BE 381: WN9 or O8 Iafpe?

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As John Hutchings summarized at the opening of this symposium the most easily detected symptom of mass loss in hot stars is emission at Hα. Some years ago I made a survey of the Large Magellanic Cloud for stars with Hα in emission (Bohannan and Epps 1974) and since then have obtained low resolution spectra of some of these stars to establish their spectral identity. I would like to talk today of one of these objects, BE 381, which displays spectroscopic features of both the extreme Of and low excitation WN Wolf-Rayet classifications.

The spectrum of BE 381 (Figure 1) exhibits well developed P Cygni profiles on the hydrogen transitions to Hε and on the neutral helium triplet lines (λ3889, λ4026, λ4471). N IIIλ4634-40 and He II λ4686 are in emission as in an Of - type star. The Si IV doublet around Hδ is strongly in emission. Ionized helium λ4542 and λ4200 are in absorption. In the table equivalent widths of the spectral lines in BE 381 are compared with those in HD 152408 (O8 Iafpe).

Identification wavelength	log Wλ (mÅ)	
	BE 381	HD 152408*
HeIλ3889 abs	2.67	
em	3.70E	
H_ϵλ3970 abs	1.90	
em	2.92E	
HeIλ4026 abs	2.98	
em	2.64E	
SiIV λ4116	3.18E	2.70E
H_γλ4340	3.70E	
N IIIλ4378	2.98E	
HeIλ4471 abs	2.85	2.98
em	3.28E	2.86E
HeIIλ4542	2.83	2.81
NIIIλ4634.40	4.25	
HeIIλ4686	3.21E	3.52E

P. S. Conti and C. W. H. de Loore (eds.), Mass Loss and Evolution of O-Type Stars, 479–482.

The strength of He IIλ4542 in BE 381 is roughly equal to that in HD 152408, an extreme Of star (Hutchings 1968), which suggests comparable atmospheric conditions near the photosphere. The much stronger hydrogen and neutral helium P Cygni features in BE 381 indicate that the extended atmosphere is much more massive or the velocity law is slower. BE 381 is observed at an absolute visual magnitude fainter than that estimated for the extreme Of stars, a value of -6 is found if the reddening correction is only a few tenths in B-V, a typical value in the Large Magellanic Cloud.

The overall appearance of the spectrum of BE 381 is remarkably similar to HDE 269227, a Wolf-Rayet star in the LMC designated as WS 12 and classified as WN 8 by Westerlund and Smith (1964). The hydrogen, neutral helium and N III spectra are essentially the same, but Si IV emission is much stronger in BE 381. He II λ4542 absorption is slightly stronger in BE 381. N II λ3995 emission, present in HDE 269277 (Walborn 1977), is very weak or absent in BE 381.

It appears then that BE 381 should probably be considered a Wolf-Rayet type star rather than an extreme Of-type. If so classified, two arguments suggest that the type is later than WN 8. The typical WN 8-A star HD 86161 has N IV 4058 present (Walborn 1974), a line which is missing in both HD 269227 (WS 12) and BE 381. The excitation class vs. line width relation for WR stars suggests that BE 381 is of later type than HD 269227 because of the narrower lines in BE 381. The appropriate classification for BE 381 appears to be WN 9 or WN 10, (types previously undefined), similar to HDE 269227 (Walborn 1977). Further work is needed to define the sequence of low excitation Wolf-Rayet stars.

The relationship between WR and Of stars has been reviewed by Conti (1976, 1978). The WN 7-8 sub-types are much less pathological in their spectra than the earlier types. Peter Conti and Tony Moffat have independently described this afternoon how the low excitation WN stars may have evolved by mass loss from O-type stars with masses larger than 35 $M_{\odot}$. The location of the low excitation Wolf-Rayet stars near the low temperature limit of main sequence stellar evolution suggests that they represent massive stars which have completed core hydrogen burning and have just undergone gravitational contraction of the core. The subsequent envelope expansion causes a much more extended atmosphere with only a slight increase in mass-loss rate. The enhanced N III and Si IV are a consequence of the extended atmosphere rather than mixing of interior material. Helium, nitrogen or carbon may come to the surface later in the star's evolution.

