Two New Variable Stars in the Fields of Nova Cygni 2006 and Nova Cygni 2007

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Received January 20, 2010; revised March 16, 2010; accepted March 25, 2010

Abstract Two new variable stars have been identified close to the recent novae V2362 Cygni (Nova Cyg 2006) and V2467 Cygni (Nova Cyg 2007). VSX J211145.0+444530 is likely to be a magnitude 11.6 γ Doradus variable with principal period 1.459(6) day and full amplitude 0.047 magnitude. VSX J202751.9+414727 is probably a magnitude 12.7 δ Scuti variable with period 0.05951(2) day and full amplitude 0.012 magnitude.

1. VSX J211145.0+444530

VSX J211145.0+444530 is not listed in SIMBAD but VIZIER reveals that it has already been catalogued under the names TYC 3181 1907, GSC 03181-01907, GSC 2.2 N0331312630, GSC 2.3 N31Y000630, USNO-A2.0 1275-14959662, USNO-B1.0 1347-0415391, 3UC 270-212234, and 2MASS J21114500+4445303. Its variability has not previously been recognized. Its position was measured as R.A. 21^h 11^m 45.00^s, Dec. +44° 45' 30.4" (J2000.0) using Astrometrica (Raab 2010) and UCAC3. It is 3.4 arcmin SE of the nova V2362 Cygni (= Nova Cygni 2006), see Figure 1.

11,997 *V*-filtered CCD observations were made of VSX J211145.0+444530 on eleven nights between 2006 June 5 and 2006 November 16 using a 0.35-m SCT operating at *f*/5.3 and an SXV-H9 CCD camera. Image scale was 1.4 arcsec/pixel with a typical FWHM of 2.5-3 pixels. Images were dark-subtracted and flat-fielded, and instrumental magnitudes were measured by aperture photometry using AIP4WIN (Berry and Burnell 2000). The magnitude of VSX J211145.0+444530 was measured relative to an ensemble of TYC 3181 1401 (C1, *V* = 11.24, (*V–I*) = 0.39) and GSC 03181-00369 (C2, *V* = 12.48, (*V–I*) = 0.68). Comparison star magnitudes were obtained from field photometry by Henden accessed through the AAVSO VSP service. The standard deviation of the zero points of these stars with respect to the mean ensemble zero point for each image averaged over all images was 0.007 magnitude. All times of observation were converted to HJD. Example light curves from two nights are shown in Figure 2.

Period analysis using the Lomb-Scargle (Lomb 1976; Scargle 1982) method in PERANSO (Vanmunster 2010) gives the power spectrum shown in Figure 3. The strongest signal is at frequency 0.685(3) c/d, period 1.459(6) days, with multiple-day aliases as expected from the spectral window. Removing the signal at 0.685 c/d leaves the power spectrum shown in Figure 4. The most prominent remaining signals in order of decreasing strength are at 0.212 c/d, 0.789 c/d, 0.143 c/d, and 0.710 c/d plus aliases of these. Removing either of the signals at 0.212 c/d or 0.789 c/d also removes the other signals plus their aliases leaving only signals a factor of four lower in power. Figure 5 shows the phase diagram of the data for a period of 1.459 days. The full amplitude of variation is 0.047 magnitude.

This variable could potentially be interpreted either as an eclipsing binary system or a pulsating variable. If it is the former, we would expect a significant signal at twice the above period, namely 2.92(1) days, but the nearest prominent signal is at 3.10(2) days. Folding the light curve on the expected binary period gives the phase diagram in Figure 6. This has too many gaps to be able to discriminate between the two interpretations. On balance, the absence of a clear signal at the expected binary period and the presence of multiple periods in the spectrum favor interpreting it as a pulsating variable.

