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**VARIABLES IN THE GLOBULAR CLUSTER M12 (NGC 6218)**

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Messier 12 (NGC 6218) is a moderately low metallicity ( $[\text{Fe}/\text{H}] = -1.33$ ) globular cluster which belongs to the inner Galactic halo. Only a few variables were known in it until a recent survey by Kaluzny et al. (2015) (hereafter KAL) found 36 variables in its field. All but two of these are new and twenty are shown by their proper motions to be members of the cluster. This paper reviews the known cluster variable candidates in M12 and also five more variable sources in the cluster field that are taken from the GUVV2 catalog of *GALEX* far-ultraviolet variables (Wheatley et al., 2008).

Two of the variables in M12 have been known for some time: one is a W Vir star with a 15-day period (Clement et al. 1988) and the other is a W Ursa Majoris star with a period of 0.2431 days (von Braun et al., 2002). Besides these, Malakhova et al. (1997) suggested that two RR Lyrae candidates are also cluster members and identified them on their finding chart as V2, ( $V = 14.85$ ,  $B - V = 0.57$ ) and V3, ( $V = 15.11$ ,  $B - V = 0.58$ ). Their suggestion that these stars are variables was based solely on their place in their color-magnitude diagram; they gave no photometric evidence. In the proper motion study of M12 by Zloczewski et al. (2012) (hereafter ZLO), V2 has coordinates  $\text{RA} = 251^{\circ}76088$   $\text{Dec} = -1^{\circ}90454$  and is a non-member. V3 consists of two member stars (separation 1.1 arcsec) with coordinates  $251^{\circ}80799, -01^{\circ}914043$  ( $V = 15.78$ ,  $B - V = 0.98$ ) and  $251.809007, -01.914341$  ( $V = 15.59$ ,  $B - V = 0.20$ ); they have a combined magnitude and color of  $V = 14.97$  and  $B - V = 0.47$ . Neither object is included in KAL's list of 36 variables in the M12 field and so there is no evidence that they are variables. KAL do, however, include the EW variables found by von Braun et al. (2002) but none of the X-ray sources in the M12 field given by Lu et al. (2009) or the single *GALEX* source in M12 given by Schiavon et al. (2012).

The Second *GALEX* Ultraviolet Variability Catalog (GUVV-2) of Wheatley et al. (2008) has 5 sources (Nos. 333 to 337 inclusive) in a 1.2 degree diameter field centered on M12. These variables all lie within 5 arcmin of the cluster center given by Goldsbury et al., (2010). They occupy an area that is only 2% of the observed GUVV-2 field of M12; this makes it very likely that they are all cluster members.

Table 1 gives the data for these 5 GUVV-2 sources. The nearest ZLO stars to these sources are given in the footnotes to this table in which the distances (in arcsec) between these *GALEX* sources and ZLO stars are given in parentheses. It is surprising that if

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we identify these ZLO stars with the *GALEX* variables, none of them correspond to the variables listed by KAL. Also in this case, they would have  $(NUV - V)_0$  and  $(B - V)_0$  colors that would not be those expected for globular cluster stars except that No 333 might possibly be a blue straggler. The lack of identifications of any of the *GALEX* variables with the stars in ZLO and KAL suggests that neither of these compilations are complete.

