Astron. Astrophys. 93, 285–289 (1981)

ASTRONOMY AND ASTROPHYSICS

The Reflection Nebula Surrounding HD 87643*

A. Surdej[1]***, J. Surdej[1]** ***, J. P. Swings[2], and W. Wamsteker[3]

[1] European Southern Observatory, c/o CERN, CH-1211 Geneva 23, Switzerland
[2] European Southern Observatory, ESO, La Silla, Chile and Institut d'Astrophysique de Liège, Belgium
[3] European Southern Observatory, ESO, La Silla, Chile

Received April 14, accepted June 3, 1980

Summary. Direct plates in narrow bands (Hα, [O III], [S II]) and in the broad (*B*)-band show that the nebula surrounding the nova-like object HD 87643 is of reflective origin. Furthermore, a spectrogram of the filamentary condensation lying east-west at 17″ north of HD 87643 reveals strong Balmer emission lines, with a P Cygni structure at Hβ→Hε, as well as many diffuse emission lines of Fe II: such features essentially form a replica of the spectrum of the central object.

These results and other arguments strongly support the idea that the *reflection nebula* surrounding HD 87643 is associated with the mass-outflow observed from the central hot star.

Key words: reflection nebula – HD 87643 – mass-loss

Table 1. List of the direct plates observed for HD 87643

Plate number	Date	Plate + filter combination	Exp. (min)
788	1977 May 19/20	IIaO(B) + GG385	20
789	1977 May 19/20	IIaO(B) + GG385	5
790	1977 May 19/20	IIIaF(B) + Hα	20
800	1977 May 19/20	IIaO(B) + GG385	40
801	1977 May 19/20	IIaO(B) + GG385	0.5
1238	1978 January 20/21	IIIaJ(B) + [O III]	10
1928	1979 February 18/19	IIIaJ[a](B) + Hα	15
1930	1979 February 18/19	IIIaJ[a](B) + [S II]	20

[a] IIIaJ(B) plate behind a red image tube (EMI 9914 + S 20 extended red photocathode) camera

1. Introduction

The spectral type of the star HD 87643 (= CPD − 58°1865 = MWC 198 = He 3-365) was first reported in the Henry Draper catalogue where the object is classified as B-type with Hβ in emission. More recent spectral observations have been published by Henize (1962), Hiltner et al. (1968), Stephenson (1974), Swings (1974), and Carlson and Henize (1979). These investigations reveal that the spectrum of HD 87643 is mainly composed of strong and diffuse emission lines of Fe II and of complex P Cygni profiles for the Ca II H and K and the Balmer lines, from which it is deduced that a mass-outflow occurs from this star at velocities greater than 1200 km s^{-1}. Carlson and Henize (1979) find that this spectrum is, to some extent, similar to that of the principal spectrum of a nova shortly after its appearance in the early post-maximum phase and therefore that HD 87643 should preferably be classified as nova-like. Furthermore, spectra obtained at different epochs reveal considerable variation in the structure of the Balmer emission and absorption lines and it is well established (Hiltner et al., 1968) that the emission activity of HD 87643 has greatly increased since its discovery in 1909. More puzzling, however, is the apparent absence of light variation with time (see Carlson and Henize, 1979).

Henize (1962) has obtained a direct photograph with the Mount Stromlo 1.9 m reflector which shows the star to be embedded in a small irregular nebula. This nebulosity has been independently discovered by van den Bergh (1972) during a two-color survey of the southern milky way. However, up to now, the nature of this nebula has remained unknown.

Allen (1973) has reported the following infrared magnitude and color indices for HD 87643

$$K(2.2\ \mu) = 3.59, \quad H-K = 1.17, \quad K-L = 1.61.$$

The large infrared excess that is observed is believed to originate in a circumstellar dust shell surrounding HD 87643 ("Dn" category in Allen, 1973).

In order to better understand the nature of the nebula surrounding HD 87643, we have obtained some narrow- and some broad-band direct plates as well as one low resolution spectrogram of it at the European Southern Observatory (Chile).