We measured the (*V*–*I*) color of the variable as 0.49 magnitude. Other published colors of the star are Henden (*B*–*V*) = 0.36, TYC2 (*B*–*V*) = 0.34, TASS (*V*–*I*) = 0.47, 2MASS (*J*–*H*) = 0.064, and (*H*–*K*) = 0.059. These suggest an early F spectral type assuming the star is unreddened. To give the observed apparent *V*- magnitude, a main sequence star with this spectral type would lie at a distance of ~600 parsecs. As the star is only 2.4° from the galactic plane, it will inevitably have suffered some degree of reddening. Galactic dust reddening and extinction data from Schlegel *et al.* (1998) give a cumulative reddening in this direction of ~0.7 magnitude. More helpful are measurements of the open cluster NGC 7039, which is less than a degree from the variable on the sky and has reddening of 0.13 magnitude and a distance of 951 parsecs (WEBDA 1). The relative distances of the cluster and variable suggest a reddening of ~0.08 magnitude for the variable, which makes its intrinsic color $(B–V)_o$ ~0.28. This places the star at the lower end of the instability strip in the region occupied by the γ Doradus stars and close to the red edge of the distribution of δ Scuti stars (Henry *et al.* 2007). The observed period of 1.459 days is too long for a δ Scuti star but is consistent with γ Doradus (Percy 2007) so, subject to spectroscopic confirmation, we consider it likely that VSX J211145.0+444530 is a new γ Doradus variable.

2. VSX J202751.9+414727

VSX J202751.9+414727 is also not listed in SIMBAD but has been catalogued as GSC 03160-01853, GSC2.2 N0331103671, GSC2.3 N30Z000671, USNO-A2.0 1275-13940451, USNO-B1.0 1317- 0417130, UC3 264-197075, and 2MASS J20275193+4147278. It has not previously been recognized as variable. Its position was measured as R.A. $20^h 27^m 51.94^s$, Dec. +41° 47' 27.8" (J2000.0). It is 4.0 arcmin SW of the nova V2467 Cygni (= Nova Cygni 2007), see Figure 7.

3,185 *V*-filtered CCD observations of VSX J202751.9+414727 were made on ten nights between 2007 August 26 and 2007 November 12 using a 0.35-m SCT operating at *f*/5.3 and an SXV-H9 CCD camera. Image scale was 1.4 arcsec/pixel with a typical FWHM of 2.5-3 pixels. Images were dark- subtracted and flat-fielded, and instrumental magnitudes were measured by aperture photometry using AIP4WIN (Berry and Burnell 2000). The magnitude of VSX J202751.9+414727 was measured relative to an ensemble of GSC 03160-01807 (C1, *V* = 13.12, (*V–I*) = 0.60), and GSC 03181-01708 (C2, *V* = 13.64, (*V–I*) = 0.74). Comparison star magnitudes were obtained from field photometry by Henden accessed through the AAVSO VSP service. The standard deviation of the zero points of these stars with respect to the mean ensemble zero point for each image averaged over all images was 0.005 magnitude. All times of observation were converted to HJD. Example light curves from two nights are shown in Figure 8.

Period analysis using the Lomb-Scargle method in PERANSO gives the power spectrum in Figure 9. There is a strong signal at frequency 16.803(4) c/d, period 0.05951(2) day, with the expected multiple-day alias signals. Removing the signal at 16.803c/d leaves the signals shown in Figure 10. The remaining signals are all relatively weak with the strongest being at 6.556 c/d, 0.695 c/d, 24.42 c/d, and 20.47 c/d plus aliases of these. Removing each of these in turn does not diminish the others.

Figure 11 shows the phase diagram of the data for a period of 0.05951 day. The full amplitude of variation is 0.012 magnitude.

