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RADIAL VELOCITIES FOR TWELVE PULSATING VARIABLES IN THE ANTICENTER

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The kinematics of the *outer* halo can be studied by using the radial velocities of tracers such as RR Lyrae stars in the direction of the Anticenter. Radial velocities of distant Anticenter RR Lyraes have been given by Pier et al. (2003). In this paper we give radial velocities for twelve more pulsating variables in the Anticenter ($171^\circ < l < 186^\circ$). Eleven are RR Lyrae variables and one (NSVS 48209670) is a δ-Scuti (DSCT) star. Five have been previously identified as RR Lyrae stars: DQ Lyn (Kinman, 1998), NSV 17902 and EN Lyn (Kinemuchi et al., 2006), BN UMa (McClusky, 2008) and CK UMa (Hoffleit, 1972).

Table 1. Identifications and positions for the variables

No.	Identification	R.A.	Dec.	Other ID
		J 2000		
01	NSVS 4732626[a]	$08^h01^m56^s.2$	$+41^\circ01'18''$	···
02	DQ Lyn	$08^h23^m41^s.0$	$+37^\circ28'11''$	···
03	NSV 17902[b]	$08^h30^m41^s.7$	$+40^\circ24'25''$	NSVS 4812548[a]
04	Case A-F 232[c]	$08^h31^m52^s.2$	$+38^\circ32'14''$	NSVS 4812987[a]
05	NSVS 4814234[a]	$08^h32^m49^s.6$	$+43^\circ16'02''$	···
06	NSVS 4819931[a]	$08^h43^m56^s.7$	$+43^\circ22'13''$	···
07	NSVS 4820967[a]	$08^h46^m10^s.2$	$+43^\circ04'31''$	···
08	EN Lyn	$08^h46^m07^s.0$	$+38^\circ02'53''$	···
09	NSVS 4822969[a]	$08^h50^m39^s.5$	$+43^\circ40'03''$	···
10	NSVS 4894895[a]	$09^h44^m36^s.3$	$+41^\circ08'35''$	BPS 16927-123 [d]
11	BN UMa	$11^h16^m22^s.9$	$+41^\circ14'02''$	···
12	CK UMa	$12^h01^m36^s.4$	$+31^\circ54'12''$	···

[a] Northern Sky Variability Survey, (Wozniak et al., 2004).
[b] New Catalogue of Suspected Variables, (Kholopov, 1982).
[c] Case A-F star.(Pesch and Sanduleak, 1989).
[d] HB-star candidate. (Beers et al., 1996).

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The remainder are A-F stars identified in the Case low-dispersion Northern Sky Survey (Pesch & Sanduleak, 1989) or unpublished stars from this survey that were kindly made available by P. Pesch (private communication, 1997). Identifications and coordinates of these stars are given in Table 1.

Most of the spectra from which the radial velocities were obtained were taken in the interval 2009 November 15 to 18 UT with the MMT blue-channel spectrograph. This gave flux-calibrated spectra that cover $\lambda\lambda$ 3600 – 4500 with a spectral resolution of 1.0Å. The spectra had a S/N in the range 50 to 100 which give radial velocities with a precision of 2 to 3 km s^{-1}. The spectra of NSVS 4822969 and CK UMa were taken on 2009 December 19 UT with the FAST spectrograph on the Whipple Observatory 1.5-m telescope. These spectra cover $\lambda\lambda$ 3600 – 5500, and have a spectral resolution of 2.3 Å and a S/N of 30. The radial velocities from these spectra have a precision of 5 km s^{-1}. The heliocentric radial velocities are presented in Table 2.

