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SEVEN NEW DOUBLE-MODE RR LYRAE STARS

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The number of known Galactic field double-mode RR Lyrae stars (type RRd) has grown rapidly (Wils, 2006) thanks to the automatic surveys such as the Northern Sky Variability Survey (*NSVS*; Wozniak et al., 2004) and the All Sky Automated Survey (*ASAS-3*; Pojmanski, 2002). The number of known RRd stars south of the equator is however still lower than in the northern sky, while the study of Wils, Lloyd & Bernhard (2006) has shown that the number of RRab stars brighter than magnitude 14, is about one third higher in the southern hemisphere, based on the above mentioned surveys.

A search for multiperiodicity in all the RR Lyrae stars found by *ASAS-3* was therefore carried out to identify the "missing" RRd stars. It was possible to identify seven more RRd stars for which Table 1 lists the fundamental light curve parameters. It includes values for the invariant Fourier parameters and for the generalized phase differences $G_{1,1}$ and $G_{-1,1}$ of the cross coupling terms $f_0 + f_1$ and $f_1 - f_0$ respectively, as defined by Poretti and Pardo (1997). Formal uncertainties are given between parentheses in units of the last significant decimal. Also listed are the *2MASS* (Cutri et al., 2003) colour index, the Galactic latitude b in degrees and the position and the total proper motion μ derived from the *UCAC2* catalogue (Zacharias et al., 2004). The position for GSC 8758-1831 was taken from *2MASS*. The electronic version of the IBVS contains direct links to the *ASAS-3* source data.

The stars GSC 6368-0742 and GSC 8833-1048 are also known as NSV 13710 and NSV 14764 respectively.

The plots in Fig. 1 give the phase diagrams for the new double-mode RR Lyrae stars for the fundamental mode and the first overtone mode, in both cases prewhitened for the other mode and its harmonics and linear combinations of the frequencies. The fundamental mode of GSC 6108-0220 has an especially low amplitude.

The Petersen diagram in Fig. 2 with the known Galactic field double-mode RR Lyrae stars (from Wils, 2006 and this paper) together with those found in the Galactic Bulge (Moskalik & Poretti, 2003; Pigulski et al., 2003; Mizerski, 2003) and the Galactic foreground stars to the Sagittarius dwarf galaxy (Cseresnjes, 2001) shows a clear trend with an almost constant period ratio at longer periods and a rapidly decreasing period ratio towards smaller periods. Two stars stand out with a larger period ratio than expected. These are bul_sc39_1568 (Mizerski, 2003) and vd5f715 (Cseresnjes, 2001), both probably have a quite different metallicity (Popielski et al., 2000).

