Astron. Astrophys. 153, 235–244 (1985)

ASTRONOMY AND ASTROPHYSICS

The 30 Doradus nebula

I. Spectral classification of 69 stars in the central cluster

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Received May 20, accepted July 29, 1985

Summary. Spectral types are given for 69 stars in and near the ionizing cluster of the 30 Doradus nebula. Out of the 60 stars classified within 25 pc of the cluster center, 49 are O stars, 12 are WR stars, 8 are B-supergiants, and one is an M-supergiant. At least 15 of the O stars have spectral types earlier than O6 and six have O3 types. These numbers, however, are somewhat uncertain because the spectral classification of early O stars in 30 Dor is difficult because of contamination by nebular lines.

The combined ionizing fluxes of the stars classified spectroscopically excluding R136a account for more than one half of the Lyman continuum photons required to explain the ionization of the 30 Doradus nebula.

The present observations argue strongly *against* the existence of a supermassive object in the core of the cluster (R136).

Key words: 30 Doradus – spectral classification – massive stars

1. Introduction

Giant extragalactic H II regions, (e.g. 30 Doradus in the LMC and NGC 604 in M33) are the best studied examples of violent star formation activity, whereby hundreds to thousands of massive stars are formed on time scales of only a few million years and in regions of space not larger than a few hundred parsecs (Melnick et al., 1985). Violent star formation activity appears to be the key to understanding a wide variety of previously poorly undertood astrophysical phenomena ranging from Blue Compact and Clumpy Irregular galaxies (Thuan, 1983; Heidmann, 1982 and references therein) to Star Burst and Seyfert nuclei (Balzano, 1983; Terlevich and Melnick, 1985 and references therein).

It is therefore very important to understand the physics of violent star formation activity and thus to investigate in detail the properties of the nearest violent star formation regions (VSFRs) such as the 30 Doradus nebula and the galactic VSFR NGC 3603. NGC 3603 has the advantage over 30 Dor of being closer and therefore better resolved but has the disadvantage of lying very close to the galactic plane and therefore of being heavily obscured by dust and contamined by foreground objects (Goss and Radhakrishnan, 1969). In addition, the distance to NGC 3603 is poorly known and its stellar distribution is significantly more compact and less rich in very massive stars than 30 Doradus (Melnick and Grosbøl, 1981; Moffat, 1983 and references therein). The 30 Dor nebula, on the other hand, is free of these shortcomings but suffers the well known resolution problem in its central region that has led several authors (Feitzinger et al., 1980; Cassinelli et al., 1981) to confuse the core of its ionizing cluster with one or more supermassive stars. Moreover, 30 Dor is closer in mass and luminosity to average VSFRs (Terlevich and Melnick, 1981) and should therefore provide a better comparison.

This paper, the first of a series of 3 dealing with the 30 Doradus nebula, presents spectral classifications for 69 stars located mostly within the central 25 pc of the ionising cluster (NGC 2070), but also including several stars in the periphery of the cluster. Specifically, this paper is devoted to the analysis of the complexities of carrying spectral classification inside the H II region, leaving most of the discussion for Paper II where the spectroscopy will be combined with *UBV* photometry of a complete sample of stars. Nevertheless, a few conclusions are presented here, dealing mostly with the age of the nebula and the evolutionary status of its ionizing stars.

2. Observations

The bulk of the observations presented here were obtained in January, 1983 with the RC Spectrograph of the CTIO 4 m telescope. The spectra were recorded with the Carnegie Image Tube camera on baked IIIa–J plates. The combination of the KPGL1 600 l/mm blue grating with a slit width of 160 μ, gave a resolution of about 3.5 Å (FWHM) at the plate center (λ4300 Å) and a spectral coverage of about 1400 Å. The spectra were widened to 1 mm by trailing the star in RA and the trailing speed was adjusted so that each star was exposed for 6–10 full trails. Contamination from adjacent stars in the crowded field of the cluster was minimized (though not always completely avoided) by using a moon-light eliminator. Spectral classification standards selected mostly from the lists by Walborn (1971–1973) and covering the spectral range from O3 to B1, luminosity classes I and V were also observed with the same set-up.

Sensitometric spots were recorded following standard procedures regarding plate selection and developing.

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The most serious difficulty in obtaining reliable spectral types for the stars in 30 Dor is contamination by nebular emission lines and in particular, by nebular He I λ4471 lines. In principle, by using linear detectors it should be possible to subtract the nebular component. With this in mind, a number of 30 Dor stars were observed in December, 1983 with the SIT Vidicon system attached to the Cassegrain spectrograph of the CTIO 1.5 m telescope. Here, an 800 l/mm grating and 200 μ slit were used giving a spectral coverage of about 1000 Å with a resolution of ~5 Å (FWHM). Since the resolution perpendicular to the slit that can be obtained with this system is only about 3″.5, these observation were restricted mostly to stars in the external part of the cluster, where the crowding is less severe but the emission lines are strongest. In fact, in the central regions of the cluster the nebular contamination is very weak and the He I λ4471 lines are not detected (Melnick, 1983).

Spectra of a few stars in the central regions were obtained on nights of exceptional seeing with the Intensified Reticon Scanner at the 2.5 m DuPont telescope at Las Campanas, during several observing runs devoted to other programs. These spectra cover the range from 3500 to 7000 Å and have a resolution of 4.5 Å.

3. Data reduction

3.1. Photographic spectra

Contamination by nebular continuum emission meant that in general the plates were dark and the stellar spectral features appeared very weak thus greatly hindering spectral classification by visual inspection. Consequently, the plates were digitized with the ESO PDS microdensitometer and converted to intensity using the spot sensitometry described above. The digitized spectra were collapsed to one-dimentional tracings by adding together the scan lines making no attempt to correct for *S*-distortion. Wavelength calibration was obtained by using the nebular emission lines for the program stars and the Balmer absorption lines for the standards.

