THE INTERACTION OF THE SUPERMASSIVE OBJECT R136a WITH THE INTERSTELLAR ENVIRONMENT

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R136a is the luminous object in the core of the 3o Dor nebula in the LMC, embedded in the extremely young star cluster NGC 2o7o with the most recent star forming event less 1o^{6} yr ago. R136a-1 (V = 11.o8) lies in the center of this cluster. The companion or foreground star R136a-2 (ca. 1.2^{m} fainter than R 136a-1) o″.5 apart does not impair the dominating role of R136a-1. The light distribution is strongly peaked to the center of R136a and disagrees completely with Moffat and Seggewiss's (1983) description and their interpretation as a dense core of a cluster (Chu and Wolfire, 1983). This is strenghtened by the UV observations (Cassinelli et al. 1981, Feitzinger et al. 1983, Savage et al. 1983): the spatial spread function of the IUE satellite is dominated by an object of extremely small ultraviolet extent, less than that of a gaussian with 1″.5. Speckle observations (Meaburn, 1982; Weigelt, 1981), are discordant in the interpretation of the faint background, but concordant in revealing the existence of a small bright component, with an upper limit of the diameter $<$ o.o2 pc. This is also found, with somewhat lower resolution, by Chu (1984).
The properties of this unprecedented object are listed in Table 1.

Table 1

	Multiple System or Cluster Core	Single Star R136a-1		
		Bochum	Bologna	Wisconsin
Luminosity	1o^{7} L$_\odot$ (Moffat, Seggewiss 1983)	7·1o^{7} L$_\odot$	6·1o^{7} L$_\odot$	6·1o^{7} L$_\odot$
Temperature	-	6.2·1o^{4} K	5.2·1o^{4} K	7.5·1o^{4} K
Radius	-	65 R$_\odot$	84 R$_\odot$	5o R$_\odot$
Mass	several stars with $<$ 22o - 28o M$_\odot$ (Walborn 1983)	25oo M$_\odot$	$>$2ooo M$_\odot$	21oo M$_\odot$ ($>$8oo M$_\odot$)
Mass-Loss	-	4·1o^{-4}M$_\odot$/a	5.2·1o^{-4}M$_\odot$/a	5·1o^{-4}M$_\odot$/a

The influence of the nebulae ($\sim$2o % pollution) and the neighbouring stars ($\sim$3o % pollution) is carefully taken into account. The luminosity is derived from the requirement that the star produces 5·1o^{51} hydrogen

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ionizations/sec in the 3o Dor nebula. The calculated mass loss of $3\ 1o^{-4}\ M_\odot/yr$, derived from the line profiles of CIV and NIV, fits well into the domain of the model parameters describing R136a as a supermassive object. A further realistic estimate of the stellar mass can be derived from the empirical proportionality between terminal and escape speed (Abbott 1978), $v_\infty = 3v_{esc}$; thus we obtain M ~2600 $M_\odot$. Further, R136a fits with its temperature (Table 1) extremely well into the relation between T_{eff} and v_∞ (Underhill 1983).

Ly-continuum radiation and stellar winds are structuring the 3o Dor nebula. Using the tabulation of return of mass and energy to the interstellar medium by winds from early type stars (Abbott 1982), the following energy input can be set up:

Source	Wind Energy	Comment
R136a	$2\text{-}5\ 1o^{39}$ erg/s	The uncertainty is essentially due to the error of the mass loss
Nine central stars including R136b,c	$2\text{-}4\ 1o^{38}$ erg/s	Uncertainty due to the fact that the 3o Dor objects are more luminous than normal WR stars
Stars within 9o" from R136	$1\text{-}2\ 1o^{38}$ erg/s	

The typical energy necessary to build up a stellar wind bubble is approximately $2\ 1o^{38}$ erg/s (MacCray and Snow 1979, Dyson and Williams 198o, Meaburn 1981) for a bubble with a radius of 5o pc and initial electron density of 8 cm^{-3}. This means that R136a (together with the whole stellar population of 3o Dor) is just sufficient to energize the multitude of shells and to structure the whole nebula. Walborn's (1984) O and B stars in 3o Dor can account for at most 2/3 of the excitation (assuming the earliest spectral classifications), at least 8 % (assuming the latest types) with a median of 2o %. The dominating role of R136a is corroborated.

