Optical study of V886 Her - a rapidly changing post-AGB star

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Summary. We investigate a behavior of a post-AGB object - V886 Her. The star undergoes night-to-night brightness variations which we argue are of two kinds. One of them is probably dominated by temperature changes, while the other can be mostly attributed to a variable stellar surface. Furthermore, our long-term photometric observations carried out in the period of 1998-2004 indicate that V886 Her has possibly increased both star's temperature and the nebula contribution in the spectrum.

Key words: stars: AGB and post-AGB - stars: individual (V886 Her)

1 Introduction

V886 Her (≡IRAS 18062+2410) is a low-mass ($M \approx 0.70 M_\odot$) post-AGB object which fast transition from F to B spectrum was observed during the last 100 years [2]. It was accompanied by a gradual decrease in V brightness and irregular night-to-night light variations with the amplitude up to 0.4 mag [1]. Spectroscopic observations revealed a strong Hα emission [8] and very low excitation nebular lines (*e.g.* [OII],[NII],[SII]) [4]. The underabundance of metals was evinced both in optical and UV spectra which together with the high galactic latitude ($b = +20^\circ$) led to the conclusion that V886 Her belongs to the old disk population II stars [7].

2 $UBV(RI)_C$ monitoring

Multicolor observations of V886 Her were secured in 1998-2004 in the Astronomical Observatory of Nicolaus Copernicus University in Piwnice near Torun, Poland, using 0.6 m Cassegrain telescope equipped with a single channel photometer (1998-2003) and a CCD camera (2003-2004). Our $UBV(RI)_\mathrm{C}$ measurements are presented in Figure 1. We detected no reliable period of changes in the whole set of our data.

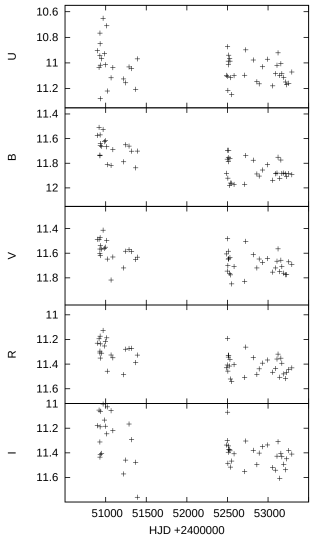

Fig. 1. Long-term $UBV(RI)_\mathrm{C}$ monitoring of V886 Her obtained in 1998-2004. No reliable periods were detected in our analysis of the whole sample.

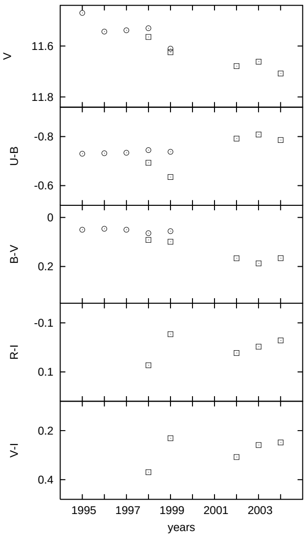

Fig. 2. Annual means of V brightness and selected color indices. We compare our observations (squares) with measurements published in [1],[2] and [3] - circles.

In order to compare our observations with previous measurements [1, 2, 3], we calculated mean values of V brightness and color indices from each observing season (Figure 2). Hence we note further gradual decrease in V brightness, a significant bluing of $U-B$ index and a reddening of $B-V$ index, which are affected by a substantial hydrogen continuum emission (see also Figure 5). On the other hand, $(R-I)_\mathrm{C}$ and $V-I_\mathrm{C}$ indices become bluer due to a rising temperature of the star from B2 photosphere in 1995 to B1 spectrum in 2004, assuming $E(B-V)=0.3$ mag (see Section 4).

3 Night-to-night changes

Time-resolved $UBV(RI)_\mathrm{C}$ photometry of V886 Her obtained during 3 nights (June 15, 16 and 20) in 2002 at the Kryoneri Astronomical Station of the National Observatory, Athens, Greece, with the 1.2 m telescope and the SI-502 CCD camera is presented in Figure 3. The observed magnitudes show linear trends responsible for night-to-night variations and no flickering in timescales of minutes [6]. In addition, we notice interesting correlation between changes in brightness and color indices during the 3 nights of our observations. The brightness on June 15 was the lowest in all bands. On June 20 the I_C brightness was almost equal to that of June 15, whereas the U magnitude was virtually the same as at the maximum on June 16. In other words, the $UBV(RI)_C$ brightness on June 16 increased in all bandpasses with respect to the values from June 15. However, the change in brightness on June 20 was dependent on the wavelength, with the values increasing more toward the shorter wavelengths. Such a dichotomy may originate from different physical instabilities that cause such variations. We connect the simultaneous changes of all color indices (as on June 16) with possible stellar surface (radius) variations and the changes increasing toward the bluer part of the spectrum (June 20) with its temperature changes.

