The Evolution in the Molecular Gas Content of Luminous Infrared Galaxies at $z = 0.25 – 0.65$

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Transformational Science in the ALMA Era: Multi-Wavelength Studies of Galaxy Evolution
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Evolution of the Molecular Gas Fraction

- 10x decline in SFR density since $z \sim 1$
- Due to decrease in $f_{\text{H}_2}$, or SFE?
- $f_{\text{H}_2}$ decreases from $\sim 50\%$ to $6\%$ between $z < 1$ and today
  $\rightarrow$ evolution due to larger gas reservoir in past
- But...
Evolution of the Molecular Gas Fraction

- ...lots of galaxies DO have high SFEs (e.g. ULIRGs)
- Most CO observations at $z < 1$ are from ULIRGs → suggest rise in $f_{H_2}$ begins at $z = 0.2 – 0.3$
- Need more gas measurements in large unbiased sample of “normal” galaxies at $z < 1$
ALMA Band 6 Observations of CO in z < 1 LIRGs

- CO (3-2) in 20 star-forming galaxies from COSMOS
- $z = 0.25 - 0.65$ (spectroscopic)
- $L_{\text{IR}} = 1 - 4 \times 10^{11} L_{\odot}$ from Herschel/PACS+SPIRE
- Accurate $M_*$ from 30-band UV to near-IR SED fitting
- Angular resolution $\sim 1.3''$
- 2 GHz bandwidth, 40 km/s channels
- 2.9 hrs on-source
- Line rms: 0.2 – 1.0 mJy
- Continuum rms: 20 – 90 μJy
- 100% detection rate!
- Several have complex dynamics

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- $f_{\text{H}_2} = \frac{M_{\text{H}_2}}{M_{\text{H}_2} + M_*}$
- $M_{\text{H}_2} = \alpha_{\text{CO}} L_{\text{CO}(1-0)}$
- $\alpha_{\text{CO}} = 0.8 \frac{M_{\odot}}{(K \text{ km s}^{-1} \text{ pc}^2)}$
- $R_{3,1} = \frac{L_{\text{CO}(3-2)}}{L_{\text{CO}(1-0)}} = 0.8$
- 2x lower than other observations at $z = 0.2 – 0.7$
Redshift $\rightarrow$

If $M_{H2} = M_{ISM}$:

- $f_{H2}$ for our sample in better agreement with Combes+13 and Geach+11

- $<\alpha_{CO}> = 2.6 \, M_{sun} / (K \, km \, s^{-1} \, pc^2)$

If $M_{H2} = M_{ISM} / 2$:

- CO and dust estimates of $f_{H2}$ for my sample agree!
Summary and Future CO Studies

- ALMA can detect CO in 20 LIRGs at $z < 1$ in 3 hrs (well, x2-3 with overheads...)

- $f_{\text{H}_2} \sim 10\%$, or 2x lower than that seen in 10x more luminous galaxies (or not...)

- $\alpha_{\text{CO}}$ remains a big uncertainty – spatially resolved CO studies will help inform on this
But I Want to Play in the Dust!

- (nearly) All of these galaxies are selected based on IR luminosity
- Scoville+14 mass-selected sample suggests IR galaxies are biased to gas-rich systems
- Evolution in the molecular gas fraction better studied through mass-selected sample
ALMA Cycle 2: Evolution of the ISM at $z < 1$ (PI Scott)

Main sequence from Karim+11