NOTES FROM OBSERVATORIES

Photoelectric Observations of the 1963–1964 Eclipse of ζ Aurigae

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The eclipsing binary ζ Aurigae has been the subject of intensive spectroscopic and photometric studies by several authors, especially in recent years. Roach and Wood[1] have summarized the earlier observations and confirmed that the eclipse effects are more marked at shorter wavelengths. A comparison of the observations of the 1958 eclipse with those of 1955–1956, led Larsson-Leander[2] to conclude that the primary component was about $0^m.02$ fainter in 1958 than in 1956. Intrinsic variations in the system have been reported by Wood and Blitzstein in 1957. Larsson-Leander, from his observations of the 1958 eclipse, has noted intrinsic variations to be of the order of 0·05 mag.

At the initiation of Commission 42 of the I.A.U., a world-wide programme, co-ordinated by Dr. K. Gyldenkerne, was organized to study the star more intensively, both spectroscopically and photometrically, during the 1963–1964 eclipse.

The star was observed photoelectrically at Kodaikanal with a photometer attached to the 20 cm Cooke refractor. The output of an unrefrigerated 1P21 photomultiplier was amplified and fed to a Brown recording potentiometer. The blue deflections were obtained through a Corning 5030 and 2 mm Schott GG 13 filter combination, while the yellow deflections were obtained through a Corning 3384 filter.

The star could be observed for 14 days during totality and for 2 days outside eclipse. Weather conditions prevented observations during ingress and egress. λ Aurigae and 2 Aurigae formed the primary standards of comparison during the entire programme. π^3 Orionis, π^4 Orionis, γ Orionis, γ Tauri and δ Tauri have been utilized as secondary standards on a few nights. The deflections have been reduced to magnitudes outside the atmosphere by applying suitable extinction corrections. These have been converted into standard B,V magnitudes using linear transformations. The blue and yellow magnitudes are given in Table I.

The mean depth of the eclipse is about $0^m.58$ in B and $0^m.16$ in V. The system was faintest some time around 1963 December 19. During totality the amplitude of the intrinsic fluctuations in magnitude is of the order of $0^m.04$.

Since the magnitude outside the eclipse is the combined magnitude of the K and B stars, one can derive the magnitude and the colour of the B component, by subtracting the intensity of the K star from that of the combined system. It is seen that the small changes in magnitude during totality and outside the eclipse produce large deviations in the derived values of colour and magnitude of the B component. Hence the mean values in magnitudes during and outside the eclipse have been used in the determination of the magnitude and the colour of the B star. The values of the magnitudes and the colour indices of the components of the system deduced from the present investigation are compared in Table II with those derived by Grant and Abt[3].

TABLE I

Photoelectric Observations of ζ Aurigae in 1963–1964

Date (U.T.)	*B*	*V*	*Date (U.T.)*	*B*	*V*
1963 Dec. 11·610	5·547	3·945	1963 Dec. 17·735	5·562	3·960
11·630	5·551	3·931	17·820	5·585	3·961
11·661	5·560	3·932	17·884	5·590	3·965
11·680	5·543	3·941	17·902	5·589	3·964
11·835	5·554	3·938	17·929	5·580	3·955
11·939	5·567	3·948			
			19·673	5·622	3·992
12·699	5·571	3·943			
12·750	5·572	3·936	20·698	5·602	3·972
12·804	5·602	3·944			
12·872	5·595	3·936	22·709	5·595	3·956
12·905	5·592	3·933	22·728	5·602	3·965
			22·772	5·579	3·942
13·666	5·587	3·940			
13·687	5·577	3·942	27·572	5·590	3·967
13·708	5·554	3·934	27·655	5·570	—
13·743	5·555	3·935			
13·776	5·557	3·938	30·602	5·622	3·985
13·800	—	3·919	30·664	5·618	3·981
13·828	5·548	3·918	30·736	5·617	3·980
			30·758	5·621	3·984
14·709	5·571	3·941			
14·740	5·559	3·929	1964 Jan. 2·793	5·620	3·970
14·757	5·572	3·934	2·811	5·599	3·982
14·773	5·588	3·927	2·841	5·594	3·977
14·793	5·573	3·926	2·882	5·606	3·982
14·818	5·566	3·936			
14·844	5·559	3·929	3·688	5·583	3·946
14·899	5·579	3·928			
14·923	5·566	3·924	4·644	5·594	3·961
			4·796	5·598	3·965
15·762	5·598	3·966			
15·822	5·580	3·955	16·675	5·015	3·805
15·918	5·595	3·958			
			21·612	5·003	3·782
			21·735	5·025	3·805

TABLE II

Star	*Spectral type*	*Present study* *V*	*B–V*	*Grant and Abt (1956 Eclipse)* *V*	*B–V*
ζ Aurigae	K4 II+B	3·80	+1·22	3·76	+1·25
	K4 II	3·96	+1·63	3·88	+1·64
	B	5·96	−0·03	6·19	−0·12

The $B-V$ colour of $+1\cdot64$ for the K component agrees well with the determination of Grant and Abt. Wellmann[4] determined the spectral type of the primary component as K4 II. The K-line method of Wilson and Bappu[5] yields for the K component $M_V=-2\cdot2$. This value of absolute magnitude agrees well with the spectral type estimated by Wellmann. The K-line method performs well over a large range of absolute magnitude, and is well tied in the giant range by virtue of the measures made of stars with well determined parallaxes and the M supergiants in h and χ Persei (Wilson[6]). The absolute magnitude of ζ Aurigae derived from the width of the K emission line cannot, therefore, have an error greater than $\pm0^m.26$ unless part of the ionized calcium emission lines originates in gaseous streams about the stars. However, it seems very likely that the emission originates from the chromosphere of the K star.

Assuming then that $M_V=-2\cdot2$ for the K component, we obtain a value of $M_V=-0\cdot2$ for the secondary component. The intrinsic $B-V$ colour for a K4 II star is in the neighbourhood of $+1^m.53$. Very few colour determinations exist for K4 II stars. The list of Argue[7] contains two stars located in a much obscured region in Cygnus that have $B-V=+1\cdot64$ and $+1\cdot65$ respectively. Two other stars in relatively unobscured regions have $B-V=+1\cdot53$. We assume that this latter value represents an upper limit of colour for an unreddened K4 II star. We then find a colour excess of 0·1 mag for ζ Aurigae. This is a very plausible feature, considering the very low galactic latitude of the binary system. The $B-V$ colour of the secondary component is then $-0^m.13$, which is the value of intrinsic colour for a B7 V star according to Johnson[8]. The absolute magnitude calibration of the B stars from measures of photoelectric Γ indices obtained by Bappu *et al.*[9] yields also a spectral class of B7 V for an $M_V=-0\cdot20$. We thus conclude that the two components are of types K4 II and B7 V respectively. The spectral type of the secondary component is also in agreement with the findings of Lee and Wright[10] on the basis of the ratios of line intensities of *H* and *He*.

An examination of the magnitude of the K component indicates that the star has grown fainter by about 0·08 mag, since the 1955–1956 eclipse. Leander has noted that the K star has grown fainter by $0^m\cdot02$, between the 1956 and 1958 eclipses. This could possibly be due to the gradual decrease of the star's effective radius as suggested by Larsson-Leander. It is very significant to note that Roach and Wood[1] have indicated that the diameter of the K star was about one per cent smaller at the time of the 1947–1948 eclipse than during that of the 1939–1940 eclipse.

Acknowledgment

We wish to acknowledge the help rendered by N. Sankaran during the observations.

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