

*HUBBLE SPACE TELESCOPE PLANETARY CAMERA IMAGES OF R136*¹

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Received 14 May 1992; revised 24 July 1992

ABSTRACT

The Planetary Camera of the *Hubble Space Telescope* has been used to obtain broad and narrowband images of R136, the core of the massive star cluster 30 Doradus in the Large Magellanic Cloud. R136a, the brightest component of R136, is shown to have at least 12 separate components, including the eight originally identified by speckle interferometry. Three of the 12 components are previously unidentified close companions of the speckle components. The stars within R136a are found to have luminosities and colors of normal evolved (Wolf-Rayet and blue supergiants) and zero-age main-sequence (ZAMS) massive stars. A narrowband He II filter was used to investigate the Wolf-Rayet stellar population. We find that three stars in R136a are of the Wolf-Rayet type; of the two identified from ground-based data, one is now resolved into two components. We present color-magnitude diagrams and a luminosity function of the stars within the larger region (~ 2 pc) defined as R136. We find that the stars in R136 are similar in color and luminosity to those of cluster members that lie outside that crowded inner region. The lower end of the color-magnitude diagram corresponds to ZAMS spectral type B3. No red supergiants have been detected within R136. The luminosity per unit area in the inner $1''$ (0.25 pc) of R136 is ≥ 50 times that of the center of Orion for a comparable area and seven times that of the core of NGC 3603. The luminosity per unit area of all of R136 is comparable to that of Orion but is sustained over 130 times the area. An F336W surface brightness profile is constructed for R136 based on the stellar photometry. The distribution is found to be consistent with a pure power law with $I(r) \propto r^\gamma$ with $\gamma = -1.72 \pm 0.06$ or with a small core with $r_c < 0.25''$, considerably smaller than predicted from ground-based observations. In the latter case $\rho_0 > 5 \times 10^4 \mathcal{M}_\odot \text{pc}^{-3}$. The implied upper limit on the relaxation time for the cluster is much smaller than the age of 3.5×10^6 yrs required by the presence of Wolf-Rayet stars. This suggests that relaxation effects have been very important in determining the observed structure of the cluster unless a large population of lower mass stars is also present.

1. INTRODUCTION

The 30 Doradus Nebula in the Large Magellanic Cloud (LMC) is a spectacular example of a supergiant H II region, near enough and sufficiently free of Galactic reddening so that most of the stellar constituents of the inner core can be resolved. Fully one quarter of the total massive star formation of the LMC is contained in a 15' radius around 30 Doradus (Kennicutt 1991). The central region of the nebula is dominated by the cluster NGC 2070, which itself contains numerous very tight clusters of extremely massive OB stars and an unusually rich grouping of Wolf-Rayet stars, most of which are classified WN from the emission lines of highly ionized nitrogen appearing in their optical spectra. The most luminous of the 30 Doradus clusters in R136 (HD 38268), whose brightest component R136a has a spectral identification of O3If in both the UV and near-infrared, and WN4.5-5+OB(n) in the optical (Melnick 1985). This component was once believed to be a single star with a mass $> 10^3 M_{\odot}$ (Cassinelli *et al.* 1981). This suggestion was based in part on the pointlike appearance of R136a in the optical end and UV ($< 3''$) and on the perceived difficulty of having as many as 30 O3 stars within a < 1 pc region as required to match the observed luminosity and inferred ionization (Savage *et al.* 1983).

Speckle interferometric observations (Weigelt & Baier 1985; Neri & Grewing 1988) and later *Hubble Space Telescope* (HST) Faint Object Camera images (Weigelt *et al.* 1991) resolved R136a into a minimum of eight components (R136a1-a8), all within 1'', but spectral classifications for these individual objects have not as yet been made. The extreme core concentration of very early-type stars around R136a, however, along with features in R136a's composite spectrum, make it likely that the non-Wolf-Rayet components in R136a itself are at least as early as O5. In addition to the apparent extreme density of early-type stars, the difficulty which originally drove the super-massive star interpretation was the apparent deficit in ionizing radiation for the nebula as a whole. This has been addressed more recently by Melnick (1985) and Moffat *et al.* (1985) who show that the early O and Wolf-Rayet stars within 2'-3' of the R136a core (but excluding R136a itself) can easily account for half the nebular ionization, requiring that as few as six early O stars be present in R136a.

The extreme concentration of very high mass ($> 20 M_{\odot}$) stars make the core of 30 Doradus a useful laboratory for massive star formation. In addition the large numbers of Wolf-Rayet and early-O spectra types in and surrounding R136 form a unique case study of the role played by Wolf-Rayet stars in massive stellar evolution. Observations which could define the luminosity (and, by inference, the mass) function in and around the core of 30 Doradus

TABLE 1. The HST PC observations.

date	filter	No. images	Exposure Time (s)	HST Image Name
8/25/90	F368M	5	40300, 10150	w0ce0102B
8/25/90	F547M	5	50100	w0ce0107B
4/12/91	F336W	1	80	w0ia0104t
4/12/91	F469N	1	140	w0ia0103t
4/11/91	F555W	1	16	w0ia0101t
4/12/91	F702W	1	26	w0ia0102t

have heretofore been limited by dynamic range of detecting faint stars and by crowding among the very brightest stars.

Therefore, in order to examine the stellar content of the heart of this extraordinary star cluster, we obtained images of R136 with the HST Planetary Camera (PC), which has a pixel scale of 0.044''. Although photometry of individual stars is compromised by the spherical aberration of the primary mirror of the telescope, the high resolution allowed by the sharp core of the point spread function enables one to identify stellar components to an extent not attainable from the ground. Furthermore, stellar photometry is possible, although the uncertainties are larger than they otherwise would have been without aberration. Early images of R136 were obtained through filters F368M and F547M, and a later set of observations were made with filters F336W, F555W, F702W, and F469N. Photometry of stars on the broadband images is used below to construct a color-magnitude diagram and luminosity function. The F469N filter is a narrowband filter that passes the emission-line He II $\lambda 4686$, which is a characteristic of Wolf-Rayet stars. Therefore, the F469N image is used below to identify Wolf-Rayet stars. We take the distance modulus to the LMC to be -18.6 and the total reddening to 30 Doradus to be $E(B-V) = 0.34$ (Fitzpatrick & Savage 1984).

2. OBSERVATIONS

2.1 Data Obtained in 1990

HST PC observations of 30 Doradus were taken as part of an evaluative program instituted shortly after the discovery of spherical aberration in the primary mirror. The core of the cluster was placed in the 800×800 CCD known as PC6 on 25 August 1990. [Details about the instrument can be found in Griffiths (1989)]. Observations were made through filters F368M and F547M. Although later data taken after UV-flooding and better calibration were used for the stellar photometry presented in this paper (see Sec. 2.2), we use the summed F368M image to illustrate the morphology of the stellar content and distribution. The F368M image is of higher signal-to-noise than the F336W image taken later, and it is on this image that we tried deconvolution. The F547M data also obtained, calibrated, and analyzed in 1990 are not presented here. The observations are listed in Table I.

Five exposures were made through filter F368M over two orbits: four at 300 s each and one at 150 s. The multiple exposures were aligned (each shifted by less than 0.2 pixels) with a sinc interpolation, cosmic rays were flagged and removed, and the images were summed. Flat-fielding was problematical due to the lack of on-orbit flats for

¹Based on observations with the NASA/ESA Hubble Space Telescope, obtained at the Space Telescope Science Institute, which is operated by AURA, Inc., under NASA contract NAS 5-26555.

²The National Optical Astronomy Observatories are operated by the Association of Universities for Research in Astronomy, Inc., under a cooperative agreement with the National Science Foundation.

F368M and the fact that the detector had not been UV-flooded. A flat obtained during prelaunch thermal vacuum tests in filter F336W was used, and it provided a relatively clean response correction, with excess noise apparent only in the extreme corners of each F368M frame.

In Fig. 1 (Plate 114) one can see the F368M image of the entire PC6 field and of the cluster center. Figure 2 (Plate 115) shows the F368M image displayed to show the individual stars in R136a. The first eight stars are numbered in the same way that Weigelt & Baier (1985) numbered the speckle components. The rest of the stars continue this numbering scheme. The results of deconvolution of the cluster region, using the method of Lucy (1974) with 100 iterations, are also shown in Fig. 2. The deconvolution produced no stellar features which are not already visible in the original images.

2.2 Data Obtained in 1991

PC images of R136 were obtained on 11 and 12 April 1991 through broadband filters F336W, F555W, and F702W and through the narrowband filter F469N. Exposure times were 80, 16, 26, and 140 s, respectively. The observations are listed in Table I. R136 itself as placed near the center of PC6; other stars near the center of 30 Doradus fell on chips PC5, 7, and 8 as well. The images were corrected for A–D conversion errors, preflash, bias, and dark current. On-orbit streak flats collected from January to April 1991 were used to flat-field the CCD's. The streak flats had many problems, but they did a reasonable job of removing pixel-to-pixel and chip-to-chip variations. However, flat-fielding problems are another major limitation on the quality of the photometry (see WF/PC Investigation Definition Team 1992). The field of view of the PC (all four CCD's) is outlined in Fig. 3 (Plate 116) on a ground-based *V*-band image of this region kindly loaned to the WF/PC team. In Fig. 4 is displayed a mosaic of the four CCD images in filter F555W.

Measurements of the brightnesses of the stars in the broadband filters were made using the crowded-field photometry package DAOPHOT (Stetson 1987). The point spread function (PSF) varies significantly across the field of view of a PC chip. Because the PSF must be determined from stars outside the core of the cluster, the variable PSF is another fundamental limitation on the accuracy of the photometry of the stars in R136. A third difficulty comes from the extended halos of the stars; the measurable PSF extends to ~ 60 pixels in radius.

In addition to wreaking havoc with photometric determinations, the tendrils of the stellar halos often lead automatic routines for finding stars to falsely identify knots in the tendrils as stars. Therefore, in order to produce a clean list of stars, we examined the stars in the original coordinate list by eye to verify their reality on the F702W and F555W images. We retained only stars that appeared in the photometry lists of both frames. We also modified a parameter in DAOPHOT so that during the fitting procedure it would be more difficult for stars to be eliminated than in

the standard software. Furthermore, for the dozen stars in the very core of R136, we made it even more difficult for DAOPHOT to toss out a star. Even so, however, star number 9 (see below) was not retained in the fitting procedure of F336W.

The DAOPHOT software returns several measures of the uncertainty of the photometry and goodness of fit. These parameters were used to eliminate objects as well. In particular stars with $\sigma > 0.6$ were deleted from the photometry lists. This has the desired effect of eliminating cosmic rays and dubious star detections although it also eliminates legitimate stars at the faint end.

Because this clean star list was compiled essentially “by hand,” it was not feasible to estimate the incompleteness of this list. To try to get a better estimate of the luminosity function, we created another star list entirely automatically, but not searching as faint in the frame. This avoided most of the problems with spurious detections. For the automatic list, we still required that objects be detected on both the F555W and F702W frames. We used the automatic technique to estimate completeness corrections as discussed below in the section on the luminosity function (Sec. 3.3).

The photometric zero points for F336W and F555W were taken from observations of the HST standard star field in Omega Cen on 2 April 1991. Since the dates of the R136 and Omega Cen observations are fairly close, the apparent zero point automatically corrects for any contamination in the optical path. This contamination increases with time after the CCD's are cooled and has the effect of decreasing the effective quantum efficiency. This is especially noticeable in the ultraviolet, where the zero point can change by tenths of a magnitude over time (see WF/PC Investigation Definition Team 1992). For F702W the 3 January 1991 measurement of the zero point was used and corrected by 0.01 mag to allow for the contamination over the intervening three months to the R136 observations.

Note that, although the broadband filters are analogs to the Johnson–Cousins UVR filters, they are not identical. Thus, the magnitudes quoted below are on the WF/PC filter system which is close to, but not equal to, the Johnson–Cousins magnitudes. We have included a zero point, as described above, that ties the flight magnitudes to those of the ground-based system, but we have not included any color term. Note also that the transformations to the Johnson system given by Harris *et al.* (1991) do not apply to stars as blue as O and B stars and that intrinsic colors of massive stars in the WF/PC filter system are not currently known. In fact, to our knowledge, this is the first study of massive stars through WF/PC filters. We expect, however, that F555W is fairly close, i.e., within our photometric uncertainties, to a *V* magnitude, and we will use it as an approximate *V* magnitude in computing luminosities below.

The stars were sorted into those within R136 and those outside. R136 is defined as a box $7.3'' \times 8.7''$ which very roughly approximates the ground-based definition of R136. In R136 we measured 214 stars. Outside of R136 we measured 800 stars on the four CCD's. The photometry for

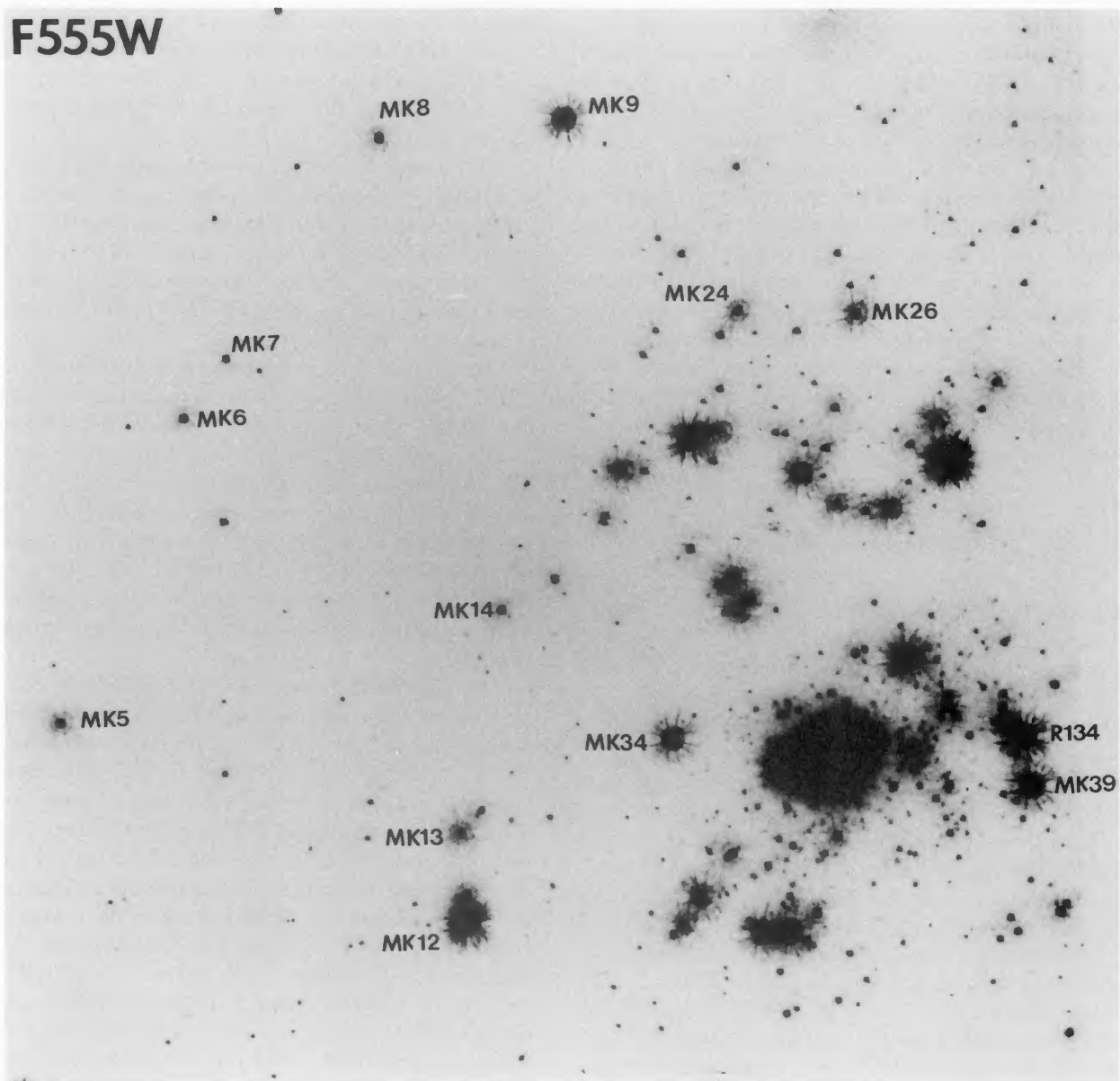


FIG. 4. A mosaic of the four PC CCD images is shown for the F555W filter. Stars not identified in Fig. 1 are identified here. Note that the individual PC images have been variously rotated in order to match the orientation on the sky.

stars in the box defined as R136 is presented in Table 2. Photometry for the rest of the stars is given in Tables 3 through 6, where the star number begins with a 5, 6, 7 or 8 to identify it as being found on PC5, PC6, PC7, or PC8, respectively. Figure 5 shows the uncertainty in the magnitudes as a function of magnitude for the F555W filter. Naturally, photometry of the more crowded R136 stars is more uncertain than that of stars outside R136 at a given magnitude level. However, the photometric uncertainties given by DAOPHOT and shown in the figure are undoubtedly an underestimate of the true uncertainties. Other sources of uncertainty include the zero point (~ 0.05 mag) and the flat fielding (~ 0.08 mag; see WF/PC Investigation Definition Team 1992).

The x, y positions given in Tables 2–6 are the original pixel coordinates on the F702W frame. That is, the origin

0,0 of each chip is the pyramid corner of the Planetary Camera. Figure 3 shows the orientation of the field of view with respect to the sky. The center of the box outlined in Fig. 3 corresponds to the coordinate of the chip pixel given in Tables 2–6 that is both outside the pyramid overlap region and closest to the 0,0 coordinate of each chip. The box in Fig. 3 has a position angle of 25° , with PC5 to the lower left and PC's 6, 7, 8 following counterclockwise. In Table 7 a match is made between star number and alternate designations in the literature. These stars are also identified on Figs. 1 and 4 and can be used to orient the coordinate system of the tables with respect to known stars.

A 140 s image of R136 was also obtained through the narrowband filter F469N. This filter is useful for isolating the stellar emission-line feature He II $\lambda 4686$ that is characteristic of Wolf-Rayet stars. The stellar continuum also

TABLE 2. Photometry of stars in R136.

