Astron. & Astrophys. 30, 271—273 (1974)

On a Possible Three-year Cycle of η Carinae

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Received September 6, 1973

Summary. Recent *UBV* observations of η Carinae combined with slightly older measures show that it has been increasing in brightness since 1940. This new data suggest also a long periodic variation with an amplitude of $0^m.20$, which is confirmed by the observations published by the southern visual observers. The combined data give a period of $P = 1110 \pm 8$ days.

Key words: variable star – nova – *UBV* photometry – cyclic variation

The peculiar object known as η Carinae has had an unusual behaviour since around 1600, when it was observed for the first time at the epoch that the Greek-letter designation was given by J. Bayer in his Uranometria. No ancient catalogues, including Ptolemy, mentioned it. The light curve according to Innes (1903), Hoffleit (1933), de Vaucouleurs and Eggen (1952), O'Connell (1956), Feinstein (1968) and this work, is given in Fig. 1. It displayed a great maximum in luminosity in April 1843 when it reached about -1 magnitude, and thus became the brightest star in the sky after Sirius. Afterwards it followed a long decline until 1870, when the star was below naked-eye visibility. However, this puzzling object exhibited two small rises in light in 1871 and again in 1889, returning in both cases to the same minimum which oscillated between 7.6 and 8.0 magnitudes. But, around 1940, η Carinae began again to increase in brightness and some years later, from 1963 to 1967 it was still increasing in light.

