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# ABELL-35 PHENOMENA IN SYMBIOTIC STARS: DISCOVERY OF 1.2 AND 6.4 DAY PERIODS IN VV8 (V471 PER)

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**Abstract.** We have collected high precision optical photometry of VV8, so far 782 individual observing runs uniformly distributed over the period 2005–2011. This dataset allows us to refine the known long periodicity of VV8 to $P$ = 16.8 yr, with peak-to-valley amplitudes of $\Delta B = 0.18$ and $\Delta V = 0.14$ mag. In addition, we have discovered two new periodicities: 6.431 d (total amplitude $\Delta B = \Delta V = \Delta I = 0.05$ mag) and 1.185 d ($\Delta B = 0.022$, $\Delta V = 0.018$, $\Delta I = 0.014$ mag). These two short periods are reminiscent of the Abell-35 phenomena displayed by binary nuclei of planetary nebulae that have gone through a common envelope phase. Twice the 6.431 d period would nicely correspond to the double-peaked light-curve that the G5 III star in VV8 would display if its Roche lobe would be ellipsoidally distorted.

**Key words:** planetary nebulae: central star – stars: symbiotic binaries

## 1. 2005–2011 PHOTOMETRIC MONITORING

VV8 (or M 1-2, V471 Per) is a remarkably quiet, point-like stellar object, with a simple and sharp emission line spectrum of moderate excitation (He II/H$\beta$ = 0.1), on top an absorption continuum resembling a normal G5 III star (see Figure 1). The object shares many properties of both yellow symbiotic binaries and of bona fide young and dense planetary nebulae with a binary nucleus, its true nature being still controversial in literature.

We are monitoring VV8 in the $B$,$V$,$R_{\rm C}$,$I_{\rm C}$ passbands with various telescopes operated by ANS Collaboration (see Munari et al. 2012). We have so far collected 782 photometric runs uniformly distributed over the period 2005–2011, 441 of them with ANS telescope R030 that provides the most accurate and homogeneous dataset for this object. The median value of the total budget error (that includes both the Poissonian component as well as the error of the transformation to the photometric sequence calibrated around VV8 by Henden & Munari 2001) is 0.008, 0.006, 0.006, 0.005 mag for the $B$,$V$,$R_{\rm C}$,$I_{\rm C}$ passbands respectively.

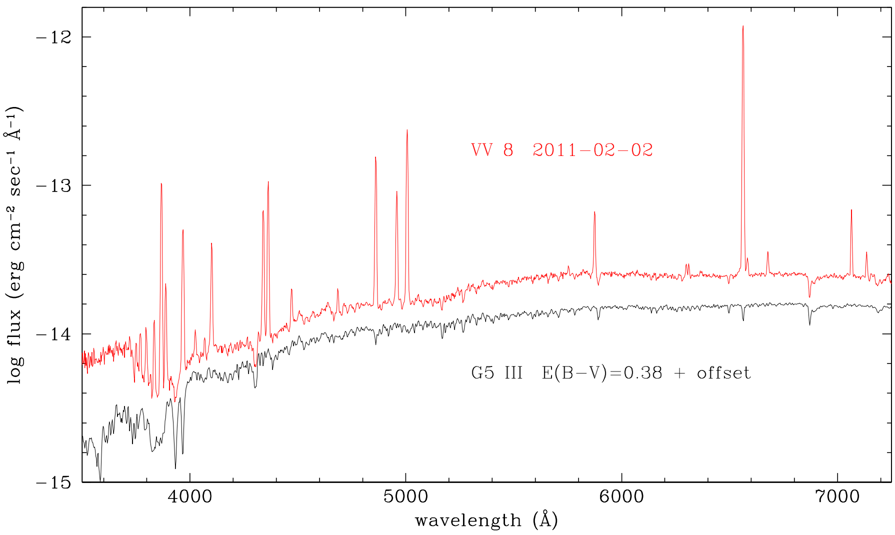


**Fig. 1.** An absolutely fluxed spectrum of VV8, recently obtained with the Asiago 1.22 m telescope, compared to the spectrum of a field G5 III star, reddened to match VV8.

