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NSV 08092: an Unusual R CrB Star or a Post-AGB Object at the "Born-again" Stage?

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We have recovered the "lost" variable star NSV 08092 = HV 8988. Form archive data, its brightness variations are rather unusual. In some aspects, it resembles R CrB stars, but it can be an analog of the famous unusual post-AGB star FG Sge.

1 Introduction

During the recent years, one of the authors (EVK) works on the program aimed at recovery and subsequent study of stars from the NSV catalog (Kukarkin et al., 1982). She found several hundred variable stars, possible identifications for stars suspected of variability by different discoverers in the first half of the 20th century. In the absence of any published finding charts, these stars were effectively "lost" for observations. Digitized sky images (the STScI Digitized Sky Survey, the USNO Image and Catalogue Archive) and databases of CCD observations from automatic telescopes that became available in the recent decades not only permit to recover many lost variables but also to study the character of brightness variations, to determine variability types for many of them (Kazarovets and Pastukhova, 2008–2011).

In this paper, we present a study of the star HV 8988 (= NSV 08092), discovered as a variable by Luyten (1935). Despite the large announced variability amplitude ($13\overset{m}{.}3$–$< 15\overset{m}{.}5$ pg), no identification candidate for this Luyten's variable was suggested so far.

2 Identification

We began our search for HV 8988 with "blinking" two $10' \times 10'$ red images from the USNO Image and Catalogue Archive, centered at the 1900.0 coordinated published by Luyten. A third red-light image was then found in the Aladin Sky Atlas (Centre de Données astronomiques de Strasbourg). This comparison of three images revealed a large-amplitude variable star rather close from the position published by Luyten, in $0\overset{'}{.}6$ to the south-east. Figure 1a,b presents the red-light images of the surroundings of HV 8988 from the ESO survey of the southern sky (July 26, 1984, epoch 1984.555), where the star is at its maximum light, and from the SERC survey (March 31, 1997, epoch 1997.248), where the star is at minimum.

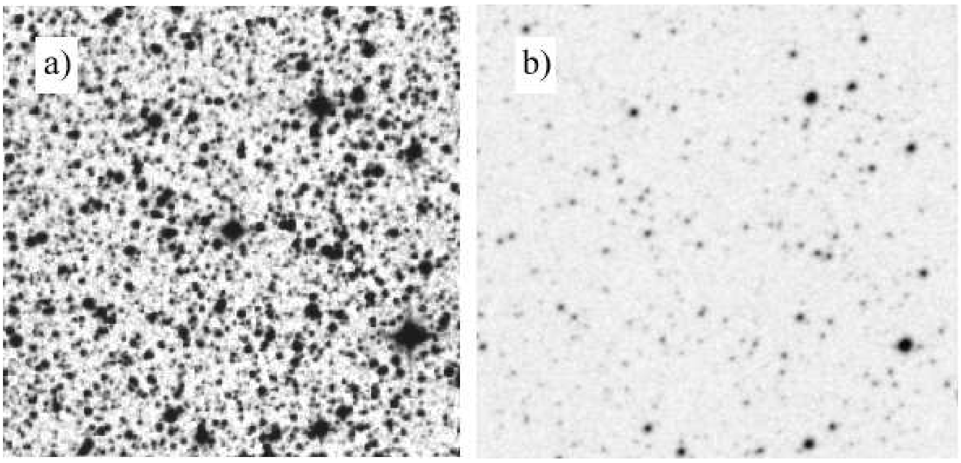

Figure 1. The red-band images of HV 8988. (a): ESO, epoch 1984.555, the star is in the center; (b): SERC, epoch 1997.248. North is on top, east is to the left. The side of the square is 5 minutes of arc.

