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DOUBLE-MODE RR LYRAE STARS IN SDSS STRIPE 82

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The Sloan Digital Sky Survey (SDSS) obtained multiple images in its five colours of a region along the celestial equator in the South Galactic Cap, Stripe 82, lying between 20 and 4h right ascension and between -1.266 and 1.266 degrees declination. It contains more than 1 million sources with brightness between magnitude 14 and 22 r', measured between 62 and 134 times during the years 1998 to 2005 for the SDSS-I calibration (Ivezić et al., 2007) and the SDSS-II Supernova Survey (Frieman et al., 2008). Sesar et al. (2007) identified 634 RR Lyrae candidates in the data, based on the colour and magnitude distribution characteristics of the objects. To determine their classification, a period analysis of these stars has been performed on the SDSS data. This showed that the candidate list contains 245 RRab, 98 RRc, 12 RRd and 87 SX Phe stars. The remaining objects are eclipsing binaries, long period variables or not variable.

As double-mode pulsators are astrophysically important objects, details of the 12 RRd stars will be given in this paper. Table 1 contains the identification of the objects, their magnitude range (r'), average colours, dominant period of variation (in days), and a running number used as identification in Table 2. The latter table contains details about the detected frequencies and amplitude ratio of the first overtone mode to the fundamental mode. All these have been derived from the r' data. Uncertainties on the quantities, calculated by Monte Carlo simulations in Period04 (Lenz & Breger, 2005), are provided between parenthesis, in units of the last significant decimal. Because of the specific observing window of the data set, with the common 1-day alias ambiguities, there are strong yearly aliases. This is illustrated in a close-up view in Fig. 1 of the spectral window for SDSS J224200.05-004222.0, the star which has the largest uncertainty for the frequencies found (due to its faintness). Therefore it is sometimes difficult to pick the right 1-year alias, and the actual frequency may differ by $1/year$ from the listed frequencies. Fourier spectra for SDSS J224200.05-004222.0 are given in Fig. 2.

In all RRd stars found, the first overtone mode has the highest amplitude, as is usual for this type of variables. Note that the second star in this list, SDSS J015058.14-005051.3, has been classified as RRab by Ivezić et al. (2000) before. It has received the designation FG Cet. For illustration purposes, phase plots of the fundamental and first overtone mode, after prewhitening by the other frequency, are given in Fig. 3 and 4 for FG Cet.

The incidence rate of RRd stars among the first overtone RR Lyrae stars in Stripe 82 is therefore 11%. This is much lower than e.g. in the Sculptor galaxy (20%; Kovács, 2001) and the LMC (14%; Alcock et al., 2000), but comparable to the incidence rate in the Sagittarius dwarf galaxy (9%; Cseresnjes, 2001).

Table 1: Double-mode RR Lyrae stars in SDSS Stripe 82.

Star	r'	$u'-g'$	$g'-r'$	$r'-i'$	$i'-z'$	Period	Seq.
SDSS J014305.32+010549.2	16.8-17.3	1.17	0.10	0.04	0.01	0.353721	1
SDSS J015058.14-005051.3	17.4-18.2	1.14	0.15	0.03	-0.01	0.363189	2
SDSS J020314.89+011220.6	16.4-17.1	1.06	0.21	0.02	0.00	0.351255	3
SDSS J031333.11+004254.7	18.0-18.6	1.22	0.14	0.12	0.02	0.354149	4
SDSS J210309.24-011210.5	16.2-16.9	1.18	0.20	0.04	-0.04	0.361126	5
SDSS J212046.86+001236.4	16.0-16.7	1.16	0.09	0.05	0.02	0.358634	6
SDSS J212629.38-002054.2	19.7-20.2	1.15	0.14	-0.01	0.06	0.439661	7
SDSS J215623.95+005630.2	18.3-18.9	1.12	0.12	0.05	0.04	0.413474	8
SDSS J220654.28-010515.6	17.7-18.2	1.28	0.19	0.05	0.05	0.356722	9
SDSS J222214.29+010059.9	17.1-17.6	1.15	0.23	0.07	0.07	0.395471	10
SDSS J224200.05-004222.0	20.0-20.6	1.14	0.11	0.05	0.00	0.3640	11
SDSS J232147.14+001408.6	19.8-20.6	1.10	0.12	0.01	0.09	0.348600	12

Table 2: Light curve parameters and detected frequencies of the double-mode RR Lyrae stars in SDSS Stripe 82.

