GF-31P

Physical Properties of Interstellar Medium in Interacting Galaxies NGC 4567/4568



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★Background

Although an enhancement of star formation activity in interacting galaxies is one of the most important phenomena in terms of galaxy evolution[1], the mechanism of the enhancement is still under question. Changes in molecular gas properties, the "cause" of star formation activity, should occur in the earlier stage of the interaction. NGC 4567/4568, a nearby (16 Mpc) interacting galaxy pair at an early stage of the interaction, is an ideal target for understanding changes in gas properties. The Hα image shows large star-forming regions where two galaxies overlap[2]. Our single-dish CO map obtained with the Nobeyama 45-m telescope[3, 4] reveals that star formation efficiency (Σ_{SFR}/Σ_{H2}: SFE) and molecular gas fraction ($\Sigma_{H2}/\Sigma_{H2+HI}$) is high in this region. These facts imply the star formation induced by the interaction has just started in the overlapping region.

Here, we observe this region with CO(J=3-2) and CO(J=1-0) lines to reveal the dense gas fraction, which would reveal the future star formation there.

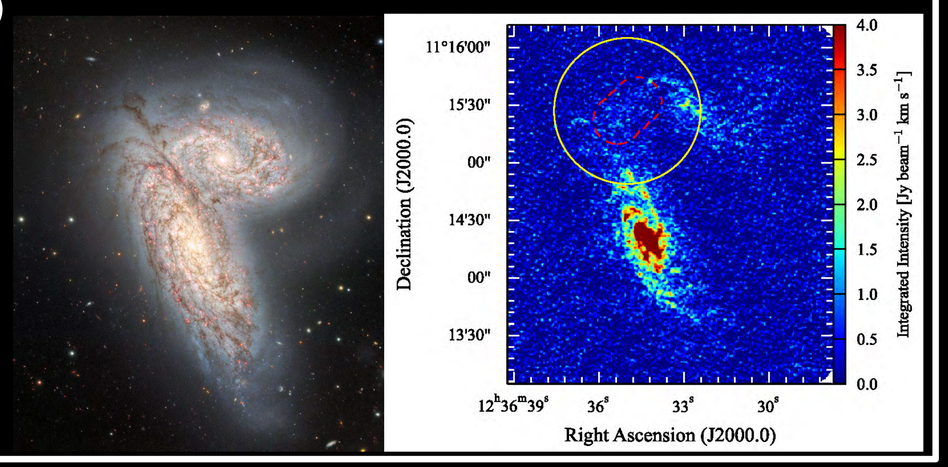


Fig.1: (right) Gemini-N optical image of NGC 4567/4568. (left) CO(J=1-0) image taken by ALMA Cycle 1[5]. Yellow circle: the FOV of new CO(J=1-0) observations. Red dashed region: the FOV of CO(J=3-2) observations.

★Observations

Target: the overlapping region of NGC 4567/4568
Distance: 16 Mpc
Telescope: ALMA (Cycle 3, PI: Hiroyuki Kaneko)
Receivers: Band 3 (CO(J=1-0)) and Band 7 (CO(J=3-2))
Angular resolution:
1.65" x 1.28" (126 pc x 99 pc at 16 Mpc)
0.56" x 0.47" (43 pc x 36 pc at 16 Mpc)
Velocity resolution: 5 km s^{-1}
Sensitivity: 1.5mJy beam^{-1} (both for CO(1-0) & CO(3-2))

★Results:

- We detect CO(1-0) and CO(3-2) lines in the overlapping region.
- Molecular filaments (350 pc x 1800 pc) are clearly detected for both lines (red boxes in Fig.2 and 3).

Fig.2 : (a)-(c) moment 0, 1, and 2 maps of CO(J=1-0) (The red dashed region is a FOV of CO(J=3-2))

