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Bulletin of the AAS • Vol. 55, Issue 2

Connecting CO-to-H_2 Conversion Factors to Molecular Gas Properties in Nearby Barred Galaxy Centers

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Published on: Jan 31, 2023

URL: https://baas.aas.org/pub/2023n2i155p04

The CO-to-H_2 conversion factor (α_{CO}) is central to measuring the amount and properties of molecular gas. However, α_{CO} is known to vary with environmental conditions, and previous kpc-scale studies have revealed 5-10 times lower α_{CO} in the centers of some nearby barred galaxies, including NGC 3351, NGC 3627 and NGC 4321. We present ALMA Band 3, 6, and 7 observations toward the inner ~2 kpc of these galaxies tracing ^{12}CO, ^{13}CO, and C^{18}O lines on ~100 pc scales. Using multi-line radiative transfer modeling and Bayesian likelihood analysis, we constrain molecular gas properties and α_{CO} on a pixel-by-pixel basis. A 2-10 times lower-than-Galactic α_{CO} value is found in most regions, and there is a strong correlation between α_{CO} and low-J ^{12}CO optical depths which dominate the α_{CO} variation in all three centers. The galaxy nuclei within the inner ~300 pc tend to show enhanced temperature, density, and velocity dispersion that may drive distinct α_{CO} in those regions. We find that the observed CO/^{13}CO (2-1) line ratio generally reflects changes in CO optical depth, and thus it may be a useful observational tracer for α_{CO} variation in galaxy centers. We also test current simulation-based α_{CO} prescriptions on these centers and find rough agreement in most regions, while clear discrepancy is seen in the inflows and nuclei with strong dynamical features.