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OBSERVATIONS OF TWO PECULIAR EMISSION OBJECTS IN THE LARGE MAGELLANIC CLOUD

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ABSTRACT

Ultraviolet and visual wavelength spectra were obtained of two peculiar emission objects, Henize S63 and Sanduleak's star in the Large Magellanic Cloud. Previously not observed in the near- or far-ultraviolet, both objects exhibit strong permitted and semiforbidden line emission. Estimates based on the absolute continuum flux of the hot companion star in Hen S63 indicate that it rivals the luminosity of the carbon star primary. The emission-line profile structure in both objects does not suggest Wolf-Rayet type emission. Carbon in Sanduleak's star (LMC anonymous) is conspicuously absent, while N V, N IV], and N III] dominate the UV emission-line spectrum. Nitrogen is overabundant with respect to carbon and oxygen in both objects. The large overabundance of nitrogen in Sanduleak's star suggests evidence for CNO processed material similar to that seen in η Car.

Subject headings: galaxies: Magellanic Clouds — stars: combination spectra — stars: emission-line — ultraviolet: spectra

I. INTRODUCTION

Two members of the Large Magellanic Cloud (LMC) have been classified symbiotic on the basis of their optical spectra (Allen 1980*a*). We report the first ultraviolet spectra of these, taken with the *International Ultraviolet Explorer* (*IUE*). New ground-based optical spectra were also obtained with 3.9 m Australian telescope (AAT) which, together with our low dispersion *IUE* spectra, indicate the presence of a very hot luminous object in both these systems. New *JHKL* photometry was also obtained at the AAT, and is given in Table 1. Existing optical spectra of Hen S63 (Allen 1980*a*) indicate the presence of a carbon star, together with intense emission lines that include [Ne III] λ3869, [O III] λλ4363,5007, He II λλ4686,5411, as well as the Balmer series. In the 1200–2000 Å (SWP camera) wavelength range, the far-UV spectrum is characterized by the presence of strong resonance and intercombination emission lines of N V, N IV], C IV, He II, O III], N III], and C III]. These emission lines are superposed on an intense continuum which rises with decreasing wavelength between 1200 and 2000 Å, and can be fitted by the continuum of a hot star with an effective temperature $T_{\rm eff} \geq 50{,}000$ K. At the distance to the LMC of 55 kpc, this hot component is unusually luminous, i.e., $L_{\rm UV} \approx 10^4\ L_\odot$, when compared to typical luminosities $\sim 10^3\ L_\odot$ (Sanduleak 1977) found for hot companions in symbiotic stars in our Galaxy.

Allen's (1980*a*) observations of Sanduleak's star (LMC anonymous) indicate unusually high extinction in the visible. Our *IUE* observations of this object also indicate a high extinction, but not as great as suggested in the optical. The emission-line spectrum of Sanduleak's star is substantially different than that of Hen S63 because of the absence of emission from carbon. Nitrogen appears very enhanced relative to carbon, with N V, N IV], and N III] dominating the emission-line spectrum. The infrared data are dominated by thermal emission from dust, but the small value of $J-H$ and the absence of a late-type stellar features in the optical spectra suggest that this object may not be a symbiotic star. Rather, its low resolution UV spectrum is instead very reminiscent of the nebula around η Car (Davidson,

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TABLE 1

A. *JHK* PHOTOMETRY OF STARS

Object	K	$J-H$	$H-K$	M_V[a]
Hen S63	11.33 ± 0.03	0.88 ± 0.04	0.27 ± 0.04	−3.1
Sanduleak's Star ...	12.87 ± 0.03	0.57 ± 0.03	1.71 ± 0.03	−3.7

B. STELLAR PARAMETERS FOR THE HOT COMPONENT IN HENIZE S63[b]

T_{eff} (K)	R (cm)	L ($L_\odot$)
80,000	4.3×10^{10}	1.4×10^{4}

[a]Based on FES apparent magnitudes and the reddening discussed in the text.
[b]Estimates of stellar parameters for Sanduleak's star cannot be accomplished because of the absence or weakness of UV continuum in the *IUE* spectral range.