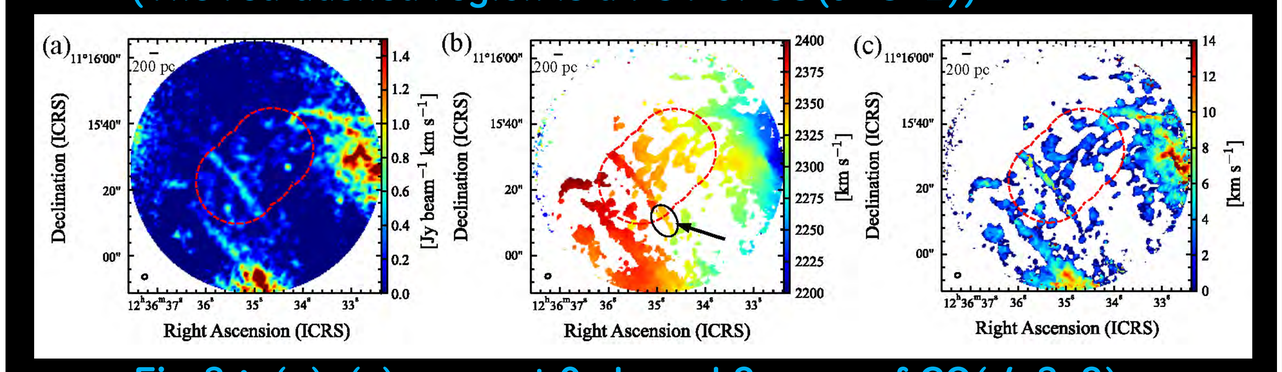
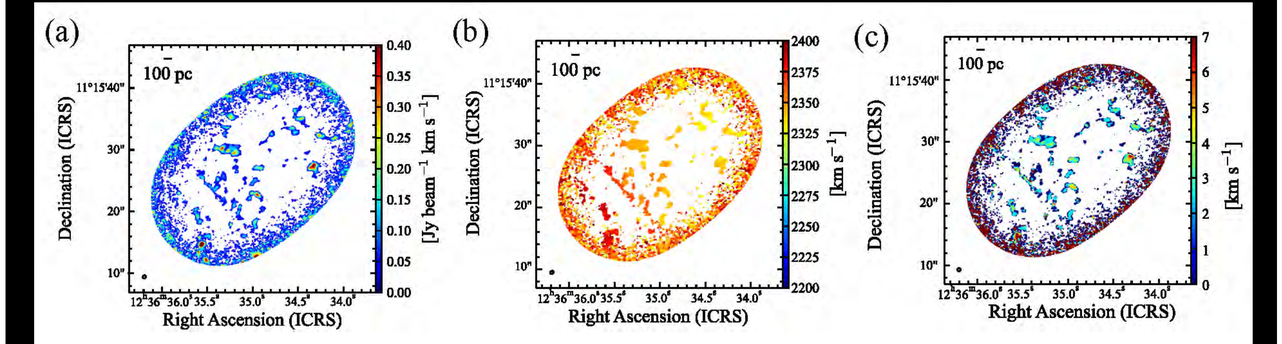


Fig.3 : (a)-(c) moment 0, 1, and 2 maps of CO(J=3-2)



- We used CLUMPFIND to identify molecular clouds.
- We identified
  - 62 clouds in the disc
  - 44 clouds in the overlapping region (the overlapping region is defined as the inside of the FOV of CO(3-2))
  - 8 clouds in the filament

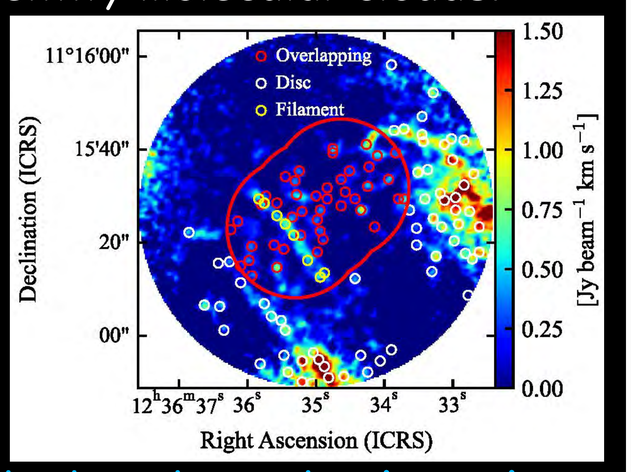


Fig. 4: Identified molecular clouds at the overlapping region.