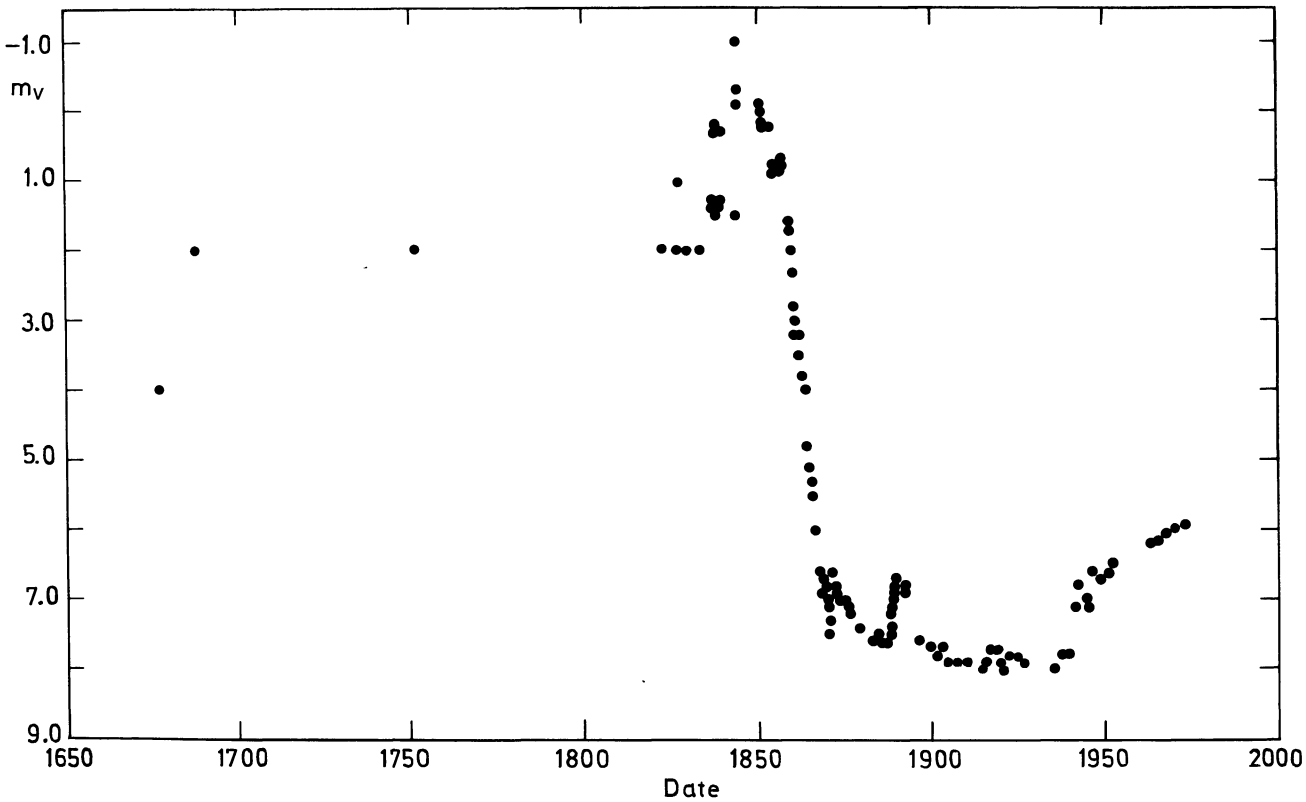

Fig. 1. The complete light curve of η Carinae in the visual magnitude

Table 1. Photoelectric observations of the η Car object

Year	Julian Day	V	$B-V$	$U-B$	R	$R-I$
	2400000+					
1968	39942.6	$6^m.16$	$0^m.55$	$-0^m.43$		
	39944.6	6.11	0.59	−0.43		
	39971.5	6.13	0.59	−0.41		
	39972.5	6.16	0.57	−0.41		
	39998.4	6.03	0.60	−0.43		
	40199.8	6.12			$4^m.99$	$0^m.78$
	40200.8	6.22			5.12	0.76
	40202.8	6.17			5.04	0.77
	40204.8	6.12			5.00	0.78
1969	40344.7	6.08	0.58	−0.44		
	40348.6	6.11	0.59		4.96	0.70
	40350.6	6.09	0.61		4.94	0.70
1970	40693.6	5.98	0.58	−0.41		
	40694.6	5.92	0.63	−0.45		
	40695.5	5.94	0.60	−0.42		
	40696.5	5.97	0.61	−0.41		
1972	41361.6	6.03	0.62	−0.35		
	41375.6	5.97	0.62	−0.38		
1973	41764.5	5.91	0.65	−0.38		
	41767.5	5.94	0.68	−0.33		
	41769.5	5.95	0.66	−0.34		

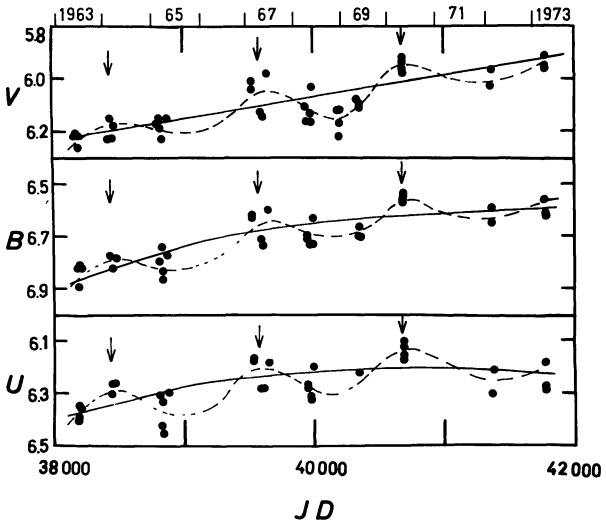

Fig. 2. Photoelectric measures on *UBV* made by the authors since 1963. A fitted mean for each magnitude is shown as a full line, and the cyclic variations are also suggested by the dashed lines. The arrows indicate the estimated dates of the maxima

Since 1963 η Carinae has been included in our list of objects to be measured photoelectrically. Recent measures (1968–1973) in the *UBV* system and a few in the *RI* are listed in Table 1. It is a very difficult object to measure, since it has an elongated shape with a nebulous envelope. Accordingly the measuring errors are larger than for a normal star. To improve this situation, care has always been taken to include all of the small nebula (the "homunculus") inside the diaphragm of the photometer.

