	+0.0113	0.035			
.2650	0.0310	0.858	605.1668	0.4695	0.715
.2769	0.0490	0.698	.1737	0.4800	0.669
.2882	0.0660	0.598	.1821	0.4925	0.758
.3026	0.0877	0.603	.1912	0.5062	0.786
			.2007	0.5205	0.803
591.0924	0.2786	0.660	.2080	0.5317	0.680
.1075	0.3013	0.749	.2148	0.5417	0.694
.1200	0.3201	0.876	.2235	0.5549	0.575
.1335	0.3403	0.781			
.1462	0.3596	0.847	606.1178	−0.0987	1.000
.1910	0.4269	0.950	.1488	−0.0521	0.948
.2032	0.4454	0.942	.1780	−0.0081	1.185

TABLE VIII

Standard B observations of BZ Eridani

J.D. (Hel.)	Phase	ΔB	J.D. (Hel.)	Phase	ΔB
2444581.1434	0.2987	$0^m.557$	2444591.2148	0.4629	$0^m.823$
.1905	0.3697	0.861	.2277	0.4823	0.926
.2033	0.3891	0.754	.2352	0.4936	0.975
.2129	0.4034	0.716	.2464	0.5104	0.907
.2350	0.4367	0.793	.2568	0.5261	0.813
.2465	0.4541	0.808	.2665	0.5407	0.909
.2596	0.4738	1.260	.2770	0.5565	0.735
.2837	0.5101	0.922			
.3014	0.5366	0.815	604.1618	−0.0436	0.869
.3116	0.5521	0.823	.1656	−0.0378	0.893
.3216	0.5672	0.923	.1714	−0.0292	1.006
			.1791	−0.0176	1.023
590.1160	−0.1934	0.694	.1856	−0.0078	1.063
.1383	−0.1597	0.646	.1920	+0.0018	1.062
.1514	−0.1400	0.702	1997	0.0136	1.017
.1634	−0.1219	0.763	.2065	0.0237	0.923
.1756	−0.1036	0.747	.2164	0.0386	0.835
.1881	−0.0849	0.702	.2268	0.0542	0.719
.2523	+0.0119	1.052			
.2655	0.0318	0.972	605.1671	0.4701	0.860
.2773	0.0496	0.891	.1742	0.4806	0.817
.2887	0.0667	0.769	.1827	0.4934	0.909
.3030	0.0883	0.790	.1917	0.5070	0.892
			.2013	0.5214	0.934
591.0929	0.2793	0.617	.2086	0.5324	0.828
.1081	0.3022	0.669	.2153	0.5427	0.827
.1206	0.3210	0.781	.2241	0.5558	0.787
.1341	0.3414	0.745			
.1467	0.3603	0.749	606.1189	−0.0971	1.034
.1914	0.4276	0.930	.1497	−0.0507	0.969
.2039	0.4463	0.952	.1794	−0.0060	1.102

component belongs to G2III spectral-luminosity class (see Arp, 1958). The colour indices at various phases have been listed in Table VI.

The $B - V$ and $U - B$ values of the individual observations have been calculated throughout the cycle, listed in Table X, and are plotted on the top of Figure 1. The colour curves show large colour variations throughout the cycle. In all six minima and five maxima of colour variations are apparent in the present colour curves. The colour curves of the earlier photometry (cf. Srivastava and Uddin, 1985a) showed six minima and six maxima. This difference most likely be emerging due to the large scatter around the phase of the secondary minimum and owing to little incomplete shapes of some minima or maxima of the colour curves. In the present photometry, the total amplitude (max. to min.) of the colour variations in $B - V$ and $U - B$ range from $0^m.11$ to $0^m.19$ and $0^m.11$ to $0^m.24$, respectively. The last (sixth) minimum in both the colour curves is not accompanied by the corresponding maximum. Likewise, the first maximum is not

