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A STUDY OF THE BRIGHT RR LYRAE STAR CN Cam

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Strohmeier and Knigge (1961) discovered that CN Cam is variable and classified it as an eclipsing system. It was shown to be a type *ab* RR Lyrae star by Campos-Cucarella, Nomen-Torres, Gomez-Forrellad and Garcia-Melendo (1996); they made CCD observations of the star in B and V for 12 nights between 16 December 1995 and 12 February 1996. Their precise light curves show that CN Cam is not only one of the brighter RR*ab* ($V_{\rm max} = 9\overset{\rm m}{.}53$) but also has one of the lowest amplitudes ($0\overset{\rm m}{.}350 \pm 0.005$ and $0\overset{\rm m}{.}474 \pm 0.004$ magnitudes in V and B respectively). They gave the following ephemeris:

$$\mathrm{HJD_{max}} = 2450080.588 \pm 0.002 + 0.6214 \pm 0.0001 \times \mathrm{E} \qquad (1)$$

New photometric observations were needed, not only to improve the ephemeris but because Campos-Cucarella et al. only gave the PPM magnitude for their comparison star, SAO 001899; consequently the zero-points of their magnitudes need to be checked. We observed this comparison star on five nights and found $V = 10.201 \pm 0.003$ and $B - V = +0\overset{\rm m}{.}356 \pm 0.005$. The variable and this comparison star were observed in 1998, 1999 and 2004 (Fig. 1) and we found the following ephemeris:

$$\mathrm{HJD_{max}} = 2450080.588 \pm 0.002 + 0.621445 \pm 0.000002 \times \mathrm{E} \qquad (2)$$

The photometric observations in 1998 and 1999 were made with the Kitt Peak 0.9-m telescope using a 512 × 512 Tektronix chip under the control of the CCDPHOT program (Tody & Davis 1992, Kinman 1998). The observations in 2004 were made with the commercial robotic f/7 0.8-m Ritchey-Chretien telescope at the Tenagra Observatory in Arizona (Schwartz, 2007). The detector on this telescope was a 1024 × 1024 SITe CCD. These data were reduced with standard IRAF routines (Tody, 1993).

Our photometric observations (Table 1) give $\langle V \rangle = 9\overset{\rm m}{.}64$ and a $V_{\rm max}$ of $9\overset{\rm m}{.}42$: this is about 0.1 mag brighter than the value found by Campos-Cucarella et al. although the amplitudes that we find ($0\overset{\rm m}{.}36$ and $0\overset{\rm m}{.}49$ in V and B respectively) are close to their values. Our range in $(B-V)$ ($+0\overset{\rm m}{.}325$ to $+0\overset{\rm m}{.}454$) differs significantly from their range of $+0\overset{\rm m}{.}26$ to $+0\overset{\rm m}{.}38$.

Wils et al. (2004) used the data in the The Northern Sky Variability Survey (Woźniak et al., 2004) to give the following ephemeris for CN Cam:

$$\mathrm{HJD_{max}} = 2451628.65 + 0.62149 \times \mathrm{E} \qquad (3)$$

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This does not agree well with our ephemeris nor the epoch of maximum given by Campos-Cucarella et al. Our examination of the Northern Sky Variability Survey shows that the best defined maximum in this data is given by the three observations at JD(hel) 2451311.6756, 2451311.6778 and 2451311.6787. If we take their epoch of maximum light to be the mean of these three epochs (JDhel 2451311.677), we find a phase of 0.010 with our ephemeris and a phase of 0.979 with the ephemeris of Wils et al. We therefore consider that there is no discrepancy between our ephemeris and the data of the Northern Sky Variability Survey, but that our ephemeris is to be preferred to that of Wils et al.

Radial velocities of CN Cam were obtained using the WIYN 3.5 m telescope and the Hydra fiber spectrograph in July, 1998. A spectral region of 510 Å centered on λ4315 was used (0.26 Å per pixel or $\sim$0.8 Å resolution). The velocity standard HD 136202 (Sp Type F8 III-IV, +54.4 km s^{-1}, Scarfe et al., 1990; Jeffery et al., 2007) was used as the template (using the whole spectrum including Hγ) to measure the radial velocities. HD 128167 (Sp Type F2 V, +0.04 km s^{-1}, Fekel, 1999) was observed as a check. The phases of the spectra were derived from our ephemeris and the γ-velocities were derived following Liu (1991). The results are given in Table 1 where T is the UT time (start), t is the integration time, JD_{hel} is the heliocentric Julian date, ϕ is the phase, V_{hel} is the heliocentric radial velocity and V_γ is the derived γ-velocity.

Table 1. Radial velocities of CN Cam and Velocity standards.

Star	Date (1998) (U.T)	T h:m	t s	JD_{hel} 2450000.+	ϕ	V_{hel} km s^{-1}	V_γ km s^{-1}
CN Cam	Jul 12	05:15	300	1006.7181	0.270	−82.7	−98.9
CN Cam	Jul 12	05:25	600	1006.7269	0.284	−81.3	−98.4
HD 136202	Jul 12	05:42	100	1006.7405	···	+54.2	···
HD 136202	Jul 12	05:49	300	1006.7467	···	+54.4	···
HD 128167	Jul 14	03:52	60	1008.6615	···	+0.9	···
HD 136202	Jul 14	03:58	90	1008.6686	···	+54.4	···
CN Cam	Jul 14	04:12	900	1008.6775	0.424	−72.9	−98.8