2. Observations

Direct plates of the nebula surrounding HD 87643 have been taken through interference and broad band filters using the 3.6 m

Send offprint requests to; J. Surdej

* Partly based on observations collected at the European Southern Observatory, ESO, La Silla, Chile

** Also, Aspirant au Fonds National de la Recherche Scientifique (Belgium)

*** Present address: Institut d'Astrophysique de Liège, Avenue de Cointe, 5, B-4200 Cointe-Ougrée, Belgium

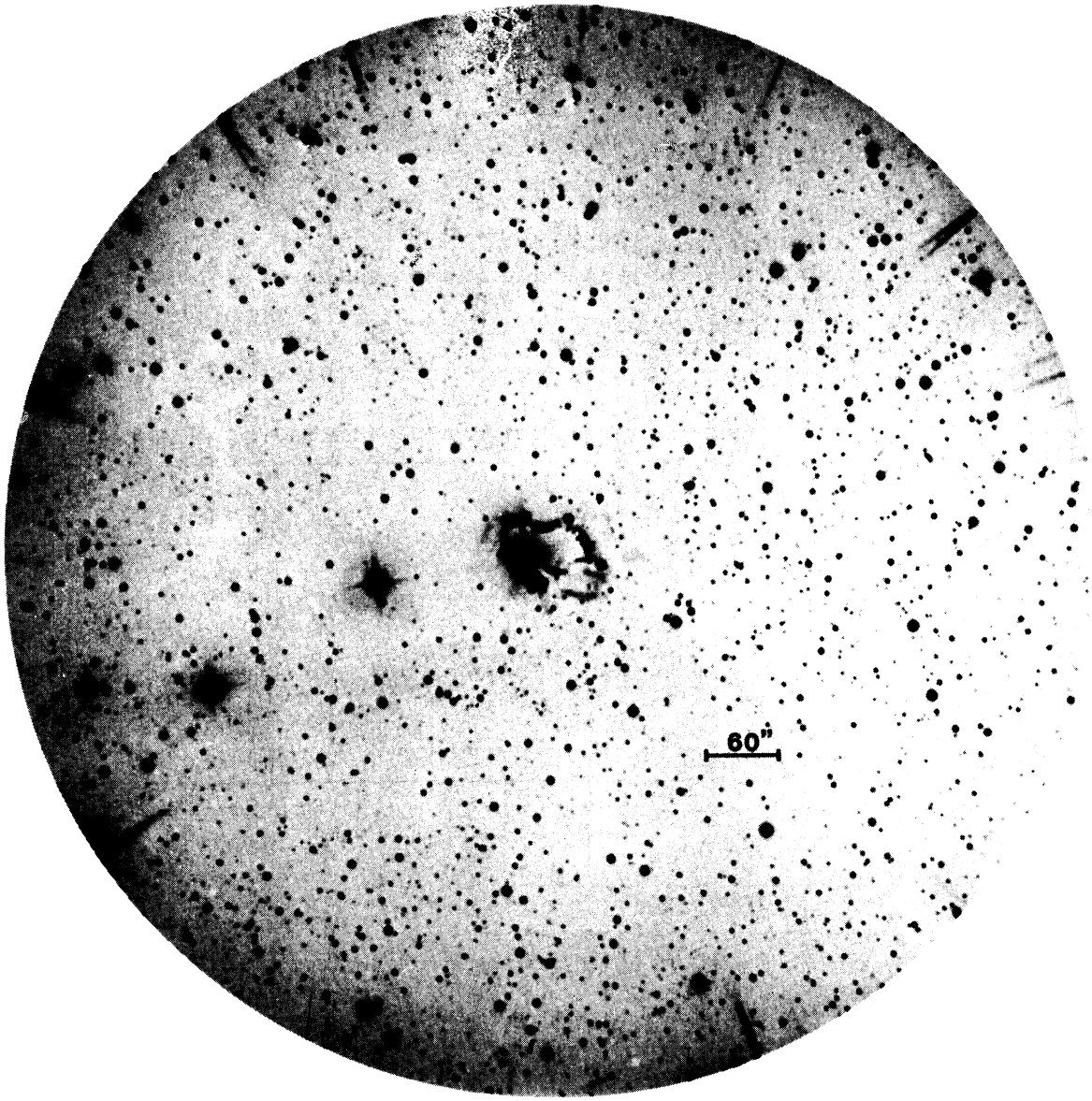

Fig. 1. HD 87643 and its reflection nebula (ESO 3.6 m telescope, IIaO(B)+GG 385, plate No. 800 in Table 1). North is at the top and east to the left

telescope (F/3 prime focus, scale 18″.9/mm) of the European Southern Observatory (La Silla, Chile). The parameters of the plates are given in Table 1. Plate No. 800 is reproduced in Fig. 1. Isodensity tracings of this plate showing the aspect of the nebula in the neighbourhood of the central star are illustrated in Fig. 2.

