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**GSC 00748-01618 AND GSC 00540-00084: NEW RR LYRAE STARS**

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Using data acquired by The Amateur Sky Survey (TASS: Droege (2002) and Henden(2001)), variability of GSC 748-1618 and GSC 540-84 was demonstrated. Extensive followup observations were performed to characterize the light curves. Figure 1 and Figure 2 show the multicolor photometry. Data was taken through standard filters, but not transformed to the standard system. Zeropoints for the photometry were obtained by using secondary standards from the US Naval Observatory (Henden priv. comm.) for GSC 748-1618 and Tycho-2 (Hog, 2000) for GSC 540-84. Johnson/Cousins  $VBR_C$  comparison star magnitudes were calculated from Tycho-2  $V_T$  and  $B_T$  magnitudes with:

$$V = V_T - 0.09(B_T - V_T) \quad (1)$$

$$B - V = 0.85(B_T - V_T) \quad (2)$$

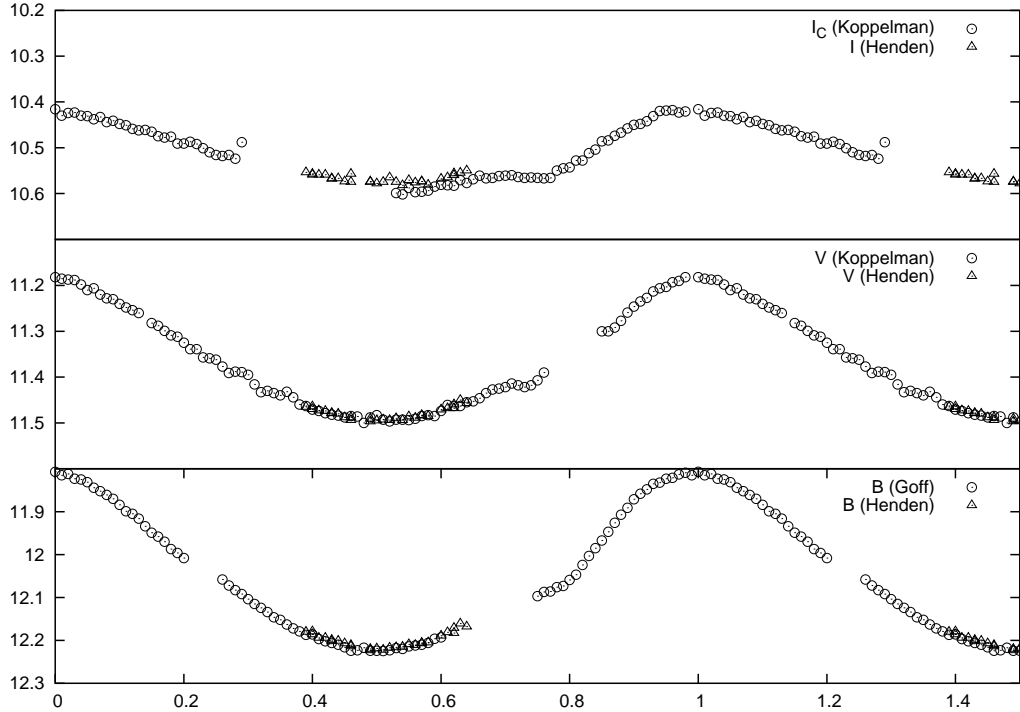
$$R_C = V - 0.5(B - V) \quad (3)$$

Photometry was performed using two comparison stars in an ensemble solution. Table 1 shows the comparison stars and magnitudes.

