THE LONG TERM BEHAVIOUR OF TWO VARIABLES IN THE GLOBULAR CLUSTER M56.

Amelia Wehlau, Philip Rice, Marcia Wehlau,
Department of Astronomy,
The University of Western Ontario.

Helen Sawyer Hogg,
David Dunlap Observatory,
University of Toronto.

Of twelve variables known in Messier 56 in Lyra, two, V1 and V6 are the subject of this paper. V1 was discovered by Shapley (1920) and first determined by Sawyer Hogg (1942) to be a Cepheid with a period of 1.5 days. V6 was discovered by Sawyer Hogg (1940) from her early plates at the David Dunlap Observatory. Later Sawyer Hogg (1949) showed it to be an RV Tauri type with a period of 90.02 days, one of the first such to be identified in a globular cluster. A.H.Joy (1949) determined spectral type and radial velocity for both of these variables.

At the present time twenty Population II Cepheids with periods shorter than five days are known to exist in galactic globular clusters. These variables, commonly called BL Her stars after the more metal-rich field star of that name, are believed to be evolving away from the horizontal branch toward the asymptotic branch. A recent study by Wehlau and Bohlender (1982) of period changes for twelve of these stars found that all of them showed either increasing periods or no detectable period change. This lack of decreasing periods agrees well with the evolutionary theory.

A number of these stars have only recently been discovered as discussed in the paper by Clement et al. (1984b) presented at this Colloquium. Period changes for these stars as well as for a few others chiefly at southern declinations cannot be determined at the present time because of a lack of older observations. However older observational data do exist for V3 in M10 and V1 in M56. The variable in M10 is discussed in the paper by Clement et al. (1984a) also given at this meeting. This star shows a more complicated period change, the period first increasing and then decreasing. However this variable has a longer period of 7.90 days and thus falls between the two groups of Population II Cepheids found in globular clusters and it may not be a true BL Her star.

In the case of M56 two long series of observations by Sawyer Hogg and Rosino existed and therefore plates of the cluster were recently taken by A. Wehlau with the 1.2 m telescope of the Observatoire de Haute Provence and the 1.2 m telescope of The University of Western Ontario, principally to investigate the period change, if any, of V1.

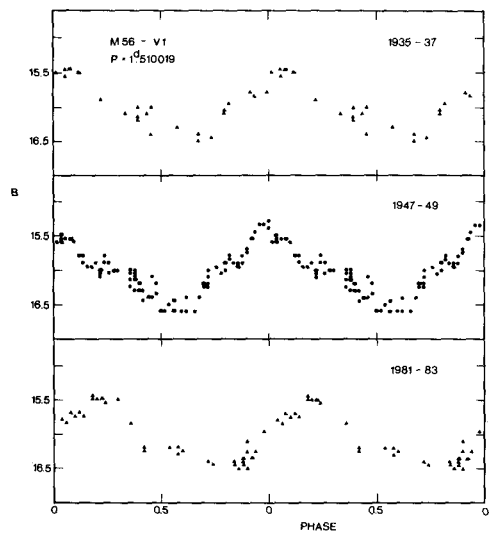
https://doi.org/10.1017/S0252921100109534 Published online by Cambridge University Press

Fig.1 shows three light curves for V1 using data from plates taken by Sawyer Hogg, Rosino and Wehlau, respectively. The light curve shown for 1947-49 is based on published data by Rosino (1949) and the other two light curves are based on measures made by P. Rice with the iris diaphragm photometer of The University of Western Ontario using an unpublished photoelectric sequence of Harris, Olszewski and Schommer (1981). In order to compare the light curves all the magnitudes given by Rosino have been increased by $0^m.2$. In agreement with the other globular cluster BL Her stars investigated, V1 shows an increasing period as can be seen by the shifts in the phase of maximum.

The light curve for V1 displays a bump on the descending branch as well as a dip shortly before maximum. The bump is similar to those seen on the light and velocity curves of other BL Her stars with periods close to 1.5 days (Carson & Stothers, 1982) which have been used to determine "bump" masses of between 0.55 and 0.60 solar masses. The dip, sometimes referred to as the "artificial viscosity dip," appears on the model light curves of Davis (1982) and Carson & Stothers who suggest it is due to higher opacity of the atmospheric Hydrogen caused by a transiting shock. It has been seen in the light curves of some other BL Her stars and of the much longer period (16.4 days) Cepheid X Cygni (Davis et al., 1981).

The long series of plates of M56 taken by Sawyer Hogg with the 1.88, 0.48 and 0.40 m telescopes of the University of Toronto and extending from 1935 through 1975 makes it possible to study the long term

Fig.1. Light curves of Variable 1 from three different epochs showing shifts in phase of maximum due to an increasing period.