A low resolution spectrogram of the nebula (see Fig. 3) has been taken using the Boller & Chivens spectrograph equipped with a Carnegie image tube at the Cassegrain focus of the ESO 3.6 m telescope (IIIaJ(B) plate, disp. 114 Å/mm, 1978 June 9/10, exp. 60 min). The slit was set about 17″ north of the central star along the east-west direction, passing through the filamentary condensation which is well seen in Fig. 1. Table 2 lists the identifications of lines present in the range $\lambda\lambda$ 4000–6500 Å of this spectrum.

The first column of this table contains the laboratory wavelengths since all line identifications are certain.

3. Discussion

a) Direct Plates

As seen from Fig. 1, the nebula surrounding HD 87643 appears very irregular, mainly composed of filamentary condensations extending, in the west direction, up to 100″ from the central object. Closer to the star, some condensations show a spiral-like form (see the condensation located at about 13″ south-west in Fig. 2). Such structures are strongly suggestive of the presence of motions (expansion plus rotation?) in the surrounding nebula. Let us also note that nebular features located a few arc s from HD 87643 are detected on our short exposure plate No. 801: for instance, the small extension lying around 8″ south-west of the star in Fig. 2 is physically real.

Because the count number of stars decreases appreciably in the east direction of HD 87643, we suspect that there is also a

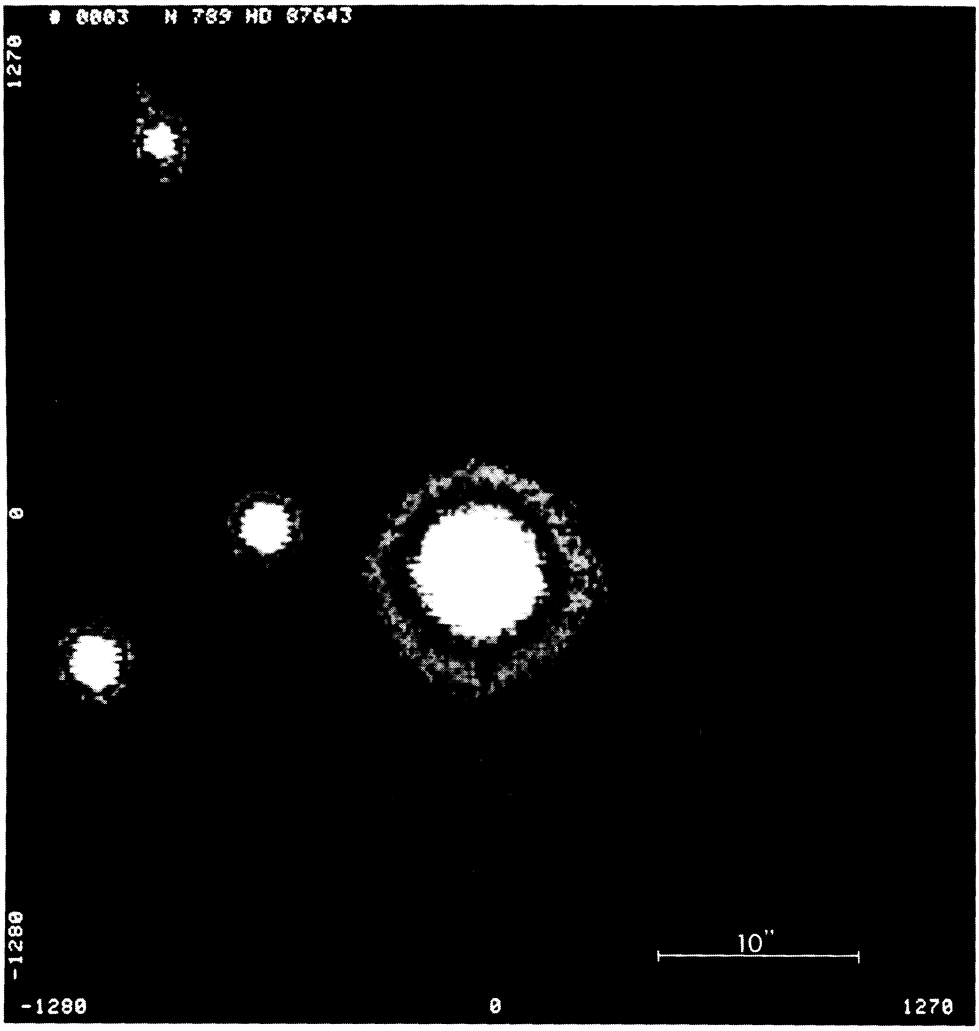

Fig. 2. Isodensity tracings of the reflection nebula in the close neighbourhood of HD 87643 (same plate as for Fig. 1). North is at the top and east to the left

high obscuration due to the nebula (presence of dust?) which probably extends ($\simeq$4–5′) much further than it is actually seen in Fig. 1. This remark is supported by the shape of the nebula around HD 87643 appearing on the deep IIIaJ plate No. 127 of the SRC survey.

