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ULIRGS: ORIGIN AND EVOLUTION

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We present our preliminary results on the study of high luminosity ULIRGs ($L_{\rm FIR} > 10^{12.3}L_\odot$) in the 1 Jy sample. Deep, high resolution optical R images with a 7 arcmin × 7 arcmin field of view for 2/3 of the whole sample, show that they are generally found in very rich environments, seem to be late-stage merger products (long tidal tails are found in only three systems), and all show multiple nuclei (double nuclei in eleven: two H II, fourLINERs, four Sy2s and one Sy1). The GTC first-light instruments are very well suited for addressing the question of the energy source of ULIRGs and will provide us with a more refined view of the proposed evolutionary sequence.

1. INTRODUCTION

The most conspicuous finding by *IRAS* (Soifer et al. 1987) was the discovery of a new population of galaxies emitting at far-infrared (FIR) wavelengths whose energies are comparable to those of the most luminous quasars. Such similar power between QSOs and luminous infrared galaxies could be explained considering the latter as dust-enshrouded QSOs. The immediate question to answer is the nature of the energy source.

The first *IRAS* data concerned a sample of nine optically very faint ($L_{\rm IR}/L_B > 20$) galaxies. Only two of these (Arp 220 and NGC 6240) had been already classified in the optical range, both with very perturbed morphologies. The most likely explanation for the large observed FIR luminosities ($\approx 10^{12}\ L_\odot$) is that they should host very strong UV-emitting sources, very deeply obscured by large amounts of dust; the dust would be heated by the UV radiation and re-radiate in the FIR. During the late 1980s and at the beginning of the 1990s the question of whether a black hole or a starburst is the nuclear source was posed. Rowan-Robinson's models for their spectral energy distributions (SEDs) showed that, whereas both cirrus and starburst components were always needed, the active nucleus was not invoked in all cases.

Optical spectra showed that most of these galaxies better resembled those of LINERs than of type 1 or 2 Seyferts. The characterization of a complete sample of ULIRGs had to await until 1995: Veilleux et al. (1995); Veilleux et al. (1999) showed that the percentage of H II-like nuclei, LINERs and Seyferts changes as a function of the IR luminosity. For low $L_{\rm FIR}$ most of the nuclei are starburst-like; up to 60% of the most luminous ULIRGs are Seyfert-like, only 20% of them being H II-like. Interestingly, the percentage of LINERs (30%) remains constant in spite of their $L_{\rm FIR}$ level. An evolutionary scheme appears to explain this dependence on $L_{\rm FIR}$ of the nature of the energy source.

2. AN EVOLUTIONARY SEQUENCE

Strongly interacting systems are highly frequent among ULIRGs, and their properties are therefore studied in connection with the effects of merging processes. Sanders et al. (1988) suggested that ULIRGs would evolve in luminosity as precursors of optically selected quasars. Following this scenario, massive star formation induced by stong gravitational interaction would be the first energy source; later in the merger sequence more and more star formation is produced and eventually very compact stellar clusters are formed that could give rise to the formation of a massive black hole (BH); the BH should be fed up with material from the circumnuclear regions, where starbursting processes would take place and consequently an obscured QSO could be observed.

The morphologies of ULIRGs have been classified (Surace et al. 1998; 2000; Surace & Sanders 1999) as: I) Pre-contact; II) first contact without tidal tails; III) pre-merger with tidal tails and double nuclei separated a) more than 10 kpc and b) less than 10 kpc; IV) merger with long tidal tails and a single a) diffuse and b) compact nucleus; V) final stage merger, with no tidal tails and strong central perturbations.

Following this classification, Veilleux et al. (2001) has found that the percentage of H II-like, LINER and Seyfert (S1, S2) nuclei is: III: 40% H II, 40% LINER, 20% Sy2; IV: 25% H II, 38% LINER, 43% Sy2, 15% Sy1; V: 25% H II, 35% LINER, 40% Sy2, 15% Sy1. That is to say, more advanced mergers host more AGN (LINERs are constant).

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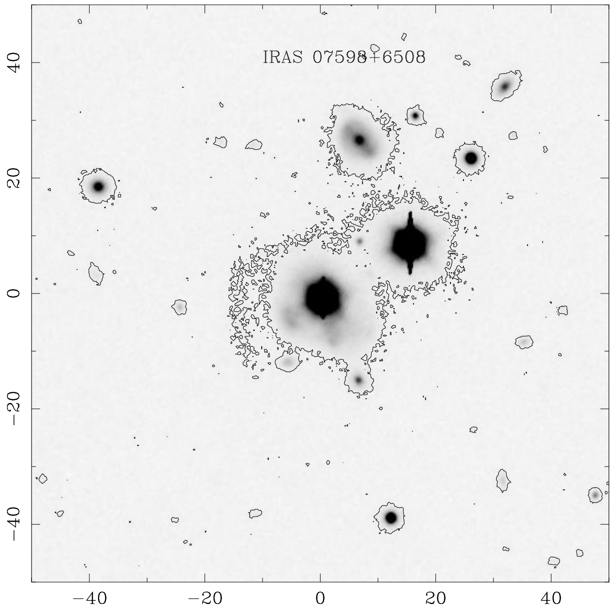

Fig. 1. $\boldsymbol{R}$ band image of IRAS 07598+6508 (FWHM = 0.8 arcsec). The contour corresponds to $\mu_R = 25.36$ mag/arcsec^2. Ticks are in arcseconds from the source.

3. OUR AIMS AND PRELIMINARY RESULTS

We plan to characterize environmental status together with the merger stage, paying attention not only to the very central regions but also to large scale structures that would allow a better determination of the "age" in the expected merger sequence. To do this, high resolution and wide field of view optical imaging is being obtained. First, we are in the process of getting $\boldsymbol{R}$ band images of the whole high luminosity strip ($L_{\mathrm{FIR}} > 10^{12.3}\ L_{\odot}$, 30 galaxies). Among the nineteen galaxies observed up to now (two H II-like, eight LINERs, four Sy2s, five Sy1s, see Figure 1 for an example) we obtain the following preliminary conclusions: 1) They are generally found in very rich environments; 2) they seem to be late stage merger products (long tidal tails are found in only three systems); 3) all of them show multiple nuclei (double nuclei in eleven: two H II, four LINERs, four Sy2s, and one Sy1).

4. ULIRGS WITH THE GTC

Both the resolution and collecting power of a 10 m class telescope will allow us to study the properties of ULIRGs from the nearby Universe to higher redshifts. The question of the nature of the energy source will obviously be better addressed, and a more refined view will be provided of the proposed evolutionary sequence from one type of object to the other and of the nature of the precursors of today's ULIRGs. The GTC's first-light instruments are very well suited for these purposes, both OSIRIS, to get optical to NIR imaging or spectroscopy, and CANARICAM, to get the valuable information provided at MIR wavelengths (note that ULIRGs are one of the scientific cases for CANARICAM). The determination of the nature of the energy source will be completed with the advent of EMIR.

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