ALMA observation of ^{12}CO(*J*=3-2) & ^{13}CO(*J*=3-2) in merging ULIRGs

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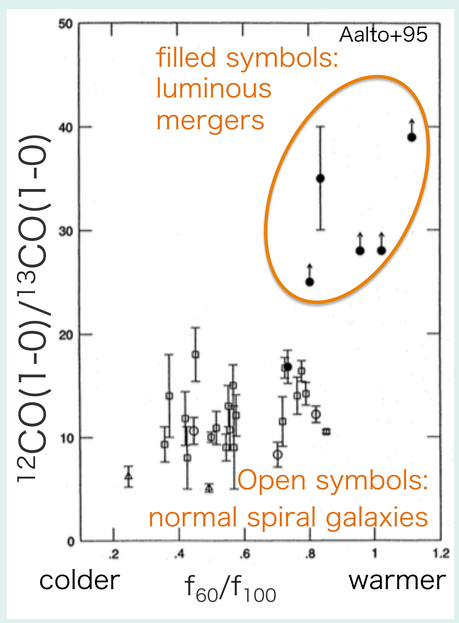
Abstract

Galaxy mergers play an important role in the evolutionary process of galaxies, as it changes the physical/chemical condition of the ISM, and intensifies the starburst activity as seen in the frequent occurrence of mergers in Ultra/Luminous Infrared Galaxies (U/LIRGs). We present here the preliminary results of ^{12}CO(*J*=3-2) and ^{13}CO(*J*=3-2) observations obtained toward merging ULIRGs with ALMA. We took ratio maps of ^{12}CO/^{13}CO and found that the ratios are typically lower at the central dust strong regions than the outer regions. We reveal that the trend of the high ^{12}CO/^{13}CO ratio in previous studies is due to the gas from the extended regions rather than the central gas. For further investigation, we are analyzing additional data such as ^{12}CO(*J*=1-0).

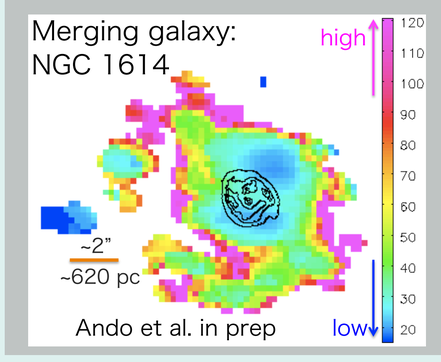
Introduction

Interaction of galaxy change morphology, and physics and chemistry of molecular gas. These activities sometimes occur intense starburst and nuclear activity. During these process, galaxy change their properties dramatically. It is therefore important to quantify the properties of gas in such merging galaxies in order to investigate the evolutionally scenario of galaxy.

One of the previous study of molecular gas in merging galaxies shows the trend of the ^{12}CO/^{13}CO line intensity. The ratio values are higher in luminous merging galaxies than in normal spirals, though the exact reason still unknown. ALMA data can offer clues of conditions causing this trend.



Our previous study:
Spatially resolved ^{12}CO/^{13}CO(2-1) line ratio maps with ALMA



Contrary to expectations, the ^{12}CO/^{13}CO ratio is low at the central region

Possibly due to gas inflow to the central star forming region

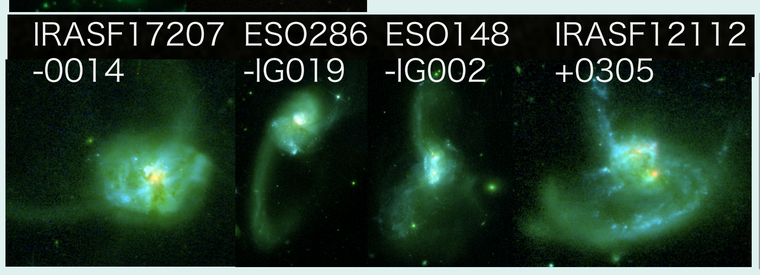
Next step is to increase the sample

Samples & Observations

Six mergers of The brightest ULIRGs in the local universe

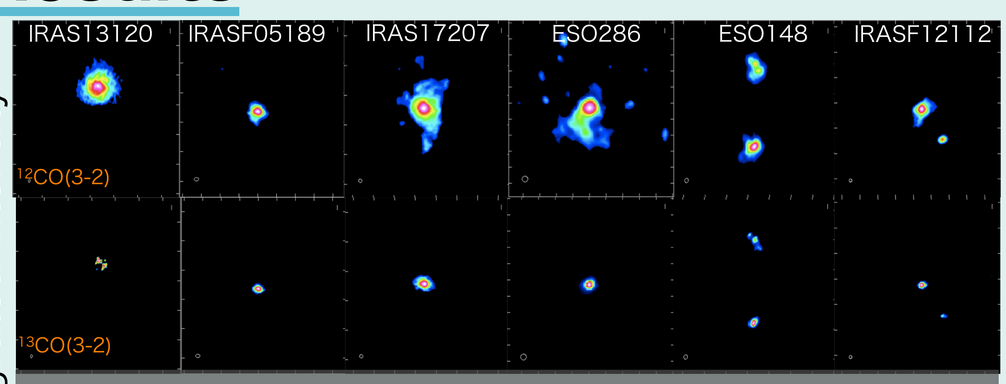
*ULIRGs: $L_{IR} > 10^{12}\ L_{\odot}$

- ALMA cycle 3-4
- Band7 observations
- Typical spatial resolution: ~ 200pc

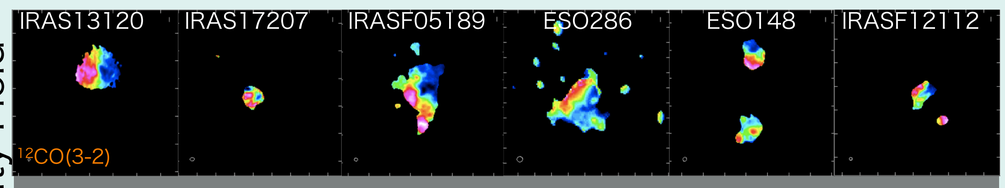


Used data here
- ^{12}CO(3-2)
- ^{13}CO(3-2)
- Dust cont.

