Three new variable stars in the field of the RR Lyrae star GY Peg

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Abstract: Three new variable stars (HMB11 = USNO-B1.0 1249-0502361, HMB12 = USNO-B1.0 1250-0498893 and HMB13 = USNO-B1.0 1251-0501729) have been identified in the field of the RR Lyrae variable star GY Peg. Full light curves for all the three stars are presented. The form of the light curve indicates that two of the stars (HMB11 and HMB12) are EW type variable stars and the third star (HMB13) is an RRab type RR Lyrae variable star.

For HMB11 a period $P = 0. 31875$ +/- 0.00005 [d] with the epoch E_0 = HJD 2454333.747 and an amplitude of the light variation of $\Delta m = 0.20$ +/- 0.05 mag. has been found. For HMB12 a period $P = 0. 27810$ +/- 0.00005 [d] with the epoch E_0 = HJD 2454340.720 and an amplitude of the light variation of $\Delta m = 0.15$ +/- 0.05 mag. has been found. And finally for HMB13 a period $P = 0. 6278$ +/- 0.0002 [d] with the epoch E_0 = HJD 2454340.774 and an amplitude of the light variation of $\Delta m = 0.75$ +/- 0.02 mag. has been found.

Participating in a multi-site and multi-photometric band campaign of the GEOS association on the RR Lyrae type variable GY Peg (GSC2652-1324) in the constellation Pegasus has resulted in many data sets of CCD observations of the field. Both a 50 cm f/8.2 Ritchey Chrétien telescope and the STL11000XM CCD camera with a clear (C) filter and a Celestron 28 cm f/6.3 Schmidt Cassegrain telescope and an ST10XME CCD camera equipped with B, V, R Schuler photometric filters have been used. The field covered by the STL11000XM is 30' x 20', by the ST10XME is 27' x 18'. During inspection of the stars in the field with the program package C-Munipack (Motl, 2006) three other stars showing variability were detected. The new variable stars HMB11 = USNO-B1.0 1249-0502361 (average R-mag. 16.15 from the USNO-B1.0 catalog), HMB12 = USNO-B1.0 1250-0498893 (average R-mag. 16.19 from the USNO-B1.0 catalog) and HMB13 = USNO-B1.0 1251-0501729 (average R - mag. 16.75 from the USNO-B1.0 catalog) are at position $\alpha(2000) = 22^h26^m04.48^s$, $\delta(2000) = +34°59'06.0"$, $\alpha(2000) = 22^h26^m26.61^s$, $\delta(2000) = +35°00'25.1"$ and $\alpha(2000) = 22^h25^m36.74^s$, $\delta(2000) = +35°07'45.7"$, respectively. All stars have been observed during 21 nights between August 28 and December 12, 2007. The image exposure was 60 sec with the STL11000XM CCD camera and 180 sec with the ST10XME. GSC 2742 2015 was used as comparison star and two check stars were GSC 2742 1019 (check 1, mag 13.95 +/- 0.40) and GSC 2742 1077 (check 2, mag 14.01 +/- 0.40). A finder chart is given in Fig. 1. The fitted light curves of the new variable stars are given in Figs. 2-4 with relative magnitude differences for HMB11, 12 and 13, respectively. The period for each of the stars was found with the period analysis software Peranso 2.2 (Vanmunster, 2006). The method used employs periodic orthogonal polynomials to fit observations, and the analysis of variance (ANOVA) statistic to evaluate the quality of the fit. This method was proposed by (Schwarzenberg-Czerny, 1996). It strongly improves peak detection sensitivity and damps alias periods.

Table 1. Observation log.

Star	Filter	JD-24000000	Nights	Points
HMB11	C	54333-54446	32	7322
HMB11	B	54351-54360	2	67
HMB11	V	54337-54381	10	380
HMB11	R	54337-54366	8	321
HMB12	C	54333-54446	32	7322
HMB12	B	54333-54446	32	7322
HMB12	B	54333-54446	32	7322
HMB12	B	54333-54446	32	7322
HMB11	C	54333-54446	32	7322
HMB11	B	54351-54360	2	67
HMB11	V	54337-54381	10	380
HMB11	R	54337-54366	8	321

All images were reduced by applying bias, dark and flat fields before instrumental magnitudes were extracted using the program package C-Munipack (Motl, 2006). This was done using typical aperture photometry techniques. The observation log is given in Table. 1.

Tables 2, 3 give the minima of the two eclipsing binaries HMB11 and 12, respectively. The given uncertainties are those derived from fitting a second order polynomial through the data around the minimum. Table 4 lists the maxima for HMB13. All maxima and minima are determined using Peranso 2.2 (Vanmunster, 2006).