Walborn, and Gull 1982). The very faint continuum observed in the SWP wavelength range of *IUE* and in the visible is likely nebular, but considerably longer exposures are necessary in order to determine the nature of the continuum flux distribution in the far-UV.

II. OPTICAL AND ULTRAVIOLET OBSERVATIONS

a) *Henize S63*

Optical spectra covering the 3200–7000 Å wavelength range of Hen S63 and Sanduleak's star were obtained on 1980 February 10 using the AAT with the image photon counting system. The spectral resolution was ~2 Å, which can be compared to the *IUE* data obtained 1982 March 21. Prominent optical and UV emission lines from S63 are shown in Table 2 and in Figures 1 and 2. The average Doppler shifts from optical emission lines are ~ +365 km s^{-1}, consistent with the LMC motion. The measured wavelength for all strong emission lines observed with *IUE* are redshifted with respect to the laboratory rest wavelength by $\Delta\lambda \approx +4$ Å. This is partly due to the LMC motion. However, a residual shift may be present in which the high excitation permitted emission lines of C IV, He II, N V, in addition to the intercombination lines, have recession velocities in excess of the LMC motion by as much as +500 to +1000 km s^{-1} (see Table 2). It is not clear whether this is a real effect or the result of the object being off-centered in the large entrance aperture of *IUE*. In a long fine error sensor (FES) exposure, the star was detected, and blind offset pointing was not necessary during the exposure, suggesting that the object was properly centered in the large aperture. The presence of interstellar O I absorption at λ1304.9 Å (rest wavelength λ 1302.1 Å) suggests that ~350 km s^{-1} in excess of the LMC motion is due to instrumental effects. We are reluctant at present to suggest that the redshifts in excess of that which can be ascribed to instrumental effects are real because they are not seen in optical spectra (see Fig. 2). Further *IUE* observations would likely determine if this curious behavior in the UV is real or instrumental in nature.

Our *IUE* observations of S63 were obtained with the large 10″×20″ entrance aperture of the satellite spectrometer with 4 hr exposures with the SWP camera (1200–2000 Å) in low dispersion (see Boggess *et al.* 1978). In addition to the prominent emission lines observed in the far-ultraviolet (Table 2), strong continuum was recorded throughout the SWP wavelength range (Fig. 1). The spectrum exhibits an absolute continuum flux which rises with decreasing wavelength over the 1200–2000 Å wavelength range and can be easily matched with a $T_{eff} \geq 50{,}000$ K blackbody law. The absolute continuum flux averaged over the *IUE* spectral sensitivity range ~10^{-14} ergs cm^{-2} s^{-1} $Å^{-1}$ and suggests the luminosity for the hot companion of the system at 55 kpc ~10^4 $L_\odot$. The T_{eff} derived from the UV continuum flux distribution and the corresponding UV luminosity falls well within the range of stellar parameters usually associated with Wolf-Rayet stars. However, the general emission-line profile structure found in our *IUE* spectra is not consistent with this object having emission characteristic of Wolf-Rayet stars. This follows because the ultraviolet lines have FWHM in the range 2–3 Å, which are narrow if compared to widths found in typical Wolf-Rayet stars (Nussbaumer *et al.* 1982). Moreover, the characteristic P Cygni profiles, evident particularly in the N V λλ1239,1243 in WN stars, are not seen in N V profiles in Hen S63. Finally, the visible spectrum of S63 does not resemble spectra of Wolf-Rayet stars in the LMC in general (see Massey and Conti 1982). For example, the He II lines in the optical have FWHM ≈ 15 Å, which again are narrow for Wolf-Rayet stars, and no suggestion of P Cygni profiles. Furthermore, of the few WR stars that show both WC and WN characteristics (defined by strong emission in either C or N), it is rare to find C III] λ1909 emission, which is quite strong in Hen S63.

