EMIR Multi-line Probe of the ISM Regulating Galaxy Evolution

- IRAM Large Program of ~600hrs (PI: F. Bigiel)
- Full galaxy maps of 9 disk galaxies at ~1-2kpc
- Targeting HCN, HCO+, HNC & 12CO, C18O
- New 13CO (1-0) high S/N maps
- Wide suite of ancillary data (radio-UV)

**TEAM:**

**PUBLICATIONS:**
- Bigiel (2016)
- Leroy (2016)
- Jiménez-Donaire (2017a)
- Comer (2018)
- Gallagher (2018)

The EMPRI Survey: Systematic Variations in the Dense Gas Fraction and Star Formation Efficiency from Full-disk Mapping of M51 (F. Bigiel+ 2016)

- EMPRI fills in the luminosity range between whole galaxies and individual clouds
- The HCN/H2 (densemass-SFR) correlation holds over 10 orders of magnitude

**12CO/13CO Gradients across the Disks of Nearby Spiral Galaxies** (M. J. Jiménez-Donaire+

- First C13CO profiles across normal disk galaxies
- Requires careful stacking of spectra
- Clear CO/13CO (1-0) gradients observed with radius
- Most likely drivers are real abundance variations

Full-disc 13CO(1-0) mapping across nearby galaxies of the EMPRI survey and the CO-to-H2 conversion factor (D. Comer+

- 13CO/13CO(1-0) varies only marginally with radius, most notably in orders
- High ratios are found in galaxies with nuclear starbursts – probably an opacity effect
- 13CO shows less, but still notable scatter compared to 13CO relative to dust-based H2 estimates

Optical depth estimates and effective critical densities of dense gas tracers (M. J. Jiménez-Donaire+

- EMPRI M51 and ALMA data for several galaxies cover optically thin isocounts
- Hard to detect in disks, even for ALMA
- Data suggest moderate optical depth (~a few), which lowers the effective critical density

The 13CO(2-1)/(1-0) Line Ratio Across Nearby Disk Galaxies in EMPRI (D. Chatziigiannakis+

- No strong, systematic trends of 13CO line ratio across EMPRI disks on ~kpc scales
- Good number to use in local disk galaxies: 0.7
- 10 scatter within and among sample ~0.1

Millimeter-wave Line Ratios and Sub-beam Volume Density Distributions (A. Leroy+

- Gas volume density plays key role in SF theories
- Unconstrained across normal galaxy disks
- Use suite of (EMIR) lines and radiative transfer to constrain volume densities

Dense Gas, Dynamical Equilibrium Pressure, and Star Formation in Nearby Star-forming Galaxies (M. J. Gallagher+

- The dense gas SFE (13CO/13CO(1-0)) decreases as a function of molecular gas surface density, stellar surface density, and hydrostatic equilibrium gas pressure
- In low pressure environment, the mean density is below HCN critical density and HCN traces mainly dense gas
- In high pressure environment, mean density approaches critical density of HCN and HCN traces bulk of gas
- No threshold density above which stars form with constant efficiency is observed

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