OBSERVING DWARF CEPHEIDS FOR FUN AND PROFIT

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Abstract

Dwarf Cepheids are pulsating variable stars with periods of 1 to 6 hours and amplitudes of $0\overset{m}{.}3$ to $1\overset{m}{.}0$. Visual observers can therefore follow them through one or more cycles on a single night, and see the results of their observations almost immediately. Such observations are useful in studies of the period changes in these stars, which in turn can shed some light on the evolutionary status of the stars. As an example, some recent observations of CY Aqr are analyzed and discussed.

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Dwarf Cepheids (also known as AI Vel or RRs stars) are pulsating variable stars with periods of 1 to 6 hours, amplitudes of $0\overset{m}{.}3$ to $1\overset{m}{.}0$, spectral types A or F, and absolute magnitudes 0 to +4. About half of the dwarf Cepheids have variable amplitudes, due to the simultaneous presence of two pulsation periods. This phenomenon adds considerably to the interest of these stars.

Most dwarf Cepheids are believed to be population I stars (of normal mass) in a phase of evolution analogous to that of the sun. A few dwarf Cepheids, including SX Phe, CY Aqr and DY Peg, are believed to be mild population II stars of low mass, in a phase of evolution which has not yet been determined.

Dwarf Cepheids should be of great interest to visual observers with access to telescopes of moderate aperture. Most of these stars have amplitudes that are large enough for visual detection, and one or more cycles of variation can be observed during a single night. The observer can therefore plot up a light curve right at the telescope, and see the results immediately!

Table I contains a list of the known dwarf Cepheids brighter than $m_v = 12$ and with $\Delta v \geq 0\overset{m}{.}50$, along with pertinent information on their position and variability.

Some years ago, Percy (1975) carried out a study of the period of the dwarf Cepheid CY Aqr, using existing photographic and photoelectric data. The study showed that the period of CY Aqr changed abruptly in 1951, and has remained constant since. Subsequently and independently, the remaining authors of this paper carried out some visual observations of CY Aqr, and published these in <u>AstroNotes</u>, the journal of the Ottawa Center of the Royal Astronomical Society of Canada. Percy saw these observations in print and realized that such observations could be quite useful in studying the period changes in this and other dwarf Cepheids. Hence this paper, to encourage other observers.

The visual observations of CY Aqr were made using the 40-cm reflector at the North Mountain Observatory of the Ottawa Center of the Royal Astronomical Society of Canada. To judge the brightness change, a method developed by M. Baldwin of the AAVSO was used, in which field stars are given relative brightness numbers rather than

TABLE I

LIST OF DWARF CEPHEIDS

Name	R.A. (1900)	Dec. (1900)	Period	$\overline{m}_v$	Δv
BS Aqr*	$23^h43^m37^s$	-08°42.1	0.197823	9.4	0.50
CY Aqr	22 32 41	+01 01.0	0.061038	10.8	0.70
RV Ari	02 09 37	+17 36.5	0.093128	11.8	0.70
VZ Cnc*	08 35 27	+10 10.8	0.178364	7.8	0.60
XX Cyg	19 45 16	+41 22.9	0.134865	11.7	0.95
RS Gru*	21 36 31	-48 38.7	0.147011	8.2	0.55
DY Her	16 26 37	+12 13.3	0.148631	10.4	0.50
EH Lib*	14 53 47	-00 32.9	0.088413	9.8	0.50
SZ Lyn*	08 02 36	+44 45.8	0.120535	9.4	0.50
DY Peg	23 03 53	+16 40.4	0.072926	10.3	0.55
SX Phe*	23 41 16	-42 07.5	0.054964	7.3	0.50
V 703 Sco*	17 35 45	-32 28.4	0.115218	7.8	0.50
CW Ser	15 48 14	+06 23.3	0.189151	11?	0.8?
AI Vel*	08 10 47	-44 16.3	0.111574	6.7	0.65

*marked on the Atlas Australis, Eclipticalis or Borealis.

TABLE II

Times of Maximum Light of CY Aqr

Date 1977	Observer	J.D. Hel. Max.	Phase
July 19-20	R. Meier	2443344.7292	0.346
July 19-29	D. Welch	2443344.7326	0.401
July 19-20	R. Dick	2443344.7361	0.459
July 21-22	D. Welch	2443346.6806	0.316
July 21-22	R. Dick	2443346.6806	0.316

Mean cycle number 281570; mean phase 0.345 ± 0.012.

