The European Large Area ISO Survey: A Pathfinder for SIRTF

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Abstract. The European Large Area ISO Survey, ELAIS, was the largest Open Time survey on the Infrared Space Observatory, ISO. It was designed to explore obscured galaxies and hence quantify the recent star-formation history of the Universe. We have recently completed our final reanalysis of the data, compiled band-merged catalogue products with associations across many wavelengths and released the data to the global astronomical community (http://astro.imperial.ac.uk/elais/). This paper summarizes some of the key results.

1 The ELAIS Project

The European Large Area ISO Survey was the largest non-serendipitous project on ESA's Infrared Space Observatory (ISO, [1]) using ISOCAM [2] and ISOPHOT [3]. The survey covered around 12 square degrees, with ISO data at 6.7, 15, 90 and 175 μm. The aims of the project and a detailed description of the observations can be found in [4]. A Preliminary Analysis was undertaken to provide early scientific results and to provide follow-up source lists at 6.7 and 15 μm [5], 90 μm [6] – the 175μm data was processed by the FIRBACK consortium [7]. To extract the maximum information from the ISO data we have now completed a very careful Final Analysis of the 15 μm data [8], [9], [10], and at 90 μm [11]. We have also cross-correlated the infrared catalogues and associated them with complementary optical, NIR and radio catalogues (including [12], [13], [14],[15], [16]). The final ISO and Radio selected compilation comprises nearly 4000 sources with limiting flux densities at 6.7, 15, 90 and 175 µm of $\sim$ 1.0, 0.7, 70, 223, 70 mJy [17], these "band-merged" catalogues have been made public (http://astro.imperial.ac.uk/elais/).

2 Motivation

The motivation for studying infrared galaxy evolution is also discussed in [18]. The original motivation for studying galaxy evolution in the infrared comes from our understanding of star formation within our own galaxy. In these regions the intrinsically bright optical and UV emission from young massive stars is strongly affected by dust. The effects of obscuration are less significant in the thermal infrared (1-3 µm) and in the mid and far infrared we actually see the reprocessed emission from the dust. Thus to properly understand star-formation

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and hence galaxy formation we must study both optical and infrared wavelengths (appropriately for the theme of this workshop). Indeed actively star forming galaxies such as M82 emit significantly more power at far infrared wavelengths than in the optical and UV. The discovery that as much or more power in the extra-galactic background emerges at far-infrared/sub-mm wavelengths as in optical/UV bands [19] emphasizes the cosmological importance of these far-infrared emitting populations. The unexpectedly numerous galaxies discovered by SCUBA (e.g. [20] and [21], [22]) are expected to be star forming galaxies at high redshifts where the rest-frame far-infrared galaxies has been shifted to sub-mm wavelengths.

The ELAIS survey was designed to study the comparatively recent evolution of obscured star formation providing a bridge between local IRAS samples and SCUBA. It also aimed to understand the AGN phenomenon by exploring emission from the dusty tori.

3 Number Counts

The first science from any new survey inevitably comes from the number counts. We analysed the preliminary counts at 6.7, 15 μm [5], 90μm [6] and the FIRBACK team presented the 175 μm counts [7]. The Final Analysis counts at 15 μm in S1 and 90 μm have been discussed by [26] and [11] respectively, an analysis of all the 15 μm data will be given by [27]. Whichever wavelength you choose the result is the same: the counts are inconsistent with any no evolution predictions, i.e. we detect significant evolution at all wavelengths. This is illustrated at 15 and 90 μm in 1. At 15 μm the departure from no evolution models is particularly abrupt at around 1 mJy. This result is enhanced by the deeper ISO-CAM surveys (e.g. [23], [24], [25], [18]) but is clear with ELAIS data alone which could not be affected by small sample biases.

4 Optical Identifications

To investigate what sort of galaxies are responsible for the excessive numbers of galaxies seen at faint fluxes requires data at other wavelengths. There have been extensive observing imaging survey campaigns or comparisons with archival data at radio [15], [16], [34], optical [12], [13], [29], NIR [14], and X-ray wavelengths [30], [31], [32], [33]. There is no room here to discuss the radio, NIR or xray associations and the reader is referred to the above publications. 80% have optical identifications to $R \sim 23$ [12] and 92% to $R \sim 24$ [13]. The optical photometry suggest a significant fraction of the sources have a high infrared to optical ratio and that this fraction increases as we move to fainter infrared fluxes ([13]). Redshifts have been obtained 500 galaxies of our infrared samples (47% of the 15μm galaxies with identifications), primarily on AAT, ESO 3.6m, WHT, and other smaller telescopes. The optical spectra can be used to classify sources as AGN (Type-1 and Type-2); star burst galaxies and normal galaxies ([12], [35]). We have dissected the number counts in S1 using these classifications (Fig.