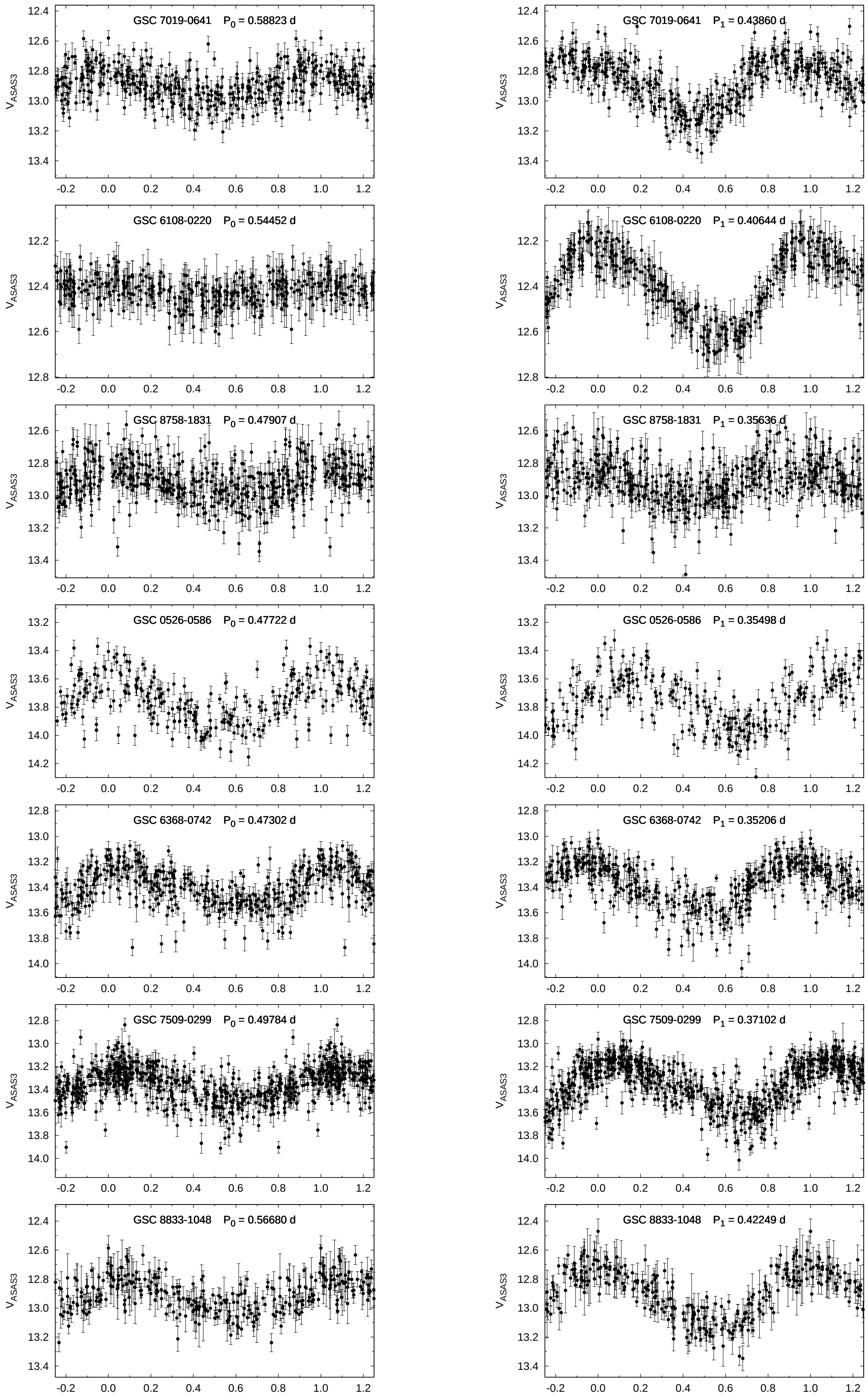

Figure 1. Phased light curves for the fundamental mode (left panels) and first overtone (right panels) periods of the new RRd stars, based on *ASAS-3* data.

Table 1: Characteristics of the new double-mode RR Lyrae stars

GSC	7019-0641	6108-0220	8758-1831	0526-0586	6368-0742	7509-0299	8833-1048
V_{ASAS3}	12.43-13.42	11.93-12.74	12.27-13.42	13.01-14.22	12.87-14.22	12.79-14.04	12.39-13.41
Period F (d)	0.58823(7)	0.54452(6)	0.47907(5)	0.47722(5)	0.47302(5)	0.49785(6)	0.56680(7)
Period 1O (d)	0.43860(4)	0.40644(4)	0.35636(3)	0.35498(3)	0.35206(3)	0.37102(3)	0.42249(4)
Period ratio	0.7456(1)	0.7464(1)	0.7439(1)	0.7438(1)	0.7443(1)	0.7452(1)	0.7454(1)
Amplitude ratio 1O/F	2.2(2)	6.0(10)	1.5(2)	1.3(1)	1.5(1)	1.6(2)	1.9(2)
R_{21}(F)	0.22(9)	–	–	–	0.29(8)	0.15(8)	0.16(8)
R_{21}(1O)	0.22(4)	0.19(3)	–	0.17(7)	0.10(5)	0.25(5)	0.17(4)
Φ_{21}(F)	3.57(33)	–	–	–	4.24(18)	4.99(31)	3.99(34)
Φ_{21}(1O)	5.21(17)	4.82(6)	–	5.23(19)	4.52(3)	4.82(19)	4.64(25)
$G_{1,1}$	4.23(37)	4.86(17)	3.64(9)	4.35(10)	4.26(5)	4.64(14)	3.87(3)
$G_{-1,1}$	3.49(9)	–	2.81(14)	4.85(24)	3.11(53)	3.52(12)	3.37(10)
b	-60.6	$+40.8$	-20.1	-29.2	-42.7	-66.2	-61.7
RA (2000)	$03^{h}05^{m}27.^{s}64$	$12^{h}25^{m}09.^{s}50$	$18^{h}40^{m}35.^{s}32$	$21^{h}07^{m}26.^{s}08$	$21^{h}27^{m}21.^{s}17$	$23^{h}04^{m}49.^{s}09$	$23^{h}56^{m}21.^{s}77$
Dec (2000)	$-30^\circ58'38.''7$	$-21^\circ39'52.''5$	$-53^\circ50'32.''1$	$+01^\circ10'17.''6$	$-19^\circ07'59.''1$	$-33^\circ45'14.''3$	$-53^\circ29'21.''9$
μ (mas/yr)	25	7	–	22	43	29	14
$J-K_s$	0.30	0.29	0.25	0.24	0.25	0.27	0.27

