RING NEBULAE AROUND WC6 STARS : NGC 6357 AROUND HD 157 504 [2]

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Three cases of ring nebulae around a WC6 star are definitely known : one is around HD 92809 north of the Carina Nebula (Lortet et al. 1980), another around θ Mus has been studied by Heckathorn et al (1982). We here study the third one, NGC 6357 around HD 157504, first quoted in the survey by Heckathorn et al (1981 and 1982).

The red print of the Palomar Observatory Sky Survey and also a red photograph reproduced in Goudis (1977) show a remarkable set of parabolic filaments well focused on the WC6 star ; however, the structure is complicated by the presence of additional very bright Hα and radio sources, one centered on the young cluster Pis 24[2], 6' west of the Wolf-Rayet star. The radio continuum at 5 GHz (Haynes et al., 1978) shows a remarkable agreement between radio and optical structures : the filaments can be traced up to the very extremities of the optical features.

From spectrograms obtained at CTIO, two stars have been studied in the region. The brightest star of the cluster Pis 24 (No. 35 in Neckel, 1978) is of spectral type O6 and shows a steep progression in Balmer lines velocities, an indication of a rather strong stellar wind. No emission lines are seen.

The spectral type WC6 of the Wolf-Rayet star HD 157504 is confirmed. In addition, Balmer series absorption lines are seen, corresponding to the existence of a companion of spectral type about O9.

Nebular spectra were obtained in april 1981 at the ESO Observatory. They will be described at more length elsewhere. The main results are :

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[2] HD 157504 = LSS 4148 = WR 93 in the Catalogues by Stephenson and Sanduleak (1971) and van der Hucht et al (1981).
Pis 24 : stellar cluster from Pismis, 1959.

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- The high excitation of the nebula near Pis 24 : [OIII] (5007 + 4959)/ Hβ reaches about 5. This is an agreement with the O6 spectral type of its brightest star. From infrared spectroscopy, Moorwood et al. (1980), studying several HII regions, had already noticed that oxygen probably was mainly in O^{++} form in G353.2+0.9.
- The remarkably high electron density 2' north of the O6 star, just between the cluster and the WC6 star, as indicated by the line intensity ratio of [SII] lines : I(6717) / I(6731) $\simeq$ 0.60.
- On constrast, spectra of the filamentary regions, south of the WC6 star, show low excitation and electron densities below 500 electrons per cubic centimeter.

Table 1 summarizes some data on the three galactic nebulae definitely associated with a WC6 star.

The three of them are located at the edge of an extended HI/HII complex, far enough from the parts where star formation is going on. They are remarkable for their large sizes (most of the other galactic nebulae have diameter 3-10 parsecs) and sharp low-excitation features. All three appear basically made out of swept up interstellar material, a fraction of which is now neutral. However, for the θ Mus nebula, the shell stage described by Chu (1981a) has been already reached, while sweeping is going on for the nebula around HD 92809. Kinematical data on NGC 6357 are lacking.

Several problems remain to be elucidated.

- Selection effects for the detection of WC6 ring nebulae. It may be that the detection of the large nebulae described here was favoured by the existence of hot stars providing part of the ionization. Indeed, dark ring nebulosities as well as emissive ones should be looked for systematically, mainly around low ultraviolet luminosity stars.
- Birth-place of WC6 stars. Did they form as isolated and single stars (HD 92809) or did they leave their birth-place ? The problem of the peculiar location of Wolf-Rayet stars at the boundary of stellar clusters is currently being studied (Gomez et al., 1981).
- What is the physical nature of the high density regions between Pis 24 and the WC6 star HD 157504.

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Table 1 - Three galactic nebulae around WC6 Stars

	Star	HD92809 = WR 23	HD 157504 = WR 93	θ Mus = WR 48
	Spectral type	WC6	WC6 + O9	(WC6+O)+O9.7 Iab
	Nebula	Anon N.Car	NGC 6357	Anon
	(1)	(2)	(3)	(4)
A	Distance (kpc)	2.5	1.70	2.5(Cen OB1)
	Diameter of the Nebula	28' → 18pc	36' → 18pc	70' → 50pc
	Cluster	Bochum 10	Pis 24 (at 3pc)	
E		projected at 13pc	earliest star O6	
	Environment	In Carina Complex	The same cloud	Cen OB1
B		next maser H_2O 287.4-0.6	contains NGC 6334	(5° in diameter)
		at about 40pc	and its OH/H_2O	earliest star O9
			masers (at about 90pc)	no masers
	Star			
C	A_v (mag.)	1.07	5.70	≃ 0.6
C	M_v (mag.)	≃ -3.3		
	Nebula			
	Structure	Ring	Ring	Ring
D		Very thin filaments	Sharp boundary	Sharp arcuate scalloped
		(7" ≃ 0.1pc) conspicuous		structure in [OIII]
		on SRC(J) map in emission		
		and in absorption as well.		
D		Ionisation bounded.	Ionisation-bounded	H+[NII] structure is
				more external and more
				diffuse
E	Electron density	< 500	<500 in filaments,	
	n_e ([SII]) cm^{-3}		about 3000-4000 near	
			Pis 24	
F	Expansion (km^{-1})	20 to 30		<7
G	Age	About $2x10^5$ years		>$2x10^5$ years

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NOTES TO TABLE 1

C1 : Using intrinsic colour of a WC6 star (b-v) = -0.22 and A_v = 4.1E(b-v) as proposed in van der Hucht et al (1981)

A2 : From probable membership in the Carina Complex (Lortet et al, 1980)

A3 : From photometry of the field stars (Neckel, 1978)

A4 : From membership in Cen OB1 (Humphreys, 1978)

B2 : Scalise and Braz, 1980

C4 : O supergiant brighter by 2.5 mag in optical(Beeckmans) et al, 1981)

E2 : This paper

E3 : This paper

D4 : Heckathorn et al (1981 and 1982)

F2 : Chu (1981b), Georgelin et al (1981)

F4 : Chu (1981b)

G2 : From the expansion and the Table in Lortet et al (1980)

DISCUSSION FOLLOWING LORTET et al.

Lundström: Can you confirm that HD 157504 actually has an O9 companion?

Niemela: Yes, it is a binary. I can see the absorption lines in my spectra.

Hogg: Could you describe the source of excitation of the diffuse nebulosity in NGC 6357? The sharp filaments are presumably from the wind. It reminds me somewhat of NGC 2359, where Schneps found a molecular cloud.

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Lortet: In the case of NGC 6357, the main source of excitation is certainly yielded by the Pis 24 cluster and its O6 star. Indeed, it might even be a more general rule that ring structures around low ultraviolet stars are detected as emissive nebulosities only when additional ionizing photons are yielded by nearby hot stars.

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