THREE DUSTY STAR FORMING GALAXIES AT $Z \sim 1.5$: MERGERS AND DISKS ON THE MAIN SEQUENCE

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Draft version March 3, 2020

ABSTRACT

The main sequence of galaxies, a correlation between the star formation rates and stellar masses of galaxies, has been observed out to $z \sim 4$. Galaxies within the scatter of the correlation are typically interpreted to be secularly evolving while galaxies with star formation rates elevated above the main sequence are interpreted to be undergoing interactions or to be Toomre-unstable disks with starbursting clumps. In this paper we investigate the recent merger histories of three dusty star forming galaxies, identified by their bright submillimeter emission at $z \sim 1.5$. We analyze rest-frame optical and UV imaging, rest-frame optical emission line kinematics using slit spectra obtained with MOSFIRE on Keck I, and calculate Gini and M_{20} statistics for each galaxy and conclude two are merger-driven while the third is an isolated disk galaxy. The disk galaxy lies ∼4× above the main sequence, one merger lies within the scatter of the main sequence, and one merger lies ∼4× below the main sequence. This hints that the location of a galaxy with respect to the main sequence may not be a useful discriminator of the recent star formation history of high-$M_\star$ galaxies at $z \sim 1$.

arXiv.2003.00016
(+ Drew et al. 2018)

Table 1
Parameters of Each Galaxy

SOURCE	450.25	450.27	850.95
RA	10:00:28.58	09:59:42.92	09:59:59.80
Dec	+02:19:28.3	+02:21:45.1	+02:27:07.4
z_{spec}	1.515	1.531	1.555
$M_\star$ ($M_\odot$)	$(3.4 \pm 0.5) \times 10^{11}$	$(3.0 \pm 0.6) \times 10^{11}$	$(3.8 \pm 3.0) \times 10^{10}$
L_{IR} ($L_\odot$)	$(1.5^{+0.7}_{-0.5}) \times 10^{12}$	$(4.1 \pm 0.5) \times 10^{12}$	$(3.0^{+1.2}_{-0.9}) \times 10^{12}$
SFR ($M_\odot$ yr^{-1})	157^{+80}_{-53}	382^{+51}_{-45}	373^{+110}_{-90}
Gini	0.53 ±0.01	0.63 ±0.01	0.48 ±0.01
M_{20}	−1.725	−1.808	−1.654
Physical Driver	Merger	Merger	Disk

Dusty SF 銀河 (DSFG) はMerger or disk？MS図のどこに属するか？

- サブミリで見つかるようなDSFGは(その星形成の強さから) merger だろうと言われてきたが、近年ではmergingの兆候を示さないものも見つかっている。
  - 星形成の要因が merger なのか否かは銀河進化において重要な情報。
- Merger-driven SFかどうかを形態と力学から推定し、さらにDSFGがMS図のどこに位置するかを調べる。(merger-drivenだとMSの上に来るのか？)

DSFG850.95の図は
Drew+18から。

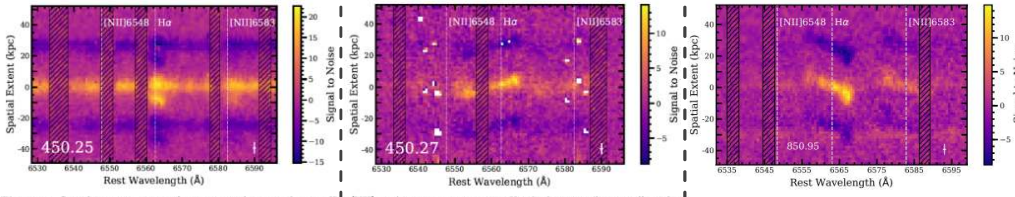

Figure 1. Signal to noise spectra for 450.25 and 450.27 showing Hα, [NII], and continuum emission. Hatched regions denote telluric line contamination and white regions denote bad pixels. The resolution in each dimension is denoted by the white cross in the lower right corners. Regions of negative SNR are artifacts from the ABBA nod pattern coaddition procedure.

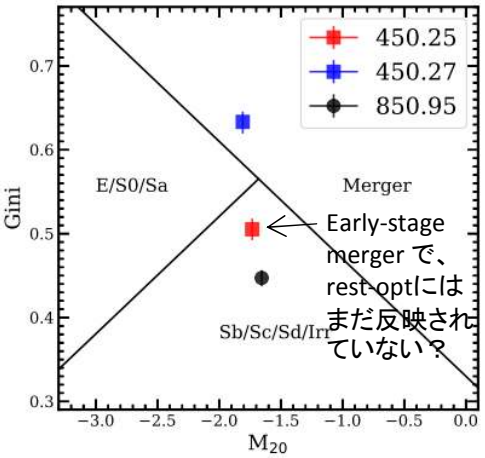

Figure 4. Gini-M_{20} diagram with our sample overplotted. Squares indicate classifications of mergers, while the circle indicates disk, as determined by our morphological and kinematic analyses. The black boundary lines are adopted from Lotz et al. (2008), which are calibrated to galaxies between $0.2 < z < 1.2$ in the EGS *HST* survey. While 450.25 is undergoing a merger it falls in the disk region. This may be due to the fact that it is observed in an early stage of the merger and H-band emission is therefore not yet concentrated in a small region. The imaging and kinematic analysis of 450.27 was a little ambiguous (see Section 3.2), but given its location in the Gini-M_{20} diagram we conclude it is a merger. Errors on Gini, calculated by performing 10^4 statistical bootstrap measurements of the pixels associated with each galaxy. Errors on M_{20} were not performed.

