Deviations from the Infrared-Radio Correlation in Massive, Ultra-compact Starburst Galaxies

2020/9/14 K.Kushibiki

Petter et al. 2020, arXiv: 2009.03906, ApJ accepted

Feedback through energetic outflows has emerged as a key physical process responsible for transforming star-forming galaxies into the quiescent systems observed in the local universe. To explore this process, this paper focuses on a sample of massive and compact merger remnant galaxies hosting high-velocity gaseous outflows ($|v| \gtrsim 10^3$ km s^{-1}), found at intermediate redshift ($z \sim 0.6$). From their mid-infrared emission and compact morphologies, these galaxies are estimated to have exceptionally large star formation rate (SFR) surface densities ($\Sigma_{SFR} \sim 10^3$ M$_\odot$ yr^{-1} kpc^{-2}), approaching the Eddington limit for radiation pressure on dust grains. This suggests that star formation feedback may be driving the observed outflows. However, these SFR estimates suffer from significant uncertainties. We therefore sought an independent tracer of star formation to probe the compact starburst activity in these systems. In this paper, we present SFR estimates calculated using 1.5 GHz continuum Jansky Very Large Array observations for 19 of these galaxies. We also present updated infrared (IR) SFRs calculated from WISE survey data. We estimate SFRs from the IR to be larger than those from the radio for 16 out of 19 galaxies by a median factor of 2.5. We find that this deviation is maximized for the most compact galaxies hosting the youngest stellar populations, suggesting that compact starbursts deviate from the IR-radio correlation. We suggest that this deviation stems either from free-free absorption of synchrotron emission, a difference in the timescale over which each indicator traces star formation, or exceptionally hot IR-emitting dust in these ultra-dense galaxies.

z~0.6のmassive(~10^{11}M$_{sun}$), compact(R$_e$~ few 100 pc) starburst galaxies

- Starburst由来のoutflow
- 高い星形成率面密度 ~ 103Msun yr-1 kpc-2 ~ Eddington limit

→ Massive galaxiesの進化に重要な天体

- Starburst driven feedback
- z>3のcompact star-forming galaxiesのanalog
  → z>1.5のcompact quiescent

⇒ 正しく星形成活動を特徴づける (特にSFR)

VLA1.5GHzの連続光から出したSFRとWISE IRから出したSFRを比較

$$\left(\frac{\mathrm{SFR}_\nu^{NT}}{\mathrm{M_\odot yr^{-1}}}\right) = 6.64\times10^{-22}\left(\frac{\nu}{\mathrm{GHz}}\right)^{-\alpha^{NT}}\left(\frac{L_\nu^{NT}}{\mathrm{W\ Hz^{-1}}}\right)$$

$$\left(\frac{\mathrm{SFR_{IR}}}{\mathrm{M_\odot yr^{-1}}}\right) = 3.88\times10^{-37}\left(\frac{L_{\mathrm{IR}}}{\mathrm{W}}\right)$$

Note: W3, W4だけだとdust連続光のピークを捉えられないので、0.5<z<3のdusty IR-luminous galaxiesのテンプレートを使用