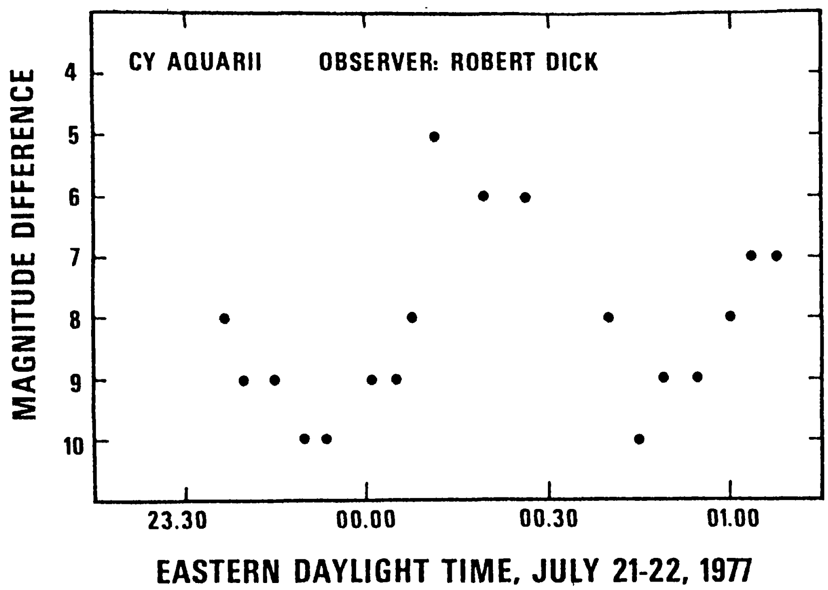

Figure 1. Light curve of CY Aqr, obtained on July 21-22, 1977 by R. Dick. The vertical scale is a relative brightness scale, using nearby field stars for comparison.

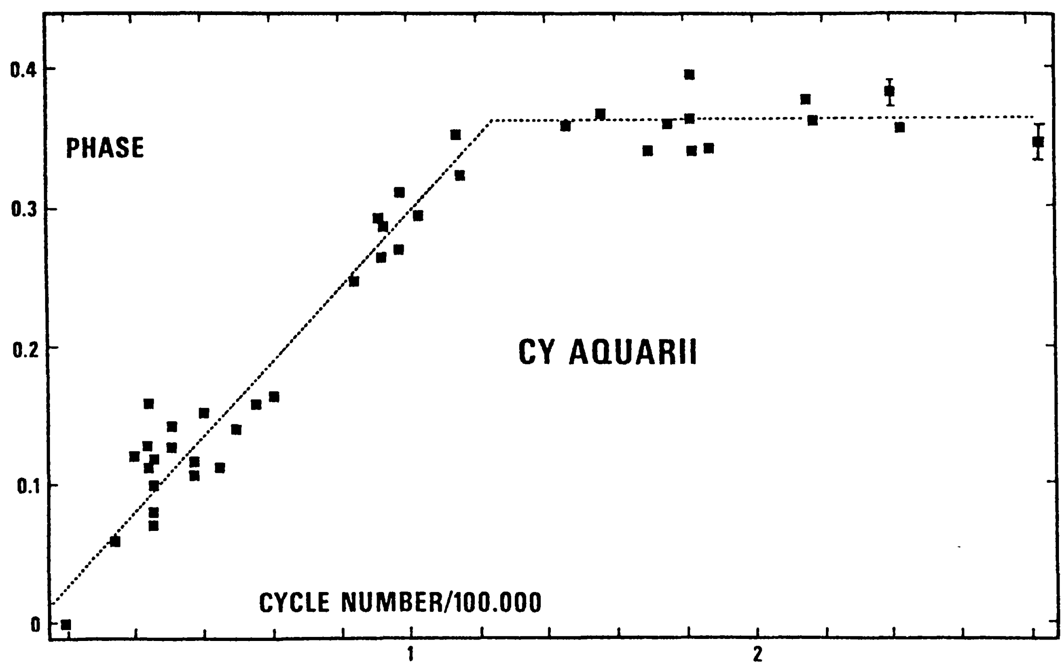

Figure 2. Graph of phase against cycle number for CY Aqr. The point on the extreme right was obtained from the present visual observations; the other points were obtained from existing photographic and photometric data (Percy 1975). The break in the graph indicates an abrupt period decrease in 1951.

actual magnitudes (which are not known). A sample light curve is shown in Figure 1. Five light curves were obtained in all. The five times of maximum light are listed in Table II.

For each time of maximum light, the phase in cycles and a fraction from an initial epoch were determined from the following ephemeris (Percy 1975):

$$\text{phase} = (t_{max} - 2426159.4850)/0.061038342$$

The individual fractional phases and integral cycle numbers and their mean values are listed in Table II. Observations on 21-22 July 1977 were given triple weight because of the better quality of the night and the increased experience of the observers. The mean phase and cycle number are plotted on Figure 2, along with the phases and cycle numbers determined previously (Percy 1975). The present point is in very good agreement with the trend of the previous data.

For a star of constant period, a graph of phase against cycle number should be a straight line; for a star of uniformly changing period, it should be a parabola. In the case of CY Aqr, the graph is a broken straight line, with the break occurring in 1951. This means that CY Aqr had a constant period until 1951, suffered an abrupt period decrease at that time and maintained a constant period since. The cause of such abrupt period changes is unknown; according to conventional evolution and pulsation theory, period changes should be uniform.

In conclusion, we wish to stress that dwarf Cepheids can be studied visually using telescopes of moderate aperture. The resulting light curves can be of good quality, and can be used to obtain times of maximum light which are accurate to a small fraction of the period. These times can then be used to study the period change of the star, which can shed some light on the evolutionary processes occurring within the star. Although most of the data in Figure 2 are photographic or photoelectric, the basic trends in Figure 2 could have been established _using visual techniques alone_. Other visual observers are encouraged to study dwarf Cepheids--for fun, practice and astrophysical profit.

REFERENCE

Percy, J.F. 1975, _Astronomy and Astrophysics_ 43, 469.