SIF3004 Final Year Project Proposal : RAdio Galaxy Environment Reference Survey (RAGERS) Project

Lim Ming Kang U2004991/1

Supervisor: Prof. Dr. Zamri Zainal Abidin

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1 Problem Statement

At the cosmological redshift of $2 < z < 3$ (observing the condition about 10.9 bllion years ago), the universe is actively producing new stars, with highest average star forming rates (SFRs). This period known as "the cosmic noon"(Schreiber & Wuyts,). Galaxies known as "Dusty Star Forming Galaxies (DSFGs) are enriched with dust that serves as the materials to forming stars.

A comprehensive understanding of those galaxies is important in understanding galaxy formation and evolution in the early universe.(Geach et al.,)

Characterisation of the region where the aforementioned galaxies reside (galaxy overdensities) with redshift, and the effect of Active Galatic Nuclei (AGN) activity on the growth of the central overdensities are to this day still not thorough.(Team,)

Obscure by dust , those galaxies are not feasible to be observed in visible region, a telescope capable in observing in far infrared wavelength is needed to detect the galaxies.

Raw telescope data needs to be reduced, cleaned and calibrated before doing analuysis, as noise and false detections may be presence, the processes are essential to obtain a clean map for analysis.

The addition of far infrared data would is significant to multiwavelength analysis of galaxies especially in obtaining photometric redshift.

2 Objectives

1. To reduce raw telescope data hence obtain analysable data (eg. source count)
2. To study statistically (eg. surface number density) of galaxy overdensities in a source field
3. To obtain photometric redshift of submm galaxies in a source field using multiwavelength analysis.

3 Background

Submillimetre Galaxies (SMGs) are rare galaxies with high star formation rates ($> 100M_{\odot}yr^{-1}$) (Da Cunha et al.,) populated in high redshift region. Suspected to be the progenitors of local giant galaxies, SMGs are valuable candidates to study evolution of galaxies in high redshift. One challenge in observing SMGs is the amount of dust, which serves as the building blocks for star formation, which obscure visible light. However, since far infrared/radio frequency are transparent to dust, the observation of SMGs is possible with submillimetre telecopes.

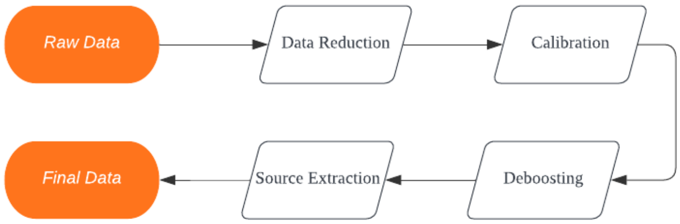

Figure 1: General process of data handling of raw telescope data

Overdensities are regions in space where the density of matter is relatively higher than others. Examples are galaxy clusters and proto-clusters. Astronomical events such as mergers of galaxies usually happen in overdensities region. Also resides giant, powerful galaxies in aforestated region. At $z > 1$, High redshift radio galaxies (HzRG) are usually in the region of overdensities where SMGs are. The dynamic between SMGs and HzRGs can be studied so have a more robust understanding of evolution of masive structure of the universe.(Saxena & Rottgering,)

Telescopes operating at submillimetre region can be used to observe SMGs. An example is Atacama Large Millimeter Array (ALMA) telesope located in northern Chile, it operates at around wavelength $0.4mm < \lambda < 2.73mm$. Other examples are Fred Young Submillimeter Telescope operating at $\lambda = 0.35mm$ and SCUBA-2 at James Clerk Maxwell Telescope (JCMT) operating at $\lambda = 0.45mm$ and $\lambda = 0.85mm$, whose data is used in the research of this proposal. Telescopes are usually associate with their proprietery software for data handling. For instances, CASA for ALMA, Starlink for JCMT and AIPS for Very Large Baseline Array (VLBA). It is extremely important to produce useful science data from noisy telescope data to remove as much noises as possible (eg. Radio Frequency Inteference (RFI)) and extract useful information to the max. Figure 2 shows an example of the comparison between raw telescope data, and image after data reduction.

4 Research Methodology

The research will be carried out on handling raw 0.85mm and 0.45mm data collected from JCMT SCUBA-2 under RAGERS Project, in collaboration with RAGERS Malaysia Team (from where the raw data is acquired). Data Reduction is run on Starlink software. The process of data handling is shown in Figure 1

James Clerk Maxwell Telescope (JCMT) is a 15m telesope designed to run on submillimetre wavelength (far infrared region). It is positioned at Maunakea, Hawaii.

SCUBA-2 is a camera attached on JCMT to observe at $450\mu m$ and $850\mu m$ (666GHz and 353GHz) The data is formatted and stored in .sdf format, which is readable by starlink software.

The RAdio Galaxy Environment Reference Survey is a JCMT program to observe overdensities within the Mpc region of 33 radio galaxies at redshift range $1 < z < 3.5$ and mass range $M* >= 1010.8M\odot$ (Team,)

Source field is a region spanning across few Mpc centered around a HzRG, which is located at $1 < z < 3.5$

Starlink is a software consisting of several packages used to reduce and analyse data recorded by SCUBA-2 telescope, including (but not limited to) SMURF for data reduction and GAIA for data visualisation.