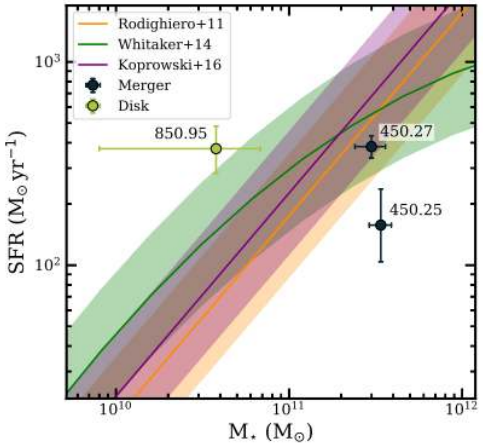

Figure 5. Our sample plotted against three main sequence fits from the literature. Our galaxies comprise the high stellar mass end of the MS. The orange line is the fit from Rodighiero et al. (2011) to data between $1.5 < z < 2.5$, the green line is the fit from Whitaker et al. (2014) to data between $1.5 < z < 2.0$, and the purple line is the fit from Koprowski et al. (2016) to data at $z > 1.5$. The shaded regions are ±0.3 dex from each fit, which is the typical 1σ scatter observed in the distribution (e.g. Whitaker et al. 2014).

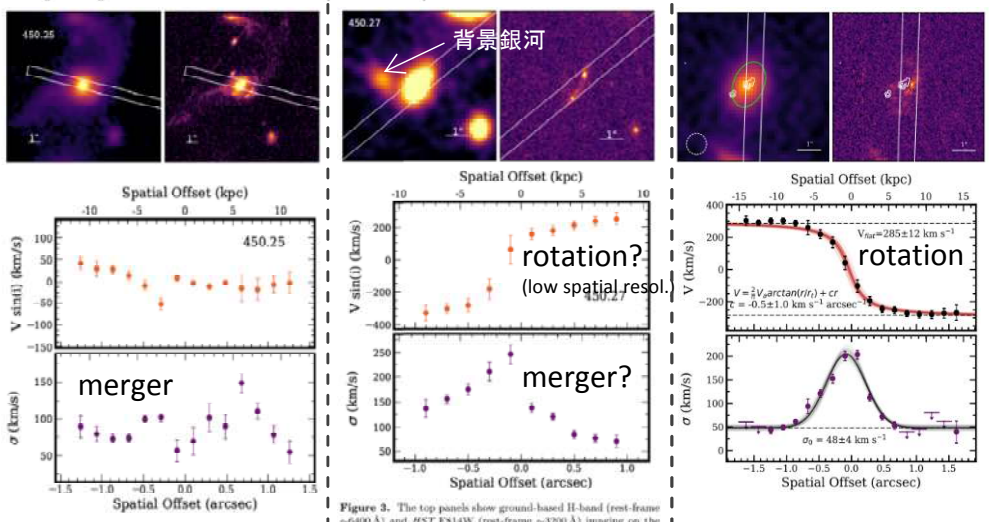

Figure 2. The top panels show ground-based H-band (rest-frame ∼6400 Å; McCracken et al. 2012) and *HST* F814W (rest-frame ∼5200 Å; Koekemoer et al. 2007) imaging on the left and right, respectively, with the MOSFIRE slit overplotted in white. The tidal tails seen in both images suggest 450.25 is undergoing an interaction or is in the early stages of a merger. The bottom panels show position velocity and position dispersion diagrams measured along the MOSFIRE slit. They are disordered fields showing no symmetry.

Figure 3. The top panels show ground-based H-band (rest-frame ∼6400 Å) and *HST* F814W (rest-frame ∼5200 Å) imaging on the left and right, respectively, with the MOSFIRE slit overplotted in white. The continuum emission running perpendicular to and outside of the MOSFIRE slit in the H band image likely belongs to a galaxy at higher redshift not physically associated with 450.27 because the colors of the two systems are very different. The bottom panels show position-velocity and position-dispersion diagrams measured along the MOSFIRE slit. The velocity curve looks Keplerian but the dispersion curve is not symmetric in the magnitudes of velocities measured on each side of the galaxy.

✓ Disk-likeな銀河がMSよりSFRが大きく、merger-likeな銀河がMSと同じか、より小さなSFRを持つ。

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- ❑ High-zでは、MsとSFR (またはsSFR) ではmergerの選別は難しい？
- ❑ DSFG (starburst銀河) のMsが間違っている？