(a)													
ID	x	y	F555W	σ	336-555	555-702	ID	x	y	F555W	σ	336-555	555-702
1	346.4	466.1	12.78	0.10	-1.46	0.58	41	313.8	484.0	14.59	0.06	-1.02	0.22
2	344.3	464.2	13.09	0.10	-0.89	0.40	42	362.6	382.3	14.60	0.04	-0.59	0.41
3	356.5	469.1	12.87	0.04	-0.80	0.31	43	375.0	437.6	14.61	0.08	-1.00	0.26
4	342.3	474.3	13.56	0.07	-0.85	0.16	44	352.7	442.9	14.70	0.07	-0.87	0.18
5	340.4	463.4	13.73	0.07	-0.66	0.21	45	293.1	456.2	14.79	0.05	-0.87	0.25
6	361.2	472.2	14.06	0.12	-0.78	0.35	46	349.0	443.9	14.90	0.08	-0.74	0.13
7	338.3	467.2	13.78	0.06	-0.85	0.23	47	387.3	448.5	14.91	0.06	-0.95	0.19
8	341.3	472.6	14.28	0.11	-1.20	0.25	48	280.8	388.2	14.92	0.03	-0.80	0.23
9	345.7	467.5	12.85	0.10	—	0.00	49	366.4	446.0	14.95	0.07	-0.80	0.26
10	354.1	472.0	14.51	0.10	-1.05	0.25	50	335.3	499.1	14.98	0.10	-0.74	0.09
11	360.1	473.3	13.58	0.09	-0.84	0.23	51	332.6	497.8	15.00	0.08	-1.32	0.08
12	335.9	469.1	14.68	0.10	-0.72	0.08	52	359.9	440.8	15.01	0.10	-0.86	0.21
13	338.2	477.2	13.92	0.06	-1.01	0.33	53	336.8	445.0	15.08	0.11	-0.90	0.04
14	350.6	482.3	15.18	0.07	-0.72	0.10	54	388.4	431.9	15.14	0.11	-0.95	0.10
15	353.5	458.2	15.06	0.09	-1.17	0.24	55	376.2	448.8	15.14	0.11	-0.84	0.19
16	360.1	461.9	14.72	0.07	-0.79	0.14	56	301.3	527.3	15.19	0.05	-1.10	0.18
17	365.4	464.5	15.12	0.09	-0.94	0.16	57	386.0	465.0	15.25	0.09	-1.11	0.14
18	361.8	458.6	15.95	0.17	-1.03	0.31	58	385.4	430.1	15.29	0.09	-0.92	0.21
19	335.5	458.6	14.66	0.06	-0.80	0.22	59	396.1	471.1	15.36	0.08	-1.00	0.05
20	332.7	463.0	14.58	0.07	-0.84	0.02	60	324.5	457.2	15.38	0.09	-0.93	0.23
21	357.3	484.2	15.05	0.06	-0.76	0.09	61	380.8	476.7	15.41	0.09	-1.08	-0.05
22	362.8	464.9	15.36	0.14	-0.75	-0.24	62	323.1	434.0	15.41	0.16	-0.87	0.16
23	339.7	484.3	14.15	0.05	-1.04	0.22	63	323.1	489.2	15.47	0.12	-1.20	0.18
24	335.5	486.5	15.20	0.08	-1.04	0.28	64	331.8	507.1	15.49	0.09	-0.99	0.14
25	359.9	392.0	12.86	0.05	-0.53	0.43	65	329.2	492.1	15.53	0.10	-0.90	0.34
26	346.6	419.3	13.03	0.04	-0.71	0.36	66	390.0	455.2	15.53	0.09	-0.75	-0.03
27	373.2	442.2	13.83	0.06	-0.86	0.16	67	322.7	470.9	15.55	0.10	-1.05	0.19
28	311.8	517.5	14.20	0.05	-1.11	0.14	68	263.5	398.7	15.55	0.05	-0.79	0.40
29	330.7	436.3	14.21	0.05	-0.84	0.36	69	418.3	395.9	15.62	0.06	-0.88	0.10
30	322.6	436.3	14.26	0.07	-0.75	0.19	70	333.9	492.8	15.64	0.13	-0.81	0.12
31	307.2	473.8	14.28	0.05	-1.00	0.18	71	395.9	487.8	15.66	0.06	-1.07	0.10
32	347.7	449.9	14.30	0.06	-0.78	0.32	72	321.1	496.1	15.66	0.11	-0.98	0.04
33	306.3	482.2	14.31	0.05	-1.03	0.16	73	370.2	419.2	15.66	0.10	—	0.42
34	345.2	506.4	14.32	0.06	-0.99	0.19	74	415.8	432.2	15.69	0.06	-0.67	0.16
35	334.3	417.5	14.37	0.05	-0.81	0.12	75	364.1	479.2	15.69	0.14	—	-0.19
36	333.5	442.3	14.47	0.06	-0.87	0.25	76	374.1	456.8	15.72	0.11	-0.95	0.26
37	321.3	373.1	14.52	0.04	-0.74	0.28	77	315.9	471.6	15.72	0.10	-0.82	-0.09
38	366.7	452.0	14.52	0.06	-1.09	0.14	78	300.0	502.8	15.76	0.08	-0.95	0.24
39	331.7	413.9	14.53	0.05	-0.89	0.24	79	329.3	456.2	15.77	0.13	-0.56	0.04
40	312.0	447.9	14.54	0.06	-0.87	0.26	80	383.6	505.6	15.78	0.08	-1.01	-0.07

(b)													
ID	x	y	F555W	σ	336-555	555-702	ID	x	y	F555W	σ	336-555	555-702
81	320.1	488.2	15.80	0.14	-0.86	0.03	121	376.1	485.0	16.24	0.14	-0.91	-0.08
82	323.2	462.1	15.81	0.12	-0.75	-0.19	122	293.7	422.7	16.28	0.09	-0.81	0.22
83	414.9	352.5	15.81	0.04	-0.92	0.15	123	323.3	385.1	16.29	0.12	-0.63	0.23
84	388.0	546.0	15.82	0.06	-0.87	0.11	124	341.5	401.5	16.31	0.10	-0.80	0.16
85	340.0	413.0	15.83	0.12	-0.72	0.27	125	367.9	502.2	16.31	0.15	-0.94	0.08
86	289.9	440.6	15.84	0.08	-0.76	0.30	126	397.3	460.8	16.32	0.13	-1.06	0.03
87	368.9	459.9	15.85	0.13	-0.20	0.06	127	365.3	511.5	16.32	0.13	-0.86	0.10
88	322.2	403.0	15.86	0.09	-0.76	0.33	128	369.6	455.9	16.35	0.21	-1.16	-0.50
89	327.9	497.0	15.86	0.14	-0.80	0.12	129	297.1	479.2	16.36	0.10	-0.60	0.06
90	263.5	482.6	15.87	0.05	-0.73	0.13	130	411.2	477.3	16.37	0.07	-0.79	0.20
91	375.3	414.3	15.88	0.12	-0.49	0.16	131	387.1	489.4	16.39	0.14	-0.90	0.13
92	272.5	353.4	15.89	0.04	-0.55	0.21	132	363.2	373.7	16.44	0.08	-0.58	0.33
93	364.2	491.4	15.89	0.13	-0.86	0.30	133	264.5	380.8	16.44	0.05	-0.80	0.24
94	378.5	492.4	15.89	0.10	-0.95	0.16	134	359.4	504.9	16.45	0.19	-0.75	0.11
95	275.8	413.7	15.91	0.05	-0.73	0.31	135	372.3	473.4	16.45	0.19	—	0.24
96	356.2	386.5	15.92	0.11	-0.24	0.73	136	355.1	403.7	16.45	0.11	-0.54	0.05
97	349.9	413.7	15.93	0.10	0.24	0.14	137	304.9	444.3	16.48	0.15	—	0.13
98	368.5	491.1	15.96	0.12	-0.68	0.16	138	324.6	526.8	16.49	0.10	-0.89	0.23
99	309.8	451.2	15.98	0.17	-0.85	0.02	139	351.9	410.1	16.51	0.16	-1.08	0.46
100	411.8	496.7	15.99	0.06	-1.21	0.35	140	330.2	525.9	16.52	0.11	-0.66	0.12
101	285.8	491.9	15.99	0.06	-0.85	0.15	141	352.0	499.2	16.53	0.23	-0.86	0.17
102	380.3	384.6	16.04	0.06	-0.68	0.11	142	304.4	458.1	16.55	0.19	—	-0.02
103	304.5	424.9	16.05	0.10	—	0.15	143	279.9	395.1	16.56	0.07	-0.80	0.09
104	354.9	376.7	16.05	0.08	-0.87	0.31	144	390.8	501.8	16.61	0.12	-1.14	0.11
105	319.1	451.6	16.05	0.18	-0.71	0.35	145	385.3	394.8	16.63	0.10	-0.69	0.18
106	363.5	454.9	16.06	0.19	—	0.05	146	362.9	366.0	16.66	0.08	-0.78	0.44
107	379.6	484.7	16.06	0.12	-1.24	0.24	147	413.8	393.3	16.67	0.09	-0.87	0.33
108	374.1	408.8	16.08	0.10	-0.75	0.33	148	372.2	495.6	16.70	0.18	—	0.20
109	301.5	486.3	16.08	0.12	-1.01	0.22	149	324.3	483.0	16.70	0.22	—	0.52
110	264.4	478.6	16.09	0.06	-1.09	0.26	150	359.7	404.9	16.75	0.15	—	0.19
111	890.5	431.2	16.09	0.19	-0.63	-0.04	151	363.0	486.6	16.77	0.29	—	0.32
112	284.2	460.0	16.11	0.08	-1.03	0.24	152	363.6	503.6	16.81	0.22	-1.11	-0.08
113	337.7	513.3	16.11	0.13	-0.70	0.07	153	372.2	491.0	16.82	0.21	—	-0.42
114	361.1	487.8	16.12	0.17	-0.33	0.11	154	290.1	479.0	16.91	0.12	-0.86	0.08
115	349.7	458.3	16.13	0.21	—	0.00	155	323.0	512.1	16.95	0.20	—	0.22
116	316.5	448.2	16.15	0.18	-0.96	0.06	156	392.1	542.4	16.99	0.08	-0.49	0.08
117	317.1	480.1	16.19	0.18	-0.35	0.18	157	384.8	362.6	16.99	0.11	—	0.28
118	313.6	403.0	16.19	0.09	-0.89	0.30	158	378.3	397.3	17.08	0.17	-0.01	0.17
119	288.1	469.8	16.20	0.08	-0.93	0.14	159	272.5	483.3	17.09	0.11	-0.82	0.21
120	348.5	499.3	16.22	0.18	-1.01	0.28	160	395.6	397.3	17.11	0.15	—	0.15

TABLE 2. (continued)

(c)													
ID	x	y	F555W	σ	336–555	555–702	ID	x	y	F555W	σ	336–555	555–702
161	288.4	497.0	17.11	0.15	-0.61	0.25	188	422.5	524.7	17.68	0.08	-0.74	0.18
162	282.2	444.7	17.11	0.14	-1.24	0.10	189	410.0	460.0	17.75	0.20	-0.90	0.01
163	410.2	499.6	17.12	0.16	-0.12	-0.59	190	405.1	536.7	17.77	0.11	—	0.21
164	309.0	414.1	17.16	0.20	-1.19	-0.01	191	402.2	412.4	17.80	0.23	-0.75	0.58
165	380.9	540.2	17.16	0.08	-0.63	-0.38	192	291.2	353.9	17.89	0.09	—	0.10
166	287.7	464.3	17.18	0.17	-0.81	0.12	193	277.4	510.9	17.90	0.19	-0.36	-0.42
167	304.5	531.2	17.18	0.16	—	-0.26	194	417.1	448.9	17.90	0.18	-0.74	-0.09
168	310.4	438.5	17.19	0.24	-0.90	0.29	195	406.6	541.2	17.94	0.12	—	-0.08
169	279.1	508.6	17.20	0.12	-0.96	0.21	196	354.5	542.2	17.94	0.14	—	0.30
170	266.9	519.4	17.24	0.08	-0.76	0.18	197	355.6	535.3	17.98	0.20	—	0.10
171	311.9	512.5	17.25	0.32	—	0.40	198	270.7	400.8	18.01	0.16	—	0.83
172	409.1	469.1	17.30	0.14	—	0.13	199	408.8	390.1	18.04	0.17	—	0.29
173	388.9	518.1	17.33	0.14	—	0.12	200	425.5	468.5	18.04	0.16	-1.04	0.37
174	292.2	488.8	17.34	0.20	-0.52	0.42	201	412.1	508.0	18.17	0.15	—	0.16
175	273.2	415.6	17.38	0.14	-1.64	0.13	202	375.3	532.3	18.25	0.19	-1.37	0.18
176	302.7	456.0	17.38	0.32	—	0.21	203	268.9	384.0	18.30	0.18	-1.20	-0.15
177	347.9	353.6	17.38	0.14	—	0.44	204	421.4	495.8	18.31	0.16	—	0.11
178	284.5	468.4	17.39	0.18	-0.24	0.01	205	320.9	538.8	18.32	0.24	-1.08	0.23
179	405.4	493.5	17.44	0.20	-1.55	0.40	206	272.1	521.6	18.40	0.16	-1.34	0.59
180	279.9	475.0	17.46	0.17	—	0.10	207	423.9	403.6	18.44	0.21	—	0.27
181	417.2	479.2	17.50	0.12	-1.09	0.08	208	287.8	534.3	18.66	0.21	—	0.13
182	411.1	450.4	17.51	0.17	—	0.03	209	264.8	536.4	18.72	0.19	—	0.41
183	407.5	493.7	17.52	0.22	—	0.03	210	420.9	510.3	18.80	0.20	—	0.40
184	276.5	482.0	17.61	0.17	-0.29	0.24	211	344.8	538.5	18.86	0.39	-1.25	0.59
185	418.6	460.7	17.62	0.14	-0.86	0.11	212	416.2	512.6	18.87	0.22	—	0.23
186	280.3	423.0	17.62	0.17	—	0.19	213	312.3	539.0	19.10	0.45	—	0.38
187	358.5	533.1	17.63	0.13	-0.94	0.06	214	280.8	521.7	19.21	0.40	—	0.56

passed by the filter passband was approximated by a linear combination of the F336W and F555W images, and the continuum was subtracted from the F469N image. The resulting image shows those stars in which He II emission can be found. These stars and their magnitudes in the subtracted F469N image relative to that of star R134 are listed in Table 8. The PC6 F469N image itself is shown in Fig. 6 (Plate 117). The center of R136 is shown in Fig. 7.

3. STELLAR CONTENT

3.1 Identification of Components

We confirm what numerous studies have concluded before: that R136a is not an unusual single star, but rather a tight collection of massive stars. R136a itself breaks up into 12 or more stars, depending on where you draw the boundary. These components include the 8 stars identified by Weigelt & Baier (1985) from speckle interferometry. Of those 8, stars 1, 3, and 6 are themselves clearly resolved as doubles in the PC images. In all we count 20 stars within the inner 1.5" centered on stars 1, 2, and 9 (see Fig. 2), and 214 stars in the box (1.9×2.2 pc) we use to define R136.

3.2 The Color–Magnitude Diagram

Before we can convert apparent magnitudes into absolute magnitudes we have to estimate the external and internal extinction of the starlight at the center of 30 Doradus. Fitzpatrick & Savage (1984) examined several stars near the core of the cluster and concluded that the total reddening is $E(B-V)=0.34$. In Fig. 8 we plot an (F336W–F555W), (F555W–F702W) color–color diagram. Also on the plot is a line indicating intrinsic UVR

colors (Johnson 1968) although one must bear in mind that the HST colors have not been transformed to the Johnson system. Also shown on the plot is the reddening line for an $E(B-V)$ of 0.34. Extinction is known to be variable across the 30 Doradus region (cf. Melnick 1986) and in principle could even vary across the small field of view of the PC, particularly between the core R136 and stars external to it. However, because the intrinsic colors of massive stars in the WF/PC filter system are not known and because the photometric uncertainties are so large, we have simply adopted the reddening determined by Fitzpatrick and Savage and have applied it to all of the stars we measured. In the color–color diagram one can see that adopting Fitzpatrick and Savage's reddening will give a reasonable correction to the extinction for the bulk of the stars. The extinction in the WF/PC filters for a given $E(B-V)$ is taken from Edvardsson & Bell's (1989) work for low mass stars. Therefore, for all stars we adopt $A_{336}=1.68$, $A_{555}=1.04$, and $A_{702}=0.68$.

In Figs. 9 and 10 we show color–magnitude diagrams. One can see that the stars in R136 cover the range of M_{555} from about -7 down to about -1 . These limits correspond approximately to Wolf-Rayet or O supergiant type stars down to that of B3 ZAMS. This confirms suggestions that the stars in R136 in R136a are not unusual in terms of their individual luminosities. Furthermore, the stars in R136 and R136a are not even the brightest stars in the 30 Doradus region in the F555W filter.

The sequence on the $(M_{336}-M_{555})_0$ vs M_{555} plot is mostly vertical at about $(M_{336}-M_{555})_0=-1.5$, reflecting the fact that we are looking at massive blue stars. The sequence is about 0.5 mag wide, due in part to the large photometric uncertainties and possibly due also to variable

TABLE 3. Photometry of stars outside R136 (PC5).

(a)												
ID	x	y	F555W	σ	336-555	555-702	ID	x	y	F555W	σ	336-555 555-702
5001	149.7	585.7	12.47	0.08	-0.68	0.30	5041	550.6	705.0	17.86	0.08	-0.66 0.26
5002	152.1	543.7	14.07	0.08	-0.91	0.21	5042	299.7	608.1	17.93	0.11	— 0.34
5003	724.5	279.5	14.09	0.00	-0.98	0.20	5043	122.7	200.6	17.96	0.10	— 0.05
5004	93.0	129.8	14.24	0.09	-0.84	0.20	5044	651.1	606.0	18.00	0.07	-0.70 0.23
5005	127.7	423.6	15.30	0.08	-1.04	0.19	5045	125.8	49.8	18.01	0.08	-0.72 0.30
5006	494.5	360.7	15.49	0.04	-1.10	0.07	5046	139.8	460.5	18.09	0.33	-1.90 0.52
5007	287.7	407.1	16.06	0.05	-1.03	0.14	5047	150.5	723.6	18.11	0.08	— 0.82
5008	293.4	459.0	16.18	0.07	0.47	0.56	5048	192.2	793.1	18.14	0.09	— 0.29
5009	78.1	775.0	16.19	0.08	-1.01	0.32	5049	429.6	702.3	18.14	0.11	-0.72 0.19
5010	659.5	539.6	16.37	0.04	-0.87	0.11	5050	75.4	656.1	18.19	0.09	-0.40 0.41
5011	84.2	439.1	16.49	0.11	-1.01	0.19	5051	668.1	214.0	18.20	0.07	-0.76 0.22
5012	226.6	555.6	16.50	0.06	-0.95	0.25	5052	487.3	289.0	18.26	0.09	— 0.64
5013	494.2	255.3	16.52	0.04	-1.02	0.09	5053	248.5	564.7	18.32	0.12	— 0.17
5014	325.6	256.0	16.54	0.07	-1.16	0.06	5054	268.9	386.2	18.35	0.11	-0.76 0.15
5015	433.9	791.0	16.67	0.06	-0.73	0.26	5055	154.7	717.9	18.36	0.11	-0.92 0.27
5016	732.6	195.6	16.78	0.02	-1.11	0.07	5056	306.5	220.8	18.44	0.12	-1.03 0.22
5017	462.7	735.8	16.85	0.07	0.44	0.60	5057	130.2	80.0	18.53	0.12	— 0.20
5018	582.1	741.3	16.87	0.07	—	-0.33	5058	548.1	84.5	18.56	0.09	-0.55 0.28
5019	395.1	691.8	16.90	0.07	-1.05	0.22	5059	241.9	419.1	18.57	0.13	-0.23 0.21
5020	320.8	613.1	16.92	0.07	-0.92	0.24	5060	496.0	108.2	18.63	0.10	-0.47 0.10
5021	208.0	586.3	16.98	0.08	-0.78	0.25	5061	754.8	711.1	18.63	0.12	-0.40 0.00
5022	258.1	100.8	16.98	0.08	-0.98	0.15	5062	127.0	65.4	18.66	0.12	-0.40 0.19
5023	304.8	608.9	16.99	0.07	-0.94	0.33	5063	311.3	758.3	18.70	0.12	— 0.39
5024	374.9	472.7	17.00	0.06	-1.14	0.14	5064	75.2	355.0	18.72	0.14	— 0.06
5025	133.7	430.7	17.04	0.15	-1.45	0.13	5065	128.0	282.6	18.74	0.10	-1.09 -0.11
5026	405.5	125.4	17.04	0.06	-0.73	0.06	5066	160.2	741.3	18.74	0.13	-0.57 0.17
5027	148.0	552.2	17.10	0.36	-2.13	0.18	5067	451.0	595.1	18.74	0.15	-0.74 0.36
5028	345.7	111.5	17.10	0.06	-0.70	0.34	5068	569.1	710.9	18.77	0.14	-0.96 0.16
5029	114.8	221.6	17.14	0.07	-0.79	0.46	5069	309.0	597.6	18.78	0.15	— 0.11
5030	404.8	730.9	17.16	0.07	-0.87	0.16	5070	467.9	276.3	18.81	0.12	-0.58 0.41
5031	82.2	369.5	17.22	0.08	-1.00	0.19	5071	202.1	213.4	18.83	0.10	— 0.23
5032	409.4	574.6	17.35	0.10	-1.28	0.41	5072	670.2	419.4	18.86	0.10	-0.71 0.37
5033	639.6	536.2	17.38	0.05	-0.85	0.26	5073	243.3	776.2	18.86	0.12	-0.79 0.16
5034	107.0	513.8	17.42	0.09	-1.13	0.37	5074	363.0	722.2	18.88	0.16	-0.62 0.22
5035	73.7	773.5	17.49	0.16	-0.04	0.00	5075	286.5	630.2	18.89	0.15	— 0.25
5036	126.8	199.8	17.54	0.08	-0.82	0.40	5076	471.6	281.3	18.91	0.13	-0.87 0.08
5037	144.5	164.6	17.57	0.09	-0.68	0.29	5077	227.1	641.2	18.91	0.19	-0.91 -0.10
5038	65.8	604.8	17.74	0.09	-0.72	0.11	5078	385.7	523.8	18.96	0.13	-1.26 0.44
5039	51.6	248.0	17.75	0.08	-0.95	0.25	5079	389.8	208.3	19.01	0.12	— 0.19
5040	225.0	582.8	17.79	0.09	-0.42	0.32	5080	618.3	333.0	19.02	0.12	-0.77 0.08

