Properties of Molecular Gas and Star Formation in Nearby Interacting Galaxies

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Question to address in this work

Whether, and by how much, galaxy interaction affects the molecular gas properties?

Methodology

We study the effect of galaxy interactions on global molecular gas properties with 59 interacting and 154 isolated galaxies. Gas properties are inferred by JCMT, PMO, CSO and xCOLD GASS observations at ^{12}CO(2-1) & ^{12}CO(1-0).

(1) Definition of paired galaxy:

(1.1) systems with projected separation (r_p) < 72 kpc and line-of-sight velocity difference < 500 km/s, or
(1.2) systems with Galaxy Zoo "weighted-merger-vote fraction" > 0.4.

(2) Quantify the effect of interactions:

For each paired and isolated galaxy, we quantify the "offset" of a given property (P) with respect to its control sample:

$$\Delta P = \log(P_{\text{galaxy in question}}) - \log(\mathtt{median}(P_{\text{control sample}}))$$

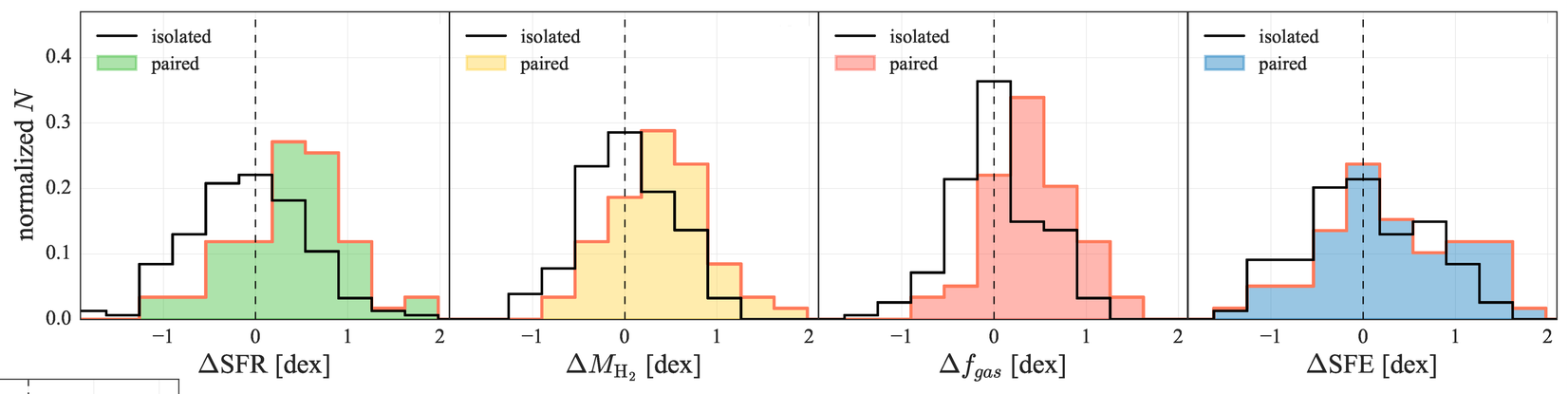
, the control sample are 5 isolated galaxies matched in stellar mass, redshift, and size with the galaxy in question.

