The missing link: How do cloud-scale molecular gas properties connect to global dense gas fraction and dense gas star formation efficiency across nearby galaxies?

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Stars form in giant molecular clouds (GMCs) in which the dense gas mass (Mdense), as traced by molecular lines like HCN, is observed to be linearly correlated to the star formation rate (SFR) suggesting a universal, constant dense star formation efficiency (SFR/Mdense; SFE) [2]. However, recent studies (e.g. [3]) have found systematic variations of SFE and dense gas fraction with environment (radiation field, molecular gas fraction and turbulence) at ~ kpc scales.

In this poster, I present the recent study that combines new ALMA observations to compare high resolution spectroscopic CO imaging (CO(2-1) at ~ 100 pc scale from PHANGS-ALMA [4]) and multi-species multi-transition spectroscopy (e.g. HCN(1-0) at ~ kpc scale from ACA). This forms a novel step in studying systematic variations of dense gas tracers as a function of cloud-scale molecular gas properties across 25 nearby galaxies.

We compare the dense gas fraction (traced by HCN/CO) and the dense gas SFE (traced by SFR/HCN) with structural and dynamical properties of the molecular gas. The foremost results are that dense gas fraction (HCN/CO) appears to correlate and dense SFE (SFR/HCN) to anti-correlate with the cloud-scale molecular gas surface density, velocity dispersion and internal turbulent pressure of GMCs. The findings are consistent with turbulent models of star formation (e.g. [5]) which infer the density distribution of GMCs as a function of their molecular gas properties.

One of the key conclusions of this work is that both HCN/CO and cloud-scale CO are tracing density. Moreover, we report for the first time that SFR/HCN systematically varies with cloud scale molecular gas properties, thus disclaiming a universal dense SFE (SFR/HCN). This study shows that density, molecular cloud properties and star formation appear interrelated in a coherent way and one that agrees reasonably well with current models.

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