(b)												
ID	x	y	F555W	σ	336-555	555-702	ID	x	y	F555W	σ	336-555 555-702
5081	175.8	260.6	19.11	0.16	-1.33	-0.29	5093	236.0	170.6	19.57	0.22	— -0.05
5082	187.9	63.0	19.13	0.17	—	1.38	5094	235.0	604.0	19.57	0.31	— 0.24
5083	721.3	519.1	19.16	0.16	—	0.34	5095	60.4	566.6	19.59	0.26	-1.48 0.82
5084	290.9	392.8	19.20	0.21	—	0.20	5096	455.2	672.8	19.60	0.32	— 0.42
5085	141.7	672.2	19.20	0.19	—	0.34	5097	320.3	296.8	19.70	0.34	-1.35 0.59
5086	229.2	545.3	19.22	0.23	—	0.13	5098	465.2	679.2	19.79	0.36	— 0.20
5087	567.6	181.9	19.24	0.18	—	0.58	5099	524.7	608.5	19.86	0.21	— 0.52
5088	328.0	365.1	19.27	0.22	—	0.14	5100	459.0	512.0	20.06	0.22	— 0.51
5089	232.9	295.0	19.29	0.17	—	-0.39	5101	323.4	782.7	20.15	0.34	— 0.80
5090	204.3	353.8	19.33	0.19	-1.51	-0.04	5102	343.5	563.2	20.22	0.52	— 0.51
5091	258.2	305.7	19.40	0.20	—	0.30	5103	284.6	316.0	20.58	0.48	— 1.27
5092	621.1	501.8	19.48	0.21	—	0.16	5104	157.7	455.9	13.77	0.08	-1.05 0.05

reddening across the cluster. However, some spread is likely to be intrinsic since the relatively uncrowded stars outside R136 show the same spread as those within R136, where the photometric uncertainties are larger. Intrinsic spread could be due to the natural spread among massive stars as they evolve (Stothers & Chin 1977; Schaller *et al.* 1992) and could be a signature of stars undergoing extreme mass loss and convective overshoot (Maeder & Meynet 1987). At about $M_{555} = -2$ one may possibly see a clump of slightly redder stars, presumably as the main sequence begins to curve to the right for cooler, lower mass stars. Also, at $M_{555} \sim -6.5$ one begins to see a slight turn to the red. This shows up clearly as the main-sequence turnoff in

the color-magnitude diagrams of the larger 30 Doradus region measured by Melnick (1986). On the ($M_{555}-M_{702}$) vs M_{702} plot, the sequence is narrower and does not curve redward at the faint end although it does show the redward turn at the bright end. The narrowness is due to the fact that all O and B stars have basically the same $V-R$ color and to the higher photometric accuracy in F702W and F555W compared to F336W. In the upper right of this plot one can also see the star Mk9, classified as an M supergiant by Melnick (1985). No red supergiants were found within R136 itself.

One other point of interest is that the color-magnitude diagrams of R136 and of the stars measured outside of

TABLE 4. Photometry of stars outside R136 (PC6).
(a)

ID	x	y	F555W	σ	336-555	555-702	ID	x	y	F555W	σ	336-555	555-702
6001	317.2	724.7	12.57	0.07	-0.80	0.32	6041	314.7	651.4	15.57	0.05	-0.99	0.17
6002	199.8	568.3	12.67	0.05	-1.08	0.15	6042	692.7	460.7	15.60	0.06	-0.77	0.34
6003	388.6	736.0	12.94	0.05	-1.01	0.18	6043	179.8	699.8	15.62	0.06	-0.96	0.24
6004	314.5	232.1	12.95	0.01	-0.73	0.32	6044	597.1	227.3	15.62	0.06	-1.16	0.09
6005	595.5	395.3	13.30	0.03	-0.88	0.25	6045	543.9	395.6	15.68	0.06	-0.97	0.14
6006	542.3	269.1	13.36	0.03	-1.03	0.16	6046	650.8	378.7	15.69	0.07	-1.18	0.23
6007	595.4	352.2	13.46	0.03	-0.85	0.28	6047	250.7	459.4	15.70	0.04	-0.65	0.45
6008	76.7	327.7	13.52	0.05	-0.87	0.20	6048	334.2	558.7	15.70	0.05	-0.96	0.14
6009	128.4	332.0	13.67	0.04	-0.88	0.20	6049	153.4	558.8	15.79	0.06	-0.81	0.21
6010	582.4	243.0	13.81	0.04	-1.18	0.09	6050	556.6	776.8	15.81	0.06	-0.90	0.18
6011	346.3	582.8	14.01	0.06	-0.97	0.00	6051	130.0	310.5	15.82	0.08	-0.75	0.20
6012	264.0	621.4	14.08	0.06	-1.14	0.12	6052	188.1	508.7	15.82	0.06	-0.43	0.47
6013	110.4	348.9	14.20	0.05	-0.32	-0.30	6053	479.0	282.5	15.90	0.04	-0.96	0.17
6014	87.5	304.2	14.21	0.05	-0.87	0.17	6054	376.5	723.6	15.93	0.10	-0.98	0.03
6015	459.5	465.4	14.21	0.04	-1.00	0.12	6055	461.9	381.6	15.93	0.05	-1.07	0.16
6016	568.1	434.0	14.39	0.04	-0.83	0.19	6056	127.0	384.4	15.93	0.06	-0.74	0.30
6017	482.3	315.7	14.40	0.05	-0.91	0.10	6057	483.3	447.3	15.97	0.04	-0.99	0.09
6018	608.3	417.4	14.47	0.04	-0.70	0.32	6058	606.8	687.2	15.98	0.06	-1.34	0.28
6019	568.5	768.8	14.57	0.05	-0.98	0.14	6059	425.8	53.1	15.99	0.05	-1.04	0.15
6020	75.5	66.5	14.66	0.05	-1.02	0.14	6060	138.8	601.5	16.00	0.06	-1.05	0.19
6021	192.9	495.2	14.66	0.05	-0.71	0.33	6061	387.0	581.4	16.03	0.06	-0.96	0.19
6022	273.3	696.2	14.69	0.05	-1.08	0.17	6062	118.1	523.0	16.03	0.06	-0.86	0.22
6023	386.6	623.0	14.75	0.04	-0.88	0.13	6063	455.8	622.0	16.05	0.05	-0.92	0.27
6024	242.0	767.1	14.99	0.07	-1.05	0.06	6064	400.0	695.5	16.11	0.08	-0.72	0.18
6025	294.4	686.9	14.99	0.07	-0.89	0.08	6065	663.7	501.1	16.12	0.04	-0.87	0.29
6026	286.5	634.5	15.02	0.05	-1.08	0.14	6066	410.4	713.8	16.15	0.07	-0.62	0.06
6027	739.8	775.3	15.14	0.07	-0.89	0.23	6067	254.5	443.0	16.20	0.04	-0.63	0.28
6028	285.8	612.3	15.20	0.05	-1.22	0.12	6068	478.1	551.8	16.20	0.05	-0.87	0.18
6029	596.2	711.7	15.25	0.06	-0.86	0.14	6069	523.1	730.3	16.21	0.07	-0.97	0.24
6030	499.7	365.6	15.31	0.04	-0.89	0.17	6070	435.4	641.0	16.24	0.05	-0.04	0.83
6031	332.9	566.0	15.34	0.05	-1.08	0.19	6071	523.7	54.5	16.29	0.05	-1.01	0.07
6032	304.5	707.2	15.35	0.07	-1.07	0.17	6072	245.0	671.4	16.29	0.07	-1.09	0.21
6033	710.3	386.4	15.37	0.04	-0.86	0.26	6073	436.5	721.5	16.31	0.06	-1.15	0.23
6034	405.4	603.4	15.39	0.04	-1.00	0.20	6074	280.6	264.6	16.32	0.03	-0.53	0.19
6035	254.4	698.0	15.44	0.05	-1.03	0.15	6075	670.2	138.4	16.32	0.05	-1.11	0.06
6036	576.0	702.1	15.45	0.06	-0.98	0.23	6076	564.7	196.1	16.33	0.05	-0.95	0.09
6037	471.6	401.3	15.45	0.03	-0.93	0.15	6077	575.8	337.7	16.35	0.06	-0.56	0.24
6038	599.8	375.1	15.49	0.05	-0.36	0.14	6078	332.8	597.2	16.36	0.07	-1.21	0.22
6039	200.9	609.3	15.49	0.07	—	-0.37	6079	704.2	400.8	16.37	0.06	-0.74	0.30
6040	625.9	478.6	15.50	0.07	-0.68	0.33	6080	222.6	546.7	16.38	0.08	-0.88	0.15

(b)

ID	x	y	F555W	σ	336-555	555-702	ID	x	y	F555W	σ	336-555	555-702
6081	596.9	371.5	16.38	0.10	-1.09	0.27	6121	428.3	164.2	16.89	0.03	-0.19	0.12
6082	231.7	509.8	16.41	0.05	-0.67	0.20	6122	244.9	592.5	16.90	0.07	-1.00	0.14
6083	392.8	333.6	16.42	0.04	-0.73	0.19	6123	724.1	143.8	16.90	0.06	-0.92	0.21
6084	192.2	446.7	16.45	0.05	-0.22	0.38	6124	644.9	300.8	16.91	0.06	-0.89	0.15
6085	554.9	386.1	16.45	0.06	-0.77	0.13	6125	418.6	335.6	16.92	0.05	-0.70	0.03
6086	668.3	676.1	16.46	0.04	-0.95	0.21	6126	451.4	424.9	16.92	0.06	-0.73	0.18
6087	143.1	155.8	16.48	0.05	-0.91	0.17	6127	541.7	294.5	16.92	0.07	-0.46	0.23
6088	434.5	617.7	16.48	0.05	-0.98	0.18	6128	456.8	625.4	16.94	0.10	-0.70	-0.03
6089	487.8	307.7	16.49	0.12	-1.18	0.42	6129	456.5	645.9	16.94	0.06	-0.86	0.12
6090	304.2	584.5	16.50	0.06	-0.89	0.15	6130	47.2	244.9	16.95	0.08	-0.97	0.04
6091	611.4	553.5	16.51	0.05	-0.84	0.27	6131	221.2	469.5	16.96	0.06	-0.50	0.16
6092	728.5	205.6	16.52	0.05	-1.02	0.11	6132	357.4	556.2	16.97	0.08	-0.90	0.11
6093	240.0	612.0	16.53	0.07	-1.03	0.08	6133	693.0	196.8	16.97	0.07	-1.06	0.16
6094	613.2	428.7	16.53	0.07	-0.20	0.14	6134	182.5	611.7	16.97	0.09	-0.73	0.09
6095	250.0	464.3	16.53	0.07	-0.76	0.13	6135	613.7	177.8	16.97	0.06	-1.02	0.18
6096	485.7	573.7	16.54	0.06	-0.94	0.27	6136	439.4	540.2	16.98	0.05	-0.89	0.18
6097	561.7	393.2	16.57	0.06	-0.45	0.21	6137	489.0	214.8	16.98	0.05	-0.70	0.17
6098	174.8	706.1	16.61	0.06	-1.08	0.22	6138	272.5	316.6	16.99	0.04	-0.69	0.27
6099	515.4	346.3	16.64	0.04	-0.60	0.18	6139	539.2	306.1	16.99	0.06	-0.74	0.27
6100	490.7	633.8	16.64	0.08	-0.84	0.29	6140	453.0	754.8	17.01	0.06	-0.89	0.12
6101	436.4	475.5	16.65	0.06	-0.93	0.14	6141	179.2	671.9	17.04	0.06	-0.60	0.17
6102	527.1	514.5	16.66	0.07	-0.92	0.12	6142	365.8	579.3	17.05	0.09	-0.78	0.12
6103	483.3	566.0	16.67	0.07	-0.69	0.04	6143	483.8	308.4	17.05	0.11	-0.47	0.11
6104	491.9	391.8	16.68	0.05	-0.42	0.12	6144	318.2	604.6	17.06	0.07	-0.63	0.21
6105	526.9	399.4	16.69	0.06	-0.74	0.11	6145	363.2	572.1	17.06	0.11	-0.72	0.09
6106	286.3	707.5	16.69	0.10	-0.90	0.31	6146	587.8	330.0	17.06	0.10	—	1.11
6107	528.2	572.8	16.75	0.07	-1.16	0.16	6147	576.2	357.7	17.07	0.12	-0.66	0.32
6108	438.2	444.8	16.75	0.06	-0.80	0.15	6148	422.1	294.4	17.07	0.05	-0.76	0.21
6109	195.4	641.0	16.77	0.05	-0.87	0.16	6149	433.5	763.4	17.09	0.07	-0.91	0.23
6110	373.8	617.6	16.80	0.07	-0.69	0.19	6150	607.8	364.6	17.09	0.13	—	0.41
6111	194.2	751.4	16.80	0.07	-0.68	0.34	6151	290.6	95.8	17.10	0.04	-0.51	0.07
6112	322.6	591.2	16.84	0.07	-1.16	0.24	6152	784.0	90.7	17.12	0.06	-0.93	0.19
6113	699.0	488.2	16.84	0.07	-0.65	0.43	6153	63.5	320.2	17.13	0.12	-0.68	0.27
6114	162.6	662.6	16.84	0.06	-0.73	0.23	6154	493.7	436.6	17.13	0.06	-0.60	0.17
6115	328.0	579.7	16.84	0.08	-1.04	0.12	6155	603.5	641.3	17.14	0.05	-0.47	0.57
6116	339.5	78.5	16.85	0.03	—	0.16	6156	307.0	557.5	17.16	0.10	-0.90	0.18
6117	366.1	576.6	16.87	0.09	-1.08	0.16	6157	187.4	529.8	17.16	0.12	-0.80	0.21
6118	242.7	578.6	16.88	0.06	-0.56	0.13	6158	437.5	500.3	17.19	0.07	-0.88	0.12
6119	206.4	508.5	16.88	0.07	-0.85	0.17	6159	247.0	344.6	17.19	0.06	-0.27	0.22
6120	553.8	400.1	16.89	0.07	-0.52	0.13	6160	304.6	599.4	17.21	0.08	—	0.18

TABLE 4. (continued)

(c)													
ID	x	y	F555W	σ	336-555	555-702	ID	x	y	F555W	σ	336-555	555-702
6161	486.6	309.1	17.22	0.17	-0.62	-0.05	6201	306.5	311.0	17.55	0.06	-0.27	0.22
6162	660.0	302.1	17.22	0.06	-0.55	0.22	6202	387.5	666.2	17.56	0.07	-0.63	0.37
6163	364.8	552.8	17.23	0.08	-0.67	0.23	6203	564.9	399.2	17.56	0.13	-0.77	0.36
6164	145.7	691.5	17.24	0.07	-0.71	0.24	6204	475.0	774.2	17.57	0.08	-0.74	0.20
6165	415.7	207.4	17.24	0.04	-0.40	0.09	6205	218.8	638.0	17.58	0.06	-0.51	0.18
6166	651.1	381.4	17.25	0.21	—	-0.62	6206	711.5	775.3	17.60	0.08	-1.04	0.26
6167	529.8	756.3	17.26	0.10	-0.92	0.32	6207	310.4	549.8	17.61	0.11	-0.61	0.26
6168	442.9	431.4	17.26	0.08	-0.61	0.10	6208	616.8	796.8	17.62	0.09	-0.68	0.12
6169	97.1	79.7	17.28	0.09	-0.79	0.14	6209	485.2	462.8	17.62	0.11	-1.08	0.25
6170	198.6	414.0	17.29	0.05	-0.60	0.23	6210	526.0	620.5	17.62	0.07	-0.88	0.20
6171	256.1	721.2	17.30	0.09	-0.73	0.20	6211	117.9	689.5	17.64	0.08	-0.43	0.25
6172	322.6	345.1	17.31	0.06	-0.81	0.22	6212	239.9	761.3	17.64	0.19	—	-0.20
6173	522.9	243.6	17.33	0.09	-0.69	0.17	6213	448.4	501.5	17.65	0.09	-0.55	0.09
6174	240.4	433.2	17.34	0.09	-1.18	0.37	6214	411.5	642.1	17.66	0.08	-0.14	0.24
6175	520.2	259.5	17.34	0.09	-0.99	0.26	6215	368.4	623.2	17.66	0.10	—	0.20
6176	527.9	317.6	17.35	0.06	-0.18	0.12	6216	308.1	623.5	17.67	0.13	—	0.19
6177	178.1	48.3	17.35	0.05	-0.83	0.12	6217	45.8	319.2	17.67	0.15	—	0.25
6178	562.3	777.8	17.36	0.14	-1.26	0.22	6218	200.3	590.6	17.67	0.31	—	-0.04
6179	427.5	453.7	17.36	0.11	-0.82	0.27	6219	476.4	413.2	17.68	0.08	-0.10	0.09
6180	663.2	765.5	17.36	0.08	-0.66	0.38	6220	557.7	763.9	17.69	0.15	-0.32	0.35
6181	104.2	288.3	17.38	0.18	-0.09	0.26	6221	222.8	616.8	17.70	0.10	-0.89	0.00
6182	430.2	405.2	17.38	0.07	-0.85	0.22	6222	310.2	342.7	17.70	0.08	-0.74	0.23
6183	317.0	557.0	17.40	0.08	-0.95	-0.05	6223	235.1	533.5	17.73	0.10	-0.57	0.30
6184	681.5	298.5	17.41	0.06	-0.72	0.17	6224	257.2	408.2	17.73	0.12	-1.08	0.29
6185	473.6	277.6	17.42	0.09	-0.41	0.16	6225	325.4	268.1	17.74	0.11	—	0.52
6186	349.3	606.7	17.42	0.12	—	0.20	6226	226.3	497.4	17.74	0.12	-0.39	0.28
6187	588.3	444.5	17.44	0.10	—	0.18	6227	616.5	774.0	17.74	0.10	-0.46	0.18
6188	487.7	444.1	17.44	0.07	-0.59	0.24	6228	474.4	604.1	17.75	0.08	-0.38	0.21
6189	686.7	618.9	17.46	0.07	-0.44	0.32	6229	188.8	676.7	17.75	0.11	-0.27	0.29
6190	414.2	613.5	17.46	0.10	—	0.31	6230	588.2	193.1	17.76	0.08	-0.86	0.09
6191	434.8	279.5	17.47	0.06	-0.67	0.40	6231	313.9	685.8	17.76	0.19	-0.56	0.27
6192	211.4	425.9	17.47	0.06	—	0.32	6232	593.0	649.0	17.77	0.07	-0.96	0.29
6193	302.4	566.5	17.48	0.09	-0.62	0.25	6233	546.7	47.1	17.77	0.08	-1.15	0.28
6194	31.1	510.4	17.49	0.07	-1.01	0.20	6234	50.3	215.8	17.78	0.07	-0.58	0.07
6195	238.1	687.9	17.50	0.09	-0.95	0.26	6235	167.1	614.8	17.79	0.10	—	0.15
6196	514.3	417.4	17.52	0.06	-0.61	0.23	6236	346.5	565.8	17.80	0.12	-0.08	0.17
6197	586.8	592.2	17.52	0.06	-0.99	0.14	6237	493.1	443.5	17.80	0.08	-0.31	0.34
6198	157.6	63.3	17.52	0.05	-0.80	0.16	6238	237.1	665.6	17.80	0.10	-1.06	0.38
6199	253.0	625.6	17.53	0.13	-1.03	0.28	6239	530.7	301.2	17.80	0.13	-0.57	0.07
6200	443.2	311.7	17.54	0.07	-0.62	0.17	6240	556.4	436.4	17.81	0.13	-0.77	-0.05

