VISUAL AND PHOTOELECTRIC OBSERVATIONS OF DM PERSEI

David B. Williams
9270-A Racquetball Way
Indianapolis, IN 46260

Received: June 10, 1991

Abstract

A light curve of the Algol-type eclipsing variable DM Persei formed from 256 visual estimates, supported by a photoelectrically determined time of minimum, indicates that the light elements of Scaltriti (1976) are reliable. A comparison between visual and photoelectric timings of minima indicates that routine visual timings are prone to large errors when long, shallow eclipses are observed.

DM Persei is an Algol-type eclipsing binary located 1° southeast of the Double Cluster in Perseus. The early observational history has been reviewed in detail by Scaltriti (1976). The amplitude of variation during primary eclipse, 7.9-8.6 V, is sufficient for visual timings by a skilled observer, but the eclipse duration is 11 hours. The rate of light change, averaging less than 0.15 magnitude per hour, requires an observing session of 7 or 8 hours to achieve coverage of at least 0.5 magnitude of variation on both branches of the eclipse light curve.

Even if an observer is able to invest this much time, it is difficult to control the sources of random and systematic error that affect visual estimates over so many hours (see, e.g., Williams 1987). The resulting scatter of individual estimates and asymmetry of the light curve make the time of mid-eclipse difficult to define. In addition to these problems, the need to observe for up to eight hours limits suitable eclipses to those that occur near the meridian near midnight. Only one or two such eclipses occur each month during the prime observing season, October to January.

Considering all these factors, I chose to make regular estimates of DM Per throughout the observing season. Comparison stars were selected and step values established; the step values were later converted to magnitudes by equating the variable's observed step range with its published magnitude range. Observations were made every hour or two on each clear night, and more frequently when the variable appeared faint. A total of 256 estimates were obtained with 20x60 binoculars during the 1983-84 and 1984-85 seasons.

These observations could then be reduced to phase (the decimal fraction of the orbital period following a predicted time of minimum) and plotted as a composite light curve (Figure 1). On such a plot, the primary minimum occurs at phase 0.0 if the adopted light elements are correct. I reduced the observations according to the light elements of Scaltriti (1976), which have also been adopted in the *General Catalogue of Variable Stars* (GCVS)(Kholopov *et al.* 1985):

$$\text{Min I } (JD_{hel.}) = 2441920.4543 + 2.7277427\ E. \qquad (1)$$

Mean magnitudes were determined for each 0.01-phase bin during primary eclipse. Using the tracing paper method, I then found the phase of minimum to be $+0.0040 \pm 0.0035$. This is equivalent to an O-C residual from a predicted time of minimum of $+0.011$ day ± 0.010.

I also collected published times of minima and plotted an O-C diagram (Figure 2) according to equation (1). The photoelectric minima plotted on this diagram suggested that Scaltriti's light elements were reliable. However, the most recent photoelectric timing was discordant, and the visual data were too scattered to indicate whether this point represented a major period change or an error of some kind.

I kept this problem in mind and found an opportunity to obtain photoelectric observations during an eclipse in 1990 (Figure 3). The measures were made with a 28-cm Schmidt-Cassegrain telescope and an Optec SSP-3 solid-state photometer with V filter. Only a few points could be obtained during interruptions in the night's planned observing program. However, analysis by the tracing paper method results in a time of minimum of Heliocentric JD 2448210.629 with an uncertainty of ± 0.004 day. This time agrees exactly with equation (1).

The severe scatter of the visual O-C points suggests that routine visual timings of minima are of little value in monitoring the period of DM Per. By routine visual timings I mean a series of estimates made on the same night, defining both the descending and ascending branches of the light curve. Mallama (1974a, 1974b) has attempted to quantify the likely errors of visual timings according to the amplitude and duration of eclipsing binary minima. Some of the visual timings plotted in Figure 2 are more than one hour too early. And worse, the visual points do not scatter randomly about the well-determined zero line.

My observations during individual eclipses produced residuals with little better accuracy than the other visual data points in the O-C diagram. But the composite light curve, combining estimates made during many cycles, is closer to the zero-residual line of Scaltriti's light elements than any of the other visually determined times of minima.

