UNCOVERING ULTRA-LUMINOUS GALAXIES IN THE IRAS FSC THROUGH RADIO AND OPTICAL CROSS-IDENTIFICATION

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1. Introduction

Ultraluminous infrared galaxies (ULIRGs) have luminosities ($10^{12} L_{\odot}$) once exclusive to QSOs. This suggests they might be the early, dust-enshrouded stages of QSOs. ULIRGs have $\sim 3.5\times$ the space density of QSOs at the present epoch. Quasars reached their peak space density at $z \sim 2$, so if ULIRGs are QSO precursors, there should be a dramatic increase in their space density up to $z \sim 2$. The small number of known ULIRGs makes it difficult to explore links between ULIRGs and QSOs, much less measure their evolution. To do so, a large sample of ULIRG candidates must be identified. The *IRAS* FSC contains $\sim 60,000$ probable galaxies, of which 1%–3% should have $L_{FIR} > 10^{12} L_{\odot}$. We discuss an efficient and reliable method which uses *IRAS*-VLA-*APS* cross-identification and flux ratios to mine the FSC for likely ULIRGs.

2. Exploiting the L_{FIR} versus F_{FIR}/F_{opt} Correlation

Likely ULIRGs can be identified by using the strong correlation between F_{FIR}/F_{opt} and L_{FIR}, as shown in Figure 1. Since the *IRAS* positions are too crude for a direct cross-identification, the radio-FIR correlation (see below) was exploited using the *NVSS* (Condon, this volume, p. 19) to refine the positions. Fits to the forward and inverse relation are shown as dashed lines. The inverse relation has $\sigma \sim 0.22$ dex once outliers are rejected. Among the sub-sample of 64 *IRAS* galaxies with $F_{FIR}/F_{opt} > 10^{1.2}$, 18 of 22 ULIRGs would be found. This translates to an efficiency of $\sim 30\%$ and a completeness of $\sim 80\%$.

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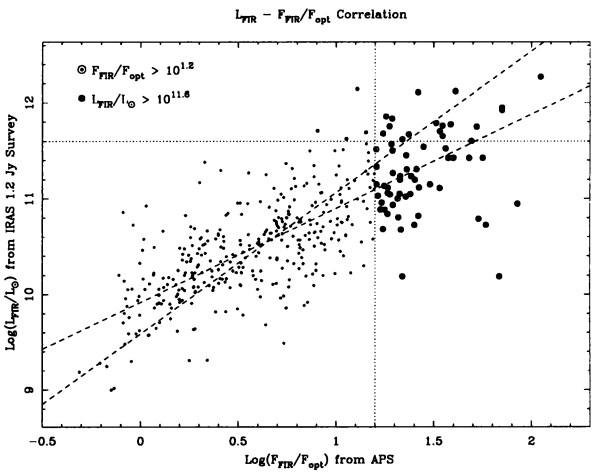

Figure 1. The F_{FIR}/F_{opt}–L_{FIR} relation constructed from sources matched between the *IRAS* 1.2 Jy survey, the *NVSS* 1.49 GHz radio catalog, and the available *APS* catalogs. The forward and inverse unweighted least-squares fits are shown. The solid symbols highlight those galaxies with $L_{FIR} > 10^{11.6}\ L_\odot$. The concentric circles highlight ULIRG candidates selected using $F_{FIR}/F_{opt} \geq 10^{1.2}$. These cuts have been used to estimate the efficiency and completeness of the F_{FIR}/F_{opt}-excess selection technique.

3. Increasing Reliability using the Radio-FIR Correlation

Determining reliable optical identifications for sources with large F_{FIR}/F_{opt} is plagued by the large size of the *IRAS* error ellipse at the limit of the FSC ($\sim 7'' \times 25''$) relative to the surface density of faint optical candidates. The presence of IR cirrus further complicates the identification of faint 60 μm *IRAS* sources. The strong correlation between radio continuum emission and FIR flux, $L_{1.49GHz} = 10^{11.379\pm0.004}(L_{FIR}/L_\odot)^{1.030\pm0.014}$ with $\sigma \sim 0.18$ dex determined from the Figure 1 dataset, enables confirmation and positional refinement of faint FIR sources.

4. Application

We are performing cross-identification of sources from the *IRAS* FSC as the corresponding radio (NVSS & FIRST) and optical (POSS I & POSS II) data become available. The entire sky with $\delta > -33°$ and $|b| > 20°$ is being processed. ULIRGs are out there waiting to be found; in related work, we have recently discovered one ULIRG at $z = 1.1$, and two at $z = 1.3$ from spectroscopic follow-up of sources in the *IRAS* VFSS. These were found in relatively small samples, suggesting an excess of high redshift ULIRGs, as expected if ULIRGs evolve like QSOs.