(d)													
ID	x	y	F555W	σ	336-555	555-702	ID	x	y	F555W	σ	336-555	555-702
6241	363.9	570.2	17.82	0.19	-0.83	0.30	6281	474.0	324.8	18.05	0.14	-0.85	0.52
6242	430.4	781.3	17.82	0.09	—	-0.01	6282	314.4	330.7	18.06	0.09	—	0.06
6243	296.0	588.5	17.83	0.14	—	0.00	6283	140.9	639.1	18.07	0.09	-0.32	0.14
6244	163.6	495.9	17.83	0.09	—	0.64	6284	513.6	341.0	18.07	0.12	—	0.43
6245	430.4	566.3	17.83	0.07	-0.15	0.16	6285	350.9	163.2	18.07	0.08	-0.87	0.17
6246	650.0	514.0	17.86	0.08	-0.89	0.24	6286	290.3	139.3	18.08	0.07	-0.67	0.15
6247	221.9	492.0	17.88	0.14	—	0.38	6287	114.4	604.7	18.09	0.12	—	0.19
6248	258.1	456.1	17.88	0.14	—	-0.05	6288	209.1	548.3	18.10	0.40	-1.46	0.25
6249	350.4	339.4	17.88	0.16	—	0.27	6289	196.9	654.0	18.10	0.10	-0.55	0.12
6250	329.8	192.3	17.89	0.10	-1.05	0.43	6290	440.5	487.5	18.11	0.15	—	0.28
6251	649.0	126.2	17.90	0.08	-0.77	0.17	6291	483.6	439.4	18.11	0.10	-0.35	0.37
6252	284.5	339.5	17.90	0.08	—	0.26	6292	232.7	600.6	18.11	0.12	—	0.19
6253	180.6	204.9	17.90	0.05	—	0.23	6293	206.9	405.1	18.12	0.09	—	0.24
6254	429.2	626.2	17.90	0.10	-0.53	0.12	6294	153.4	624.4	18.12	0.09	-0.70	0.16
6255	434.3	694.8	17.91	0.08	-1.07	0.15	6295	367.4	258.4	18.12	0.07	—	0.35
6256	721.3	448.8	17.91	0.08	-0.56	0.33	6296	669.5	505.7	18.12	0.10	-0.95	0.24
6257	496.5	547.4	17.92	0.10	-0.91	0.23	6297	55.9	653.8	18.13	0.13	-1.09	0.38
6258	284.8	330.9	17.93	0.08	—	0.19	6298	393.0	567.2	18.13	0.18	-0.21	0.10
6259	153.4	752.6	17.94	0.08	-0.29	0.46	6299	124.8	730.8	18.13	0.09	—	0.80
6260	430.9	289.1	17.94	0.08	-0.29	0.20	6300	305.9	560.0	18.13	0.19	—	0.00
6261	310.7	283.0	17.95	0.08	—	0.30	6301	259.2	737.6	18.14	0.14	-0.72	0.20
6262	141.9	285.3	17.95	0.09	—	0.17	6302	324.4	582.6	18.14	0.19	-0.60	0.11
6263	131.5	647.9	17.95	0.09	-0.28	0.21	6303	493.1	633.3	18.14	0.23	—	-0.50
6264	490.3	307.0	17.96	0.25	—	-0.35	6304	677.5	645.5	18.15	0.07	-0.84	0.24
6265	442.5	631.9	17.96	0.10	-0.39	0.32	6305	356.0	571.8	18.15	0.18	—	0.40
6266	544.1	221.2	17.96	0.10	-0.10	0.16	6306	195.2	405.2	18.15	0.09	—	0.46
6267	317.5	310.9	17.97	0.08	-0.95	0.20	6307	361.6	279.8	18.15	0.07	-0.68	0.23
6268	450.9	632.9	17.97	0.10	-0.55	0.10	6308	235.5	570.3	18.15	0.14	-0.99	0.00
6269	461.9	242.2	17.97	0.07	—	0.18	6309	55.1	302.8	18.18	0.22	—	0.53
6270	654.4	726.2	17.99	0.07	-0.79	0.33	6310	318.5	574.0	18.19	0.14	—	0.26
6271	84.9	391.5	17.99	0.07	-0.64	0.72	6311	466.4	290.4	18.19	0.18	—	0.21
6272	564.8	97.5	17.99	0.09	-0.91	0.16	6312	425.4	564.8	18.20	0.11	-0.65	0.04
6273	555.0	363.5	18.00	0.15	—	0.33	6313	306.3	669.2	18.20	0.20	—	0.49
6274	225.9	314.3	18.00	0.07	—	0.12	6314	391.1	673.7	18.20	0.12	—	0.25
6275	287.0	664.9	18.01	0.17	—	0.33	6315	252.7	123.4	18.25	0.08	—	0.15
6276	35.9	704.2	18.01	0.07	-1.00	0.40	6316	509.1	388.6	18.25	0.14	—	0.13
6277	225.9	614.8	18.01	0.13	—	0.27	6317	289.2	562.0	18.25	0.30	—	0.52
6278	453.3	417.1	18.02	0.09	-0.45	0.33	6318	381.6	604.8	18.26	0.19	—	0.03
6279	209.1	339.2	18.04	0.07	—	0.50	6319	538.6	483.1	18.26	0.08	—	0.32
6280	593.0	676.9	18.05	0.15	-0.82	0.10	6320	390.8	344.1	18.26	0.15	-1.06	0.10

TABLE 4. (continued)

(e)													
ID	x	y	F555W	σ	336-555	555-702	ID	x	y	F555W	σ	336-555	555-702
6321	782.0	477.0	18.26	0.08	-0.68	0.58	6361	793.7	376.5	18.57	0.15	—	0.35
6322	132.7	163.1	18.27	0.09	—	0.19	6362	604.6	551.6	18.57	0.14	—	0.55
6323	426.2	393.1	18.27	0.12	—	0.16	6363	662.5	576.4	18.58	0.10	—	0.40
6324	681.7	397.0	18.29	0.15	—	0.09	6364	433.4	372.5	18.58	0.12	—	0.22
6325	328.2	573.9	18.30	0.19	-0.70	0.14	6365	484.5	603.6	18.59	0.13	—	0.40
6326	198.6	462.8	18.30	0.14	-0.58	0.32	6366	573.0	292.7	18.59	0.22	-1.29	0.03
6327	507.7	363.8	18.30	0.15	—	0.44	6367	295.2	333.9	18.60	0.13	—	0.26
6328	635.9	441.1	18.31	0.19	—	0.31	6368	322.6	64.9	18.62	0.10	-1.36	0.24
6329	433.1	533.7	18.31	0.11	-0.93	0.28	6369	389.1	125.7	18.64	0.11	—	0.13
6330	678.8	686.6	18.31	0.09	-1.15	0.25	6370	481.6	409.6	18.65	0.15	—	-0.22
6331	315.0	334.7	18.32	0.12	-0.49	0.09	6371	604.6	633.2	18.65	0.10	—	0.89
6332	552.7	444.2	18.34	0.17	—	0.47	6372	375.5	610.5	18.65	0.23	—	0.30
6333	618.3	495.6	18.34	0.13	—	0.57	6373	450.1	436.0	18.66	0.20	—	0.29
6334	744.6	271.1	18.35	0.07	-0.78	0.17	6374	579.0	480.5	18.68	0.09	—	0.39
6335	607.6	320.0	18.40	0.24	—	0.38	6375	514.9	254.3	18.69	0.24	—	0.50
6336	194.3	483.7	18.40	0.22	—	0.12	6376	489.1	745.4	18.70	0.15	—	0.06
6337	535.3	319.6	18.41	0.12	—	-0.56	6377	447.4	717.9	18.70	0.16	—	0.11
6338	492.6	547.6	18.42	0.14	—	0.34	6378	256.7	252.8	18.71	0.10	—	0.44
6339	200.3	651.3	18.43	0.12	—	0.06	6379	120.8	684.8	18.71	0.14	—	0.17
6340	509.0	269.3	18.44	0.16	—	0.35	6380	730.4	198.0	18.71	0.14	-0.92	0.61
6341	302.6	608.3	18.45	0.21	-0.89	0.30	6381	451.1	461.4	18.72	0.32	—	0.51
6342	729.8	231.0	18.46	0.11	-1.18	0.30	6382	323.3	578.0	18.72	0.27	—	0.43
6343	241.0	604.5	18.46	0.15	—	0.00	6383	448.5	711.8	18.72	0.14	—	0.30
6344	451.9	362.6	18.47	0.11	-0.90	0.49	6384	162.9	528.7	18.72	0.23	-0.77	0.55
6345	427.1	260.0	18.47	0.10	—	0.18	6385	280.8	301.5	18.74	0.12	-0.81	0.48
6346	490.3	377.9	18.48	0.17	—	0.33	6386	415.4	589.5	18.75	0.20	—	0.17
6347	496.6	285.2	18.48	0.20	—	0.02	6387	460.1	610.4	18.76	0.17	—	0.40
6348	498.4	551.2	18.48	0.14	—	0.04	6388	444.8	604.3	18.76	0.17	—	0.21
6349	499.3	532.0	18.48	0.13	—	0.23	6389	236.4	163.8	18.77	0.12	—	0.40
6350	512.5	478.2	18.50	0.08	—	0.34	6390	310.7	274.6	18.80	0.15	-1.00	0.62
6351	461.4	374.6	18.50	0.12	—	-0.14	6391	573.1	288.5	18.81	0.27	—	0.46
6352	212.2	403.2	18.51	0.10	—	0.38	6392	436.8	457.9	18.81	0.32	—	0.29
6353	304.2	326.6	18.51	0.12	-0.54	0.16	6393	199.3	336.5	18.82	0.13	—	0.68
6354	592.0	477.9	18.51	0.08	—	0.28	6394	458.1	664.9	18.82	0.19	—	0.16
6355	575.9	519.4	18.52	0.10	—	0.40	6395	291.8	166.7	18.83	0.11	—	0.15
6356	578.2	524.5	18.52	0.10	—	0.00	6396	83.1	459.6	18.83	0.11	-0.88	-0.02
6357	783.0	328.1	18.52	0.09	—	0.20	6397	213.4	719.7	18.83	0.13	—	0.51
6358	469.2	503.9	18.53	0.14	-0.74	0.23	6398	268.5	343.1	18.84	0.18	—	-0.04
6359	469.0	432.0	18.56	0.15	—	0.13	6399	558.2	329.6	18.84	0.19	—	0.13
6360	290.7	564.2	18.56	0.28	—	-0.02	6400	135.5	389.6	18.86	0.20	—	0.43

(f)													
ID	x	y	F555W	σ	336-555	555-702	ID	x	y	F555W	σ	336-555	555-702
6401	232.9	332.3	18.89	0.14	—	0.15	6440	503.8	314.5	19.26	0.33	—	0.33
6402	546.3	547.2	18.90	0.14	—	0.10	6441	438.6	367.7	19.27	0.17	—	0.49
6403	493.0	417.8	18.91	0.21	—	0.04	6442	688.2	730.8	19.27	0.16	-0.98	0.33
6404	45.8	719.2	18.92	0.13	-1.62	0.58	6443	420.8	241.3	19.29	0.17	—	0.20
6405	370.1	109.5	18.95	0.11	—	0.34	6444	441.9	379.6	19.29	0.21	—	0.25
6406	284.1	295.3	18.96	0.12	—	0.66	6445	87.0	516.5	19.33	0.16	—	0.65
6407	193.6	656.1	18.96	0.20	—	0.25	6446	451.8	357.4	19.33	0.24	—	0.06
6408	205.2	381.0	18.96	0.14	—	0.49	6447	124.8	632.2	19.34	0.20	—	0.71
6409	475.6	410.1	18.96	0.24	-1.34	0.53	6448	343.5	169.9	19.34	0.19	—	0.35
6410	476.8	138.9	18.97	0.12	—	0.05	6449	419.8	342.8	19.35	0.25	—	0.30
6411	489.1	532.1	18.97	0.17	—	0.14	6450	480.3	589.2	19.37	0.26	—	0.53
6412	423.2	264.7	18.98	0.18	—	0.23	6451	467.8	306.3	19.37	0.37	—	-0.13
6413	590.6	693.6	18.98	0.34	—	0.45	6452	562.8	603.3	19.40	0.20	—	0.08
6414	33.2	689.7	18.98	0.14	—	0.35	6453	429.9	365.6	19.40	0.23	—	0.21
6415	652.7	565.6	19.00	0.12	—	0.22	6454	113.8	680.9	19.41	0.25	—	0.43
6416	430.0	612.1	19.00	0.23	—	0.64	6455	168.5	736.0	19.41	0.23	—	0.54
6417	235.3	623.9	19.01	0.22	—	0.31	6456	433.6	343.5	19.46	0.28	—	0.02
6418	499.8	302.0	19.01	0.24	—	-0.03	6457	371.5	312.2	19.47	0.23	—	0.41
6419	531.2	571.4	19.02	0.34	—	0.17	6458	232.0	286.6	19.48	0.19	—	0.75
6420	581.9	558.9	19.03	0.18	—	0.42	6459	432.1	352.4	19.51	0.26	—	-0.18
6421	287.0	151.3	19.03	0.12	—	-0.08	6460	517.8	564.0	19.57	0.30	—	0.14
6422	510.6	559.8	19.04	0.18	—	0.22	6461	371.6	653.9	19.60	0.31	—	0.33
6423	251.7	476.5	19.04	0.38	—	0.51	6462	467.1	717.8	19.63	0.30	—	0.40
6424	391.5	178.2	19.10	0.16	—	0.01	6463	445.3	368.8	19.66	0.30	—	0.42
6425	480.6	543.1	19.10	0.21	—	0.48	6464	352.7	284.5	19.66	0.21	—	0.46
6426	396.4	210.5	19.11	0.15	—	0.07	6465	578.1	544.7	19.72	0.28	—	0.31
6427	160.7	706.0	19.11	0.29	—	0.43	6466	175.1	272.9	19.72	0.23	—	0.48
6428	275.4	291.8	19.12	0.17	—	0.47	6467	455.5	382.7	19.72	0.39	—	0.50
6429	254.4	344.3	19.13	0.20	—	0.20	6468	364.3	288.7	19.78	0.27	—	0.33
6430	662.0	633.7	19.13	0.15	-1.15	0.44	6469	681.5	515.7	19.79	0.32	—	0.74
6431	227.7	646.3	19.14	0.19	—	0.13	6470	102.6	769.4	19.80	0.27	—	0.13
6432	669.8	711.0	19.15	0.15	—	0.50	6471	90.4	461.2	19.84	0.29	—	0.82
6433	469.9	527.3	19.16	0.21	—	0.14	6472	446.6	553.5	19.85	0.35	—	0.26
6434	402.7	650.2	19.17	0.18	—	0.39	6473	706.7	732.0	19.91	0.30	—	1.16
6435	458.8	371.9	19.17	0.20	—	0.24	6474	505.2	599.6	19.95	0.44	—	0.50
6436	249.6	300.2	19.17	0.15	—	0.51	6475	137.8	768.4	20.07	0.38	—	0.41
6437	249.8	524.9	19.18	0.26	—	0.42	6476	371.6	304.1	20.29	0.40	—	0.63
6438	99.7	177.3	19.20	0.14	—	-0.08	6477	773.0	439.1	20.39	0.52	—	1.43
6439	439.2	264.8	19.23	0.17	—	-0.03							

TABLE 5. Photometry of stars outside R136 (PC7).

