Molecular gas structure of AGN in Circinus galaxy

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Abstract

As a result of conducting non-LTE radiation transfer, we obtained spatial distributions of intensities of CO and HCN. We also carried out observing simulations using CASA. The simulated SLED implies that the lines are not thermalized. The large dispersion of conversion factor reflects non-uniform structure of molecular gas. For a given line of sight, the observed line ratios do not necessarily reflect the physical conditions of the ISM on a sub-pc scale. The CO line profile observed by ALMA Cycle4 was reproduced by the numerical model.

Introduction

We investigate physical structures of AGN of the nearest type-2 Seyfert, Circinus galaxy. We use "radiation driven fountain model" (Wada et al. 2016), which successfully reproduced the SED of Circinus, as an input data to investigate line emissions from molecular gas. Using 3D non-LTE line transfer calculation, we obtained spatial distributions of molecular line intensities and their correlation with 3D physical structure of molecular gas. We discuss SLED, molecular lines to H_2 conversion factor and internal distributions of the optical depth, intensity and source function. We also run CASA(Common Astronomy Software Applications) simulations to compare with the observations by ALMA.

Method

This model SED well reproduce Circinus galaxy in the infrared region(Fig1, diamond). Using a snapshot of the hydrodynamical result, level populations of CO and HCN are obtained by applying Monte Carlo method and non-LTE method. In this calculation microturbulence of 10km/s.