The star is not present in the GSC catalog (epoch 1975.298) or in the USNO-A2.0 catalog (epoch 1979.930). It enters the UCAC3 catalog as 3UC 080–305383, its accurate coordinates are: $\alpha = 17^{\mathrm{h}}01^{\mathrm{m}}01\overset{\mathrm{s}}{.}414$, $\delta = -50°15'34\overset{''}{.}82$ (J2000.0). The catalog quotes the star's brightness, $F_{\mathrm{mag}} = 12.67$, measured in yellow light (R_{UCAC}, in the 0.579–0.642 nm band). The epoch in the catalog, 1998.310, is the mean epoch of astrometric measurements; unfortunately, it does not coincide with the time of the brightness estimate.

In the 2MASS catalog, this is a star with a large IR excess: $J = 13\overset{\mathrm{m}}{.}972$, $H = 11\overset{\mathrm{m}}{.}414$, $K_s = 9\overset{\mathrm{m}}{.}351$, $J-K = 4\overset{\mathrm{m}}{.}62$ for the epoch 1999.483. The IRAS fluxes at 12, 25, and 60 μm are respectively 1.68, 0.91, 0.94L Jy, the point-source-catalog name being IRAS 16571–5011. In the IRAS two-color diagram [12]–[25], [25]–[60] μm, the star is among R CrB variables and planetary nebulae.

3 Variability

We measured the brightness of HV 8988 from all available archive images (or photographic atlas maps) by comparison to surrounding stars with known B and R magnitudes from the USNO-A2.0 catalog. The results are presented in the Table; its columns contain the archive name, image epoch, our magnitude estimate, and its photometric band. The last column contains magnitudes from catalog archives, measured by other authors using the same images.

The star is not listed in the Pojmanski et al. (2006) catalog of variable stars discovered in the ASAS-3 survey in 2002–2006, meaning that the star was below the limiting magnitude of the survey, $V \sim 15^{\mathrm{m}}$. It became visible after JD 2454000, and ASAS data show its subsequent brightening to the maximum at $V = 11\overset{\mathrm{m}}{.}6$ (JD 2455093.5). The brightness stayed at this level till the end of publicly available ASAS observations for 40 more days, i.e. till November, 2009.

The smoothly brightening light curve is superposed with variations having an amplitude up to $0\overset{\mathrm{m}}{.}5$ and a timescale from dozens of days to a hundred days. They were best expressed in 2009. We were not able to derive a cycle length for these variations.

Figure 2 presents the photometric measurements of HV 8988 from 1970 till 2009; Fig. 3 is the detailed V-band light curve from 2007 to 2009 based on the ASAS archive observations. Our analysis of the photometry demonstrates that the brightness variation amplitude is at least $5^{\mathrm{m}} - 6^{\mathrm{m}}$ in the blue and red spectral ranges. The brightness maxima are recurrent, there were at least three of them in 40 years. The rate of egress from the minimum can be reliably estimated only from the ASAS data, being $\sim 3^{\mathrm{m}}$ in ~ 1000 days, though it could have been higher prior to 2007.

