IUE OBSERVATIONS OF THE WN-C STAR HD 62910

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We have obtained low resolution UV spectrophotometry of the WN-C star HD 62910 in both the SWP ($\lambda\lambda$1150-2000) and LWR ($\lambda\lambda$1850-3250) IUE spectrographs, and also for HD 117688, WN6, used for comparison. The UV spectrum of HD 62910 is shown in Fig 1 and is seen to be dominated by many strong emission lines, which by comparison with the IUE spectra of other galactic WR stars (Nussbaumer et al. 1981) is found to reflect a predominantly WN-type spectrum, but in addition, weaker features characteristic of WC spectra are also seen, particularly in the LWR wavelength range. In Table 1 we list the principal observed WN and WC features in HD 62910. A comparison of the relative strengths of the WN emissions with those observed in various WN subtypes (Nussbaumer et al. 1981) and with our spectra of HD 117688 confirms the subtype of HD 62910 as WN6 as inferred in the visible (Smith 1968, Van der Hucht et al. 1981).

The NVλ1240, SiIVλ1400, CIVλ1550 and NIVλ1718 lines are seen as well developed P-Cygni profiles. The mean velocities of the centres of the violet displaced absorptions in these features is found to be 1630 + 200 km/s compared to the corresponding value of 1700 ± 250 km/s in HD 117688. This implies similar stellar winds. An estimate of the terminal velocity in the wind of HD 62910 is 2000 km/s, consistent with that of a normal WN6 star, but somewhat lower than the value of $\sim$2700 km/s expected for a WC star earlier than WC7 (Willis 1981). It is not certain whether in HD 62910 we are dealing with a single star or a binary system with WN and WC components. The peak emission line intensity/continuum ratios for 30 WN emissions in HD 62910 compared to HD 117688 show a mean ratio of 1.06 ± 0.17 (rms), indicating no swamping of the WN spectrum by a WC companion and suggesting a single star, which has been assumed herein.

Clearly seen in Fig 1 is a strong interstellar 2200A band, which on nulling using the mean galactic interstellar extinction law given by Seaton (1979) gives a colour excess of E_{B-V} = 0.85, somewhat higher than the value of 0.72 derived by Smith (1968) from visible (b-v) colours. The same nulling procedure for HD 117688 gives E_{B-V} = 0.70, in agreement with that given by Smith (1968) and we suggest that her low value for HD 62910 may result from WC line contamination in the visible data.

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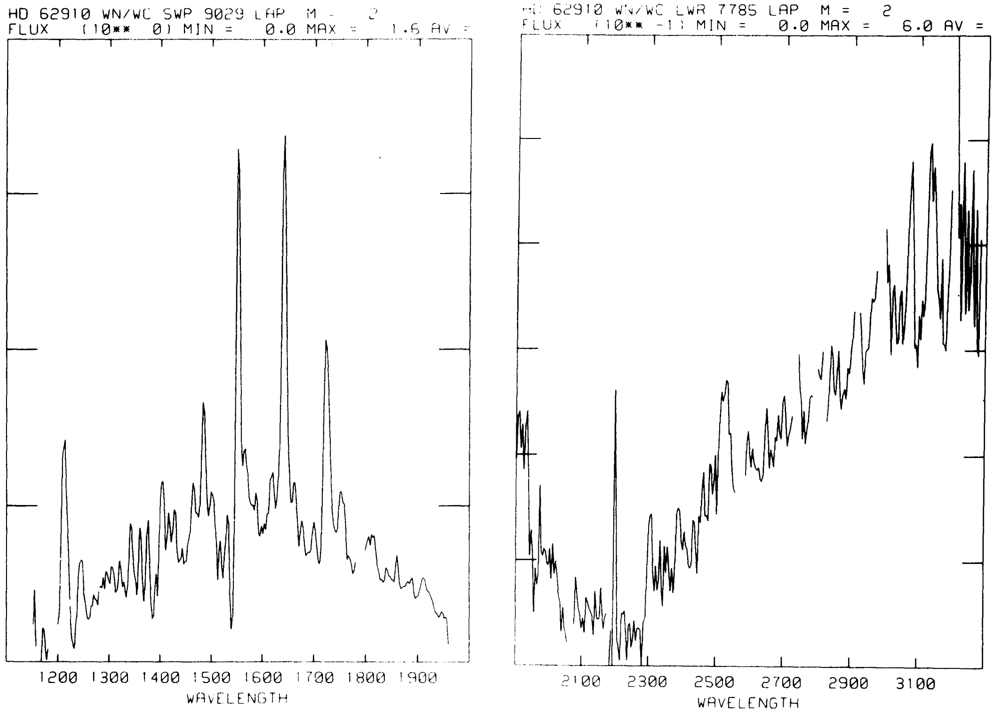
Fig 1: IUE spectrophotometry ($10^{12}F_\lambda$ erg cm^{-2} s^{-1} Å^{-1}) of HD 62910