The star HMB11 = USNO-B1.0 1249-0502361 $\alpha(2000) = 22^h26^m04.48^s$, $\delta(2000) = +34°59'06.0")$ is an eclipsing binary of the EW type with the following elements HJD = 2454333.747 + 0.31875(5) E. A very symmetric light curve is observed with a shallower secondary minimum. The change in amplitude is about 0.2 mag for the secondary and about 0.3 mag for the primary minimum.

The star HMB12 = USNO-B1.0 1250-0498893 $\alpha(2000) = 22^h26^m26.61^s$, $\delta(2000) = +35°00'25.1")$ is also an eclipsing binary of the EW type with the following elements HJD = 2454340.720 + 0.27810(5) E. It shows a slightly asymmetric light curve, the maximum after the secondary minimum is slightly higher than the one after the primary minimum, the difference being in the order of 0.05 mag. The total amplitude change is about 0.15 mag.

Finally the star HMB13 = USNO-B1.0 1251-0501729 $\alpha(2000) = 22^h25^m36.74^s$, $\delta(2000) = +35°07'45.7")$ shows the typical RRab type of light curve with an amplitude variation of about 0.75 mag. Also the typical bump at the end of the descent and a further reduction in amplitude just before the steep rise is nicely visible. The rising time amounts to about 17 % of the period.
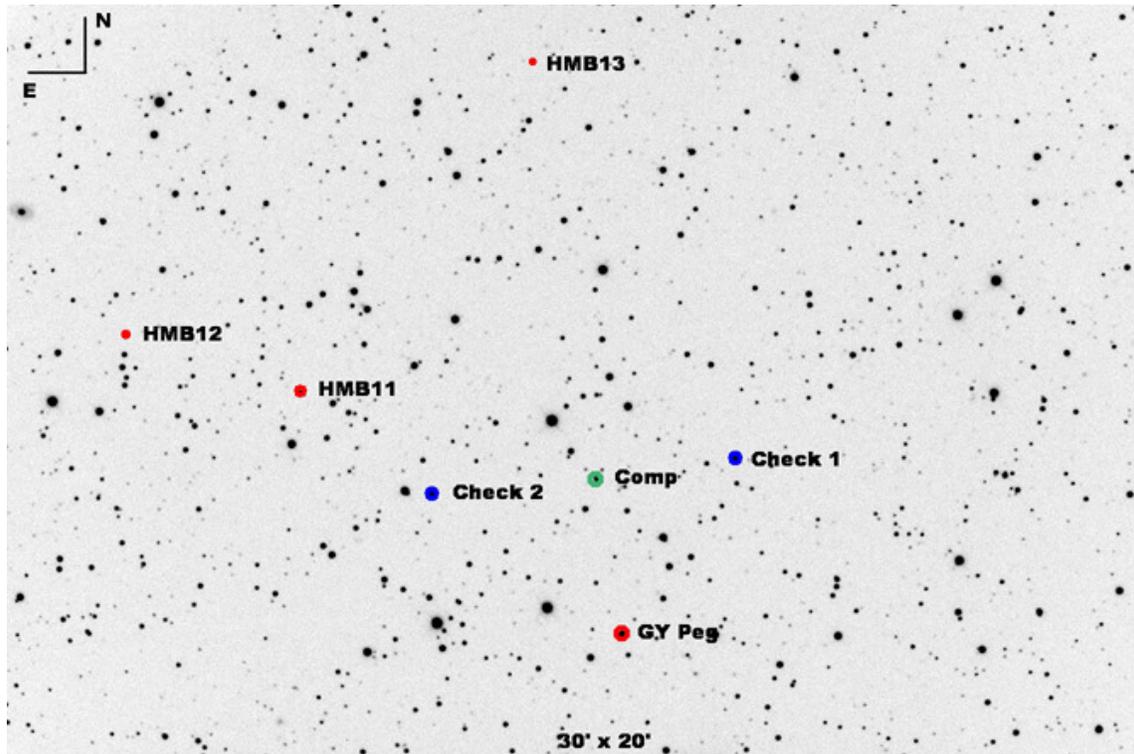

Fig. 1. Finding chart of the new variables (red circles) including comparison (green circle) and check stars (blue circles). The star is indicated by the red circle. GY Peg is also given.