The use of composite light curves would seem to be strongly indicated for DM Per and similar eclipsing binaries with long, shallow minima. Combining estimates from many cycles helps to average out most forms of observational error. To determine the phase of minimum, it is not necessary to observe the entire light curve, of course; observations can be limited to the eclipse phases.

A composite light curve has the additional advantage of making all estimates equal in value. Every eclipsing binary observer has a collection of "busted minima" from observing sessions terminated by clouds or other reasons before enough estimates were obtained to adequately define the eclipse light curve. These observations are useless by themselves, but when combined with similar observations from many other cycles, they are of equal value in forming a mean light curve.

Photography can also be recommended. DM Per and several other eclipsing binaries with long, shallow minima are bright enough to be recorded in brief exposures with a 35-mm camera and 100-mm to 200-mm telephoto lens. The images can then be estimated or measured in ways that are not affected by the most common problems of visual observation.

References

Kholopov, P. N. *et al.* 1985, *General Catalogue of Variable Stars,* Fourth Edition, Moscow.

Mallama, A. D. 1974a, *J. Amer. Assoc. Var. Star Obs.,* 3, 11.

Mallama, A. D. 1974b, *J. Amer. Assoc. Var. Star Obs.,* 3, 49.

Scaltriti, F. 1976, *Astron. Astrophys. Suppl.,* 25, 291.

Williams, D. B. 1987, *J. Amer. Assoc. Var. Star Obs.,* 16, 118.

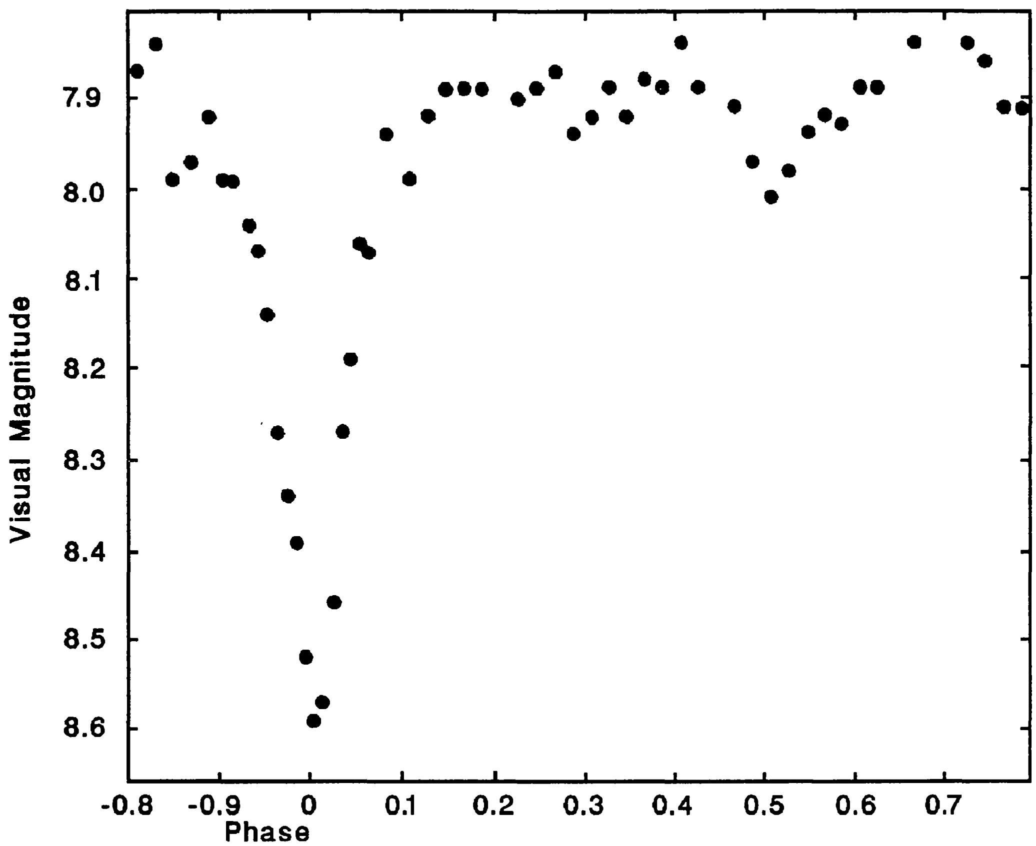

Figure 1. DM Per, light curve compiled from 256 visual estimates reduced to phase by the light elements of equation (1). Each point is the mean magnitude in each 0.01-phase bin between phases 0.9 and 0.1, and each 0.02-phase bin from phases 0.1 to 0.9.

