Photographic Time of Minimum Light for VV Orionis

Woo-Baik Lee and Il-Seong Nha
Department of Astronomy and Meteorology
Yonsei University
(Received October 15, 1975)

Abstract

A time of minimum light for VV Orionis has been determined photographically using techniques developed by Jeong. The observed time of minimum light shows that VV Ori exhibits a constant orbital period. The O-C computed with the light elements given by Eaton is found to be $-0^d.0070$. An attempt to correct for night-to-night shifts for plates taken on three nights in February and March 1975, was unsuccessful and thus the complete light curve initially planned was not obtained.

Photographic observations of the bright eclipsing variable star VV Orionis, HR 1868, were made at the Yonsei University Observatory in order to determine the time of minimum light and possibly obtain a full light curve using the mutiple-exposure and reduction techniques developed by Jeong (1975). VV Ori was chosen as a program star because it is bright enough to produce multi-images on a single plate with short exposures and because its reasonably short orbital period allows for the completion of a whole light curve in one season. The depths of the primary and secondary minima of VV Ori are shallow and they are, respectively, about $0^m.3$ and $0^m.2$. However, it has been proved by Jeong that his technique is applicable to stars with small light variation in this range.

Observations of VV Ori were conducted on three nights in February and March, 1975. The preset exposure time for a single image on a given night was determined according to the sky condition of that night. The exposure time and the number of exposure employed on each plate are given in Table I. On the first night only, two plates, Nos. 48 and 49, were taken to assure data on both descending and ascending portions of the light curve.

Table I. Plate Information.

Date (1975)	Plate No.	Exposure (minute)	No. of images
Feb. 15-16	48	1	10
	49	1	4
Mar. 17-18	60	2	6
Mar. 18-19	61	1	10

High sky transparency in the early spring enabled us to make images of good quality on the plates, with a few exceptions which were probably due to interference by a search light which illuminated the night sky during our observation runs. Careful examination of individual images on plates 48 and 49 indicates that one image of VV Ori was superimposed with the image of a nearby faint star, and possibly four others appeared very close to those of same and additional nearby stars. The separations between the images of VV Ori and the nearby stars are so small that even with the smallest diaphragm of the microdensitometer it was not possible to trace images individually.

Table II. VV Ori, Comparison and Check Stars

Star	HD	Position(1975.0)		Sp	V	$B-V$
		R.A.	Dec.			
VV Ori	36695	$05^h32^m24^s.4$	−01°12′26″	B1		
ω Ori	37490	05 37 51. 9	04 06 30	B3p	4.51	−0.09
φ Ori	35715	05 26 31. 6	03 04 31	B2	4.59	−0.22

Each of these extra faint images due to the nearby stars was included with VV Ori and thus has increased the density of VV Ori superficially on the micrometer tracings. As a result of this extra density, we found one saturated and four unusually deep tracing for VV Ori.

For reference, we chose two bright, non-variable stars, ω Ori and φ Ori, whose images on each plate were clearly separated from those of nearby stars. Information on these stars and VV Ori are given in Table II. Values of V and B-V listed in the last two columns for ω Ori and φ Ori are the average values listed in the Photoelectric Catalogue (Blanco *et al.* 1971). The light variation of VV Ori was related to ω Ori as the comparison star, which was checked by φ Ori.

For all three nights the extinction coefficients were determined from the average slopes for ω Ori and φ Ori in the sec Z diagrams and the differential extinctions were utilized for the determination of the star magnitudes outside the atmosphere. Differential magnitudes Δm in the sense of (VV minus ω) and (φ minus ω) for all three nights were calculated, but only those for the first night are listed in second and third columns of Table III.

The light curve of Δm versus the heliocentric Julian date for the first night is shown in Figure 1. Since the phase coverage appeared to be satisfactory for the determination of minimum light, a free-hand curve was drawn through all observations but the four points marked with *a* through *d*. These four points are, indeed, those already explained above and they are marked with a colon in Table III. Excluding these four points the probable error for a single observation with respect to the smooth light curve is computed as to be $\pm 0^m_{\cdot}01$.