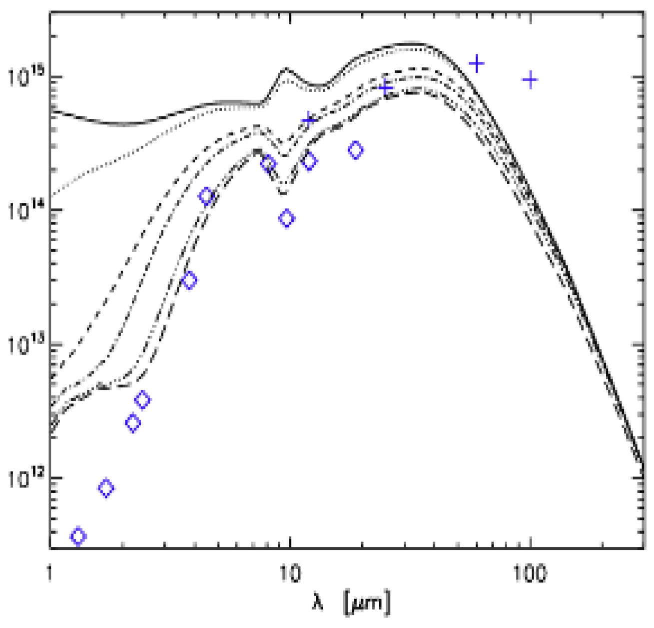

Fig1. Dust continuum radiative transfer SEDs

Results

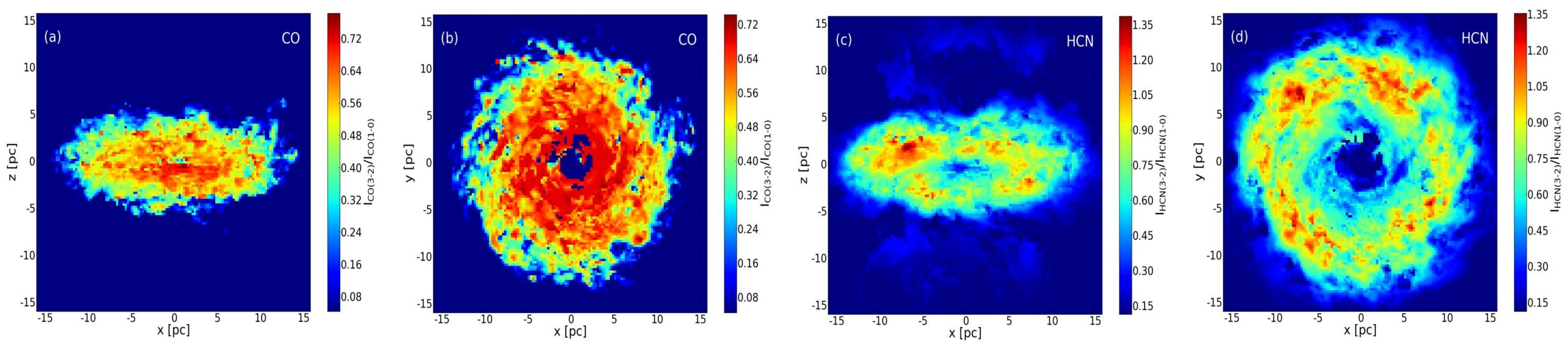

Figure2. (a)(b) Line ratio distributions of $I_{CO(3-2)}/I_{CO(1-0)}$ for θ=75° and θ=0°
(c)(d) Line ratio distributions of $I_{HCN(3-2)}/I_{HCN(1-0)}$ for θ=75° and θ=0° .

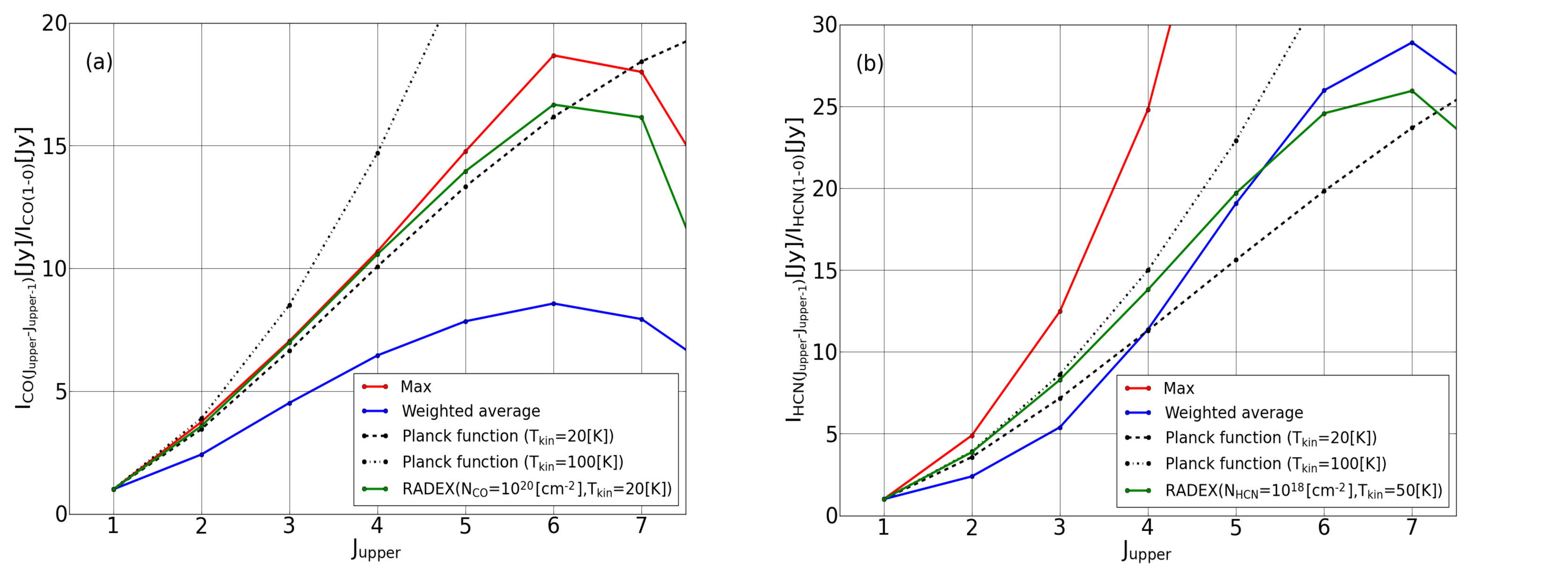

Figure3. (a) SLED of CO lines which normalized to the intensity of J=1-0 for the brightest grid point(red), intensity weighted average of the whole area(blue) and the blackbody of uniform gas(black). The green line is the modeled SLED reconstructed by RADEX to confirm the validity of the non-LTE radiation transfer. (b) Same as (a), but SLED of HCN lines.