We measured the (*V–I*) color of the variable as 0.43 magnitude. Other published colors of this star are Henden (*B–V*) = 0.37, TASS (*V–I*) = 0.37, 2MASS (*J–H*) = 0.104, and (*H–K*) = 0.040. These suggest an early F spectral type for this variable also, again assuming no reddening. To give the observed *V*-magnitude, a main sequence star with this spectral type would lie at a distance of ~1000 parsecs. Since the star is only 1.8° from the galactic plane, it will also have experienced reddening. Galactic dust reddening and extinction data from Schlegel *et al.* (1998) give a cumulative reddening in this direction of > 5 magnitudes. We get more useful information from the open cluster Collinder 421, which is less than a degree from the variable on the sky and coincidentally has very similar measured parameters to NGC 7039 with reddening of 0.10 and a distance of 950 parsecs (WEBDA 2). The relative distances of the cluster and variable suggest a reddening of ~0.11 magnitude for the variable, which makes its intrinsic color $(B–V)_o$ ~0.26. This places the star among the δ Scuti variables at the lower end of the instability strip (Breger and Montgomery 2000). The observed period of 0.06 day, its small amplitude, and the sinusoidal nature of the light curve are all consistent with the interpretation of VSX J202751.9+414727 as a new δ Scuti variable.

3. Acknowledgements

We acknowledge with thanks use of the SIMBAD and VIZIER services operated by CDS Strasbourg and the VSP service provided by the AAVSO. We also thank the anonymous referee for helpful comments. This research has made use of NASA's Astrophysics Data System Service.

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WEBDA 2, http://www.univie.ac.at/webda/cgi-bin/ocl_page.cgi?dirname=cr421

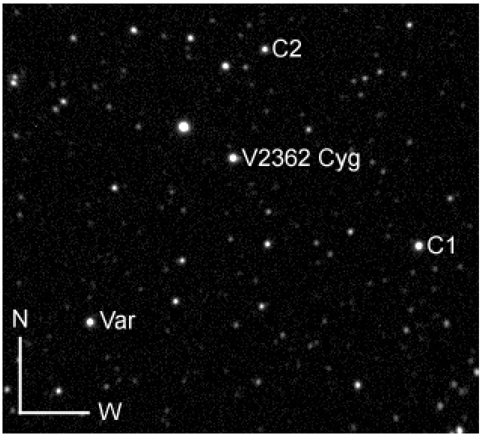
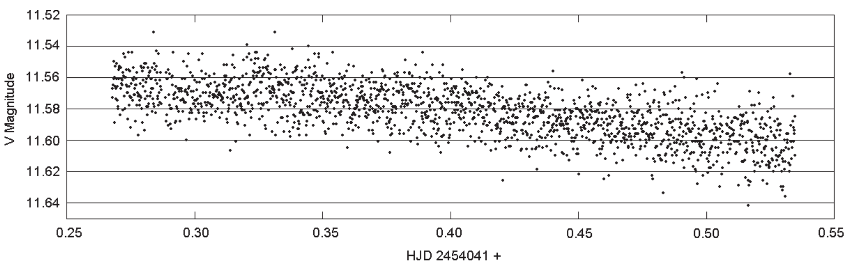


Figure 1. Location of the variable VSX J211145.0+444530 and comparison stars C1 and C2 (6’ × 6').



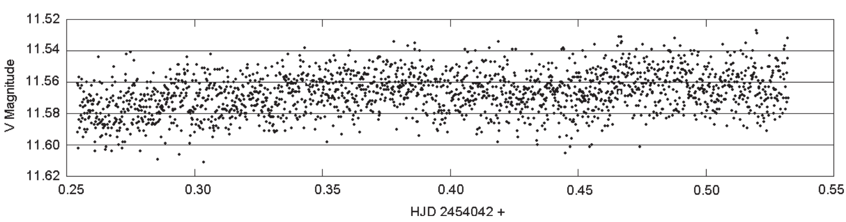


Figure 2. Example light curves of VSX J211145.0+444530 from 2006 November 1 and November 2.

