COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS

Number 5593

Konkoly Observatory
Budapest
15 January 2005

HU ISSN 0374 – 0676

FOUR NEW SOUTHERN DOUBLE-MODE RR LYRAE STARS

WILS, PATRICK[1]; OTERO, SEBASTIÁN A.[2]

[1] Vereniging Voor Sterrenkunde, Belgium; e-mail: patrick.wils@cronos.be

[2] Grupo Wezen 1 88, Centro de Estudios Astronómicos (CEA); e-mail: varsao@fullzero.com.ar

Double-mode pulsators, and double-mode RR Lyrae stars (type RRd) in particular, are very important in the study of pulsation models. Although they are abundant in the Magellanic Clouds (Alcock et al., 2000) and Galactic globular clusters (e.g. Walker and Nemec, 1996), very few Galactic Field RRd stars are known. The online edition of the General Catalogue of Variable Stars (GCVS, Kholopov et.al., 2003) only lists five RRd stars (new GCVS type RR(B)). A few other field and faint Galactic Bulge RRd stars have been discovered since, but there is still an apparent lack of relatively bright RRd stars in the Southern hemisphere and with negative Galactic latitudes.

By examining the publicly available data for the Southern RR Lyrae stars discovered by the *ASAS3* survey (Pojmanski, 2002), we found four previously unknown double-mode RR Lyrae stars.

Table 1 lists fundamental light curve parameters for the four stars, derived from the *ASAS3* data. 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 errors are given between parentheses in units of the last significant decimal. Also listed are the Galactic latitude b in degrees, the total proper motion μ derived from the *UCAC2* catalogue (Zacharias et al., 2004), and *Tycho-2* (Høg et al., 2000) and *2MASS* (Cutri et al., 2003) colour indices. The electronic version of the IBVS contains direct links to the *ASAS3* source data.

GSC 4868-0831 is the brightest RRd star known thus far. The amplitude of the first overtone is much higher than that of the fundamental mode for this star. For the other stars the amplitudes of both modes are more alike.

For GSC 7411-1269 the additional cross-coupling frequencies $2f_0 + f_1$, $f_0 + 2f_1$ and $2f_0 + 2f_1$ are present in the power spectrum.

GSC 8403-0647 is the Southern component of a close pair separated by $11''$, which the *ASAS3* camera cannot resolve. The *ASAS3* average position is in fact about midway between the two stars, but slightly closer to GSC 8403-0647 (40% of the distance), so that the latter is most probably the brightest of the two in V. This is confirmed by their *UCAC2* magnitudes. The *2MASS* catalogue indicates that the companion is slightly brighter in near infrared wavelengths ($J = 11.94$ compared to $J = 12.01$), but is also much redder with $J - K_s = 0.62$. Due to its redness, it is unlikely that the companion is the RR Lyrae variable. The pair is most probably physically unrelated, as shown by their *UCAC2* proper motions.

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

Star	GSC 4868-0831	GSC 7411-1269	GSC 8403-0647	GSC 8936-2145
V_{ASAS3}	10.45−11.05	11.95−13.00	12.05−12.80	12.25−13.25
HJD Maximum	2452940.85	2452789.60	2453108.83	2452614.70
Period F (d)	0.56391(11)	0.46126(7)	0.46781(6)	0.51721(9)
Period 1O (d)	0.42079(6)	0.34247(4)	0.34778(4)	0.38521(5)
Period ratio	0.7462(2)	0.7425(1)	0.7434(1)	0.7448(2)
R_{21}(F)	0.11(4)	0.20(2)	0.17(4)	0.23(3)
R_{21}(1O)	0.21(2)	0.18(2)	0.19(4)	0.14(2)
Φ_{21}(F)	4.00(19)	4.10(8)	3.91(23)	3.95(10)
Φ_{21}(1O)	4.90(7)	4.82(4)	5.05(11)	4.68(4)
Amplitude ratio 1O/F	2.45(10)	0.98(2)	1.05(6)	1.37(5)
$G_{1,1}$	4.26(8)	4.01(2)	4.28(10)	3.99(9)
$G_{-1,1}$	3.68(8)	3.88(7)	3.35(21)	3.86(5)
b	+23.8	−11.8	−30.7	−17.0
μ (mas/yr)	54.6(1.7)	36.2(2.3)	13.7(3.0)	28.2(4.6)
$(B-V)_T$	0.41	−0.30	−0.07	–
$J-K_s$	0.30(3)	0.30(4)	0.23(4)	0.31(3)

The plots in Figs. 1 to 8 give for each of the stars the phase diagram for the fundamental mode and the first overtone mode, in both cases prewhitened for the other mode and its harmonics.

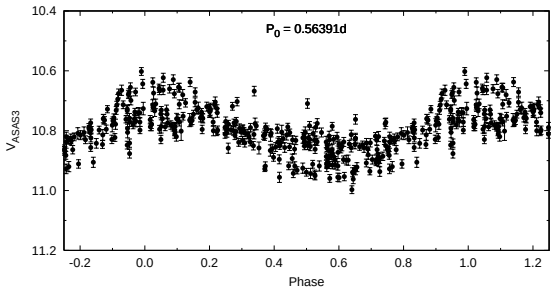

Figure 1. ASAS3 phased light curve for the fundamental period of GSC 4868-0831.