(a)													
ID	x	y	F555W	σ	336-555	555-702	ID	x	y	F555W	σ	336-555	555-702
7001	615.8	150.2	11.81	0.04	-0.90	0.37	7041	365.6	81.9	15.98	0.05	-1.01	0.18
7002	251.8	187.9	12.57	0.05	-1.04	0.41	7042	432.0	267.7	16.11	0.06	-1.05	0.17
7003	411.6	133.1	13.26	0.04	-1.02	0.19	7043	652.2	464.0	16.12	0.05	-1.11	0.09
7004	77.2	650.7	13.28	0.03	—	1.87	7044	185.8	316.0	16.15	0.09	-1.20	0.39
7005	535.6	79.7	13.48	0.05	-1.15	0.26	7045	443.4	131.7	16.21	0.09	-1.01	-0.01
7006	492.0	367.2	13.61	0.04	-1.11	0.26	7046	734.6	493.0	16.22	0.05	-0.99	0.10
7007	298.0	198.3	13.65	0.06	-1.11	0.15	7047	375.6	233.5	16.25	0.06	-0.88	0.02
7008	602.9	210.0	13.65	0.04	-0.95	0.16	7048	497.0	658.2	16.31	0.06	-1.14	0.09
7009	325.1	375.2	13.77	0.04	-1.11	0.14	7049	214.1	430.2	16.34	0.06	-0.86	-0.02
7010	460.2	88.9	13.92	0.06	-1.32	0.26	7050	112.9	226.4	16.36	0.08	-1.16	0.22
7011	684.5	264.3	14.40	0.04	-1.08	0.18	7051	184.3	184.0	16.39	0.07	-0.35	0.06
7012	299.0	340.9	14.49	0.05	-1.09	-0.09	7052	250.1	100.7	16.42	0.07	-0.99	0.22
7013	564.5	174.6	14.58	0.04	-1.14	0.06	7053	348.2	343.0	16.42	0.08	-0.59	0.14
7014	500.6	77.9	14.65	0.05	-1.21	0.19	7054	582.5	105.9	16.45	0.05	-0.78	0.06
7015	447.1	171.5	14.66	0.05	-1.32	0.20	7055	196.9	207.8	16.47	0.07	-0.79	0.20
7016	461.3	230.5	14.72	0.05	-1.21	0.19	7056	707.2	684.2	16.47	0.06	-0.99	0.10
7017	286.1	155.1	14.80	0.07	-1.07	0.15	7057	545.4	196.2	16.49	0.06	-0.51	0.13
7018	297.5	262.0	14.83	0.05	-1.11	0.09	7058	114.2	142.9	16.50	0.10	-0.79	0.10
7019	402.8	138.2	14.91	0.06	-1.06	0.08	7059	515.2	419.6	16.52	0.06	-1.09	0.20
7020	186.6	142.8	14.93	0.07	-0.85	0.25	7060	353.1	264.3	16.60	0.06	-1.04	0.27
7021	128.4	77.6	14.94	0.06	-1.00	0.29	7061	536.0	282.1	16.62	0.05	-1.10	0.13
7022	466.2	455.3	15.04	0.04	-1.13	0.14	7062	373.9	52.3	16.65	0.06	-0.91	0.19
7023	407.9	345.0	15.08	0.05	-1.23	0.22	7063	674.5	343.1	16.67	0.04	-0.71	0.12
7024	324.5	580.5	15.10	0.04	-1.14	0.15	7064	564.9	43.4	16.68	0.08	-0.69	0.29
7025	660.6	55.3	15.12	0.05	-1.01	0.19	7065	144.4	179.1	16.72	0.11	-0.51	0.12
7026	663.4	224.9	15.22	0.04	-1.04	0.09	7066	67.6	99.3	16.74	0.08	-0.53	0.22
7027	389.5	194.3	15.27	0.05	-0.89	0.09	7067	757.3	718.5	16.74	0.07	-1.22	0.05
7028	589.5	217.1	15.28	0.05	-1.04	0.08	7068	394.8	379.9	16.74	0.06	-1.01	0.19
7029	125.5	67.6	15.34	0.10	-0.71	0.40	7069	499.7	101.2	16.80	0.10	-0.89	0.00
7030	483.7	408.7	15.39	0.04	-1.09	-0.06	7070	596.7	84.0	16.83	0.05	-0.49	0.04
7031	709.5	483.5	15.42	0.05	-1.12	0.14	7071	656.2	274.0	16.89	0.08	-0.56	0.04
7032	417.1	178.8	15.49	0.07	-1.19	0.16	7072	606.4	249.7	16.91	0.09	-0.75	0.12
7033	721.0	406.8	15.51	0.06	-1.00	0.19	7073	624.0	260.2	16.91	0.06	-0.77	0.18
7034	206.0	349.2	15.51	0.07	-1.19	0.29	7074	722.1	760.9	16.92	0.08	-0.92	0.15
7035	375.2	195.8	15.52	0.05	-1.03	0.60	7075	157.1	66.2	17.01	0.08	-0.67	0.12
7036	211.1	481.3	15.57	0.06	-1.06	0.08	7076	546.1	654.0	17.05	0.08	-1.09	0.07
7037	617.2	269.5	15.89	0.05	-1.13	0.25	7077	413.2	211.8	17.06	0.10	-0.74	0.09
7038	188.7	312.3	15.93	0.07	-0.97	0.19	7078	759.7	354.7	17.07	0.06	-0.61	0.17
7039	561.7	119.6	15.93	0.05	-1.03	0.08	7079	414.7	281.6	17.10	0.08	-0.80	0.40
7040	709.1	631.6	15.96	0.06	-1.03	0.01	7080	166.4	153.6	17.10	0.15	—	0.21
(b)													
7081	662.4	482.9	17.10	0.07	-1.02	-0.03	7121	483.6	230.1	17.94	0.12	-1.01	0.13
7082	637.7	67.4	17.16	0.06	-0.84	0.07	7122	201.6	358.2	17.94	0.16	-0.93	0.09
7083	365.8	59.8	17.19	0.08	-0.88	0.15	7123	678.4	254.5	17.94	0.16	-0.42	0.09
7084	98.8	79.6	17.22	0.09	—	0.05	7124	438.6	210.2	17.95	0.14	—	0.16
7085	140.7	262.3	17.25	0.10	-0.89	0.29	7125	473.0	557.6	17.97	0.09	-0.86	-0.08
7086	551.5	97.8	17.25	0.10	-0.81	-0.12	7126	154.9	118.1	17.98	0.23	—	0.28
7087	599.9	480.5	17.29	0.06	-0.75	0.00	7127	335.6	552.7	18.01	0.12	-1.54	0.26
7088	205.4	198.4	17.30	0.16	-0.29	0.15	7128	301.6	499.1	18.06	0.11	-1.30	0.32
7089	314.3	703.8	17.33	0.08	-1.10	-0.02	7129	483.3	123.3	18.12	0.23	-0.72	-0.07
7090	622.8	341.0	17.33	0.06	-0.83	0.13	7130	200.3	324.7	18.27	0.20	—	0.13
7091	577.4	559.1	17.35	0.07	-1.03	-0.03	7131	615.6	627.7	18.32	0.14	-1.14	0.02
7092	367.7	308.4	17.39	0.11	-0.45	0.02	7132	716.6	338.1	18.35	0.12	-0.54	0.24
7093	496.3	539.9	17.41	0.08	-1.10	0.22	7133	453.9	373.3	18.36	0.20	—	0.38
7094	768.2	293.7	17.46	0.07	-0.96	0.11	7134	623.6	208.0	18.37	0.28	—	0.51
7095	365.7	52.2	17.47	0.09	-0.60	0.13	7135	716.8	721.8	18.40	0.18	—	0.14
7096	190.1	465.1	17.48	0.11	-0.86	0.21	7136	157.7	94.4	18.41	0.30	—	0.05
7097	377.7	61.0	17.49	0.10	-0.83	0.06	7137	644.0	463.2	18.45	0.15	-1.07	0.21
7098	342.2	299.3	17.50	0.08	—	0.10	7138	368.4	385.0	18.50	0.29	—	0.08
7099	510.6	244.4	17.50	0.08	-0.60	0.20	7139	74.0	499.0	18.51	0.13	—	0.18
7100	506.5	172.1	17.52	0.10	-0.86	0.11	7140	47.8	520.5	18.51	0.13	—	0.20
7101	390.8	48.7	17.53	0.09	-0.71	0.21	7141	162.2	465.1	18.55	0.19	—	0.22
7102	647.3	110.6	17.59	0.07	—	0.05	7142	536.5	593.0	18.60	0.19	—	-0.07
7103	727.5	579.9	17.60	0.07	—	0.55	7143	377.1	564.5	18.66	0.16	—	0.16
7104	495.9	198.9	17.60	0.10	-1.06	0.13	7144	553.0	136.5	18.70	0.23	—	0.14
7105	681.5	401.8	17.61	0.11	-1.00	0.20	7145	188.2	422.7	18.70	0.21	-1.28	0.16
7106	654.5	284.5	17.70	0.12	—	0.05	7146	404.5	527.8	18.80	0.16	—	-0.12
7107	369.4	583.4	17.71	0.10	—	0.06	7147	533.2	472.7	18.81	0.18	—	0.22
7108	225.3	73.8	17.72	0.11	0.09	0.25	7148	750.8	319.8	18.97	0.20	—	0.28
7109	455.9	176.7	17.72	0.14	-0.50	0.47	7149	455.0	657.3	19.01	0.26	—	0.04
7110	309.8	442.2	17.73	0.09	-0.66	0.29	7150	280.1	577.3	19.03	0.26	—	0.34
7111	661.2	608.7	17.73	0.09	—	0.09	7151	312.1	469.6	19.08	0.19	—	0.74
7112	552.5	122.4	17.77	0.13	-0.26	-0.19	7152	559.8	415.0	19.10	0.25	—	0.33
7113	637.9	442.7	17.80	0.09	—	0.07	7153	589.1	338.8	19.10	0.23	—	0.28
7114	526.3	177.8	17.80	0.11	-0.28	0.16	7154	628.1	420.0	19.11	0.20	—	-0.08
7115	467.6	250.4	17.82	0.12	-0.84	0.24	7155	312.3	725.3	19.15	0.21	—	0.78
7116	451.2	351.6	17.82	0.17	-0.34	0.19	7156	320.8	290.7	19.26	0.41	—	0.41
7117	754.6	480.3	17.85	0.11	-0.98	0.04	7157	583.7	370.0	19.32	0.28	—	-0.22
7118	291.8	90.4	17.91	0.12	-1.02	0.12	7158	134.0	386.1	19.36	0.21	—	0.54
7119	656.7	204.3	17.93	0.18	—	0.24	7159	441.9	263.8	19.73	0.58	—	0.34
7120	653.1	306.9	17.94	0.10	-0.37	0.06	7160	155.1	141.2	14.27	0.04	-0.78	0.19
							7161	153.2	143.3	14.30	0.06	-1.32	0.19
							7162	139.6	146.0	14.52	0.04	-1.02	0.07

TABLE 6. Photometry of stars outside R136 (PC8).

ID	x	y	F555W	σ	336–555	555–702	ID	x	y	F555W	σ	336–555	555–702
8001	618.7	253.0	14.18	0.03	-1.20	0.18	8030	599.8	452.7	19.14	0.11	—	0.51
8002	223.9	539.4	14.37	0.03	-1.20	0.19	8031	123.2	183.2	19.19	0.11	-1.00	0.29
8003	310.2	477.6	14.77	0.04	-1.08	0.21	8032	128.5	219.1	19.23	0.11	—	1.44
8004	71.3	484.3	15.05	0.05	-0.89	0.28	8033	31.4	222.8	19.32	0.12	-0.91	0.26
8005	793.4	393.6	15.23	0.05	-1.28	0.12	8034	379.3	336.8	19.37	0.11	—	0.07
8006	581.8	371.0	15.69	0.03	-1.07	0.16	8035	429.6	89.7	19.52	0.17	—	0.76
8007	118.7	47.0	15.75	0.04	-0.78	0.26	8036	689.1	70.2	19.55	0.16	-1.20	0.51
8008	510.9	490.1	15.95	0.04	-1.17	0.18	8037	155.9	547.7	19.73	0.17	-0.92	0.63
8009	291.9	430.3	16.12	0.03	-1.08	0.18	8038	756.7	217.4	19.74	0.17	—	1.52
8010	213.8	618.7	16.13	0.04	-1.12	0.22	8039	533.1	124.2	19.76	0.19	—	0.48
8011	478.6	63.6	16.83	0.04	-1.01	0.33	8040	399.5	526.5	19.82	0.20	—	0.11
8012	501.6	84.7	17.57	0.05	-0.87	0.31	8041	186.6	241.4	19.85	0.18	—	0.50
8013	481.2	110.6	17.60	0.05	-0.99	0.27	8042	113.1	91.8	19.86	0.30	—	0.41
8014	368.2	195.1	17.60	0.05	-0.81	0.24	8043	37.6	263.3	19.88	0.21	—	0.17
8015	520.7	196.6	17.65	0.03	—	0.25	8044	673.6	154.4	19.90	0.17	—	0.98
8016	209.1	289.4	17.69	0.05	-0.79	0.32	8045	457.8	96.9	19.94	0.27	—	0.25
8017	238.1	78.8	17.70	0.05	-0.79	0.36	8046	496.5	577.5	19.95	0.23	—	0.34
8018	321.9	377.4	17.75	0.05	-0.78	0.26	8047	297.2	53.1	19.96	0.25	—	1.29
8019	695.2	222.7	17.89	0.06	-0.89	0.25	8048	556.0	603.6	19.98	0.21	—	0.34
8020	578.5	525.7	17.91	0.05	-0.62	0.34	8049	505.0	479.0	19.98	0.33	-1.10	0.68
8021	565.5	221.1	18.10	0.05	-0.83	0.32	8050	629.8	693.2	20.05	0.23	—	1.09
8022	31.1	128.6	18.14	0.06	-0.45	0.23	8051	319.2	330.6	20.07	0.25	—	0.51
8023	256.6	66.9	18.28	0.06	-0.74	0.34	8052	767.9	116.9	20.13	0.29	—	0.74
8024	362.7	224.6	18.53	0.07	-0.12	0.36	8053	100.5	201.6	20.14	0.25	—	0.51
8025	457.1	186.1	18.60	0.09	—	1.01	8054	435.7	250.6	20.17	0.22	—	0.42
8026	511.7	322.4	18.72	0.07	-0.88	0.15	8055	711.2	670.2	20.22	0.21	—	0.82
8027	472.1	214.6	18.80	0.08	-1.05	0.34	8056	123.1	107.2	20.28	0.41	—	0.89
8028	107.1	618.5	18.82	0.10	-0.45	0.18	8057	448.6	548.0	20.28	0.34	—	0.34
8029	230.7	171.3	19.05	0.08	—	0.40	8058	378.3	138.8	20.99	0.55	—	1.67

R136 are very similar. In the $M_{336}-M_{555}$ color, however, there appears to be a small, ~ 0.05 to 0.1 mag, offset in the loci of points such that the R136 stars are slightly redder than stars outside of R136. However, this offset is primarily an offset between CCD chips. That is, the stars within R136 and outside of R136 but on PC6 fall in the same area of the diagram, but both are offset from the stars outside of R136 that fall on PCs 5, 7, and 8 although PCs 5 and 8 are sparsely populated. If this offset is due to a difference in reddening, it would imply that the stars on PC6 are undercorrected for reddening relative to the stars on PCs 5, 7, and 8 which are further away from the core. This is possible but counterintuitive since one might expect the interstellar medium within the R136 region to be more cleared out due to the winds from the concentration of massive stars. A more likely explanation is that the offset is due to the host of difficulties in cross-normalizing the flat-fields among the CCD chips. The flat-fielding problems can cause effects of this order of magnitude. The WF/PC Investigation Definition Team (1992; see Chaps. 6 and 12) gives a detailed discussion of this problem. Therefore, with the current data we cannot be sure that the offset that is seen in the loci of stars in the color-magnitude diagram is real.

3.3 The Luminosity Function

We have counted stars in 0.5 mag luminosity bins for R136 and for the area outside. The log of the luminosity function is shown in Fig. 11, and the log of the cumulative luminosity function is shown in Fig. 12. One can see that the slopes of the luminosity functions within and without R136 are very similar between $M_{555} = -7$ and -4 . Fainter than $M_{555} = -4$, the star counts within R136 clearly be-

come incomplete; it is harder to detect and measure faint stars in the crowded region of R136 than outside of it.

We estimated incompleteness by using the automatic star finding technique mentioned in Sec. 2.2. One hundred artificial stars per magnitude bin were placed on the F555W and F702W frames, one at a time, in annuli centered on R136 with widths of 20 pixels. For each radius and each magnitude bin, incompleteness was estimated by seeing how many of the 100 stars were found and measured by the automatic routine. We then applied these corrections to the raw luminosity function. Results are presented in Fig. 13 for stars within 40 pixels of R136 and for stars outside of this region. The number of stars in the outer region was normalized to match approximately the number found in the inner region. With this completeness correction, the apparent turnover seen in Fig. 11 for the center of R136 goes away. Fainter than $M_V \sim -3$, it is impossible to estimate completeness corrections in the center of R136 because essentially none of the artificial stars were found. Figure 13 shows that there is a slight hint that there may be more massive stars relative to lower mass stars inside of R136 than outside the central region. However, the differences are within the estimated errors, so we do not take this as strong evidence for mass segregation. We hope to explore this question in more detail with higher signal-to-noise data to be obtained in the future. We note that mass segregation from dynamical effects would be expected only for the very central region of the cluster. Mass segregation resulting from a variable initial mass function, however, could occur anywhere.

For the range $M_{555} = -4$ to -7 , the slope $\delta(\log N)/\delta M_V$ of the luminosity function is 0.3 . No significant contamination by Galactic foreground stars is expected in the

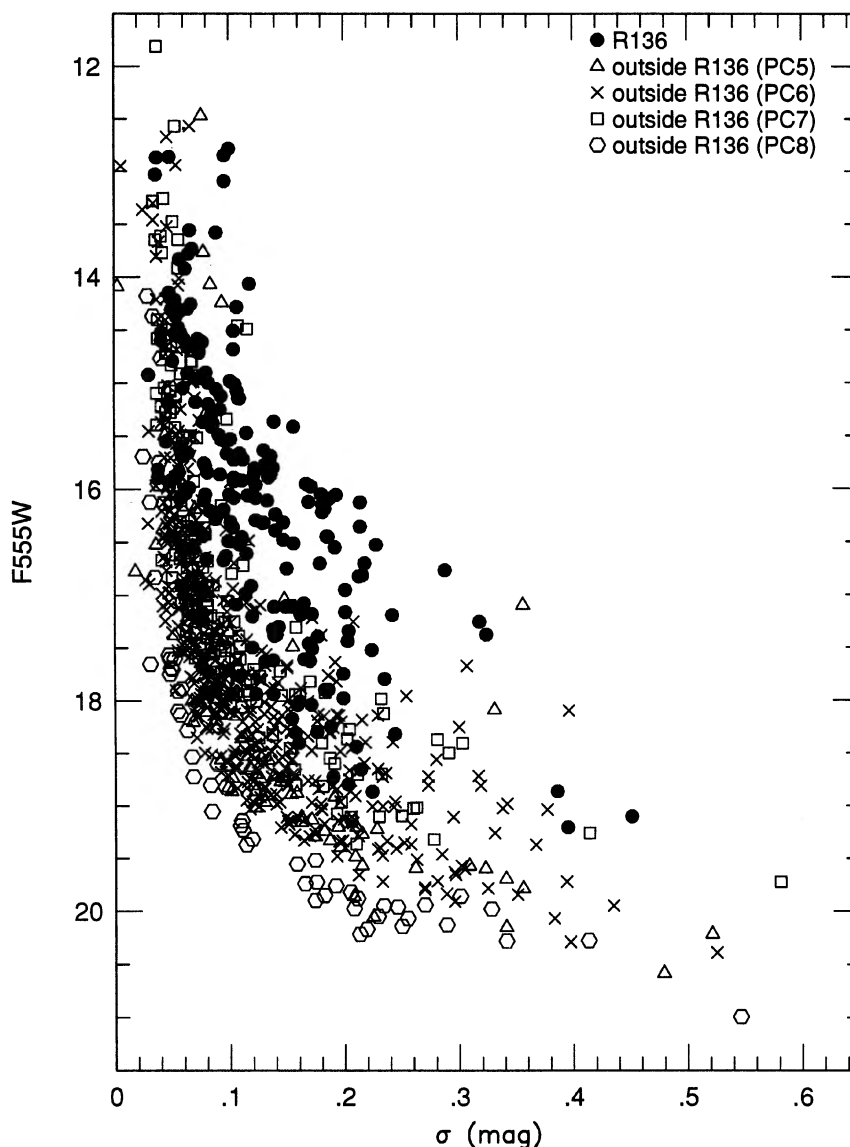


FIG. 5. The uncertainty, σ , in the magnitudes as a function of the magnitudes for filter F555W. Stars within R136 are shown with filled circles and those without are triangles (PC5), $\times$'s (PC6), squares (PC7), and hexagons (PC8). Stars with $\sigma > 0.6$ have been eliminated from the star lists. Clearly, stars within the more crowded R136 region have a higher uncertainty for a given magnitude than those stars outside of the core.

direction of the LMC (Ratnatunga & Bahcall 1985). This slope can be compared with that measured from the luminosity function plotted by Melnick (1986) for stars in 30 Doradus but outside R136. For the same luminosity range his slope is ~ 0.26 , which is in very good agreement with ours for the core of the region. This would imply that the luminosity function is similar throughout 30 Doradus (but see Parker 1992). Unfortunately, without spectral classifications for the stars in R136 we are unable to translate the luminosity function into a true mass function (Massey 1985). Melnick, however, uses a relationship between M_V and ZAMS mass for a star cluster of 2 Myrs to convert his

luminosity function to a mass function. From this he determines a mass function slope of 1.0 ± 0.3 where a Salpeter function has a slope of 1.35.