Seq.	f_0 c/d	f_1 c/d	Freq. ratio	Ampl. ratio	f_0+f_1	f_0-f_1	$2f_0$	$2f_1$
1	2.102805(8)	2.827085(7)	0.7438	1.4(1)	✓	-	✓	✓
2	2.04983(2)	2.75339(1)	0.7445	1.2(1)	✓	-	-	-
3	2.11387(3)	2.84693(2)	0.7425	1.2(2)	✓	-	-	-
4	2.09919(5)	2.82367(3)	0.7434	1.2(3)	✓	-	-	-
5	2.05805(2)	2.76912(2)	0.7432	1.2(1)	✓	-	-	-
6	2.07540(2)	2.788361(8)	0.7443	1.4(1)	✓	✓	-	✓
7	1.6936(1)	2.27448(2)	0.7446	2.1(5)	-	-	-	-
8	1.80320(2)	2.41853(2)	0.7456	1.5(2)	-	-	-	-
9	2.08647(1)	2.80330(1)	0.7443	1.3(1)	✓	✓	-	-
10	1.88608(3)	2.52863(2)	0.7459	1.9(2)	✓	-	-	-
11	2.041(2)	2.747(3)	0.7429	1.7(7)	-	-	-	-
12	2.13248(2)	2.86862(2)	0.7434	1.3(2)	✓	-	✓	-

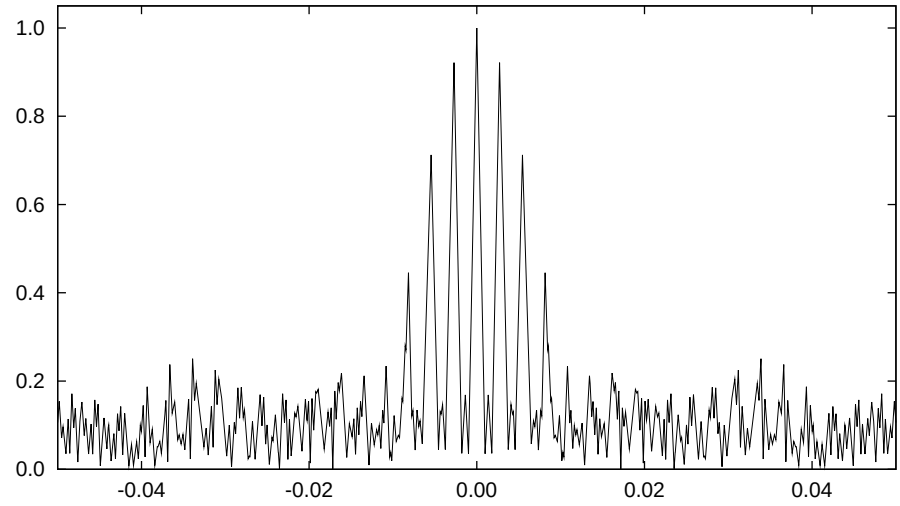

Figure 1. Spectral window for SDSS J224200.05-004222.0 showing strong 1-year aliasing.