Table 2. List of minima for the EW variable HMB11 = USNO-B1.0 1249-0502361

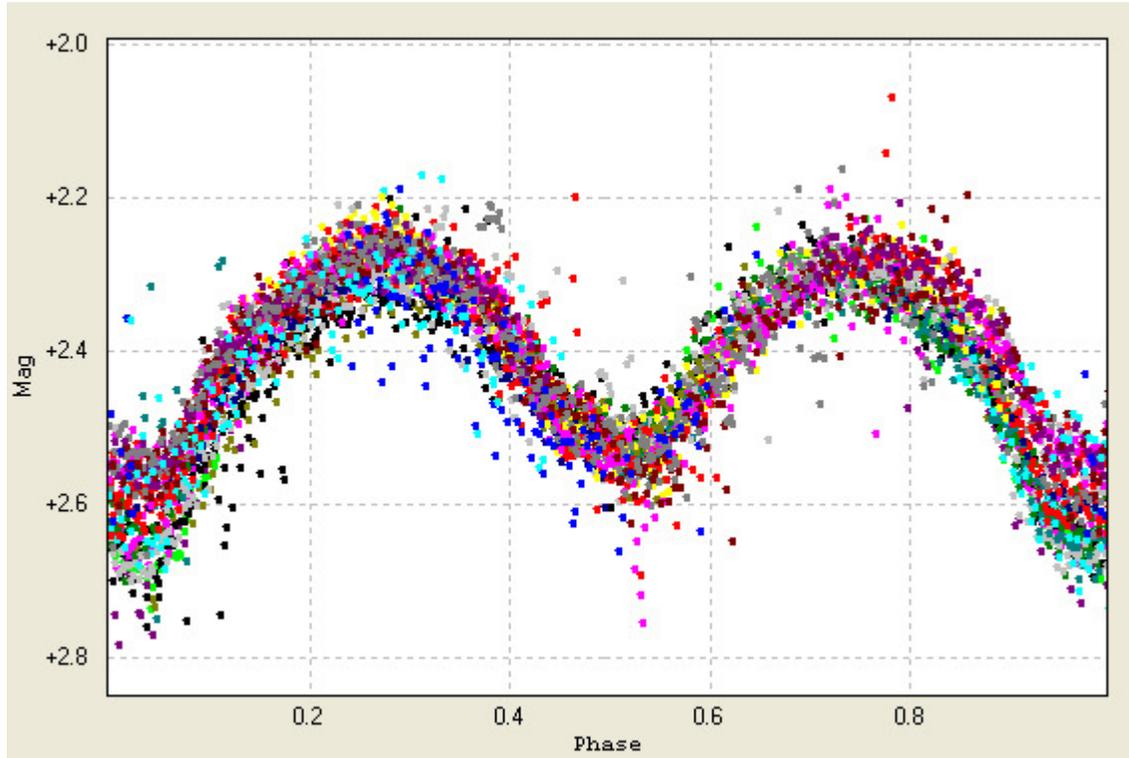| Epoch HJD-2400000	Uncertainty [days]	Minimum	Filter
54340.921	0.003	secondary	C
54345.701	0.005	secondary	C
54345.861	0.003	primary	C
54348.403	0.012	primary	V
54348.412	0.006	primary	R
54348.730	0.003	primary	C
54348.891	0.004	secondary	C
54351.442	0.006	secondary	B
54351.440	0.001	secondary	V
54351.438	0.007	secondary	R
54357.502	0.008	secondary	V
54357.494	0.007	secondary	R
54357.654	0.002	primary	C
54357.816	0.004	secondary	C
54360.364	0.007	secondary	V
54360.363	0.009	secondary	R
54360.525	0.009	primary	V
54360.523	0.007	primary	R
54361.797	0.003	primary	C
54365.458	0.005	secondary	V
54365.460	0.012	secondary	R
54366.417	0.005	secondary	V
54366.425	0.018	secondary	R
54366.577	0.008	primary	V
54366.573	0.006	primary	R
54368.809	0.005	primary	C
54376.778	0.004	primary	C
54380.446	0.008	secondary	V
54380.600	0.008	primary	V
54394.627	0.003	primary	C
54396.705	0.005	secondary	C
54397.662	0.004	secondary	C
54400.687	0.005	primary	C
54401.643	0.004	primary	C
54402.600	0.004	primary	C
54402.763	0.005	secondary	C
54403.725	0.006	secondary	C
54408.656	0.003	primary	C
54410.731	0.004	secondary	C
54418.698	0.006	secondary	C
54418.695	0.005	secondary	C
54418.696	0.005	secondary	C
54419.652	0.009	secondary	C
54420.607	0.007	primary	C
54423.640	0.006	primary	C
54423.640	0.005	primary	C
54423.640	0.006	primary	C
54439.579	0.005	primary	C
54439.580	0.007	primary	C
54446.593	0.005	primary	C

Fig. 2. Phase diagram for the star HMB11 = USNO-B1.0 1249-0502361. The different colours are the different observing runs.