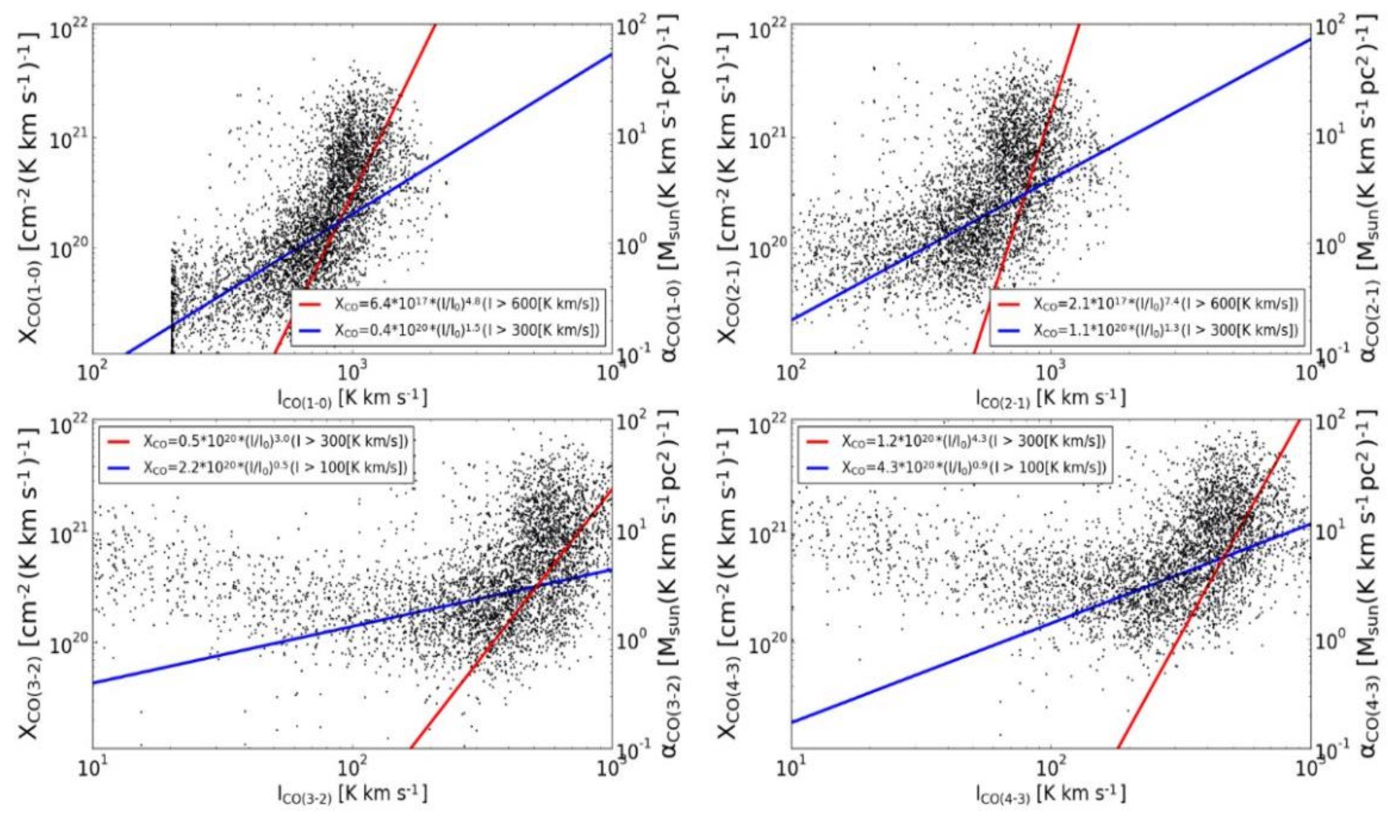

Figure4. CO to H_2 conversion factor for four lines(J=1-0~4-3) for θ=75° .

