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Z Gru AND GSC 9092-1397 ARE DOUBLE-MODE RR LYRAE VARIABLE STARS

WILS, PATRICK

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

Recently a number of Galactic field double-mode RR Lyrae stars (type RRd) have been discovered in the publicly available data from the Northern Sky Variability Survey (*NSVS*; Wozniak et al., 2004) and the All Sky Automated Survey (*ASAS-3*; Pojmanski, 2002). The most recent discoveries were announced by Oaster, Smith & Kinemuchi (2005) and Wils, Lloyd & Bernhard (2006). Still, the number of field RRd stars is much lower than for example in the Large Magellanic Cloud (Alcock et al., 2000).

Further examination of the southern RR Lyrae stars listed by the *ASAS-3* survey, has revealed two more previously unknown double-mode RR Lyrae stars: Z Gru and GSC 9092-1397.

Table 1 lists fundamental light curve parameters for these stars, derived from the *ASAS-3* 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 uncertainties are given between parentheses in units of the last significant decimal. Also listed are the Galactic latitude b in degrees, the position and the total proper motion μ derived from the *UCAC2* catalogue (Zacharias et al., 2004), and the *2MASS* (Cutri et al., 2003) colour index. The electronic version of the IBVS contains direct links to the *ASAS-3* source data.

The plots in Figs. 1 to 4 give the phase diagrams for both stars for the fundamental mode and the first overtone mode, in both cases prewhitened for the other mode and its harmonics.

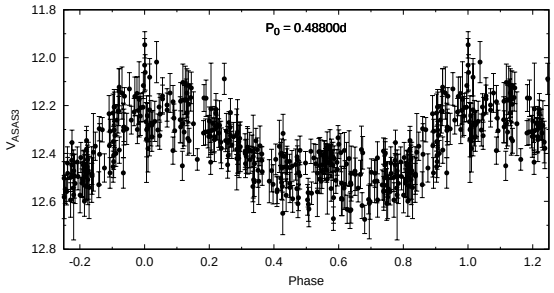

Figure 1. *ASAS-3* phased light curve for the fundamental period of Z Gru.

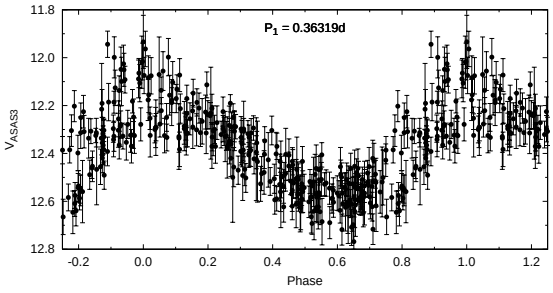

Figure 2. *ASAS-3* phased light curve for the first overtone period of Z Gru.

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

Star	GSC 9092-1397	Z Gru
V_{ASAS-3}	12.91-13.71	12.01-12.70
HJD Maximum	2452535.59	2452909.70
Period F (d)	0.49152(5)	0.48800(5)
Period 1O (d)	0.36574(3)	0.36319(3)
Period ratio	0.7441(1)	0.7442(1)
R_{21}(F)	0.23(5)	0.26(3)
R_{21}(1O)	0.21(4)	0.17(2)
Φ_{21}(F)	3.92(9)	3.65(10)
Φ_{21}(1O)	4.84(19)	4.99(10)
Amplitude ratio 1O/F	1.17(7)	1.30(5)
$G_{1,1}$	3.97(11)	3.92(8)
$G_{-1,1}$	3.56(18)	3.82(8)
b	-29.5	-46.5
RA (2000)	$19^{\rm h}39^{\rm m}33\overset{\rm s}{.}50$	$21^{\rm h}34^{\rm m}37\overset{\rm s}{.}12$
Dec (2000)	$-65^\circ 28' 51\overset{''}{.}1$	$-49^\circ 07' 28\overset{''}{.}6$
μ (mas/yr)	22.3	33.6
$J - K_s$	0.28	0.29