Another region of star formation that was undoubtedly once comparable to 30 Doradus in terms of overall intensity of star formation is Constellation III, located to the north. Reid *et al.* (1987) examined the V -band luminosity function for that region and found a slope of 0.55. This slope is similar to that compiled by Scalo (1986) for the Milky Way field stars and by Freedman (1985) for a large sample of nearby galaxies. Thus, the slope of the luminosity function that we find for R136 appears to be shallower

TABLE 7. Identification of stars.

ID from Literature ^a	ID in Tables 2-6	Spectral type ^b
Mk5	5003	B2: Ip?
Mk6	8002	O8-9
Mk7	8003	O(7) V
Mk8	8001	O5-6
Mk9	7004	—
Mk12	5001	B0-0.5 Ia
Mk13	5104	O3-4
Mk14	5004	O3-6 V
Mk14N	6020	O V
Mk15	7160, 7161, 7162	O7 V
Mk15S	7021, 7029	O3-6 V
Mk24	7009	O3-4 V
Mk26	7006	O3-4 V
Mk30	7005	O3 If/WN6-A
Mk32	7003, 7019	O8 II
Mk33S	6009, 6013	—
Mk33N	6008, 6014	—
Mk34	6004	WN4.5
Mk35	6006	O3 If/WN6-A
Mk35N	6017, 6089, 6143, 6161, 6264	O5-7:
Mk35S	6010	O5-6 V
Mk37	6007	WN7-A
Mk37W	6005	—
Mk39	6003	O3 If/WN6-A
Mk42	6002	O3 If/WN6-A
R134	6001	WN7
R136b	26	—
R136c	25	—
R141	7002	B0.5 I
R142	7001	B0.5-0.7 I

NOTE.—

^aFrom Melnick (1985) or Feitzinger *et al.* (1980).^bFrom Walborn (1986).

than the slope found for Constellation III; more higher mass stars are present in R136. However, this difference in slope is probably due to a difference in the evolutionary state of the regions rather than an actual initial mass function difference. Constellation III is a much older region, and Reid *et al.* find a main-sequence turnoff at about $M_V \sim -3$. In fact Reid *et al.* compiled a luminosity function for the ring around Constellation III where star formation is in progress today. For that young region the

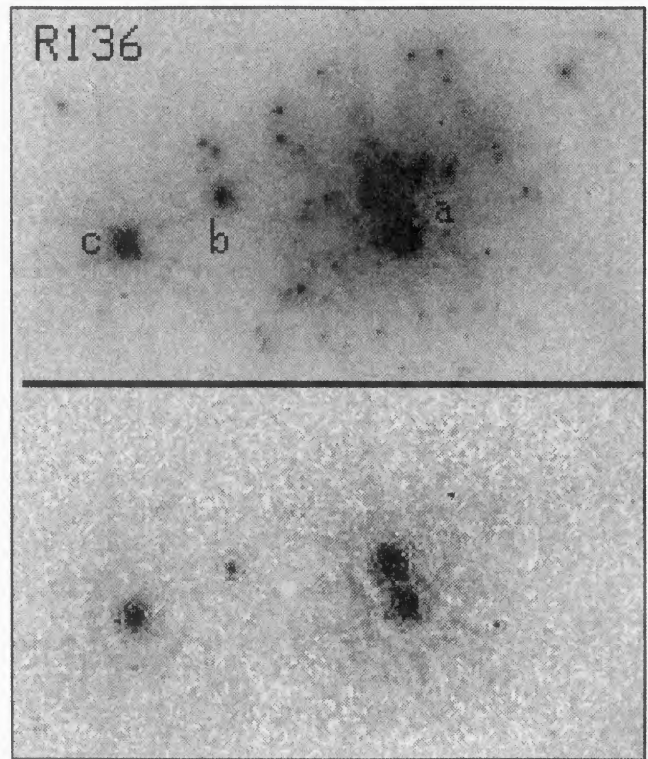


FIG. 7. An enlarged version of Fig. 6 showing only R136a, b, and c (Feitzinger *et al.* 1980). The top panel is the continuum image, and the bottom panel is the net emission image. One can see that the upper component of R136a is itself elongated.

slope of the luminosity function is much flatter, with a slope much more like that which we measure for R136.

3.4 Wolf-Rayet Stars

Several ground-based studies have recognized that R136a had spectral features characteristic of Wolf-Rayet stars and was likely to contain one or more WN-type stars (cf., Walborn 1973; Moffat & Seggewiss 1983; Chu *et al.* 1984; Melnick 1985; Moffat *et al.* 1985). The net F469N emission image, shown in Figs. 6 and 7, confirms this prediction. R136a is resolved by the PC into three components. Star number 3 is Moffat *et al.*'s R136a-B, and stars 1 and 2 are their R136a-A. In addition to R136a, two other Wolf-Rayet stars were detected in R136: R136b and R136c. R136c was already known to be a Wolf-Rayet star, while R136b was not. Chu *et al.* (1984) did not detect R136b and stated that it must be at most a weak-lined Wolf-Rayet star or a transitional type. Although we have detected it in our emission image, R136b is indeed much fainter than stars like R134, R136c, and the R136a's and therefore is indeed likely to be a weak-linked Wolf-Rayet or transitional stellar type. Outside of R136 we detected additional stars, most of known spectral type. The stars detected on the F469N net-emission image are listed in Table 8, and magnitudes measured from this image relative to R134 are given. The presence of the Wolf-Rayet stars

TABLE 8. Emission-line stars.

star	m(469)–m _{R134} (469) ^a	σ	ID ^b	type ^c
1	0.55	0.06	R136a-AS	—
2	0.66	0.07	R136a-AN	—
3	0.40	0.04	R136a-B	—
25	0.56	0.01	R136c	—
26	2.16	0.04	R136b	—
6001	0.00	0.01	R134	WN7
6002	3.84	0.11	Mk42	O3If/WN6-A
6003	5.03	0.34	Mk39	O3If/WN6-A
6004	0.90	0.01	Mk34	WN4.5
6005	3.67	0.09	Mk37W	WN7-A (Mk37)
6006	3.41	0.08	Mk35	O3If/WN6-A
6007	3.19	0.06	Mk37	WN7-A
6013	0.64	0.01	Mk33S	WC5+O4 (Mk33)
6018	3.43	0.08	—	—
7002	4.53:	0.18	R141	B05.I
7003	5.51:	0.44	Mk32	O8II
7005	2.65	0.04	Mk30	O3If/WN6-A
7006	4.62:	0.19	Mk26	O3-4V
7009	4.19:	0.14	Mk24	O3-4V
8001	3.27	0.04	Mk8	O5-6
8002	3.33	0.04	Mk6	O8-9
8003	4.09:	0.07	Mk7	O(7)V
8004	4.26:	0.09	—	—

NOTE.—

^aMagnitudes measured in the net F469N image (on-band minus continuum) relative to the magnitude of R134. A colon following the magnitude means that the residual is uncertain.^bR136a-A and R136a-B refer to Moffat *et al.*'s (1985) designations. The "N" and "S" appended to R136a-A indicate the northern and southern subcomponent respectively.^cFrom Walborn's (1986) review.

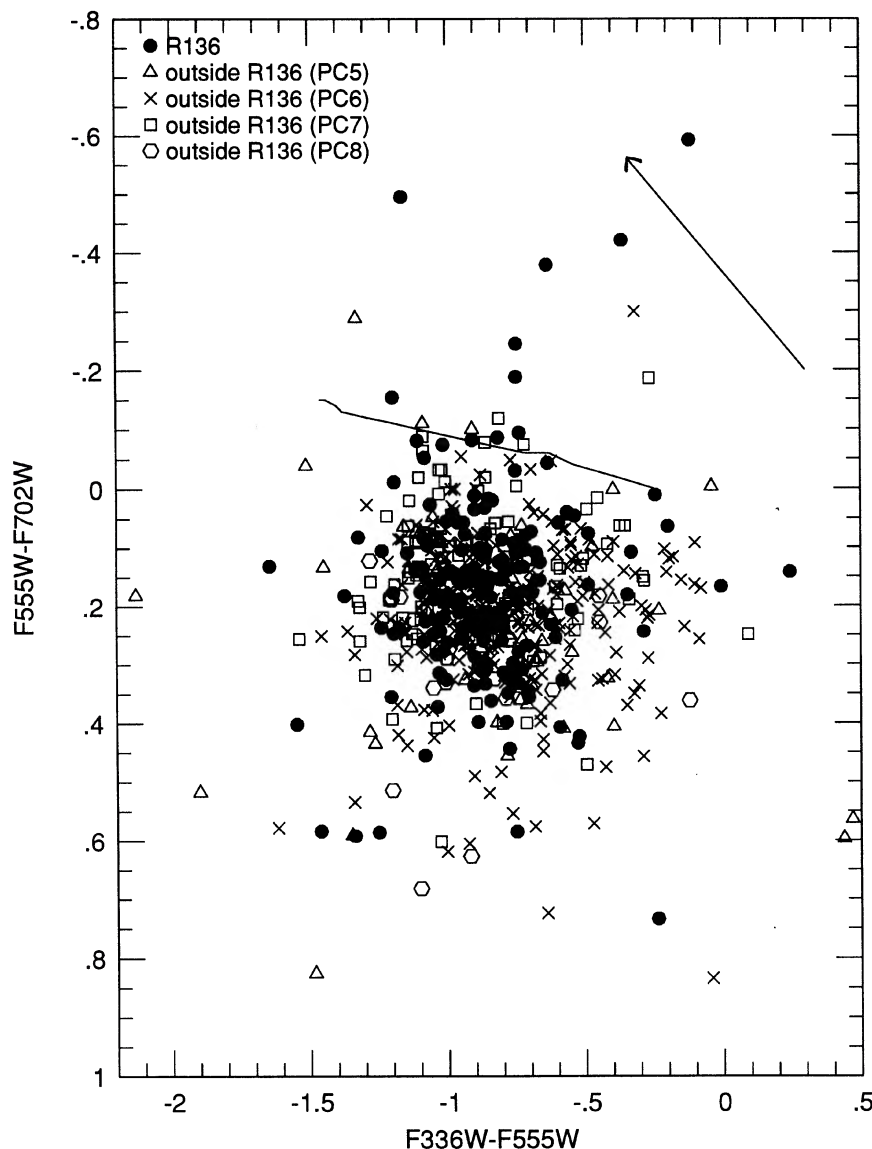


FIG. 8. A $F336W-F555W$ vs $F555W-F702W$ color-color diagram for the stars listed in Tables 2 through 6. The colors have not been corrected for reddening. The straight line in the upper right is a reddening line for $E(B-V)=0.34$; the curved line designates the intrinsic UVR colors for O and B stars in the Johnson system (Johnson 1968).

argues that R136a formed at least 3.5×10^6 yrs ago, since that is the time it takes a massive star to evolve to that stage (Maeder & Meynet 1987).

3.5 *Mk5*

The star *Mk5* is classified by Walborn (1986) as “B2: Ip?”. Given the peculiar nature of the spectrum, we examined the PC5 image for any evidence that the star might be multiple. The image of *Mk5* is shown in Fig. 14. No bright companion can be seen within several arcseconds. There is a star $1.2''$ southwest of *Mk5*, but it is 4.8 mag fainter in *F702W* and does not show up in the *F336W* image. There-

fore, the reason for the peculiar nature of the spectrum remains unknown.

4. STELLAR DENSITIES AND THE SURFACE BRIGHTNESS PROFILE OF THE CLUSTER

The *F336W* surface brightness profile for R136 is shown in Fig. 15 and listed in Table 9. The profile was generated by binning the stellar photometry given in Tables 2 and 4. The center was calculated from the luminosity centroid of stars contained within the innermost arcsecond of R136 and is at (346.26, 467.40) in the system of coordinates given in the tables. For the few stars in the inner $10''$ that were detected in *F555W* but not *F336W*, a $U-V$ color of

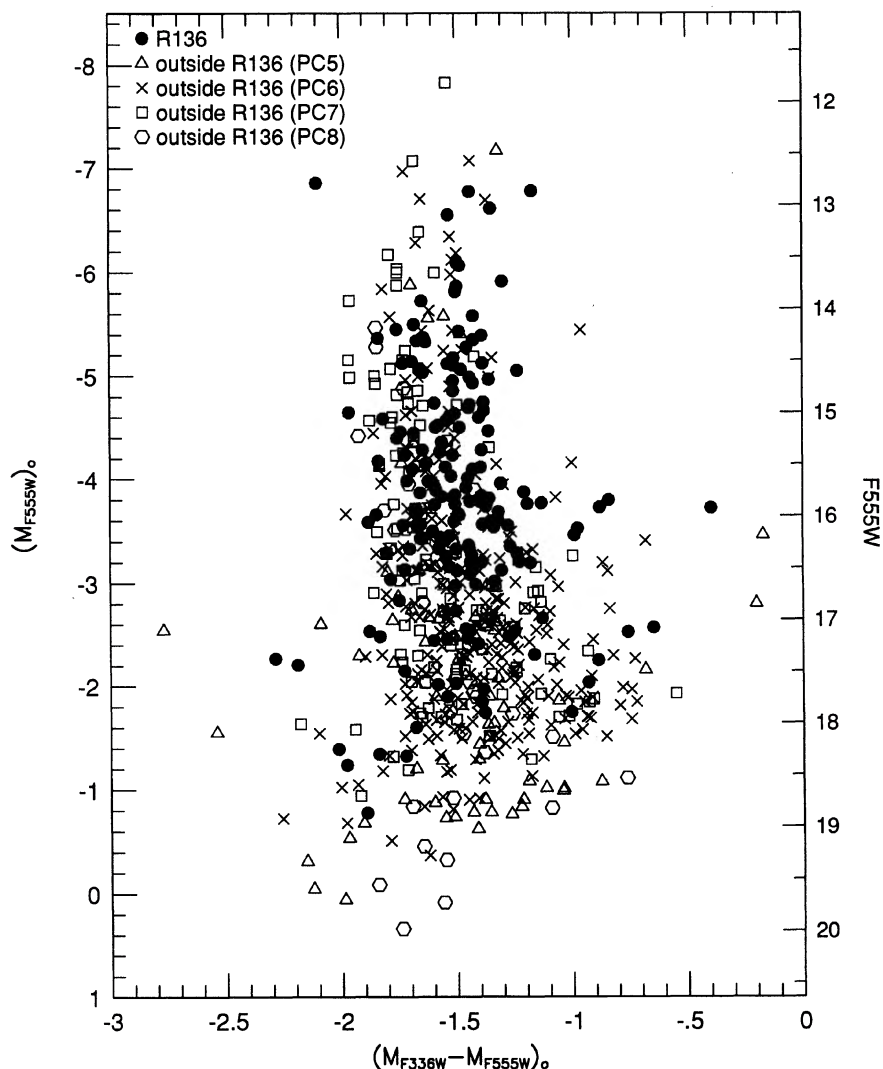


FIG. 9. A color-magnitude diagram with $F336W-F555W$ vs $F555W$ for the stars listed in Tables 2 through 6. The absolute, reddening-corrected magnitude is given on the left vertical axis; the apparent magnitude on the right. The colors have been corrected for reddening.

-0.80 has been assumed. The points shown in Fig. 15 and Table 9 have been corrected for absorption. The error bars reflect the luminosity weighted Poisson statistics of the number of stars in a given radial bin.

Figure 15 shows that the distribution of stars in R136 is consistent with a pure power law of the form $I(r) \propto r^\gamma$ with $\gamma = -1.72 \pm 0.06$. Description of the innermost structure of R136 is problematic, however, given the small number of stars and poor statistics at the very center. We thus also consider the possibility that the brightness profile might really have a small core, that is a central region of the profile that has $\gamma \rightarrow 0$ as $r \rightarrow 0$. Experiments with profiles including a central core lead us to conclude that the core radius, or half-power point, of the profile has $r_c < 0''.25$ or 0.06 pc; a profile with $r_c = 0''.25$ is shown in Fig. 15 for comparison. This value of r_c is significantly smaller than

the upper limit of $0.82''$ obtained by Moffat *et al.* (1985) from ground-based data.

Estimating the central mass density from the brightness profile can only be done crudely as we must, without the benefit of spectral classifications, estimate individual stellar masses. However, we are only interested in rough numbers for comparison with other objects, and we have made assumptions that should err on the conservative side so that the total masses and luminosities will be lower limits. We assumed a luminosity class based on the absolute magnitude M_{555} of each star and determined spectral types, bolometric corrections, and masses from Conti & Underhill (1988), Morton & Adams (1968), and Flower (1977). Thus, we have made the following assumptions for stars in R136a and R136: (1) $M_V = -6.5$ to -6 : Wolf-Rayet or supergiant stars, $40 M_\odot$, $BC = -4$; (2) $M_V = -6$ to -5.5 :

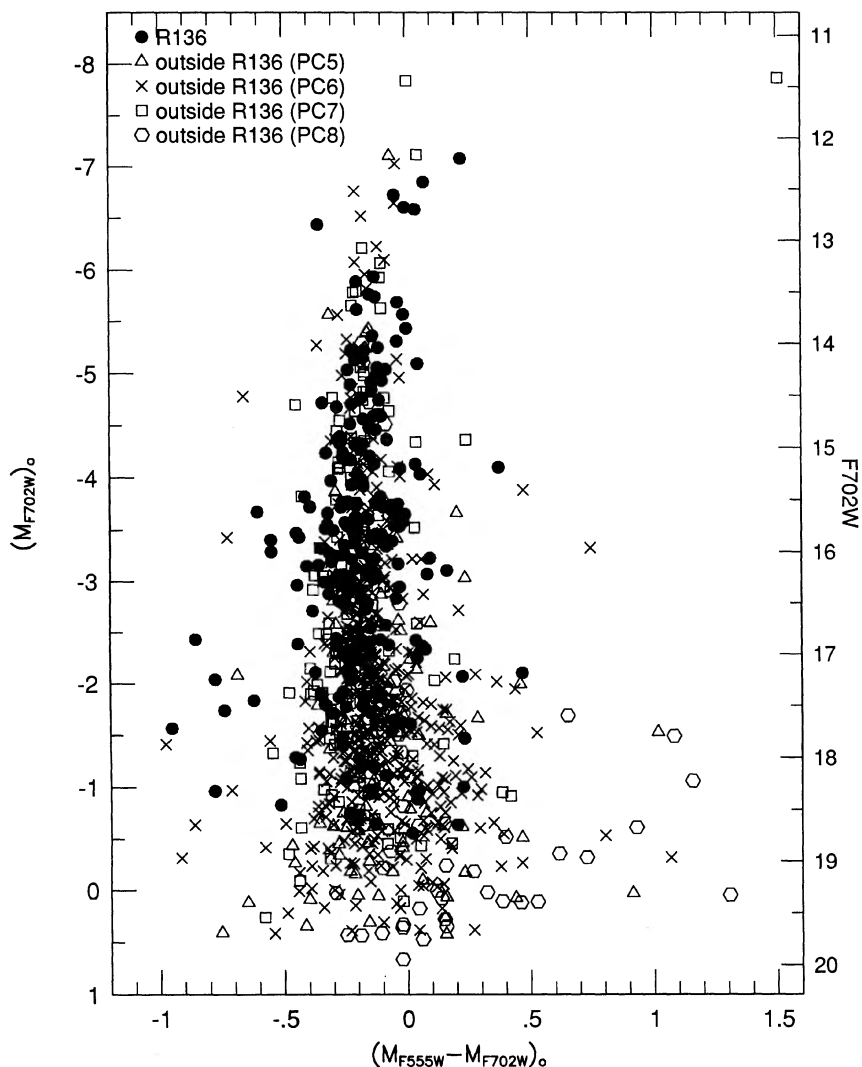


FIG. 10. A color-magnitude diagram with $F555W-F702W$ vs $F702W$ for the stars listed in Tables 2 through 6. The absolute, reddening-corrected magnitude is given on the left vertical axis; the apparent magnitude on the right. The colors have been corrected for reddening. The star in the upper right corner of the plot is M9, an M1 star (Melnick 1985).

