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A "VARIABLE" STELLAR OBJECT IN A VARIABLE
 BLUE NEBULA V-V 1-7

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Introduction. V-V 1-7 is supposed¹ to be one of the few planetary nebulae with A₀ central stars and was included in the planetary-nebula catalogue by Perek and Kohoutek² as PK 235 + 1°1. The nebula was seen on the blue Palomar Observatory Sky Survey (POSS) print but not on the red print; as a result, Kohoutek and Wehmeyer³ thought that it might be a reflection nebula. However, the symmetry of the nebula around the central star (HD 62001), and also the ultraviolet photometric variability of this central star led Gilra *et al.*⁴ to suggest that the nebula might be a nova shell. Subsequently we found that the nebula V-V 1-7 has disappeared^{5,6}. It is not seen on any direct plate known to us except the POSS blue plate. In this paper we report the disappearance (along with the nebula) of a stellar object, which appears within the 'nebular shell' of V-V 1-7 on the POSS blue plate, but not on the red plate.

TABLE I

Plates inspected for the nebula V-V 1-7 and stellar object

Plate	Region Emulsion	Date Exp. time (min.)	Stellar object	Neb.	Plate limit (mag.)
Lick 51-cm astro- graph (AB 739)	Blue	1948 Jan. 14	No	No	19.0
POSS O 683	Blue	1953 Mar. 7	Yes	Yes	21.0
	103a-O	05 ^h 11 ^m UT	18 ^m		
POSS E 683	Red	1953 Mar. 7	No	No	20.0
	103a-E	04 ^h 23 ^m UT			
ESO "Quick Look" blue	Blue	1976 Nov. 26	No	No	21.5
4-m CTIO ⁶	Blue	1979 Jan. 21	No	No	23.0
	IIIa-J				
1-m Kavalur	Blue	1980 Jan. 19	No	No	20.0
	103a-O				
1-m Kavalur	Red	1980 Jan. 19	No	No	19.0
	103a-E				
SRC J 5625	Blue	1980 Jan. 23	No	No	22.5
	IIIa-J	51			

Plate II shows the nebula and the stellar object as they appear on the POSS blue print, and the same area of sky as shown on the European Southern Observatory (ESO) blue survey. It can be seen that the ESO print has better resolution and higher sensitivity than the POSS print; even so, neither the nebula nor the stellar object is visible on the ESO print. Table I lists the various direct plates we have examined, with their plate limits. If the nebula