TABLE 2

EMISSION LINES IN HENIZE S63[a]

Ionic Transitions	λ(Å) Laboratory	λ(Å) *IUE*[b]	Flux ($\times 10^{-13}$ ergs cm^{-2} s^{-1})[c]
N V	1238.8, 1242.8	1245.4	0.9
O I[d]	1302.1	1304.9	...
O IV]	{1397.2, 1399.8; 1401.2, 1404.8; 1407.4}	1404.4	0.2
N IV]	1483.3, 1486.5	1489.6	1.9
C IV	1548.2, 1550.8	1553.8	6.2
[Ne IV]	1601.5, 1601.7	1603.6	0.1
He II	1640.4	1644.6	1.5
O III]	1660.8, 1666.2	1664.0, 1670.2	0.3
N IV	1718.6	1722.6	0.2
N III]	{1748.6, 1749.7; 1752.2, 1754.0}	1753.6	0.9
Si III]	1892.0	1896.8	0.111
C III]	1908.7	1912.0	0.359
[Ne III]	3869	3873	0.05
N IV	4058	4734	0.08
Hδ	4102	4107.5	0.42
Hγ	4340	4345.5	0.67
[O III]	4363	4368	0.05
He II	4686	4692	0.23
Hβ	4861	4866	1.70
He I	4922	4928	0.06
[O III]	5007	5014	0.11
He II	5411	5420	0.03
He I	5876	5883	0.21
Hα	6563	6570.5	13.6
He I	6678	6687	0.26

[a]Optical data obtained 1980 Feb 10; ultraviolet data obtained 1982 Mar 21.

[b]Mean velocity for measured shifts 365 km s^{-1} in the visible; 790 km s^{-1} in ultraviolet.

[c]Unreddened fluxes (see text).

[d]Absorption line due to the interstellar medium in the LMC.

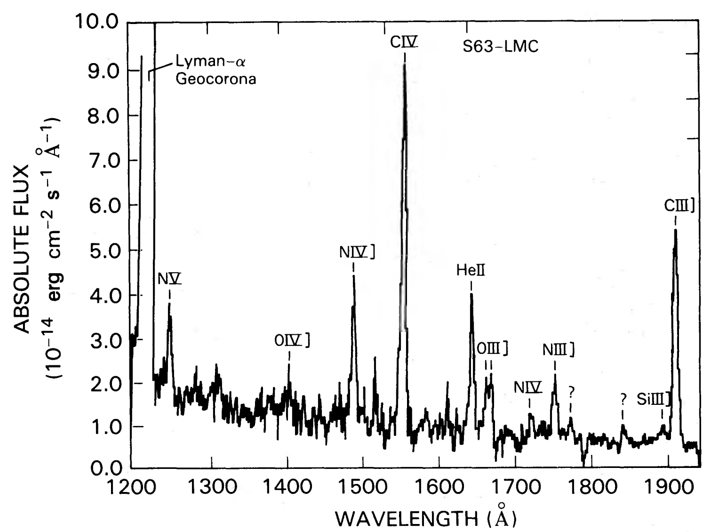

FIG. 1.—Low dispersion spectrum of LMC Hen S63-LMC obtained 1981 March 21 in the large 10″ × 20″ entrance aperture. The absolute flux scale shown in given, assuming negligible extinction in the direction of the object. Prominent emission lines of N V, N IV], C IV, He II, O III], N III], and C III] are apparent. The UV continuum is seen rising steadily with decreasing wavelength over the SWP wavelength range.

