ATMOSPHERIC ECLIPSING BINARY ZETA AURIGAE IN THE 1987-1988 ECLIPSE*

IL-SEONG NHA
Yonsei University Observatory, Seoul 120-749, Korea.

ABSTRACT. A total of 1,037 *UBV* observations was made for the latest eclipse of Zeta Aur in 1987-1988 at Yonsei University Observatory. These observations furnish *UBV* light curves which cover the phases before, during, and after the eclipse. The current issues regarding the radius variations of K supergiant component are discussed.

INTRODUCTION

Zeta Aur (V_{max} = 3.72, Sp = K4Ib + B7V, P = 972 days = 2.66 yrs) has been one of objects observed regularly for over 50 years since the photoelectric techniques of high precision became in practice. Intensive photometric observations were particularly made in every 8 years equivalent to three orbital cycles of this star when a B-type secondary star is eclipsed by the extended atmosphere of K-type supergiant in a favorable season of the year.

For variety of photometric interests on each of these eclipses, a great number of investigations were carried out for the conventional subjects of eclipsing binary star research in general and particularly for the unique phenomena to have access to Zeta Aur-type stars. Among those of latter cases, the radius variations of K supergiant is the main subject of the present investigation.

OBSERVATIONS

UBV observations of Zeta Aur have been made since January, 1983, as a part of the *Ten-Year Observing Program For Long Period Eclipsing Binary Stars* (1982-1992) at Yonsei University Observatory (YUO). The completion of whole phase coverage of this star is hopefully expected by 1993. During the present photometric monitoring two eclipses, one in 1985 and the other in 1987-1988, were observed. Not like the former, the latter was under favour of extra-ordinary weather, and thus 55 nights and 27 nights were available for the observations at Ilsan Station and Campus Station, respectively. A total of 1,037 *UBV* observations in the sense of $\triangle m$ (Zet Aur - Lam Aur) are made and these magnitudes were converted to the standardized individual magnitudes for Zet Aur.

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UBV and color curves of Zet Aur with respect to Julian dates are made with data only from JD2447090 to JD2447177 and are given in Figure 1, which is just enough to see the light levels at the pre- and post-eclipse. Each data point in the figure represents the mean value of the night. In general, the agreement between the two stations is fairly good for the outside eclipses in all three passbands, but data from Campus Station during eclipse show fainter than those of Ilsan Station with larger scatter, particularly in *U* and *U - B*, which are not the intrinsic but the results of suffering by the city lights and air pollutions in an over populated city of Seoul.

The brightness of Zeta Aur during the present monitoring shows no significant light variations in three passbands as a whole. This means that the over-all light levels remained unchanged within observational errors in each part of the light curves which were divided into 4 parts; phases of pre-eclipse, between the 2nd contact and mid-eclipse point, beween the mid-eclipse and the 3rd contact, and of post-eclipse. However, systematic differences are there if one compares those two different parts. For examples, the magnitude differences in the sense (pre- minus post-eclipse) in *V* and *B* are -0.03 and -0.01,

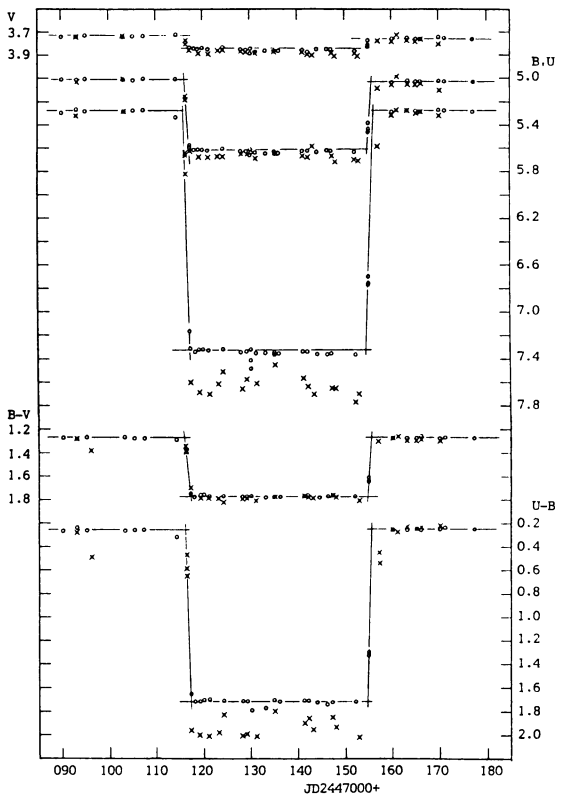

Figure 1. Light and color curves of Zeta Aur before, during and after the 1987-1988 eclipse made at Ilsan Station (open circles) and Campus Station (x) of YUO.

