Challenges in Panchromatic Modelling with Next Generation Facilities
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Mid-infrared PAH emission from star-forming galaxies selected at 250 μm

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Abstract. The infrared (IR) galaxies detected at Herschel/SPIRE 250 μm band over the AKARI's NEP-Wide field are various types of dusty star-forming (SF) galaxies ranging from quiescent to starbursts, having mid-IR polycyclic aromatic hydrocarbon (PAH) features near 8 μm. The measurements of the 8 μm luminosity ($L_{8\mu m}$) along with the total infrared luminosity (L_{IR}) based on the physical modeling of SEDs a take unique advantage of the continuous near- to mid-IR coverage, far-IR data points, and spectroscopically determined accurate redshifts. Our sample shows shortage of 8 μm luminosity compared to the total IR luminosity. This deficit gets severe in more luminous IR galaxies, suggesting PAH molecules in these galaxies are destroyed by a strong radiation field from SF regions, or the existence of a unexpectedly large amount of cold dust in the ISM that contributes to L_{IR}.

Keywords. galaxies: evolution – infrared: galaxies

1. Introduction

The 8 μm luminosity (dominated by PAH features) of a normal SF galaxy is believed to have a relation with the overall SF activity of a whole galaxy (Elbaz *et al.* 2011; Schreiber *et al.* 2016). With expanding interests in dust contents of dusty SF galaxies, infrared (IR) wavelengths are getting more important in terms of physically motivated SED modeling and for the better understanding of dusty star formation activities. Thanks to the surveys over the north ecliptic pole (NEP) region by AKARI and Herschel (Matsuhara *et al.* 2006; Pearson *et al. in preparation*), we have a large number of mid-IR (MIR) galaxies observed at far-IR bands. The detection in the Herschel/SPIRE bands provides an important basis to select various types of IR-luminous populations of galaxies while the AKARI continuous band coverage gives more detailed information about the spectral energy distribution (SED) in the MIR. Now, we can derive more accurate 8 μm luminosity based on the continuous mid-IR coverage and carry out the consistent comparison with total infrared luminosity determined using reliable constraints on the far-IR peak.

2. Total infrared luminosity and 8μm luminosity

Our sample is composed of 250 mid-IR galaxies observed by AKARI over the NEP region (Kim *et al.* 2012), selected based on the SPIRE 250 μm detection as well as the optical spectroscopic redshift (Shim *et al.* 2013). The modeling of SED was carried out using `MAGPHYS` (da Cunha *et al.* 2008) based on the energy balance argument. We obtained physically meaningful fits to the observed photometric data from optical to sub-mm bands. This physical modeling gives important physical quantities such as star formation rate (SFR), stellar mass (M_*), and total infrared luminosity (L_{IR}). The sample galaxies analysed in this study appear to be various types, normally classified as SF/spiral, and ranges from quiescent to starburst in terms of the SFR–M_* relation. As shown in Fig. 1,

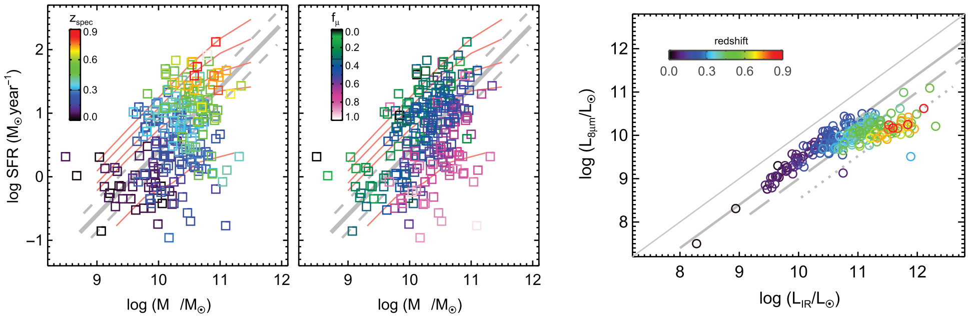

Figure 1. Distribution of our sample in the plane of SFR vs M_* with color bars showing redshift (left panel) and f_μ (middle panel). Thick gray lines in the background represent the IR galaxy main sequence (MS) and its 1-σ dispersion (Elbaz *et al.* 2011). Orange lines show the redshift evolution of MS from $z = 0$ to $z = 2$ (Schreiber *et al.* 2016). The right panel shows the distribution of $L_{8\mu m}$ as a function of L_{IR}. The long dashed line represents $L_{IR}/L_{8\mu m} = 10$. The dotted line represents $L_{IR}/L_{8\mu m} = 30$.

the wide spread of our sample seems to be due to the combination of types and the redshifts. Although it is not easy to get a clear and meaningful census on and off the main sequence (MS), we can test evolutionary properties of galaxies that have MIR PAHs. According to one of the resultant parameters, f_μ (defined by the fraction of cold dust contributing to the total IR luminosity), there seems to be an IR-luminous population which has abundant cold dust irrelevant to current SF activity. The shortage of 8 μm luminosity (dominated mostly by mid-IR PAH emission features) compared to the total IR luminosity seems mostly due to a strong radiation field from the SF region. As shown in the right panel of Fig. 1, some of our galaxies ($z > 0.6$) show an unexpectedly and surprisingly severe deficit.

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