# Probing the link between molecular clouds, star formation, and environment in nearby galaxies with multi-transition observations of dense gas tracers

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In the last decade, the combined sensitivity, resolution, and bandwidth capabilities of the IRAM telescopes opened a new avenue to investigate the relation between molecular cloud properties, star formation, and environment in nearby galaxies. A number of surveys targeting both line tracers of bulk gas (e.g., low-J CO) and lines more sensitive to denser phases (e.g., HCN, $HCO^+$) have revealed that the density structure of the clouds and their ability to form stars vary systematically across galaxy disks.

So far, most of these dense-gas mapping surveys have been carried out in the 3mm atmospheric window. Here, we present new IRAM-30m telescope and ALMA Compact Array sensitive observations of 4 galaxies that build upon the IRAM Large Program EMPIRE and extend these studies to the dense gas tracers in the 1mm window (e.g., HCN and HCO+ J=3-2). These high excitation lines become very faint in the outer disks of galaxies, thus enhancing the contrast between central and disk regions.

In combination with our previous IRAM and ALMA campaigns mapping the ground transition of these molecules, our new observations provide a multitransition data set that we model with standard and physically-motivated radiative transfer models. From this we derive the spatial distribution of several gas/cloud properties across the observed galaxies, which will help us link the spatial variations in: (1) the physical conditions of the dense, star forming gas; (2) the cloud properties measured from our cloud-scale CO observations at higher resolution; (3) the environment the clouds live in. Further, HCN and $HCO^+$ excitation via line ratios is essential to constrain the conversion factors from which dense gas masses are derived. This will allow us to update scaling relations between dense gas and star formation and differentiate between competing models for how star formation is regulated across galaxies.