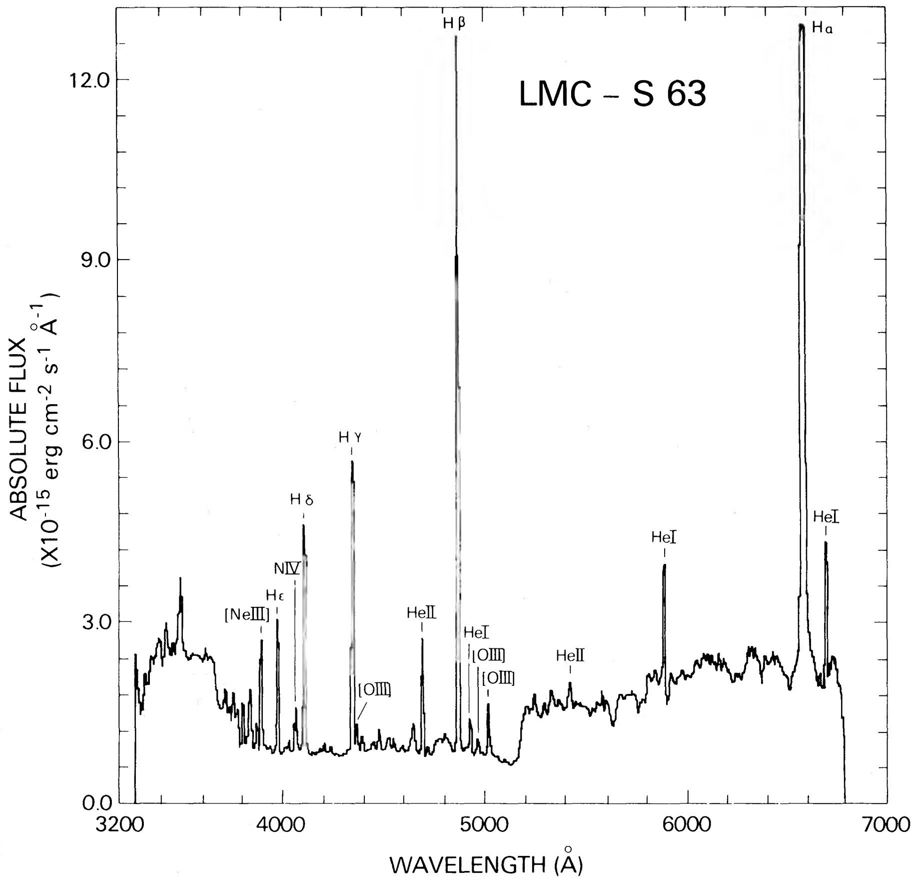

FIG. 2.—Optical spectrum of Hen S63 on 1980 February 10 at the AAT with the image photon counting system

The extinction is difficult to obtain from the optical data alone, but infrared observations show no evidence of circumstellar dust. The general level of extinction in the vicinity of S63 in the LMC is $E_{B-V} \lesssim 0.1$ (Page and Carruthers 1981). A more precise value of E_{B-V} can be obtained by comparing the intensities of the He II λ1640 to He II λ4686. These ratios can be found in Seaton (1978) and are generally in the range $I(\lambda1640)/I(\lambda4686) \approx 6.5$–$7.5$. We have adopted theoretical ratios appropriate for high density symbiotic nebulae ($n_e \gtrsim 10^6$ cm^{-3}, $T_e \approx 10^4$ K). The wavelength dependence of extinction in the visible is from Seaton (1979). We find that $E_{B-V} \lesssim 0.02$, although errors may be introduced when comparing optical and UV observations obtained at different epochs. With values of $E_{B-V} = 0.02$ we can account for the observed UV continuum flux distribution between 1200 and 2000 Å satisfactorily with a $T_{\rm eff}$ blackbody law. If large values of absorption are applied to the UV data using the extinction law for the LMC (Koorneef and Code 1981), the dereddened UV continuum distribution with wavelength departs significantly from a blackbody law and produces a flux distribution which is not easily explained by a hot thermal source. We suspect, therefore, that Hen S63 is not appreciably reddened, and adopt a value $E_{B-V} = 0.0$.

b) *Sanduleak's Star*

The optical spectrum of Sanduleak's star shows numerous emission lines and a weak flat continuum (Allen 1980*a*) that indicate a nebular (free-free) origin. In contrast to Hen S63, a late-type spectrum is not evident. The emission lines and their fluxes in the ultraviolet and visible are given in Tables 3 and 4. The ultraviolet spectrum obtained with *IUE* was taken on 1982 October 17 (Fig. 3). Weak UV continuum just above the background noise level is evident in the SWP photowrite image of this object. A number of UV emission lines are present, the most prominent of which are those of N V, N IV], and N III]. Again, there is no evidence for Wolf-Rayet line profiles.

