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The Mid-Infrared luminosity function of galaxies using the AKARI mid-infrared All-Sky Survey Catalogue

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Abstract. We present the first determination of the 18 μm luminosity function (LF) of galaxies at $0.006 < z < 0.7$ (the average redshift is ~ 0.04) using the AKARI mid-infrared All-Sky Survey catalogue. We have selected a 18 μm flux-limited sample of 243 galaxies from the catalogue in the SDSS spectroscopic region. We then classified the sample into four types; Seyfert 1 galaxies (including QSOs), Seyfert 2 galaxies, LINERs and Star-Forming galaxies using mainly [OIII]/Hβ vs. [NII]/Hα line ratios obtained from the SDSS.

As a result of constructing Seyfert 1 and Seyfert 2 LFs, we found the following results; (i) the number density ratio of Seyfert 2s to Seyfert 1s is 3.98 ± 0.41 obtained from Sy1 and Sy2 LFs; this value is larger than the results obtained from optical LFs. (ii) the fraction of Sy2s in the entire AGNs may be anti-correlated with 18 μm luminosity. These results suggest that the torus structure probably depends on the mid-infrared luminosity of AGNs and most of the AGNs in the local Universe are obscured by dust.

Keywords. catalogs, surveys, galaxies: active, galaxies: fundamental parameters,galaxies: Seyfert, galaxies: luminosity function, infrared: galaxies

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1. Introduction

The luminosity function (LF) of galaxies is one of the fundamental statistics to describe the formation and evolution of galaxies in the Universe. When we focus on the infrared (IR), an infrared luminosity function is an important probe of the activity of galaxies and galaxy formation history hidden by dust since galaxies emit their entire IR through dust.

The infrared astronomical satellite AKARI, launched in 2006, is the first Japanese space mission for infrared astronomy in Japan (Murakami *et al.* 2007). One of the most important results of AKARI is a mid-infrared (9 and 18 μm) all-sky survey, the detection limits for which reach 50 mJy and 100 mJy respectively (Ishihara *et al.* 2010).

Using AKARI, we constructed 18 μm LFs of galaxies, a unique output since only AKARI only has an observing band at 18 μm. The coverage of objects from which the LFs are constructed is about 8032 deg^2, with a depth in redshift of about 0.7.

2. Data and analysis

Our sample is constructed out of objects detected by AKARI which are detected in the the Sloan Digital Sky Survey Data Release 7 (Abazajian *et al.* 2009) spectroscopic region (8032 deg^2). We achieved this by cross-matching with the SDSS and ZCAT (eq: Huchra *et al.*1995). We then selected the objects which met the following criteria as the final sample.

(a) z > 0.006 (in order to exclude stars and nearby galaxies.)

(b) $F_{18\mu m} > 0.181$ Jy (which corresponds to a 50 % completeness).

These processes resulted in a 18 μm flux-limited sample of 243 galaxies.

Furthermore, we classified these 243 galaxies into four catagories: Seyfert 1 galaxies, Seyfert 2 galaxies, LINERs and Star-Forming galaxies. We used the optical flux line ratio and the information in the catalogue for a type classification. Th final division of galaxies between the four types is 36 Seyfert 1 galaxies, 62 Seyfert 2 galaxies, 12 LINERs, and 68 Star-Forming galaxies.

3. Results

After adopting K-corrections and a correction for completeness, we derived LFs using the $1/V_{\rm max}$ method (Schmidt *et al.* 1968). An advantage of the $1/V_{\rm max}$ method is that it allows direct computation of the LF from the data, with no parameter dependence or a model assumption.

Figure 1 shows the resulting luminosity functions at 18 μm. 12 μm LFs from (Rush *et al.* 1993) are also plotted for comparison (after converting their result for a Hubble constant of 70 km s^{-1} Mpc^{-1}. The shapes of these LFs resemble each other closely.

