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Citation: AIP Conference Proceedings **393**, 506 (1997); doi: 10.1063/1.52822
View online: http://dx.doi.org/10.1063/1.52822
View Table of Contents:
http://scitation.aip.org/content/aip/proceeding/aipcp/393?ver=pdfcov
Published by the AIP Publishing

The ISO-IRAS Faint Galaxy Survey: Early Results

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Abstract. We present preliminary results for AGNs and starburst galaxies the ISO-IRAS Faint Galaxy Survey (IIFGS). The goal of the survey is to produce a database of infrared-luminous galaxies at redshifts of about 0.1–1 to help explore the AGN-starburst relationship, study the cosmological evolution of luminous infrared galaxies, and identify possible protogalaxy candidates. The candidate list of ~3700 sources has been extracted from the IRAS Faint Source Survey using criteria selecting for faint, infrared-bright galaxies. The ISO observations will confirm the IRAS detections, yield sensitive 12 & 90 μm fluxes, and provide positions to ~6″ accuracy which will allow unambiguous optical identifications. Confirmed sources are being followed up with ground-based observations to determine optical magnitudes and accurate redshifts. In this preliminary phase we have in hand ~100 observed fields and are developing techniques to maximize the sensitivity of the observations. Early results for the ISOCAM 12 μm images indicate we can reliably detect sources as faint as ~0.5 mJy; ~80% of the fields contain at least one source.

CP393, *Star Formation Near and Far*, edited by Stephen S. Holt and Lee G. Mundy
AIP Press, New York © 1997

INTRODUCTION

One of the many discoveries of IRAS was the population of Luminous Far Infrared Galaxies (LFIRG's) which radiate the bulk of their energy at wavelengths longwards of 10 μm. Such emission is almost certainly powered by warm dust surrounding starbursts and/or AGN [1–3]. However, such samples of IR-bright galaxies are limited by the sensitivity of IRAS and most likely underrepresent such sources at intermediate and large redshifts.

The goal of the ISO-IRAS Faint Galaxy Survey (IIFGS) is to compile a catalog of several hundred LFIRG's at a redshift range of ~0.1–1. Such a sample will allow studies of the mechanisms driving these objects to extend to greater distances and earlier times, and to potentially address issues of evolution. The sample is based on the faintest IRAS detections of potential LFIRG's for which ISO can obtain good photometry and positions. Presented here is a description of and progress report for the IIFGS.

Sources from the IIFGS were selected from IRAS Faint Source Survey (FSS) using criteria to select for distant LFIRG's. The sources were required to have non-stellar colors (i.e. increasing flux density from 12 to 60 μm). To bias the sample towards distant, luminous galaxies, the 60 μm fluxes were constrained to be less than 0.3 Jy (to assure faintness) with ratios of L_{fir}/L_{blue} exceeding 10 (implying $L_{fir} > 10^{11}\ L_{\odot}$, using the strong correlation between L_{fir}/L_{blue} and L_{fir}). Blue magnitudes and upper limits were obtained using IPAC's Optical Identification Database, OPTID, which matches FSS sources against digitized sky survey plate data. To further optimize the sample, only candidates at Galactic latitudes exceeding 30 deg were included in the sample to avoid cirrus contamination. The remaining candidates were inspected individually and only those passing a rigorous cirrus rejection procedure were included in the final sample of ~3700 sources.

The IIFGS has been implemented in the ISO mission as a "filler" survey. The IIFGS sources populate many ISO sky bins and are intended to fill in between other observations, helping to optimize the observing efficiency of the satellite. The survey consists of linked short-wavelength ISOCAM and long-wavelength ISOPHOT observations for each object.

The ISOCAM observation uses the LW10 filter (corresponding roughly to the IRAS 12 μm band). The pixel scale of 6″/pixel, provides a total field of view of about 3′x3′. The source is observed with a 2x2 raster using 30″ offsets, allowing confirmation of the source in multiple detector pixels. The integration time is 2.1 sec with a total effective exposure time of about 70 sec. The ISOCAM observations are much more sensitive than IRAS and allow the positions of the infrared sources to be determined with 6″ accuracy, allowing for unambiguous optical identifications.

The ISOPHOT observation is a chopped PHT22 exposure at 90 μm. Total on-source integration time is 64 sec. In addition to confirming the IRAS detection, it will fill in the spectrum energy distribution between the IRAS wavelengths.