3.2. SIT Vidicon spectra

From inspection of the 2-*D* Vidicon frames, it was determined that the intensity of the nebular lines varies significantly over scales of only a few arc-seconds. Since the spatial resolution of the Vidicon system at the CTIO 1.5 m telescope is of several arc-seconds, it was decided not to attempt to correct the stellar data for nebular contamination, but instead, to visualy refer to the 2-*D* frames to assess the importance of nebular emission line contamination. Thus, the spectra were reduced by simply coadding the relevant scan lines in each frame after correction for *S*-distortion. Generally, 2–3 frames of each star were obtained and added together to improve the signal-to-noise ratio. Wavelength calibration was obtained using observations of a He-Ar comparison lamp and the spectra were flux-calibrated via observations of standard stars.

3.3. Reticon data

As with the photographic and SIT Vidicon data, the Reticon spectra were resuced using standard procedures with the IHAP image processing package at ESO Garching. An important difference is that the Reticon data is 1-dimensional and gives no possibility to check the degree of nebular contamination.

4. Data analysis

It was found that in general, tracings of the photographic spectra were superior to the SIT Vidicon spectra for classification purposes. In part, this may be due to the fact that the Vidicon data were taken with a smaller telescope and in parts of the nebula where the gas emission was particularly strong but in general, the Vidicon data are of inferior quality than the photographic spectra. Table 1 presents the list of stars classified and a brief description of each spectrum. An identification chart for these stars is presented in Fig. 1. The criteria employed in the classification process are described below.

4.1. The O3 V and O4 V types

The single most important classification criterion for early O stars is the ratio of He II λ4541/He I λ4471 line intensities (Walborn, 1982a). Because the He I lines in 30 Dor stars are generally contamined by nebular features, the following supplementary criteria were adopted in the classification of O3 and O4 stars:

A star was classified as O3 V if the spectrum was dominated by He II lines (λλ4686, 4541, 4200, and 4026 Å) and when no He I lines were visible in the tracings. Reference was made to the original 2-dimensional spectra to check if absorption wings could be seen in the nebular He I λ4471 lines or if the nebular emission was present in the immediate vicinity of stars that showed no He I absorption features. The presence of the N V λλ4604–20 lines in absorption was also regarded as a high temperature indicator.

A star was classified as O4 V if any He I absorption feature was seen in the tracings or when the He II λ4200 feature was weaker, relative to He II λ4541, than in the O3 V standard stars.

Since these criteria are different from the standard used to classify O3–O4 stars (Walborn, 1982a) and also somewhat subjective, tracings of the spectra of all the stars classified O3 V and O4 V are presented in Figs. 2 and 3 together with relevant standard stars.

4.2. O5 V–O9 V stars

For these types, the wings of the He I λ4471 absorption lines could be seen even in the presence of moderately strong nebular contamination. The strengths of the He I λλ4388, 4713 lines were used as well as the wings of the λ4471 feature. Additional criteria for the later types were the presence of Mg II λ4481 and Si III λ4553,68 lines. Representative spectra are presented in Figs. 4 and 5.

It was found extremely difficult to classify O V stars in the regions were the nebular lines were strong. There, contamination by He I λ4471, [Fe III] λ4658 and Ar IV+He I λ4711–14 nebular lines as well as strong nebular continuum allowed only the He II λ4541 and λ4686 lines to be clearly visible in the tracings. These stars were classified as O(*n*) V with "best guess" (*n*) types in parentheses or simply as O (?) when no guesses could be made.

4.3. Supergiants

Virtually all stars of spectral types O9 and later were found to be supergiants. For these, the classification criteria followed closely the standard MK definitions making reference to the tracings of the standard stars observed as part of this program and to the atlas of Yamashita et al. (1977).

The classification of early O supergiants was again made difficult by nebular contamination. However, here it was possible

