Doubling the number of pulsating DB white dwarfs

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Doubling the Number of Pulsating DB White Dwarfs

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Abstract. We are searching for new pulsating DB white dwarf stars (DBVs) based on the newly found white dwarf stars from the spectra obtained by the Sloan Digital Sky Survey. DBVs pulsate at hotter temperature ranges than their better known cousins, DAVs or ZZ Ceti stars. Since the evolution of white dwarf stars is characterized by cooling, asteroseismological studies of DBVs give us opportunities to study white dwarf structure at a different evolutionary stage than the DAVs. The hottest DBVs are thought to have neutrino luminosities exceeding their photon luminosities (Winget et al. 2004), a quantity measurable through asteroseismology. Therefore, they can also be used to study neutrino physics in the stellar interior. At the time of the meeting, we reported on the nine new DBVs, doubling the number of previously known DBVs. Here we report the new nine pulsators' lightcurves and power spectra.

1. Fourier Transform and the DBV instability stirp

The more detail description of this work have been recently published (Nitta et al. 2009). The table shows the list of objects we have observed at the time of the meeting. In the status section, we note which ones are new DBVs and which ones are observed not to vary with their amplitude limits. (1) means we only have one observation of the object. Beating of multiple modes and amplitude modulation can make a pulsator appear as a non-pulsator. Therefore, we try to observe each object at least two separate times. We also observe a new pulsator two different times to ensure we have found a real pulsator

This work is on-going and we are happy to report that since the time of the meeting, we have discovered three new DBVs, although two of them does not have confirmation observations yet. We also were granted observing time on Gemini telescopes to get high signal to noise spectra of the nine new DBVs reported here. So we hope to have better physical parameters in the near

Table 1. Here is the list of DBs we observed by the time of the meeting. The top section of the table details the objects that showed variability during at least one observation. Separated by a double horizontal line, the second half of the table lists the objects for which we have not (yet?) seen significant variability. In the status section, we note new variable objects by "DBV". For objects in which we have not detected variability, we give the amplitude limit in mma in the status section. If we have only observed an object once, then we add a "(1)". Due to lack of observing time and a large number of candidates, we have yet been able to observe all DBV candidate objects, nor all these a second time. The physical parameters here come from fitting SDSS DR6 spectral data with a denser, but otherwise consistent, model grid than used in the DR4 WD catalog.

Object SDSS J	Plate	Fiber	MJD	g [mag]	Teff [K]	$\sigma_{\rm Teff}$ [K]	logg	$\sigma_{\rm logg}$	Status
034153.03 − 054905.8	462	506	51909	18.25	25087	524	8.02	0.062	DBV
085202.44 + 213036.5	2280	604	53680	18.50	25846	6361	8.02	0.056	DBV
094749.40 + 015501.8	480	520	51989	19.95	23453	1659	8.13	0.192	DBV
104318.45 + 415412.5	1361	155	53047	18.95	26291	919	7.77	0.138	DBV(1)
122314.25 + 435009.1	1371	205	52821	18.98	23442	1069	7.84	0.127	DBV
125759.03 − 021313.3	338	436	51694	19.16	25820	1296	7.57	0.151	DBV
130516.51 + 405640.8	1458	21	53119	17.46	24080	414	8.14	0.056	DBV(1)
130742.43 + 622956.8	783	513	52325	18.83	23841	913	8.14	0.097	DBV(1)
140814.63 + 003838.9	302	490	51688	19.19	26073	1227	7.98	0.117	DBV
001529.74 + 010521.3	389	530	51795	18.94	34379	1079	7.96	0.163	8.20(1)
031609.12 − 062556.8	459	605	51924	19.97	24478	2520	7.96	0.222	17.0(1)
081904.19 + 354255.8	826	422	52295	18.22	22540	867	8.18	0.079	4.80(1)
085950.29 − 000339.6	469	49	51913	20.19	23729	2391	8.12	0.291	13.3(1)
090409.03 + 012740.9	470	442	51929	17.96	23183	533	7.95	0.062	4.28
090456.11 + 525029.8	552	547	51992	18.95	37584	953	7.99	0.091	10.1(1)
092200.97 + 000834.3	474	388	52000	18.56	22581	769	8.10	0.074	7.56(1)
095256.68 + 015407.6	481	513	51908	17.50	32920	323	8.16	0.041	4.84(1)
095455.11 + 440330.3	942	275	52703	18.18	20072	368	8.29	0.064	5.85(1)
095649.55 + 010812.4	481	20	51908	20.48	17125	1257	7.37	0.261	13.0(1)
101131.88 + 050729.3	574	331	52355	18.97	24301	984	7.71	0.115	8.98(1)
101502.95 + 464835.3	944	328	52614	18.61	23312	830	8.01	0.076	7.24(1)
105929.60 + 554039.2	908	317	52373	18.47	24742	571	8.17	0.101	8.46(1)
122241.27 − 003614.4	288	63	52000	18.10	24023	676	8.21	0.073	4.66(1)
131148.49 + 053847.6	850	522	52338	17.65	20249	268	8.30	0.041	11.7(1)
133215.93 + 640656.2	603	118	52056	18.41	21365	1694	7.99	0.097	9.73(1)
135610.32 − 002230.6	301	232	51641	19.38	18584	397	8.20	0.149	13.1(1)
141258.17 + 045602.2	583	432	52055	17.35	30343	329	7.97	0.038	2.88
231324.24 − 001636.9	381	72	51811	19.83	19588	1987	7.93	0.298	3.19
235322.16 + 002653.8	386	549	51788	19.71	25012	1800	8.15	0.203	13.0(1)