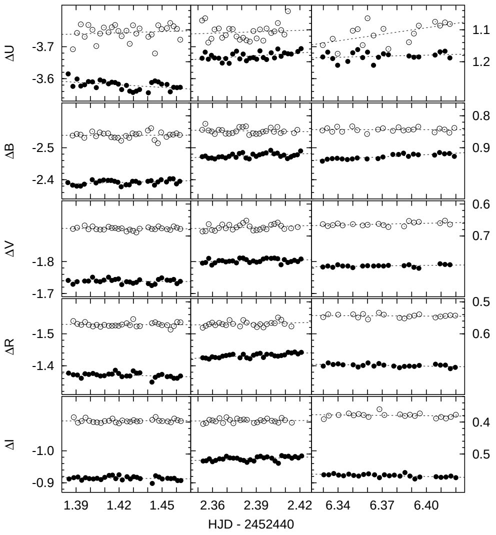

Fig. 3. Time-resolved observations of V886 Her secured in June 15, 16 and 20, 2002. Dots represent the magnitude differences between V886 Her and our comparison star. Open circles show the differences between the comparison star and a check star. Dashed lines visualize linear trends. We note two different patterns of brightness changes with respect to color index changes.

Subsequently, we made an attempt to divide our long-term photometric data (Figure 1) into two subgroups where each mechanism dominates the brightness variations (Figure 4). Firstly, we selected measurements which have brighter Ic and redder $(R-I)_C$ index as dominated by surface variations (19 dots in Figure 4). Secondly, we chose observations with weaker I_C and bluer $(R-I)_C$ as dominated by temperature changes (20 open circles in Figure 4). The remaining measurements were excluded from further analysis (11 triangles in Figure 4). Afterwards, we searched for periodicities with using Scargle-Lomb algorithm. We found reasonable period of $P_1 = 51.22$ and $P_2 = 4.03$ days for changes dominated by stellar surface variations and temperature instabilities, respectively. We show the phased light curves in Figure 4.

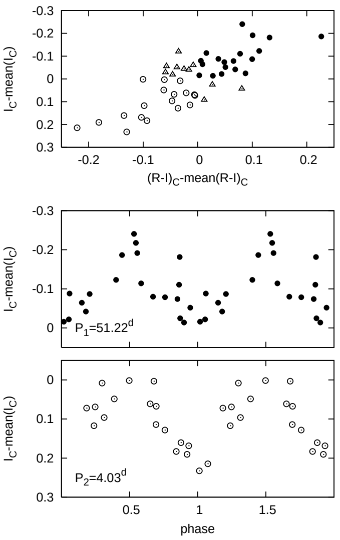

Fig. 4. First panel presents the Hertzprung-Russel diagram for all I_C versus $(R-I)_C$ data relative to corresponding mean values which separated changes dominated by surface changes (dots) and temperature variations (circles). Remaining points close to the mean value have unclear status (triangles). Two bottom panels show periodic variations of the data selected in the top panel.

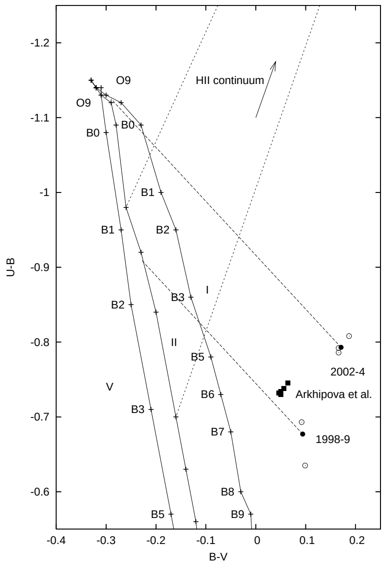

Fig. 5. A color-color diagram with our (open circles) and Arkhipova‘s data during 1995-99 (filled squares) annual means of $U-B$ and $B-V$ color indices of V886 Her. We draw the sequences of normal colors for dwarfs (V) and supergiants (I, II) with solid lines, the reddening lines with long dashed lines and the direction towards hydrogen continuum emission with short dashed lines. In addition, filled circles represent mean values of $U-B$ and $B-V$ color indices for our observations in 1990s and 2000s.

4 Color-color diagram

The annual means of $U-B$ and $B-V$ color indices on a color-color diagram (Figure 5) show that V886 Her has most probably B1-2 II spectrum with $E(B-V) = 0.3$ mag in 1990s. As pointed out by Arkhipova et al. [2], that value of reddening includes $E(B-V) = 0.2$ mag produced by circumstellar matter. A considerable shift is apparent in the diagram toward the top right corner between 1998 and 2004, almost precisely in the direction of hydrogen continuum emission [5].

Moreover, our prismatic spectra obtained with 60/90 Schmidt telescope confirm an increase in hydrogen flux with respect to older observations. Dereddened ($E(B-V) = 0.3$ mag) flux in Hα in May 2 and May 16, 2007, was 5.64 and $6.64 \times 10^{-12} erg \cdot cm^{-2} s^{-1}$, respectively. In comparison to the former value of $2.57 \times 10^{-12} erg \cdot cm^{-2} s^{-1}$ in 1997 [2] it confirms a rapid growth of the ionized volume of hydrogen. Together with increasing photospheric temperature it suggests the beginning of a transition between a protoplanetary and a planetary phase.

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