NEW OPTICAL OBSERVATIONS OF R136

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Introduction

R136 is the luminous central object of the 30 Doradus nebula in the LMC. Its bluest and brightest component R136a has been interpreted as a supermassive star with a mass of approximately 2000 $M_{\odot}$, based on its unusual UV spectral properties and the assumption that it is responsible for most of the ionization of the 30 Dor nebula (Feitzinger et al. 1980; Cassinelli et al. 1981; Savage et al. 1983). On the other hand, R136a has also been argued to be the core of a dense cluster, since the integrated light distribution from 0.2 to 22 pc radius centered on R136a is similar to that of a globular cluster (Moffat and Seggewiss 1983), and its optical spectrum can be synthesized by its nearby early-type stars (Melnick 1983).

Observations

We obtained a series of prime focus plates of R136 on the 4m telescope at Cerro Tololo Inter-American Observatory during two observing runs in January and February 1983. These new plates are characterized by their short exposure time and the use of narrow interference filters. The exposure time is typically 30 sec to 4 min for the single exposure plates, and 2 to 10 sec for each exposure on the multiple exposure plates. The filters used are centered on 1) blue continuum, 4765 Å, 2) HeII line, 4686 Å, 3) red continuum, 6485 Å, and 4) Hα line, 6563 Å. These filters were chosen to allow us to detect line emission objects and determine the colors of the stellar components.

The star R131 (B9I, V=10^{m}.24) was used to calibrate both the flux and the seeing for each exposure.

Results

1) Light Distribution in R136 - R136 is clearly resolved into a, b, and c components. R136a apparently has a bright component and several fainter components superposed on an extended background (3"x4"). The shapes of the innermost isophotes are consistent with the micrometer measurements of a_1 and a_2, a_2 being at (0".5, 220°) from a_1. Farther away from a_1, there are two components about 2-3 mag fainter at (1".2, 80°) and (1".5, 160°), a much fainter component at (1".6, 10°), and

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a still fainter component at (2".6, 320°). Since these components and the extended background are detected in passbands that exclude nebular emission lines, the light sources must be stellar, not nebular.

2) Color and Brightness of R136a_1 and the Background - Assuming that R136a has two unresolved components a_1 and a_2, and an extended background, we can use the 2-D brightness profile of R131 as point spread function to decompose R136a. In this analysis, the ratio of a_2:a_1 may be uncertain by 50%, depending on the estimated positions of a_1 and a_2. However, the brightness of a_1 can be relatively accurately determined to 10%. We have also integrated the total light within a 3" diameter area. The brightness of R136a_1 and 3"-aperture in the four passbands is summarized in the following:

	BC	HeII	RC	Hα
R136a_1:R131	0.42:1	0.54:1	0.33:1	0.44:1
(3") :R131	1.14:1	1.34:1	0.92:1	1.12:1
R136a_2:R136a_1*	0.3:1	0.3:1	--	0.4:1

* This ratio may be uncertain by 50%.

Note that the brightest unresolved component a_1 only contributes about 37% of the light from a 3" area.

We have interpolated between the BC and RC passbands to obtain V magnitudes. Assuming an A_V of $1^m.2$ for R136, we derive

$$V\ (\mathrm{R136}a_1) = 11^m.22, \quad V\ (3'') = 10^m.13 \quad \text{and}$$
$$M_V\ (\mathrm{R136}a_1) = -8^m.58, \quad M_V\ (3'') = -9^m.67$$

The flux ratio $F_\lambda(4700Å)/F_\lambda(6500Å)$ is essentially a color indicator. We find this ratio to be 3.5 and 3.4 for R136a_1 and (3"), respectively. This flux ratio for a B9 star or a WN5 star is about 2.5, while for hot stars with T_{eff}=35,000 to 45,000 the flux ratio is about 3.6.

Conclusion

The new data of R136a presented here do not exclude either a single supermassive star hypothesis or a core of a cluster hypothesis; however they do set tighter constraints on the properties of R136a.

a) Single Supermassive Star - So far this hypothesis is still consistent with all observations. If the stellar components of R136a all have similar spectral energy distribution, then R136a_1 only contributes 37% of the UV flux, and its mass would be reduced accordingly to ≈ 750 $M_\odot$.

b) Core of a Dense Cluster - If R136a_1 consists of "normal" stars, then about 6-8 luminous O3 stars like R122 or about 15-20 "normal" O3 stars like HD 93250 are needed to provide the UV spectral features. So many O3 stars in a volume of diameter≈0.03 pc would be more remarkable than any known clusters.

References

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