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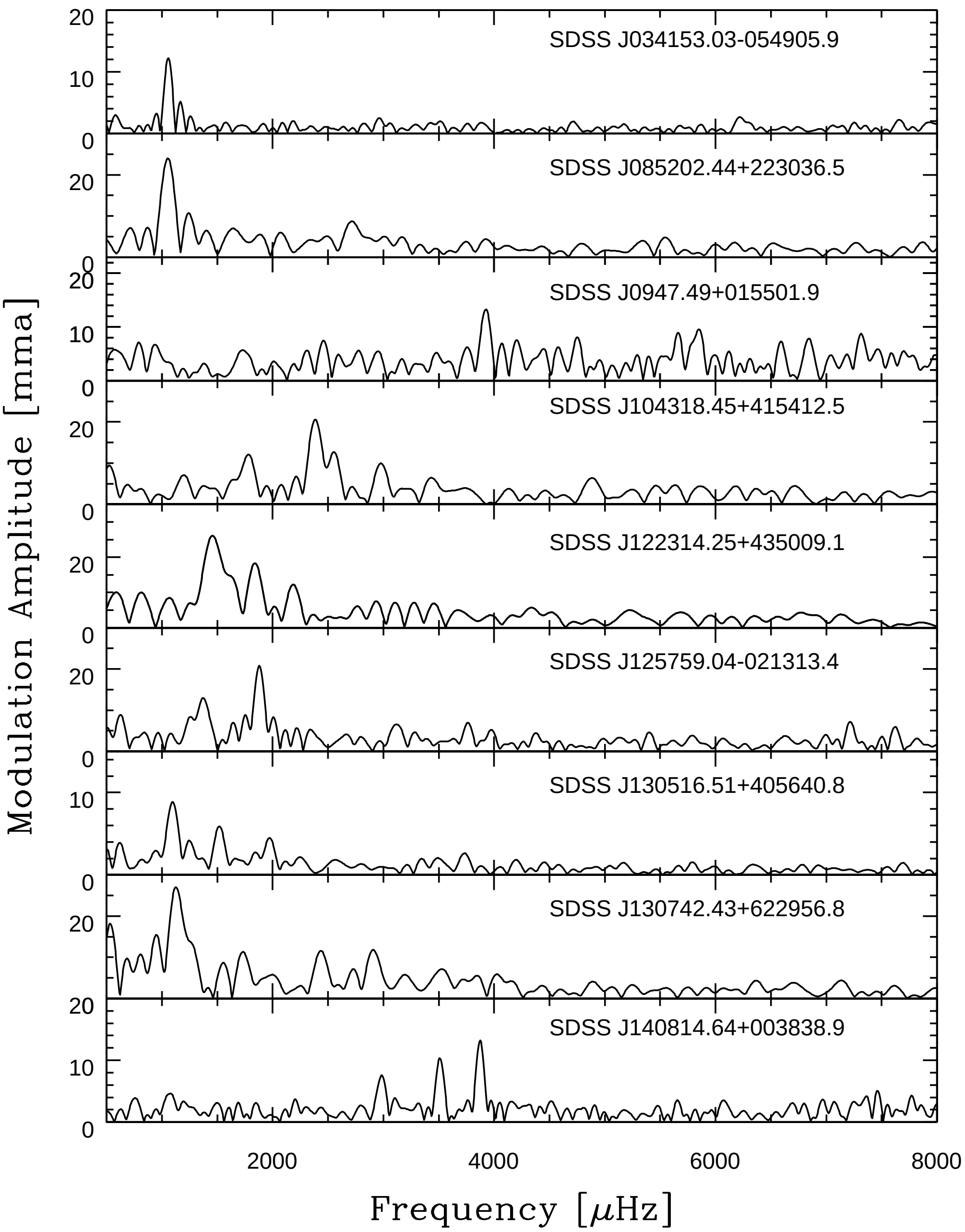