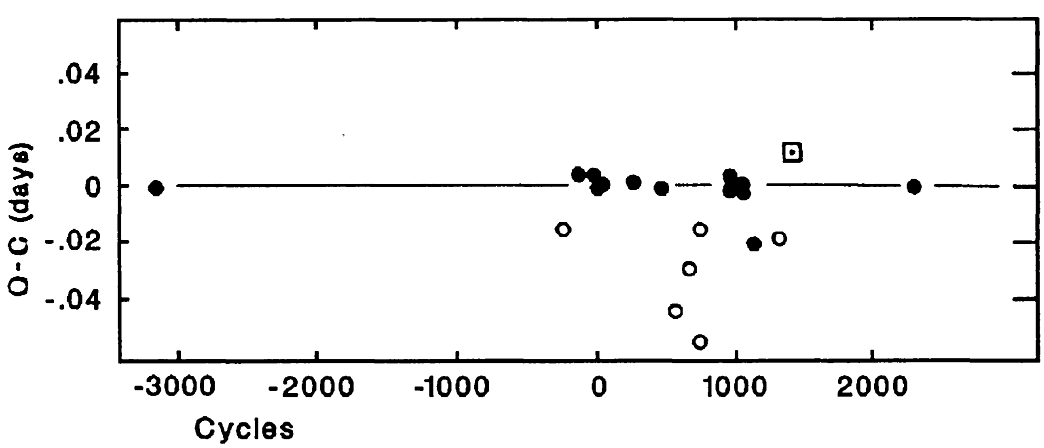

Figure 2. DM Per, O-C diagram based on equation (1). The solid circles are photoelectric times of minima, the open circles are visual timings. The square represents the time of minimum derived from the composite visual light curve in Figure 1. The last solid circle is the author's photoelectric timing in 1990.

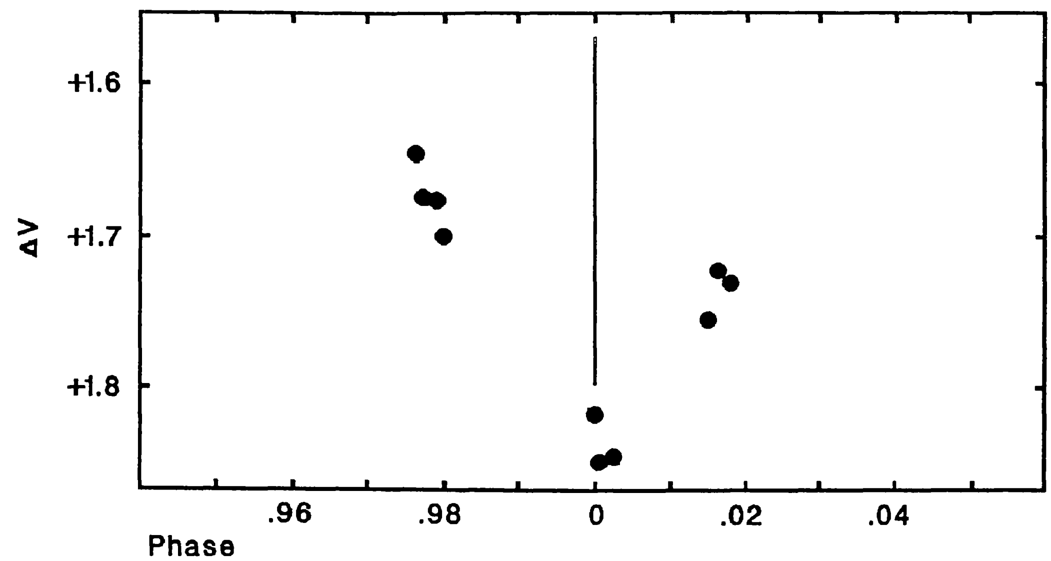

Figure 3. DM Per, differential photoelectric observations during the minimum E = 2306 of equation (1). The three data sets are very limited but are distributed symmetrically about the zero-phase axis and indicate that minimum occurred within ± 5 minutes of the predicted time.