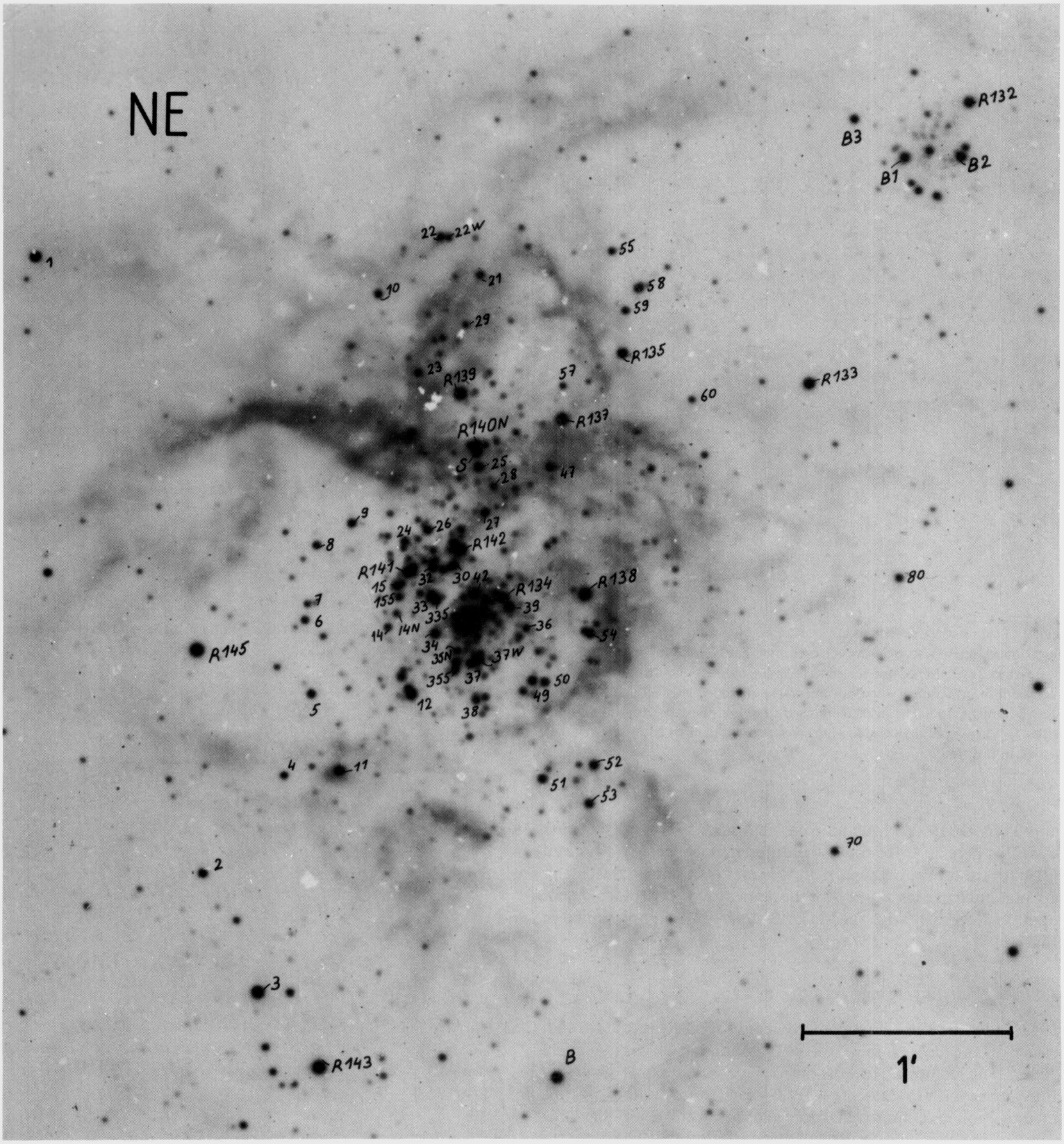

Fig. 1. Finding chart for the stars listed in Table 1. This photograph was made from a 3 min V-electronograph obtained by *P.* Grosbøl with the Danish 1.5 m telescope at La Silla and a 40 mm McMullan camera

to rely more heavily on the N V λλ4604–20 and the N III λλ4640–50 emission lines as secondary criteria. Thus, a star was classified as O3If when, in addition to no He I lines being present, the N III λλ4640–50 emission was not visible and when the He II λ4541 and N V λ4604–20 absorption lines were strong. A star was classified O4If or later if the He I and/or the N III λ4640–50 lines were visible.

There seems to be considerable overlap in the literature between Of stars and WN-A stars (see e.g. Walborn, 1982b) and, although in this paper Walborn's classification criteria have been followed as much as possible, there are some stars in 30 Dor that appear to be transition types between Of and WR. In particular, Walborn (1985, private communication) prefers to classify stars 42

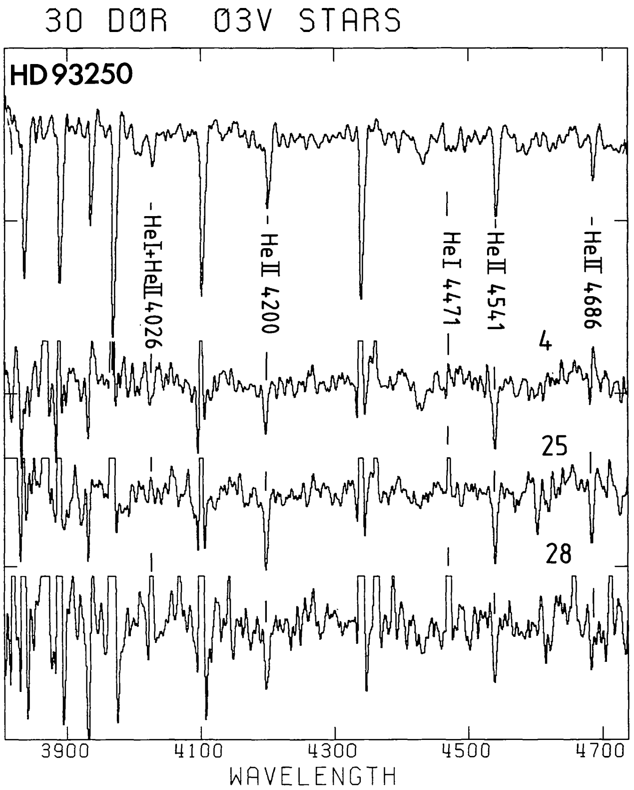

Fig. 2. Tracing of the spectra of O3 V stars in 30 Doradus. The intensity scale is linear but different and arbitrary for each star. The continuum of each star has been arbitrarily flattened and scaled to facilitate plotting and therefore contains no useful information. The spectrum of the standard star HD 93250 is also shown in this figure. The instrument used to obtain these spectra are given in Table 1. When more than one instrument was used, the first entry in Table 1 is shown in this figure

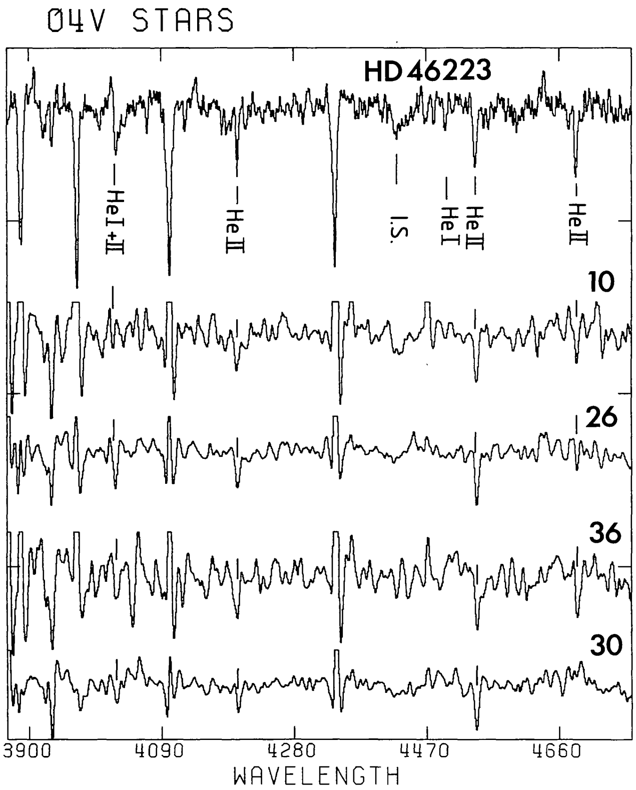

Fig. 3. O4 V stars in 30 Doradus. The continuum shapes and levels have been adjusted as described for Fig. 2

and 35 as O3If*/WN-A and to assign types WN-A to the stars classified here as O4If. Since the differences between WN-A and Of stars are subtle, tracings of all O3f and O4f stars in the cluster are presented in Figs. 6 and 7 for the reader to form an independent opinion. Representative spectra of B-supergiants are presented in Fig. 8.