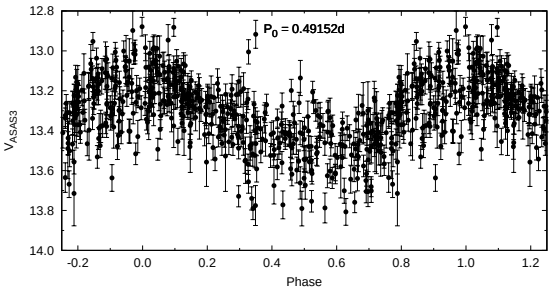

Figure 3. *ASAS-3* phased light curve for the fundamental period of GSC 9092-1397.

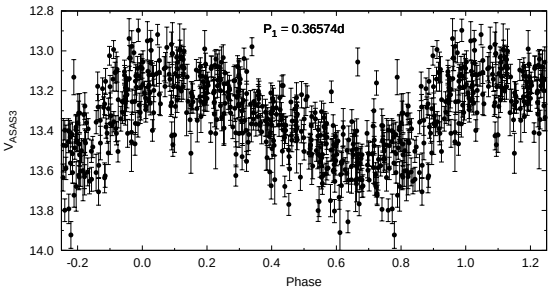

Figure 4. *ASAS-3* phased light curve for the first overtone period of GSC 9092-1397.

Table 2: Galactic field double-mode RR Lyrae stars

Star	f_0	f_1	Ratio	A_1/A_0	Ref.
GSC 4868-0831	1.7733	2.3764	0.7462	2.45	1
AQ Leo	1.8182	2.4369	0.746	1.65*	2
CU Com	1.8377	2.4645	0.7457	2	3
GSC 4421-1234	1.8491	2.4802	0.7456	2.25*	4
GSC 8936-2145	1.9335	2.5960	0.7448	1.37	1
EN Dra	1.9537	2.6228	0.7449	2.03	5
GSC 3059-0636	2.0243	2.7255	0.7427	0.38	6
GSC 9092-1397	2.0345	2.7342	0.7441	1.17	7
BS Com	2.0463*	2.7544*	0.7429*	1.42*	8
Z Gru	2.0492	2.7534	0.7442	1.30	7
V458 Her	2.0673	2.7780	0.7442	2.17*	4
GSC 3047-0176	2.1070	2.8330	0.7437	1.29*	9
V372 Ser	2.1220	2.8507	0.7444	1.4	10
GSC 8403-0647	2.1376	2.8754	0.7434	1.05	1
EM Dra	2.1518	2.8953	0.7432	1.18	5
V2493 Oph	2.1582	2.9050	0.7429	1.58	11
GSC 7411-1269	2.1680	2.9199	0.7425	0.98	1

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[1] Wils & Otero, 2005
[2] Jerzykiewicz & Wenzel, 1977
[3] Clementini et al., 2000
[4] Wils, Lloyd & Bernhard, 2006
[5] Clement, Kinman & Suntzeff, 1991
[6] Oaster, Smith & Kinemuchi, 2005
[7] This paper
[8] Bragaglia et al., 2003
[9] Koppelman et al., 2004
[10] García-Melendo, Henden & Gomez-Forrellad, 2001
[11] García-Melendo & Clement, 1997

Table 2 lists all isolated Galactic field double-mode RR Lyrae stars known in the literature, in the order of increasing fundamental frequency. The table also gives the first overtone frequency and the frequency and amplitude ratio. Missing values in the literature were derived from *NSVS* or *ASAS-3* data when possible and are marked with an asterisk. This list does not include the double-mode RR Lyrae stars found in the Galactic Bulge (Moskalik & Poretti, 2003; Pigulski et al., 2003; Mizerski, 2003), nor the Galactic foreground stars to the Sagittarius dwarf galaxy (Cseresnjes, 2001).
The double-mode nature of BS Com was suggested by Bragaglia et al. (2003), but *ASAS-3* and *NSVS* data demonstrate its reality.

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