★Discussion

Physical statistics of molecular clouds in the filament:

- larger virial parameter $\alpha_{vir}=5\sigma^2R/GM_{CO}$ than those in the disc and overlapping regions
- larger velocity dispersion σ_v
- no difference in radius R, luminosity mass M_{CO}, and surface density Σ_{CO}

	Filament	Disc	Overlapping region
Virial Parameter α_{vir}	0.56±0.14	0.26±0.16	0.28±0.12
Velocity Dispersion σ_v	5.5±1.3	4.6±2.3	3.4±1.0
Cloud Radius R	48±15	45±18	41±13
Luminosity Mass M_{CO} (x 10^6 $M_\odot$)	3.0±0.8	4.5±3.5	2.2±1.4
Surface Density Σ_{CO} (x 10^2 $M_\odot$ pc^{-2})	6.0±5.0	8.5±6.5	4.5±2.0

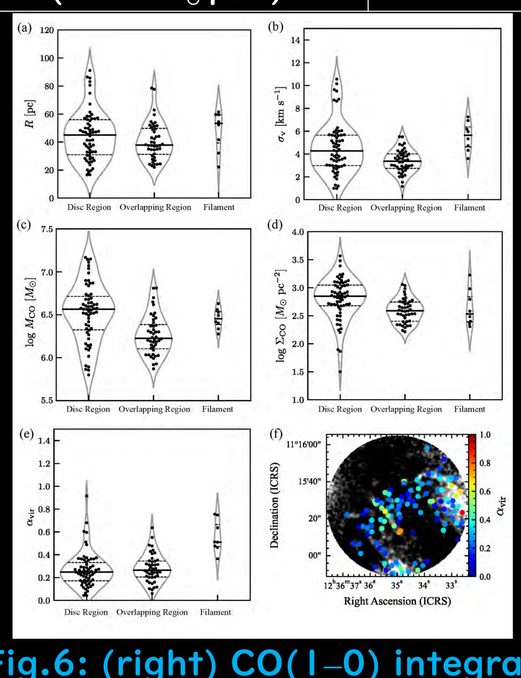
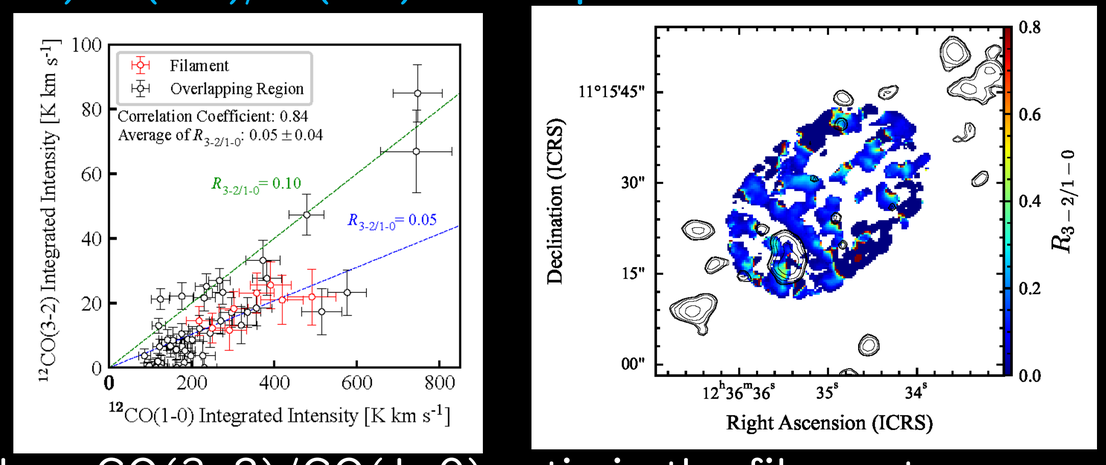


Fig.5 : (a)-(e) Violin plots of physical properties of molecular cloud. (f) Positions of the identified molecular clouds. The color indicates α_{vir} with CO(1-0) moment 0, shown as a gray-scale image.

Fig.6: (right) CO(1-0) integrated intensity vs. CO(3-2) integrated intensity in each molecular cloud. (left) CO(3-2)/CO(1-0) ratio map



Low CO(3-2)/CO(1-0) ratio in the filament
→ No dense gas formation occurs
… NGC 4567/4568 is very early stage of the interaction, or the filament would not yet fulfil the physical conditions to trigger star formation

References: [1] Bushouse 1986 AJ, 91,2; [2] Koopmann, Kenney, & Young 2001, ApJS, 135, 125; [3] Kaneko et al. 2013, PASJ, 65, 20; [4] Kaneko et al. 2017, PASJ, 69, 66; [5] Kaneko, Kuno & Saitoh, 2018 ApJL, 860, L14