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miniTAO/ANIR Paα Survey of Local LIRGs

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ABSTRACT

ANIR (Atacama Near InfraRed camera) is a near infrared camera for the University of Tokyo Atacama 1m telescope, installed at the summit of Co. Chajnantor (5640m altitude) in northern Chile. The high altitude and extremely low water vapor (PWV=0.5mm) of the site enable us to perform observation of hydrogen Paα emission line at 1.8751μm. Since its first light observation in June 2009, we have been carrying out a Paα narrow-band imaging survey of nearby luminous infrared galaxies (LIRGs), and have obtained Paα for 38 nearby LIRGs listed in AKARI/FIS-PSC at the velocity of recession between 2800 km/s and 8100 km/s. LIRGs are affected by a large amount of dust extinction (A_V∼3mag), produced by their active star formation activities. Because Paα is the strongest hydrogen recombination line in the infrared wavelength ranges, it is a good and direct tracer of dust-enshrouded star forming regions, and enables us to probe the star formation activities in LIRGs. We find that LIRGs have two star-forming modes. The origin of the two modes probably come from differences between merging stage and/or star-forming process.

key words: Infrared - Paα: Galaxies - LIRGs: Conferences - proceedings

1. INTRODUCTION

In recent years, many large deep cosmological surveys have revealed that the star forming rate (SFR) density of the universe (cosmic SFR density) increases by an order of magnitude from the present to z ∼ 1. The densities at high redshifts are dominated by infrared bright galaxies, especially Luminous Infrared Galaxies (LIRGs; L_{IR} = L [8–1000 μm] = 10^{11}–10^{12} $L_\odot$) and Ultra Luminous Infrared Galaxies (ULIRGs; L_{IR} = 10^{12}–10^{13} $L_\odot$) (e.g., Goto et al. 2010). Their IR emission is thermal dust emission in the mid-IR (MIR) to far-IR (FIR) wavelengths caused by absorbing UV photons from intensive star formation and/or luminous active galactic nuclei (AGNs). In order to know the detailed properties of these galaxies, and to understand how they have formed and evolved, local U/LIRGs are ideal laboratories for spatially resolved SF processes.

However, U/LIRGs are affected by a large amount of dust extinction (A_V > 3 mag for LIRGs; Alonso-Herrero et al. 2006), produced by their star formation activities. Then, hydrogen Paα (1.8751μm) represents a nearly unbiased tracer of the ongoing obscured SFR by its strength and relative insensitivity to the extinction. However, due to poor atmospheric transmittance around that wavelength, ground-based observations of Paα have so far been difficult.

2. OBSERVATION

2.1. *miniTAO/ANIR*

ANIR is a near infrared camera for the University of Tokyo Atacama 1.0m telescope (miniTAO), installed at the summit of Co. Chajnantor (5640m altitude) in northern Chile (Yoshii et al. 2010). The high altitude and low precipitable water vapor (PWV=0.5mm) of the site enable us to perform observations of Paα. The first light observation was carried out in July 2009, and Paα images have been successfully obtained using $N1875$ and $N191$ narrow-band filters.

2.2. *Sample Data*

Galaxies listed in the catalog of AKARI/FIS-PSC were drawn using a criteria with a recession velocity of 2800 km/s $\sim$ 8100 km/s and $4.5\times10^{10} < L_{IR}$(8–1000$\mu$m) [$L_\odot$] $< 6.5\times10^{11}$. In total, 38 objects were observed with $N191$ (for redshifted Paα), and H and K_s broad-band filters (for continuum) in June 2009–October 2011 (5 observation runs).

3. Paα DISTRIBUTIONS OF LOCAL LIRGs

To quantify the morphology of local LIRGs, the concentration index (Conselice et al. 2003) is used. The definition is $C = 5 \log (r_{80}/r_{20})$, where r_{80} and r_{20} are the radii which contain 80% and 20% of the total flux, respectively. The total flux is defined as a flux contained within 1.5 times the Petrosian radius. We estimated the C-Index for Paα line images (C_L; star-forming) and 1.9μm continuum images (C_C; stellar population). Our result shows quantitatively that there are two types of star-forming region profile of LIRGs (Figure 1). There are two possible scenarios which can explain the origin of the two star-forming modes. One is the difference in merging stage; Group-B is in the early, and Group-A is in the late phase of the merging, and the other is the difference in star forming process; Group-A is in the minor merging mode in which gas falls into the center of elliptical-galaxy like potential, while Group-B is in the major merger mode.

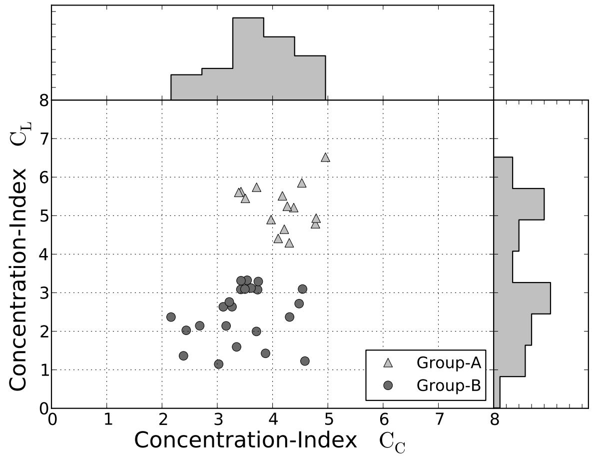

Figure 1: Comparison of C_L and C_C, where a bimodal distribution of Paα profile is seen.

4. SUMMARY

38 objects were observed by miniTAO/ANIR with Paα narrow-band filter. We find that LIRGs fall into two star-forming modes. The origin of the two modes probably comes from the differences between the merging stage and/or the star-forming process.

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REFERENCES

Goto, et al., 2010, Evolution of infrared luminosity functions of galaxies in the AKARI NEP-deep field. Revealing the cosmic star formation history hidden by dust, A&A, 514, A6

Alonso-Herrero, et al., 2006, Near-Infrared and Star-forming Properties of Local Luminous Infrared Galaxies, ApJ, 650, 835

Conselice, et al., 2003, The Relationship between Stellar Light Distributions of Galaxies and Their Formation Histories, ApJS, 147, 1

Yoshii, et al., 2010, The University of Tokyo Atacama Observatory 6.5m telescope project, SPIEproc., 7733