Table 3. List of minima for the EW variable HMB12 = USNO-B1.0 1250-0498893

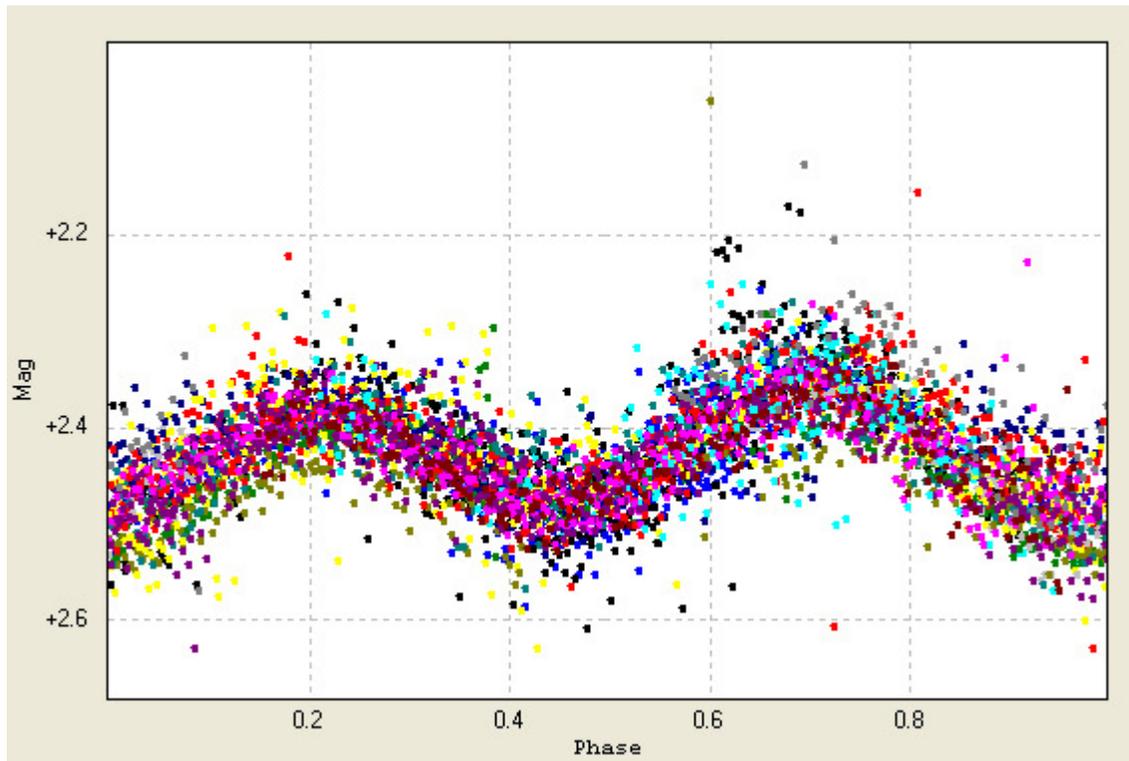| Epoch HJD-2400000	Uncertainty [days]	Minimum	Filter
54340.842	0.007	primary	C
54345.849	0.007	secondary	C
54348.777	0.004	primary	C
54348.911	0.005	secondary	C
54357.809	0.006	secondary	C
54361.701	0.006	secondary	C
54361.849	0.005	primary	C
54376.862	0.007	secondary	C
54393.826	0.005	primary	C
54397.727	0.008	primary	C
54400.638	0.007	secondary	C
54401.750	0.008	secondary	C
54402.589	0.005	secondary	C
54402.734	0.009	primary	C
54403.697	0.005	secondary	C
54408.578	0.003	primary	C
54408.701	0.003	secondary	C
54410.646	0.005	secondary	C
54418.589	0.006	primary	C
54418.594	0.009	primary	C
54418.603	0.008	primary	C
54418.713	0.010	secondary	C
54418.713	0.012	secondary	C
54418.711	0.007	secondary	C
54439.570	0.009	secondary	C

Fig. 3. Phase diagram of HMB12 = USNO-B1.0 1250-0498893. The different colors are for the different observing nights.