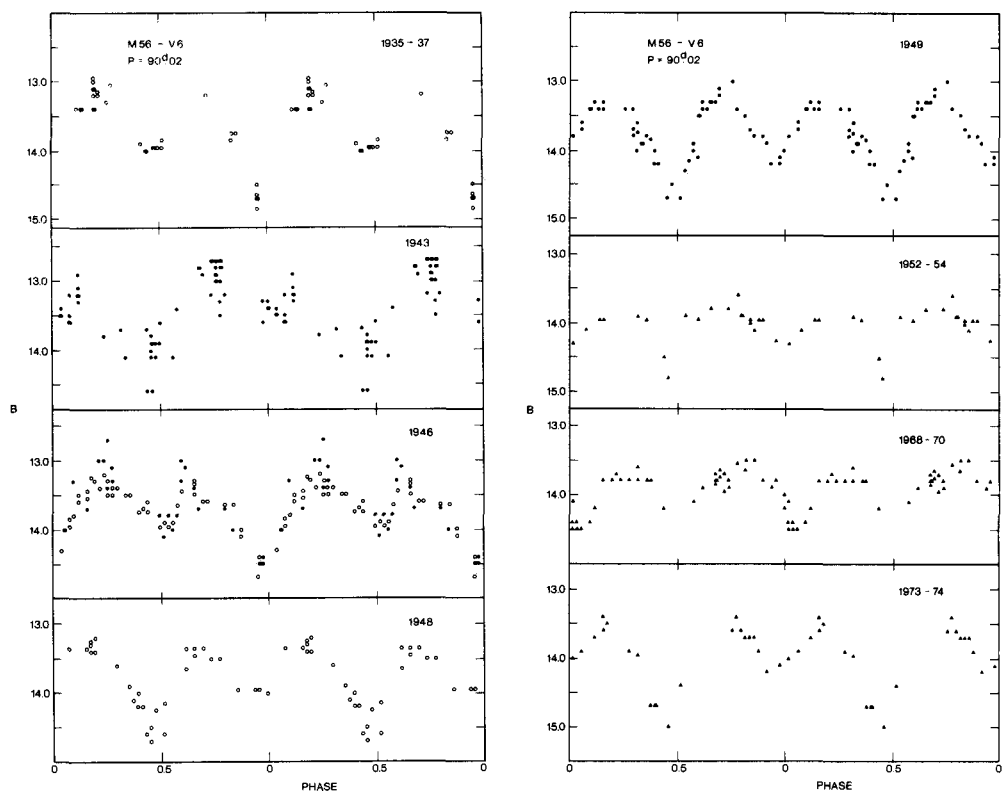
https://doi.org/10.1017/S0252921100109534 Published online by Cambridge University Press

behaviour of V6, the RV Tauri star. Fig.2 shows eight light curves for this variable with various symbols representing the measures made by the different observers. The published magnitudes of Rosino (1944, 1949) are shown as filled dots and the eye estimates made by Sawyer Hogg from her plates taken from 1935 through 1949 are shown as open circles. Triangles represent eye estimates based on the new sequence as made by M. Wehlau from Sawyer Hogg's plates taken from 1950 through 1975. It can be seen that there have been several reversals of primary and secondary minima in the light curve but that the period has remained stable at the value of 90.02 days.

The data used for this paper will be published later along with a more complete discussion of the results.

The authors are grateful for the support of the National Science and Engineering Research Council of Canada. A. Wehlau wishes to thank the director and staff of the Observatoire de Haute Provence for their hospitality and assistance.

Fig.2. Light curves of the RV Tauri star, Variable 6, showing reversals of primary and secondary minima.



References

Carson, T.R., and Stothers, R. 1976, Astrophys.J.,204, 461.
Clement, C., Sawyer Hogg, H. and Lake, K. 1984a, in IAU Colloquium 82, Cepheids: Observation and Theory, edited by Barry F. Madore (University of Cambridge, Cambridge), p. 260.
Clement, C., Sawyer Hogg, H. and Wells, T. 1984b, in IAU Colloquium 82, Cepheids: Observation and Theory, edited by Barry F. Madore (University of Cambridge, Cambridge), p. 262.
Davis, C.G. 1982, in Pulsations in Classical and Cataclysmic Variable Stars, edited by J.P. Cox and C.J. Hansen (University of Colorado, Boulder), p.232.
Davis, C.G., Moffett, T.J. and Barnes, T.G. 1981, Astrophys.J.,246, 914.
Harris, H.C., Olszewski, E.W. and Schommer, R.A. 1981, private communication.
Joy, A.H. 1949, Astrophys.J.,110, 105.
Rosino, L. 1944, Pub.Oss.Astr.Bologna IV, No.7.
Rosino, L. 1949, Pub.Oss.Astr.Bologna V, No.12.
Sawyer, H.B. 1940, D.D.O. Pub.1, No.5.
Sawyer, H.B. 1942, Pub.A.A.S.,10, 233.
Sawyer, H.B. 1949, J.Roy.Astr.Soc.Can.,43, 38.
Shapley, H. 1920, Astrophys.J.,52, 73.
Wehlau, A. and Bohlender, D. 1982, Astron.J.,87, 780.

Table 1. Known BL Her stars in globular clusters.

NGC	Var.	Period Days	Period Change $d/10^6yr.$	NGC	Var.	Period Days	Period Change $d/10^6yr.$
2419	18	1.58		6333 (M9)	12	1.34	
5139	43	1.15	+ 0.54±0.11				
(ωCen)	48	4.47	+15.8 ±1.6	6402	2	2.79	+ 0.34±1.09
	60	1.34	+ 0.62±0.09	(M14)	76	1.89	+ 7.4 ±0.4
	61	2.27	+ 0.52±0.26				
	92	1.34	+11.3 ±0.6	6656 (M22)	11	1.69	+ 0.01±0.19
6205	1	1.45	+ 0.05±0.19				
(M13)	2	5.11	+18.0 ±2.0	6715	1	1.34	
	6	2.11	+ 0.36±0.34	(M54)			
6273 (M19)	4	2.43		6752	1	1.38	
				6779	1	1.51	+ 3.5 ±0.2
6284	1	4.48		(M56)			
	4	2.82					
				7078	1	1.43	+ 4.7 ±0.2
				(M15)	72	1.13:	

https://doi.org/10.1017/S0252921100109534 Published online by Cambridge University Press