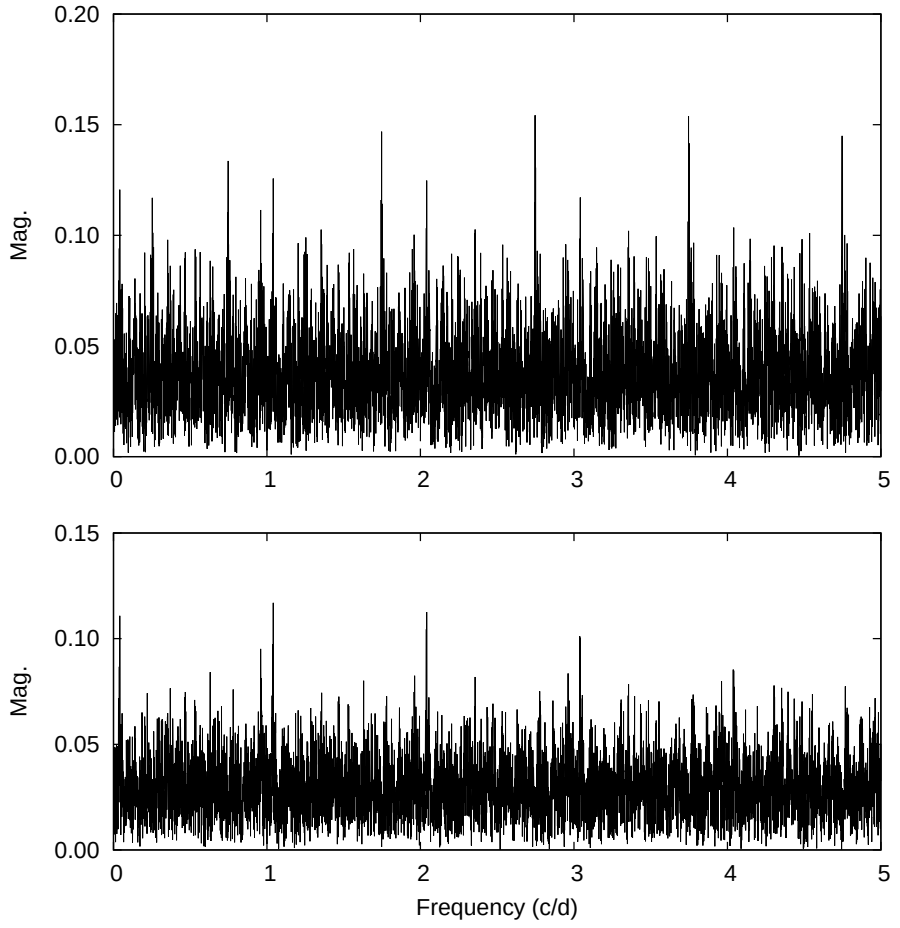

Figure 2. Fourier spectrum for star SDSS J224200.05-004222.0 before (top panel) and after (bottom) prewhitening for the dominant frequency.

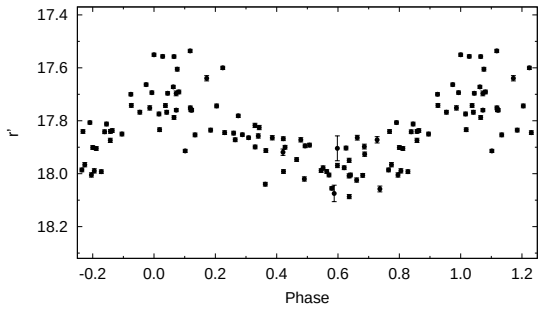

Figure 3. Phased light curve for the fundamental period of FG Cet.

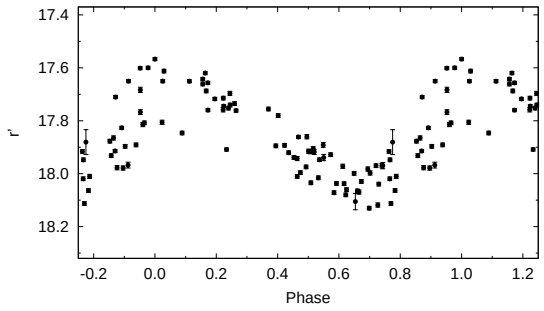

Figure 4. Phased light curve for the first overtone period of FG Cet.

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References:

Alcock C., Allsman R., Alves D. R. et al., 2000, *ApJ*, **542**, 257
Cseresnjes P., 2001, *A&A*, **375**, 909
Frieman J. A., Bassett B., Becker A., 2008, *AJ*, **135**, 338
Ivezić Ž., Goldston J., Finlator K. et al., 2000, *AJ*, **120**, 963
Ivezić Ž., Smith J.A., Miknaitis G. et al., 2007, *AJ*, **134**, 973
Kovács G., 2001, *A&A*, **375**, 469
Lenz P., Breger M., 2005, *Comm. in Asteroseismology*, **146**, 53
Sesar B., Ivezić Ž., Lupton, R. H. et al., 2007, *AJ*, **134**, 2236