Table 1: Comparison Stars

GSC ID	RA (J2000)	Dec (J2000)	$B$	$V$	$R_C$	$I_C$
GSC 748-1662	06 54 15.84	+07 59 09.6	11.42	11.10	10.89	10.67
GSC 748-2116	06 54 35.76	+08 02 42.0	11.49	11.18	10.92	10.69
GSC 540-0960	21 18 35.82	+06 07 42.7	11.28	10.58	10.22	
GSC 540-0646	21 18 50.87	+06 01 19.1	11.11	10.46	10.13	

For GSC 748-1618, the light curve is quite symmetrical (M-m=0.49). There is evidence of the "bump" after the minimum, believed to be related to shockwave phenomena. Data from Henden at the USNO has  $B - V = 0^m.72$  at minimum which implies a late-F or early-G type star. This appears to be an RRab star, but the low amplitude and symmetry are more typical of an RRc type star, although the period is longer than is typical for RRc stars. The pulsation seems to be of the fundamental only, so a classification as an



**Figure 1.** Light Curve of GSC 748-1618 (binned)

RRab star is probably most appropriate. Using the terminology of Alcock et al (2000) we would classify GSC 748-1618 as an RR0.

GSC 540-84 shows significant amplitude and/or phase modulation. The apparent scatter in the light curve is related to these modulations and is not observational error. The exact nature of these modulations is not known but is probably related to the Blazhko effect. The low amplitude, short period and light curve symmetry indicate this is an RRc star. It is not known whether this is an RR0 or RR01 star.

A Fourier decomposition of the GSC 540-84 light curve is presented in Figures 3 and 4 and Table 3.

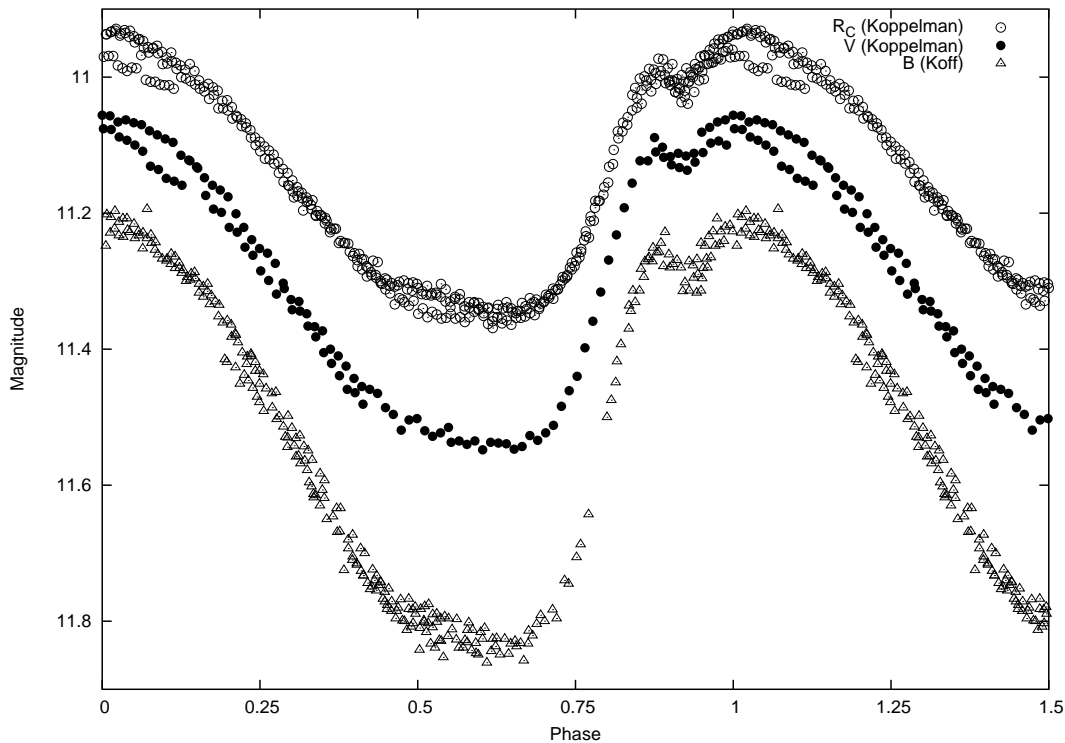
We make use of three relations to make initial estimates of the absolute magnitude ( $M_V$ ) and metallicity ( $[\text{Fe}/\text{H}]$ ) from our photometry. Santis et al (2002) present an equation for determining  $M_V$  from the period  $P$  and the amplitude in  $B$  for RRab stars:

$$M_V = -1.842 \log P - 0.137 A_B + 0.26 \quad (4)$$

Smith (1995) concludes a discussion of  $M_V$  as a function of  $[\text{Fe}/\text{H}]$  with a generalized (although perhaps cautionary) formula of:

$$M_V = +0.2[\text{Fe}/\text{H}] + 0.9 \quad (5)$$

For GSC 748-1618, using  $P=0.7775$  and  $A_B=0.42$  Equation 4 yields an absolute magnitude of  $M_v=0.40$ . Using this value in Equation 5 and solving for  $[\text{Fe}/\text{H}]$  yields  $[\text{Fe}/\text{H}]=-2.48$  which, according to Butler (1975), corresponds to  $\Delta S=14.1$ . This indicates a very metal-poor star in relation the Sun. As a crosscheck, we use the relation derived by



**Figure 2.** Light Curve of GSC 540-0084

Sandage (1993a):

$$[\text{Fe}/\text{H}]_{\text{ZW}} = (-\log\langle P_{\text{AB}} \rangle - 0.389)/0.092 \quad (6)$$

where ZW refers to the Zinn and West (1984) scale. Using our data this relation yields  $[\text{Fe}/\text{H}]_{\text{ZW}} = -3.04$ . Although this value does not match all that closely, it does seem to confirm the extremely metal-poorness of this star.

As discussed in Smith(1995), Kemper(1982) presents a large sample of  $[\text{Fe}/\text{H}]$  measurements of RRc stars. Using a linear fit to these data a relationship between period and metallicity for RRc stars is derived (Figure 3 and Equation 7). The goodness of the fit is  $R^2 = 0.19$ . Polynomial fits up to 4th order show a similar goodness of fit and trend. While these fits have a fair amount of scatter they indicate a slight trend towards metal-poorness with longer periods and provide a mechanism to make an initial estimate of metallicity.

$$[\text{Fe}/\text{H}] = -3.73P - 0.15 \quad (7)$$

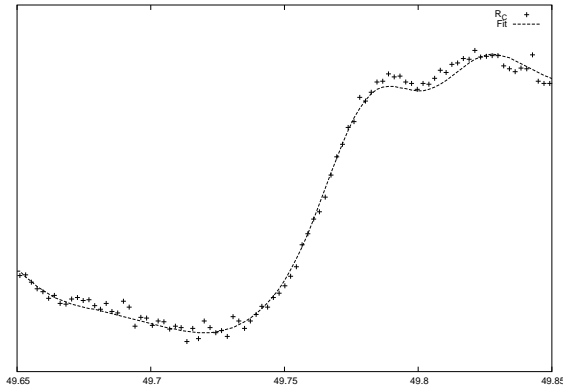
For GSC 540-84 Equation 7 yields  $[\text{Fe}/\text{H}] = -1.23$  ( $\Delta S = 6.3$ ) and this value in Equation 5 gives  $M_V = 0.65$ . This value of  $M_V$  is  $\pm 0^m.07$  due to the scatter in the fit of Equation 3. As a crosscheck, we use the relation derived by Sandage (1993a):

$$[\text{Fe}/\text{H}]_{\text{ZW}} = (-\log\langle P_{\text{C}} \rangle - 0.670)/0.119 \quad (8)$$

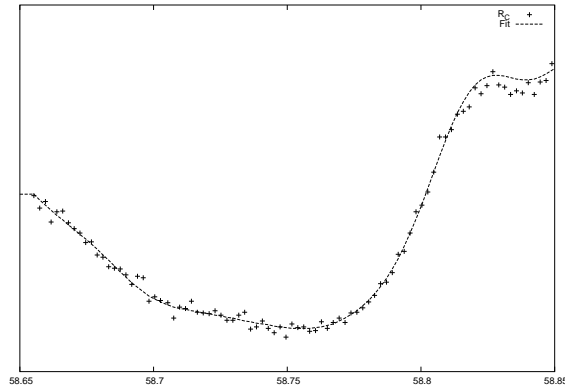
Using our data this relation yields  $[\text{Fe}/\text{H}]_{\text{ZW}} = -1.13$  which is in reasonable agreement.