4.4. *The Wolf-Rayet stars*

30 Doradus is known to contain many Wolf-Rayet stars and, clearly, is the ideal place to test WR evolutionary ideas (Melnick, 1982). The complete list of the 30 Dor WR stars is given by Breysacher (1981). No new WR stars were found in this investigation but improved spectral types were determined for some of the WR stars in Breysacher's catalog that had hitherto uncertain types. The classification criteria of Van der Hucht et al. (1981) were closely followed in this respect. Figure 9 presents tracings of four representative 30 Doratus WN stars.

The two known WC stars in 30 Dor (#33 MkE and R 140) are clearly multiple systems (cf. Fig. 1). Each of these "stars" is the composite of at least 4 stellar images. In the case of R 140, two of the components, separated by 1"5, are much brighter than the other two while, in #33, the components appear to consist of two pairs of comparable brightness also separated by about 1"5. An attempt was made to separate the components of the two WC "stars" by suitably aligning the spectrograph-slit to include only

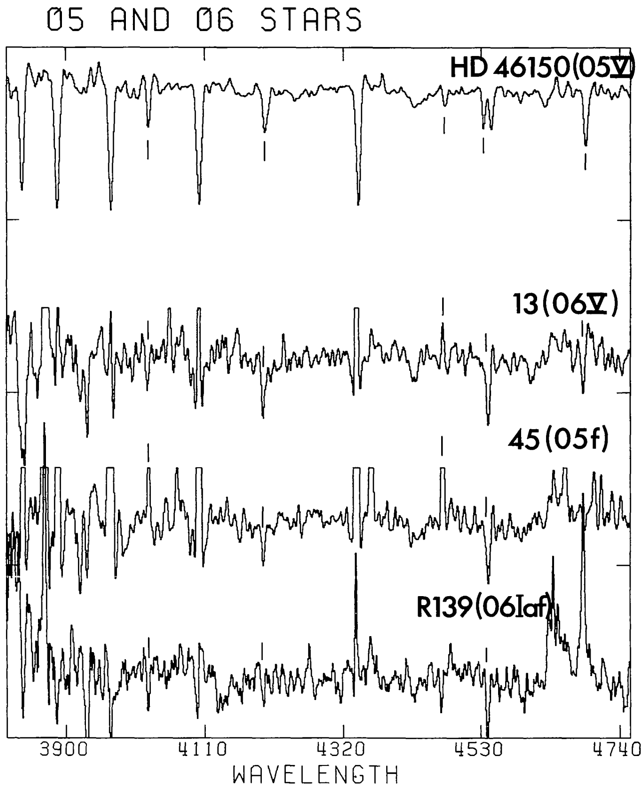

Fig. 4. Tracings of representative O5 and O6 stars in 30 Doradus. The continuum shapes and levels have been adjusted as described for Fig. 2

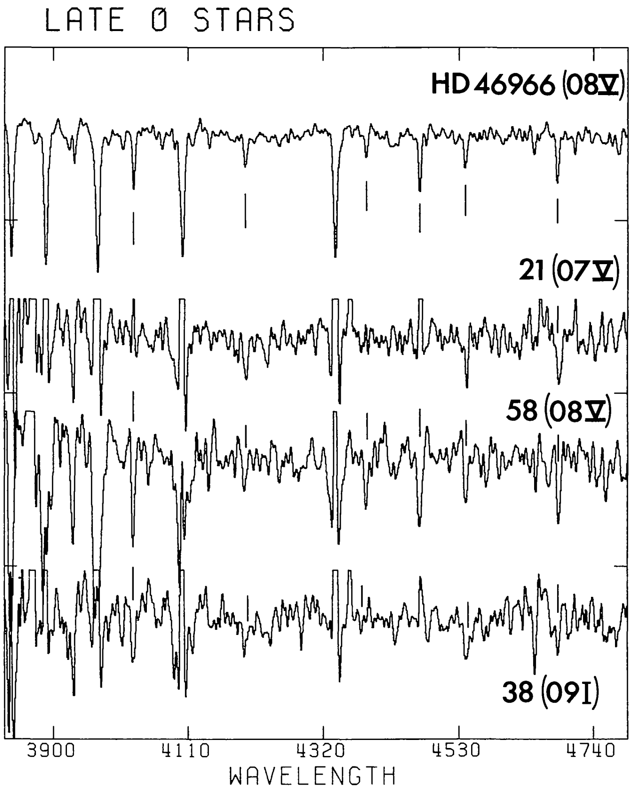

Fig. 5. Tracings of representative 30 Dor O stars of spectral types later than O6. The continuum shapes and levels have been adjusted as described for Fig. 2

