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A NEW β CEPHEI STAR IN THE RX J0136.7+6125 FIELD: BD +60°282

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The sky was surveyed in the X-ray region of the spectrum by the ROSAT satellite (Bade et al. 1998) and catalogs of the sources included RX J0136.7+6125 = GSC 4031_953. The star was one of the subjects of an investigation by Motch et al. (1997), who concluded from spectral observations that it was "a late type star displaying strong CaII H&K emission consistent with the measured X-ray flux".

The automated 0.5-m. telescope, Cousins R filter and CCD camera of the Climenhaga Observatory of the University of Victoria and the usual reduction methods (Robb and Greimel, 1999) were used to make photometric observations from 17 December 1996 to 25 February 1997 UT ('400' series), 20 October to 21 November 1997 ('700' series) and from 17 to 29 January 2000 ('1500' series).

The field we observed is shown in Figure 1, and listed in Table 1 are the stars' designations, coordinates (J2000) and magnitudes from the Hubble Space Telescope Guide Star Catalog (GSC) (Jenkner et al., 1990). In the table the ΔR differences in magnitude are found from our data in the sense GSC 4031_1099 minus the star. The ΔR magnitude given in the table is the mean of the eight nightly mean differential magnitudes of the '700' series. The standard deviations of these then measure night to night variations and are listed as "Std Dev Between". The standard deviation of the differential magnitudes during the best night are listed in Table 1 as the "Std Dev Within". Since the field of view is so small extinction effects were negligible and no corrections have been made for them. No corrections have been made to transform the R_c magnitude to a standard system.

Table 1: Stars observed in the field of RX J0136.7+6125

GSC No. in Region 4031	RA J2000	Dec J2000	GSC Mag	ΔR Mag	Std Dev Between	Std Dev Within
0953	$01^h36^m43^s$	61°25′50″	10.7	0.258	0.008	0.004
0631	$01^h36^m39^s$	61°25′54″	10.2	0.433	0.007	variable
1099	$01^h37^m00^s$	61°25′04″	10.6	-	-	-
1001	$01^h36^m37^s$	61°25′06″	12.4	−1.413	0.004	0.006

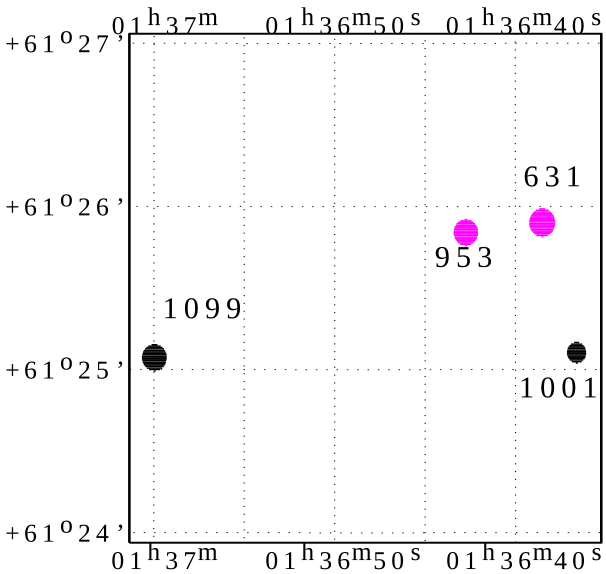

Figure 1. Finder chart labeled with the GSC numbers from region 4031.

GSC 4031_953 was monitored and found not to vary by more than approximately $0\overset{\mathrm{m}}{.}01$ during any night. The (GSC 4031_1099 – GSC 4031_953) nightly means are given in Table 2 for all series. We believe the apparent variations in the '400' series data to be at least partly instrumental in nature. The '1500' series data are significantly different in brightness from the other years.

Brightness variations in GSC 4031_0631 were evident during a night. To increase the signal to noise GSC 4031_953 was used as the comparison star and plots of the differential R magnitudes for a few nights are shown in Figure 2. The peak to peak amplitude of the light curve was generally about 0.05, but on three of fifteen nights the amplitude approached 0.01. As can be seen from Figure 2 the light curve recovered its full amplitude between HJD 2450461 and 2450462, while on most occasions the light curve retained its full amplitude for many consecutive nights.