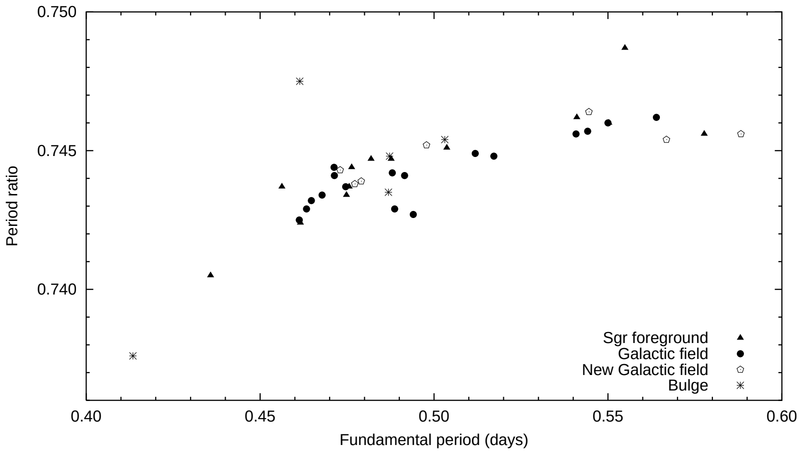

Figure 2. Petersen diagram for the known Galactic RRd stars.

With these newly identified RRd stars, there are now 9 known in the northern sky brighter than magnitude 14, compared to 13 south of the equator. The latter does not take into account the stars near the centre of Milky Way, which are fainter and in a crowded region so that they are not detectable by either *ASAS-3* or *NSVS*. The fainter stars EM and EN Dra have not been included in the number for northern RRd's. These numbers are in line with the ratio found for the RRab stars.

The total number of RRd stars brighter than magnitude 14 depends on the completeness of the search for RR Lyrae variables in general, especially for RRc variables, among which most RRd variables will be found. Wils et al. (2006) give an estimated 75% for the completeness ratio of *ASAS-3* RRc variables (and 92% for RRab variables). The completeness ratio for the RRc stars found in *NSVS* data is lower, but in the northern sky more RRd stars have been found that could not be identified in the *NSVS* data. Overall, it may be assumed that at least 75% of all RRd stars brighter than magnitude 14 have been discovered.

The distribution of all Galactic RRd stars across the sky in Galactic coordinates is given in Fig. 3.

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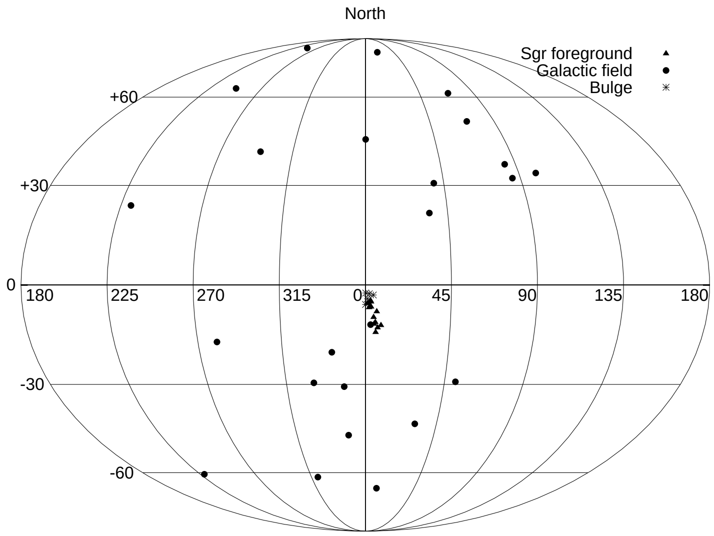

Figure 3. Distribution of the Galactic RRd stars in Galactic coordinates (the central horizontal line represents the Galactic equator).

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