近傍の銀河では二つのSFRのタイトな相関
→そこからのズレが今回のサンプルのISMの特徴に情報を与える

Fig. 2

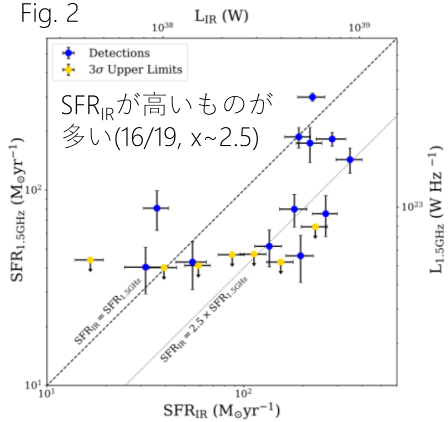
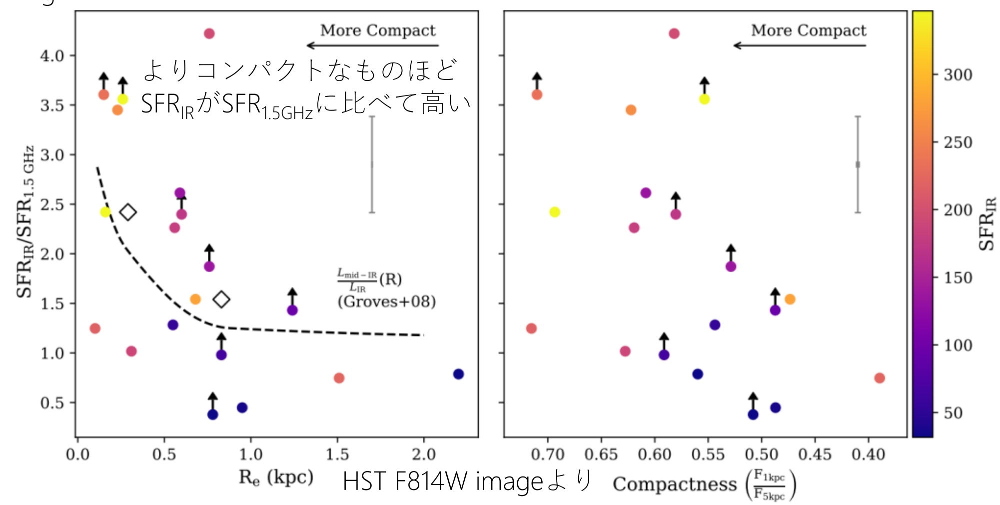


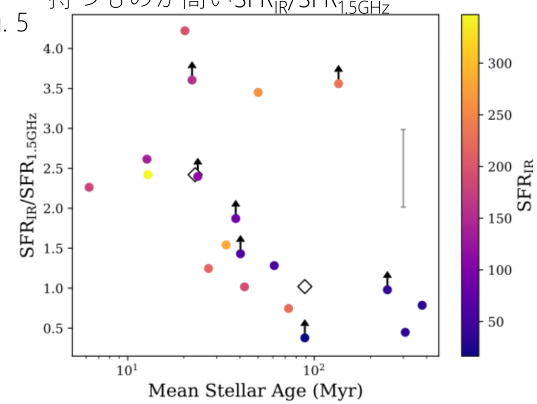
Fig. 4



HST F814W imageより

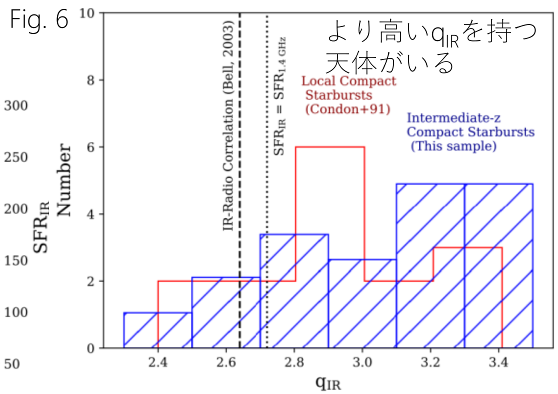
より若いstellar populationを持つものが高いSFR$_{IR}$/SFR$_{1.5GHz}$

Fig. 5



GALEX, SDSS, WISE SEDより

Fig. 6



$$q_{\mathrm{IR}} = \log_{10}\left(\frac{L_{\mathrm{IR}}}{3.75\times10^{12}\ \mathrm{W}}\right) - \log_{10}\left(\frac{L_{1.4\mathrm{GHz}}}{\mathrm{W\ Hz^{-1}}}\right)$$

4つの可能性

- Free-free absorption (Fig. 6, 4) : Condon+1991の近傍銀河研究ではfree-free吸収で説明がつく。
- Hot dust (Fig. 4): Compact galaxiesでのmid-IR enhancement (Groves+2008)
- Tracer timescale (Fig. 5): 星形成の立ち上がりではIRが早く反応。一方で星形成が減衰するときはradioが早く落ち込む。
- Convective wind: cosmic ray electronを銀河外に放出し、synchrotron放射が弱まる(Lisenfeld+2004)