SASSy objects

First steps towards investigating their nature

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Background

The submillimetre (submm) part of the electromagnetic spectrum is at wavelengths ~ 0.3 - 1 mm. It is therefore located between the infrared/far infrared (FIR) and millimetre/microwave bands and can be used to probe the cold (T ~ 10 – 30 K), dusty regions of the interstellar medium (ISM) that are opaque and/or dark at other wavelengths but optically thin and at their peak of emission in the FIR and submm. Of particular interest are observations of infrared-dark, dense molecular cloud cores where early star formation may take place. [1][2][3][4][7]

From Earth, observations at these wavelengths are limited mainly by atmospheric emissions and absorptions from e.g. water vapour. Observing sites should therefore be dry, cool, and with stable weather conditions. From space, the size of the telescope determining the diffraction limit and cirrus confusion are the main constraints for angular resolution and sensitivity respectively. [2][4][7]

SASSy (see blue box on the left for key facts) is a recently completed wide-field shallow survey of the Outer Galaxy at 850 μm using the SCUBA-2 camera (bottom box) of the James Clerk Maxwell Telescope (JCMT) in Hawaii. It aims at finding rare Galactic objects (mainly cold cores/very early phases of star formation) that can then be followed up by additional observations. Given the lack of surveys of this type and resolution SASSy is expected to lead to a number of new and interesting discoveries. This is vital to make full use of the capabilities of future submm facilities. [3][7]

Hi-GAL[1][4]

- Herschel infrared Galactic plane survey
- Using the Herschel Space Observatory
- Entire Galactic disk, ~ ± 1°
- Instruments: PACS and SPIRE
- 70, 160, 250, 350, 500 μm (FIR & submm)
- Resolution ~ 5 (-12), 11 (-16), 18, 24, 35”
- Detector sensitivities ~ 18, 27, 13, 18, 15 mJy; but cirrus confusion limit ~ 75 – 160 mJy
- Square tiles ~ 2 x 2° at changing angles
- Ideal wavelengths to complement SASSy
- Access to data provided by team

SASSy (OGF)[3][7]

- SCUBA-2 Ambitious Sky Survey
- 850 μm (and 450 μm): submm
- 14” resolution, sensitivity ~ 30mJy
- Mapping rate > 0.8 deg²/h
- Galactic longitudes ~ 120° - 240°
- Galactic latitudes ~ ± 3°
- Circular tiles of diameter ~ 2.5°, each observed 3 times
- ‘Grade 4’ weather conditions
- Started 2012, recently completed
- Data provided by team

SCUBA-2[2][3]

- Submillimetre Common-User Bolometer Array 2 on JCMT
- Mauna Kea, Hawaii → cool & dry
- Sampling rate ~ 200 Hz
- Band width ~ 85 μm
- Ideal due to its high resolution and rapid mapping capability

This project aims at determining physical properties and hence constraining the nature of a few selected SASSy objects in the Outer Galaxy Field (OGF) in combination with complementary Hi-GAL data (top right blue box) and spectral energy distribution models. It will help the team prioritize their analysis.

PACS[4]

- Photoconductor Array Camera and Spectrometer
- ‘blue’: 70 μm, ‘red’: 160 μm

SPIRE[4]

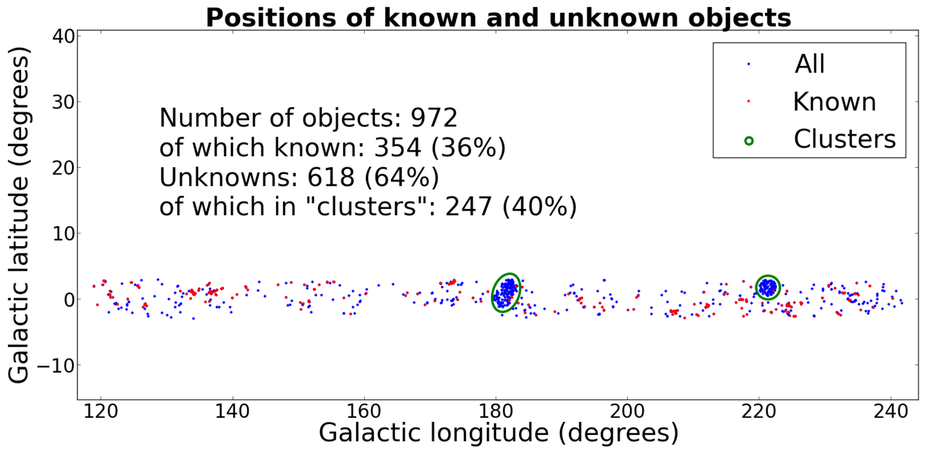
- Spectral and Photometric Imaging Receiver
- ‘PSW’: 250 μm, ‘PMW’: 350 μm, ‘PLW’: 500 μm

