ULTRAVIOLET SPECTRAL MORPHOLOGY OF ON AND OC STARS

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We have undertaken a systematic survey of 115 O-B0 type spectra between 1200 and 1900Å, by means of International Ultraviolet Explorer high-dispersion data rebinned to a constant wavelength resolution of 0.25Å and uniformly normalized (Walborn and Panek 1983). The ultraviolet spectral features, both photospheric and stellar wind, are found to be smoothly correlated with the optical spectral types for the majority of normal stars. In particular, the C IV (λλ1548,1551) and N V (λλ1239,1243) resonance doublets show similar strong P Cygni profiles, which decline along the main sequence beginning at type O7 but remain strong in all higher luminosity spectra. In contrast, the stellar wind effect in the Si IV (λλ1394,1403) doublet displays a pronounced luminosity dependence, being absent from the main sequence spectra at all types and developing gradually through the intermediate luminosity classes into a full P Cygni profile in the supergiants. Relative to this consistent framework provided by the normal stars, a number of peculiar spectra can be succinctly described, including several of types OBN and OBC (Walborn 1976).

For instance, the supergiants HD 105056 (ON9.7 Iae), 123008 (ON9.7 Iab), 152249 (OC9.5 Iab), and 152424 (OC9.7 Ia) show pronounced anomalies in the ultraviolet C and N features relative to the normal standard α Cam (O9.5 Ia). The saturated Si IV P Cyg profiles confirm that all of these stars are indeed supergiants. However, the two OC spectra have weak, unsaturated N V profiles, while conversely C III λ1247 is strikingly deficient in the two ON spectra. Similarly, the latter have weaker C IV P Cyg profiles, with peculiar sharp emission at λ1551 in HD 105056. An additional anomaly in HD 105056 is the presence of strong stellar wind profiles in Al III λλ1855, 1863, unlike any other star at these spectral types examined so far. These spectrograms will be published shortly (Walborn and Panek 1984).

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A. Maeder and A. Renzini (eds.), Observational Tests of the Stellar Evolution Theory, 255–259.

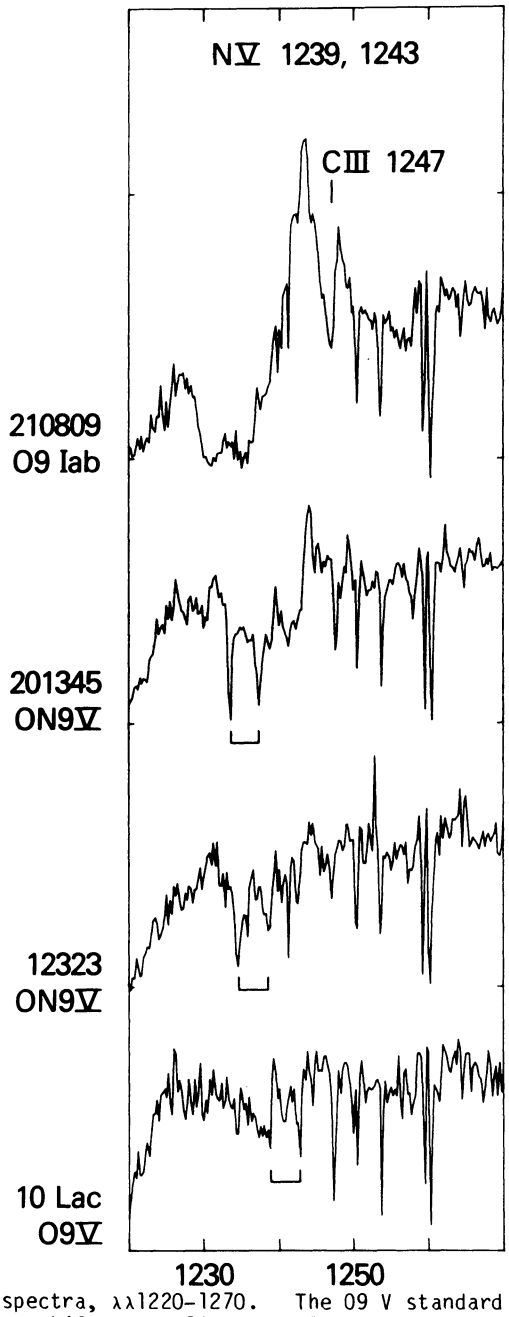

Fig. 1 - O9 spectra, λλ1220-1270. The O9 V standard shows weak, asymmetrical but unshifted N V lines, while the supergiant has a strong P Cygni profile. However, the two ON spectra have strong, highly blue-shifted sharp wind absorptions in N V, with emission as well in HD 201345. Note also the weaker C III line in the two ON spectra.