The observed velocity components (Fig. 1) (optical and UV absorptions and emissions) can be combined to give an overall picture of the velocity structure in that particular region (Feitzinger et al. 1984). Different shells and the central bubble, powered by R136, determine the morphology of the 3o Dor region.

The expansion velocity of 25 km/s can be used to derive the age of the innermost shell (see Fig. 4, 5 of Feitzinger and Schmidt-Kaler 198o). The radius of this shell is ~1o pc, giving an expansion age of $4\ 1o^5$ yr. By stellar evolutionary arguments R136a cannot be much older than $1o^6$ yr, in excellent agreement with the age of the giant population deduced by IR measurements (McGregor and Hyland 1981). Finally, the lifetime of supermassive objects should be smaller than $1o^6$ yr to overcome the inherent instability. The high mass loss rate may stabilizes such objects.

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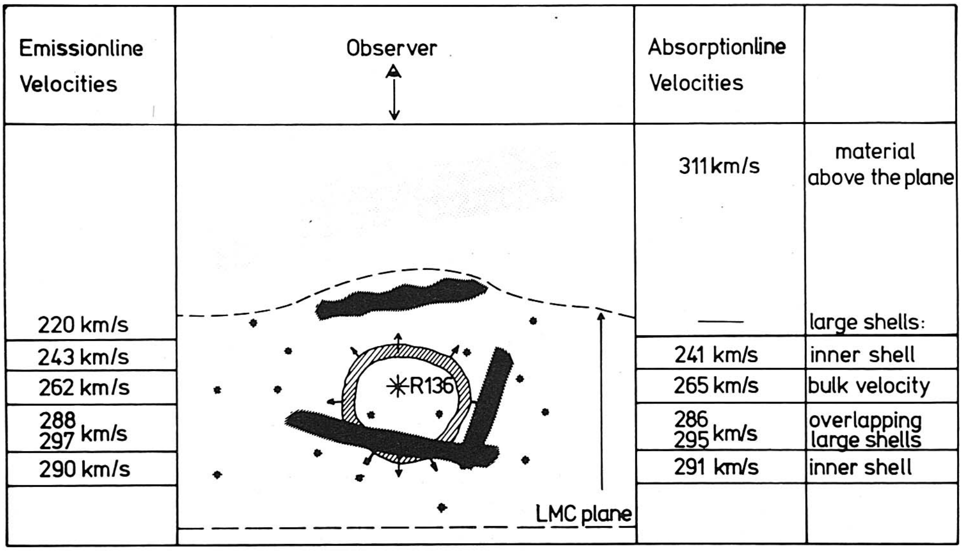

Fig. 1 A schematic model attempting to explain the observed velocity components in the innermost part of 3o Dor.

DISCUSSION

Walborn: At IAU Symposium 108 in Tübingen last week 2 hours of review and panel discussion plus 4 posters were devoted to R136. Many new observations were presented, most of which support the interpretation of R136 as a compact, massive multiple system. The three principal points are (1) more than half of the ionization of the 30 Doradus Nebula probably is provided by over 100 O-stars in the central cluster other than R136; (2) detailed comparisons between R136 and HD 97950 in the supergiant galactic HII region NGC 3603 show that they are very similar O+WN multiple systems and (3) the multiple structure of R136 is observed directly by 4 independent and concordant visual micrometer, photographic and speckle interferometry techniques. A weak upper limit for the most massive single object in R136 is now a few hundred, and not a few thousand, solar masses. The interpretation of R136 is of course vital for that of the more distant objects.