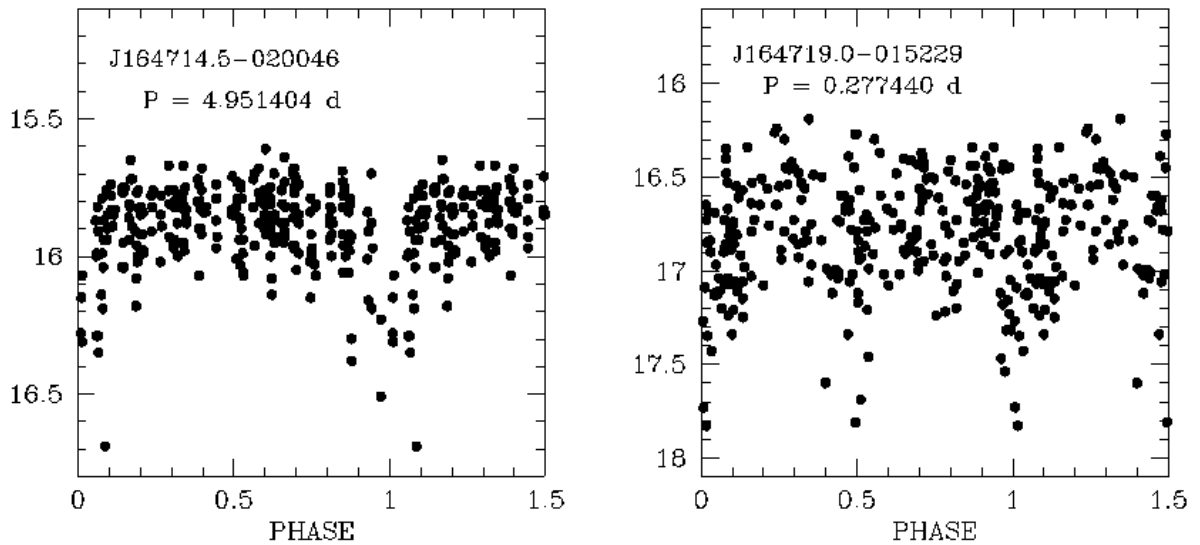
For example, J164714.5-020046 and J164719.0-015229 are two candidate variables that are 3.86 and 4.59 arcmin respectively from the cluster center. The first of these is 1.2 arcsec from a cluster member in ZLO with  $V = 16.06$  and  $(B - V) = 0.09$ ; it seems very likely that it is a cluster variable although it is not given by KAL. The second candidate is within 0.7 arcsec of a 17th magnitude star with a proper motion of  $7 \text{ mas y}^{-1}$  listed by Fedorov et al. (2011) but not by ZLO or KAL; its proper motion shows that it is not a cluster member. The ephemerides and light curves of these two variables were derived from data given in the CSS Survey (Drake et al. 2009).

The ephemerides of the two variables are:

Min = HJD 2453632.2877 ;  $P = 4.951404$  days for J164714.5-020046, and

Min = HJD 2454004.9723 ;  $P = 0.277440$  days for J164719.0-015229.

The light-curves of these two variables are given in Fig. 1.



**Figure 1.** Light curves for variables J164714.5-020046 and J164719.0-015229.

Table 1. Data for GUVV-2 variables in M12 field.

No.	Identification	R.A.	Dec.	NUV	Ampl.	$(NUV - V)_0$	$R^a$
		(J2000)		(mag.)	(mag.)	(mag.)	(arcmin)
333 <sup>b</sup>	J164714.3-020035.7	251.80958	-2.00992	19.77	1.09	+1.54	3.16
334 <sup>c</sup>	J164718.2-015603.4	251.82583	-1.93428	17.31	1.16	-1.30	1.13
335 <sup>d</sup>	J164718.8-015221.4	251.82833	-1.87261	19.38	1.03	-1.09	4.70
336 <sup>e</sup>	J164725.0-015505.9	251.85417	-1.91831	19.02	0.88	-1.20	3.26
337 <sup>f</sup>	J164727.8-020040.7	251.86583	-2.01131	18.37	2.11	-0.56	5.08

- <sup>a</sup> Radial distance in arcmin from cluster center.  
<sup>b</sup> 251.81002,  $-2.00930$  (2.65),  $V = 18.22$ ,  $B - V = 0.65$  (member);  
<sup>c</sup> 251.82527,  $-1.93485$  (2.89),  $V = 19.13$ ,  $B - V = 0.81$  (member);  
<sup>d</sup> 251.82827,  $-1.87651$  (14.04),  $V = 20.40$ ,  $B - V = 0.92$  (member);  
<sup>e</sup> 251.85442,  $-1.91819$  (1.03),  $V = 20.00$ ,  $B - V = 0.89$  (member);  
<sup>f</sup> 251.86600,  $-2.01089$  (1.90),  $V = 19.94$ ,  $B - V = 0.80$  (member).

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