The European Large Area ISO Survey
ISOPHOT results using the MPIA-pipeline

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ABSTRACT

The European Large Area ISO Survey (ELAIS) will provide Infrared observations of 4 regions in the sky with ISO. Around 2000 Infrared sources have been detected at 7 and 15 \(\mu\)m (with ISOCAM), 90 and 175 \(\mu\)m (with ISOPHOT) over 13 square degrees of the sky. We present the source extraction pipeline of the 90 \(\mu\)m ISOPHOT observations, describe and discuss the results obtained and derive the limits of the ELAIS observation strategy.

Key words: ISO; ISOPHOT; Survey; Methods: data-analysis.

1. INTRODUCTION

ELAIS (P.I.: M. Rowan-Robinson) is a consortium involving 19 European institutes. The project consists on an ISO survey of 13 square degrees of the sky distributed mainly in 4 areas (3 in the northern hemisphere, 1 in the southern one). These areas have been chosen to be at high ecliptic latitude, to have low cirrus background, and to avoid the presence of strong 12 \(\mu\)m sources closeby [Oliver et al. 1998]. We used the mapping mode of ISOPHOT and the C100 detector. Each area was initially planned to be covered by a 20 \times 10 raster map without overlapping. Details on the observing modes and the characteristics of the survey can be found in [Oliver et al. 1997]. Because ELAIS is the largest open time project (around 360 hours) being undertaken by ISO, the regions observed will be one of the most well studied at several wavelengths and will be some of the most adequate regions to explore the extragalactic universe.

To treat the large amount of data several data extraction pipelines have been set-up at Imperial College (London), IAS and CEA (Paris) and MPIA (Heidelberg). These pipelines provide the basic data for ground based telescope follow-ups at different wavelengths [Héraudeau et al. 1999, Ciliegi et al. 1998] (see [Rowan-Robinson et al. 1999] for a review) and essential information to constrain the spectral energy distribution in the Mid and Far Infrared Band.

In the following sections I will describe the ISOPHOT MPIA data extraction pipeline and discuss quantitatively the results obtained.

More information about the status of the survey and ELAIS ground-based follow-ups is available at the WEB address: \texttt{http://athena.ph.ic.ac.uk/}.

2. Data analysis

2.1. Data raw analysis

The raw data have been analyzed using the isoPhot Interactive Analysis tool \textsuperscript{1} (PIA Version 7.2.2). We use PIA to reduce the raw data from the “Edited Raw Data (ERD)” level to the “Auto Analysis Product (AAP)” level, keeping the integrated values during the ISO slewing mode. For de-glitching we used the very low sigma value of 1.5 for the sigma-de-glitching in order to get rid of the fluctuations of the detector after being hit by a glitch. We use the FCS measurements to calibrate the data.

The calibration was checked using dedicated measurements (see section 2.2). We used private routines [Surace et al. 1997] to reduce the pixel-to-pixel response fluctuations and to derive the final surface brightness values and fluxes of the objects.

2.2. Calibration

The calibration step of the ISOPHOT data is still on discussion despite of the constant progress in building good calibration files. We decide to check the quality of the FCS calibration of the survey observing calibration stars and sources detected in the ELAIS survey. The strategy is to observe alternatively a standard star and an ELAIS source, in each field and to compare the fluxes obtained in these measurements with theoretical values [Schultz private communication] and the flux values derived previously from the

\textsuperscript{1} PIA is a joint development by the ESA Astrophysics Division and the ISOPHOT consortium
The measurements have been performed using the ELAIS observing mode for better consistency. The fig 1 shows examples of observations performed for that purpose.

![Observation Images]

Figure 1. Two calibration dedicated measurements. Each frame is composed by the DSS image (upper left, rotated by the value of the roll angle) the ISOPHOT C100 image (lower left, intensity range is display besides in MJy/sr) the 3D view of the total map (lower right corner). The upper frame is the standard star, the lower one is one ISOPHOT source.

We found that the fluxes derived in our pipeline where in relatively good agreement for the point-like sources:

- The fluxes derived using the FCS calibration and the theoretical values agree within 15% of the total fluxes.
- The fluxes derived during calibration measurements agree within 5% with those derived from the survey.