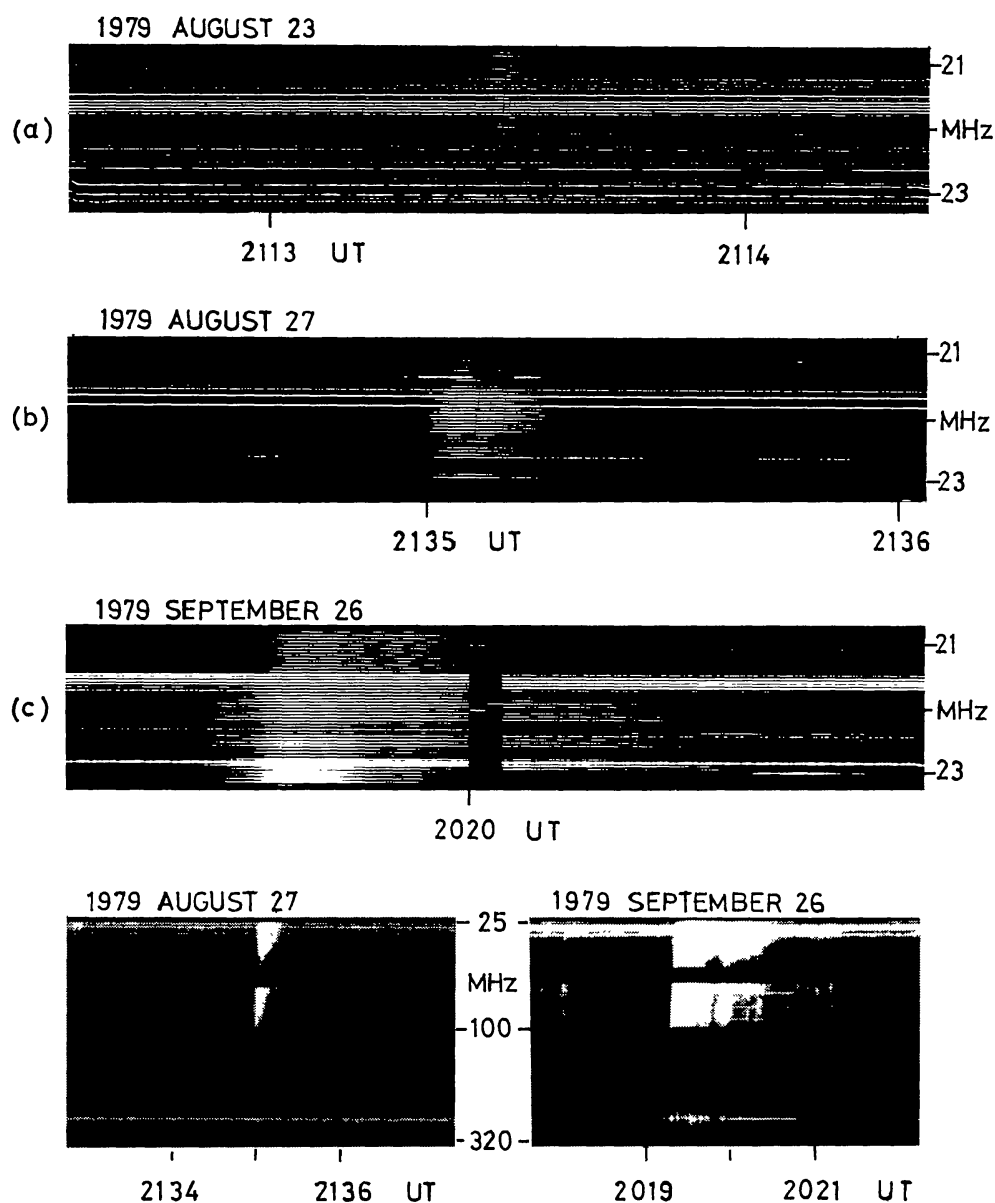


PLATE III

Sample records of night-time radio bursts. The burst in (a) is unidentified but most probably solar; bursts in (b) and (c) are identified as decametric extensions of type III solar bursts displaying some type V emission. The horizontal lines are produced by interfering radio stations. Records in (b) and (c) can be identified with the Harvard records of 25-320 MHz shown at the bottom.

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stellar object were non-variable, they should have appeared on POSS.

Stellar Object. Milne & Aller⁷ found a radio source near V-V 1-7, close to the stellar object, with a peak flux density of 0.031 ± 0.016 Jy at 5 GHz. Probably the same source is also seen at 2.7 GHz by Aller & Milne⁸ with a flux density of 0.05 ± 0.02 Jy. The position of this source is given in Table II along with the positions of the stellar object and HD 62001. The positional uncertainty in the radio source is ~ 1 arc minute. Within this uncertainty the stellar object and the radio source seem to be coincident.

TABLE II
Positions of objects of interest

Object	α			δ			Error	Authority
	h	m	s	1950	o	'		
HD 62001	07	39	00.929	-18	52	34.39		SAO
Stellar object	07	38	54.25	-18	51	13.2	$\pm 0''.6$	*
Radio source	07	38	50.1	-18	51	25	$\pm 1'$	ref. 7

*Measured from POSS print.

Examination⁹ of the glass copies of POSS blue plates confirms the existence of an apparently stellar image which does not look particularly like a knot (condensation) in the nebulosity or a plate flaw. In the following discussion we assume the image to be real and illustrate two possibilities regarding the nature of the object. To be consistent with the information given in Table I, this stellar object should be variable in m_b by upwards of 3 magnitudes.