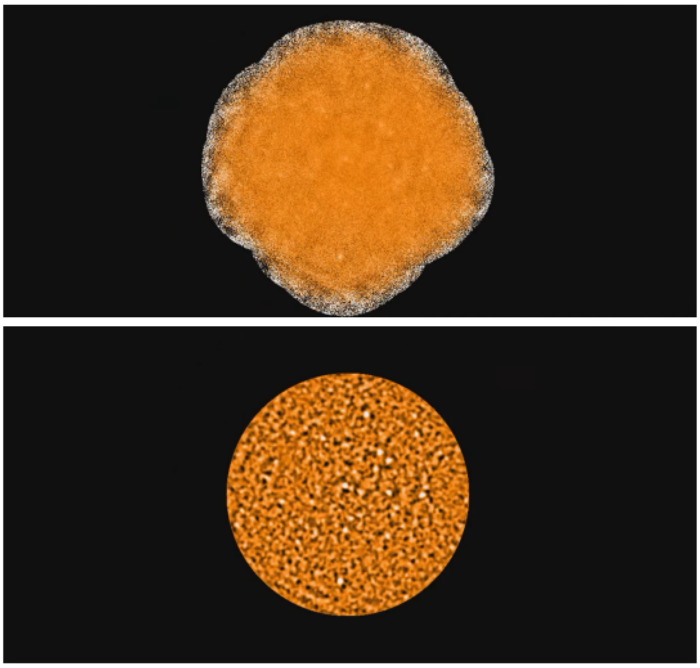

Figure 2: An example of the comparison between raw telescope data (up), where there is no clear galaxies count, and image after data reduction (down), where SMGs appear as white dots

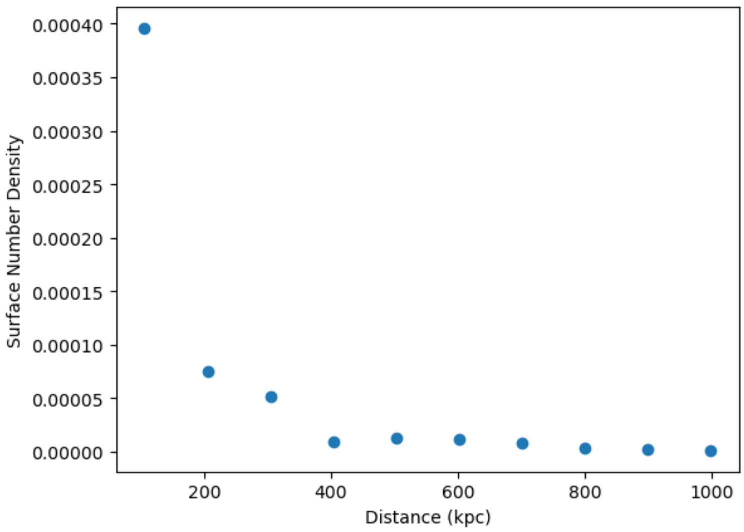

Figure 3: Surface number density as the function of distance from cluster center

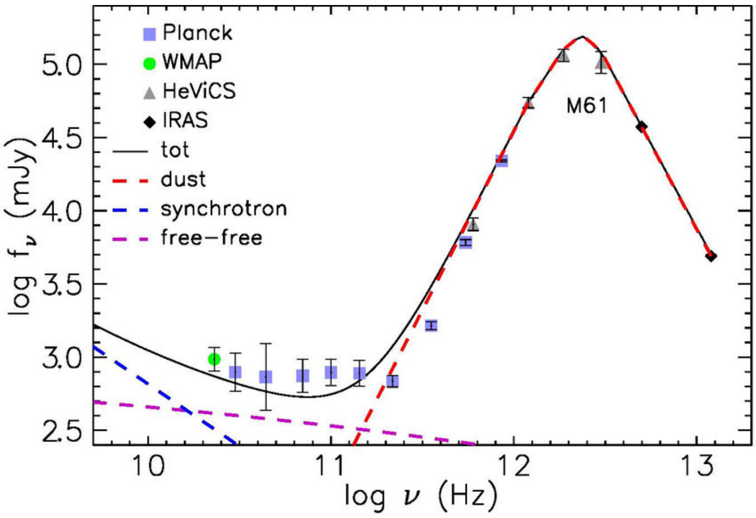

Figure 4: An example of Spectral Energy Density graph, a logarithmic graph of flux density vs frequency

5 Expected Results

A reduced, low noise data similar to figure 2b should be obtained. From the reduced data, surface number density as the function of radius from center HzRG can be calculated from the number counts. Figure 3 shows one example of graph of surface number density of cluster galaxies vs distance from a cluster center. A Spectral Energy Density (SED) of each detected submm galaxy can be calculated by combining multiwavelength flux density to obtain photometric redshift. An example of the stated graph is shown in figure 4, obtained from article (De Zotti, Bonato, & Cai,)

6 Significance

Surface number density is essential in studying the effect of HzRG on the environment. The addition of 0.85mm and 0.45mm in SED will give a more accurate photometric redshift of galaxies, which is crucial to study the evolution of galaxies with redshift. More comprehensive data of proto-cluster dynamic will probe into a more robust understanding of galaxies structure evolution.

References

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