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# THE PERIOD AND COLOR OF V666 CASSIOPEIAE

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**Abstract**

A five-year visual light curve has been used to derive a revised period of 427.1 days for the very red Mira variable V666 Cas. Photoelectric measures indicate that the color index at maximum is +4.74 B-V.

## 1. Introduction

The variability of V666 Cas was first reported by Dahlmark (1986), who gave this star the designation LD 103 in his discovery list. V666 Cas is unusually red. Dahlmark estimated the B-V index as +3.8 from simultaneous blue and photovisual plates.

Variability was discovered independently by Kaiser (1987), who designated the star as DHK 1. Based on visual and photographic observations over two seasons, Kaiser *et al.* (1989) reported that V666 Cas is a Mira star varying from 10.0 to 13.8 V with a period of 360 days. A chart and visual comparison star sequence appeared in Kaiser and Baldwin (1989), and the AAVSO has issued preliminary "d" and "e" scale charts (0154+57 V666 Cas) with this sequence. I.A.U. Commission 27 gave LD 103 = DHK 1 the official designation V666 Cas (Kholopov *et al.* 1989).

A variety of photometric systems are referred to in the following report. Abbreviations include B, V (standard Johnson photoelectric system), v (untransformed instrumental V magnitude), vis (visual system of the dark-adapted eye), and ptv (photovisual).

## 2. Visual Observations

We have continued to observe V666 Cas visually and have accumulated a total of 300 observations during the interval JD 2447100 to 2449250. These observations (Figure 1) provide coverage of five light cycles and show that our preliminary period of 360 days was erroneous. That period was based on incomplete coverage of the light curve (see Figure 1, Kaiser and Baldwin 1989), in which the data points appeared to reach a maximum but in fact only reached the end of the observing season.

Table 1 lists the five times of maxima determined from our visual observations and photoelectric measures during the fifth maximum. From these times of maxima, we derived the following least squares light elements:

$$JD_{max} = \underset{\pm 4.0}{2448097.4} + \underset{\pm 2.8}{427.1}\ E \qquad (1)$$

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The O-C residuals in Table 1 were calculated according to equation 1. A phase diagram of all our visual observations, based on these same light elements, shows that the mean light curve of V666 Cas is almost symmetrical, with minimum occurring near phase 0.43 (that is, the decline from maximum to minimum is a little steeper than the rise from minimum to maximum).

Table 1. Maxima of V666 Cas.

| *JD 2440000+* | *E* | *O-C(d)* |
|---|---|---|
| 7240 | -2 | -3.2 |
| 7666 | -1 | -4.3 |
| 8111 | 0 | +13.6 |
| 8523 | 1 | -1.5 |
| 8947 | 2 | -4.6 |

The visual magnitudes of all five maxima were consistent in the range 11.0 ± 0.2 vis and the first three minima were similarly steady in the range 13.6 ± 0.2 vis. During the fourth cycle an anomalous shoulder or stillstand appeared on the rising slope, lasting for about 100 days centered around JD 2448400. The following minimum does not appear as deep as the previous three minima. This may be more apparent than real, however, because only Baldwin made observations at that point, and he estimates this very red star a few tenths of a magnitude brighter at minimum than Kaiser or Williams does. At least one observation in the AAVSO database shows V666 Cas as faint as 13.6 vis at this minimum.

### 3. Photoelectric Photometry

Our published preliminary estimate of V666 Cas' magnitude at maximum, 10.0 V, was influenced by Dahlmark's photovisual observations, which included estimates as bright as 9.8 ptv. Our subsequent visual observations of five consecutive maxima within 0.2 magnitude of 11.0 vis raised concerns about possible differences between our magnitude system and Dahlmark's. Alternatively, perhaps a star as red as V666 Cas, even when observed accurately, might differ significantly in the three V-band photometric systems: visual, photovisual, and photoelectric V.

To help resolve this question, photoelectric observations (Table 2) were made during the 1992 maximum by Kaiser with his 35-cm Schmidt-Cassegrain telescope and Optec SSP-5 photometer, and by Kaiser and Williams using the same photometer and the 90-cm Cassegrain reflector at Indiana University's Goethe Link Observatory. The observations were made differentially using the comparison star HD 12150 (BD +57° 451, SAO 22841), for which we adopted the magnitude 8.64 V and color index +0.27 B-V from Johnson and Morgan (1955).

Because of its very large B-V index, V666 Cas was only marginally detected through the B filter with the 35-cm telescope. Therefore, all the V observations have been transformed to the standard system using the B-V index measured with the 90-cm telescope. The one B-V index from the 35-cm telescope in Table 2 is uncertain and is reported only to show that it generally confirms the more accurate value determined with the larger aperture.

At 10.1 V, the photoelectric magnitude at maximum is about 0.8 magnitude brighter than our contemporaneous visual estimates and is closer to Dahlmark's brightest photovisual observation of 9.8 ptv. Before drawing any conclusions, however,

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Table 2. Photoelectric observations of V666 Cas.

| *JD 2440000+* | *Apert.* | *V* | *s.d.* | *B-V* | *s.d.* |
|---|---|---|---|---|---|
| 8885.7 | 35-cm | 10.438 | ±0.016 | -- | -- |
| 8956.6 | 35-cm | 10.095 | ±0.007 | +4.606 | ±0.182 |
| 8977.6 | 90-cm | 10.183 | ±0.004 | +4.743 | ±0.042 |
| 8981.6 | 35-cm | 10.317 | ±0.018 | -- | -- |
| 9007.7 | 35-cm | 10.642 | ±0.021 | -- | -- |

possible errors in the visual comparison star sequence must be considered.