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* Conti and Alschuler 1971

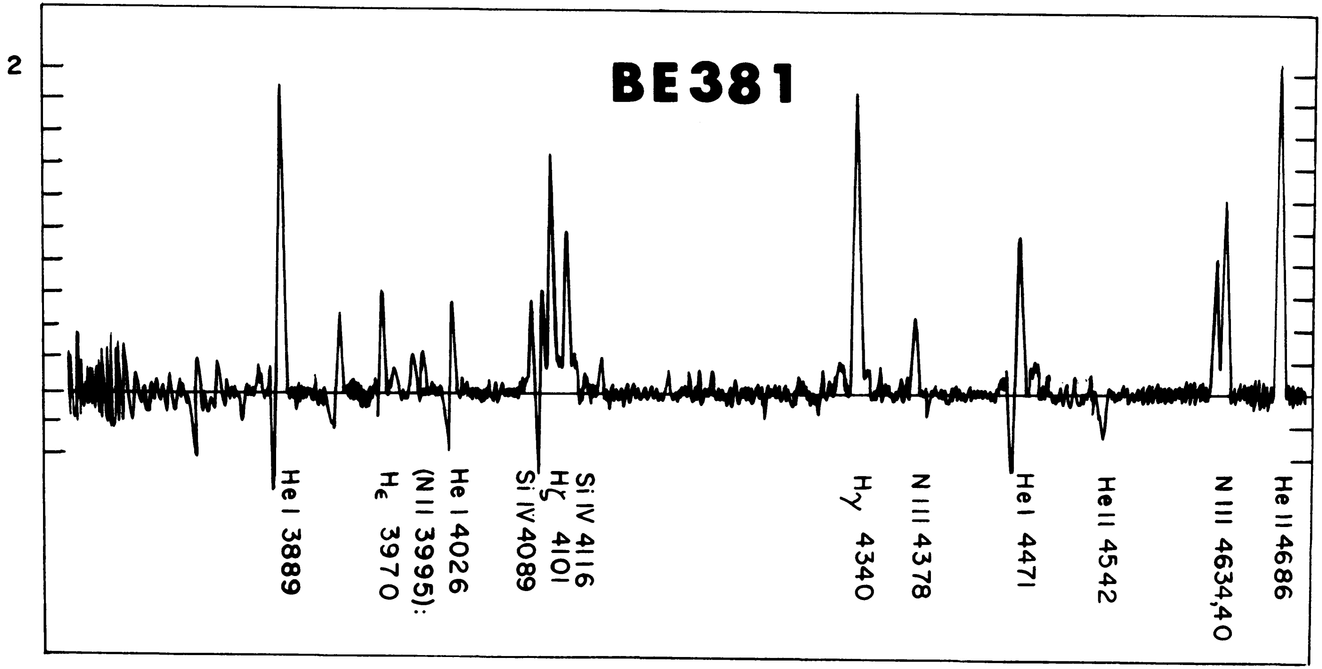

Figure 1: Spectrum of BE 381. This is an intensity tracing of a spectrogram taken with the image tube camera on the Four meter Cassegrain spectrograph at Cerro Tololo Inter-American Observatory. Original dispersion is 27 A/mm.

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DISCUSSION FOLLOWING BOHANNAN

Chiosi: Did you test whether your suggestion about the evolutionary status of the Of stars is consistent with the number of Of relative to main sequence stars, and the ratio of lifetimes? This ratio is in fact quite different in the two alternatives.

Sreenivasan: Would you care to indicate empirically theoretical mass loss rates for these WN stars? How does this compare with the rates for Of stars?

Bohannan: Only two to three times that of an Of star, say roughly 3 x 10^{-6} M_{o}/yr.

Breysacher: Does your star have a number in the LMC WR stars catalogue published by Fehrenbach et al.? I have observed their star No. 56 which is very similar to the one you described here.

Bohannan: I have a copy of my survey with me and could give you the identification. It is not one of those identified by Fehrenbach.

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