THE ON STARS: A WIDER SPECTROSCOPIC DEFINITION

G.F. Bisiacchi, J. López and C. Firmani
Instituto de Astronomía
Universidad Nacional Autónoma de México

During the last years, many authors have recognized the existence of some OB stars that show the nitrogen absorption lines enhanced (Walborn 1970, 1971; Conti 1973; Jashek and Jashek 1974).

One of the main problems at present to better understand this OBN group is the small number of these objects. Two different causes may be responsible for the poor sample of OBN stars available. First: the OBN phenomenon is rather improbable among massive stars; second: the spectroscopic criterion used to detect such anomalous objects is self limited and reduces the detection to a small range of spectral types and luminosity classes. An evidence that this second effect is probably important is the fact that, for example, all the stars defined as ON by Walborn, have spectral type restricted between 09 and 09.5 for the dwarfs, and at 09.7 for the super giants. The probable explanation of this fact is that the NIII line λλ4634-40 normally used as criterion to define ON star, shows a strong tendency into emission when temperature and luminosity increases. Due to this behaviour there is a wide range in luminosity and temperature when the blend reaches minimum intensity values or completely disappears when tending into emission. In addition the positive luminosity effect shown by NIII λλ4634-40 at the higher temperature is so strong that it becomes very difficult to distinguish any anomaly from the normal luminosity dependence. In an attempt to extend the detection of the nitrogen anomalies to a wider range of spectral types and luminosity classes we have carried out a spectroscopic analysis of the NIII line λ4514.

Our goal is to demonstrate that for the spectral type for which the criterion based on the intensity of λλ4634-40 is useful and that it makes possible to extend the definition of ON stars up to 06 a criterion based on λ4514 is also useful, a first comparative analysis on the behaviour of these lines is shown in Figure 1. Here we have plotted the equivalent width of NIII λ4514 versus NIII λ4634-40 for dwarf stars of spectral type between 09 and 09.5. These equivalent widths have been measured on spectra of intermediate dispersion, 0.7 Å $channel^{-1}$, to obtain a better measure of the blend λλ4634-40. The three stars at the

C. W. H. de Loore and A. J. Willis (eds.), Wolf-Rayet Stars: Observations, Physics, Evolution, 393–396.

top are ON stars defined by Walborn. It is evident from this figure that both lines are useful to define ON stars.

Figure 2 shows the equivalent width of NIII λ4514 versus spectral type. Open circles are dwarf stars, filled circles are giants and triangles are supergiant. Symbol under dashed line represents stars where the line was not strong enough to be measured.

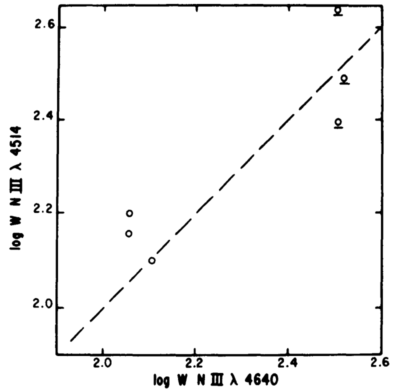

Fig. 1. Log W of NIII λ4514 vs. NIII λ4540. The three underlined stars have been classified by Walborn as ON.

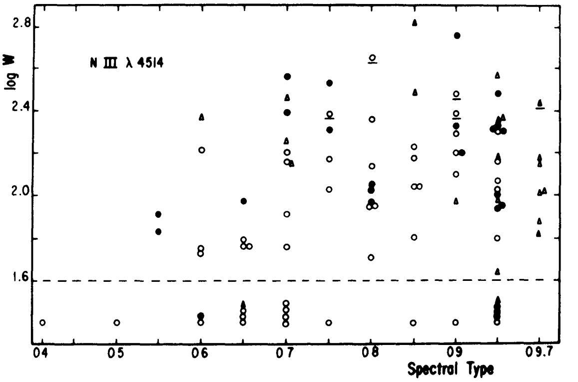

Fig. 2. Run of measured equivalent widths of NIII λ4514 vs. spectral type.

We have taken as candidates to be ON stars those stars that show the maximum intensity of the line at a given spectral type and luminosity class. In order to avoid errors due to missclassification each single case was analyzed to explore contradictions among the helium silicon frame of classification and the intensity of NIII λ4514.

Two facts must be noted in this figure. First, that for any luminosity class and for many spectral types the equivalent width covers a wide range of values. This continue distribution should imply that the ON stars must be regarded as the most extreme examples of a general atmospheric phenomenon of the O stars.