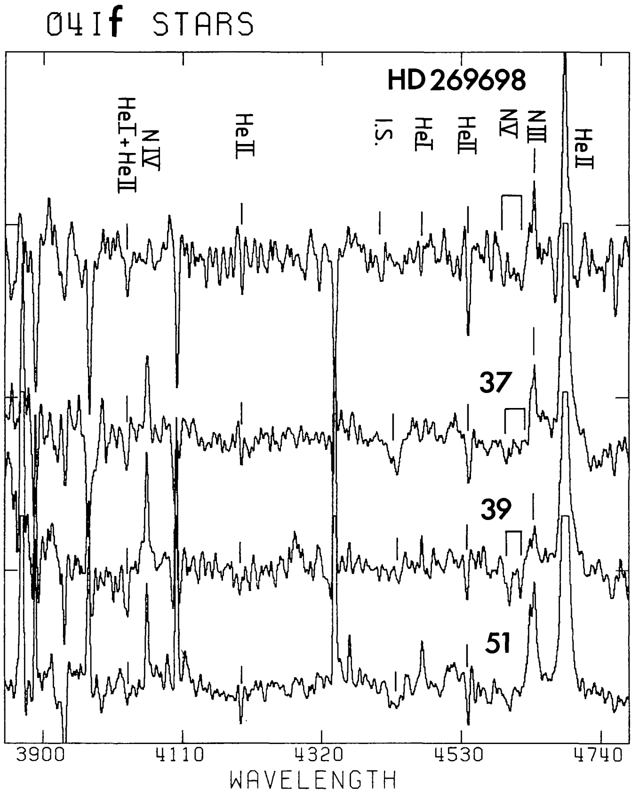

Fig. 7. O4 If stars in 30 Doradus. The continuum shapes and levels have been adjusted as described for Fig. 2

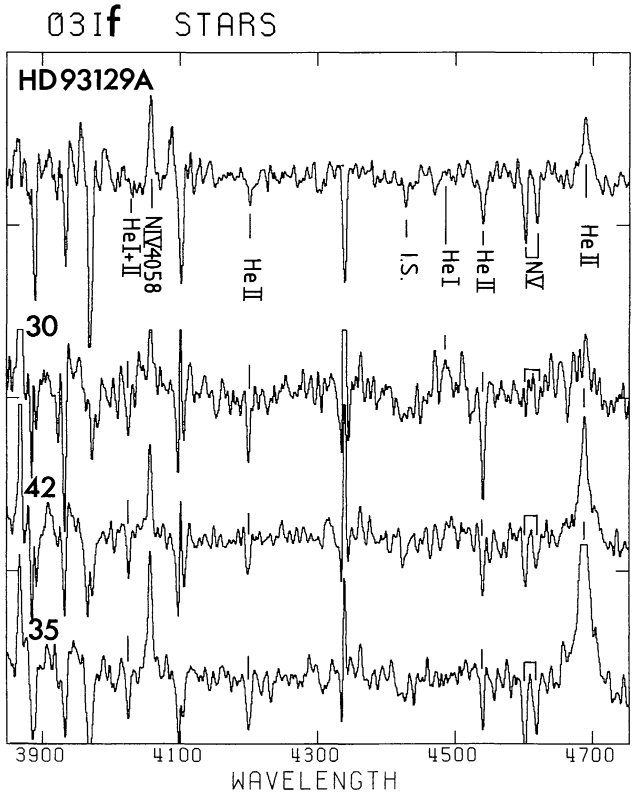

Fig. 6. O3 If stars in 30 Doradus. The continuum shapes and levels have been adjusted as described for Fig. 2

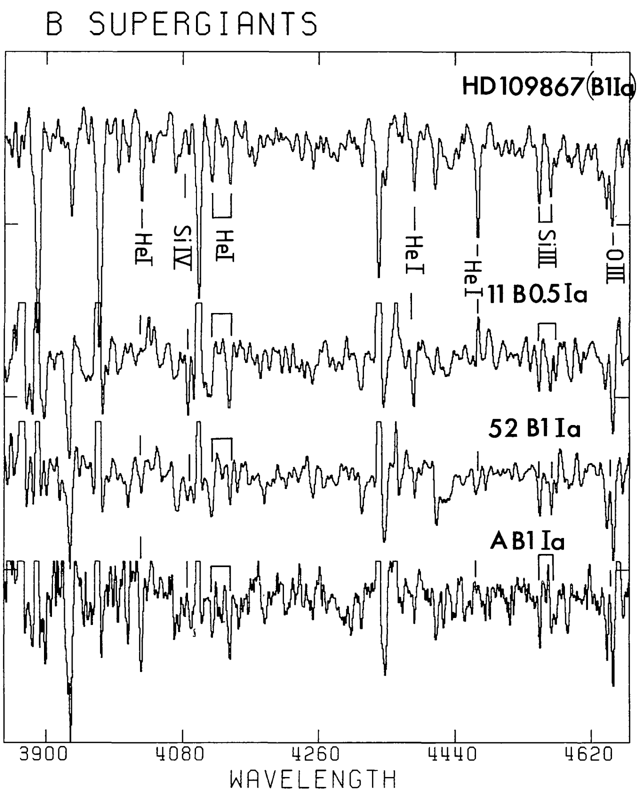

Fig. 8. Spectra of representative B supergiants in 30 Dor. The continuum shapes and levels have been adjusted as described for Fig. 2

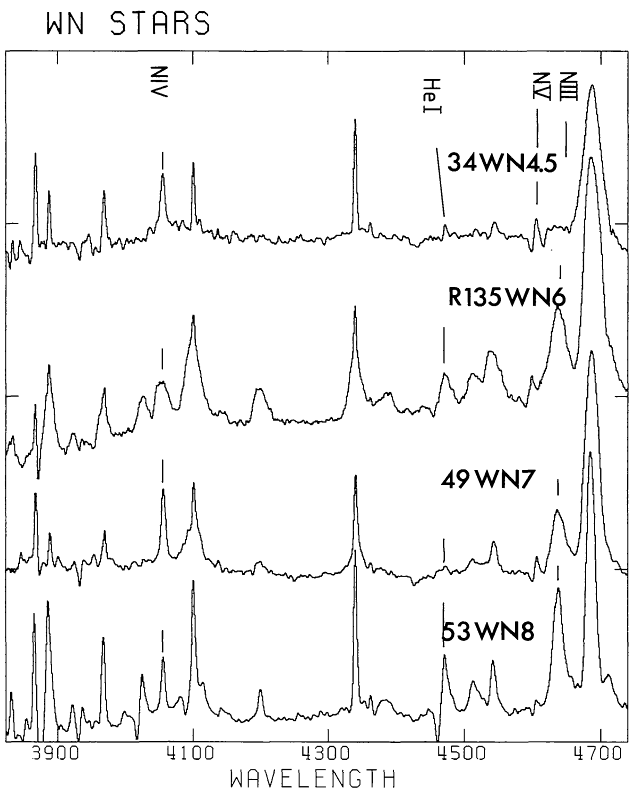

Fig. 9. Tracings of the spectra of representative WN stars in 30 Dor. The continuum shapes and levels have been adjusted as described for Fig. 2