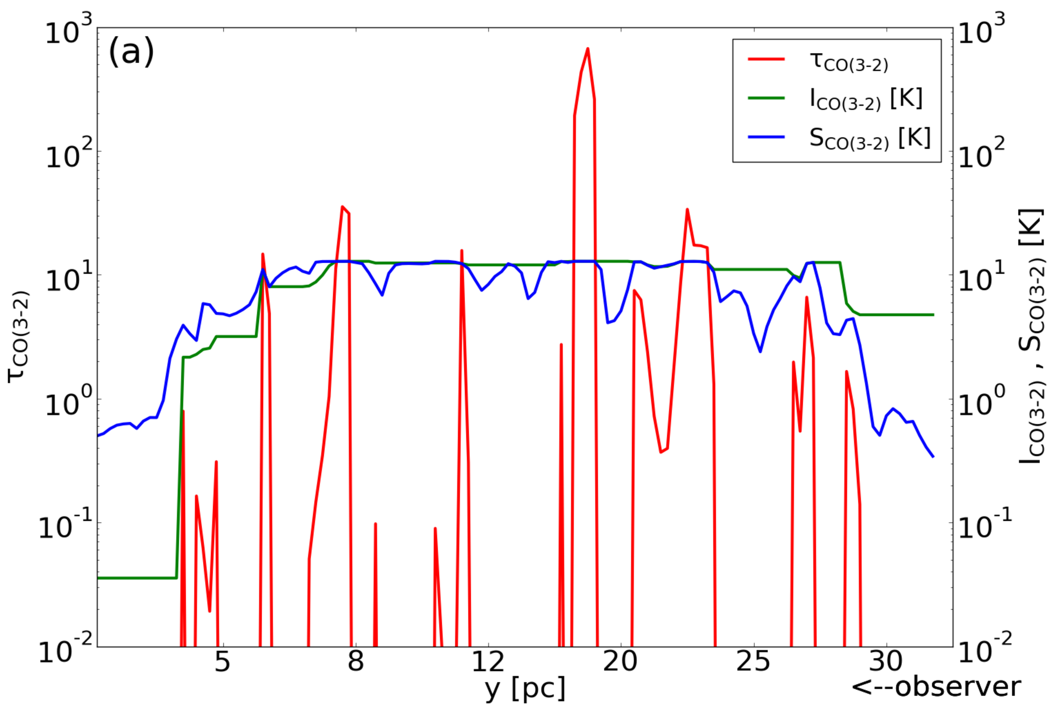

Figure5. Optical depth($\tau_{CO(3-2)}$), intensity($I_{CO(3-2)}$),and source function($S_{CO(3-2)}$) in each grid cell along line-of-sight. The ray is transferred from the left to right, where the observer is located.