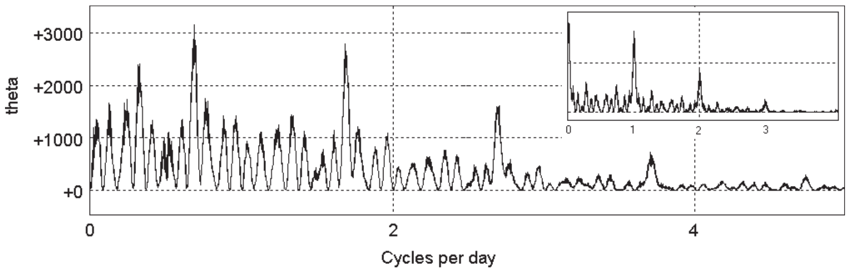


Figure 3. Power spectrum of VSX J211145.0+444530 also showing the spectral window.

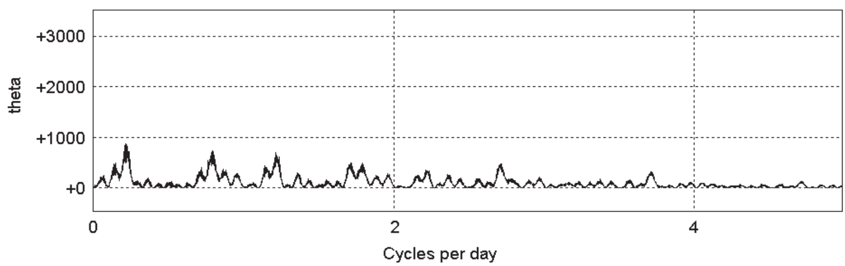


Figure 4. Power spectrum after removal of the signal at 0.685c/d.

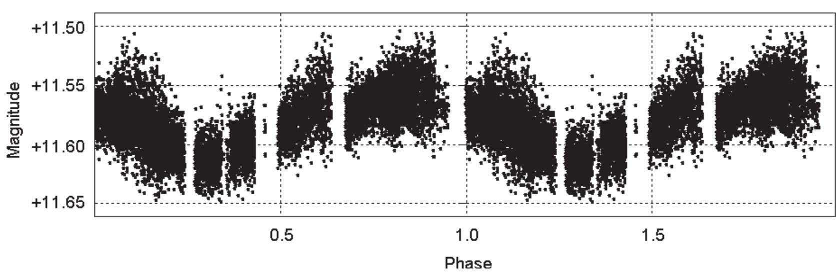


Figure 5. Phase diagram of VSX J211145.0+444530 for a period of 1.459 days.

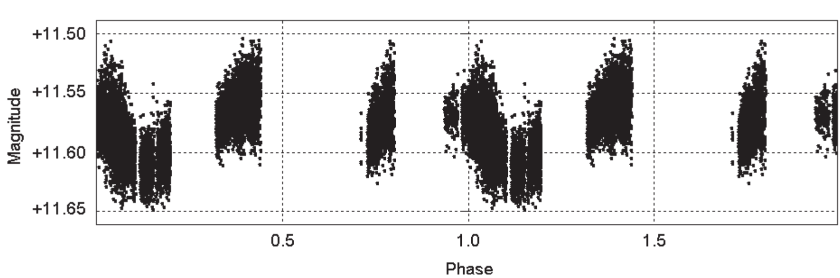


Figure 6. Phase diagram of VSX J211145.0+444530 for a period of 2.918 days.

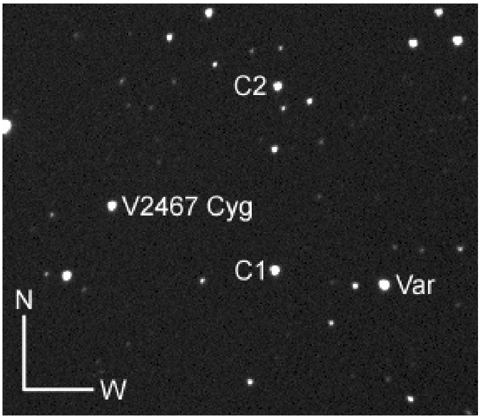


Figure 7. Location of the variable VSX J202751.9+414727 and comparisons stars C1 and C2 (7' × 6').