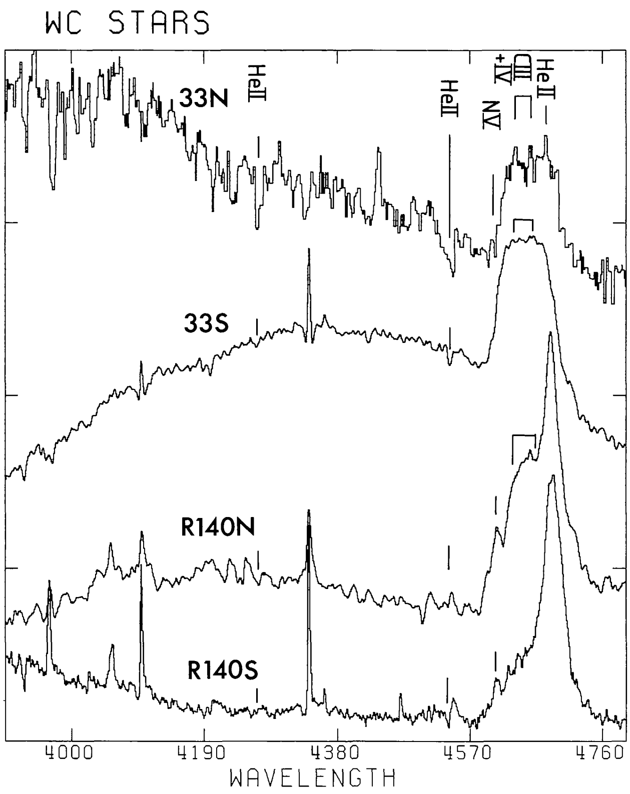

Fig. 10. Spectra of the two brightest components of the two WC "stars" in 30 Doradus. The WR features of #33 N are probably due to contamination from #33 S. Most of the absorption features in the spectrum of R140 N are not real but due to photographic contamination from an overexposed star in the same plate. The continuum shapes and levels have been adjusted as described for Fig. 2

one star (at CTIO) or by using a small aperture (1″ × 1″ at Las Campanas). Thus, several spectra were obtained of #33N, #33S and R140S but unfortunately only one (photographic) poor quality spectrum was obtained for R140N.

Figure 10 shows tracings of the spectra of the 4 components. The spectra of #33N and #33S look extremely similar most likely as the consequence of mutual contamination (either through atmospheric refraction or guiding). In both components the He II λ4541 and λ4200 absorption lines are quite intense while no He I λ4471 absorption nor emission is seen thus indicating an early O type. The continuum of #33N however, is significantly bluer than that of the southern component. Although the apparent difference in continuum slope and the similarity of the spectral features of the two components may be entirely due to contamination, on the basis of only the observed spectra star #33N was classified as O(4) while #33S was given the type WC5+O4 indicating that most likely #33 is the superposition of a WC5 star and at least two early O stars.

The brightest components of R140 are brighter than those of #33 and therefore easier to resolve. R140 has been classified as a mised WN+WC type (Breysacher, 1981; Phillips, 1981), and therefore assumed to be the superposition of one WN and one WC star. The spectra presented in Fig. 10 however, show that, while R140S is a probably a single WN4.5 star, the brightest component, R140N, has a mixed WN+WC type. As in the case of #33, R140N was observed typically at airmass 1.4 and contamination by R140S cannot be excluded. However, since this component is itself composite, the WC5+WN4 type given by Breysacher (1981) for R140 has been retained for R140N.

4.5. R136

Under good seeing conditions, R136, the core of the 30 Dor cluster, can be resolved into three distinct components named R136a, b and c by Feitzinger et al. (1980). Spectra of R136a and R136c obtained under excellent seing conditions with the SIT Vidicon by suitably rotating the spectrograph to avoid contamination by the other components are presented in Fig. 11. Several attemps were made at Las Campanas to obtain uncontamined spectra of R136b on nights of sub-arcsecond seeing but all are contamined by light from R136a and therefore the spectral type of R136b was not obtained. The following are the principal characteristics of the spectra of R136a and R136c:

4.5.1. R136a

Walborn (1977) gives a spectral type OB(n)+WN5−A(B) for R136a while Conti and Ebbets (1977) and Melnick (1983) classify it as WN4.5+OB. The spectrum presented in Fig. 11 support the latter classification although no single spectral type seems to fit the absorption component. It is interesting to note that the near infrared spectrum of R136a (Vreux et al., 1983) corresponds to an O3If type again showing the composite nature of this object. Spatially resoved spectra of R136a have been presented by Melnick (1983).

