

The Spitzer Space Telescope: New Views of the Cosmos
ASP Conference Series, Vol. 357, 2006
L. Armus and W.T. Reach

Spitzer Space Telescope Observations of a Complete Sample of Luminous Infrared Galaxies in the Local Universe

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Abstract. We summarize the scientific goals and observing strategy for our GO-1 Spitzer program to study IRAC and MIPS images of all 202 luminous and ultraluminous infrared galaxies in the IRAS Revised Bright Galaxy Sample.

Motivation

Ultraluminous infrared galaxies (ULIRGs, objects with $L_{\text{ir}} \geq 10^{12}L_{\odot}$) continue to be the focus of a great deal of attention at all observable wavelengths, primarily due to hypothesized evolutionary connections with QSOs, powerful radio galaxies and elliptical galaxy formation, as well as a continuing controversy over whether their bolometric luminosities are dominated by dust-obscured AGNs or vigorous massive star formation. The origin of ULIRGs and their subsequent evolution are poorly understood. ULIRGs may evolve from a subset of the much larger population of luminous infrared galaxies (LIRGs, $10^{11}L_{\odot} \leq L_{\text{ir}} < 10^{12}L_{\odot}$). The superb sensitivity of Spitzer provides a unique opportunity to survey the physical properties of star formation, AGNs and the interstellar medium in a large, statistically complete, flux-limited sample of nearby LIRGs and ULIRGs.

Primary Science Questions and Goals

(1) How do star formation rates and the spatial distribution of dust emitting regions vary with the stage of the interaction/merger, the mass ratio of the galaxies, the geometry of the encounter, and the properties of each galaxy known from optical, near-infrared, H I, CO, and radio continuum observations? (2) Which LIRGs most likely represent progenitors of ULIRGs and QSOs, and what characteristics of the galaxies and their merger geometries likely lead to dust heating dominated by AGNs rather than starbursts? (3) What are the relative amounts of cold (10 - 30 K), cool (30-50 K) and warm ($T_{\text{d}} > 50\text{K}$) dust components, and can this be used to age-date merger events? Are there regions with very hot dust (600 - 1000 K) in some of these objects? This survey will also provide an important archive for interpreting the global infrared properties of high redshift IR/sub-mm galaxies, which cannot be spatially resolved like their local analogs.

The Sample

The parent population is the IRAS Revised Bright Galaxy Sample (RBGS), a flux-limited survey of all extragalactic objects with $f_{\nu}(60\mu\text{m}) > 5.24$ Jy, covering the entire sky surveyed by IRAS at $|b| > 5^{\circ}$ (). The sample under investigation consists of all 202 LIRGs and ULIRGs in the RBGS.

The Spitzer Observing Program & Data Analysis Plan

We were awarded 91.6 hours of GO-1 Spitzer time to image all LIRGs and ULIRG in the RBGS which are not covered in the ROC, comprising 362 AORs. The IRAC observations consist of 179 targets (24 in the ROC) to be observed in all 4 bands (3.6, 4.5, 5.8, 8.0 μm). The $1''.2$ pixels and $5' \times 5'$ fields are well matched to most objects in the sample. HDR mode is used to correct pixels saturated in the longer 5x30 sec integrations. The MIPS observations consist of 183 targets (20 in the ROC) to be covered in all 3 bands (24, 70 & 160 μm). Photometric mapping and Super Resolution mode is used with multiple 3 sec integrations. The observing strategy includes mapping, clustering, and dithering to optimize coverage of pairs and groups. Each field was visualized using SPOT to optimize the observing strategy, and the AORs were designed to provide suitable redundancy for S/N and transient removal. Repeated observations with the shortest integration time avoids saturation near bright nuclei.

We will measure surface brightness profiles, synthetic aperture fluxes and relative contributions of nuclear, bulge, disk, overlap, and tidal feature components. Higher resolution images will be beam-matched to lower resolution images to construct flux ratio maps. Results will include an image atlas, color maps, tables of derived quantities, model fits and interpretation to address the key questions outlined above. Ancillary data, including our extensive archive of ground-based imaging at B, V, R, I and K' , combined with radio continuum images, CO and H I data from the literature (via NED) will be used to determine how the dust properties correlate with stellar populations, synchrotron radiation from relativistic electrons and free-free emission from HII regions, and the molecular and atomic gas content of the ISM. We will utilize SINGS () to compare the dust properties of LIRGs and ULIRGs with normal, optically selected galaxies.

At the time of this conference, about 30 AORs were scheduled, but unfortunately no data were yet available from the pipeline. A proposal for a spectroscopic survey with IRS has been submitted for Cycle 2.

Acknowledgments. This research is making extensive use of the NASA/IPAC Extragalactic Database (NED), which is operated by JPL/Caltech, under contract with NASA.

References

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