(a) *Flare star.* The red POSS plate was obtained before the blue one (Table I). Unless the star is extremely blue, it must have brightened by upwards of 2 magnitudes in a time of the order of 15 minutes or less. Flare stars of the UV Ceti type do show variations of this amplitude (or more) with a rate of brightening of 0.05 to 0.1 magnitude/second with $\Delta U > \Delta B > \Delta V > \Delta R$. Moreover, at the time of the flare they show very blue colours¹⁰. Thus, if the stellar object in V-V 1-7 is a flare star then it could be a late M dwarf with $m_r \gtrsim 20^m$. In this respect, the flare in this object might be similar to that observed in T53b by Tovmassian *et al.*¹¹, which was also invisible on the POSS plates in the quiescent state. However, if the stellar object is identical with the radio source, then it is hard to account for the presence of radio emission ~ 20 years after the flare, unless there are frequent flares. The object has been quiescent on all the occasions its field has been photographed except at the time of the POSS blue plate.

(b) *Variable QSO.* The observation of the stellar object only on the blue POSS plate ($m_b \sim 18$) and not on the red plate ($m_r \gtrsim 20$) leads to very blue colours ($(B-V) \sim -1^m.1$) at the time of the outburst, unless indeed the object varied in the few minutes between the red and blue exposures. Allowance for interstellar extinction makes the colours still bluer. Such blue colours are not shown by any other QSOs listed in the catalogue by Burbidge *et al.*¹² The outburst of 3-4 magnitudes might have occurred after the Lick plate was obtained in 1948 January. Apparently similar blue brightenings are not uncommon in QSOs. Sandage *et al.*¹³ observed a brightening of $\Delta B \sim 1^m.5$ in 3C2. Thus the time-scale for the light variability of a few years, the coincidence with the radio source, and the spectral index of -0.8 between 2.7 and 5 GHz (although very uncertain) seem to be consistent with this object's identification with a QSO. However, it is very desirable to get a more precise position for the radio source and also photometric monitoring for the detection of light variability.

The Nebula V-V 1-7. The structure and symmetry of the nebula around the star HD 62001 suggest that the two are physically related. There seem to be two things which need explanation regarding the nebula: the blueness (*i.e.* the presence on only the blue POSS plate), and the disappearance. Our observations of the central star HD 62001, both ground-based and with *IUE*, indicate that it is an Algol-type binary with an A0 primary and a possible cooler companion. There is also evidence for mass being transferred from the secondary to the primary. If the nebula V-V 1-7 is a result of an ejection from the central star, then it does not appear to be a typical nova shell like that of DQ Her, since it is not seen on the red plate. However, it could be a low-excitation nebula in which hydrogen is not ionized. In such a case the strong emission lines may be mostly due to *Fe II*, which has more lines in the blue region than in the red. The dramatic event about the nebula is its disappearance in ~ 23 years. Any explanation with high expansion velocities for the nebula cannot account for its absence on the 1948 Lick plates. In the context of the Algol-type binary nature of the central star we offer a tentative explanation that normally the source of the illumination (*i.e.* HD 62001) is obscured in the direction of the nebula, but this obscuration was not present in 1953 when the POSS blue plate was obtained.

A transient gaseous disk (due to mass transfer from the secondary) might be present around the primary star most of the time and obscure the star light towards the nebula (without much obscuration in the direction of the Earth). It might have become tenuous in 1953, so that the nebula received radiation from the central star. However, Mendez *et al.*⁶ invoke a light-echo phenomenon from a flare of the faint companion star illuminating nearby interstellar clouds.

Finally, it seems unlikely for the stellar object, whether it is a flare star or a QSO, to be related to the nebula V-V 1-7 unless it is a knot in the nebulosity. Of all the direct plates examined, the stellar object and the nebula V-V 1-7 occur only on the POSS blue plate. We strongly recommend a search in other plate collections to see if one or both of these are present. The precise position of the radio source should also be determined. Unless there is some more corroborative evidence for the reality of these two objects, their explanation as plate flaws cannot be ruled out.

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