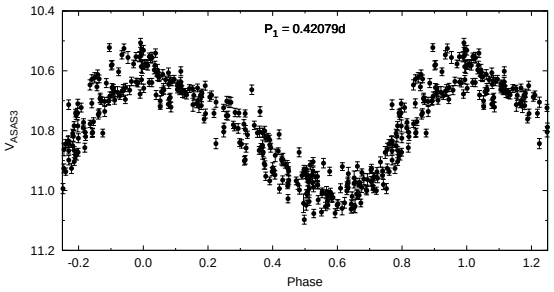

Figure 2. ASAS3 phased light curve for the first overtone period of GSC 4868-0831.

Acknowledgements: This research has utilised the *ASAS3* public photometry catalogue and the SIMBAD and VizieR databases operated at the *Centre de Données Astronomiques (Strasbourg)* in France. Use was made of the data products from the *Two Micron All Sky Survey*, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation. John Greaves is acknowledged for helpful suggestions and comments.

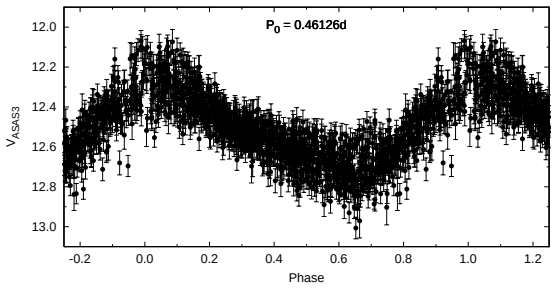

Figure 3. ASAS3 phased light curve for the fundamental period of GSC 7411-1269.

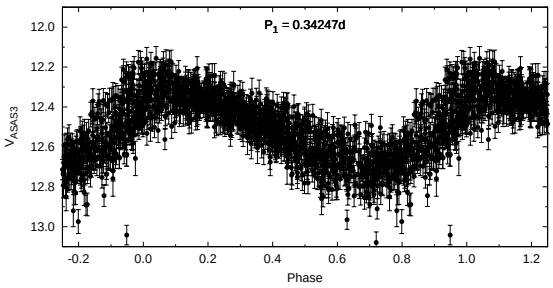

Figure 4. ASAS3 phased light curve for the first overtone period of GSC 7411-1269.

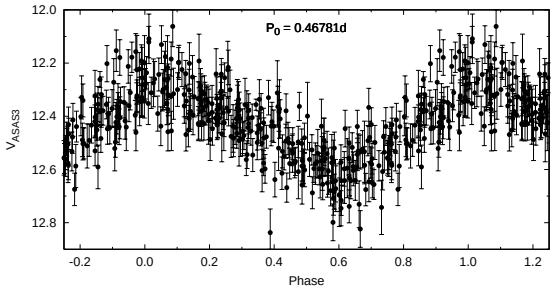

Figure 5. ASAS3 phased light curve for the fundamental period of GSC 8403-0647.

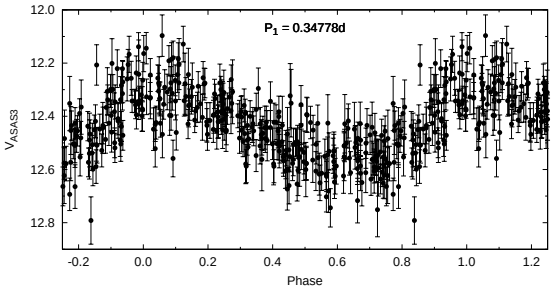

Figure 6. ASAS3 phased light curve for the first overtone period of GSC 8403-0647.

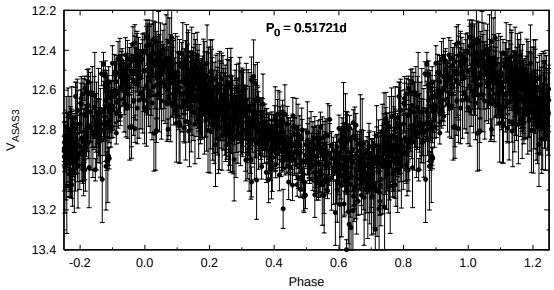

Figure 7. ASAS3 phased light curve for the fundamental period of GSC 8936-2145.

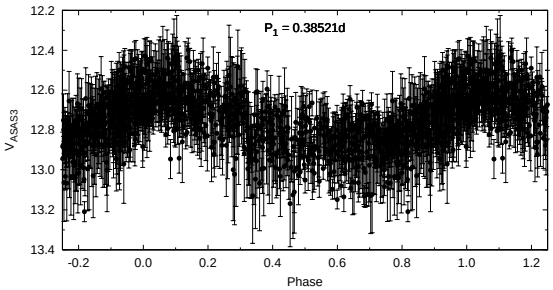

Figure 8. ASAS3 phased light curve for the first overtone period of GSC 8936-2145.

References:

Alcock C., et al., 2000, *ApJ*, **542**, 257
Cutri R.M., et al. 2003, Expl. Suppl. To the 2MASS All Sky Data Release, `http://www.ipac.caltech.edu/2mass/releases/allsky/doc/explsup.html`
Kholopov P.N., et. al., 2003, General Catalogue of Variable Stars version 1.4 Vol. IV, `http://www.sai.msu.su/groups/cluster/gcvs/gcvs/`
Høg E., Fabricius C., Makarov V.V., Urban S., Corbin T., Wycoff G., Bastian U., Schwekendiek P., Wicenec A., 2000, *A&A*, **355**, L27
Pojmanski G., 2002, *Acta Astronomica*, **52**, 397
Poretti E., Pardo I., 1997, *A&A*, **324**, 133
Walker A.R., Nemec J.M., 1996, *AJ*, **112**, 2026
Zacharias N., Urban S.E., Zacharias M.I., Wycoff G.L., Hall D.M., Monet D.G., Rafferty T.J., 2004, *AJ*, **127**, 3043