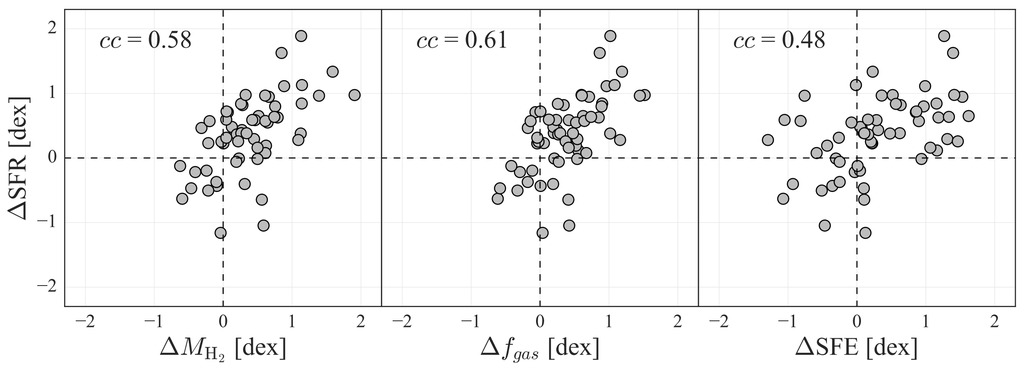
Results

SFR: star formation rate; **M***: stellar mass; **M_{H2}**: molecular gas mass (≡ Lco × physically-motivated α_{co}); **f_{gas}**: molecular gas fraction (≡M_{H2}/(M_{H2}+M*)); **SFE**: star formation efficiency of gas (≡ SFR/M_{H2})

(1) How are SFR and molecular properties affected by galaxy interactions?

- Normalized distribution of offset properties.
- When taking all galaxy pairs into account (median), SFR, M_{H2}, f_{gas} are enhanced in pairs with a similar factor (0.32 — 0.38 dex or 2.0 — 2.4 times), while the enhancement of SFE is smaller (0.2 dex or 60%).

