Towards a Spatially Resolved SF Law at z~0.3

Sarah Leslie (MPIA)

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with: Toshiki Saito, Daizhong Liu
Motivation: Filling out observed space

- Galaxies had higher SFRs and higher gas fractions at high-z.
- Spatially resolved Kennicutt-Schmidt law at $z \sim 0.3$
- Fill-out redshift space $0.05 < z < 1$: Age of disk settling.
  - LIRGs are more often rotationally supported spiral discs rather than the extreme interacting systems found locally (<30%; Bell et al. 2005)
  - Molecular gas mass fractions are factor of ~5 higher (Bauermeister et al. 2013)

Madau & Dickinson (2014)
Starbursts: where is the transition?

- Main sequence and 2 modes of star formation

Rodighiero +2011

Daddi +2010
CO(3-2) for LIRGS at 0.3<z<0.6

N. Lee et al. (2017) PI: K. Scott

HST I-band
VLA 1.4GHz
CO(3-2)
Example data from Lee et al. 2017

13/20 galaxies show linewidths > 300 km/s

Expected center from optical spec-z

ALMA03, $z = 0.308$

ALMA05, $z = 0.323$

ALMA07, $z = 0.354$
Calculating $M_{H_2}$ from CO(3-2)...

- $R_{31}$

- Evolution of molecular Gas Normal Galaxies (EGNoG)
  Bauermeister+2013

- 4 SDSS selected SFG
  $M_* > 10^{11}$, $z \sim 0.3$ CO(3-2) and CO(1-0) FWHM~3.5"
  3 detected have $r_{31} \sim 0.5$

- Varies across galaxy?

- Metallicity-dependent $\alpha$ CO described in Genzel et al. (2015)
Starburstiness and global depletion time not strongly correlated

\[
\log\left(\frac{L_{IR}}{L'_\text{CO}}\right) \quad \log\left(\frac{\text{SFR}}{\text{SFR}_{\text{MS}}}\right)
\]

Lee et al. 2017
Global KS law at $z \sim 0.3$

\[ \Sigma_{SFR} \propto (\Sigma_{gas})^{1.07 \pm 0.25} \]
VLA 3GHz Large Project & Radio SFR

- COSMOS JVLA 3GHz Large Project.
  - Smolcic et al. 2017
- 2 sq deg rms $\sim 2.3 \mu$ Jy at 0.75” resolution.
- SFR: IR – Radio correlation
  - Redshift evolution
  - (Magnelli+2015)
  - Slope -0.8

Side note: We can use this 3GHz map and the COSMOS photometric stellar mass and redshift data to investigate the stellar mass – SFR (MS) relation of different galaxies!
CO(3-2) follow-up for LIRGS at $z \sim 0.3$

PI: S. Leslie

VLA 1.4GHz

CO(3-2)
CO(3-2) follow-up for LIRGS at $z \sim 0.3$

Pl: S. Leslie

VLA 1.4GHz

CO(3-2)
SFR-molecular gas relation

\[ \log\left(\frac{\Sigma_{SFR}}{M_{\odot}\,yr^{-1}\,kpc^{-2}}\right) \]

\[ \log\left(\frac{\Sigma_{H_2}}{M_{\odot}\,pc^{-2}}\right) \]

Pixel is \( \frac{1}{2} \) Beam FWHM \( \sim 1.5kpc \)

WORK IN PROGRESS

\( N \sim 1 \)
Spatially resolved studies

\[
\log\left(\frac{\Sigma_{SFR}}{M_{\odot} \text{yr}^{-1} \text{kpc}^{-2}}\right) = \log\left(\frac{\Sigma_{H_2}}{M_{\odot} \text{pc}^{-2}}\right)
\]

\[\tau = 10 \text{ Myr} \]
\[\tau = 100 \text{ Myr} \]
\[\tau = 1 \text{ Gyr} \]
\[\tau = 10 \text{ Gyr} \]

Azeez+2016, z=0.004
ALMA03
ALMA05
ALMA07
Freundlich+2013, z\sim 1.2
Genzel+2013, z=1.5
Chen+2017, z=2.1
Sharon+2013, z=2.6
Hatsukade+2015, z=3.0
Hodge+2015, z=4.0
Rawle+2015, z=5.2

Global ALMA03
Global ALMA05
Global ALMA07

Leroy+2013

WORK IN PROGRESS
Global relation of normal galaxies

\[ \log\left( \frac{M_{H_2}}{M_\odot} \right) \]

\[ \log\left( \frac{SFR}{M_\odot \text{yr}^{-1}} \right) \]


WORK IN PROGRESS
Barred and interacting galaxies tend to have lower values of $\log (t_{\text{center}}/t_{\text{disk}})$ than the unbarred, isolated and smaller molecular gas disk. Bar drives the gas inward/interaction loss of angular momentum.
Lee et al. 2017 studied 20 LIRGS at 0.3<z<0.5
  "Fine line between normal and starburst galaxies"
  At ΔSFRMS<0.6dex, increased SF driven by more gas rather than more efficient SF (but see e.g. Scoville+2017)

Combining interferometric ALMA CO(3-2) data and radio continuum data for higher resolution studies.

Continue local galaxy trends to higher SFRs.

Varied radial trends

To do: look at dynamics, stellar mass profile, …
  Continue expand parameter space!

Comments welcome 😊
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