Star Formation in the Merging Galaxy NGC3256

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Abstract

We have mapped the central 5kpc of the ultra-luminous merging galaxy NGC3256 (Graham et al. 1984) at J, H, K, L, & 10μm, and obtained 2μm spectra of the nuclear region. We use this data to identify and characterize the super-starburst which has apparently been triggered and fuelled by the merger of two gas-rich galaxies. We will also show that the old stellar population has relaxed into a single spheriodal system, and that a supernova driven wind might eventually drive any remaining gas from the system to leave a relic which will be indistinguishable from an elliptical galaxy.

1 Introduction

NGC3256 is a spectacularly disturbed galaxy which has been identified as a merger (Toomre 1977). At a distance of 50Mpc (H_0=50km/s/Mpc) this is one of the closest and most luminous such systems, and therefore it can be studied in some detail. The IR maps of NGC3256 were made at a resolution of 5", which corresponds to 1.3kpc. These maps show emission extending over 5kpc.

2 Mapping and Spectroscopy

The 10μm emission is quite remarkable both in its extent and luminosity (see figure 1). The 10μm luminosity (defined as νL_ν) in the central kpc corresponds to $1x10^{10}$ $L_\odot$, this increases to $3x10^{10}$ $L_\odot$ within 2kpc of the nucleus, and to $6x10^{10}L_\odot$ in IRAS band I (12μm, projected aperture of 12x70kpc). Thus not only does this galaxy rank among the most luminous galaxies known (e.g NGC6240 or Mrk231, Wright et al.; 1984, Rieke et al. 1978) but most of the IR luminosity arises from outside the central kpc!

Table 1

10μm Luminosity

Aperture (")	Corresponding Distance (kpc)	10μm Luminosity ($L_\odot$)
3.5	0.9	$8.4x10^9$
5	1.3	$1.4x10^{10}$
15	3.9	$3.4x10^{10}$

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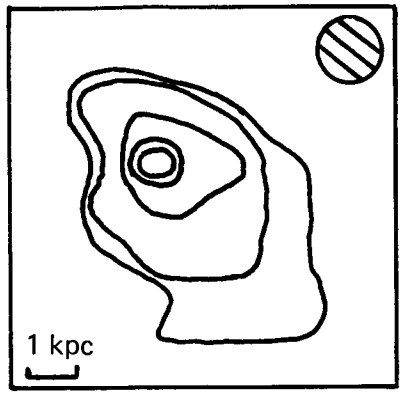

Figure 1

A map of NGC3256 at 10μm. The map was made at a resolution of 5" which corresponds to a distance of 1.3kpc. This map, and multi-aperture 10μm photometry shows that most of the emission at this wavelength arises from beyond the central kpc. The map contours are 44, 88, 175, 350, 700 mJy/beam.

Although this galaxy is thought to be the merger of two disc galaxies there is no evidence for two distinct systems from the near-IR colour maps (J, H, & K). These maps show that the distribution of old stars is relatively smooth. The structure which is present can be interpreted as due to extinction. The J-H map demonstrates that the structure to the south of the nucleus is caused by a dust lane with $A_V \sim 2$ mags. The near-IR colours can be explained in terms of emission from the old stellar population, reddened at J, and with some evidence for an additional hot dust component at K. The K-L colour on all pixels on and around the nucleus is > 1.0, indicating a strong non-stellar dust component at 3.5μm. The K-L colour map shows 2 off-nuclear 'hot-spots' indicating positions of high star formation efficiency. Multi-aperture photometry at K shows that the distribution of old red stars can be described accurately by a $r^{1/4}$ profile out to a radius of at least 5kpc. This indicates that as predicted violent relaxation has occurred following the collision producing a stellar distribution similar to that found in elliptical galaxies.

A spectrum of NGC3256 at 2μm shows two strong lines at $\lambda = 2.163$ and 2.134μm, which we identify as Bγ and H_2 1-0 S(1). The luminosity in these lines is approximately the same and equal to $7 \times 10^6 L_\odot$. The luminosity in these lines is high. In particular the H_2 flux exceeds that of NGC1068 (Thompson et al. 1978) and is comparable to Arp220, but an order of magnitude less than NGC6240 (Joseph et al. 1984)

Table 2

Spectroscopy

Wavelength (μm)	Line	Luminosity ($L_\odot$)
2.163	Bγ	7×10^6
2.134	H_2 1-0 S(1)	7×10^6

3 NGC3256 as a super-starburst.

The observational evidence overwhelmingly points to recent and extensive star formation triggered and fuelled by the merger of two gas-rich disc galaxies. The sheer extent of the luminosity at 10μm (5kpc), and its lack of confinement to nuclear regions is the single most persuasive piece of evidence in favour of star formation. Combining the above data the starburst within a radius of 1.5 kpc of the nucleus can be characterized by $4x10^6$ B0 stars producing a total of $3x10^{54}$ Lyman continuum photons per second, and a luminosity of $2x10^{11}L_\odot$ (see table 3).

Table 3

The Starburst within 1.5kpc of the nucleus

Total Luminosity ($L_\odot$)	$L_{B\gamma}/L_{IR}$	Spectral Type	# of Stars required
$2x10^{11}$	$4x10^{-5}$	B0	$4x10^6$

The ratio of H_2 emisssion in the 1-0 S(1) line to total luminosity is $4x10^{-5}$. A ratio of $1x10^{-5}$ would be expected for a star formation region such as Orion.

Finally we note that the energy that will be released when these young stars explode as supernovae exceeds the binding energy of the gas (as determined from the rotation curve) by a factor of 50. Thus, it is very likely that a supernova driven wind will blow away any gas remaining after the starburst has faded, and leave a relic which will be indistinguishable from an elliptical galaxy.

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