In Fig. 2 is plotted our observational material obtained since 1963 for the *V*, *B* and *U* bands. Also a fitted mean line is indicated in each case.

It is apparent that there is a continuous rise in brightness in each of the three magnitudes, but with different slopes. The distribution of the points shows a quite large scatter, which may suggest a variation of light with a period of around 1100 days. However, the observations are not distributed well enough in time to be sure about this result.

The *RI* magnitudes from 1965 to 1969 are too few in number to show any significant variations.

On the other hand the data obtained by the visual observers in the southern hemisphere and compiled by Bateson (1952–1970) are presented in Fig. 3 as 100 day means. The increase in brightness is confirmed, but the cycle of $0^m.20$ amplitude and 1100 days period is only apparent between JD 2435000 and 2438000. A possible reason for this is as follows. Shortly after the announcement of the brightening (de Vaucouleurs, 1952) several southern visual observers began to make estimates. By JD 2435000 as η Carinae had made no other "explosion", the number of observers declined and from this date to JD 2438000 the star was monitored almost entirely by two patient and skillful observers: A. F. Jones and F. M. Bateson. This interval of the light curve shows very nicely the cyclic variations. After JD 2438000 a new group of observers began observations and the small $0^m.20$ amplitude variation was washed out in the averages, as it was before JD 2435000.

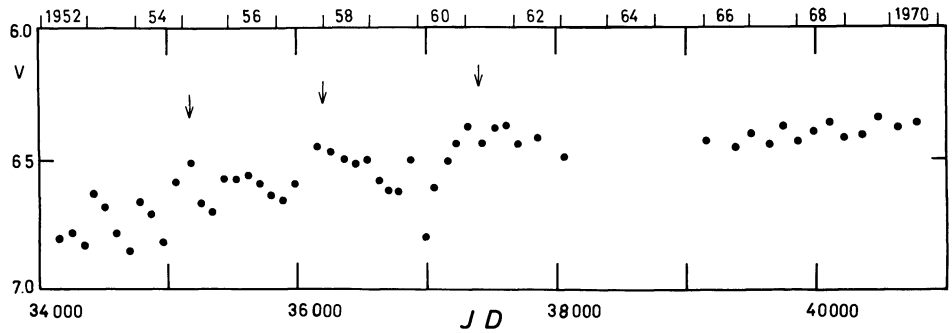

Fig. 3. 100 days mean of visual estimates from the Circulars of the Variable Star Section of the Royal Astronomical Society of New Zealand, covering the interval 1952–1970. The arrows indicate the estimated dates of the maxima

Table 2. Dates of maxima of the periodic variations of η Car

Epoch	Julian Date	O–C
1	2435180	33^d
2	36200	−57
3	37400	33
4	38450	−27
5	39600	13
6	40700	3

In the above mentioned interval of good coverage, we determined from visual inspection of Fig. 3, three epochs of maxima, which we marked with arrows. From the photoelectric data we obtained another three dates of maxima, marked similarly in Fig. 2.
Combining these data we have derived the following ephemeris of maximum:

$$\begin{aligned} \text{JD} \quad &= 2434037^d + 1110^d\,\text{E} \\ \text{(m.s.e.)} \quad &\pm 30 \qquad\quad \pm 8 \end{aligned}$$

The epoch of maxima and the residuals are collected in Table 2.

The evidence of this periodic variation is weak, as the photoelectric observations are not well distributed in time, nevertheless this is an interesting object to follow and to check all possible changes in brightness.

Acknowledgement. One of us (A.F.) acknowledges the Cerro Tololo Inter-American Observatory for the use of its facilities. This work was partially supported by a contract of A. Feinstein with the Consejo Nacional de Investigaciones Cientificas y Técnicas. We are grateful to María Cristina Fanjul and Roberto Leonardi for their assistance in the preparation of this paper.

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