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PHOTOMETRIC VARIABILITY OF THE CHEMICALLY PECULIAR HOT SUBDWARF LS IV-14°116

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LS IV-14°116 was first catalogued as a luminous star by Nassau & Stephenson (1963). Kilkenny & Pauls (1990) classified it as an O-type subdwarf (sdO), while Viton et al. (1991) described it as an He-rich sdO star. Ahmad & Jeffery (2005) found the star to be photometrically variable with periods in the 30 – 90 minute range, and amplitudes of ≈ 0.003 mag. The star currently constitutes the sole member of the class of He-sdBVs (Kilkenny et al., 2010). Its variability is not reconciled with any theory of pulsational instability; g-modes would be indicated by the period, but are inconsistent with theoretical models of g-mode excitation in hot subdwarfs (Jeffery & Saio, 2006).

Although showing significantly more helium ($n_{\text{He}} = 0.21$, Ahmad & Jeffery, 2003) than the majority of sdB stars, LS IV-14°116 is not as extremely helium-rich as a few. Analysis of the spectrum at high-resolution has revealed a super-abundance ($\approx 4 \text{ dex}$) of zirconium, strontium, yttrium and germanium (Naslim et al., 2011), suggesting a heavily stratified atmosphere in which these particular elements have accumulated in the line-forming region. The question arises as to whether the photometric variability is in any way connected to the extreme chemical peculiarity of this star.

Night	Date	UT Start	$t_{\rm exp}$	$N_{\rm obs}$
N1	$2005 \ 06 \ 15$	23:00:43	10	1505
N2	$2005\ 06\ 16$	22:21:49	10	2093
N3	$2005\ 06\ 17$	22:19:18	15	336
N4	$2005\ 06\ 19$	22:42:46	15	1459

Table 1: Photometric observations of LS IV-14°116.

The very low-amplitude variations detected in the discovery data demanded confirmation. Additional observations were obtained with the South African Astronomical Observatory 1.0m telescope in 2005 June, using the University of Cape Town (UCT) high-speed CCD camera operated in 'frame-transfer' mode. Although the weather was not perfect, approximately 12.5 hours of data, and 5393 images were obtained (Table 1). The field size was the same as reported by Ahmad & Jeffery (2005), so that only one star was available as a useful comparison (GS2.2: S331330313746, R=14.1). A third star was too faint to provide a satisfactory check of the photometry. Regrettably, an unmarked improvement in seeing led to approximately 1300 frames obtained on the night of 2005 June 16 being saturated. These frames were easy to identify and discard during analysis of the light curve. The observer was duly chastened.



Figure 1. Differential photometry of LS IV-14°116 from June 2005.

The data were reduced using the ULTRACAM data reduction pipeline software (Dhillon & Marsh, 2001), extracted to differential magnitudes, and normalised (*i.e.* corrected such that $\langle V - C \rangle = 0$). Because the comparison star is substantially redder then LS IV-14°116, differential extinction is significant (> 0.04 mag/airmass), so data for each night were detrended by subtracting a third order polynomial fit. The final differential light curve is shown in Fig. 1, where variations of up to ± 0.01 mag. are clearly visible.

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f/mHz	a/mag	(f_{2004})	(a_{2004})
0.2908	0.0027		
0.2011	0.0018		
0.3368	0.0019	0.3484	0.0019
0.5203	0.0018	0.5119	0.0021

The Scargle power spectrum and window function for the entire dataset are shown in Fig. 2. The power spectrum resembles that obtained in 2004 (Ahmad & Jeffery, 2005) in so far as there is power at around 0.34 mHz and at 0.52 mHz in both cases. Any power at f < 0.05mHz has been removed by the detrending procedure. Best-fit frequencies and semi-amplitudes obtained using the period analysis software PERIOD04 (Lenz & Breger, 2005) are shown in Table 2. Errors are ± 0.0116 mHz in frequency (*i.e.* at least one cycle per day) and ± 0.0005 mag. in semi-amplitude. Allowing for such errors, we note that three frequencies might be construed as an harmonic series of 0.17, 0.34 and 0.51 mHz.



Figure 2. Scargle periodogram and window function (inset) for LS IV-14°116 from June 2005.

Ahmad & Jeffery (2005) suggested that the periodic variability in LS IV-14°116 could be due to pulsation. This view has been difficult to reconcile with the effective temperature and surface gravity of LS IV-14°116, and the known instability mechanisms for subdwarf B stars (Jeffery & Saio, 2007). The discovery of extreme chemical peculiarity (Naslim et al., 2011) suggests at least one alternative; namely that the stellar surface could be chemically inhomogeneous and that the surface flux might be modulated by rotation as in the strongly-magnetic Bp(He) stars. Arguing against such a proposition is the projected rotation velocity which is less than $2 \,\mathrm{km} \,\mathrm{s}^{-1}$.

Given the quantity and quality of the 2005 photometric data, there is substantially little new information to be extracted from the light curve. The persistence of power at 0.34 and 0.52 mHz from 2004 to 2005 suggests that the underlying mechanism is physically robust, and not due to some stochastic process. Substantially better data are needed to establish the power spectrum more securely.

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