Jurcsik & Kovács (1996), Kovács & Walker (2001) and Sandage (2004) have shown that the metallicity [Fe/H] can be derived from the shape of the light curve and period of an RR Lyrae star. A Fourier combination ϕ_{31} of 2.467 was derived from the V light curve given by Campos-Cucarella et al. (1996); this gave [Fe/H] = −1.095 using Sandage's equation (3). A visual amplitude of $0\overset{m}{.}357$ gave [Fe/H] = −1.013 with Sandage's equation (6) while a rise-time of 0.25 gave [Fe/H] = −1.135 with Sandage's equation (7). These agree well with the approximate [Fe/H] = −1.2 that Castelli (2004) derived from our 1998 Jul 14 spectrum by comparison with spectra derived from model atmospheres. If we assume [Fe/H] =−1.1 and the absolute magnitude relation:

$$M_v = 0\overset{m}{.}214[\mathrm{Fe/H}] + 0\overset{m}{.}86 \qquad (4)$$

of Clementini et al. (2003), we find $M_v = +0\overset{m}{.}62$. The extinction $E(B-V) = 0\overset{m}{.}047$ (l = 126$\overset{\circ}{.}$4 and b = +35$\overset{\circ}{.}$3) was taken from Schlegel et al. (1998) to give a distance of 594 pc. If we assume a 10% error in the parallax (1.684 mas), and the TYCHO proper motions $\mu_\alpha = -113.2\pm1.1$ mas, $\mu_\delta = -81.5\pm1.1$ (Hog et al., 2000), we get the following heliocentric galactic coordinates in km s^{-1}:

$$\mathbf{U} = -222 \pm 24, \quad \mathbf{V} = -338 \pm 24 \quad \text{and} \quad \mathbf{W} = +27 \pm 8$$

using the right-handed system which is positive towards the Galactic Centre, the direction of Galactic rotation and the North Galactic Pole (Johnson & Soderblom, 1987). CN Cam is therefore a halo RR Lyrae star with a significant retrograde galactic rotation and is consequently likely to belong to an *accreted* halo population (Kinman et al., 2007).

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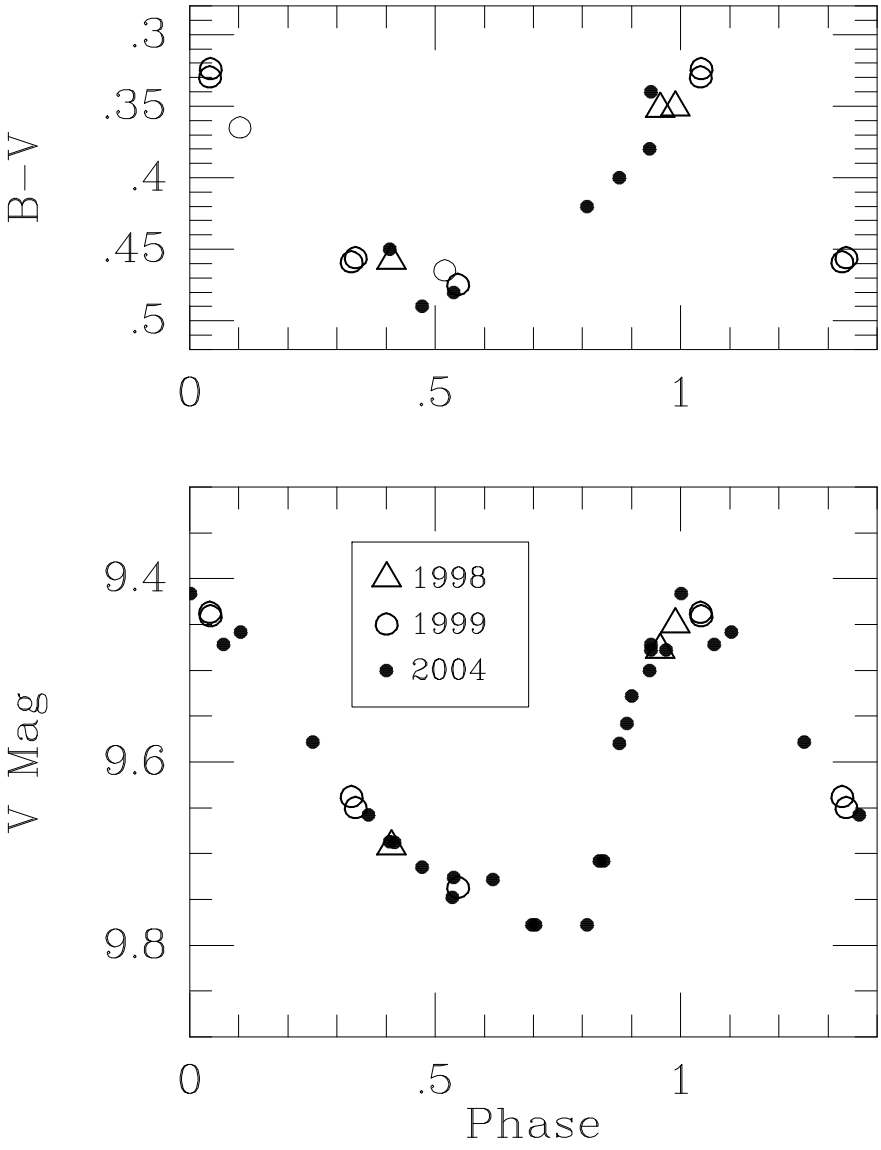

Figure 1. Fig. 1 (above) The $(B-V)$ colours and (below) the V magnitude of CN Cam as a function of phase (ϕ). 1998 observation (triangles), 1999 observations (open circles) and 2004 observations (filled circles).