Kaiser determined the photovisual magnitudes of five comparison stars on the AAVSO charts by a simple photographic technique (Kaiser and Baldwin 1989). We can now report photoelectric measures of the same stars. The 10.5 ptv comparison star was used by Kaiser as a check star during observations of V666 Cas with his 35-cm telescope. It was observed on several nights in both V and B and can be fully transformed to the standard V system.

The four fainter stars were measured by Kaiser and Williams with the 90-cm Link reflector. Due to limited observing time, only instrumental v magnitudes were determined for these stars. However, none of these four stars appears noticeably red on Palomar Sky Survey blue and red prints. The photometer's V-band transformation coefficient is only -0.03, so the transformed standard V magnitude of a star a full magnitude redder than HD 12150 would differ from the instrumental v value by only 0.03 magnitude.

The agreement between the photovisual magnitudes and the photoelectric magnitudes is remarkably close:

10.5 ptv = 10.53 v, +0.36 B-V
11.4 ptv = 11.56 v
12.2 ptv = 12.31 v
13.0 ptv = 12.97 v
14.0 ptv = 14.13 v

The largest difference is 0.16 magnitude and the root mean square error is 0.11 magnitude. When the zero point of the photovisual sequence is adjusted to match the photoelectric zero point by adding 0.08 magnitude to each photovisual magnitude, the r.m.s. error is reduced to just 0.07 magnitude.

## 4. Discussion

The close agreement between the photovisual and photoelectric comparison star magnitudes shows that no significant error was introduced by the comparison star sequence used to obtain the light curve in Figure 1. Nonetheless, the photoelectric photometer used to measure the comparison star sequence sees V666 Cas almost 1 magnitude brighter at maximum than visual estimates by observers using the same comparison magnitudes.

Much of this difference can be eliminated by applying a correction that represents the difference between the visual magnitude scale of the dark-adapted eye and V of the photoelectric UBV system. Many visual observers have noticed that photoelectric V magnitudes do not always represent the apparent brightness of stars. Discrepancies result from color differences and the fact that the peak wavelength of the

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photoelectric V passband and the peak sensitivity of the dark-adapted eye are not the same. See, for example, Figure C1 of Liller (1992) and the discussion by Sterken and Manfroid (1992).

Stanton (1981) proposed the following formula to correct photoelectric V magnitudes to the visual scale of the dark-adapted eye:

$$vis = V + 0.182\ (B-V) - 0.15 \qquad (2)$$

When our photoelectric values for V666 Cas obtained with the 90-cm reflector, V = 10.18 and (B-V) = +4.74, are introduced into equation 2, the visual magnitude becomes 10.9. This is only 0.1 or 0.2 magnitude brighter than our visual observations. Uncertainty in the values for the two constants in equation 2 could account for this remaining small difference between the V and visual magnitudes of V666 Cas.

The photovisual magnitudes obtained by Dahlmark (1986), using Kodak 103a-D emulsion and Schott GG-11 yellow filter, are close to the photoelectric V system with peak sensitivity near 550 nm. This explains why his brightest observation at 9.8 ptv is closer to our brightest photoelectric V observation than to our brightest visual estimates.

Five light cycles are too small a sample to establish the characteristic behavior of a long-period red variable. We will continue to monitor V666 Cas and invite other AAVSO observers to add this star to their observing lists, using the comparison star sequence on the "d" and "e" scale AAVSO preliminary charts.

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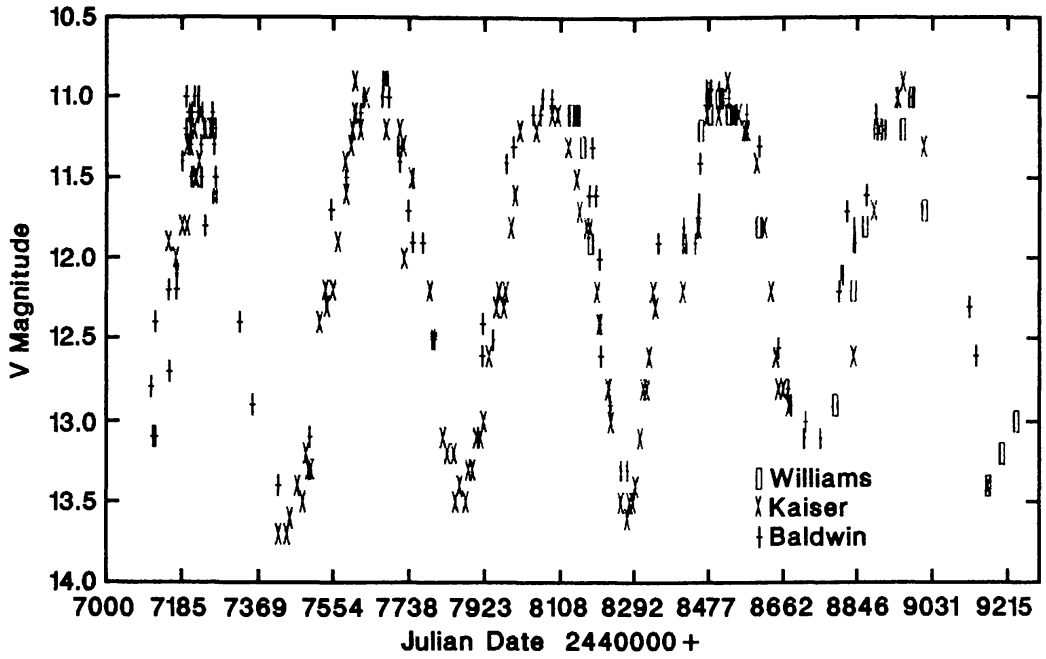


Figure 1. Visual observations of the Mira star V666 Cas = LD 103 = DHK 1.

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