Table 2. Spectroscopic Observations

No.	JDH[a] +2400000.	Exp.[b] (sec)	RV[c] km s^{-1}	ϕ^d	No.	JDH[a] +2400000.	Exp.[b] (sec)	RV[c] km s^{-1}	ϕ^d
01	55154.046	210	+67	0.366	07	55152.040	150	−37	0.268
02	55151.049	30	+56	0.408	08	55154.048	90	−43	0.941
03	55151.046	150	+38	0.320	09	55185.058	570	+46	0.245
04	55151.038	300	+316	0.875	10	55154.035	60	+61	0.181
05	55151.042	130	+10	0.472	11	55154.038	90	+7	0.936
06	55152.043	120	−203	0.530	12	55185.049	180	−10	0.018

[a] Heliocentric Julian Date of mid-exposure;
[b] Exposure time;
[c] Heliocentric radial velocity;
[d] Phase of mid-exposure

The variability type of the new RR Lyrae stars was established by photometry in the 1990's but the ephemerides derived from these observations are now out of date. New photometric data were therefore needed to establish the phases of the spectroscopic observations. The JD(hel.), phases and V magnitudes of these new data are given in Table 3 (available electronically through the IBVS website as `5935-t3.txt`) and were obtained with the commercial robotic f/7 0.8-m telescope of the Tenagra Observatory in Arizona which has a 1024 × 1024 SITe CCD. Details of similar photometry with this telescope are given by Kinman & Brown (2010). Periods were determined using the periodogram program of Horne & Baliunas (1986); in the case of previously known variables, these were in satisfactory agreement with those found earlier. The JDH of the maxima of var. 6 and 9 take into account NSVS photometry and the 1990's photometry referred to above.

Phases for the times of observation of these spectra were derived from new ephemerides and are shown by vertical lines in the light curves (Fig. 1). The velocities of the type *ab* variables were then corrected to γ- velocities by the method given by Liu (1991) which scales the velocity amplitude against the V-mag. amplitude. In the case of the type *c* and type *d* variables, we took the known γ velocity and radial velocity curve of the type *c* variable T Sex (Liu & Janes, 1989, 1990) and scaled the correction to the γ-velocity by the ratio of the V- mag. amplitudes. As the referee has pointed out, these corrections can only be approximate — particularly for stars showing Blazhko effect (Jurcsik et al., 2002). These heliocentric γ-velocities are given with the new ephemerides and V_{max} and V_{min} in Table 4.

