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O-C Analysis of the Pulsating Subdwarf B Star PG 1219 + 534

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Abstract

PG 1219 + 534 (KY Uma) is a subdwarf B pulsating star with multiple periodicities between 120 – 175 s. PG 1219 + 534 was monitored for 90 hours during 2010-1 and 2016 using the 0.9m SARA-KP telescope at Kitt Peak National Observatory (KPNO) in Arizona and the 0.8 m Ortega telescope at Florida Institute of Technology in Melbourne, Florida.

So far, the most promising theory for the origin of subdwarf B (sdB) stars is that they result from binary mass transfer near the Helium Flash stage of evolution. The observations of PG 1219+534 reported here are part of our program to constrain this evolutional theory by searching for companions and determining orbital separations around sdB pulsators using the Observed-minus-Calculated (O-C) method. A star's position in space will wobble due to the gravitational forces of any companion or planet. If the star emits periodic signal like pulsations, its orbital motion around the system's center of mass causes periodic changes in the light pulse arrival times. In this poster, we present our time-series photometry and O-C analysis of this data.

Photometry Results of 2016 Observation Run

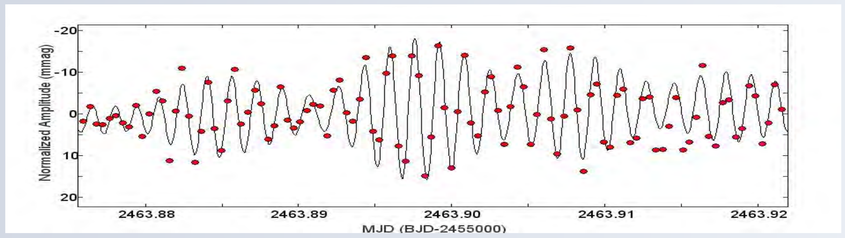

Figure 1. Example of light curve for PG 1219+534 of 2016 observation run. The curve is the fitted light curve with all the frequencies.

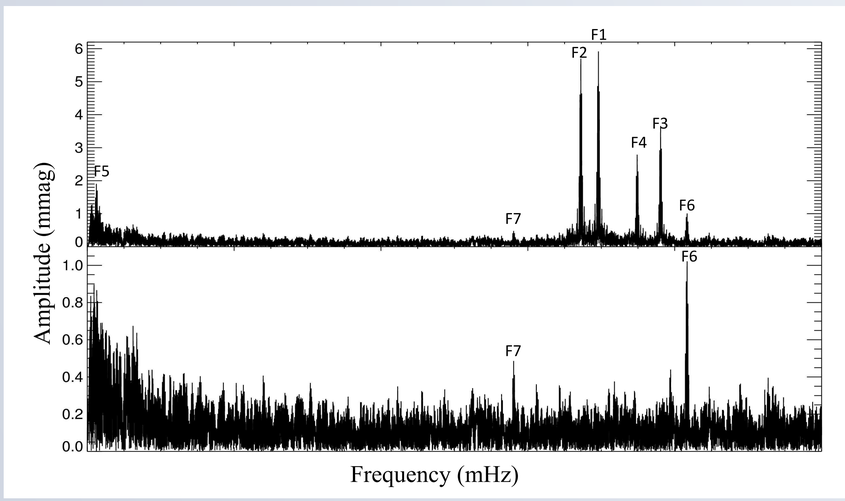

Figure 2. DFT plot for PG 1219+534 using 2016 observation run, which shows the all seven detected pulsation peaks. All peaks which are higher than 4σ noise levels are considered to be real pulsation peaks. The second panel shows the successive steps of pre-whitening by removal of the five largest pulsation peaks. The horizontal lines indicate 4σ noise levels. F1, F2, F3, F4, F5, F7, and F8 matched with the published results that are p-mode pulsation (Charpinet et al.2005). F6 is a possible p-mode pulsation candidate. All frequencies' information is showen in Table 1.

Table 1: Pulsation Peak Frequencies of PG1219+534

mode	Freq(*mHz*)	Freq σ (*mHz*)	Period (s)	Amp(*mmag*)	Amp σ (*mmag*)	S/N
F1 (p)	6.9614	0.0016	143.6	6.0	0.1	50.3
F2 (p)	6.7215	0.0017	148.8	5.8	0.1	50.3
F3 (p)	7.8077	0.0027	128.1	3.6	0.1	31.7
F4 (p)	7.4890	0.0031	133.5	3.0	0.1	25.4
F5 (g)	0.1244	0.0051	8039.0	1.9	0.1	4.3
F6 (p)	8.1688	0.0094	122.4	1.0	0.1	8.9
F7 (p)	5.8065	0.0199	172.2	0.5	0.1	4.2