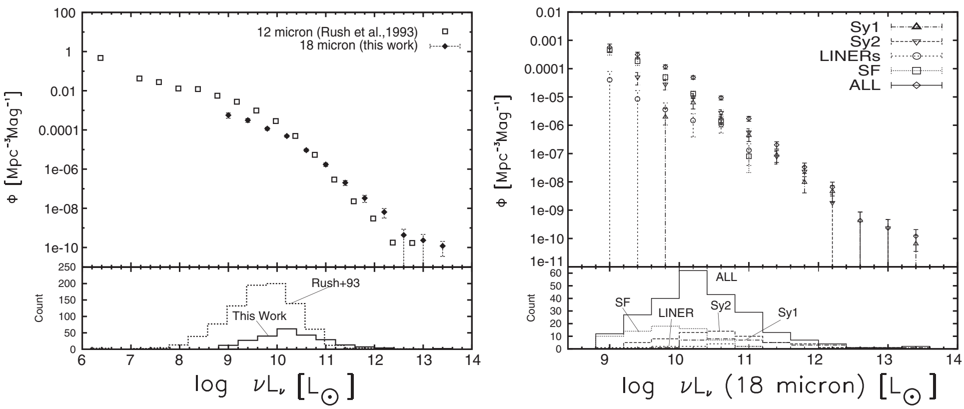

Figure 1. The 18 μm luminosity function of all samples compared to the 12 μm luminosity function after correcting for Hubble constant (Rush *et al.* 1993). The error bar is calculated considering Poisson-statistical uncertainties (left). The LFs including their types (right).

4. Discussion

4.1. *The number density ratio of Sy1s and Sy2s*

In order to establish the comparison between the number densities of Sy1s and Sy2s, we used the 18 μm luminosity, which is expected to be direct radiation from the dust torus and to be uninfluenced by dust extinction. By integrating the LFs of Seyfert 1s and Seyfert 2s (Fig.1), we obtained the number density ratio, $\Phi_{\rm Sy2}/\Phi_{\rm Sy1}$. In this work,

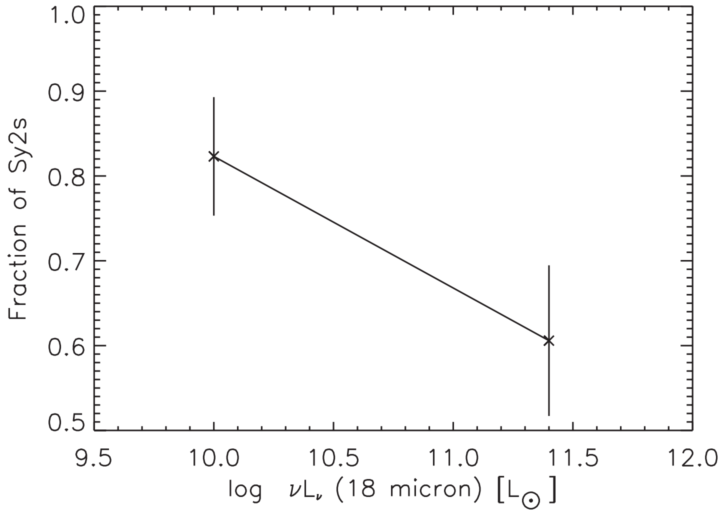

Figure 2. The fraction of Sy2s versus 18 μm luminosity.

the integral range is $\log(\nu L_\nu) > 9.6$ L$_\odot$ for both AGNs. Our results yield a value for $\Phi_{\rm Sy2}/\Phi_{\rm Sy1}$ of 3.98 $\pm$ 0.41, which is greater than the value of 0.96 obtained from the corresponding optical LFs (Huchra *et al.* 1992).

This results indicate that there are a large number of dusty AGNs in the local Universe. The result mentioned above is consistent with previous work using X-ray observations (Maiolino *et al.* 1998; Risaliti *et al.* 1999; Malizia *et al.* 2009).

4.2. *Luminosity dependence of the fraction of Sy2s*

In Figure 2 we show the fraction of Sy2s as function of 18 μm luminosity. The fraction of Sy2s seems to be anti-correlated with the 18 μm luminosity. This anti-correlation probably means that the emission from the central engine has influenced the structure of the torus. Therefore, this relation indicates that the torus structure may be different for AGNs with different 18 μm luminosities.

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