TABLE IX

Standard V observations of BZ Eridani

J.D. (Hel.)	Phase	ΔV	J.D. (Hel.)	Phase	ΔV
2444581.1439	−0.2995	$0\overset{\mathrm{m}}{.}261$	2444591.2153	0.4635	$0\overset{\mathrm{m}}{.}757$
.1908	0.3703	0.672	.2282	0.4830	0.705
.2037	0.3897	0.551	.2357	0.4943	0.767
.2134	0.4041	0.477	.2470	0.5113	0.711
.2354	0.4373	0.577	.2573	0.5268	0.791
.2470	0.4547	0.490	.2669	0.5413	0.665
.2601	0.4745	0.645	.2773	0.5570	0.606
.2840	0.5106	0.679			
.3019	0.5375	0.686	604.1622	−0.0430	0.751
.3120	0.5526	0.616	.1660	−0.0372	0.743
.3221	0.5680	0.825	.1719	−0.0284	0.859
			.1797	−0.0167	0.888
590.1161	−0.1931	0.395	.1860	−0.0071	0.912
.1388	−0.1591	0.582	.1926	+0.0028	0.922
.1518	−0.1394	0.560	.2003	0.0145	0.879
.1639	−0.1212	0.508	.2070	0.0244	0.866
.1761	−0.1028	0.558	.2170	0.0395	0.646
.1885	−0.0841	0.582	.2274	0.0553	0.591
.2526	+0.0124	0.838			
.2659	0.0324	0.765	605.1673	0.4704	0.757
.2784	0.0512	0.698	.1749	0.4817	0.774
.2892	0.0675	0.577	.1832	0.4943	0.775
.3033	0.0887	0.637	.1923	0.5080	0.690
			.2018	0.5222	0.655
591.0934	0.2801	0.439	.2091	0.5332	0.624
.1087	0.3030	0.373	.2159	0.5434	0.645
.1212	0.3219	0.571	.2247	0.5567	0.615
.1348	0.3424	0.467			
.1473	0.3612	0.644	606.1194	0.0963	0.785
.1918	0.4282	0.571	.1504	0.0497	0.698
.2042	0.4469	0.675	.1805	0.0043	0.753

accompanied by the corresponding minimum. The amplitudes of the largest minimum and maximum in $U - B$ and $B - V$ colour curves are $0\overset{\mathrm{m}}{.}24$ and $0\overset{\mathrm{m}}{.}19$, respectively. In the earlier photometry, these turned out to be $0\overset{\mathrm{m}}{.}27$ and $0\overset{\mathrm{m}}{.}16$. In the present photometry, these strongest features lie at $0\overset{\mathrm{p}}{.}32$ and $0\overset{\mathrm{p}}{.}19$. These were found at $0\overset{\mathrm{p}}{.}08$ and $0\overset{\mathrm{p}}{.}46$ in the earlier photometry. These values of the amplitudes and the positions of the strongest changes suggest that in comparison to the earlier photometry, the system has dimmed by $0\overset{\mathrm{m}}{.}03$ in $U - B$, while it has brightened up by the same amount in $B - V$. Also, the positions of these features have unequally shifted in the opposite directions.

6. Discussion

The eclipsing binary system BZ Eri is discussed as under comparing the results of the earlier photometry (cf. Srivastava and Sinha, 1981; Srivastava and Uddin, 1985a).

TABLE X

Standard normal colour indices of BZ Eridani

Phase	$U-B$	$B-V$	Phase	$U-B$	$B-V$
−0.1942	$0^m.281$	$0^m.797$	0.2994	$0^m.483$	$0^m.768$
−0.1603	0.335	0.562	0.3201	0.459	0.708
−0.1408	0.137	0.640	0.3403	0.435	0.776
−0.1227	0.357	0.752	0.3596	0.497	0.603
−0.1043	0.330	–	0.3689	0.276	0.686
−0.0987	0.365	0.822	0.3883	0.274	0.701
−0.0856	0.287	0.618	0.4026	0.261	0.737
−0.0521	0.378	0.720	0.4314	0.332	0.788
−0.0385	0.498	0.644	0.4454	0.379	0.855
−0.0299	0.387	0.644	0.4537	0.288	0.723
−0.0180	0.333	0.633	0.4620	0.455	0.564
−0.0083	0.399	0.748	0.4727	0.213	0.807
+0.0012	0.315	0.638	0.4808	0.318	0.630
0.0119	0.306	0.674	0.4908	0.352	0.668
0.0229	0.326	0.555	0.5094	0.365	0.710
0.0310	0.285	0.704	0.5229	0.342	0.717
0.0375	0.303	0.687	0.5339	0.290	0.603
0.0513	0.276	0.658	0.5408	0.266	0.700
0.0660	0.228	–	0.5540	0.383	0.664
0.0877	0.212	0.651	0.5666	0.336	–
0.2786	0.442	0.676	0.5672	–	0.596

Present standard deviations of the individual observations in *U*, *B*, and *V* filters are slightly lesser than those of the earlier ones.