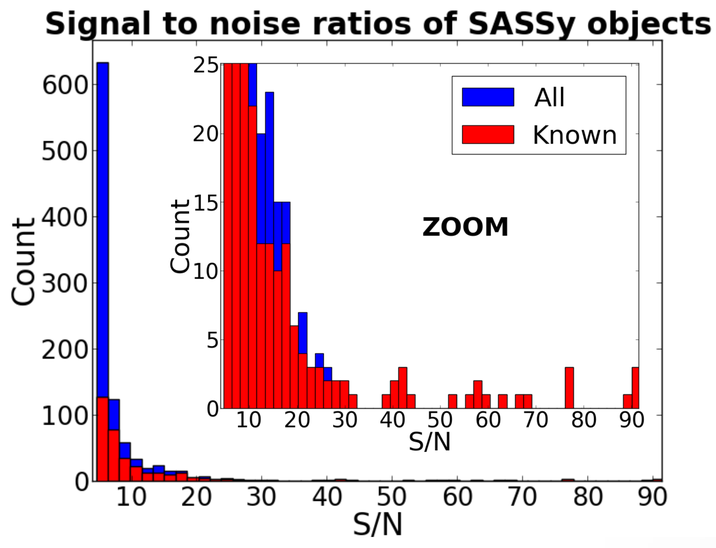
Preliminary Findings

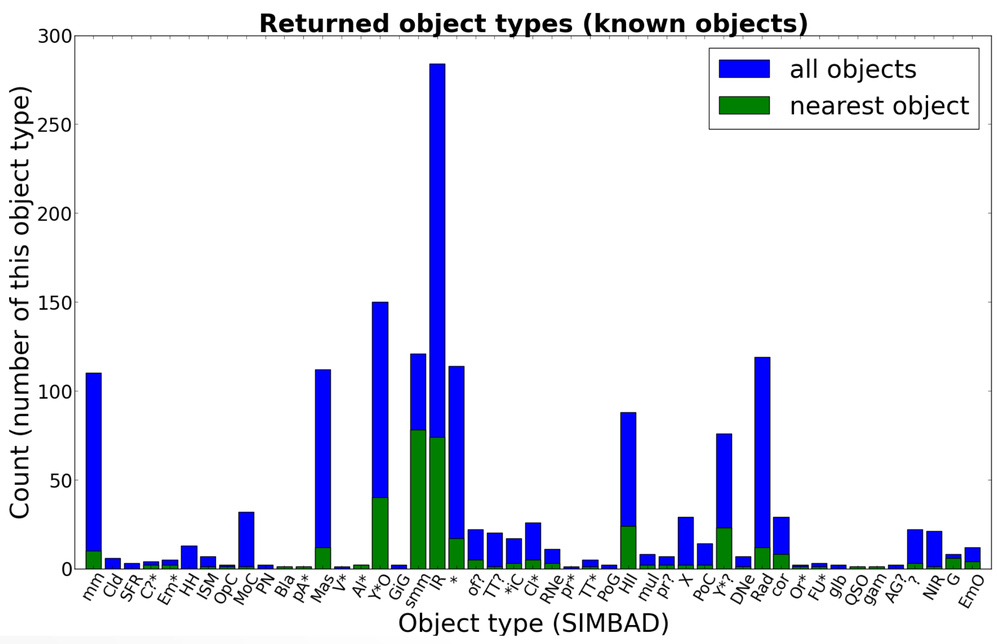
The preliminary SASSy catalogue of nearly 1000 compact sources detected at 4.6 sigma or higher was cross-matched with SIMBAD using a search radius of 14 arcseconds. Objects were classed as “known” or “unknown” according to whether they returned a match or not.

SIMBAD[6]

- Set of Identifications, Measurements, and Bibliography for Astronomical Data
- Large database with many catalogues