The reddening appropriate for Sanduleak's star is estimated as $A_V = 4$ mag using the Balmer line ratios (Allen 1980*a*). In the ultraviolet, one can obtain an

TABLE 3

SANDULEAK'S STAR IN THE ULTRAVIOLET[a]

Ionic Transition	λ(Å) Laboratory	λ(Å) IUE[b]	Flux (E_{B-V} = 0.0) ($\times 10^{-13}$ ergs cm^{-2} s^{-1})	Flux (E_{B-V} = 0.3) ($\times 10^{-11}$ ergs cm^{-2} s^{-1})
N v	1238.8,1242.8	1242.4	2.3	1.0
N iv]	1486.5	1483.4,1489.4	1.5	0.4
C iv?	1548.2,1550.8	1551.8	0.3	...
He ii	1640.4	1644.0	0.8	0.1
?	...	1661.6	0.2	...
?	...	1678.4	0.3	...
?	...	1723.2	0.2	...
N iii]	{1748.6,1749.7 1752.2,1754.0	1746.8 1754.0	1.3	0.2

[a]Data obtained 1982 October 17.

[b]Not corrected for LMC motion. Mean velocity for measured shifts 600 km s^{-1} in the ultraviolet.

TABLE 4

SANDULEAK'S STAR IN THE VISIBLE

Ionic Transition	λ(Å) Laboratory	Flux ($\times 10^{-14}$ ergs cm^{-2} s^{-1})[a]	Ionic Transition	λ(Å) Laboratory	Flux ($\times 10^{-14}$ ergs cm^{-2} s^{-1})[a]
[Ne v]	3425	2.2	[O iii]	4959	7.7
O iii	3444	1.4	[O iii]	5007	26
[Fe vii]+O iii	3758	2.1	He i + Fe ii	5017	0.6
[Ne iii]	3869	4.1	Si ii	5040	0.4
He i + H_8	3888	1.1	Si ii	5056	0.2
[Ne iii]+Hε	3970	2.3	Fe ii	5169	0.2
[S ii]	4068/4074	0.4	Fe ii	5198	0.4
Hδ	4102	2.3	Fe ii + [Fe vii]	5273	0.5
Fe ii	4233	0.3	Fe ii	5316	0.6
[Fe ii]	4287	0.3	He ii	5411	0.5
Hγ	4340	3.9	[Cl iii]	5538	0.1
Fe ii	4352	0.2	[Ca vii]	5612	0.7
[O iii]+[Fe ii]	4363	2.6	[Fe vii]	5721	0.2
[Fe ii]+[Fe ii]	4414	0.3	[N ii]	5754	1.6
He i	4471	0.5	He i	5876	1.9
Fe ii	4491	0.5	[Fe vii]	6087	0.8
Fe ii	4521	0.2	[O i]	6300	0.5
Fe ii + He ii	4542	0.6	[S iii]	6312	0.2
Fe ii	4549	0.6	Si ii	6347	0.15
Fe ii	4556	0.4	[O i]	6363	0.15
Fe ii	4583	0.7	Si ii	6371	0.15
Fe ii	4630	0.6	Fe ii	6456	0.15
N iii	4634	0.8	[N ii]	6548	5.3
N iii	4640	1.3	Hα	6563	240
He ii	4686	6.2	[N ii]	6584	18
[Fe ii]	4813	0.2	[S ii]+[S ii]	6717/6731	0.25
Hβ	4861	16	...	6830	2.1
Fe ii + He i	4922	0.5	He i	7065	1.6

[a]Unreddened absolute line fluxes.

estimate of E_{B-V} by the same method as we used for Hen S63, i.e., by comparing the intensity of He ii λ1640 to He ii λ4686. The observed ratio $I(\lambda1640)/I(\lambda4686) \approx 1.3$ yields E_{B-V} in the approximate range 0.25–0.30. We adopt $E_{B-V} = 0.3$, resulting in $A_V \approx 1$ mag, which is much smaller than that obtained from the Balmer decrement. High optical depths in the hydrogen lines could account for the difference in the two methods. In Table 3 we show the absolute emission-line fluxes for two values of reddening, $E_{B-V} = 0.0$ and 0.3. The strongest emission line in the UV is N v λλ1238.8,1242.8, whereas the usually prominent C iv λλ1548,1550 emission