CURRENT STATUS

The IIFGS in presently at an early stage of production. To date, ~150 sources have been observed by ISO; we hope to double that number before the end of the mission. Data from the CAM and PHOT detectors are being evaluated and reduction strategies are being developed for the dataset. The IIFGS data product to be made available to the community shall include positions, fluxes, redshifts, and images of the sources.

The ISOCAM pixels have a characteristic time response to illumination which affects the quality of flat-fielding and coadding. Sample detector responses to an observation are illustrated in Figure 1. The four graphs represent the four detector pixels that are exposed to a single sky position. The horizontal axis represents the time steps for a single pixel (the exposure is 2.1 sec/frame). The actual detector data are indicated with '+' symbols; evident is the slow 'ramp-up' of the background and the presence of the same point source in each of the four raster positions.

By modelling the data with a fit that accounts for both the instantaneous response to illumination and the slower transient ramp, the data may be recti-

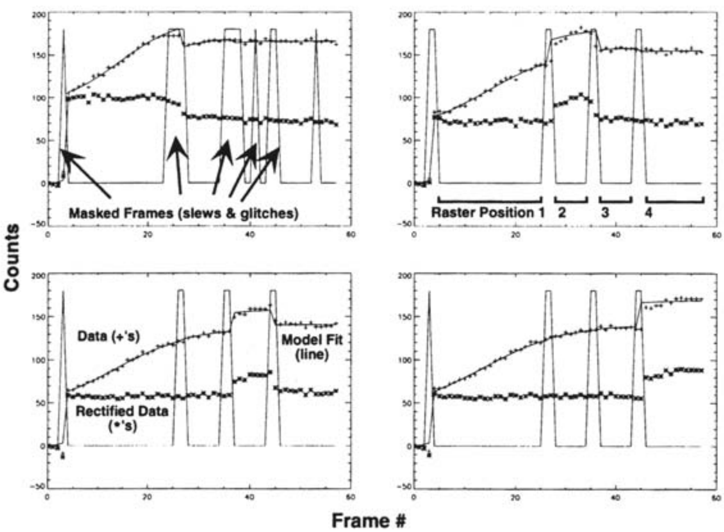

FIGURE 1. ISOCAM Transient Response and Removal. The '+' symbols represent detector responses of an individual pixel for the sequence of frames in the observation. The solid line is the best-fit model of the detector response, and the '*' symbols represent the data with the 'slow' response subtracted out.

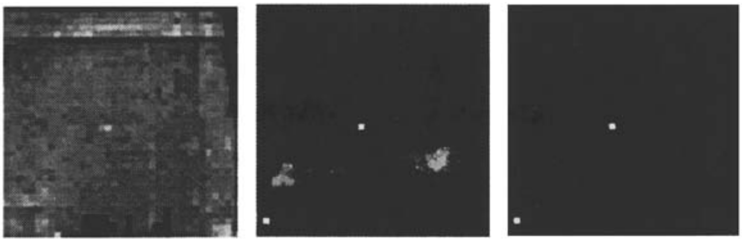

FIGURE 2. ISOCAM Images Before and After. These three images present the same ISOCAM field for the IRAS source F12513+7605. The first is the standard pipeline-processed image in which the source is visible but artifacts seriously corrupt the image. The second is the same image after applying the transient model of Fig. 1; the background is flatter and the SNR is improved by a factor of ~7. In the third image, cosmic ray glitches which have affected processing have been flagged out, and the resulting mosaic shows only the real source.

fied to flatten the response (rectified data are indicated by '*'s). Once rectified, it is possible to construct much-improved flats and more sensitive mosaics of the ISOCAM data. Figure 2 shows a single ISOCAM image, first using the standard data reduction pipeline (with no transient modeling), second after rectifying the dataset, and third after blanking pixels with lingering cosmic ray effects. At this early stage of processing, we have doubled the number of detections from the pipeline processing and improved the sensitivity by factors of five or more.

Complete detection statistics are currently available only for the pipeline-processed data. Of the 115 fields currently reduced, 61 have clear detections. Most of the fluxes range from 1–10 mJy. Inspection of the transient-processed images suggest that 80% of our fields contain at least one source, though this statistic includes serendipitous background sources unrelated to the IRAS FSS detections. Early ISOPHOT results are likewise promising; unambiguous 90 μm detections have been found for many of the brightest ISOCAM detections, although final calibrations are still pending.

Ground-based follow-up for the IIFGS is already underway. Observing time at Lick and Palomar has been allocated to the project for the determination of optical magnitudes and redshifts. Additional proposals are underway for other optical, infrared, and radio observations of the sources observed by ISO.

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