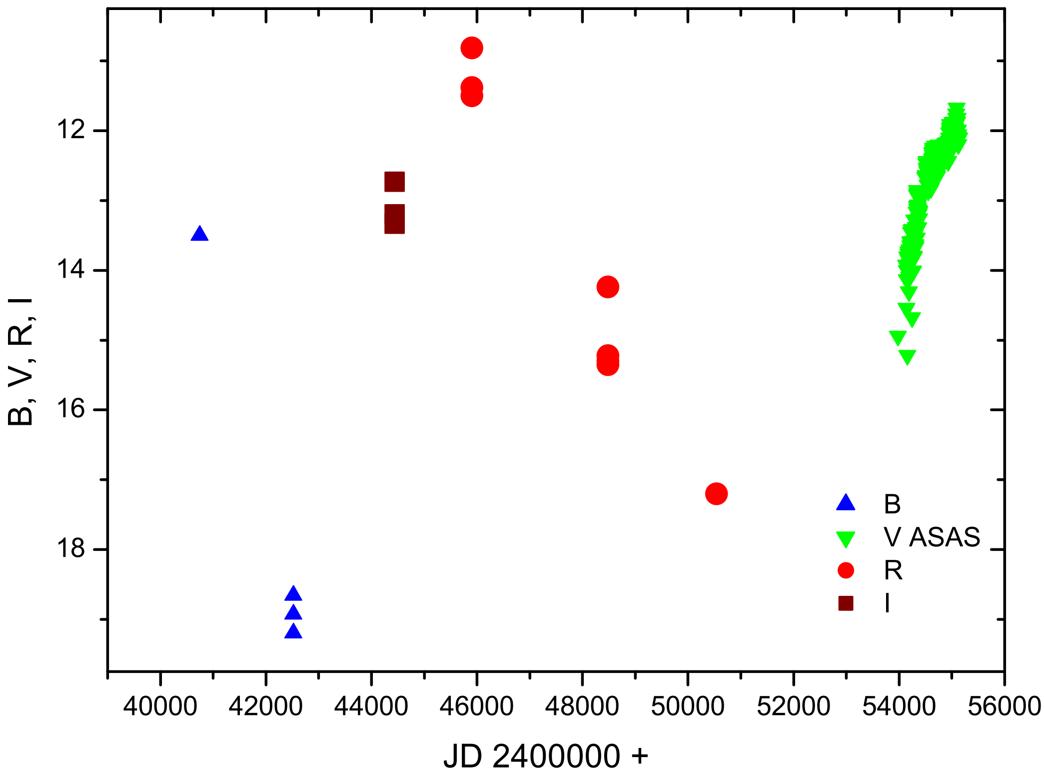

Figure 2. Photometry of HV 8988 in different spectral bands (B, V, R, I) in 1970–2009.

The optical-range color index of HV 8988 remains unknown because no simultaneous multiband observations are available. The maximal interstellar extinction towards HV 8988 ($l = 337.^{\circ}59$, $b = -4.^{\circ}99$) is $E(B-V) = 0.56$, or $A_V = 1.^{\mathrm{m}}73$, as estimated using maps from Schlegel (1998).

4 Discussion

Taking into account the presence of deep fadings as well as brightness variations (pulsations?) with an amplitude about $0.^{\mathrm{m}}5$ and a timescale of dozens of days, it is reasonable to assume that the star can belong to R CrB variables, so that we observed it emerging from a deep dust minimum in 2007–2009. The presence of a large excess in the near-IR range as well as at 12–25 μm for HV 8988 also indicates its similarity to R CrB stars. In the JHK range, these stars feature the presence of hot dust, with the temperature ~ 1000 K, formed during sporadic ejections of matter.

Figure 4 displays the $J-H$, $H-K$ two-color-diagram with the positions of HV 8988 (big red asterisk) and blackbodies with temperatures from 800 to 1400 K (straight line)