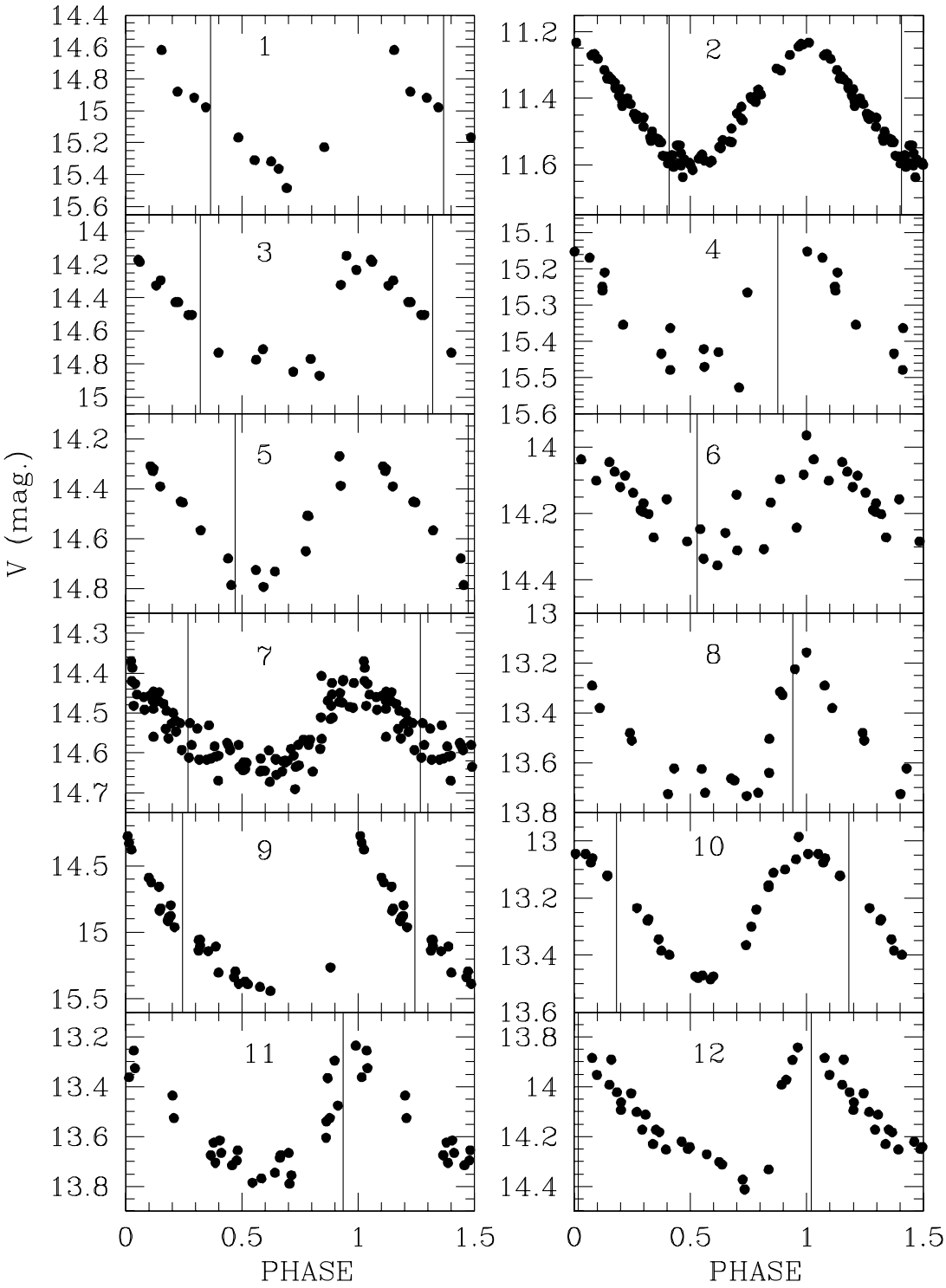

Figure 1. Light curves of variables (ordinate V magnitude).

Table 4. Radial Velocities and Ephemerides for the Variables

No.	ID	Period (days)	JDH Max +2400000.	V_{max} (mag)	V_{min} (mag)	RV† km s^{-1}	RR type	Notes
01	NSVS 4732626	0.5945	55149.667	14.6	15.5	+69	RR*ab*	
02	DQ Lyn	0.4948041	55153.816	11.23	11.60	+53	RR*c*	(1)
03	NSV 17902	0.6292137	52999.563	14.15	14.8	+42	RR*ab*	(2)
04	Case A-F 232	0.2887838	53000.790	15.18	15.47	+316	RR*c*	
05	NSVS 4814234	0.3091869	53000.192	14.20	14.72	+3	RR*c*	
06	NSVS 4819931	0.2831657	51274.504	14.0	14.3	−211	RR*c*	(3)
07	NSVS 4820967	0.087382	55153.939	14.44	14.62	−33	DSCT	
08	EN Lyn	0.6251465	55153.460	13.18	13.70	−32	RR*ab*	(4)
09	NSVS 4822969	0.497256	49338.200	14.30	15.46	+60	RR*ab*	
10	NSVS 4894895	0.35881	55208.509	13.02	13.48	+70	RR*c*	
11	BN UMa	0.39966	55208.817	13.25	13.75	+19	RR*d*	(5)
12	CK UMa	0.61031	55208.840	13.82	14.35	+16	RR*ab*	(6)

† Heliocentric γ radial velocity.

Notes:

(1) Period = 0.49489 days (Wils et al., 2006).

(2) Period = 0.62941 days (Kinemuchi et al., 2006).

(3) The considerable scatter appears to be caused by a Blazhko effect with a period of a few days.

(4) Period = 0.62532 days (Kinemuchi et al., 2006).

(5) McCluskey (2008) gives a fundamental period of 0.535786 days and a first overtone period of 0.39966 days. The first overtone has an amplitude of 2.48 times that of the fundamental.

(6) The adopted period is that given by Hoffleit (1972).

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*This version of the paper contains corrections, and differs from the one appeared on-line originally.

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