Figure 1. Fourier transform of the 9 new DBVs. SDSS J0947.49+015501.9's FT, perhaps, is not as visually convincing as other new DBVs shown here. The FT of the second observation of this target also shows the largest peak at a consistent frequency as the data shown here with similar significance.

feature. That will help the error bars in Figure 2 to reduce so we have better picture of the DBV instability strip.

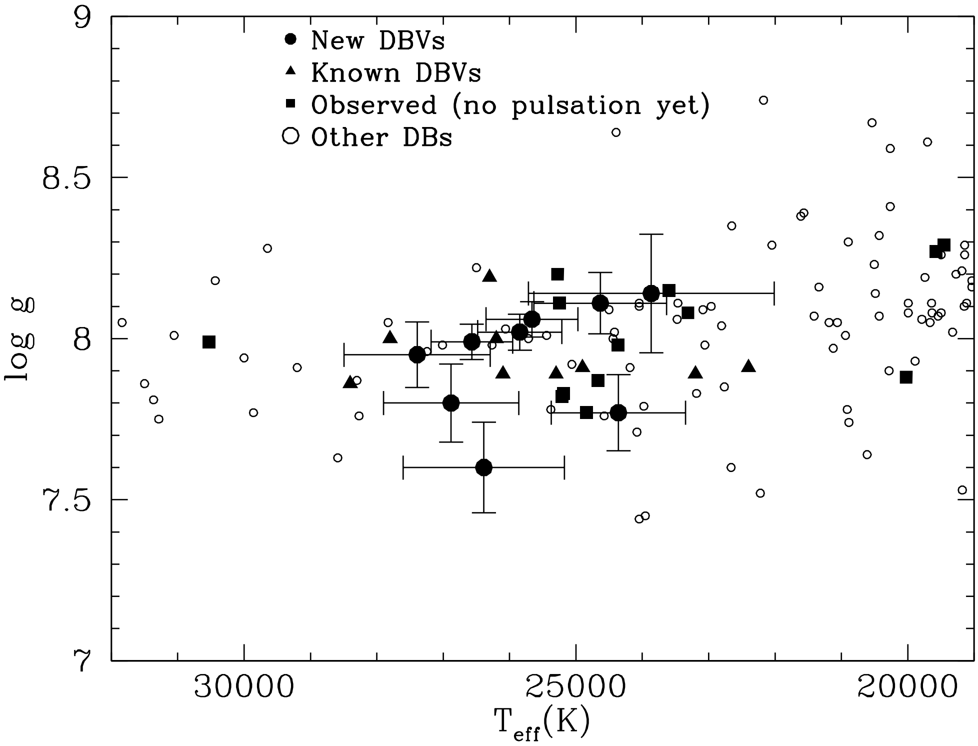

Figure 2. The effective temperatures and surface gravities of the SDSS DBs (our latest fits to the DR6 SDSS spectra) around the DBV instability strip, along with the previously known DBVs (with their physical parameters taken from Beauchamp et al. 1999). Circle dots show the new DBVs and triangles, the previously-known DBVs. The square show the non-pulsating DBVs we have observed and the hollow dots show the rest of the DBs in the WD catalog (Eisenstein, et al. 2004). Most of the DBs observed not to pulsate so far have such high amplitude limits that we cannot tell if they are truly non-pulsators or not. In order to better characterize the instability strip, we need better determinations of the physical parameters for some of the DBs (which requires better signal-to-noise spectra) and better variability amplitude limits (1mma or better). We have been granted observing time on Gemini to observe the nine new DBVs so we should have better estimates of their parameters in the near future. So far we have not found any pulsator hotter than EC20058 and hence the best chance of determining the neutrino production rates still lies with this star.

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