The narrow-band plates No. 790 (Hα, λ 6563$\pm$20 Å) and No. 1238 ([O III], λ 5007$\pm$10 Å) do not reveal any trace of the surrounding nebula. Its faint detection on the plates No. 1928 (Hα) and No. 1930 ([S II], λ 6731$\pm$20 Å), taken behind a red image tube camera (see Table 1), can only be interpreted as due to the contribution of the reflected stellar continuum. Indeed, the surface brightness of the nebula on these plates appears quite identical to that seen on the short exposure of the broad-band plate No. 801.

All these observations lead us to conclude that the nebula surrounding HD 87643 is not an emissive one.

b) Spectrum

The spectrogram (see Fig. 3) of the filamentary condensation lying east-west at 17″ north of HD 87643 presents more than 20 Fe II emission lines, rather diffuse, as well as strong Balmer emission lines with a P Cygni structure at H$\beta\rightarrow$Hε. Comparing our Table 2 to the line identifications of HD 87643 reported in Table 4 of Carlson and Henize (1979), one directly sees that the spectrum of the surrounding nebula is a perfect reflection of the star's spectrum. From the well-defined P Cygni profile at Hγ, we could accurately measure the velocities of the blueshifted absorption component with respect to the center of the emission line component. We respectively found for the greatest and for the mean velocities

$$v_{abs} = 1243 \pm 20 \text{ km s}^{-1},$$
$$\bar{v}_{abs} = 946.$$

These results are in good agreement with those determined by Carlson and Henize (1979), from the stellar spectrum.

Furthermore, by measuring the positions of the Fe II emission lines in the spectrum of the surrounding nebula, it is found that the value of the mean velocity is

$$\bar{v}_{Fe\,II} = 41 \pm 30 \text{ km s}^{-1},$$

in contrast to the value $\bar{v}_{Fe\,II} = -80 \pm 4$ km s^{-1} reported by Carlson and Henize. The discrepancy between these results can be due to

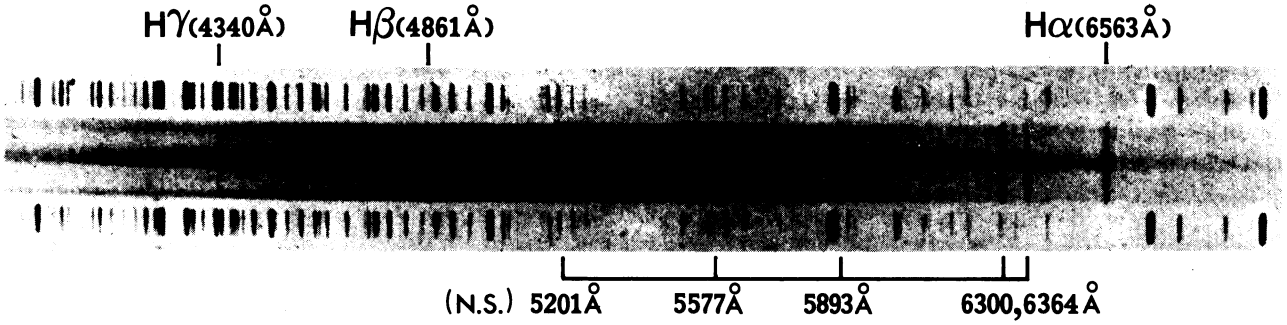

Fig. 3. Spectrogram of the reflection nebula (see text). A few Balmer and night sky lines are indicated as references

Table 2. Line identifications for the spectrum illustrated in Fig. 3

$\lambda_{lab.}$	Ion	Multiplet no.	Remarks
3933.7 Å	Ca II	"H"	Broad P Cygni
3968.5[a]	Ca II	"K"	absorptions are seen at the limit detection of the plate
3970.1[a]	Hε		
4101.7	Hδ		P Cygni profile
4173.5	Fe II	27	
4178.9	Fe II	28	
4233.2	Fe II	27	
4340.5	Hγ		P Cygni profile
4385.4	Fe II	27	
4416.8	Fe II	27	
4489.2[a]	Fe II	37	
4491.4[a]	Fe II	37	
4520.2[a]	Fe II	37	
4522.6[a]	Fe II	38	
4549.5[a]	Fe II	38	
4555.9[a]	Fe II	37	
4583.8	Fe II	38	
4629.3	Fe II	37	
4731.4	Fe II	43	
4861.3	Hβ		P Cygni profile
4923.9	Fe II	42	
5018.4	Fe II	42	
5169.0	Fe II	42	
5197.6	Fe II	49	
5234.6	Fe II	49	
5276.0	Fe II	49	
5316.6[a]	Fe II	49	
5316.8[a]	Fe II	48	
5362.9	Fe II	48	
5534.9	Fe II	55	
6562.8	Hα		overexposed