Table 4. List of maxima for the RRab variable HMB13 = USNO-B1.0 1251-0501729

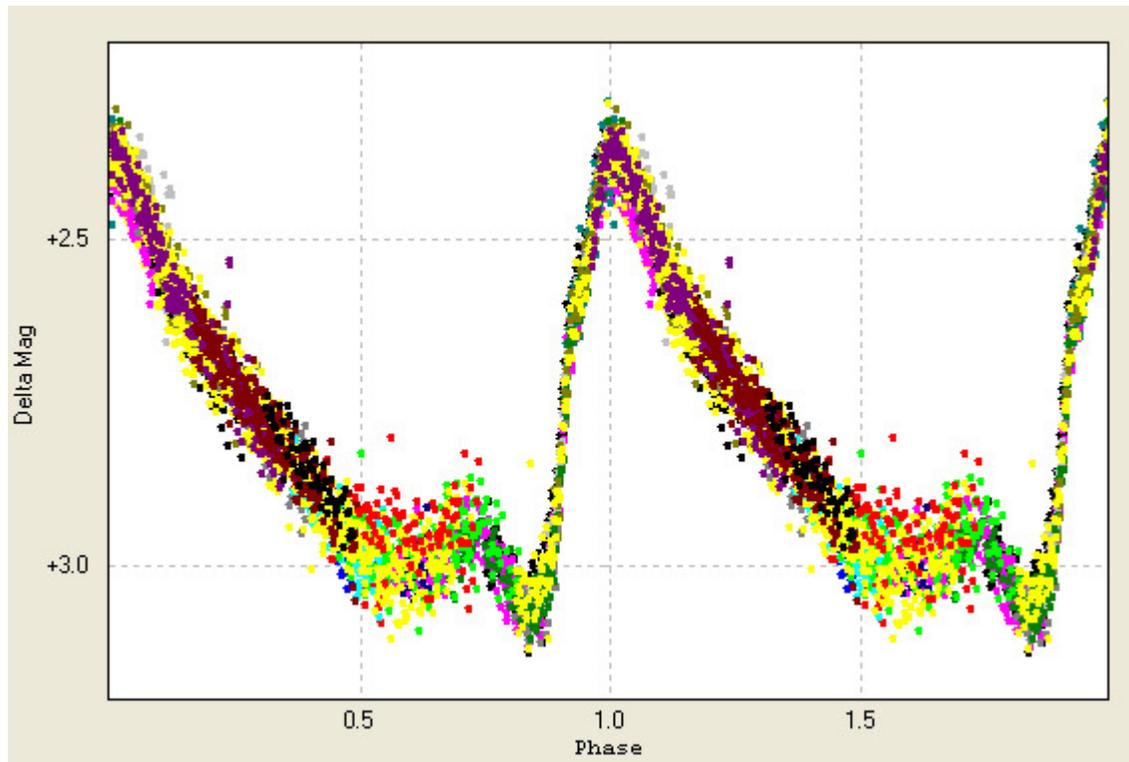| Epoch HJD-2400000	Uncertainty [days]	Filter
54345.797	0.004	C
54348.937	0.003	C
54351.456	0.010	B
54351.457	0.010	V
54351.460	0.019	R
54357.729	0.003	C
54365.886	0.004	C
54366.512	0.009	R
54380.332	0.011	V
54394.770	0.003	C
54396.653	0.003	C
54401.674	0.003	C
54408.582	0.003	C
54418.634	0.005	C
54418.631	0.007	C
54418.632	0.006	C
54423.654	0.006	C
54423.655	0.007	C
54423.654	0.010	C

Fig. 4. Phase diagram of HMB13 = USNO-B1.0 1251-0501729. The different colors are for the different observing nights.

The International Variable Star Index Database (VSX) of the AAVSO (AAVSO, 2006) has been consulted and checked whether the three mentioned variable stars are already known. This was not the case for all of them. The following table summarizes the deduced information of the newly detected variables:

Name	Magnitude	Delta-Mag.	Epoch (HJD)	Period [d]
HMB11	16.15 - 16.35	0.20 +/- 0.05	2454333.747	0.31875 +/- 0.00005
HMB12	16.19 - 16.34	0.15 +/- 0.05	2454340.720	0. 27810 +/- 0.00005
HMB13	16.75 - 17.50	0.75 +/- 0.02	2454340.774	0. 6278 +/- 0.0002

References:

- Motl D., 2006, C-Munipack Project V1.1, http://integral.physics.muni.cz/cmunipack/index.html
- Vanmunster T., 2006, Peranso V2.xx, http://www.peranso.com
- Schwarzenberg-Czerny, A., 1996, ApJ, 460, L107-110
- AAVSO, 2006, The International Variable Star Index Database (VSX), http://www.aavso.org/vsx/