

miniTAO/ANIR Pa α 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 (5,640 m altitude) in northern Chile. The high altitude and extremely low water vapor (PWV = 0.5 mm) of the site enable us to perform observation of hydrogen Pa α emission line at 1.8751 μ m. Since its first light observation in June 2009, we have been carrying out a Pa α narrow-band imaging survey of nearby luminous infrared galaxies (LIRGs), and have obtained Pa α for 38 nearby LIRGs listed in AKARI/FIS-PSC at the velocity of recession between 2,800 km/s and 8,100 km/s. LIRGs are affected by a large amount of dust extinction ($A_V \sim 3$ mag), produced by their active star formation activities. Because Pa α 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: Pa α ; 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 $z \sim 1$. The densities at high redshifts are dominated by infrared bright galaxies, especially Luminous Infrared Galaxies (LIRGs; $L_{IR} = L [8-1,000 \mu\text{m}] = 10^{11}-10^{12} L_{\odot}$) 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 Pa α (1.8751 μm) 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 Pa α 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 (5,640 m altitude) in northern Chile (Yoshii et al., 2010). The high altitude and low precipitable water vapor (PWV = 0.5 mm) of the site enable us to perform observations of Pa α . The first light observation was carried out in July 2009, and Pa α 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 2,800 km/s \sim 8,100 km/s and $4.5 \times 10^{10} < L_{IR}(8\text{--}1,000 \mu\text{m}) [L_{\odot}] < 6.5 \times 10^{11}$. In total, 38 objects were observed with N191 (for redshifted Pa α), and H and K_s broadband filters (for continuum) in June 2009–October 2011 (5 observation runs).

3. Pa α 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 Pa α line images (C_L ; star-forming) and 1.9 μm 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.

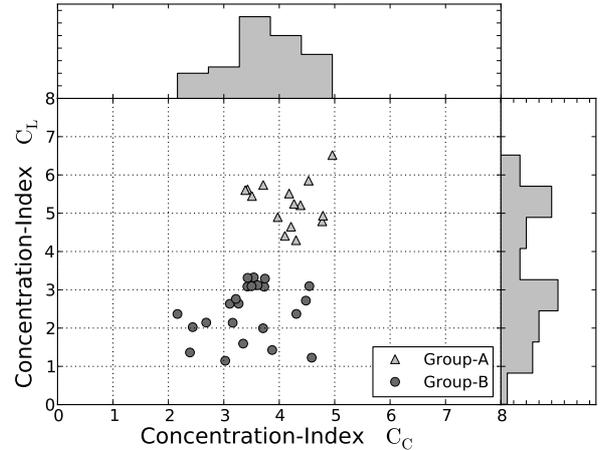


Fig. 1. Comparison of C_L and C_C , where a bimodal distribution of Pa α profile is seen.

4. SUMMARY

38 objects were observed by miniTAO/ANIR with Pa α 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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