Period-Changing RR Lyrae Stars in M107

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Abstract

Out of the 22 RR Lyrae stars observed by Ferro et al. (1), 17 were analyzed using the PROMPT telescope data collected by Dr. Layden and Justin Chapman (MS'22). Four of those 17 stars had noticeable scattering in their light curves, which may be due to incorrect period recordings or a change in the period over time. Three of the four possible period-changing stars (V10, V12, and V16) had a decrease in period (-β) which indicates the stars are evolving leftward on the horizontal branch. V17 had an increase in period (+β), which indicates the star is evolving rightward on the horizontal branch.

Methodology

We used Supermongo to find the best period for 17 of the 22 stars in M107 using the BGSU data from the PROMPT telescope (starting by converting fluxes to magnitudes). Some of these periods conflicted with the Ferro et al. (1) data, which indicates that their period was incorrect, or the star was changing its period. To examine this, phased light curve models were created for each star to confirm the new-found periods and examine their behavior over time as shown in Figures 5-6. V10, V12, V16, and V17 all contained curvature in their O-C diagrams, as shown by Ferro et al. (1), indicating those stars have changing periods.

To inspect this observation, programs were coded to analyze data from the PROMPT telescope and put it into a format that could be added to the Ferro et al. (1) data. These programs found three times of maximum light in different time intervals (each containing around 50 data points in the light curve fit) for all 17 stars, with a focus on the period-changing stars.

Excel was used to create Figures 1-4, where the original Ferro et al. (1) data (blue) is plotted with BGSU's three new data points (orange arrow). IRAF derived the coefficients of the second-order polynomials applied to each O-C curve, which can be used to calculate the period change rate (β). Applying Equation 1, where A_2 is the quadratic coefficient of the models in from Figures 1-4, the period change rate can be calculated. P_0 indicates the observed periods (1) of each star. β was calculated with and without weighted points; the average value is recorded in table below in days per million years.

Equation 1: $$\beta = \beta_0 = \frac{2A_2}{P_0}$$

PROMPT telescopes in Chile (Fitzgerald)

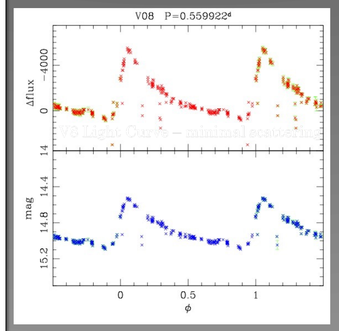

Fig 5: V8 Light Curve – minimal scattering

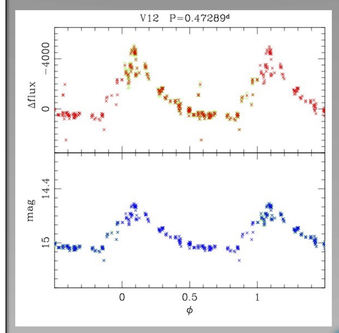

Fig 6: V12 Light Curve – noticeable scattering

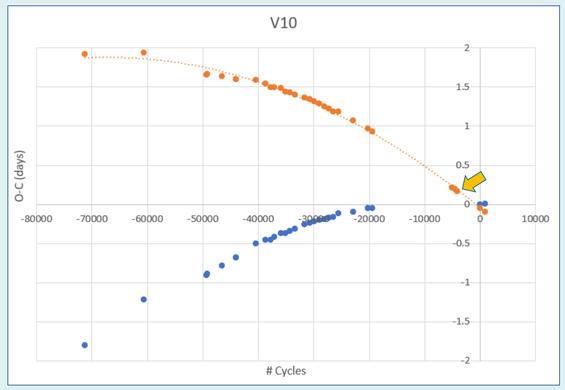

Fig. 1

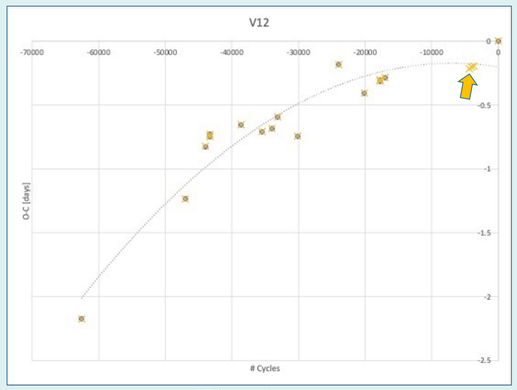

Fig. 2

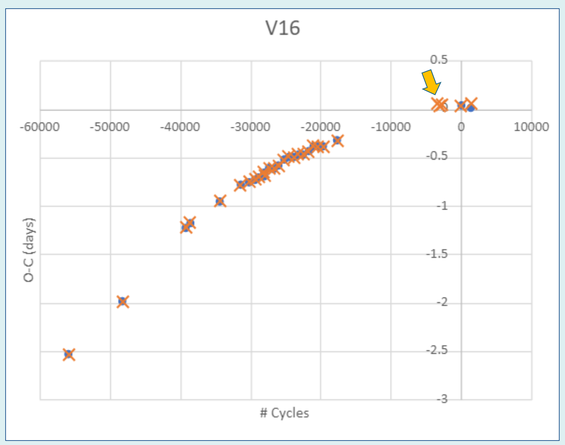

Fig. 3

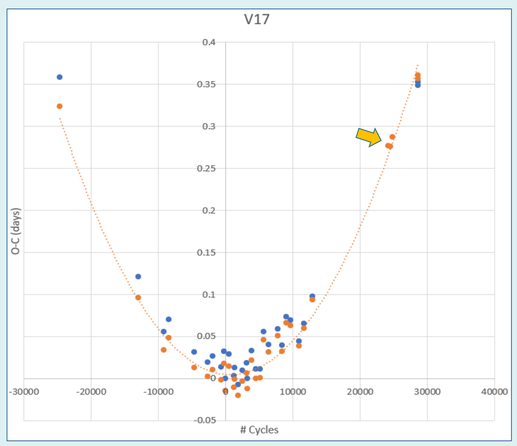

Fig. 4

Results

	V10	V12	V16	V17
Ferro et al. - β	-0.714 ± 0.039	-0.756 ± 0.168	-1.088 ± 0.045	$+0.624 \pm 0.021$
BGSU - β	-0.753	-0.883	-1.04	$+0.616$

Interpretation

A negative β value indicates the period rate is decreasing over time, and is evolving towards the left and bluer end of the horizontal branch. V10, V12, and V16 are all observed to have a negative period change rate. A positive β value indicates the period rate is increasing over time, and is evolving towards the right and redder end of the horizontal branch. V17 is the only star observed following this behavior. BGSU's β values closely align with Ferro et al. (1) values, meaning our data points confirm and refine the Ferro et al. results.

What's Next?

- The BGSU 0.5m telescope data collected before the PROMPT data will be utilized in Fall 2023 to further analyze these stars.
- More data may be mined from existing sky survey archives.
- The findings will be written up beginning Fall 2023.

References

(1) Arellano Ferro, A., et al. "Period Changes in the RR Lyrae Stars of NGC 6171 (M107)," *Astronomische Nachrichten*, vol. 339, no. 2-3, 15 Apr. 2018, pp. 158–167, https://doi.org/10.1002/asna.201813409.