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FOLLOW-UP OBSERVATIONS OF KNOWN EC 14026-TYPE PULSATORS

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Abstract. We present follow-up observations of pulsating sdB stars as part of our efforts to resolve the pulsation spectra for use in asteroseismological analyses. This paper reports on our overall efforts, but specifically on our results for the pulsating sdB stars KPD 2109+4401 and PG 0154+182.

Key words: stars: hot subdwarfs – stars: oscillations – stars: individual (PG 0154+182, KPD 2109+4401)

1. INTRODUCTION

The scientific goal of this observational study is to resolve the pulsation structure of pulsating sdB stars by combining limited amounts of data from larger telescopes with data from smaller ($\sim$ 0.5 m) telescopes. This combination allows us a long time base sufficient to resolve closely spaced pulsations and the increased signal-to-noise of the larger telescopes allows us to detect pulsations with low amplitudes. Table 1 lists stars we have observed and observatories from which we have obtained data. Though the majority of our data is from Baker, MDM and McDonald observatories, we routinely participate in multisite collaborations, including the Whole Earth Telescope.

2. OBSERVATIONS AND ANALYSES

KPD 2109+4401. Our dataset for KPD 2109+4401 (hereafter KPD 2109) consists of 29 data runs with a total length of 182.6 hours over 31 days. The temporal resolution is 0.4 μHz with a detection limit of 0.3 mma (milli-modulation amplitudes). We detect eight pulsation frequencies extending from 4701 to 8375 μHz, corresponding to periods of 119.4 to 212.7 s. Table 2 lists the frequencies we

Table 1. List of observations of pulsating sdB stars.

Target	Inclusive dates	Hours observed	Sites[†]
EC 05217-3914	1999 Nov. 6 – 15	59	1, 2
PG 1336-018	2001 Apr. 14 – May 1	288	13
HS 2201+2610	2000 Sep. 17 – Oct. 4	95.0	3, 14
Feige 48	1999 Mar. 6 – Apr 13	63.6	7, 8, 13
	1999 Dec. 10 – 16	17.5	3
	2000 Feb. 8 – Mar. 05	42.4	3, 7, 8
	2000 Nov. 2 – Dec. 22	45.7	3, 9, 12
	2001 Jan. 18 – Feb. 1	55.0	3
	2001 Apr. 19 – 30	52.0	13
	2002 Apr. 5 – 21	56.8	13
KPD 1930+2752	2003 Aug. 15 – Sep. 9	246.5	13
KPD 2109+4401	2004 Sep. 12 – Oct. 14	182.6	4, 5, 7, 9, 11
PG 0154+182	2004 Oct. 6 – 14	28.4	5
PG 1325+101	2003 Mar. 3 – Apr. 3	264	4, 14
PG 1219+534	2003 May 13 – Jun. 4	48.6	4, 7
	2004 Mar. 9 – 15	21.5	4
	2005 Feb. 25 – Mar. 2	23.8	4
PG 0014+067	2004 Oct. 8 – Oct. 20	142	5, 13
PG 1618+563	2005 Mar. 17 – May 1	200.5	4, 6, 7, 9, 10
HS 1824+5745	2005 May 24 – July 11	Unknown	6

[†] Observing sites: (1) CTIO 1.5 m, (2) SAAO 1.9 m, (3) Fick 0.6 m, (4) Baker 0.4 m, (5) MDM 1.3 m, (6) MDM 2.4 m, (7) McDonald 2.1 m, (8) McDonald 0.9 m, (9) Suhora 0.6 m, (10) Lulin 1.0 m, (11) Greece 0.4 m, (12) Beijing 0.85 m, (13) Whole Earth Telescope Campaign, (14) Other campaign (non-PI)

Table 2. Periods, frequencies and amplitudes for KPD 2109. Formal least-square errors in parentheses.

Period (s)	Frequency (μHz)	Ampl. (mma)	Period (s)	Frequency (μHz)	Ampl. (mma)
182.42120(8)	5481.819(3)	6.13(9)	196.31012(10)	5093.981(2)	6.44(9)
184.71248(23)	5413.819(6)	2.63(10)	198.19774(30)	5045.466(8)	2.03(9)
184.74037(25)	5413.002(7)	2.32(10)	209.14104(20)[†]	4781.462(45)	0.35(9)
191.84271(36)	5212.604(10)	1.63(9)	212.71520(22)[†]	4701.122(49)	0.32(9)

[†] These frequencies are only above the detection threshold in the MDM data.

detected and Figure 1 shows temporal spectra of the complete data set as well as successive prewhitening steps.

We confirm five of the known frequencies previously identified by both Koen (1998; hereafter K98) and Billères et al. (1998), but do not detect the 5084 μHz frequency detected by K98. We resolve a doublet that was suspected by K98, but at 0.8 μHz, was not resolvable in his data. Furthermore, our high signal-to-noise datasets detect the feature at 4781 μHz, which was suspected by K98 and marginally detect another frequency at 4701 μHz. The peak around 4781 μHz was also marginally detected in the spectroscopic analysis by Jeffery & Pollacco (2000).