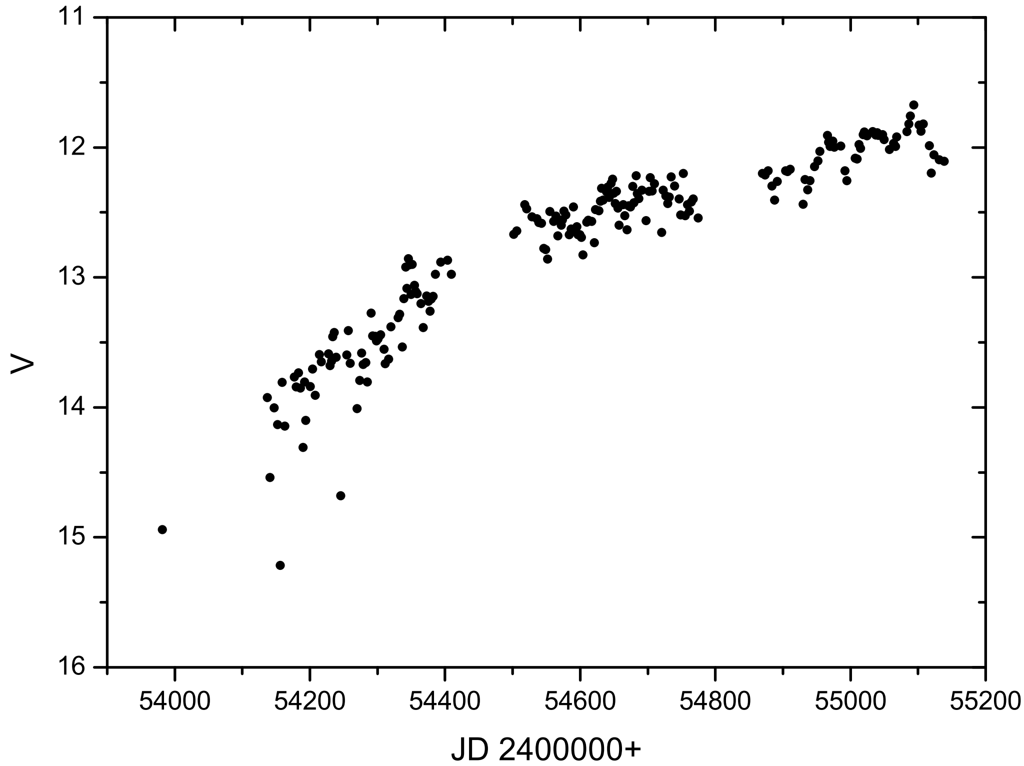

Figure 3. The V-band light curve of HV 8988 for 2007–2009 from ASAS-3 data.

marked. We see that the 2MASS observations, made in 1999, give the dust temperature about 1000 K, and all the light in this range comes from the dust component of HV 8988. Unfortunately, we have no data on the star's optical brightness in 1999.

Brightness variations with amplitudes of $0\overset{m}{.}5$ are not typical of classical R CrB stars, whose amplitudes are usually much lower, though it is pulsations and shock waves that probably cause ejection of matter and subsequent dust condensation. In this sense, the photometric behavior of HV 8988 resembles that of FG Sge, the central star of a planetary nebula that experienced the last helium flash of its shell source some 100 years ago (Arkhipova et al. 2009a). By now, FG Sge has returned to the region of AGB supergiants. Since 1992, it systematically exhibits deep fadings due to ejection of dust clouds, continuing to pulsate with a period about 110 days and a variable V-band amplitude of $0\overset{m}{.}5$–1^{m} (Arkhipova et al. 2009b).

Small green asterisks in Fig. 4 are infrared data for FG Sge from observations by Taranova and Shenavrin (2002) and Taranova (2010) performed after 1992; the blue curves represent combined radiation of a K0 supergiant and dust at different temperatures. The behavior of FG Sge in the two-color diagram (Fig. 4) is quite similar to that of typical R CrB stars during their dust fadings (Feast 1997), and thus we describe its state after 1992 as an R CrB evolution phase. The difference is only in the presence of an old planetary nebula around FG Sge, while R CrB stars do not possess nebulae. Possibly, HV 8988 could have lost its nebula at the last flash of its helium shell source, so that it is now difficult to distinguish it from classical R CrB stars.

Table 1: Photometry of HV 8988

Archive, atlas	Epoch	Our estimate	Band	Other estimates
Vehrenberg atlas	1970.437	13.5	B (pg)	—
SERC J plate	1975.297	19.2	B (0.468 nm)	18.95 (GSC2.3)
			B	18.66 (SuperCOSMOS)
SERC I plate	1980.542	—	I (0.807 nm)	12.73 (SuperCOSMOS)
			I	13.20 (USNO-B1.0)
			I	13.33 (GSC2.3)
ESO R plate	1984.555	11.5	R (0.66 nm)	10.81 (SuperCOSMOS)
			R	11.38 (USNO-B1.0)
AAO R plate	1991.608	15.3	R (0.64 nm)	14.24 (SuperCOSMOS)
			R	15.22 (USNO-B1.0)
			R	15.35 (GSC2.3)
SERC SR plate	1997.248	17.2	R	—
Kodak CCD images	1998 – 2002	—	R_{UCAC} (0.61 nm)	12.38 (UCAC2)
	1998 – 2004		R_{UCAC}	12.63 (UCAC3)