These data are summarized in Table 2.

Coordinates are from UCAC2 (Zacharias et al 2003).



**Figure 3.** Fourier Fit with 2452849



**Figure 4.** Fourier Fit with 2452858

Table 2: Summary of Data

GSC ID	RA (J2000)	Dec (J2000)	HJD Max	Period	[Fe/H]	$M_V$
748-1618	06 54 13.53	+07 56 29.1	2452679.7076	0.7775	-2.48	0.40
540-0084	21 18 39.29	+06 12 15.9	2452869.6447	0.2915	-1.23	0.65

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Table 3: Fourier Components

	$F_1$	$2F_1$	$3F_1$	$4F_1$	$F_2$	$5F_1$	$6F_1$	$F_1 - F_2$	$7F_1$	$8F_1$
Freq. (c/d)	3.430	6.859	10.289	13.719	3.193	17.148	20.578	0.236	24.008	27.437
Amplitude	0.203	0.031	0.019	0.014	0.015	0.009	0.008	0.005	0.004	0.002
Phase	0.821	0.146	0.496	0.889	0.087	0.179	0.380	0.555	0.656	0.803

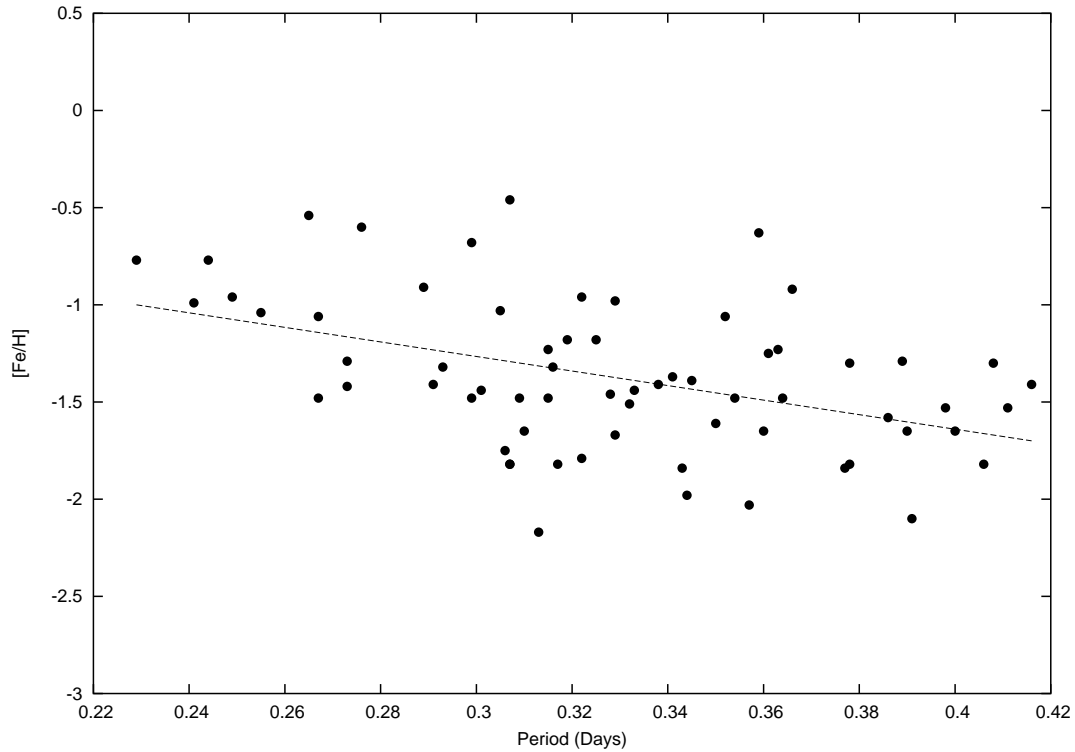


Figure 5. Period vs. [Fe/H] after Kemper (1982)