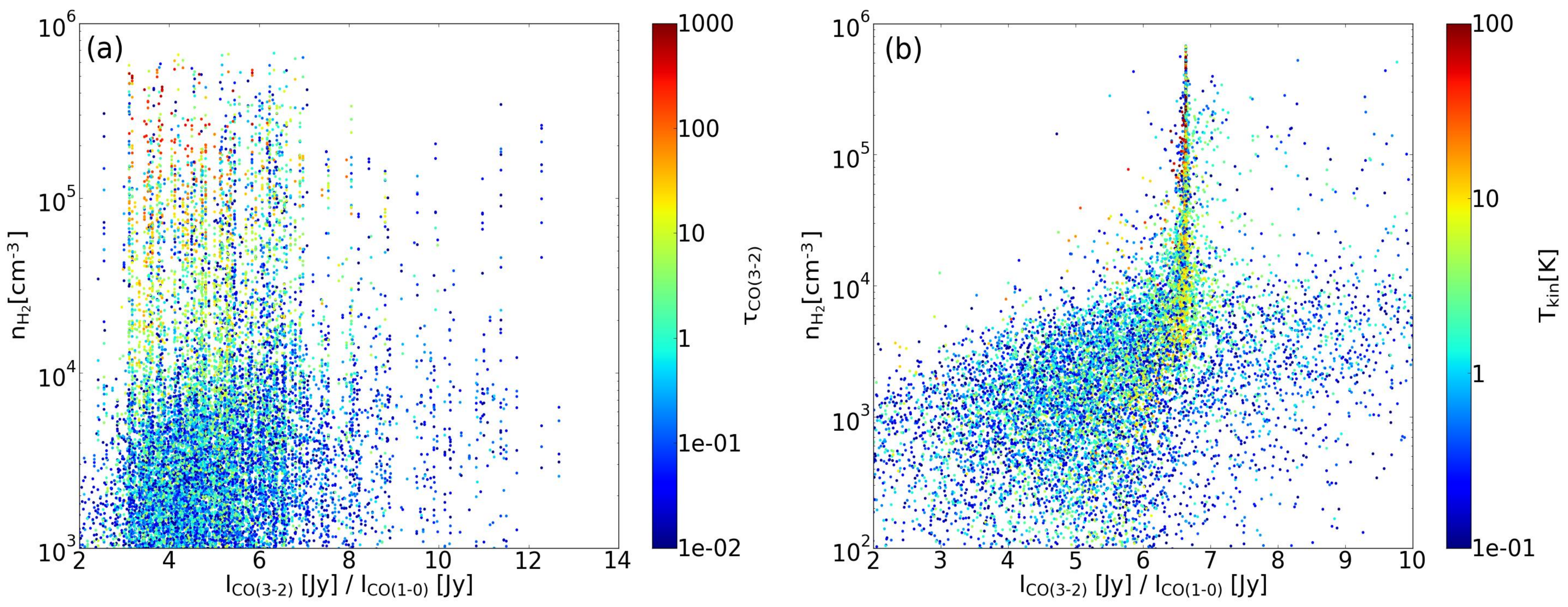

Figure6. (a) Observed line ratio (Ico(3-2)/Ico(1-0)) as a function of volume density and temperature of each grid cell. (b) Same as (a), but for local line ratio calculated in each grid cell.

