EVIDENCE FOR EXTENDED IR EMISSION IN NGC2798 AND NGC6240

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ABSTRACT

Extended emission at 10 and 20 μm can be used to distinguish starbursts from "monsters" as the underlying energy source driving the luminous infrared emission in the central regions of galaxies. We have investigated the spatial extent of the mid-infrared emission in the interacting galaxy NCG2798 and the merger NGC6240. The 10 and 20 μm profiles of the IR source in NGC2798 are significantly wider than beam profiles measured on a standard star, supporting a starburst interpretation of its IR luminosity. For NGC6240 there is marginal evidence for an extended 10 μm source, suggesting that a significant fraction of its IR luminosity could be produced by a burst of star formation.

I. INTRODUCTION

One of the outstanding questions in extra-galactic IR astronomy is the nature of the underlying energy source powering the large IR luminosities found for many interacting galaxies.

Evidence is emerging that bursts of star formation of exceptional intensity compared to normal spirals and canonical "starburst" galaxies are responsible for the IR activity in interacting galaxies (cf. Joseph et al. 1984, Lonsdale et al. 1984, Cutri and McAlary 1985). Moreover, the subset of interacting galaxies in which a merger of the two participating galaxies has occurred are among the most luminous IR galaxies known (Joseph and Wright 1985) and it appears that the merger has resulted in a "super-starburst". However, this interpretation is open to debate because the interaction may provide the material to feed an accretion disk around a collapsed object in the nucleus. This "starbursts and monsters" debate (cf. Heckman et al. 1983) is especially controversial for the ultra-luminous merging galaxies such as NGC6240 and Arp220, although it applies to all the IRAS galaxies to some degree.

Potentially one of strongest arguments in favour of a starburst interpretation is spatially extended mid-IR emission. For a single central source heating a dust cloud, the dust can be heated sufficiently to radiate at 10 μm only if it is within a few pc of the source. So, measuring the extent of the IR emission discriminates between a compact source heating a dust cloud and luminosity sources distributed over several hundred pc, the latter being expected if the underlying energy source is a burst of star formation.

II. OBSERVATIONS

Observations of the interacting galaxy NGC2798, for which $L_{IR} \sim 6 \times 10^{10}$ L$\odot$, and the merger NGC6240 which has $L_{IR} \sim 10^{12}$ L$\odot$, were made at UKIRT in February 1986. N-S and E-W profiles of the IR sources were made by obtaining photometry on the optical

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nucleus of the galaxy and then moving off the central pixel 0.75 arcsec at a time, using the UKIRT TV crosshead to obtain as accurate an offset as possible. To minimise systematic effects, such as drifts, each step out from the central pixel was made first to one side and then to the other. Observations of a nearby standard star were obtained using exactly the same method, so any residual systematic effects should be the same for both the galaxy and the star observations. A chopper throw of ~ 30 arcsec perpendicular to the offset direction was used for all the observations.

III. RESULTS

Profiles of NGC2798 in a N-S direction were obtained at both 10 and 20 μm and in an E-W direction at 10 μm. NGC6240 was observed with offsetting in a N-S direction at 10 μm. Figure 1 shows the profiles of the galaxies compared to the profiles of a nearby standard star. The position marked (0,0) is the position of the optical nucleus. The horizontal error bars are an estimate of the pointing error relative to the (0,0) position, based on the degree of consistency of the standard star profiles and the ease of guiding on the TV. The profile of the standard star has been scaled to give the best fit to the peak flux, and centred to produce the best alignment of the profiles. It is evident from these figures that the data for the galaxies indicate a wider profile than the beam profiles measured on a standard star. To estimate the significance of the difference between the galaxy profile and that of the star, we have calculated the significance with which each point lies outside the beam profile by comparing the point to profile distance with the error ellipse. The overall significance of the evidence for spatial extent is obtained by summing in quadrature the significances of each point. The significance levels of the spatial extents indicated in the galaxy profiles are given in Table I.

Table I

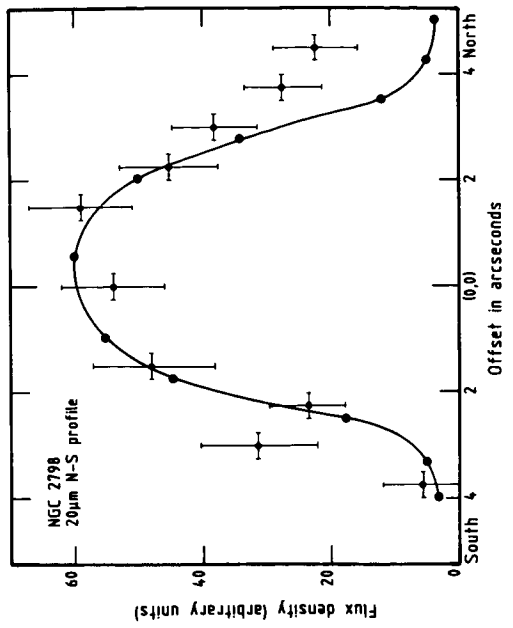
The significance of the difference between the galaxy and standard star profiles