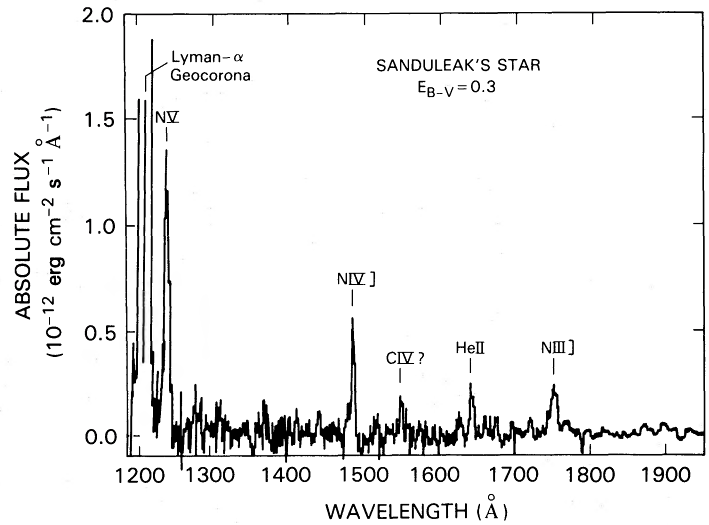

FIG. 3.—Sanduleak's star (LMC anonymous) observed 1982 October 17 with *IUE* in the low dispersion mode. Nitrogen lines of N v, N IV], and N III], as well as He II, dominate the emission-line spectrum. C IV λλ1548,1550 is perhaps present, but very weak relative to N v λλ1239,1243. The continuum is underexposed but detectable on the *IUE* photowrite image of the spectrum. Evident in N v and N IV] line profiles is extended emission in the blue wing of the line.

doublet is weak or totally absent. The mean velocity for measured shifts is $\sim +600$ km s^{-1} in the UV, somewhat smaller than those of Hen S63, but still in excess of the LMC motion. The UV lines have FWHM in the range 2–3.5 Å when fitted with a Gaussian. The intercombination lines of N IV] and N III] exhibit a conspicuous extended blue wing emission. The line profile structure of the nitrogen lines can be approximated with a double Gaussian fit. The redward emission peak is the stronger of the double-peaked profile. The wavelength separation of the two Gaussian peaks corresponds to ~ 1200 km s^{-1}. We have no explanation for this line profile structure, but note that this type of line profile structure is not seen in galactic symbiotics.

III. DISCUSSION AND CONCLUSIONS

Allen (1980*a*) has estimated that the electron density in the S63 nebula is at least 10^7 cm^{-3}. We used [O III] line ratios $[I(\lambda 4959)+I(\lambda 5007)]/I(\lambda 4363)$ for S63 and the computations of Kafatos and Lynch (1980) to obtain $n_e \approx 10^8$ cm^{-3} and $n_e \approx 10^7$ cm^{-3} that correspond to values of $T_e = 10^4$ K and $T_e = 2\times10^4$ K, respectively. The observed intensity of Hα is then used to obtain an estimate of the size of the ionized nebula $L \approx 5.3\times10^{14}$ cm and $L \approx 3.1\times10^{15}$ cm for $T_e = 10^4$ and 2×10^4 K, respectively. For Sanduleak's star we have used the same method after correcting for the extinction of $E_{B-V} = 0.3$ (see below). In our analysis of nebular parameters for Sanduleak's star we also used the [N II] ratio $[I(\lambda 6548)+I(\lambda 6584)]/I(\lambda 5754)$ and the [S II] ratio $I(\sim\lambda 6725)/I(\sim\lambda 4068)$, which yield slightly lower temperatures. Our best values for both stars are for $T_e \approx 10^4$ K. In Table 4 nebular parameters are shown for two assumed values of T_e, 10^4 and 2×10^4 K. The high densities prevalent make it likely that radiative transfer effects are important when determining the hydrogen line ratios, which are inferred from values shown in Table 2 for S63. The Balmer decrement (Allen 1980*a*) is not consistent with a case B. For densities and sizes of the ionized regions in symbiotic stars (Kafatos 1982), we find that the optical depth at the Lyα line center is $\tau(\mathrm{Ly}\alpha) \approx 8\times10^8 (n_e/10^8\ \mathrm{cm}^{-3})(L/10^{14}\ \mathrm{cm})$. Such high optical depths make it likely that the Balmer line optical depths are also finite, which would result in weakened Hβ strength (Osterbrock 1974). This would explain the unusually high Hα/Hβ ratio from values in Tables 2 and 4 when compared to the theoretically expected ratio for case B of 2.80. Radiative transfer effects may also be important for the He I lines (see Osterbrock 1974).