The Period98 (Sperl 1998) program was used to search the data for periodicities. A frequency of 4.8 cycles per day was found to be common to all three seasons, but no clearly significant common second frequency was found. In Figure 3 we plot three nights from the '1500' series data which clearly show the changing amplitude. Surprisingly the

Table 2: Individual Nights of (GSC 4031_1099 – GSC 4031_953)

HJD – 2450000	ΔR Mag	Std Dev	No. Pts	HJD – 2450000	ΔR Mag	Std Dev	No. Pts	HJD – 2450000	ΔR Mag	Std Dev	No. Pts
434	0.242	.008	187	742	0.277	.005	143	1561	0.369	.005	252
436	0.236	.010	51	764	0.259	.006	236	1567	0.368	.005	101
461	0.324	.018	176	765	0.251	.006	298	1571	0.346	.018	42
462	0.334	.010	144	766	0.258	.005	59	1572	0.338	.006	212
463	0.296	.012	118	767	0.253	.005	124				
464	0.308	.009	211	768	0.253	.005	119				
				773	0.256	.004	117				
				774	0.256	.007	56				

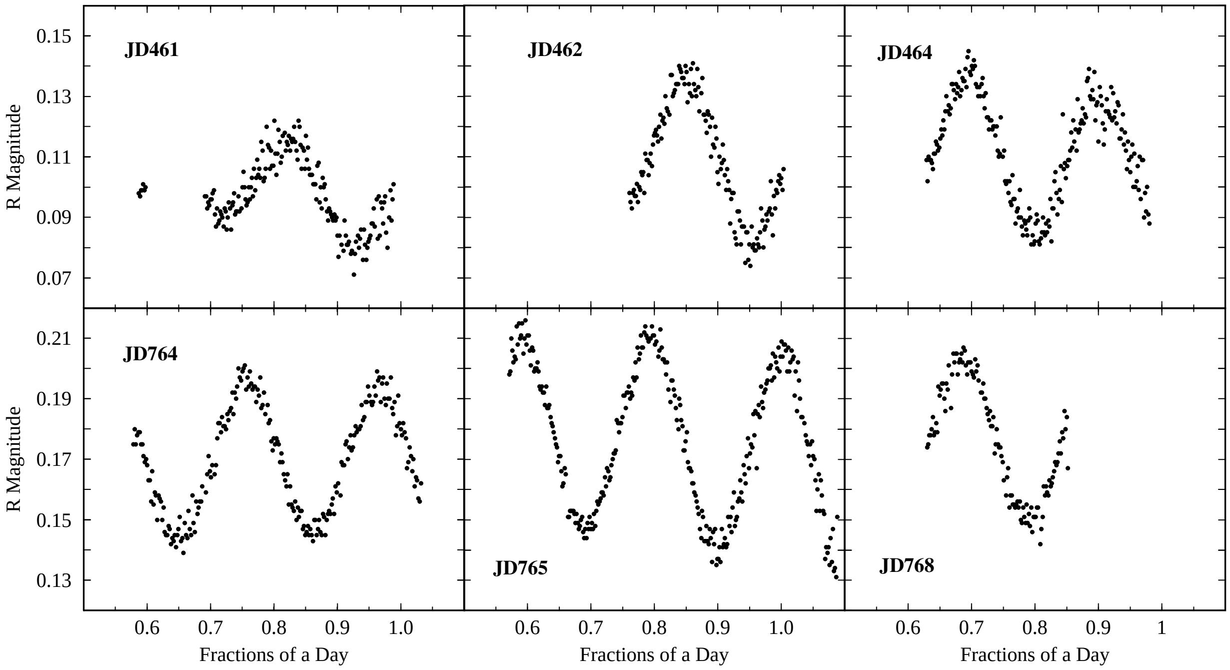

Figure 2. Sample light curves of the differential R data of (953–631) during 1997

minimum brightness levels are coincident, *not* the mean level. This behavior was also observed for the '700' series data, but for the '400' series the mean level varied from night to night due to flatfield variations.