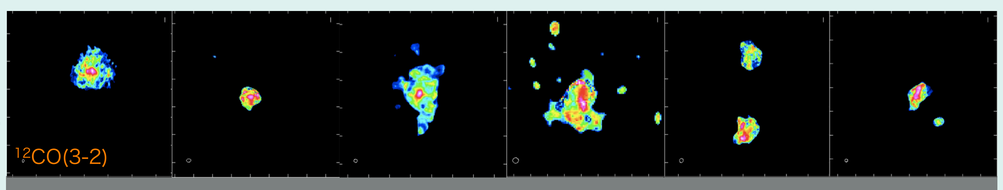
Results



- The structures are spatially resolved
- The distributions of ^{12}CO are more extended than ^{13}CO
  => Making ratio maps from these two



- Rotational motions are seen in most sources
- Complex velocity field are also seen in some sources
  => outflow, inflow or tidal motion caused by merging events?



- Velocity dispersions are highest around the center of galaxies

Discussion

Most sources have lower regions at the center, compering to the outer region.

The global mean ratio in the whole region is about 20, which is typical for luminous mergers and higher than normal spiral galaxies.

Ratio values measured at the dust continuum peak are around 13.5, and typically lower than the whole averaged values.

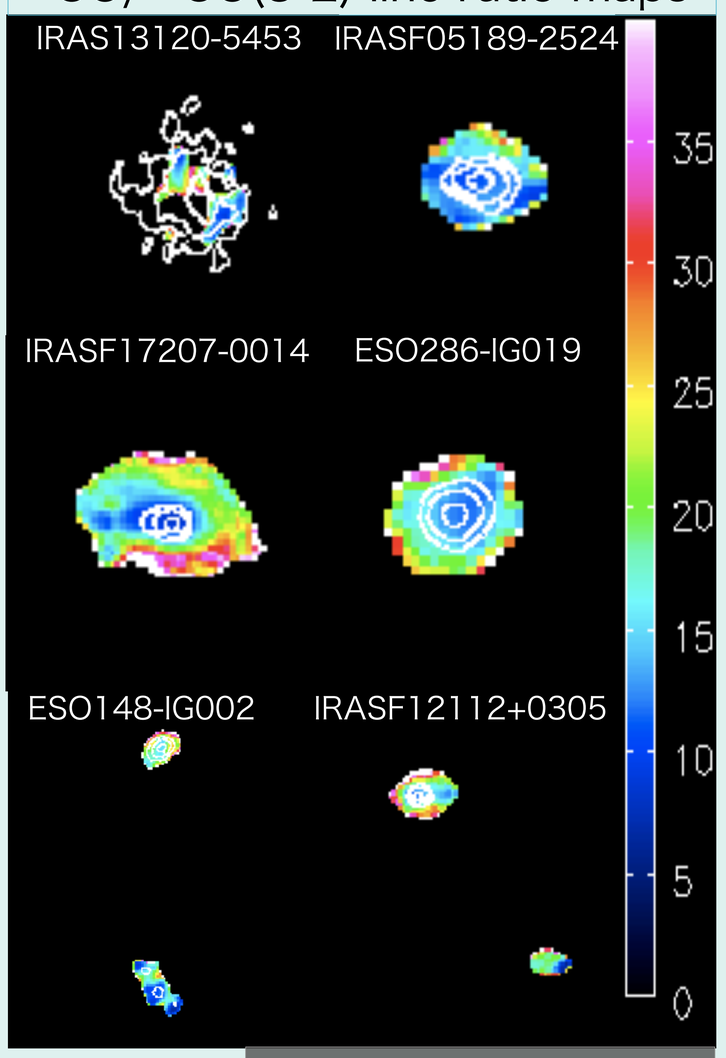
The typical values at the outer region are about 40.

=> The high global ratio known from the previous studies is due to extended (~kpc) gas.

The ratio values for each galaxy

^{12}CO/^{13}CO ratio values	IRAS 13120	IRAS 17207	IRASF 05189	ESO 286	ESO 148	IRASF 12112	Spiral galaxies
Average (Whole region)	21	17	14	22	22	21	~11
Ratio at the SF peak	22	8	11	12	15	13	

^{12}CO/^{13}CO(3-2) line ratio maps



White contour:
Dust thermal continuum
=> Star formation tracer

Possible reasons change the isotopic ratio in one galaxy

1. Opacity

Opacity of gas in merging galaxies may change because of some reasons such as large velocity dispersion and/or highly excited conditions. This may cause the variation of ^{12}CO/^{13}CO line ratio values.

e.g. Aalto et al. 1991

2. Gradients in relative abundance

The variation of intrinsic abundance ratio is also reported. For example, [^{12}CO]/[^{13}CO] abundance ratio differ between the center and the outer regions in Arp 220, which is a merging starburst.

Sliwa et al. 2017

Constrain the conditions by solving radiative transfer in future!