2.3. Target detection

The non overlapping mapping mode of the ELAIS survey makes impossible the use of the built-up map for detection purpose. The noise resulting in building the map will not allow an efficient detection. The detection of the ISOPHOT sources is based directly on the time sequence analysis of the AAP files. The analysis process is summarized in fig 2. The basic idea of the pipeline is to detect the maximum of objects by a 1.5 sigma threshold search over the time sequence of the ratio of one pixel over the other 8 pixels of the C100 detector. The spurious detections are rejected by a second threshold search on the redundancy. The pipeline can be summarized by the different steps:

- ratio by raster point of each pixel over the 8 others of the C100 pixels (8 values for 1 pixel)
- 1.5 sigma threshold detection over the time sequence of a pixel (median over 5 raster points)
- 1.5 sigma threshold detection over the time sequence of the ratio for each pixel (median over 5 raster points and fit of the background over 5 raster points)
- selection of the pixels the sum of the detections of which is greater than 4.
- computation of the flux of the detection (flux of the detection pixel - median(flux of 26 surrounding pixels))
- computation of the coordinates of the detections

The detections are visually inspected by 5 different people and classified in 5 groups define as follows:

- class 1: Clear detection of a bright source
- class 2: Clear detection of a source
- class 3: probable detection of a source
- class 4: affected by glitches, not a source
- class 5: spurious detection

A final classification is given to the detections. In the following we will only consider the detections belonging to the classes 1, 2 and 3. These detections represent approximately 10% of the total number of detections.

The closeby (separation < 50") "real" detections are grouped and the corresponding fluxes are added. The data are saved in an IDL structure format and include in an IDL database. An ASCII table is also provided, with:

- num: numero of the detection in the raster
- α: right ascension (J2000)
- δ: declination (J2000)
- flux: flux in mJy
- sigma: uncertainty in mJy
- det: detection level (1 < det < 10)
- time: central time of the detection in seconds
- pix: pixel number (0 < pix < 8)
- rp: raster point ID of the detection
- classif: classification given to the detection.

see table 1 for an exemple.

The optical identification is performed on the DSS images, and R-band survey when available, using a maximum likelihood method.

3. Results and limits
3.1. detection limit

The figure shows the distribution of the fluxes derived from our pipeline. Even if some sources have been detected down to 10 mJy. The uncertainties of the fluxes is found between 20 and 60 mJy, depending on the observation itself. The detection of some sources with a signal to noise value less than one is due to the fact that the detection and the computation of the flux and uncertainties are based on two different processing modes. While the detection is performed on each individual pixel the computation of the flux is derived on all the pixels of the detector. The sigma values on the fluxes include also the pixel-to-pixel fluctuations.

Nevertheless, some rasters have been lost due to the fact that they have been observed during the end of the orbit. Indeed the resulting noise is too high to be able to detect any source contribution.

The drop off of the histogram indicates a detection limit at 60 mJy. While the median is 80 mJy and the completeness of the survey is reached for a limit of 100 mJy (Rowan-Robinson et al. 1999).

One has to be aware that due to this detection limit, some objects which are brighter than 100 mJy could be missed by the survey. Indeed if, due to the position of an object in the field, its flux could be distributed among at least two neighbouring pixels, and then not be detected by the pipeline. We estimate to miss 20% of these objects in the survey. This situation improves when using the overlapping observational (overlap 3/2 pixels) mode.

3.2. Spatial distribution

Up to now 45 fields have been analyzed leading to a total of 8164 detections that have been eye-balled. The observers have agreed on a number of 274 “reliable detections” (class 1 or 2) and 642 “probable sources” (class 3). One has to remind however that a bright object could be detected several times. This leads to a density of 30 detections by square degrees. The large number of “class 3” object is due to the behaviour of the C100 detector, when hit by glitches. A forthcoming new deglitching method will improve the reliability of the sources.

The figure shows the spatial distribution of the detections on the N2 ELAIS field. The light crosses show the detections by the pipeline. The dark filled circles are the so-called “class 3” detections while the light filled circles are the “class 2” detections.

The overdensity of the detections in some area is an artificial effect due to the overlapping regions between two rasters. There is no clear evidence of some 2D clustering properties of the ”real sources”. They look smoothly distributed in the field. However the “class 3” detections are often linked to the “class 2” detections.
This could be explained by the fact that:
- the source could have a morphology leading to a bright center and fainter outer parts,
- the source is not centered in the pixel so part of the flux is in the neighbouring pixels
- the beam profile of bright sources, could affect as well the neighbouring pixels

A more elaborate analysis taking into account the signal to noise ratio of each raster as well as the overlapping regions is ongoing.

4. Conclusion

In this contribution we have presented the MPIA ISOPHOT ELAIS pipeline. The results from this pipeline will be cross checked with those obtained with other pipeline, in order to get a complete source list to deliver to the scientific community. We have cross-checked the ELAIS calibration using some dedicated measurements of standard stars and ELAIS sources. We claim that the MPIA ELAIS fluxes are calibrated with an accuracy better than 20%. We listed 274 reliable detections and 642 probable detections. A 2D and 3D spatial correlation analysis is on-going.

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