DI Carinae—A Visual Phase Plot

Peter F. Williams
3 McAuley Close, Heathcote, NSW 2233 Australia

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Abstract Visual observations of DI Car between 2001 June and 2005 August are plotted according to phase relative to the previously published elements HJD 2438553.70 + 29.210 days. They support the suggestion that DI Car is a regular pulsating star and confirms the variable depth of minimum brightness.

1. Introduction

The variability of DI Car was first noted by Cannon (Shapley 1922). The star received the designation HV 3634 and was considered a variable of peculiar class. The *General Catalogue of Variable Stars* (Kholopov 1985) lists DI Car as a unique variable of uncertain class and includes a remark indicating Cepheid-like variations with occasional deep minima. It is also regarded as spectroscopically peculiar, type "pec(R)," with an excess of carbon present.

An investigation by Seggewiss (1970) presented photoelectric light and color curves from which he concluded DI Car was a population II Cepheid with an ephemeris of HJD 2438553.70 + 29.210. Here, zero phase coincides with the end of initial rise to maximum. The data presented there covered essentially one complete cycle. A magnitude range in *V* of 9.6 to 11.3 is evident from the light curve.

Harris (1981) obtained photometric data between 1979 May 22 and June 3 that showed DI Car decline in *V* magnitude from 10.17 to 12.19. This is in contrast to the range given by Seggewiss and he noted DI Car was therefore not a Cepheid and its behavior was more consistent with that of an RW Aurigae variable.

DI Car has been included amongst the Type II Cepheids showing carbon spectra (Lloyd Evans 1983), which also included reference to the variable amplitude. It was later included in a discussion on circumstellar material and RV Tauri stars (Lloyd Evans 1985).

2. Observations

DI Car is shown on chart 116 of the Variable Star Section, Royal Astronomical Society of New Zealand (Bateson *et al.* 1967). *V* magnitudes for the lettered comparison stars were determined at the Auckland Observatory (Menzies 1977) and have been used here to estimate the brightness of DI Car.

The author observed DI Car on a nightly basis, subject to weather, during 2002 through 2005, with a limited number of estimates obtained at the end of the 2001 observing season. The aim of this concentrated effort was to confirm the validity

of the previously published period and epoch of maximum brightness and to attempt to determine the shape of the visual light curve. A total of 206 magnitude estimates was obtained during this interval and these provide a homogeneous set of observations.

The observations were plotted according to phase based on the above elements. These were then averaged in to bins equal to 0.04 phase, the approximate equivalent of daily means.

The resulting phase plot is shown in Figure 1. The phase plot shows that, within the limitations of visual data, the elements of Seggewiss remain valid after an interval of thirty-five years. DI Car is indeed a star of regular cycle with the initial peak in brightness coinciding with phase zero.

The mean visual magnitude at maximum is 10.1, and there is evidence of a shallow hump in the light curve occurring immediately after maximum, a feature that is also present in the *V*-magnitude light curve of Seggewiss.

An interesting feature is the variable depth of minimum, supporting the remark by Kholopov, based on the observations of Harris, that DI Car shows large weakenings in brightness.

The visual data indicate DI Car falls to a mean minimum magnitude 11.1 at phase 0.6, in good agreement with the *V* data of Seggewiss. However, DI Car was also observed to fall up to one full magnitude fainter during some cycles, reaching a mean minimum brightness of 12.0 magnitude also at phase 0.6, as noted by Harris.

The Cepheid-like variations with an amplitude of 1 magnitude are present as shallow minima, represented as solid circles in Figure 1. The deep fadings—to a full magnitude fainter—reported by Kholopov are shown as open circles.

Unfortunately, the density of the visual data is not sufficient to tabulate with confidence the relative frequency of shallow and deep minima. Inspection of the ASAS3 data (Pojmański 2002), which include DI Car as a variable of miscellaneous type with ASAS identification 111553-6954.8, confirms the variable depth of minimum brightness, but the spacing of these observations, between three and ten days, also does not allow for better determination of the relative frequency of shallow and deep minima.

To improve the density of the data in an effort to determine the frequency of shallow and deep minima, the ASAS3 data (Pojmański 2002) have been combined with the visual data. This combined set has data on forty cycles during the interval of this investigation. Of these, sixteen cycles are shallow and one probably shallow. There are fifteen deep minima with one probably deep minimum, and a further seven have insufficient observations at phase 0.6 to determine the depth of minimum.

Table 1 lists the minimum magnitude at phase 0.6 observed for DI Car during these forty cycles, indicating whether that cycle was a shallow (S) or deep (D) minimum. Here, cycles indicated in italics with the suffix "A" have minimum brightness based solely on the ASAS3 data. Parentheses indicate the faintest magnitude observed at phase 0.5 to 0.7 where no observation was made at phase 0.6. Missing cycles are due to seasonal gaps in the data.

Figure 2 shows a representative light curve of DI Car over seven cycles during the 2004 observing season. Because of the systematic difference between the visual and ASAS3 data at brighter magnitudes, the ASAS3 values brighter than 11.0 have been shifted downward (fainter) by 0.3 magnitude. This is an arbitrary adjustment to reduce scatter in the light curve near maximum. The variable brightness at minimum is clearly evident.