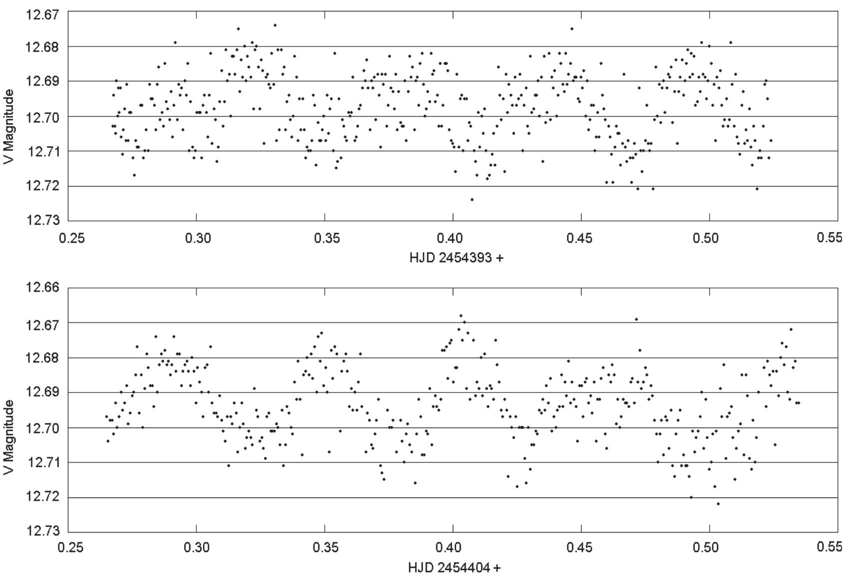


Figure 8. Example light curves of VSX J202751.9+414727 from 2007 October 19 and October 30.

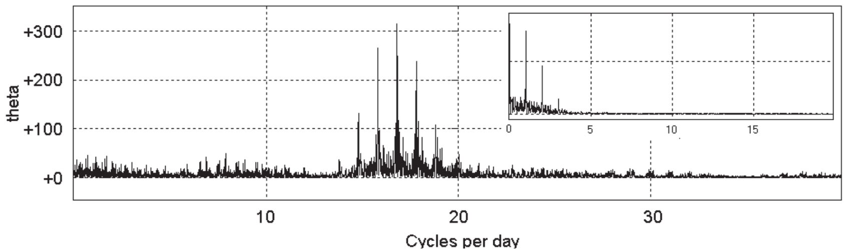


Figure 9. Power spectrum of VSX J202751.9+414727 also showing the spectral window.

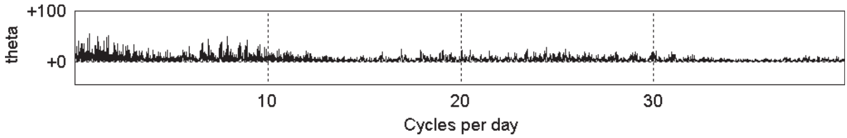


Figure 10. Power spectrum after removal of the signal at 16.803c/d.

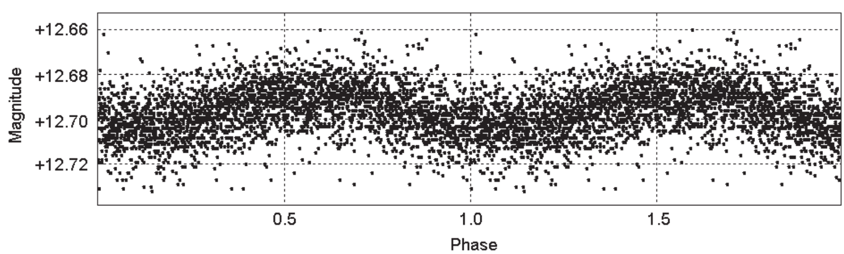


Figure 11. Phase diagram of VSX J202751.9+414727 for a period of 0.05951 day.