[a] A blend between two lines is marked with an asterisk

the fact that the surrounding nebula is in motion with respect to the central star. However, one should also be aware that the extended atmosphere around HD 87643, from which the Fe II and P Cygni Balmer lines arise, might not be spherically homogeneous and/or in isotropic expansion and that, consequently, the reflection spectrum could also differ from the stellar one for that reason.

4. Conclusions

By means of narrow band and broad-band photographs and of one relatively low resolution spectrogram, we deduced that the nova-like object HD 87643 is surrounded by an irregular reflection nebula. Indeed, contrary to the typical reflection nebulae, whose appearance is quite amorphous, the nebulosity around HD 87643 mainly consists of well defined filamentary condensations. Also, the structure of the nebula, including the spiral-like form of some condensations located near the central star, and the mean radial velocity $\bar{v}_{\mathrm{Fe\,II}} = 41$ km s^{-1} of the filamentary condensation lying east-west at 17″ north of HD 87643 seem to indicate the presence of motions in the nebula with respect to the stellar core.

Furthermore, the large infrared-excess (see Sect. 1) which is believed to originate in a circumstellar dust shell around HD 87643 ($T^{\mathrm{shell}} \simeq 1100$ °K; see Allen, 1973), and the presence of a mass-outflow seen from the P Cygni profiles of the Ca II H and K, and of the Balmer lines strongly suggest that the reflection nebula is a result of mass-loss from the central star. It should be remarked here that the value $v_{\mathrm{max}} = 1200$ km s^{-1} of the maximum velocity derived from the visual spectrum is to be regarded as a lower limit of the real maximum velocity at which matter is expelled from HD 87643. Indeed, as for early type stars (cf. Snow and Morton, 1976; Snow and Jenkins, 1977), it is likely that a maximum expansion velocity greater by a factor of two or more would be deduced from the analysis of P Cygni resonance lines observed in the ultraviolet spectrum of HD 87643.

Thé et al. (1980) performed photometry of HD 87643 in the Walraven system: by de-reddening their data, they estimated a spectral type B0V for the star. Following van den Bergh (1972), but assigning to HD 87643 an absolute magnitude $M_v = -4.1$, one derives its approximate distance $d \simeq 1$ kpc. At such a distance, the geometrical extension of the nebular features located at 100″ in the west direction from the central object corresponds roughly to $r \simeq 0.5$ pc. A shell ejected by HD 87643 at a constant velocity $v_{\mathrm{max}} \gtrsim 1200$ km s^{-1} would reach this radius in less than 400 yr.

In order to test the spherical homogeneity as well as the isotropic expansion of the extended atmosphere around HD 87643 (see Sect. 3), we plan to obtain high resolution ($\simeq 40$ Å/mm) spectra of different parts of the reflection nebula. Polarimetric and spatial infrared observations are also intended in order to derive more quantitative results for the reflection nebula.

Acknowledgements. We wish to thank G. Roman, A. Zuñiga, H. Herborn, M. Pizarro, and J. Yagnam for their help in obtaining the data.

References

Allen, D.A.: 1973, *Monthly Notices Roy. Astron. Soc.* **161**, 145
Bergh, S. van den: 1972, P.A.S.P. **84**, 594
Carlson, E.D., Henize, K.G.: 1979, *Vistas in Astron.* **23**, 213
Henize, K.G.: 1962, *Astron. J.* **67**, 612
Hiltner, W.A., Stephenson, C.B., Sanduleak, N.: 1968, *Astrophys. Letters* **2**, 153
Snow, T.P., Morton, D.C.: 1976, *Astrophys. J. Suppl.* **32**, 429
Snow, T.P., Jenkins, E.B.: 1977, *Astrophys. J. Suppl.* **33**, 269
Stephenson, C.B.: 1974, *Astrophys. J.* **191**, 685
Swings, J.P.: 1974, *Astron. Astrophys.* **34**, 333
Thé, P.S., Swings, J.P., Wesselius, P.R., Savage, B.D., van Paradijs, J.: 1980 (in preparation)