In the earlier photometry, the average shifts of the primary and the secondary minima turned out to be $-0^d.0062$ and $0^d.0054$, respectively, while in the present photometry these were found to be $-0^d.0031$ and $-0^d.0059$, respectively.

The mean shifts of the primary and the secondary minima from the earlier and the present photometries comes out to be $-0^d.0058$ and $-0^d.0045$, respectively. Thus, the average shifts of all the minima from two photometries stands at $-0^d.0052$. These values suggest that the minima are separated nearly half period apart within error of determination of minima.

The period of the system BZ Eri from earlier and the present photometry turn out to be $0^d.6641701$ and $0^d.6641703$, respectively. These values indicate that the period of the system has not significantly changed since Meinunger's (1966) epoch, however, it shows slightly increasing trend compared to the period derived from the earlier photometry (cf. Srivastava and Sinha, 1981). The fact that the period of the system has not significantly changed in both the photometries since Meinunger's (1966) epoch, does not conform to our recent findings (cf. Srivastava, 1985) that the period of BZ Eri shows both the increasing and the decreasing trends. The O–C diagram presented by us (cf. Srivastava, 1985a) takes into account all the minima, which are available in the literature, and indicates strong changes in the period in different time intervals. They range from 10^{-6} d to 10^{-3} d. This may be due to the fact that at the times of 1975–1976 and 1980–1981 photoelectric observations, we may have observed the system having the period nearly to that of the Meinunger (1966).

Table IV reveals the following situation. The depth of the primary minimum has reduced by $0\overset{m}{.}07$, while the depth of the secondary minimum has increased by $0\overset{m}{.}04$ in comparison to earlier photometry. Likewise, the duration of the primary eclipse has reduced by $0\overset{p}{.}09$, while the duration of the secondary eclipse has reduced considerably by $0\overset{p}{.}13$. The duration of totality has not largely changed since earlier photometry, however, it also shows a minor change. It has increased only by $0\overset{p}{.}01$.

Some new features have emerged in the present photometry, which have been absent in the earlier photometry. The largest duration of the primary eclipse is noticed in the *V* filter, while the largest duration of the secondary eclipse is found in the *U* filter.

Minor difference in the shifts of the primary and secondary minima from their expected positions, unequal durations of the eclipses, and very small asymmetry in the branches of both minima indicate the small eccentricity may be present in the system. It is difficult to attempt the rectification of the light curves due to complications, hence, nothing can be said quantitatively about the reflection and the ellipticity effects. Since outside eclipse light shows no continuous variation, or it is masked by the complications, hence, it is inferred that the effect of the ellipticity of the components, if at all it exists, may not be appreciable.

The changing depths of minima suggest either the intrinsic variability of the system or the presence of the mass transfer process. Some points around phase 0.7 appear higher than those at phase 0.2. This fact, in addition to the large period variations, further suggest the possibility of mass transfer taking place between the components of BZ Eri. The first fact indicate that the mass from the secondary (fainter) component may be transferred on to the primary (brighter) component.

The dips around both minima suggest the presence of shells around (both) the components.

The varying durations of minima in *U* and *V* filters indicate some physical change associated with the system. Normally extended atmospheres around the components are proposed to explain such features, but considering the spectral luminosity classification of the components, such explanation seems unreasonable. Because the duration of the primary and the secondary minima are largest in *V* and *U* filters, respectively; hence, it is possible that some physical phenomenon may be operative in the components which give more contribution of the primary and the secondary components in *V* and *U* filters, respectively.

The large scatter and the distortion of light around the phase of the secondary minimum suggest that the primary component may be the contributing source to these variations.