We have applied the Zanstra method to obtain the effective temperature of the hot star in S63 following the approach of Seaton (1960). The ratio I(He II, λ4686)$/I$(Hβ, λ4861) ≈ 0.13 yields $T_{\mathrm{eff}} \approx 120{,}000$ K. The ratio I(He I, λ5876)$/I$(Hβ) ≈ 0.12 yields $T_{\mathrm{eff}} \approx 45{,}000$ K. In view of the radiative transfer effects, it is not surprising that the two ratios yield different values of T_{eff}. More precise model atmospheres (Hummer and Mihalas 1970) yield similar values for T_{eff}. Fitting the observed SWP continuum of S63 with blackbody curves yields $T_{\mathrm{eff}} \gtrsim 50{,}000$ K, in agreement with the lower limit obtained by the Zanstra method. Even though an exact value of T_{eff} is not known, we can estimate the luminosity and radius of the hot star in Hen S63, using the observed UV continuum, and assuming a distance to

Hen S63 of 55 kpc. For $T_{\rm eff} = 45{,}000$, 80,000, and 120,000 K we find the luminosity of the hot component is 3.6×10^3, 1.4×10^4, and 3.2×10^4 $L_\odot$, respectively, while its radius is 7×10^{10}, 4.3×10^{10}, and 2.9×10^{10} cm, respectively (see Table 1B). These values correspond to 0.1–0.8 of the Eddington luminosity for 1 $M_\odot$ star! Accordingly, the hot star in S63 is unusually luminous if compared to typical luminosities $\sim10^2$–10^3 $L_\odot$ for hot companions in symbiotic stars in our Galaxy (see Michalitsianos *et al.* 1982; Kafatos 1982). The primary star of S63 is a carbon star (Allen 1980*a*) and has a luminosity at maximum $\sim1.8\times10^4$ $L_\odot$. The hot component star in Hen S63, therefore, rivals the cool primary in luminosity in the ultraviolet. In the visible the cool primary dominates the light by virtue of its low surface temperature, ~3000 K. The visual magnitude of the cool star is estimated at $m_V \approx 14.7$. The apparent visual magnitude of the hot secondary would only be $m_V \approx 19.5$, even if $T_{\rm eff}$ were as low as 50,000 K.

In contrast to Hen S63, late-type spectral features have not been found in Sanduleak's star (Allen 1980*a*). The continuum in the visible is likely free-free and bound-free nebular. We find very weak continuum in the 1200–2000 Å wavelength range. The total visual and ultraviolet luminosity output is $\sim10^3$ $L_\odot$, after correcting for an extinction $E_{B-V} \approx 0.3$. The discrepancy between the extinction $E_{B-V} \approx 0.3$ found from the He II line ratios and the extinction $E_{B-V} \approx 1.25$ found from the Balmer line ratios could be explained if radiative transfer effects are important in Sanduleak's star as well. As such, the value $E_{B-V} = 0.3$ which we have adopted appears to be more reliable because radiative transfer effects would not be important for the He II lines.