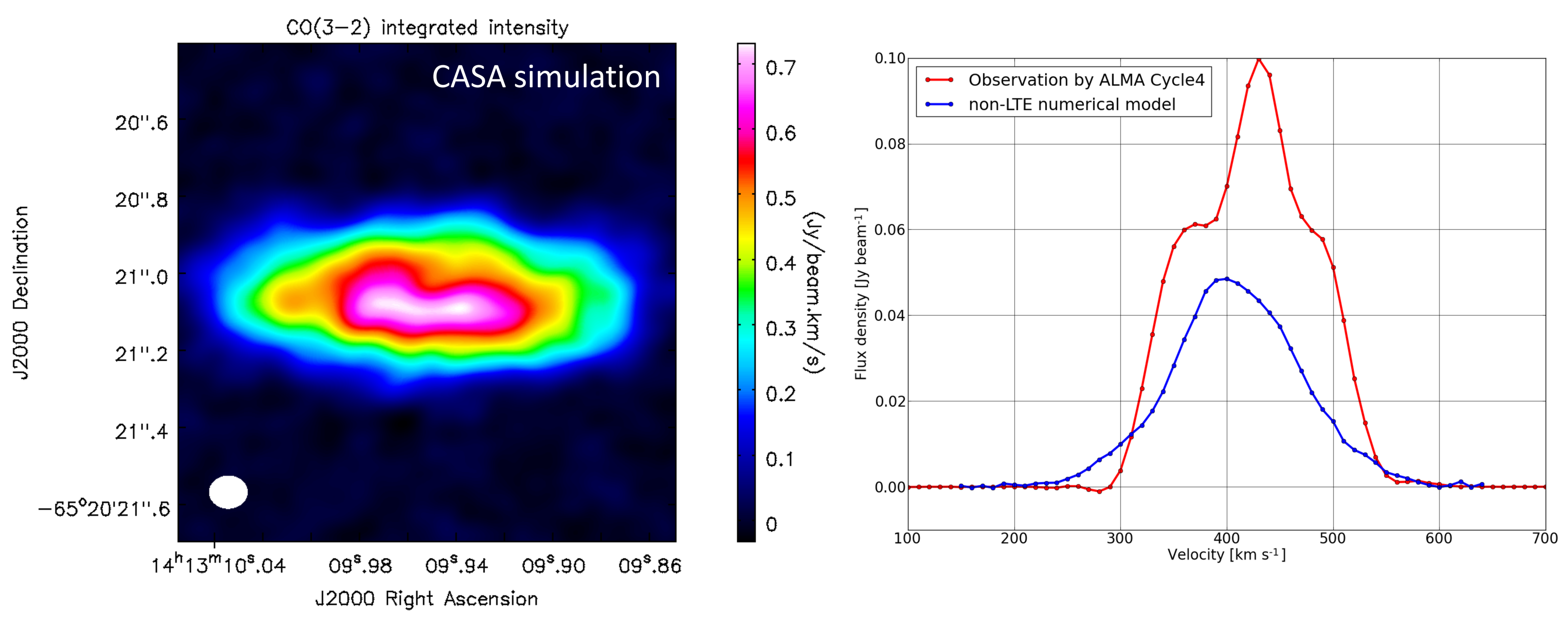

Figure7. (a) Integrated intensity map obtained from CASA simulation. (b) The line profile of CO(3-2) obtained from radiation-driven fountain model(blue) and observation by ALMA Cycle4(red).

Discussion

If microturblence(Vturb) increased, intensity at the line center decrease, but the total intensity increase (Vturb≤40[km/s]). The result suggests that we can determine the relevant value of Vturb in molecular clouds with comparison observation .

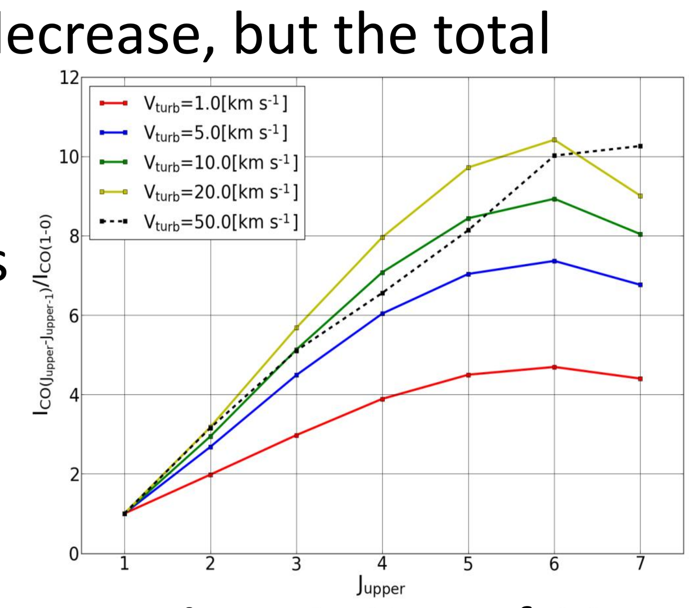

Figure8. SLED of CO lines by different Vturb .

Conclusion

- The features of both CO and HCN SLEDs are not LTE, especially for high J. It suggests that the lines are not thermalized in most regions (**Fig3**).
- The conversion factor depends strongly on integrated intensity , and the dispersion of Xco for each transition reflects the non-uniform physical conditions of disk(**Fig4**).
- The physical conditions of the local ISM for a given line of sight is highly inhomogeneous, therefore the observed ratio does not imply a single state of the ISM. These results suggest that we need to carefully analyze the molecular line observations of the circumnuclear gas when we obtain them with a high spatial resolution(**FIg5**,**Fig6**).
- We performed pseudo observations using CASA. We may understand physics nearby AGNs by comparing these results with future observations by ALMA(**Fig7**).

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