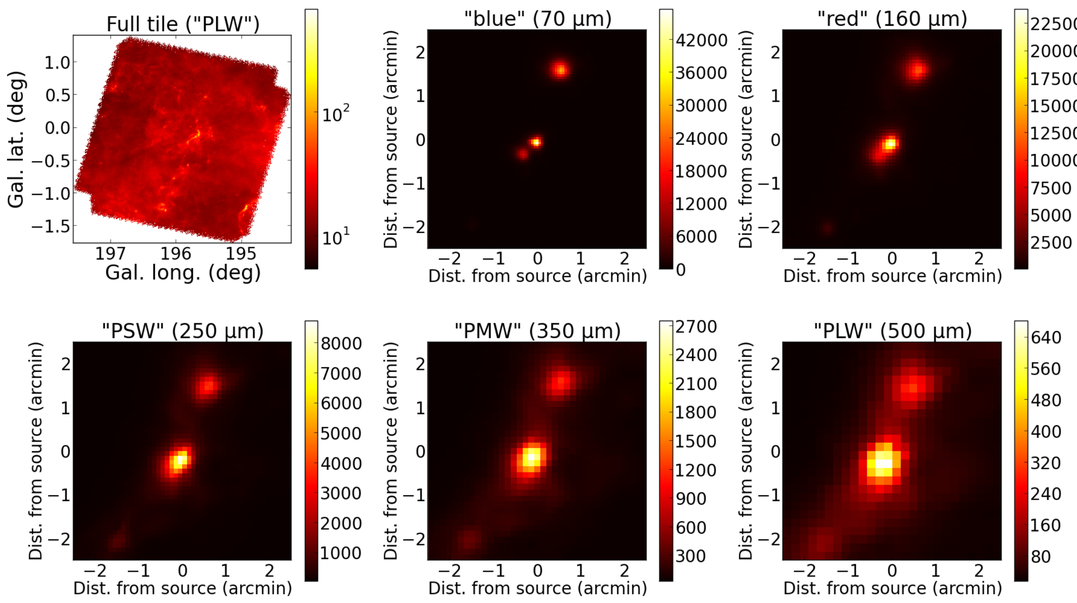
Known objects were analysed briefly: Their type mostly corresponds to what SASSy would be expected to detect: Mainly infrared, submm and radio sources, young stellar objects, HII-regions and a few stars (see figure to the left). It is therefore mostly the cold parts of the ISM that SASSy finds – corresponding to where emission is strongest in its wavelength band. [3][7]

The more “interesting” objects are the unknown ones since they are likely to be studied little or not at all to date and so have a potential for new discoveries. Roughly 40% of them were found in “clusters” that are most likely artefacts of data reduction (blooming). They were excluded from further analysis (top left figure).

Unknown objects generally tend to be fainter, but there are 5 unknown sources with a signal to noise ratio above 20. These were selected for initial analysis (top right figure).

NED[5]

- NASA/IPAC Extragalactic Database



In order to derive physical properties of SASSy sources, their distances (provided by the team) and spectra are needed; which can then be fitted by spectral energy distribution models (also provided). Flux measurements at several wavelengths are therefore required, for which the Hi-GAL data is used.

A Hi-GAL cut-out around one of the bright unknown SASSy objects is shown on the right. The source is clearly present at all 5 wavelengths. It was then checked against NED and turned out to be a known infrared source (not included in SIMBAD).

As the next stage of the project, the python code developed to obtain Herschel cut-outs will be applied to a large number of SASSy objects. A selection of these will then be studied in depth.

Outlook

- Measure fluxes of the sources
- Fit spectral energy distribution models
- Find luminosity, temperature and mass with the help of CO-distances

DETERMINE NATURE OF OBJECTS

References

[1] Elia, D. et al. (2013). “The First Hi-GAL Observations of the Outer Galaxy: A Look at Star Formation in the Third Galactic Quadrant in the Longitude Range 216.°5 ≤ l ≤ 225.°5” In: ApJ 772, 45, p. 45. DOI: 10.1088/0004-637X/772/1/45. arXiv: 1304.7358 [astro-ph.GA].

[2] Holland, W. S. et al. (2013). “SCUBA-2: the 10 000 pixel bolometer camera on the James Clerk Maxwell Telescope”. In: MNRAS 430, pp. 2513-2533. DOI: 10.1093/mnras/sts612. arXiv: 1301.3650 [astro-ph.IM].

[3] MacKenzie, T. et al. (2011). “A pilot study for the SCUBA-2 `All-Sky' Survey”. In: MNRAS 415, pp. 1950-1960. DOI: 10.1111/j.1365-2966.2011.18840.x. arXiv: 1012.1655 [astro-ph.CO].

[4] Molinari, S. et al. (2010). “Hi-GAL: The Herschel Infrared Galactic Plane Survey”. In: PASP 122, pp. 314-325. DOI: 10.1086/651314. arXiv: 1001.2106 [astro-ph.GA].

[5] *NED: NASA/IPAC Extragalactic Database*. http://ned.ipac.caltech.edu/. Accessed November 11, 2014.

[6] *SIMBAD Astronomical Database*. http://simbad.u-strasbg.fr/simbad/. Accessed October 15, 2014.

[7] Thompson, M. A. et al. (2007). “The SCUBA-2 "All-Sky" Survey”. In: *ArXiv e-prints*. arXiv: 0704.3202.