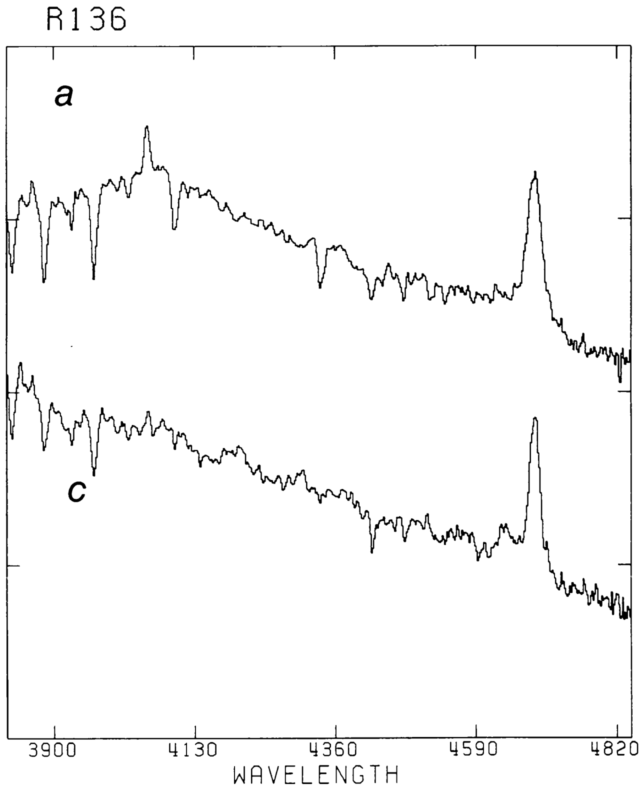

Fig. 11. Tracings of the spectra of the two of the three brightest components of R136. These spectra are flux calibrated but the continuum levels have been adjusted to facilitate plotting. Thus, the continuum slopes are the ones observed but may be significantly affected by differential refraction

4.5.2. R136c

The spectrum of this star appears to be a transition between Of and WR, showing strong N III λ4640,50 and N IV λ4058 in emission and N V λλ4604,20 in absorption. However since contamination cannot be excluded in R136, this component was classified as WN7+OB.

5. Discussion

Because a full discussion of the mass distribution of the cluster stars will be given in Paper II together with the *UBV* photometry, the present discussion will be restricted to some very simple statistical considerations.

The sample of 30 Dor stars classified spectroscopically is not complete to any well defined spectral type or apparent magnitude. The stars were arbitrarily selected to be the basis of the photometric study of the cluster (Paper II), and thus only to cover an adequate number of stars. We remark, however, that most of these stars lie within 25 pc of the cluster center and, given their spectral types, are most likely cluster members.

5.1. The O stars

Two thirds of the stars classified in the central 25 pc of the luster are O stars. Presumably other regions of recent star formation in the LMC contaon similar proportions of O stars and this must be considered in any statistical study of the stellar content of the LMC.

Within the uncertainties stressed in Sect. 4.1, out of the 40 O stars, six were found to have O3 types while only two O3 stars were previously known in the LMC and only eight are known in the Galaxy. This confirms early statements about the importance of 30 Dor as a laboratory for stellar evolution (Melnick, 1982).

5.2. The evolutionary status of the ionizing cluster

The presence of late-type supergiants in 30 Doradus has led McGregor and Hyland (1981, and references therein) to conclude that at least two star formation events have taken place in 30 Doradus over the past 10–20 Myr. However, if one looks at the spatial distribution of supergiant stars in the 30 Doradus region, one finds that the late-type supergiants (and also the A and B supergiants) appear to be randomly scattered in the region showing no concentration towards the center of the cluster. This gives the general impression that quiescent (i.e. non-violent) star formation activity has taken place in the 30 Dor region (say within a few hundred parsecs of R136) over the past 10 or 20 million years and that the violent star formation event that gave birth to the nebula and its ionizing cluster was a single event that occurred only a few million years ago. The lack of O5–O8 supergiants in the cluster suggests that the age of the cluster is only about 2 million years.

There are a number of questions regarding the evolutionary status of the most luminous cluster stars that should be addressed in 30 Doradus; What are the masses of the WR stars? Are some of the O3If and O4If stars transition Of–WR types? Has star formation propagated inwards in NGC 2070?

A detailed discussion of these important topics is beyond the scope of the present paper and will be presented in Paper II.

5.3. R136

The core of the 30 Dor cluster, R136, and its brightest component, R136a, have been the subject of intense research in recent years owing to the claim that it was (or contained) a supermassive star (Feitzinger et al., 1980; Cassinelli et al., 1981; Massey and Hutchings, 1983). Even today, when it is known that R136a is resolved into several components, some authors continue to claim that R136a may contain a supermassive star (Savage et al., 1983). These claims are essentially based on the following two assumptions:

a) R136 is a point source in the UV (i.e. in the IUE spectral range) and,

b) the brightest component or R136a in the optical, R136a$_1$, is also the brightest component in the UV.

The observations presented in this paper, however, indicate than both assumptions are probably wrong. Firstly, the observation of several extremely bright O3 and O4 stars with a marked concentration towards the cluster core (R136) strongly suggest that R136 must contain more of these stars. Thus, if anything, the only reasonable a-priori assumption that can be made about the ultraviolet light distribution in the central 3″ of R136 (the spatial resolution the IUE) is that it is not a point source.

Secondly, while the optical spectral type of R136a is WN4.5 +OB, the UV (and also the near IR) type is closer to O3Iaf indicating that the components that dominate the optical luminosity of R136a are probably different from the stars that emit most of the UV and near IR radiation.

As consequence of these two a priori assumptions being erroneous, it follows that: a) the UV luminosity they derive for R136a is overestimated by a factor of 2 (Melnick, 1983), and b), that optical and UV observations cannot be combined in any

Table 1. Spectral types for stars in 30 Doradus. Notes: Published spectral types are quoted in parentheses. The key to these references is: *Br* = Breysacher (1981); *CCW* = Chu et al. (1984); *Co* = Conti (1982); *Mk* = Melnick (1978); *Ph* = Phillips (1981); *R* = Feast et al. (1960); *Wa* = Walborn (1984)