## 2. 16.8 YR, 6.431 DAY AND 1.185 DAY PERIODICITIES

Arkiphova & Noskova (1988) suggested the existence of a very long periodicity of small amplitude in the photometric evolution of VV8. Siviero et al. (2007) derived a preliminary 21 yr period combining the Arkiphova & Noskova (1988) measurements with the first two years of ANS Collaboration data. Incorporating into the analysis four additional years of ANS Collaboration observations and the 1999–2000 data from the multi-epoch photometric catalog of symbiotic stars of Henden & Munari (2008), we confirm the existence of this periodicity and constrain its length to 16.8 yr, following the ephemeris

$$\text{Max}\,(16.8\text{ yr}) = 2453115 + 6150 \times E\ . \qquad (1)$$

The $B$ and $V$ light curves in Figure 2 are plotted from yearly averages, and the full amplitude of the observed variability is $\Delta B = 0.18$ and $\Delta V = 0.14$ mag.

After cleaning the data from the 16.8 yr periodicity, we subjected them to a Fourier analysis and subsequently to a $\chi^2$ minimization onto a single sinusoidal component. The analysis revealed the presence of a strong periodicity at

$$\text{Max}\,(6.4\text{ d}) = 2455504.40 + 6.431 \times E \qquad (2)$$

characterized by $\Delta B = \Delta V = \Delta I = 0.05$ mag full amplitude of variability. It was already pretty evident to a simple visual inspection of the rough data. The resulting light curve, plotted with the 2005–2006 data, is presented on the left panel of Figure 3.

Looking to the rough data in detail (especially to multiple observations during the same night) suggests the presence of a further and appreciably shorter periodicity. To investigate it, we cleaned the input data from *both* the 16.8 yr and the 6.431 d variability, and again run a Fourier analysis and subsequent $\chi^2$ minimization that revealed the presence of a clear periodicity at 1.184882 day, following the