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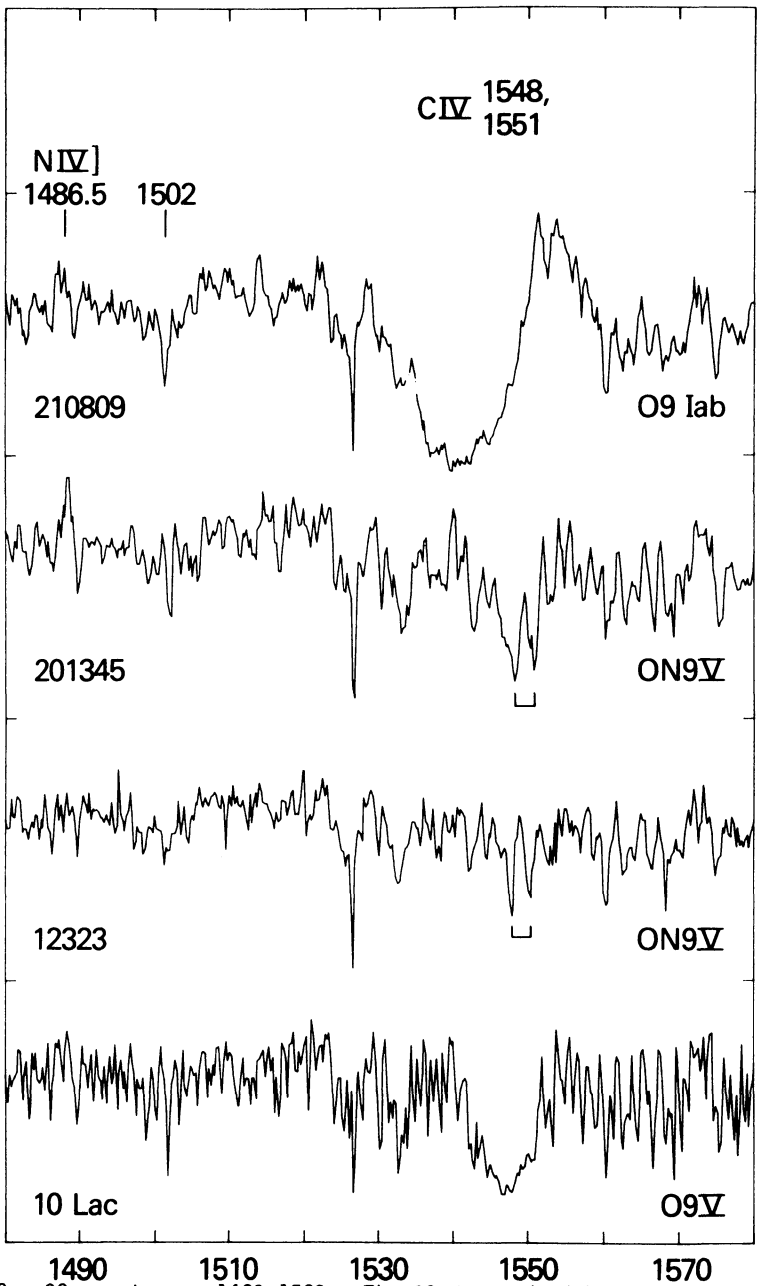

Fig. 2 - O9 spectra, λλ1480-1580. The O9 V standard has a very strong C IV absorption trough but no emission, while the supergiant has a strong P Cygni profile. The weakening of the C IV in the two ON spectra is striking; the doublet may be entirely interstellar in the case of HD 12323. Note also the enhanced N IV]λ1486.5 emission in HD 201345.

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Figures 1 and 2 compare ultraviolet C and N features in two ON9 V spectra to those of normal dwarf and supergiant standards at the same spectral type; blue-violet spectrograms of three of these stars are illustrated by Walborn (1970). The ultraviolet Si IV doublet shows no stellar wind effect in 10 Lac, HD 12323, or HD 201345, but a strong P Cyg profile in HD 210809, in agreement with the optical luminosity classifications. Since the C IV and N V emissions have disappeared from the normal main-sequence spectra by type O9, these features now also show a luminosity effect similar to the Si IV. The pronounced anomalies in the C and N features of the two ON9 V spectra, relative to the systematic behavior of those features in the normal spectra, strongly suggest an origin in abundance effects. This spectral type is later than the C IV and N V maxima in normal spectra, in which the two features are strongly correlated; hence, it is difficult to imagine how a change in other physical conditions could simultaneously weaken the former and strengthen the latter. The enhanced N IV] emission found in HD 201345 is also seen in the nitrogen-rich globular cluster UV star discovered by Bohlin et al. (1983).

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DISCUSSION

Iben: What fraction of all O stars are ON stars?
What is the abundance of N in ON stars?

Walborn: I have classified 327 galactic O stars among which I found 7 of type ON, 5 of type OC, and 11 with more moderate CNO anomalies (Ap.J. 205, 419, 1976; A.J. 87, 1300, 1982). However, these fractions are upper limits because several of the peculiar objects were selected on the basis of suggestive remarks by authors of more extensive, lower dispersion surveys. The main sequence ON stars may well be products of mass transfer in binary systems. On the other hand, a possible interpretation of the anomalous supergiants is that the OC's, found predominantly in certain young associations, have normal CNO abundances, while the morphologically "normal" majority of O-type supergiants are moderately nitrogen-rich due to mixing and/or mass loss, and the ON's are extreme cases. In this picture, all O-type supergiants would be involved in the phenomenon.
Baschek, Kodaira and Scholz (Ap.Lett. 12, 227, 1972) found a nitrogen abundance >2.5 times larger in HD 188209 (morphologically normal) than in ζ Orionis (moderately N-deficient), suggesting an admixture of 20 to 40 per cent CNO-cycled material in the atmosphere of the former star. Lester (Ap.J. 185, 253, 1973) found N 33 times more abundant in HD 201345 than in 10 Lacertae. Kudritzki, Méndez, Simon, Heber and Schönberner (ESO Workshop on Primordial Helium, p. 189, 1983) found N overabundant by at least a factor of 10 in HD 48279 relative to τ Scorpii.

Kudritzki: D. Schönberner, K.P. Simon and myself have recently finished the NLTE-analysis of some ON V-star and found an overabundance of a factor of 10 for nitrogen accompanied by an increase of the helium number fraction to 14 % (relative to the "normal" value of 9 %). This has been published in the recent proceedings of the ESO-Workshop on "Primordial Helium".

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