30 Dor	Sp. type	Instrument	Notes
1	B1Ia	IT	Beyond 25 pc from the cluster center (R136)
3	KOV	IT	Foreground star
4	O3V(f)	IT	Weak N III in emission
5	O9.5V pec.	IT	Binary?
6	O(7)V	VID	
7	O(7)V	VID	
8	O(?)V	VID	
9	MI	IT	McGregor and Hyland (1981) star IR 18
10	O4V	IT	Strong nebular He I
11	B0.5Ia	IT	
12	B0.5Ia	VID	
13	O6V	IT	Strong neb. He I
14	O(5)	RET	
14N	O(?)V	VID	
15	O7V	IT	
15S	O4V	VID, RET	Weak neb. He I
21	O7V	IT	Strong neb. He I
22	O(?)	VID	Very strong neb. He I
22W	Of	VID	Very strong neb. He I; He II 4686 in em.
23	O(?)V	VID	Very strong neb. He I
24	O7V	VID	
25	O3V	IT	
26	O4V(f)	IT	N III in em.; N V in abs.; He II 4686 in abs.
28	O4V	IT, VID	Strong neb.
30	O3If	IT, VID	
33N	O(4)	VID, RET	*Mk*E (WN6); *Ph* (WC4 – 5);
33S	WC5+O4	IT, VID, RET	Probable contamination
34	WN4.5	IT, RET	*Mk*C (WN+OB); *Br* #84; *Co* (WN4.5);
35	O3If	IT, VID	
35N	O(7)V	VID	Very strong neb.
35S	O(5)V	VID	Very strong neb.
36	O4V	IT	Weak neb. He I
37	O4If	IT, VID	*Mk*A (WN7); *Br* #78; *Ph* (WN7); *Co* (Of);
37W	WN7:	RET	Likely contamination from 37.
38	O9I	IT	
39	O4If	IT	Weak neb. but no abs. wings
42	O3If	IT, RET	*Mk*G (WN+OB); *Br* #77;
47	O5If	IT	Strong neb. type may be earlier
49	WN7	IT	*Mk*J (WN5); *Br* #79 (WN6); *Co* (WN6)
50	O9.5I	VID	Weak nebular He I 4471
51	O4If	IT	
52	B1Ia	IT	
53	WN8	IT	*Br* #81 (WN8)
54	B0.5Ia	IT	
55	O5(f)	RET, VID	N IV in emission
58	O8V	IT	
59	O(?)V	VID	
60	B0I	VID	
80	O9.5I	IT	
B	A0Ia	VID	
R133	O7pec	IT	Binary? *R* (O8); *Wa* (O7:)
R134	WN7	IT, RET	*R* (WN7); *Mk* (WN5); *Br* #75 (WN6); *Co* (WN6)

Table 1 (continued)

30 Dor	Sp. type	Instrument	Notes
R135	WN6	IT, RET	*R*(WN7); *Br* #80 (WN7); *Co* (WN7)
R136a	WN4.5+OB	VID, RET	*R*(O+WN); see text for other references
R136c	WN7+OB	VID, RET	*CCW*(WR)
R137	B1Ia	VID	*R*(B0.5Ia); *Wa*(B0.7−1.5)
R138	A0Ia	IT	*R*(A0I:); *Wa*(A0I:)
R139	O6Iaf	IT, RET	*R*(WN7+O); *Br* #86; *Co*(Of); *Wa*(O6−7Iaf)
R140N	WC5+WN4	IT	for N and S together: *R*(WN6); *Mk*(WN6);
R140S	WN4.5	IT, VID, RET	*Br* #87 (WC5+WN4); *Ph*(WC4−5 pec+WN7)
R142	B0Ia	IT	*R*(B); *Wa*(B0.5−0.7I)
R143	F71a	IT	*R*(F7Ia)
R145	WN6	IT	*R*(WN6−7); *Br* #90 (WN7); *Ph*(WN6); *Co*(WN6)
Stars in the NW clump			
R132	B0.5Ia	VID	*R*(B−A)
B1	A0Ib	VID	
B2	AIb	VID	
B3	A5Ib	VID	

simple way to derive the bolometric luminosity of the optically brightest component (R136a_1).

Without including aperture corrections, the IUE observations give a UV luminosity for the central 3″ of R136 equivalent to six times the luminosity of the most luminous O star in the LMC, R122 (Savage et al., 1983; Chu et al., 1984). Since 30 Dor contains O stars at least as luminous as R122 (Melnick, 1983, Paper II) this number is an upper limit to the number of 30 Dor-like O-supergiants that might be present in the core of the cluster, and coincides with the number one would expect on the basis of the stellar population in the immediate vicinity of R136 (Melnick, 1983).

5.4. *The integrated ionizing flux of NGC 2070*

A lower limit for the ionizing flux of NGC 2070 can be obtained from the data in Table 1. Adopting the Lyman continuum fluxes tabulated by Panagia (1973) for stars later than O3, the values given by Walborn (1984) for O3 and late WR stars, and assuming that early WN's and WC's emit the same ionizing radiation as O3I stars, the Lyman continuum radiation of the stars included in Table 1 is approximately 3 10^{51} phot/s close to the value obtained by Walborn (1984) from the analysis of photometry of the brightest stars in the cluster. Thus, without even considering R136a, the stars in NGC 2070 provide at least half of the $\sim$5 10^{51} ionizations/s required to explain the ionization of the 30 Doradus nebula (Mills et al., 1978; McGee et al., 1972). Adding the equivalent of 6 O3If stars to take into account the contribution from R136a raises the ionising flux from the cluster to 4.5 10^{51} phot/s, very close to the value required by the observations of the nebular gas.

6. Epilogue

The central cluster of the giant 30 Doradus nebula contains enough hot luminous stars to provide the Lyman continuum photons required to explain the ionization of the H II region and there is no need for the presence of an exotic object in the core of the cluster to explain the ionization of the nebula nor any observational property of its ionizing cluster.

30 Doradus, however, is a unique celestial laboratory and detailed observations of stars in its central cluster may provide crucial information on how massive stars are formed and evolve.

Acknowledgements. It is a pleasure to thank Nolan Walborn for sharing with the some of his art of spectral classification and for many discussions regarding the 30 Doradus stars. I also wish to thank Phil Massey for his help during the initial stages of this project and Peter Conti for his advice on the classification of WR stars.

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