A MID-INFRARED DEEP GALAXY SURVEY IN THE SSA13 FIELD

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ABSTRACT

We have executed a deep ISOCAM LW2 (7 μm) imaging survey in the SSA13 field. So far 26 sources are detected down to 10 μJy in the area of 16.8 arcmin^2. We could find optical counterparts of these sources in many cases. But some sources are only found in the LW2 band. Their nature should be investigated further.

Key words: survey; cosmology; galaxies

1. INTRODUCTION

We have executed deep cosmological surveys using Japan/ISAS Guaranteed Time (Principal Investigator: Y. Taniguchi). ISO gave us two new windows for searching the distant universe. One is in the mid-infrared where dust extinction for stellar continuum emission is negligible, and the other is in the far-infrared where energy generated in stars is transferred to dust and we can see its re-radiated emission directly. We use these windows to explore dusty star-forming galaxies which had not been found yet.

Results of the far-infrared part of this program, carried out in the Lockman Hole, is reported in Kawara et al. 1998a, Kawara et al. and Matsuhara et al. (in these proceedings).

For the mid-infrared, we have done two deep imaging surveys in the Lockman Hole and the SSA13 as the Japan/UH cosmology program. The former one is reported in Taniguchi et al. (1998). Here we report initial results gained in the SSA13 field.

2. FIELD

The SSA13 field, one of the UH selected area to search general properties of field galaxies, was chosen as the second and final target for our deep ISOCAM LW2 ($\lambda_c = 6.75\,\mu$m) imaging survey.

This field is located at high ecliptic and Galactic latitudes ($\beta \sim 46^\circ$ and $b \sim 74^\circ$) and has very small atomic hydrogen (HI) column density (N(HI) $= 1.5 \times 10^{20}$ cm^{-2}).

In addition to these quite good conditions to explore the distant universe, high quality data are available such as deep optical (B and I bands) and near-infrared (K band) images and spectroscopic redshifts (Cowie et al. 1996). Recently we have got a deep submillimeter image as well (Barger et al. 1998).

3. OBSERVATIONS

Our SSA13 observation is very similar to that which was executed in the Lockman Hole. The fundamentals are: ISOCAM, LW2 filter, 6 arcsec pixel-field-of-view (PFOV) lens and a concatenated chain of micro-scans with their center positions defined to sample the PFOV.

The observations were executed in revolutions 560, 561, 610, 612, 613 and 614 using almost all time available for the SSA13 field. Roughly three hours for each of the first two and four hours for the remains; summing up about 23 hours. This implies we could not release any longer lasting observations. This limitation required to change some observational parameters used in the Lockman Hole.

We noticed that accurate registration of ISOCAM frames is critical to detect faint sources. Thus we decided to use non-integer pixel size offsets in micro-scans and a fundamental integration time of 20 seconds hoping to go even deeper in a short chain of micro-scans.

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4. DATA REDUCTION

Use of the same program developed for the Lockman Hole image failed due to increased impacts by cosmic rays. Their rates themselves and following transients are the main reasons.

After dark subtraction, we corrected long timescale trends with median and smooth filtered pixel history. A width of more than 2 × the number of readouts in each pointing was used.

Then short timescale glitches were removed inside each pointing. Deviant readouts from the median were masked out iteratively.

The flatfield was constructed after removing readout frames which will be flatfielded.

After subtracting the median sky, all the images were summed up into fine grids aligned with the North-East direction. We performed field distortion correction using calibration files in the CIA, determined by Aussel (1998).

The final image is shown in Figure 1 as a signal-to-noise (SN) image to express statistical significance adequately.

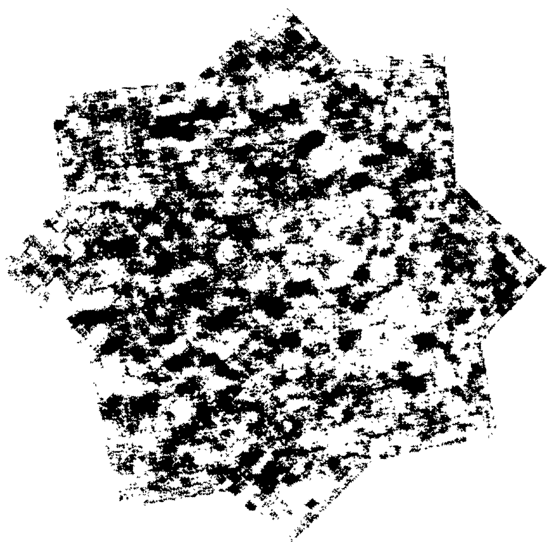

Figure 1. ISOCAM LW2 (7 μm) signal-to-noise image of the SSA13 field. Darker in the image is brighter in surface brightness. North is up and east is to the left. Map size is 5.4 arcmin in Right Ascension and 5.5 arcmin in Declination. The area covered is 16.8 arcmin^2.