We adopt E_{B-V} = 0.85 for HD 62910 herein and dereddened the UV continuum fluxes estimated from Fig 1 to form intrinsic UV-visible colours, $(U_\lambda-v)_o$ for $(U_\lambda)_o$ every 50Å from 1150-3100Å. Each colour has been interpolated in a blackbody grid to give a colour temperature. The mean and rms values derived in this way are: T_c = 38000 ± 4000 K, with no significant variation in T_c with varying UV wavelength employed, suggesting that T_c may be close to T_{eff}. Such a value is close to that recently derived for WN6 stars by Underhill (1980) and Nussbaumer et al. (1981). Our adopted E_{B-V} = 0.85 is very similar to that quoted by Turner (1977) who suggests that HD 62910 may be part of the NGC 2439 association with a distance modulus of 12.69. This would give M_V = -4.91 which is close to the values usually quoted for WNE (or WC) stars (Conti 1978).

In the IUE spectra of HD 62910 all the C and N lines used by Smith and Willis (these proceedings) for their chemical Sobolev analysis of WN and WC spectra, are observed in the same star, and thus we can carry out an Escape Probability Modelling (EPM) where no reliance is needed on any upper limits to line strengths. In Table 1 we list the measured emission equivalent width of the relevant He, C and N lines used in our EPM analysis, which follows the techniques set out by Willis and Wilson (1978) and Smith and Willis (these proceedings). The emission line region is assumed to be homogeneous with atmospheric parameters derived at a single, representative radius, R_p, surrounding a continuum emitting core of radius R_c and blackbody temperature T_c (as derived above),

Table 1: Principal WN and WC Features seen in the IUE spectra of HD 62910. In () we give the measured equivalent widths in Å (emission) of lines used in the Sobolev analysis.

λ_{obs}	WN LINES	λ_{obs}	WN LINES	λ_{obs}	WC LINES
1182e	NIII 1183.1	1617e	NV 1616.3	1910e (6.6)	CIII 1908.7
1232a	NV 1238.8, 1242.8	1630e		1924e	CIII 1923
1247e	NV 1238.8, 1242.8	1641e (37.0)	HeII 1640.4	2300e (35.0)	CIII 2296.8
1296e	NIV 1296.6	1622e	OIII 1661	2530e	CIV 2529
1307e	NIV 1309.6	1676e	NII 1675	2700e	CIV 2698
1323e	NIII 1323.4, NIV 1324.0	1700e	NIV 1696	2820e	CIV 2819.0
1331e		1710a	NIV 1718.5	2840e	CIII 2844.1
1345e	NIII 1345.8, OIV 1343	1722e (27.0)	NIV 1718.5, SiIV 1725	2915e	CIV 2906.3
1363e		1806e	NIII 1805, SiII 1808	2960e	
1378e		1815e	NV 1811, 1812	3008e?	
1386a	SiIV 1393.7	1842e	NIII 1845.7	3022e?	OIII 3023.4
1396a	SiIV 1402.8	1858e	NV 1857.8	3047e	OIII 3047.1
1407e		1885e	NIII 1885.2, NIV 1883	3070e	OIII 3063.5-3071.7
1420e		2076e	NIII 2076.8	3127e	OIII 3121.7
1429e		2348e		3140e	
1444e	NIV 1446.1	2390e (2.9)	HeII 2385		
1466e	NIII 1470.7-1471.7	2515e (5.4)	HeII 2512		
1486e (15.0)	NIV 1486.5	2648e	NIV 2645.6-2646.9		
1504e		2735e (11.7)	HeII 2734		
1519e		2982e	NIII 2983.6		
1532e		3203e (20.0)	HeII 3202		
1542a	CIV 1548.8, 1550.7				
1553e (28.0)	CIV 1548.8, 1550.7				
1567e					
1582e	OIII 1584 ?				
1590e	OIV 1590 ?				