The colour ($B - V$ and $U - B$) curves show variation throughout the cycle, which fact is suggestive of the intrinsic variability. Such colour variations were also apparent in the earlier photometry. The ranges of $B - V$ and $U - B$ variations were $0\overset{m}{.}02$ to $0\overset{m}{.}16$ and $0\overset{m}{.}11$ to $0\overset{m}{.}27$, respectively, in the earlier photometry, while in the present photometry, these were found to be $0^{m}.11$ to $0^{m}.19$ and $0^{m}.11$ to $0^{m}.27$. The largest elevation of $0^{m}.16$ at $0^{p}.46$ in the $B - V$ colour curve, and the largest dip of $0^{m}.27$ at $0^{p}.08$ in the $U - B$ colour curve, were seen in the earlier photometry, while in the present photometry these were seen of $0^{m}.19$ at $0^{p}.19$ and $0^{m}.24$ at $0^{p}.32$. The amplitudes of the strongest colour variations suggest that these remain more or less of the same amplitude within error of observations. However, they indicate dimming and brightening of $0^{m}.03$ in these respective colours. The positions of these variations have, of course, shifted as compared to the earlier photometry. This latter fact indicate that these variations may be associated with some variable source. Also, the unsymmetrical dips around both the minima suggest that these changes are associated with some external source. It is also important to note that, in the earlier photometry (cf. Srivastava and Uddin, 1985a), the observed points showed declining trend after $0^{p}.70$, while in the present photometry, the observed points indicated the increasing trend after $0^{p}.65$. In addition, the colours at the tip of the secondary minimum appear redder than those found at the tip of the primary minimum, which is not possible. All these features of colour changes and the varying duration of eclipses in different filters suggest that the intrinsic variability of the components cannot solely explain these changes, but some external light source may be affecting these variations. In this regard, it will be important to investigate if the whole system is surrounded by an envelope, which is variable. The possibility of the presence of a third body and/or apsidal motion do not agree with the O–C diagram features. However, minor changes in the shifts of minima positions require the presence of a third body to be searched in future by collecting several primary and secondary minima. Since the strongest dips and elevations are changing their amplitudes and positions, and $B - V$ colour variations in the two photometries do not behave similarly, and also the colours at the tips of both minima do not conform to the geometry of the eclipses, hence, there is a need to search for a third body or a system, or alternatively the presence of a colud in or near the system, which may be the contaminating sources of the systemic light. The dimming and the brightening of the system in colours may be caused by the intrinsic variability of the components or due some internal physical change such as mass transfer. Presently, it is difficult to say definitely which of the two or both the components are intrinsically variable. Since the colour variations of varying degree are found throughout the cycle; hence, both the components may be thought to be responsible for these colour variations. However, their random nature further demands notice for any external contaminating source.

In contrast to the earlier colour curves, it is important to point out that, in the present colour curves, all the minima and the maxima occur correspondingly while in the earlier colour curves some of these features have been found to be differing. In addition, unequal shift of dips are present, comparing the two photometries. This fact, to some extent, further indicate that these colour variations of BZ Eri are not solely intrinsic, but some external source, e.g., the surrounding envelope, the presence of a cloud in or near the system, the presence of a distant third body or some other system, may be the contributing factors to these colour changes. Also, the colour changes on both sides of the primary and the secondary eclipses require attention to search for the shells around both the components.

It is strange to note that, even after so many complications present in the system, the spectral luminosity-classes of the system and the components show no appreciable change in the two photometries. The system BZ Eri appears to be a very complicated system like another system, DX Aqr (cf. Srivastava and Sinha, 1985; Srivastava, 1985b), which we have come across.

7. Conclusions

Both the photometries reveal that the period of the system BZ Eri has not significantly changed since Meinunger's (1966) epoch, but our recent results (cf. Srivastava, 1985) suggest that strong period changes are present in the system. Unequal shifts from their expected positions and changing durations of minima do point that small eccentricity may be present in the system. The light curves suggest some complications or variations outside the eclipses. Considering these facts alongwith the presence of little asymmetry in the branches of minima, we may expect small effect of the ellipticity present in BZ Eri. The large scatter around the phase of the secondary minimum, the light distortions throughout the cycle, more prominent being around the phase of the secondary eclipse, and our recent finding (cf. Srivastava and Uddin, 1985b), that the O–C values of the secondary minimum show stronger fluctuations than the primary minimum, indicate that both the components of BZ Eri are responsible for changing features. The dips seen on both sides of the primary and the secondary minima, the continuous colour variation and their random behaviour suggest the presence of the intrinsic variability, and the possibility of shells. The shift of strongest colour features and their positioning demands notice to see if the system is surrounded by an envelope, which is variable, or alternatively the presence of a cloud, some other body or a system in or nearby the system. Irrespective of the above complications the spectral-luminosity types of the system and the components show no appreciable variation. This fact suggests that the source of colour variations may also be extrinsic. The features of BZ Eri (Table V) are changing. We feel that BZ Eri ($\delta \simeq -6°$) is a very complicated system like DX Aqr ($\delta \simeq -17°$) (cf. Srivastava and Sinha, 1985; Srivastava, 1985).

The present knowledge of the eclipsing binary system BZ Eri is far from satisfactory. The spectroscopic and/or the scanner observations are badly needed for this system. Because the system is faint, hence, new photometric observations are needed, which may be secured with a large telescope. These will reveal the mysteries of this curious system.

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