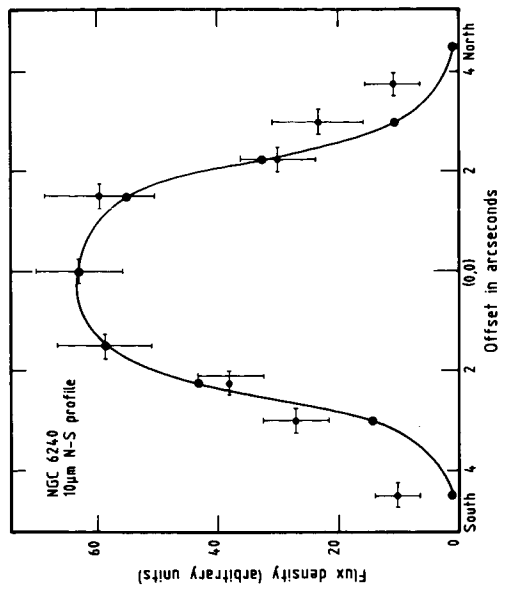
NGC2798 20 μm N-S	NGC2798 10 μm N-S	NGC2798 10 μm E-W	NGC6240 10 μm N-S
4.5 σ	4.5 σ	3 σ	3 σ

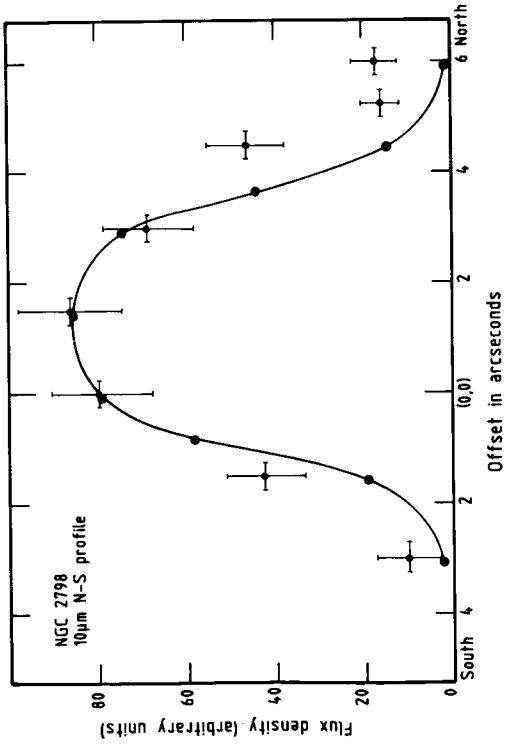
We have also explored the likely size of the sources, by convolving the beam profile with a top hat function of variable width and adjusting the width of the top hat, the scaling of the profile and its alignment to obtain the best fit to the data points. This gives a source size of approximately 4 arcsec for all the profiles.

IV. DISCUSSION

For NGC2798 there is good evidence for extent at both 10 and 20 μm, and this is consistent with our multi-aperture photometry at 10 μm. We find a flux of 190 ± 18 mJy in a 5 arcsec beam and 520 ± 105 mJy in an 8 arcsec beam. The IRAS data (770 and 3130 mJy at 12 and 25 μm respectively) when compared with our 10 and 20 μm data are also consistent with a spatially extended IR source. Non-equilibrium heating of small dust grains by a compact underlying energy surce is unlikely to be producing this extended emission because there is extent at 20 μm, where such grains would radiate less effectively, on a similar scale to the 10 μm emission. The spatial extent inferred for the source, ~ 4







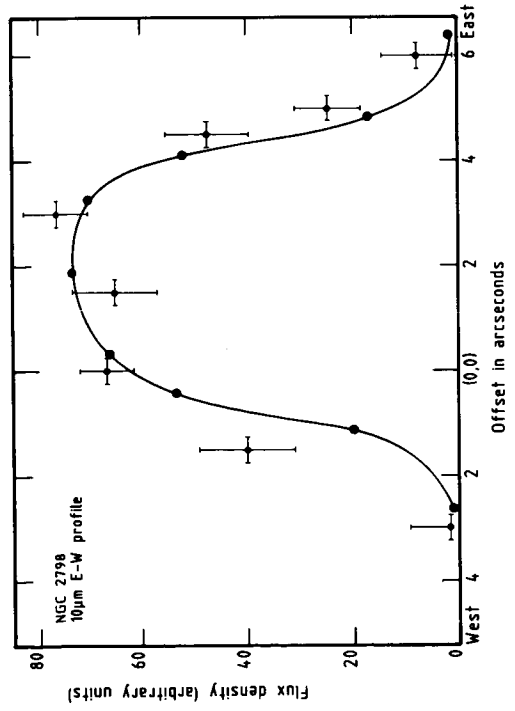


Figure 1. Profiles of the galaxies NGC2798 and NGC6240 compared with those obtained on a nearby standard star. The position marked (0,0) is the position of the optical nucleus.

arcsec, corresponds to 660 pc in NGC2798. This is much larger than the ~ 1 pc source size expected if the dust is heated by a single nuclear source. A burst of star formation is thus the most natural interpretation of the IRAS luminosity of NGC2798. The results for NGC6240 are more marginal than those for NGC2798. Nevertheless they indicate that for this ultra-luminous IR galaxy the nuclear source may be extended. This suggests that a massive burst of star formation could be the underlying energy source for a significant fraction of the enormous IR luminosity of this galaxy.

V. CONCLUSIONS

The data presented provide good evidence for spatially extended 10 and 20 μm emission in NGC2798 supporting a starburst interpretation for the 6 x 10^{10} $L_\odot$ IR luminosity of this interacting galaxy.

For NGC6240 there is marginal evidence (~ 3 σ) for an extended 10 μm source. This suggests that this ultra-luminous IR galaxy may indeed be the result of a super starburst, a conclusion which would be strengthened by the detection of extended 20 μm emission.

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