O6.5 III, $30 M_{\odot}$; (3) $M_V = -5.5$ to -5 : O9 III, $19 M_{\odot}$; (4) $M_V = -5$ to -4.5 : O7.5 V, $25 M_{\odot}$; (5) $M_V = -4.5$ to -4 : O9 V, $19 M_{\odot}$; (6) $M_V = -4$ to -3.5 : B0.5 V, $10 M_{\odot}$; (7) $M_V = -3.5$ to -3 : B0 ZAMS, $12 M_{\odot}$; (8) $M_V = -3$ to -2.5 : B0.5 ZAMS, $10 M_{\odot}$; (9) $M_V = -2.5$ to -2 : B1 ZAMS, $8 M_{\odot}$; (10) $M_V = -2$ to -1.5 : B2 ZAMS, $7 M_{\odot}$; (11) $M_V = -1.5$ to -1 : B3 ZAMS, $5.5 M_{\odot}$; and (12) $M_V = -1$ to -0.5 : B4 ZAMS, $4.3 M_{\odot}$.

For $r_c < 0.25$, the implied central mass density is $\rho_0 > 5 \times 10^4 M_{\odot}/\text{pc}^3$, using the star masses given above. This is consistent with Moffat *et al.*'s (1985) estimate of $\sim 10^5 M_{\odot}/\text{pc}^3$ for the inner $1.5''$ and is 7×10^5 times the stellar mass density in the solar neighborhood. This mass, of course, includes only those stars that we have detected and whose brightnesses we have measured. Whether additional lower mass stars have been formed in the same region, to produce a "normal" initial mass function, we do not know.

In addition we estimate the total luminosity to be $\geq 8 \times 10^6 L_{\odot}$, where $L_{\odot}$ is the bolometric luminosity of the sun. The luminosity per unit area is $\geq 2 \times 10^8 L_{\odot}/\text{pc}^2$, which is ~ 50 times the luminosity per square parsec in the inner 0.2 pc of the Orion Molecular Cloud heated by the Trapezium stars (Thronson *et al.* 1986).

We have also estimated the mass and luminosity of the core of NGC 3603, the most massive optically visible star-forming region in the Milky Way. We used the spectral classifications given by Moffat (1983) for components A through G, and the numbers and magnitude differences of subcomponents of A from speckle observations (Baier *et al.* 1985). Estimating the masses and luminosities as for R136a, we find that, compared to the 0.34 pc region at the heart of NGC 3603, R136a has roughly three times as much stellar mass per unit volume and seven times the luminosity per unit area.

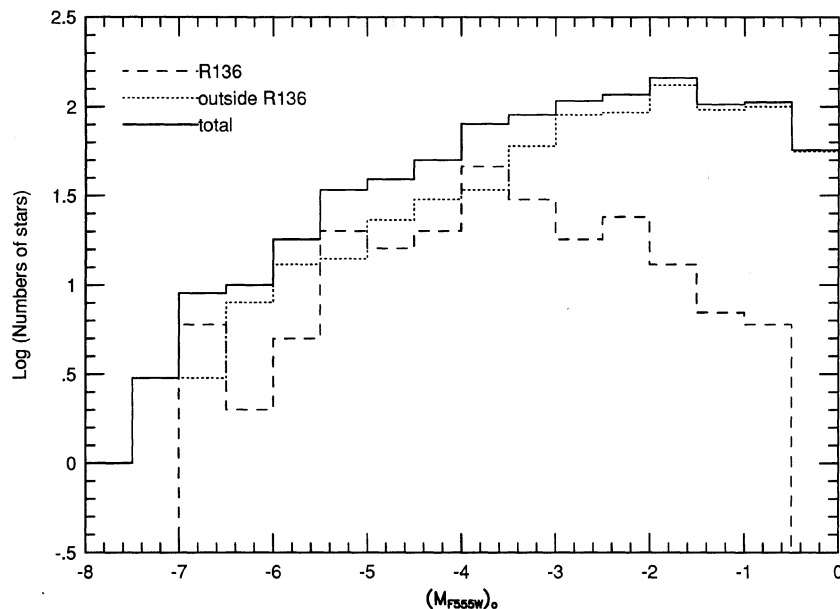


FIG. 11. The log of the luminosity function for the absolute, reddening-corrected F555W magnitude. Stars from Tables 2 through 6 have been placed in 0.5 mag bins.

We have also made estimates of the mass density and luminosity for the 214 stars in R136 using the assumptions of stellar masses given above. In the 1.9×2.2 pc region we define as R136, we total $\geq 3000 M_{\odot}$ and $\geq 1.5 \times 10^7 L_{\odot}$. The average density is $\geq 360 M_{\odot} \text{ pc}^{-3}$, which is ≥ 6000 times the stellar density of the solar neighborhood. The luminosity density is $\geq 4 \times 10^6 L_{\odot} \text{ pc}^{-2}$, which is about the same as the luminosity density of the center 0.2 pc of Orion. In other words, R136 has the same concentration of

stellar luminosity as in the core of Orion, but in R136 it continues over 130 times the area.

Because the limits on r_c are fairly small and ρ_0 is fairly large in absolute terms, it is possible that relaxation effects might be important in R136. The relaxation time is given by

$$t_r = \frac{0.34 \sigma^3}{G^2 m \rho \ln(0.4N)}, \quad (1)$$

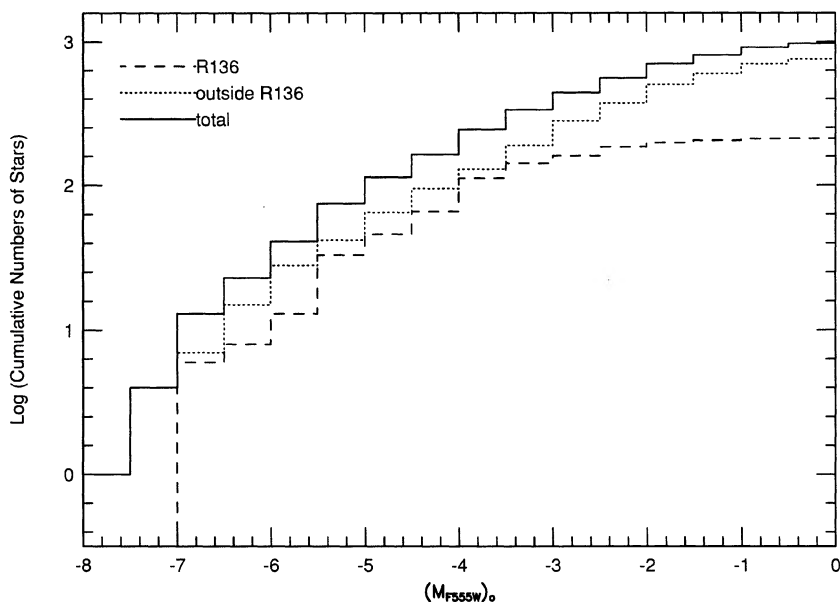


FIG. 12. The log of the cumulative luminosity function for the absolute, reddening-corrected F555W magnitude. Stars from Tables 2 through 6 have been placed in 0.5 mag bins.

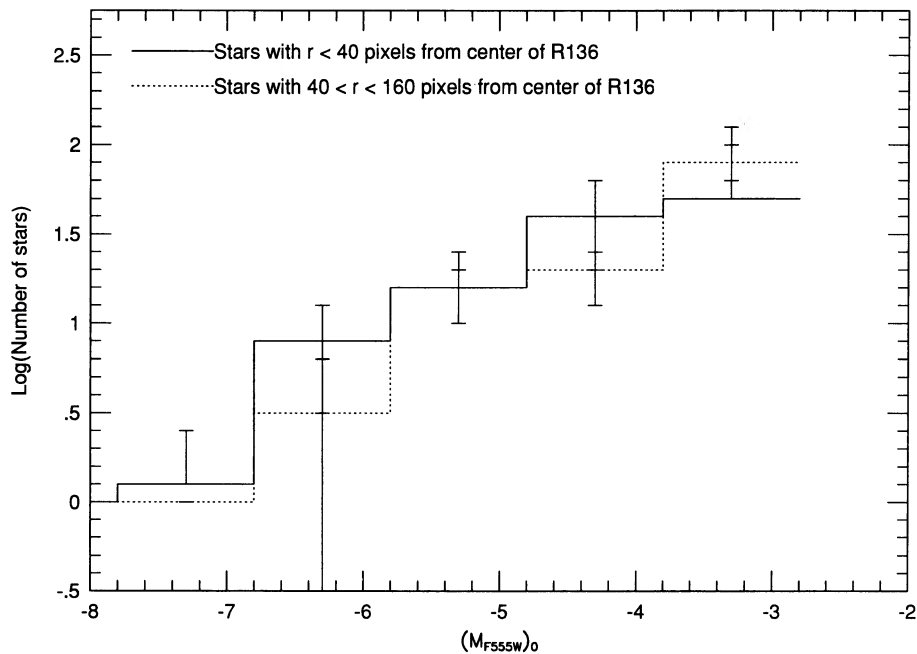


FIG. 13. The F555W luminosity function corrected for incompleteness is shown in one magnitude intervals. The stars are binned into two groups; those within 40 pixels ($1.8''$) of the center of R136 and those in the annulus of 40 to 160 pixels (1.8 – $7''$) from the center. The number of stars in the outer region is normalized to that found in the inner region.

where σ is the one-dimensional velocity dispersion, m is the typical stellar mass, ρ is the total mass density, and N is the number of stars in the system (Binney & Tremaine 1987). If we assume $\sigma = r_c \sqrt{4\pi G \rho_0 / 9}$, then we get

$$t_r \approx 3 \times 10^4 \left(\frac{10 M_\odot}{m} \right) \times \left(\frac{r_c}{0.06 \text{ pc}} \right)^3 \left(\frac{\rho_0}{5 \times 10^4 M_\odot \text{ pc}^{-3}} \right)^{1/2} \left(\frac{1.4}{\ln(0.4N)} \right) \text{ yr.} \quad (2)$$

This time scale is two orders of magnitude shorter than the age of 3.5×10^6 yrs for the cluster required by the presence of Wolf-Rayet stars, and it will be even shorter for smaller values of r_c . This suggests that R136a has undergone core collapse and that its present structure is strongly influenced by relaxation effects.

5. THE CONSEQUENCES OF A LOW MASS STAR POPULATION

One can estimate the mass in low mass stars that should be present in R136 if the initial mass function is not highly unusual. One can apply a mass-to-light ratio for this system and assume that most of the light arises from the observed stars. This assumption should be quite valid since the observed stars are typically 10^4 times more luminous than the average star. The mass-to-light ratio for a burst model between the ages 3×10^6 and 1×10^7 years is between 0.013 and 0.02 (Charlot & Bruzual 1991). This corresponds to a total mass in stars between 260 and 400 times the mass in detected stars. With 400 times greater mass

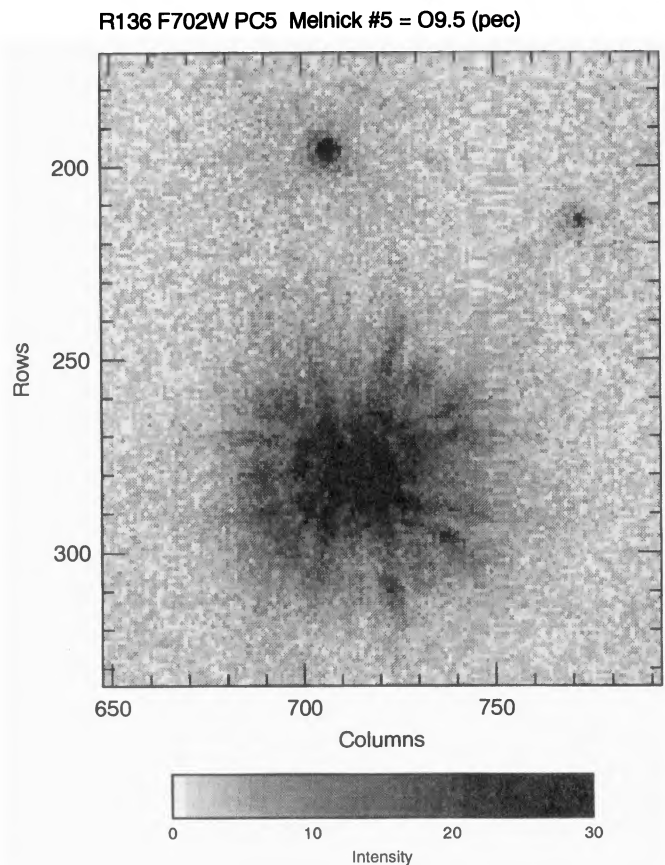


FIG. 14. The image of the peculiar star Mk5 is shown from the F702W frame. The only companion appears to be the much fainter star $1.2''$ to the lower right of Mk5. Ten columns are $0.44''$.

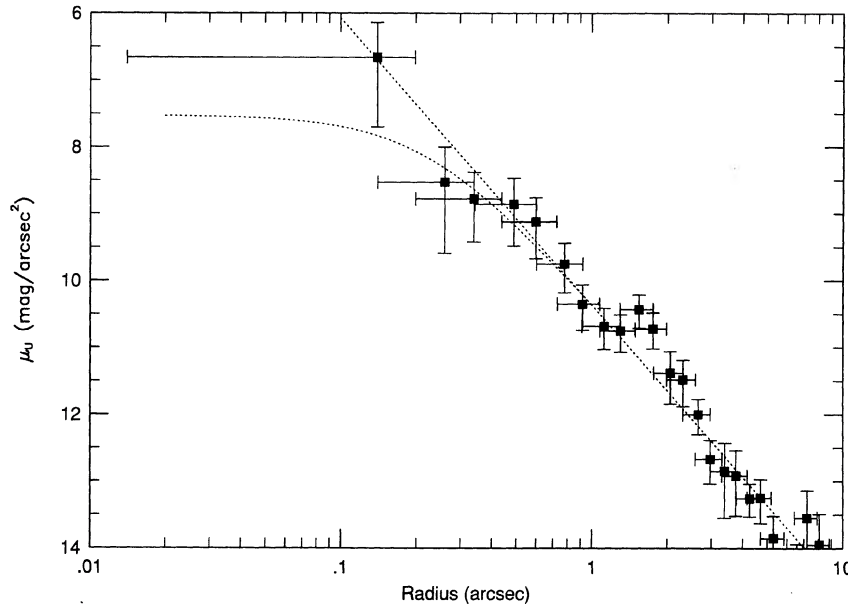


FIG. 15. An F336W surface brightness profile of R136. The upper dotted line shows the form $I(r) \propto r^{-\gamma}$ with $\gamma=1.72$; the lower dotted line shows a profile with $r_c=0.25''$.

and most of that in stars near one solar mass, t_{relax} grows to 5.0×10^5 years. Thus, a factor of 20 in relaxation time is gained by including the low mass stars. In this case, the R136 core would probably not yet have gone through a core collapse.

Equipartition will occur in a few relaxation times. The result of this is that the high mass stars settle down closer to the center of the cluster than the lighter stars. In equi-

librium, the $10 M_{\odot}$ stars will sink to a mean radius of one third the cluster radius defined by the low mass stars. The relevant core radius is therefore somewhat larger than 0.06 pc and subsequently the relaxation time is somewhat longer still. This effect, plus the fact that there have been several full relaxation periods, are indications that the core densities have risen substantially from their initial values and help to explain how such high present densities of high mass stars were obtained. The original core density was probably at least 30 times lower than the present one.

Since the high end slope of the initial mass function is different in R136 and the densities are very high, a natural question to ask is, could collisional mergers have altered the initial mass function? With 1.6×10^5 stars in a 0.25 pc radius, the collision time per star is 10^{11} years. If we say the system is 10^7 years old, then one in 10^4 stars has undergone a collision. This implies that there have been 14 collisions. Therefore, collisional merger is unlikely to have substantially altered the initial mass function.

6. SUMMARY

We have used images obtained with the Planetary Camera on the *HST* through filters F368M, F336W, F555W, F702W, and F469N to explore the stellar population of R136, the core of the 30 Doradus cluster. We found that R136a, the brightest knot at the center of R136, is indeed a tight cluster of stars, containing at least 12 components in a $1''$ region. Three of these stars are of the Wolf-Rayet type. None of the stars in R136a is individually remarkable in terms of its luminosity or color compared to blue massive stars observed elsewhere in 30 Doradus and in other

TABLE 9. F336W surface brightness profile.

r (")	F336W ^a	+σ ^b	-σ ^b	σ _r ^c	σ _μ ^c	No. stars	μ (M _⊙ /pc ²) ^d
0.14	6.66	-0.52	1.04	-1.000	0.151	3	1.475E+04
0.26	8.53	-0.53	1.06	-0.267	0.116	3	6.097E+03
0.34	8.78	-0.40	0.64	-0.233	0.110	6	7.012E+03
0.49	8.86	-0.39	0.62	-0.156	0.090	8	5.801E+03
0.60	9.12	-0.36	0.55	-0.136	0.083	10	4.810E+03
0.78	9.75	-0.31	0.43	-0.110	0.073	13	3.754E+03
0.92	10.35	-0.29	0.39	-0.100	0.068	16	2.772E+03
1.12	10.68	-0.27	0.35	-0.088	0.063	19	2.200E+03
1.30	10.75	-0.24	0.32	-0.082	0.060	24	2.250E+03
1.54	10.43	-0.22	0.28	-0.075	0.056	32	2.570E+03
1.75	10.72	-0.24	0.30	-0.072	0.054	28	1.876E+03
2.05	11.38	-0.32	0.46	-0.067	0.051	24	1.071E+03
2.30	11.48	-0.29	0.40	-0.065	0.050	32	1.126E+03
2.65	12.00	-0.23	0.30	-0.061	0.048	42	9.554E+02
2.96	12.67	-0.28	0.37	-0.060	0.047	38	5.884E+02
3.38	12.85	-0.42	0.70	-0.057	0.045	37	4.093E+02
3.75	12.92	-0.38	0.60	-0.056	0.045	44	4.017E+02
4.26	13.26	-0.22	0.27	-0.054	0.043	52	3.710E+02
4.70	13.25	-0.28	0.38	-0.053	0.043	56	3.272E+02
5.30	13.85	-0.33	0.48	-0.052	0.042	51	2.184E+02
5.84	14.47	-0.21	0.25	-0.051	0.042	55	1.849E+02
6.56	14.16	-0.22	0.28	-0.050	0.041	72	2.068E+02
7.21	13.55	-0.41	0.67	-0.050	0.040	70	1.720E+02
8.07	13.95	-0.46	0.81	-0.049	0.040	70	1.254E+02
8.85	14.90	-0.23	0.29	-0.049	0.040	77	1.147E+02
9.89	14.35	-0.30	0.42	-0.048	0.039	76	1.077E+02

NOTE.—

^aF336W magnitudes corrected by A_{336} .

^bUncertainties in the F336W magnitudes.

^cLeft and right radial bin error (log units). Each point is at the center of a radial bin. The left error extends to the inner radius of the bin, the right to the outer.