We have used a similar analysis to that employed in our work for symbiotic stars in the Galaxy (see Kafatos, Michalitsianos, and Hobbs 1980) to estimate the chemical abundances of C, N, O, denoted as n(C), n(N), and n(O) in the two nebulae. These values depend on the value of temperature assumed, as well as on the relative ionic abundances $N(X^z)$ of element X with charge z. The ionic abundances for nitrogen are easy to estimate since we likely see all the ions present (viz., N II, N III, N IV, and N V). For carbon and oxygen an abundance estimate is considerably difficult because only the lines of one stage of ionization are seen (for carbon we have an upper limit from *IUE* data, for oxygen we used the [O III] intensity from optical data). We have made reasonable estimates for the relevant ionic abundances of carbon and oxygen guided by the more accurately known ionic abundances of nitrogen. The results are shown in Table 5. The quantities $\eta_{\rm O}$, $\eta_{\rm C}$, and $\eta_{\rm N}$ are defined as the relative chemical abundances of O, C, and N compared to hydrogen, divided by the same ratio of solar abundances; i.e., $\eta_{\rm O} \equiv [n({\rm O})/n({\rm H})]/[n({\rm O})/n({\rm H})]_{\rm solar}$, etc. Finally, the chemical abundance of N to O and N to C is shown as n(N)/n(O), and n(N)/n(C). The ratios $\eta_{\rm O}, \eta_{\rm C}, \eta_{\rm N}$ depend on the temperature assumed, although, as we have mentioned above, we believe that appropriate temperatures are $T_e \approx 10^4$ K. However, the ratios n(N)/n(O), n(N)/n(C) are insensitive to values of T_e assumed. We find that nitrogen is overabundant with respect to O and C by a factor of $\sim$ 3–7 in S63, and by large factors 70–150 in Sanduleak's star!

The most striking property of Sanduleak's star is the strength of the nitrogen lines. Such an effect has not been seen in any other galactic symbiotic stars. This leads us to believe that Sanduleak's star may not be a symbiotic star, a contention made stronger by the lack of evidence for a late-type stellar spectrum. We note,

TABLE 5
NEBULAR PARAMETER VALUES

T_e[a] (K)	n_e (cm^{-3})	L (cm)	$\eta_{\rm O}$	$\eta_{\rm C}$	$\eta_{\rm N}$	n(N)/n(O)	n(N)/n(C)
			Henize S63				
10^4	10^8	5×10^{14}	3.7[b]	1.9[c]	14.4	3.9[b]	7.5[c]
2×10^4 ...	10^7	3.1×10^{14}	2.6×10^{-2}[b]	1.3×10^{-2}[c]	8.2×10^{-2}	3.1[b]	6.3[c]
			Sanduleak's Star				
10^4	10^7	3.7×10^{15}	3[d]	≤ 1.3[e]	200	67[d]	≥ 154[e]
2×10^4 ...	10^6	2.2×10^{16}	2.5×10^{-2}[f]	$\le 7.5\times10^{-3}$[g]	0.8	32[f]	≥ 107[g]

[a] T_e is varied as a parameter; the other quantities then follow.
[b] For N(O I)+N(O II)+N(O V) ≈ 0.5.
[c] For N(C II)+N(C V) ≈ 0.5.
[d] For N(O III) ≈ 0.1.
[e] For N(C IV) ≈ 0.2.
[f] For N(O III) ≈ 0.25.
[g] For N(C IV) ≈ 0.25.

however, that this is the only example of a star showing λ6830 emission which is not demonstrably symbiotic (Allen 1980*b*). The spectrum of Sanduleak's star is remarkably similar to that of the S condensation in η Car observed with *IUE* (Davidson, Walborn, and Gull 1982). If this comparison is appropriate, it would indicate nitrogen enrichment from the CNO cycle is a clue to the evolutionary status of a massive star (see Maeder 1983), although the large overabundance of nitrogen may not entirely be explained by CNO enrichment alone (e.g., precipitation of carbon and oxygen onto grains). It is of interest to note that Renzini and Voli (1981) have investigated CNO abundances in asymptotic giant branch stars of 3–5 $M_\odot$. Following the second ignition of the He-burning shell, convective penetration of the helium core would enhance the surface abundance of nitrogen and helium due to convective dredge up, while depleting oxygen and carbon at the surface. If material is tidally drawn from the extended envelope of the late-type primary onto the hot secondary companion or onto an accretion disk, the ionization of this material that leads to the formation of the emission-line spectrum might then be reflected in the strength of the permitted and intercombination emission lines that are observed. The interesting emission properties of Sanduleak's star described here should form the basis for further investigation of this remarkable object. To our knowledge, Sanduleak's star provides the first direct evidence for nucleosynthesis in the LMC.

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