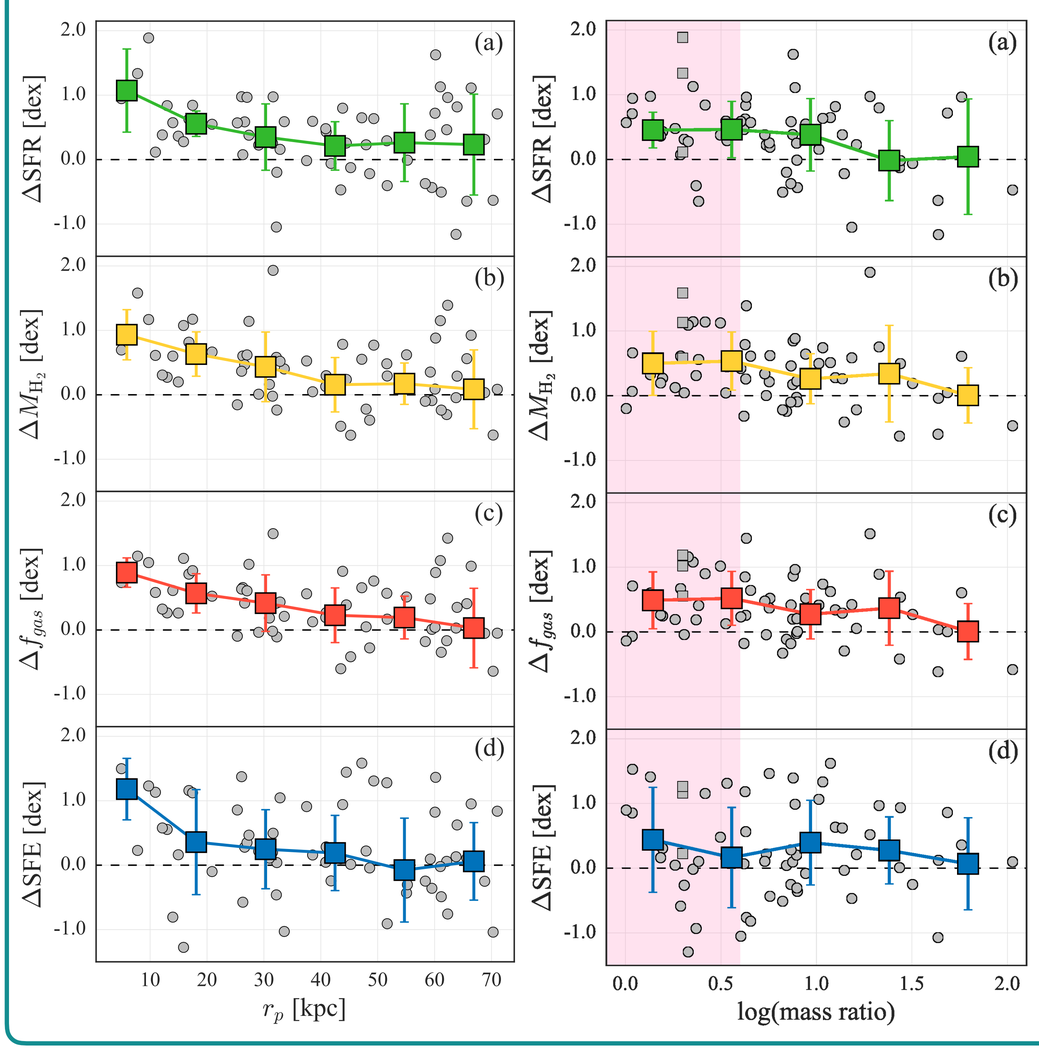




(2) Which gas property is correlated with ΔSFR?

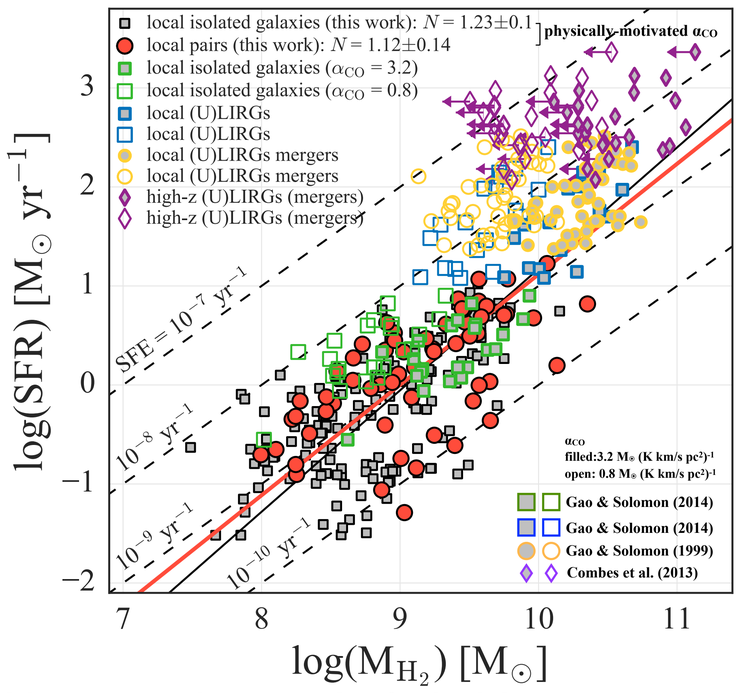
- ΔSFR versus ΔM_{H2} (left), Δf_{gas} (middle) and ΔSFE (right).
- Figure shows that SFR is influenced by both gas content and SFE.
- All gas properties offsets increase with ΔSFR, though more strongly for ΔM_{H2} and Δf_{gas} vs. ΔSFR as indicated by the Pearson's correlation coefficient (*cc*).

(3) Which property is correlated with merger properties?



- Offset properties versus projected separation r_p (left) and M* ratio of two galaxies in a pair (right).
- SFR, M_{H2}, and f_{gas} are enhanced as two galaxies approaching each other, and enhanced from minor to major (red area in the left figure) mergers.
- Statistically, SFE is only enhanced in strongly interacting objects (small r_p) and major mergers. SFE is enhanced in all pairs with approximately equal mass.
- Origins of the gas mass and gas fraction enhancement could be an accelerated HI-H_2 transition or a ^{12}CO emission contamination from companions.

(4) Star formation relation.



- Literature data are included for comparison.
- SFE of our paired and isolated galaxies (● & ■) is comparable that of local NGC galaxies (□□), several times lower than that of local (U)LIRGs (□□ & ○○), and about 10 times lower than high-*z* inferred mergers ((U)LIRGs) (◇◇).
- Gap between local galaxies and high-*z* (U)LIRGs on the SFR-M_{H2} plane can be bridged by local (U)LIRGs as shown by Saintonge+11.

Conclusion

On the galaxy-wide scale, galaxy interactions do affect molecular gas properties of a galaxy, though more strongly for total gas reservoir (M_{H2} and f_{gas}) than SFE. Moreover, the strength of the effect is merger configuration dependent (i.e., pair separation and stellar mass ratio).

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