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respectively, and the brightnesses are gradually decreasing from the 2nd contact toward the 3rd contact making the differences in V, B, and U by -0.02, -0.01, and -0.04, respectively.

DURATION OF TOTAL ECLIPSE AND THE RADIUS VARIATIONS OF K STAR

Although many results were reported for the determination of duration of the total eclipse of Zeta Aur, it would not be so easy to get an accurate value from the observations. The reason for this is simply because of the limitations of good weather and the telescope time available to observers for an object of such a long period. Theoretically, it is impossible at one fixed station to get critical phases such as the 1st (or 4th) or 2nd (or 3rd) contact phases with partial eclipse phases, both ingress and egress, no matter how the weather favorable. This is why no single eclipse was successful to have both ingress and egress phases at one place except the eclipse in 1947-48 by Wood(1951). Therefore, most timings of the totality are made by the extrapolation with either ingress (or egress) or one of contacts alone. Under these circumstances, the determination of the duration bears a large uncertainty.

The subject under discussion here is, however, the variations of the totality which may be interpreted as the result of the variation of radius of K component of Zeta Aur. The decrease of the radius of the K supergiant of Zeta Aur by 1% was noticed first by Roach and Wood(1952) from the analysis of the 1939-40 and 1947-48 eclipse curves of theirs, but later Tanabe and Nakamura(1957) have found that the variation of the radius was the opposite way, the increasing. Furthermore, Kiyokawa(1967) brought to attention the increase of the duration with the data available for five eclipses since 1934; Christie and Wilson(1935) for the 1934 eclipse, Christie(1940) and Roach(1941) for the 1939-40, Pettit(1948) and Roach and Wood(1952) for the 1947-48, Tanabe and Nakamura(1957) for the 1955-56, and Kiyokawa (1967) for the 1963-64. His interpretation of this increase of totality has deduced a rate of increase of the diameter of K star as much as 0.18 Ro/yr (0.06 d/orbital

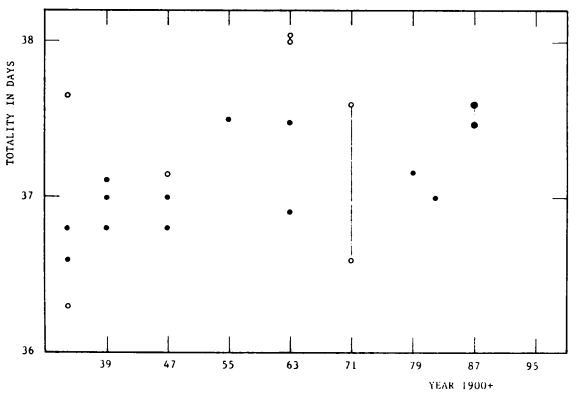

Figure 2. Durations of the totality of Zeta Aurigae. Small closed circles are for values available and open circles for the estimates by the present author. Large closed circles in the 1987-88 represent the present investigation. Two values connected by a straight line are B (upper) and U (lower) values made by a same observer.

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revolution). This was, however, questioned by Kitamura(1974) who analysed Gordon's(1973) observations for the 1963-64 eclipse and found smaller value of the duration than that by Kiyokawa, and has concluded that a hypothesis of gradual expansion of the K supergiant could not be tenable. The argument of the duration of the totality has resumed again by Saijo and saito(1978) who derived the rate of expansion of K star of the order of 0.02 d per eclipse (0.05% of the radius) through the reanalyses of data available by then.

Observations of three more eclipses since the work by Saijo and Saito became available; Guo *et al.*(1981) for the 1979-80, Fernandes(1982) for the 1982, and Nha and his collaborators for the 1987-88 eclipses. These observations make the time span of the accurate measurements longer and hopefully would suffice them to see the variation of duration of the totality. The present author has made an attempt to collect older data with some success and then plotted them in Figure 2 together with new data mentioned above. As was discussed earlier, the determination of the duration of each eclipse is not sufficiently accurate, so that a large disagreement among observers even for a given eclipse cannot be avoided.

As are shown in Figure 2, the determinations by different observers are widely dispersed for most eclipses and the accuracy of individual measurements is different from one another. Therefore, a marginal tendency of the increase of duration in the figure cannot be interpreted as an evidence of the radius increase of K star. It is worth of notice the identical results made in 22 years apart; one by Kiyokawa(1967) photometrically, and the other by Di Beneditto and Ferluga(1990) by Michelson intherferometry. For the radius of K supergiant the former gives 156 $R_\odot$ and the latter 154 $\pm$ 13 $R_\odot$.

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