5. PHOTOMETRY

Smoothing by Boxcar filtering with width of 5 was used both in the signal and the noise images. All the areas which exceed a signal-to-noise (SN) ratio = 1 were regarded as sources. We have got 26 such sources.

The photometry was done using this area. In order to account for flux below SN = 1, we padded some pixels to this. Note that we applied statistical transient correction for faint point sources; namely we just divided signals by 0.6 (initial response). We assumed there were no significant signal growth due to quite large time constants for such faint sources. We used an initial response of 0.6 reported in Abergel et al. (1996).

SN was calculated from a sum over the same area but on the SN image. Noise was estimated as a ratio between the two measurements.

Measured flux spans from roughly 10 to 100 μJy, while the SN ranges between 6 to 40. Noise marks 1.2 μJy (1σ) but raises up to 7 times due to small integration in the peripheries.

6. OPTICAL COUNTERPARTS

We used ground-based B, I, K and HST I band images to find optical counterparts of detected 7 μm sources. Five bright 7 μm sources are used for registration on optical images, and it gave quite good results: the root-mean-square error was around one arcsec.

Using this transformation, we could find many optical counterparts within the used PFOV of 6 arcsec. They are ranging from star, elliptical, spiral, irregular galaxies and a combination of them. Actually some sources are confused with several sources and it would be difficult to pick up only one of them.

Several sources have no or quite faint optical counterparts. Some are located in peripheries of the map and thus might be spurious ones. But the others are nearer to the center. These could consist of a new population which has not yet been discovered.

Here we show some examples of optical counterparts (Figure 2).

7. SURFACE DENSITY AND REDSHIFTS

Mobasher et al. (1996) shows that 9 sources would be detected down to 10 μJy in the Hubble Deep Field (HDF) with an area of 5 arcmin^2, if most of the galaxies detected in the HDF are undergoing a strong starburst. Scaling to our area just gives 31. It is very close to our current result of 26. Note that we could not detect fainter sources in map peripheries. Thus most of the detected sources could be star-forming galaxies.

Cowie et al. (1996) gives results of redshift measurements for eleven of the 26 sources. Highest is 1.305, though one measurement failed to determine redshift. This source is located very close to an antenna-like galaxy at $z = 1.038$. They appear to be interacting with each other. Assuming this has $z > 1$, we get a median redshift of $z \sim 0.5$, though these measurements may not be representative for our whole sample.

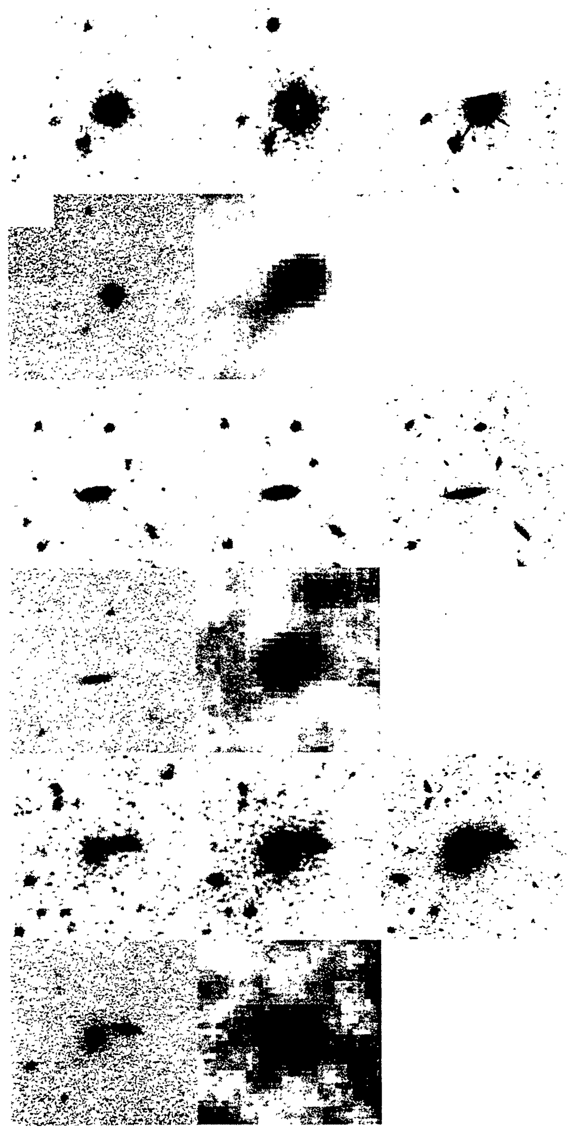

Figure 2. Some ISOCAM LW2 sources detected in the shorter wavelengths. Five images for each object. Upper row from the left are B, I, I(HST) band images and lower row are K and LW2 ones. Map size is 30 arcsec in both directions.

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