expanding at a velocity V_p taken as 2000 km/s. R_p is taken as the mean of R_c and R_e - the full extent of the emission line region. We have no direct information on these, but simply adopt those used for WNE stars by Smith & Willis (1982) for WNE stars, viz $R_c = 8R_\odot$ and $R_e = 50R_\odot$: $R_p = 30R_\odot$.

The results of the C and N line modelling are summarised in Table 2 - full details will appear elsewhere - for three values of the electron temperature, T_e. Modelling of the HeII λ1640 and HeII (n-3) series lines gives best agreement for T_e = 40000K, close to our adopted T_{eff}. We note that there is only a weak dependence on the C/N ratio with varying T_e and N_e which is a reflection on the use of similar ions and transitions in the species involved. The deduced mass abundance ratios are compared in Table 2 with those expected for WN and WC stars from the theoretical stellar evolution calculations of Gabriel & Noels (1981) reflecting various stages of CNO and He burning products. The deduced abundances for HD 62910 are seen to be those expected for a star whose chemistry is intermediate between a normal WN and WC star, as expected from its classification. The deduced N/He ratio is still quite close to that theoretically expected for WNE stars, suggesting that the object has not evolved far from this stage and is in line with its predominantly UV WN emission line spectrum. Clearly, however, the carbon (very low in normal WN stars, Smith & Willis 1982) has been quickly replenished.

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Table 2: Results of the EPM analysis for HD 62910 for three values of T_e. Numbers in () are the exponent powers of ten.

T_e (K) /N_e	IONIC DENSITIES (cm^{-3})				MASS ABUNDANCE RATIOS		
	CIII	CIV	NIV	NIII	C/N	C/He	N/He
30000/ 2.5(11)	9.5(07)	1.5(-07)	1.0(08)	1.5(08)	0.38	2.63(-3)	7.00(-3)
40000/1.3(11)	7.0(07)	1.2(07)	6.0(07)	7.0(07)	0.54	3.78(-3)	7.0(-3)
50000/8.5(10)	6.5(07)	1.0(07)	5.2(07)	6.0(07)	0.57	5.29(-3)	9.2(-3)
PREDICTED VALUES (Gabriel&Noels 1981)							
WNE					2.1(-2)	2.6(-4)	1.1(-2)
WC					3.0(5)	1.2(-1)	4.1(-7)

Although the EPM used is not fully dynamic, since no velocity/density field is used, we can get some idea of the stellar mass loss rate from the above results. Adopting the parameters given in Table 2 for T_e = 40000K we estimate $dM/dt \sim 7 \times 10^{-5}$ $M_\odot$/y which is a factor of two or so higher than the rates recently derived for WN and WC stars by Barlow, Smith & Willis (1981), although the difference is hardly significant. We deduce that currently available evidence suggests that HD 62910 is an object on its way from a WNE to a WC star.

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DISCUSSION FOLLOWING STICKLAND AND WILLIS

Nussbaumer: If you lower the mass you also lower the radius, that also lowers the mass loss.

Willis: We could adopt $v_\infty = 4\ v_{escape}$, rather than the value of 3 we assumed. I don't think this would change the mass loss rate estimate by more than a factor of 2-3, certainly not the required factor of 80 to give $\dot{M} = \dot{M}_{max}$.

Massey: Do you have any similar data on MR 111?

Willis: To my knowledge MR 111 has not been observed with IUE. It is too heavily reddened to be visible. High reddening really wipes you out in the UV.

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