It is not likely that both ω Ori and φ Ori were variable. In the lower part of Figure 1 all observations of Δm (φ-ω) are distributed on and around a broken line. This line represents the average magnitude difference $-0^m_{\cdot}07$ between ω and φ Ori and this magnitude difference is in excellent agreement with $\Delta B = -0^m_{\cdot}05$ which was deduced from V and B-V given in Table II.

The time of primary minimum light estimated

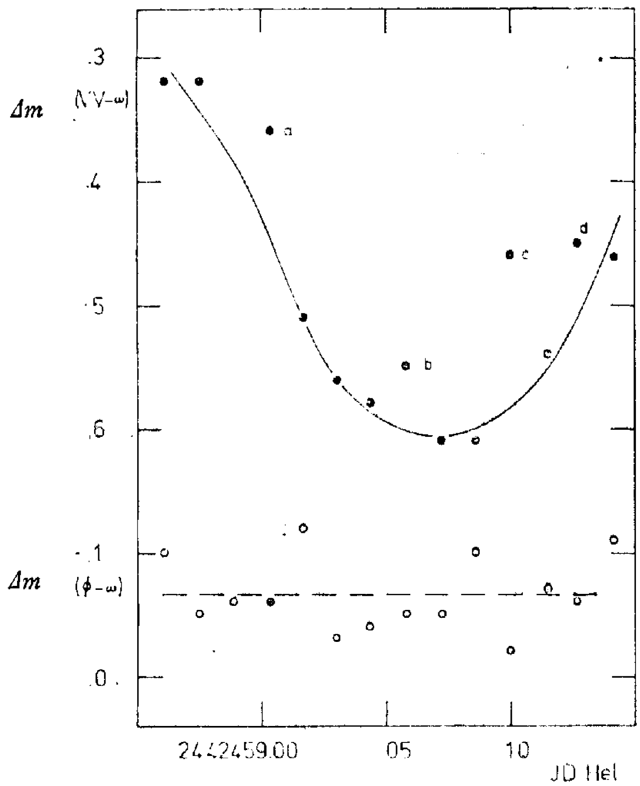

Figure 1. Photographic light curves of VV Ori (top) and of φ Ori (bottom). Symbols *a* through *d* are explained in the text.

from Figure 1 is

JD Hel. 2442459.0717±0.0020.

In order to verify the reliability of our observation, a comparison with the latest known light elements has been made. The value of the residual was computed with Eaton's (1975) light elements

Min. I=JD 2442459.0787+1.4853789 E,

and it yielded $(O\text{-}C)=-0^d.0070\pm0^d.0020$, which supports the fact already reported by others that the orbital period of VV Ori has remained constant for nearly a half century. The first column of Table III represents the heliocentric Julian date of the observation.

In spite of the consistency of the observations, there were extreme night-to-night shifts in Δm (VV-ω) and $\Delta m(\phi\text{-}\omega)$. This made it impossible to determine a homogeneous light level for Δm (VV-ω).

For this reason the observations made in March were totally excluded from Table III. The cause of this strange behavior may be interpreted as partly due to a short run in the case of March 17 and partly due to the city smog and light in the south-western sky at our location.

Table III. Journal of Observations.

JD Hel. 2442400.+	Δm(VV-ω)	$\Delta m(\phi\text{-}\omega)$
58.9611	0.32	−0.10
58.9750	0.32	−0.05
58.9889	—	−0.06
59.0034	0.36:	−0.06
59.0166	0.51	−0.12
59.0305	0.56	−0.03
59.0437	0.58	−0.04
59.0583	0.55:	−0.05
59.0722	0.61	−0.05
59.0854	0.61	−0.10
59.1000	0.46:	−0.02
59.1152	0.54	−0.07
59.1277	0.45:	−0.06
59.1416	0.46	−0.11

Acknowledgement.

We express our thanks to Mr. Jang-Hae Jeong for his guidance in the operation of his instrument, to Mr. Jung Jae Maeng of the Industrial Standard Research Institute for the use of their facilities, and to Professor R.H. Sauer of the Department of physics, Yonsei University, for his reading of this manuscript.

References

Blanco, V. M., Demers, S., Douglass, G. G. and Fitzgerald, M. P. 1968, *Publ. U.S. Naval Obs.* Vol. **21**.

Eaton, J. A. 1975, *Astrophys. J.* **197**, 379.

Jeong, J.-H. 1975, *J.Korean A. S.* **8**, 15.