"Peremennye Zvezdy",
Prilozhenie,
vol. 13, N 11 **(2013)**

Four Double-Mode Variables

A. V. Khruslov[#1], S. Huemmerich[#2,3], K. Bernhard[#2,4]

#1. Institute of Astronomy, Russian Academy of Sciences, Moscow, Russia;
#2. Bundesdeutsche Arbeitsgemeinschaft fuer Veraenderliche Sterne e.V. (BAV), Berlin, Germany;
#3. Braubach, Germany;
#4. Linz, Austria.

Received: 26.03.2013; accepted: 11.09.2013
(E-mail for contact: khruslov@bk.ru, ernham@rz-online.de, klaus.bernhard@liwest.at)

#	Name	Other	Coord (J2000)	Type	Max	Min	System	Period	Epoch (JD)	type	Sp	Comment	L.Curve	Find.Chart	Data
1	V722 Cen	USNO-A2.0 0525-17387339	14 21 54.04, -32 06 41.5	RR(B)	15.97	16.91	CV	(see Comments)	(see Comments)	max		Comm. 1	1.PNG	chart1.PNG	SSS_data_1.txt
2	NSV 7160	GSC 6189-01386	15 37 19.92, -18 00 56.7	RR(B)	14.20	14.73	CV	(see Comments)	(see Comments)	max		Comm. 2	2.PNG	chart2.PNG	CSS_data_2.txt SSS_data_2.txt
3		GSC 5195-00550	21 29 52.69, -01 10 18.9	HADS(B)	14.22	14.65	CV	(see Comments)	(see Comments)	max		Comm. 3	3.PNG	chart3.PNG	CSS_data_3.txt
4	AG Aqr	GSC 6954-00197	22 05 31.83, -22 30 00.8	HADS(B)	14.57	14.99	CV	(see Comments)	(see Comments)	max	A3	Comm. 4	4.PNG	chart4.PNG	SSS_data_4.txt

Comments:

1. The variability of V722 Cen was discovered by Hoffmeister (1963, S 6555). The variable is listed in the GCVS as an RR star without light elements. V0722 Cen has been identified as a double-mode RR Lyrae star, type RR(B), by analysis of Catalina Real-Time Transient Survey (CRTS) data (Drake et al. 2009). The light elements are:

Mode	Frequency, c/d	Semi-amplitude, CV mag	Period, days	Epoch, JD
f_0	2.180450	0.177	0.458621	2454800.818
f_1	2.936564	0.153	0.340534	2454800.828
$f_1 + f_0$	5.117037	0.053	0.1954256	2454800.609
$f_1 - f_0$	0.756184	0.044	1.32243	2454800.76

The period ratio is $P_1 / P_0 = 0.7425$. J–K = 0.634 (2MASS), B–V = 0.298 (The AAVSO Photometric All-Sky Survey, hereafter APASS).

2. The variability of NSV 7160 = GSC 6189–01386 was discovered by Hanley (1942, HV 10687). The star is classified as an RR Lyrae star ("Cluster"). The variable is listed in the GCVS as an RR star without light elements. Drake et al. (2013) give type RRAB with the following elements: HJD 2453553.3923 + 0.844092×E. We re-analyzed Catalina Sky Survey (CSS) and Siding Springs Survey (SSS) data (Drake et al. 2009), this period is wrong, the variable is actually a double-mode RR Lyrae star of RR(B) type. The light elements are:

Mode	Frequency, c/d	Semi-amplitude, CV mag	Period, days	Epoch, JD
f_1	2.32223	0.150	0.43062	2455000.647
f_0	1.72840	0.035	0.57857	2455000.800

The period ratio is $P_1 / P_0 = 0.7443$. J–K = 0.306 (2MASS), B–V = 0.426 (APASS).

3. The variability of GSC 5195–00550 was reported by Süveges et al. (2012, Id. 2345453). They classified the variable as a High-Amplitude Delta Scuti star (HADS) with the period 0.080586 days. According to the CSS data (Drake et al. 2009), it is a double-mode HADS star. The light elements are:

Mode	Frequency, c/d	Semi-amplitude, CV mag	Period, days	Epoch, HJD
f_0	12.40910	0.130	0.0805860	2454700.5735
f_1	16.01591	0.027	0.0624379	2454700.5607
$f_1–f_0$	3.606780	0.021	0.2772556	2454700.523
$f_1 + f_0$	28.42508	0.014	0.0351802	2454700.530

The period ratio is $P_1 / P_0 = 0.7748$. J–K = 0.142 (2MASS), B–V = 0.528 (APASS).

4. The variability of AG Aqr was discovered by Hughes (1931, HV 4965), The star is classified as a short-period variable. It is listed in the GCVS as an RR: star without light elements, with a reference to Bond (1978). According to the SSS data (Drake et al. 2009), it is a double-mode High-Amplitude Delta Scuti star, type HADS(B). The light elements are:

Mode	Frequency, c/d	Semi-amplitude, CV mag	Period, days	Epoch, JD
f_0	3.427745	0.098	0.291737	2454800.650
f_1	4.50041	0.040	0.222202	2454800.606

The period ratio is $P_1 / P_0 = 0.7617$. The period is unusually long period for this type. J–K = 0.237 (2MASS). B–V = 0.233 (APASS).

Remarks:

We present a new investigation of four variable stars. We analyzed all observations available for these stars in the Catalina Surveys (Drake et al. 2009) online public archives using the period-search software developed by Dr. V.P. Goranskij for Windows environment and Period04 code (Lenz and Breger 2005). According to these data, the variables are double-mode variables (RR Lyrae and High-Amplitude Delta Scuti stars), pulsating in the first-overtone and fundamental modes.

Their period ratios, P_1 / P_0, are typical of radially pulsating double-mode RR Lyrae and HADS stars. Along with the light curves, we present power spectra of the variables, for the raw data and after subtraction of the first-overtone oscillations. The structure of the power spectra shows that the secondary periods are real.

The tabulated coordinates of the variables were drawn either from the 2MASS catalog (Skrutskie et al. 2006) or from the GCVS (Samus et al. 2007–2012).

Acknowledgements: The authors wish to thank Dr. V.P. Goranskij for providing his software.
The CSS survey is funded by the National Aeronautics and Space Administration under Grant No. NNG05GF22G issued through the Science Mission Directorate Near-Earth Objects Observations Program. The CRTS survey is supported by the U.S.~National Science Foundation under grants AST-0909182.

References:

Bond, H.E., 1978, PASP, 90, 526
Drake, A. J., Catelan, M., Djorgovski, S. G., et al., 2013, Astrophys. J., 763, 20
Drake, A.J., Djorgovski, S.G., Mahabal, A., et al., 2009, Astrophys. J., 696, 870
Hanley, C.M., 1942, Harvard Observ. Annals, 109, 15
Hoffmeister, C., 1963, Veröff. Sternwarte Sonn., 6, 1
Hughes, E.M., 1931, Harvard Observ. Bull., 883, 18
Lenz, P., Breger, M., 2005, Comm. in Asteroseismology, 146, 53
Samus, N.N., Durlevich, O.V., Kazarovets, E V., et al., 2007 - 2012, General Catalogue of Variable Stars, Centre de Donnees Astronomiques de Strasbourg, B/gcvs
Skrutskie, M.F., Cutri, R.M., Stiening, R., et al., 2006, Astron. J., 131, 1163
Süveges, M., Sesar, B., Váradi, M., 2012, Monthly Not. Roy. Astron. Soc., 424, 2528