Second, a general tendency of the giants and super giants earlier than O8 to have higher values of the equivalent widths. If, as we believe, the results are showing actual abundance variation, this is easily interpreted as due to a mass loss in the stars with very massive progenitors which at the end of the hydrogen burning phase tend to show enriched nitrogen at the surface.

In Table 1 we list the ON stars of our sample ordered by spectral type. In the first column we give the CGO number (Catalogue of Galactic O-type Stars, Cruz-González et al. 1974);in the second and third column the spectral type and the distance from the galactic plane, respectively.

TABLE 1
PROPOSED ON STARS

CGO	Sp	Z(pc)
39	05.5 III	- 52
563	05.5 III	133
514	06 Ia	63
484	06 V	- 51
532	07 III	- 193
142	07.5 V	- 36
136	07 I	- 9
75	07.5 III	- 90
41	08 V	- 850
155	08.5 I	- 154
530	09 III	- 312
30	09 V	- 320
618	09 V	- 320
78	09.5 Ia	260
558	09.5 III	249
560	09.7 Iab	535

It is interesting to note that, for the earlier spectral types (05.5-07.5), the stars have a distance from the galactic plane normal for Population I objects while, for the later types, the distance become anomalous (see also Walborn 1971). We interpret this fact as an indication that, for very massive stars, the normal mechanism of mass loss is able to put the nitrogen at the surface. For the less massive stars some additional phenomenon is needed to enrich the nitrogen at the surface of the star and the same phenomenon must be responsible of the anomalous distribution in Z.

Now, if we want to speculate on the nature of this phenomenon another fact must be taken into account. Considering the late ON stars (08-09.5) as a separte group of objects, it is interesting to note that in our sample, and in the sample defined by Walborn (1971), these stars are strangely absent in the galactic disk. If we accept the common explanation for the ON phenomenon, mass exchange in binary systems plus supernova explosion, some selection effect must be invoked to reproduce this anomalous distribution in Z. Since the existence of selection effects in the samples is not evident at this moment we would propose an alternative solution to this problem.

Suppose that we reduce the distances of the late ON stars by a factor of 3, the strange "hole" around the galactic disk will disappear. Such a difference between the spectroscopic distance and the real distance of the stars is not easy to be justified; however, if these stars do not belong to the Population I but they are hot, old disk population objects (see Carrasco _et al_. 1980), the problem of the dis-

tance will be solved. This idea must be taken only as an alternative work hypothesis; further investigations are needed to give the definitive answer to the problem of the origin of the ON stars.

REFERENCES

Carrasco, L., Bisiacchi, G.F., Cruz-Gonzâlez, C., Firmani, C., and Costero, R. 1980, Astron. Astrophys., 92, 253.
Conti, P.S. 1973, Ap. J., 179, 161.
Cruz-Gonzâlez, C., Recillas-Cruz, E., Costero, R., Peimbert, M., and Torres-Peimbert, S. 1974, Rev. Mexicana Astron. Astrof., 1, 211.
Jaschek, M. and Jashek, C. 1974, Astron. Astrophys., 36, 401.
Walborn, N.R. 1970, Ap. J., 161, L149.
Walborn, N.R. 1971, Ap. J. Suppl., 198, 257.

DISCUSSION FOLLOWING BISIACCHI *et al.*

Conti: I was struck by the wide dispersion of N III λ 4514 line strength you have found. This was also found in a sample of O stars with photographic spectra a number of years ago (Conti, 1973). It seems that perhaps this may be a real effect and not just an artifact of the uncertainties. If the nitrogen and carbon abundances do have such a wide dispersion, then a heretical conclusion follows: most (all?) O-type stars may be mixing while on the main sequence, bringing up extra nitrogen and lowering the carbon as CNO processing goes on. I know this may be hard to understand theoretically.

Bisiacchi: I am sure that an explanation based on the data uncertainties must be excluded. At the same spectral type the sample goes from a very strong line to one which is absent or totally imbedded in the noise. It is also evident that for any luminosity class and almost for any spectral type the equivalent widths cover continuously a wide range of values. I will rephrase your question in a different way: the continuous distribution of values may imply that the ON stars should be regarded as the most extreme case of a general atmospheric phenomenon in the O stars. It is not difficult to understand this for the case of the supergiants because at the same temperature we have stars with very different masses and consequently a very different "evolutionary history". For the main sequence stars the explanation must be obviously different and a mechanism other than the pure mass loss by wind must be invoked. This becomes obvious if you analize the height above the galactic plane of the ON stars in Table 2. All the late ON stars show a z above the galactic plane which is really rare for population I objects.