The MOSDEF Survey:
Metallicity dependence of the PAH emission at High Redshift:
Implications for 24 micron-inferred IR luminosities and star formation rates at z~2

Irene Shivaei[1,5], Naveen A. Reddy[1,6], Alice E. Shapley[2], Brian Siana[1], Mariska Kriek[3], Bahram Mobasher[1], Alison L. Coil[4], William R. Freeman[1], Ryan L. Sanders[2], Sedona H. Price[3], Mojegan Azadi[4]

DRAFT: September 19, 2016, Submitted to ApJ

ABSTRACT

We present results on the variation of Polycyclic Aromatic Hydrocarbon (PAH) emission at 7.7μm in galaxies spanning a wide range in metallicity at $z \sim 2$. For this analysis, we use rest-frame optical spectra of 476 galaxies at $1.37 \leq z \leq 2.61$ from the MOSFIRE Deep Evolution Field (MOSDEF) survey to infer metallicities and ionization states. *Spitzer*/MIPS 24μm observations are used to derive rest-frame 7.7μm luminosities ($L_{7.7}$) and far-IR data from *Herschel*/PACS 100 and 160μm to measure total IR luminosities ($L_{\rm IR}$). We find significant trends between the ratio of $L_{7.7}$ to $L_{\rm IR}$ (and to dust-corrected SFR) and both metallicity and [OIII]/[OII] (O_{32}) emission-line ratio. The latter is an empirical proxy for the ionization parameter. These trends indicate a paucity of PAH molecules in low metallicity environments with harder and more intense radiation fields. Additionally, $L_{7.7}/L_{\rm IR}$ is significantly lower in the youngest quartile in our sample (ages of $\sim$ 400 Myr) compared to older galaxies, which may be a result of the delayed production of PAHs by AGB stars. The relative strength of $L_{7.7}$ to $L_{\rm IR}$ is also lower by a factor of ~ 2 for galaxies with masses $M_* < 10^{10}$M$_\odot$, compared to the more massive ones. We demonstrate that commonly-used conversions of $L_{7.7}$ (or 24 μm flux density; f_{24}) to $L_{\rm IR}$ underestimate the IR luminosity by more than a factor of 2 at $M_* \sim 10^{9.6-10.0}$ M$_\odot$. Consequently, the SFR-M_* relation has a shallower slope than previously derived from studies that neglected the metallicity dependence of the 24μm-to-IR conversion factor. Our results suggest a higher IR luminosity density at $z \sim 2$ than previously measured, which corresponds to a $\sim$ 30% increase in the SFR density.

Subject headings: galaxies: general — galaxies: high-redshift — galaxies: star formation — infrared: galaxies — ISM: molecules

z=1.5-2.6のUV select銀河

z=0-2.5の主系列銀河

z=1.5-2.5の
Ks select銀河

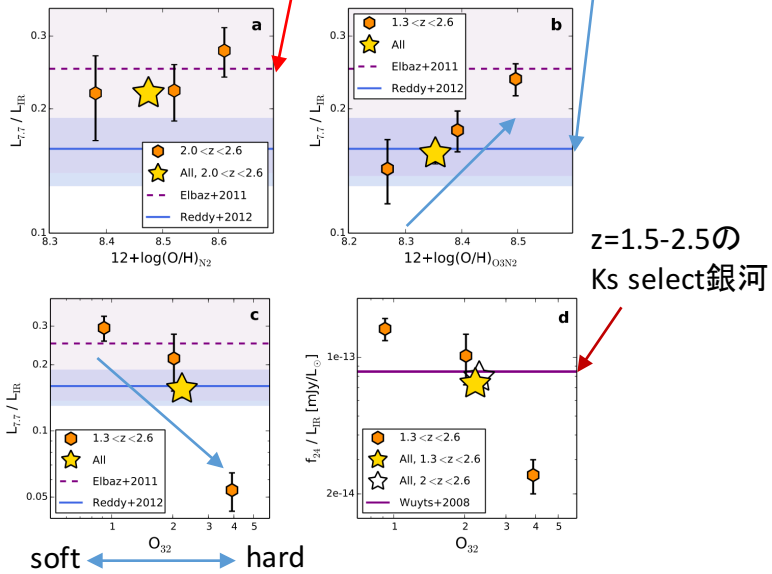
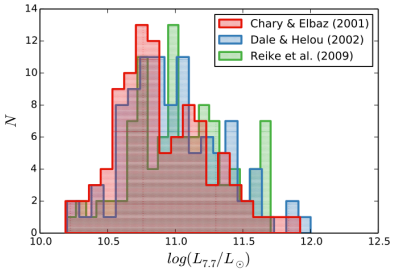


Figure 3. Relative strength of 7.7 μm luminosity to total IR luminosity as a function of N2 metallicity (a), O3N2 metallicity (b), O_{32} ratio (c), and ratio of 24 μm flux density to total IR luminosity versus O_{32} (d). In order to gain sufficient S/N in PACS bands, the lowest metallicity bins and the highest O_{32} bin have twice the number of galaxies in other bins. Yellow stars show stacks of all galaxies. For comparison, we show the $L_{7.7}/L_{\rm IR}$ conversions of E11 and R12 and the associated uncertainties with solid lines shaded regions, respectively. The $f_{24}/L_{\rm IR}$ ratio of W08 is plotted in panel d. The W08 ratio is redshift-dependent and the width of the purple line in plot (d) shows the range of values for the three bins. The N2 stacks are only performed for galaxies at $z > 2$, because otherwise the last bin would be biased towards galaxies at $z < 2.0$. Stacked values are listed in Table 2.

high-z (z=1.3~2.6)の大規模サンプル(N=476)で初めて、最も強いPAH輝線7.7μmと他の輝線との間の様々な相関を調べた。

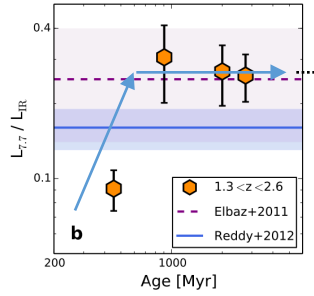
low-zでの
- 低金属量(≈低質量)のため輻射場が強くて硬い環境ではPAHが破壊される。
- PAHはAGB星によって生成される(若い銀河ではPAHがIR光度に占める割合が小さい)。

という描像と矛盾ない結果が得られた。



赤：Chary & Elbaz 01のIR templateから再現したνLν(7.7μm)

Figure 1. Histogram of rest-frame 7.7 μm luminosities converted from 24 μm flux densities using IR templates of Chary & Elbaz (2001, red), Dale & Helou (2002, blue), and Rieke et al. (2009, green) for 299 galaxies with robust redshift measurements. The systematic bias between different models is not significant compared to the measurement uncertainties.



high-Zでのintrinsicな値：
十分なdustがあればshieldが効いてPAHが破壊されず一定値に落ち着く？
年齢を重ねるにつれて、AGB起源とSN起源のdustの存在比が一定値に落ち着いてくる？
AGBとSNのdust形成への寄与はほぼ同等(Valiante+09)になるという。

Figure 4. (a): ratio of $L_{7.7}$ to $\rm SFR_{H\alpha,H\beta}$ as a function of age. Symbols are the same as Figure 2. (b): ratio of 7.7 μm luminosity to $L_{\rm IR}$ as a function of age. Symbols are the same as Figure 3. Ages are derived from the best-fit SEDs. Stacked values are listed in Tables 1 and 2.