It is apparent from this light curve that shallow and deep minima do not alternate but appear to occur in groups over a number of consecutive cycles. This behavior is somewhat similar to that expected within the RV Tauri variables.

DI Car therefore appears to be a potentially interesting object for further study.

3. Conclusion

DI Car is an interesting variable star deserving of greater attention. It shows Cepheid-like variations but has minima of variable depth similar to those seen in RV Tauri variables. The observed date of maximum brightness is consistent with the previously determined elements HJD 2438553.70 + 29.210.

4. Acknowledgement

This research has made use of the SIMBAD database, operated at Centre de Données Astronomiques de Strasbourg (CDS), Strasbourg, France, and also of NASA's Astrophysics Data System.

References

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Table 1. Minimum magnitude observed for DI Car at phase 0.6.

Cycle	*Type*	*Magnitude*	*Cycle*	*Type*	*Magnitude*
463	S	11.0	490	—	—
464	S	11.0	*493A*	*S*	*(10.7)*
465	—	—	*494A*	*D*	*(11.5)*
471	—	—	495	D	11.9
472	S	(10.6)	496	S	11.0
473A	*S*	*(10.9)*	497	D	11.9
474A	*S*	*(11.0)*	498	S	11.3
475	D	(11.5)	499	S	11.1
476A	*D*	*11.7*	500	D:	(11.6)
477	—	—	501	D	12.1
480A	*D*	*11.5*	502	—	—
481A	*D*	*11.5*	*505A*	*S:*	*10.9*
482	—	—	507	D	11.9
483	D	(11.7)	508	D	(11.9)
484	D	(11.9)	509	D	11.9
485	D	(11.7)	510	S	(10.9)
486A	*S*	*11.2*	511	S	11.0
487	S	11.1	512	D	(11.9)
488	S	11.1	513	S	(11.0)
489	S	11.2	514	—	—

Parentheses indicate faintest magnitude observed at phase 0.5 to 0.7 where no observation recorded at phase 0.6. Cycles indicated by italics with suffix A *are based on ASAS3 data.*

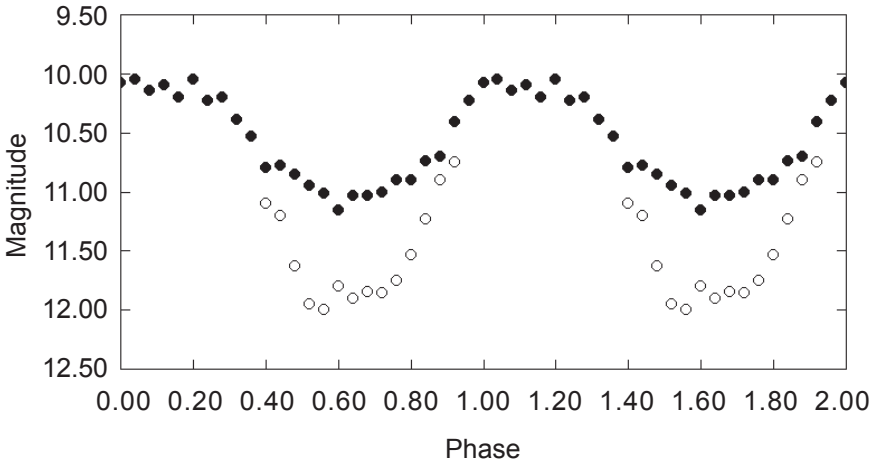

Figure 1. Phase diagram of DI Car, mean phase, 0.04 bin. Open circles denote deep cycle; filled circles denote shallow cycle; all data by author.

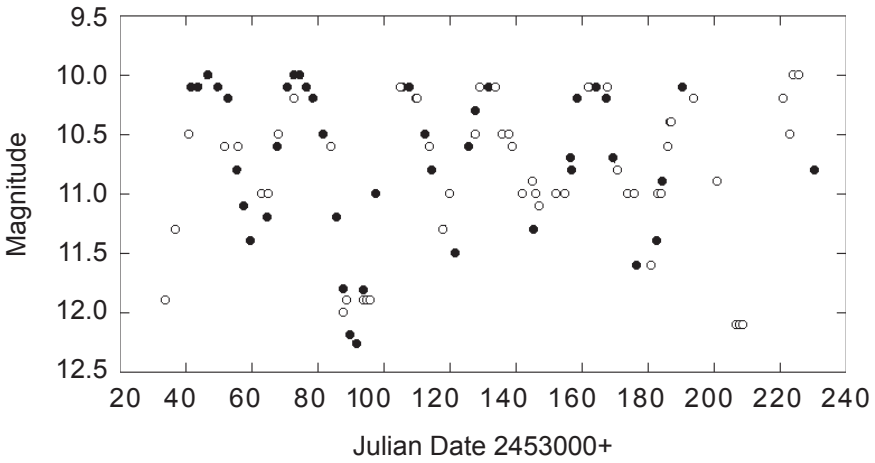

Figure 2. DI Car light curve for cycles 496 to 502. Open circles denote visual observations by author; filled circles denote ASAS3 adjusted observations.