If HV 8988 is considerably hotter than FG Sge, we find no indication for it in the IR two-color diagram (Fig. 4). As already mentioned, no optical data are available for the time of 2MASS observations.

Note that another analog of FG Sge, the Sakurai star V4334 Sgr, was completely covered with dust because of the last thermal pulse of its shell source in 1999, and it has not yet emerged from the deep brightness minimum due to the very large depth of the dust envelope. The position of V4334 Sgr in 1998–1999 is plotted in Fig. 4 according to Duerbeck et al. (2000).

Further photometry and especially spectroscopy of HV 8988 is very needed.

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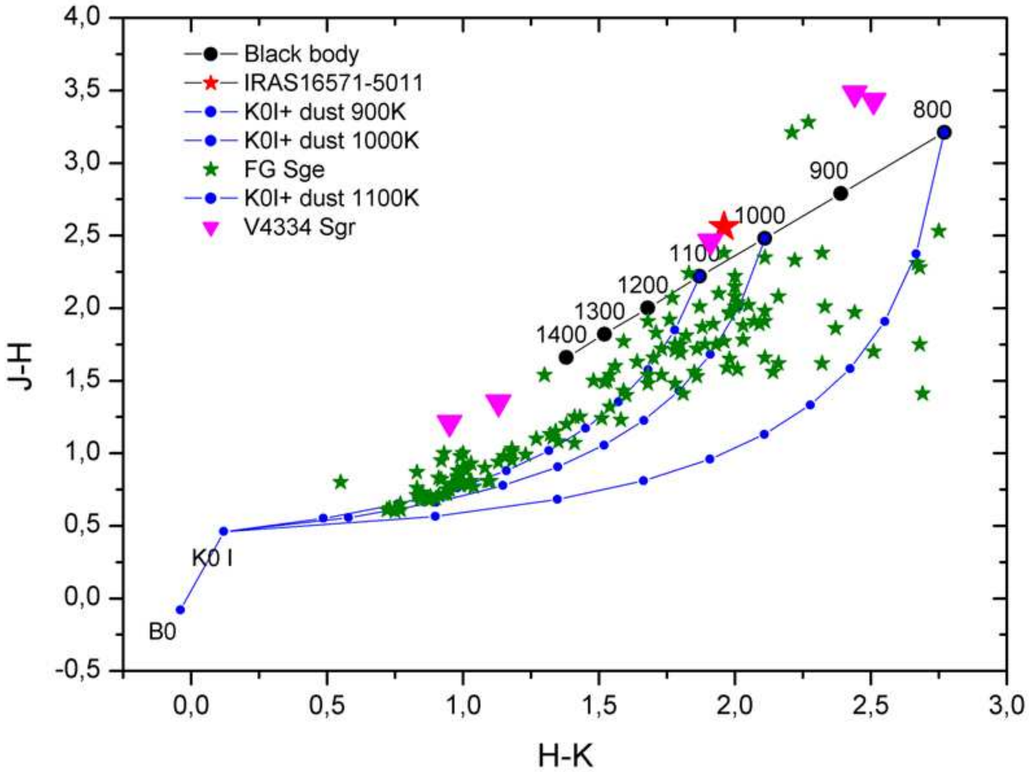

Figure 4. The $J-H$, $H-K$ two-color diagram: HV 8988, FG Sge, and V4334 Sgr compared. See text for explanation of symbols.