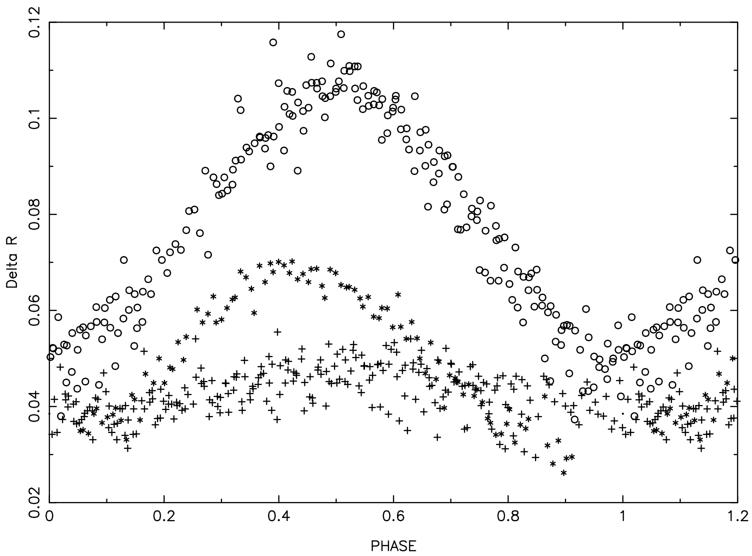

Figure 3. ΔR light curves of (953–631) for JD 1561(+), 1567($*$), and 1572($\circ$)

Times of extrema given in Table 3 with the uncertainty shown in brackets were found by the method of Kwee and Van Woerden (1956) using data within $\pm 0\overset{d}{.}05$ of the extrema. This algorithm assumes that each extremum is symmetrical, but since this is not the case, our estimates of the error are lower limits to the actual uncertainty. The periods and epochs in Table 4 were determined from the times of extrema with the uncertainty in the last significant figure given in brackets. Although the periods are statistically

Table 3: Times of Extrema (HJD − 2450000.) of GSC 4031_0631

Max	Min	Max	Min	Max	Min
461.8203(4)	434.8633(5)	742.8338(5)	742.7418(4)	1561.6952(4)	1561.7946(4)
462.8470(3)	462.9536(4)	764.7583(14)	764.6492(7)	1567.6593(4)	1572.7253(7)
463.8681(10)	464.8022(5)	764.9670(5)	764.8612(6)	1572.6249(4)	
464.6948(7)		765.7937(9)	765.6913(6)	1572.8250(7)	
464.8987(6)		765.9985(7)	765.8998(4)		
		766.6178(7)	768.7898(6)		
		767.6472(5)			
		768.6856(5)			
		773.8703(6)			

Table 4: Period and Epoch of Maxima of GSC 4031_0631

Series	Epoch	Period	RMSE
400s	$2450434^{d}.7617(76)$	$0^{d}.20647(12)$	$0^{d}.0076$
700s	$2450765^{d}.7929(14)$	$0^{d}.20680(6)$	$0^{d}.0051$
1500s	$2451561^{d}.6907(46)$	$0^{d}.20621(22)$	$0^{d}.0068$

different, the root mean square errors (RMSE) are large and we contend that the period is the same for all three series.

A SIMBAD reference search for GSC 4031_0631 reveals that it is BD+60°282 and has a $V = 10.63$, $B - V = 0.42$, $U - B = -0.48$, and a spectral class of B1III (McCuskey 1974) in agreement with a spectral classification by Motch (1997) of B2II.

Since RX J0136.7+6125 = GSC 4031_953 is a late spectral type star which shows X-ray emission and yearly timescale optical variations, we expect it to be a spotted star, which exhibits solar cycle type variations. BD+60°282 = GSC 4031_631 is a reddened early spectral type, rapidly pulsating star of the β Cephei type. Its period of variation is approximately $0^{d}.207$, but is complicated. Further photometric and spectroscopic observations will be valuable to confirm our conclusions as to the reason for the variability of these stars.

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