PG 0154+182. PG 0154+182 (hereafter PG 0154) was observed as a sec-

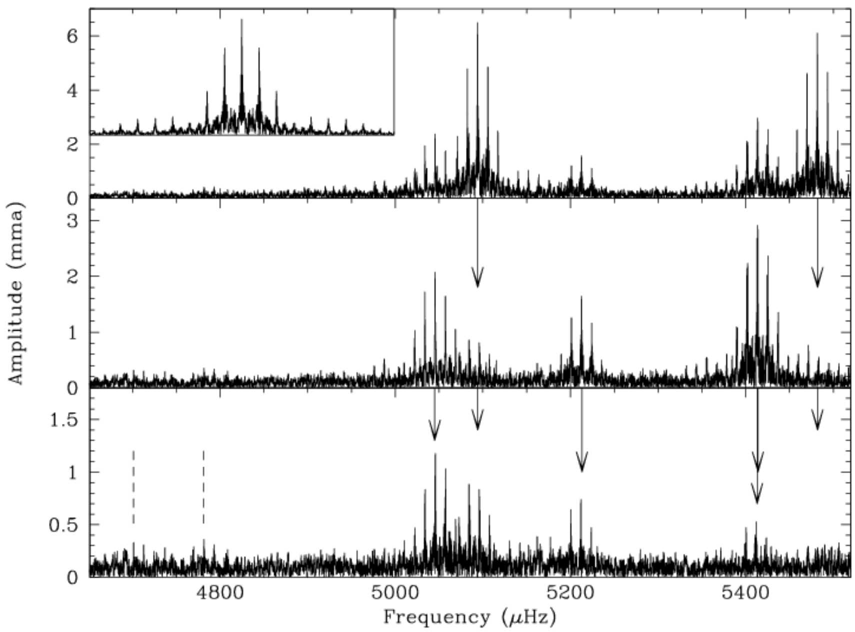

Fig. 1. Temporal spectra (FT) for KPD 2109 showing the original data (top) and prewhitening by 2 and 6 frequencies, respectively. Arrows indicate prewhitened frequencies and the dashed lines indicate low-amplitude frequencies not prewhitened in this figure. Inset is the data window.

ondary star at MDM observatory during our KPD 2109 run. It was observed for 4 hours (on average) over 9 consecutive nights. The discovery data only detected a single frequency (Koen et al. 2004), whereas we clearly detected 6 frequencies, one of which is likely an unresolved doublet. Figure 2 shows an FT of the original data (window function is inset), prewhitened data (arrows indicate frequencies removed) and the amplitude of the 6785.20 μHz frequency over the course of our run. The smooth, roughly sinusoidal appearance of the 6785.20 μHz amplitude leads us to believe this frequency is in fact two with a splitting of $\sim 1.5\mu$Hz, or a beat period slightly longer than our run.

Table 3. Periods, frequencies and amplitudes for PG 0154. Formal least-squares errors in parentheses.

Period	Frequency	Amplitude	Period	Frequency	Amplitude
110.9280(15)	9014.85(12)	1.13(22)	142.2137(7)	7031.67(3)	3.88(23)
119.5830(19)	8362.39(13)	1.04(23)	147.3795(30)	6785.20(14)	3.58(1.27)
130.2638(11)	7676.72(6)	2.15(24)	164.2108(3)	6089.73(1)	9.46(23)

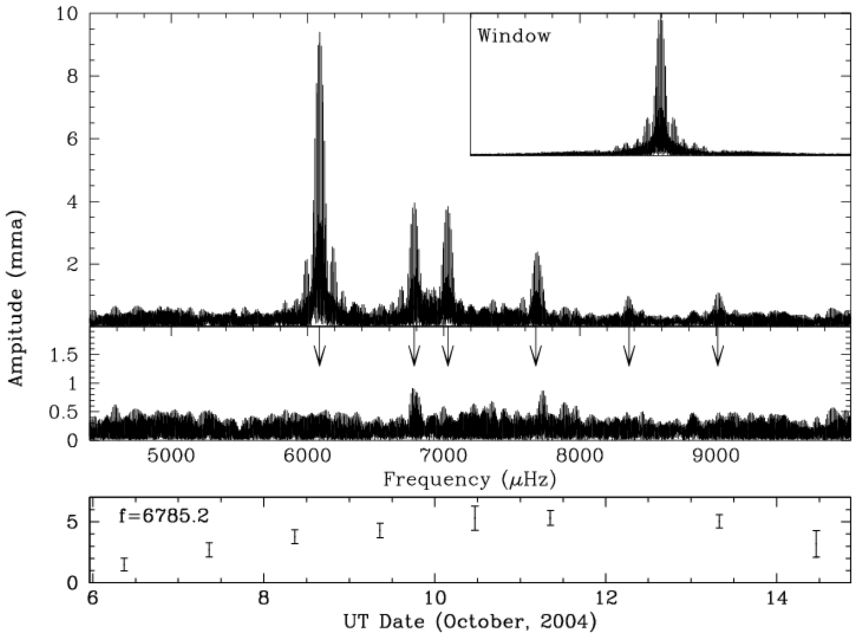

Fig. 2. Temporal spectra (FT) for PG 0154 showing the original data (top) and prewhitening by 6 frequencies. Arrows indicate prewhitened frequencies. Inset is the data window and bottom panel shows the amplitude of the 6785 μHz frequency over the course of our run.

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