^dSurface mass density.

galaxies. The brightest stars have luminosities consistent with their being massive O supergiants or Wolf-Rayet stars. In R136a the stellar mass density is at least a million times that of the solar neighborhood and three times that in the core of NGC 3603. The luminosity density is at least 50 times that of the core (0.2 pc) of Orion and seven times that in NGC 3603's inner 0.34 pc.

In the larger region known as R136 we detected and measured the magnitudes of 214 stars. A color-magnitude diagram in the F336W and F555W filters shows a range in stars from luminous O supergiants to ZAMS B3 stars. The color-magnitude diagram of the stars within R136 is very similar to that of stars outside of R136. There is a spread in $(M_{336}-M_{555})_0$ of about 0.5 mag which is probably partly intrinsic. A clump of redder stars at the faint end is probably due to early ZAMS B stars, and a turn to the red at the bright end could mark the main-sequence turnoff. No red supergiants were detected within R136. An F555W luminosity function also shows the similarity between the types of stars within and outside R136 except for $M_{555} > -4$, at which point the luminosity function becomes incomplete in R136 since fainter stars are harder to detect there. The slope of the upper end of the luminosity function is flatter than that found in Constellation III or in galaxy-wide surveys, due at least in part to the very young age of 30 Doradus. The total luminosity per unit area in R136 is found to be at least comparable to that in the core of Orion, but in R136 this density is sustained over a region that is 130 times larger.

An F336W surface brightness profile constructed from the stellar photometry was found to be best fit by a pure power law with $I(r) \propto r^\gamma$ with $\gamma = -1.72 \pm 0.06$. However, because of the small numbers of stars at the very center, the brightness profile is also consistent with a very small core with $r_c < 0.25''$, considerably smaller than that estimated by Moffat *et al.* (1985) from ground-based observations. If $r_c = 0.25''$, $\rho_0 > 5 \times 10^4 \mathcal{M}_\odot \text{pc}^{-3}$ including only stars with $M_{555} > -0.5$ and incomplete for $M_{555} > -4$. The upper limit on the relaxation time for the cluster implied by this r_c and central density is 100 times shorter than the age required by the presence of Wolf-Rayet stars, suggesting that relaxation effects have been very important in the

observed structure of the cluster unless a large population of lower mass stars is present.

Although we have confirmed that the individual stars in R136a and in R136 are themselves unremarkable, we must stress that they are part of a most remarkable star-forming region. What is extreme is not the masses of the individual stars, but that there is such a high concentration of the most massive stars made anywhere. There are something like 160 stars in R136 that are more massive than about $10 \mathcal{M}_\odot$, at least 8 of which are more massive than $40 \mathcal{M}_\odot$. And, all of this is within 2 pc. Outside of R136 there are also large numbers of very massive stars: 77 O stars, including five of the O3If-type, 11 Wolf-Rayet stars, and a smattering of red and blue supergiants (Walborn 1991). This raises the question: How does the natal cloud contract to a density necessary to form R136 without breaking up into stars sooner? Furthermore, what will be the consequence to the Large Magellanic Cloud?

The latter question is a little easier to address. Since massive stars live such short lifetimes, we expect that the stars within R136 formed pretty much all at the same time. That means that there will be several hundred supernovae exploding over a period of perhaps ten million years. The energy released is likely to have a major impact on the surrounding interstellar medium. It has been argued that 30 Doradus is on its way to blowing a hole in the interstellar medium (cf. Cohen *et al.* 1988), such as the stars in Constellation III have done (Dopita *et al.* 1985). 30 Doradus will probably also become a galactic fountain in the end, like LMC2, the supergiant shell to the east of 30 Doradus (Wang & Helfand 1991). Certainly, a star-forming event such as 30 Doradus is a major perturbation in a small galaxy like the LMC.

B.C. gratefully acknowledges the unfailing logistical and moral support of E. Jaderlund and S. Durham from her home institution. We are also grateful to T. Kreidl who made the original suggestion to include R136 among the GTO targets. This work was conducted by the WF/PC Investigation Definition Team, under NASA Contract No. NAS5-25421.

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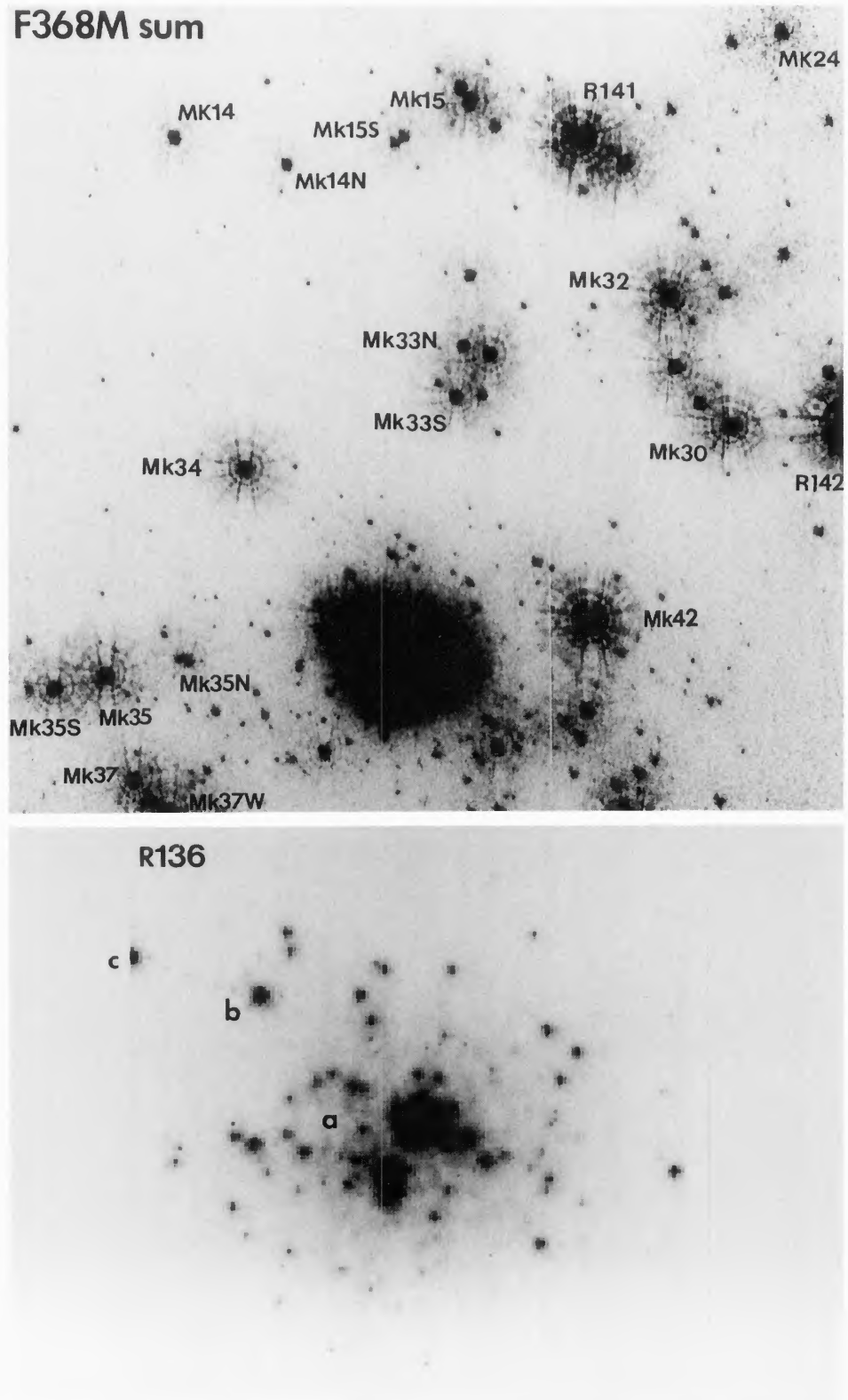
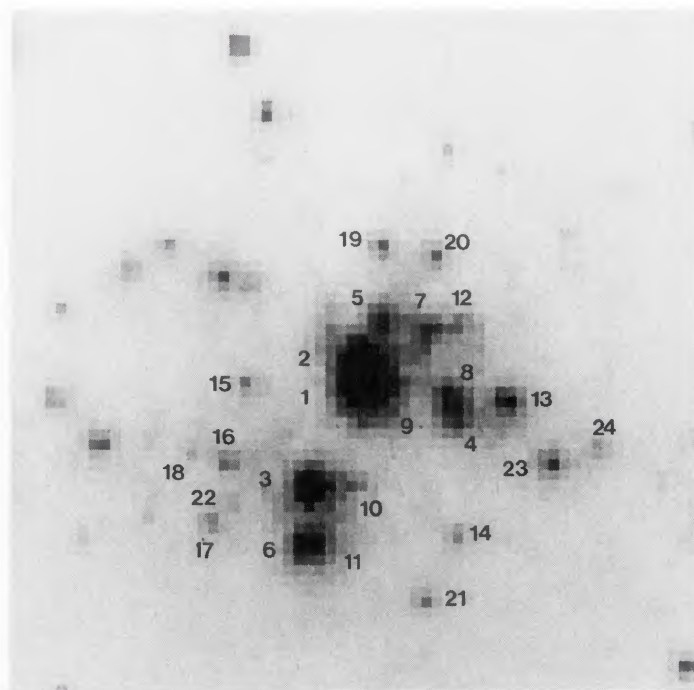


FIG. 1. The top frame is the full 800×800 (35") PC6 F368M image of the 30 Doradus field containing R136. The field is oriented such that north is rotated about 65° counterclockwise. Stars catalogued by Melnick (1985) are identified as "Mk." The bottom panel shows the inner 5.6" of the cluster from the same image. R136a, b, and c (Feitzinger *et al.* 1980) are identified.

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F368 sum

R136a



Deconvolved

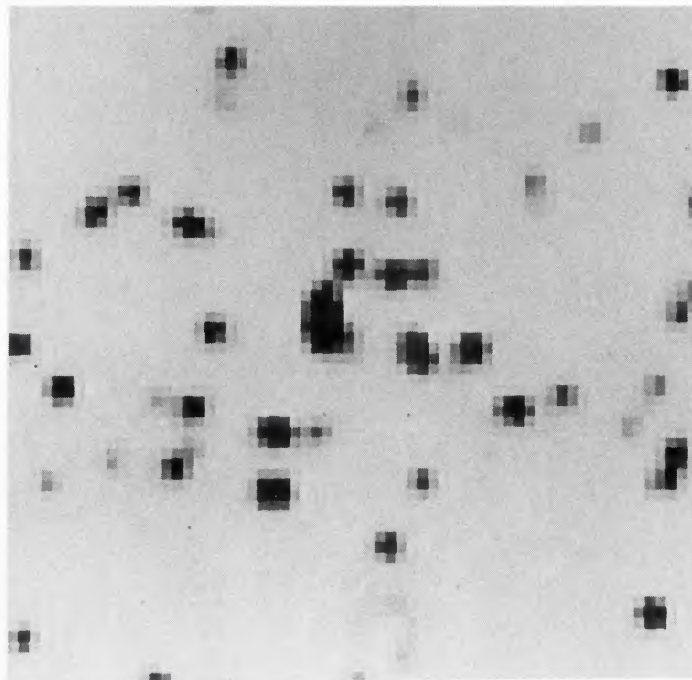


FIG. 2. (a) The top frame displays a 2.8" portion of the F368M image so that the individual stars in R136a can be seen. The stars in approximately the inner 1.5" are numbered starting with eight components identified by Weigelt & Baier (1985) from speckle observations. (b) The bottom frame shows the same field after deconvolution using the Lucy (1974) algorithm.

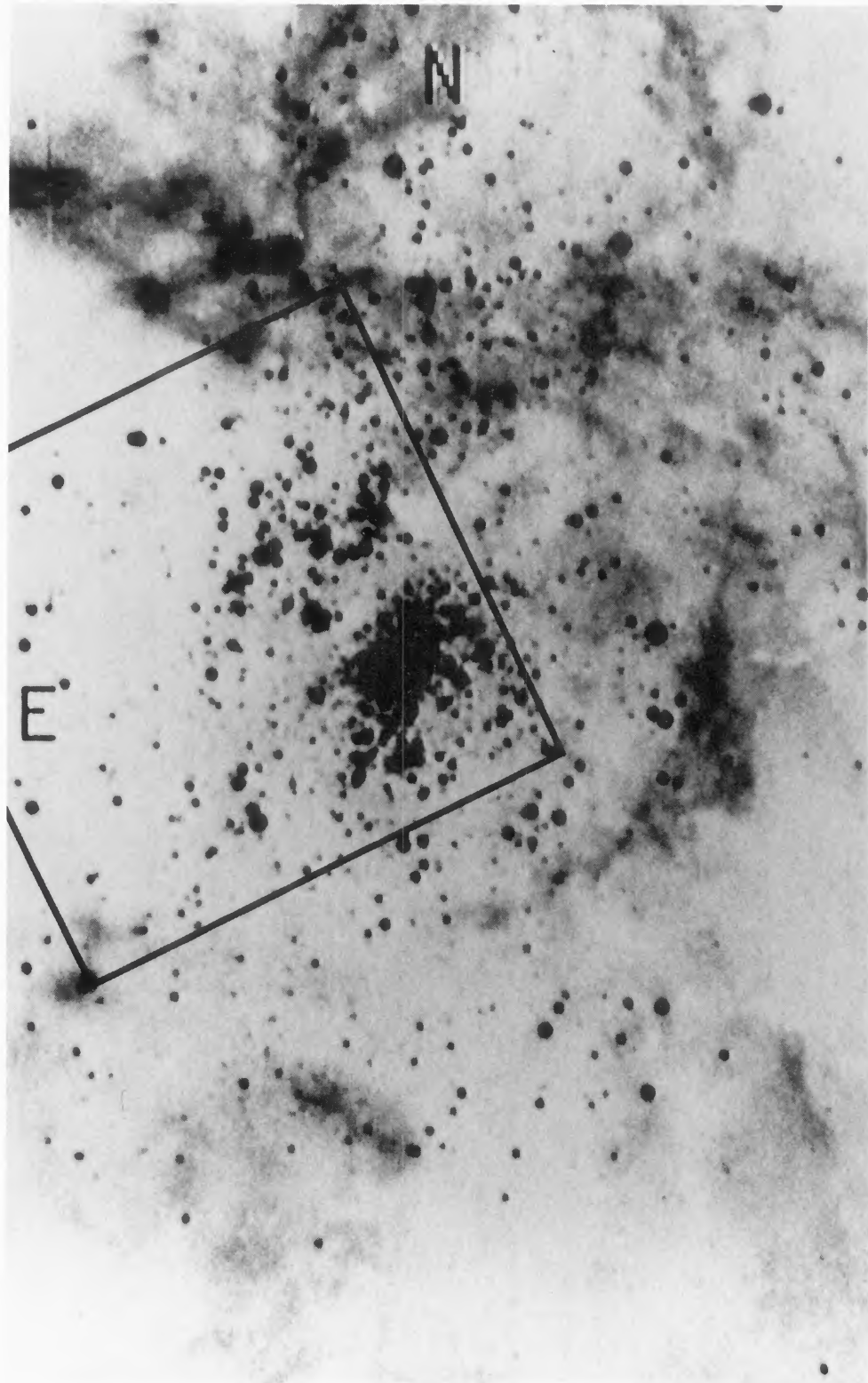


FIG. 3. The field of view and orientation of the PC (all four CCD's) in the 1991 images is outlined on a ground-based *V*-band image of the region which was kindly loaned to the WF/PC team. The field is 67'' on a side.

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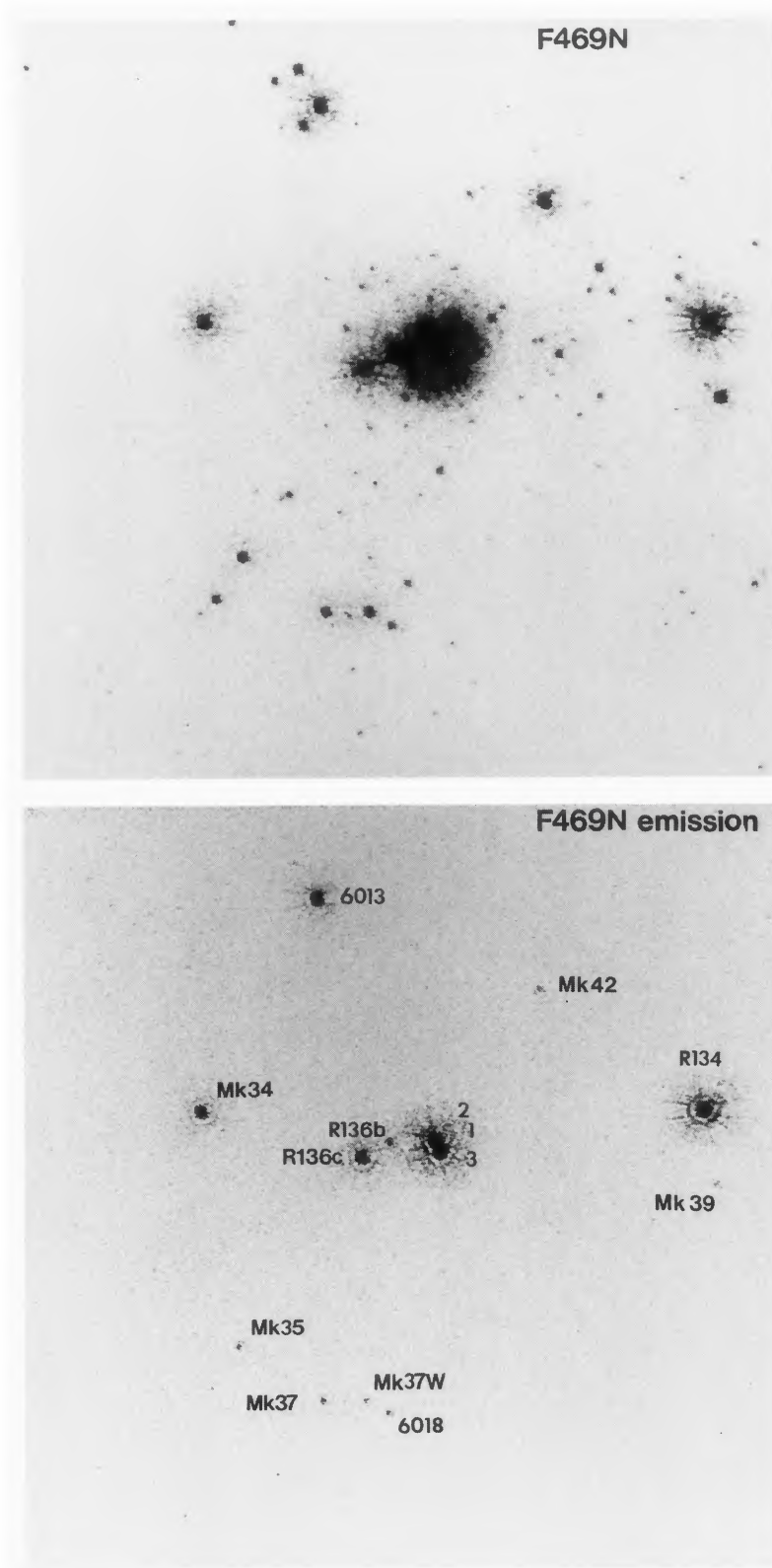


FIG. 6. The F469N PC6 images are shown. The top panel is the unsubtracted image; the bottom image has had the stellar continuum subtracted from it to leave only He II $\lambda 4486$ emission.