O-C Analysis of 2010-2011 dataset

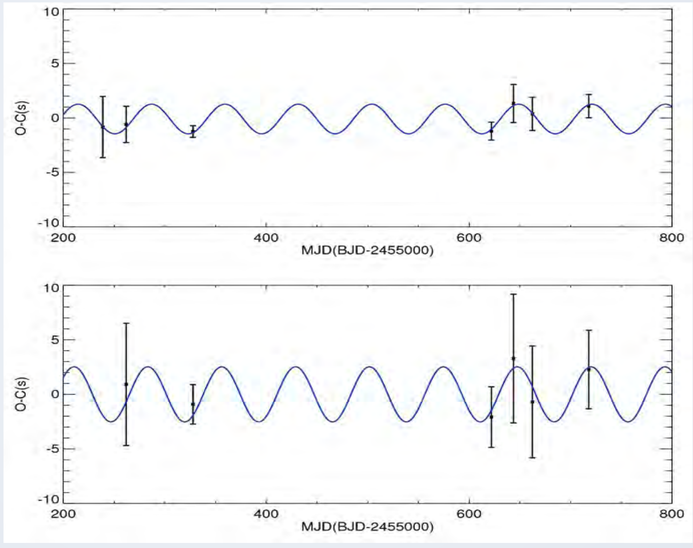

Figure 3. PG 1219+534 O-C results for F1 (top) and F2 (bottom) after removal of the sinusoidal variations due to beating fundamental frequencies (Otani 2015). The curves represent the sinusoidal curve fits. The frequency of both blue lines is the same to within the uncertainty levels of measurements. Since some of the data points represent one observation run of 2-3 days, there are horizontal error bars too. However, they are too small to display in this plot. The frequencies, amplitudes and phases of the sinusoidal fits used for both O-C diagrams in Figure 2 are the same within the uncertainty level. We proceeded to explore the possibility that the O-C variations may be caused by the orbital motion of a companion to PG 1219+534.

Due to the bad weather, 2016 data time span is only for 14 days and the data could not be added to the O-C diagram.

Table 2: O-C best fitting results for F1 and F2 pulsations

	F1	F2
O-C Amplitude A [*s*]	1.3 ± 0.3	2.5 ± 0.6
Orbital Period P_{orb} [*days*]	72.36 ± 8.01	72.81 ± 5.71
Orbital distance [*AU*]	0.262 ± 0.019	0.263 ± 0.014
Mass *M sin i* [*deg*]	5.00 ± 0.48	9.26 ± 2.24

O-C Analysis of 2016 dataset

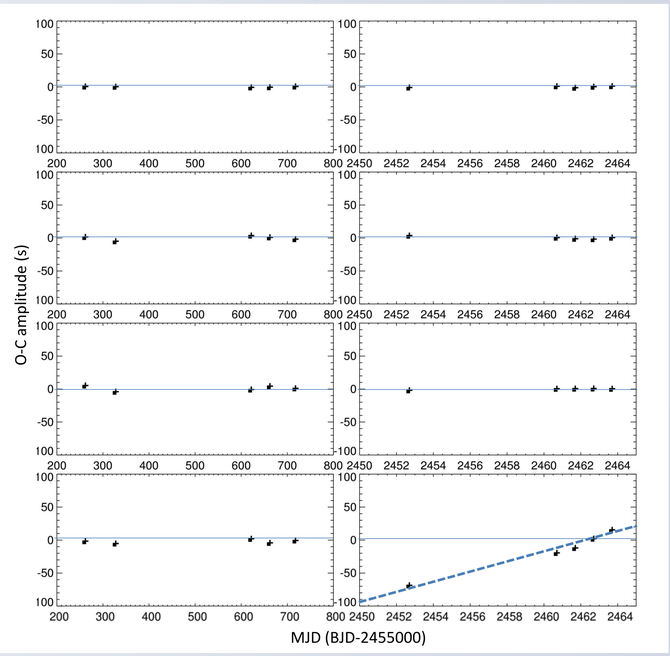

Figure 4. PG 1219+534 O-C diagram of year 2010-2011 (left) and year 2016 (right). We used the same pulsation periods that were used to make O-C diagrams in Figure 3. The phase variations of days to days are stable for F1, F2 and F3. However, the O-C diagram of F4 are changing linearly. It shows that only F4 frequencies are changing between 2010-2011 and 2016 data. The slopes (dot line) is the linear fitting of the data points. The slope of 2016 F4 data is 10.172. So the period of the 2016 data is about 0.0157 s longer than the period of the 2011 data.

References

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Charpinet, S., Fontaine, G., Brassard, P. & Chayer, P. "Structural Parameters of the Hot Pulsating B Subdwarf PG 1219+534 from Asteroseismology" 2005, A&A, 437.

Acknowledgments

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