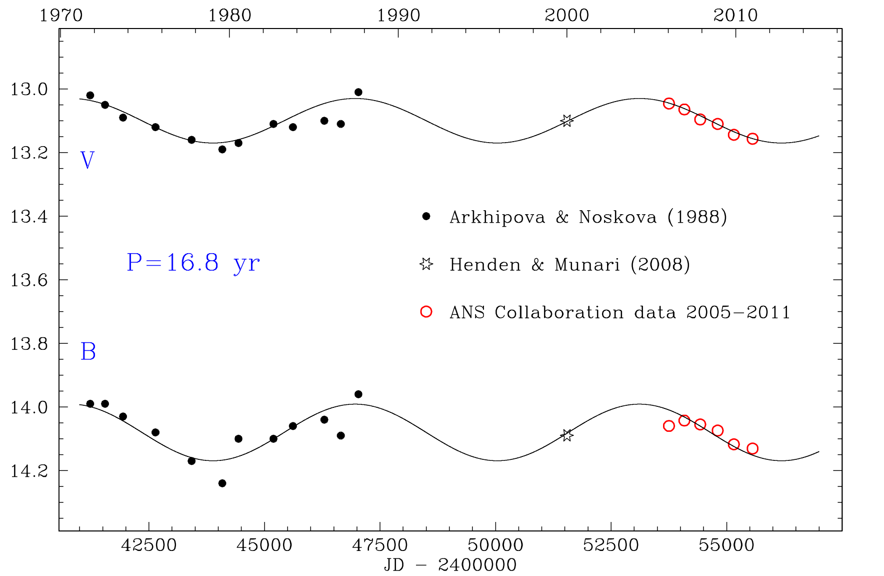


**Fig. 2.** The *B* and *V* light curves of VV8 modulated by the 16.8 yr period. The plotted points are yearly averages.

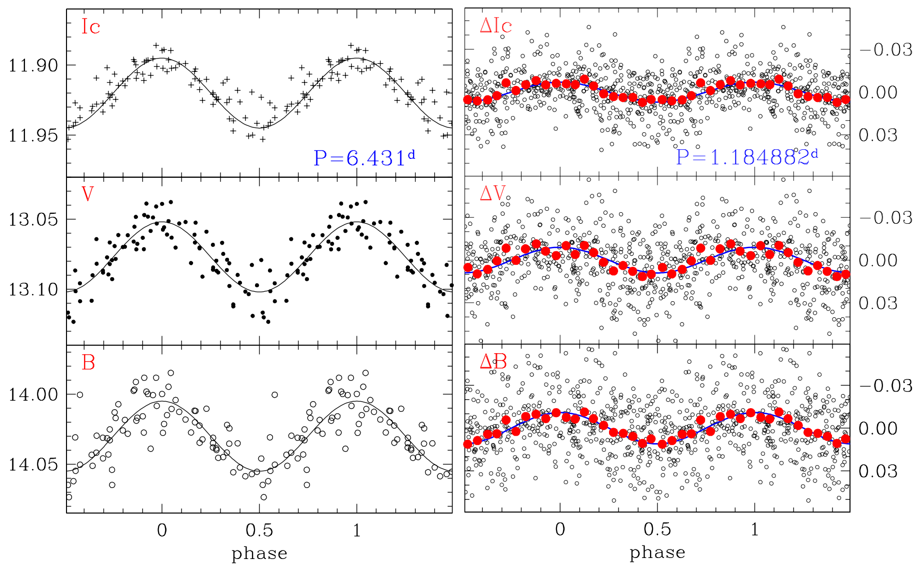


**Fig. 3.** *Left:* the 2005/06 ANS Collaboration data (for R030 telescope only) of VV8, phase plotted according to Eq.(2) for the period 6.431 day. *Right:* the 2005/11 ANS Collaboration data (for R030 telescope only) of VV8, cleaned from the 16.8 yr and 6.431 d periodicities, phase plotted according to Eq. (3) for the period 1.184882 d. Red dots are the mean values for the data divided in phase into 20 equal bins.

ephemeris

$$\mathrm{Max}\,(1.2\ \mathrm{d}) = 2455562.34 + 1.184882 \times E\ , \tag{3}$$

which is characterized by a full amplitude of $\Delta B = 0.022$, $\Delta V = 0.018$, $\Delta I = 0.014$ mag. The corresponding light-curve is plotted in the right panel of Figure 3.

## 3. THE ORBITAL PERIOD

Siviero et al. (2007) argued for a radius of 85 AU and a mass $3 \times 10^{-4}\,\mathrm{M}_\odot$ for the H II region in VV8. If the 16.8 yr period is the orbital one, it corresponds to an orbital radius of 8–9 AU for a total system mass $(M_1 + M_2) \sim 2\,M_\odot$. Thus, a 16.8 yr binary would revolve at the very core of a $\sim 10\times$ larger ionized H II region. Such a very long orbital period would be highly unusual for non-Mira symbiotic binaries, especially for yellow symbiotic stars. Such a wide separation would also appreciably reduce the amount of the (already light) G5 III wind that could be accreted by the WD.

Bond (1994) called attention to a group of 14 PNe with binary nuclei characterized by orbital periodicities ranging from 0.1 to 10 days, which must be the outcome of a deep common envelope phase of their binary progenitors. This has been popularly addressed as the *Abell-35 phenomenon*, naming it after the prototype. The 6.431 and 1.184882 d periods found in VV8 are typical of those found in PN nuclei of the Abell-35 type.

A normal G5 III star has a radius of $\sim 10\ R_\odot$, which sets to the $\sim 13$ d orbital period if the giant fills its Roche lobe and $(M_1 + M_2) \sim 2\ M_\odot$. While this rules out an orbital interpretation for the 1.184882 d period, it makes the 6.431 d period quite attractive. In fact, the ellipsoidally distorted light-curve of the Roche lobe filling star has two maxima and two minima, and twice the length of the 6.431 d period matches closely the expected orbital period for a Roche lobe filling G5 III. In such a case, the expected rotational velocity displayed by the G5 III giant should be $V \sin i \sim 80$ km/s, a value already observed in other yellow symbiotic stars, e.g., 105 km/s for the G7 III nucleus of StH$\alpha$190 (Munari et al. 2001).

While we are tempted to suggest that 13 d ($2 \times 6.431$ d) could be the orbital period of VV8, we restrain here from arguing about the nature of the 16.8 yr and 1.184882 d periodicities.

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