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PHOTOELECTRIC PHOTOMETRY OF THE MULTIPLE STAR SYSTEM ETA ORIONIS

The star Eta Orionis has proven to be at least a quadruple system. Visually it consists of a bright pair (Eta Ori A and B) separated by about 1".6. In addition Aitken's Catalogue lists a faint third component separated by about 100" from the bright pair. This component may not be physically associated with Eta Ori A and B. Kunz and Stebbins (1916) found that Eta Ori A is an eclipsing binary of the Beta Lyrae type. The total amplitude (including the contribution to the light made by Eta Ori B) was about $0^m.15$. The period of variation was given as about 8 days, but Pogo (1928) found that Eta Ori A also displayed a long-term radial velocity variation with a period of about 9 years. Thus Eta Ori A is a triple system.

Recently Zizka and Beardsley (1976) have re-determined the spectroscopic orbital elements of Eta Ori A. For the eclipsing pair, Eta Ori Aab, they find a period of 7.989229 days, and for the period of the third component, Eta Ori Ac, about this pair, they find a period of 9.174 years. McAlister (1976) has examined this system by speckle interferometry. For the visual pair Eta Ori Aabc,B he finds a separation of 1".599, and for the separation between Eta Ori Aab and Eta Ori Ac he finds 0".044.

No photometric observations of Eta Orionis appear to have been published since the early work by Kunz and Stebbins. During December, 1977 and January, 1978 this investigator made the following observations of Eta Ori in the intermediate yellow (y) and blue (b) wavebands of the uvby system. Both Eta Ori A and Eta Ori B were

included in the diaphragm. The comparison star used was HD 35777, whose spectral type is B2V and whose UBV magnitudes and colors are V = 6.61, B-V = -0.18, and U-B = -0.75. The four components of Eta Ori AB have spectral types ranging from B0 to B3. At maximum light the UBV magnitudes and colors of this system have been determined by this investigator to be V = 3.33, B-V = -0.19, and U-B = -0.95. The observations in y and b obtained are as follows:

Hel. JD	Phase	Δm(y)	Δm(b)
2443508.627	0.0219	-3.106	-3.093
10.804	0.2944	-3.278	-3.258
11.752	0.4130	-3.292	-3.285
12.825	0.5473	-3.238	-3.232
15.723	0.9101	-3.282	-3.254
16.816	0.0469	-3.261	-3.251
17.595	0.1444	-3.256	-3.252
21.593	0.6447	-3.286	-3.272
22.694	0.7826	-3.295	-3.284

The phases have been calculated using the ephemeris determined by Zizka and Beardsley shifted by 90°, so that primary minimum will fall at 0.00 phase. This ephemeris is:

$$\text{Pri. Min.} = \text{JD } 2415761.860 + 7^{d}.989229\ E.$$

If the spectroscopic orbital elements obtained by Zizka and Beardsley are assumed, and if the eclipsing system is assumed to be edge-on, then the separation between the components is 48 $R_{\odot}$. It appears that all four components have masses normal for early B-type stars, and thus we can assume that their radii are also normal. If we estimate the radii of the components of the eclip-

sing binary to be 5.5 $R_\odot$ each, then the phase angle of external tangency will be about $13^{\circ}.2$. This implies a total duration of about 14 hours for each eclipse. This is an upper limit to the duration of the eclipses, since it has been assumed that the system is inclined 90° to the plane of the sky.

Kunz and Stebbins describe Eta Orionis as a system of the Beta Lyrae type. But the system described above would be a detached system, in which the interactions arising from the ellipticity and mutual reflection of the components would be very small. If we assume values, typical for early B-type stars, of x = 0.30 and y = 0.50 for the limb-darkening and gravity-brightening coefficients, then the coefficients due for light outside eclipses due to the ellipticity and reflection effects can be calculated using expressions such as those cited by this investigator (Chambliss, 1976). When the effects due to ellipticity and to reflection are combined, the value of the A_2 coefficient is only about -0.001. Thus for such a system there should be virtually no variation of light outside eclipses. The only observation of this investigator which shows a large deviation from the mean is the first one, and this is the only observation which does not occur outside eclipses according to the ephemeris used and the assumptions made about this system.

Kunz and Stebbins reported a total amplitude in the light curve of about $0^{m}.15$, and this appears to be similar to that found by this investigator. Since the eclipsing pair, Eta Ori Aab, contributes only about 20% of the total light of the system, it appears that the eclipses are deep and total or nearly so. Thus the inclination of this system must be very near 90°. More extensive photoelectric observations are urgently needed for this system.

All observations of this investigator were made with the 40-cm telescope no. 4 of Kitt Peak National Observatory, which is operated by the Association of Universities for Research in Astronomy, Inc., under contract with the National Science Foundation.

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