CO and the Kennicutt/Schmidt law in NUGA galaxies

V. Casasola[1,2], L. K. Hunt[1], F. Combes[3], S. García-Burillo[4], & NUGA team

[1]INAF-OAA Firenze, [2]INAF-IRA Bologna, [3]Obs. de Paris-LERMA, [4]OAN Madrid

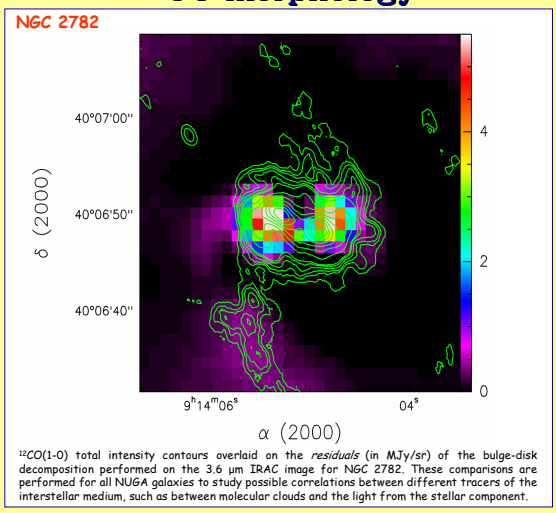
NUclei of GAlaxies (NUGA) project

NUclei of GAlaxies (NUGA) project is a high-resolution and high-sensitivity ^{12}CO survey made with the Plateau de Bure IRAM interferometer, whose aim is to understand the mechanisms for gas fueling for a sample of 12 nearby low-luminosity Active Galactic Nuclei (LLAGN). We study the distribution and dynamics of the circumnuclear molecular gas with resolutions of 60 - 300 pc, and apply a suite of diagnostics to quantify gas fueling of the AGN in the current epoch.

Star Formation & NUGA

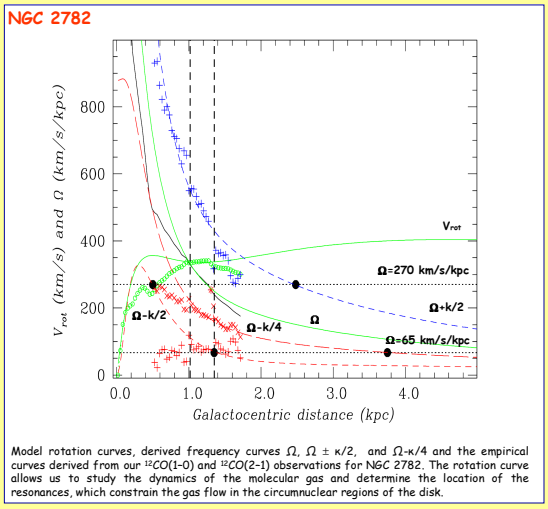
Gravitationally bound molecular clouds are considered to be the birth site of future generations of stars. Our NUGA survey in ^{12}CO(1-0) and ^{12}CO(2-1) enables us to study star formation (SF) in galaxies with high spatial resolution. Here, we derive the Kennicutt/Schmidt (KS) law for two NUGA LLAGN, NGC 2782 and NGC 5953, by comparing CO intensity to the star-formation rate (SFR) as traced by the FUV (GALEX) and the IR (Spitzer/IRAC, MIPS).

CO morphology



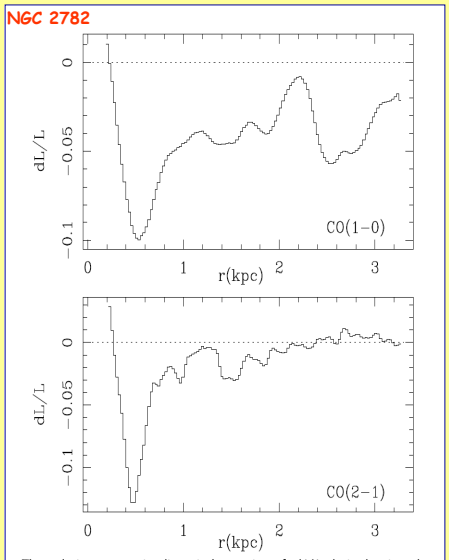
^{12}CO(1-0) total intensity contours overlaid on the *residuals* (in MJy/sr) of the bulge-disk decomposition performed on the 3.6 μm IRAC image for NGC 2782. These comparisons are performed for all NUGA galaxies to study possible correlations between different tracers of the interstellar medium, such as between molecular clouds and the light from the stellar component.

Rotation curve



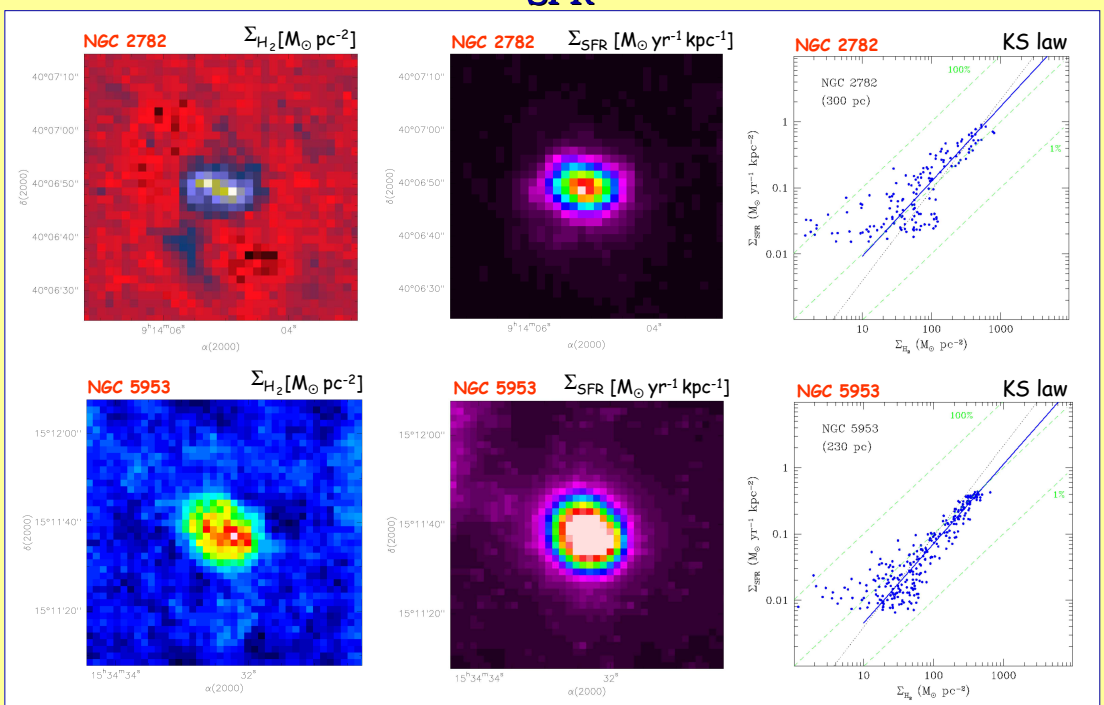
Model rotation curves, derived frequency curves Ω, Ω ± κ/2, and Ω-κ/4 and the empirical curves derived from our ^{12}CO(1-0) and ^{12}CO(2-1) observations for NGC 2782. The rotation curve allows us to study the dynamics of the molecular gas and determine the location of the resonances, which constrain the gas flow in the circumnuclear regions of the disk.

Torques



The relative torque in dimensionless units of dL/L derived using the potential obtained from the 3.6 μm IRAC image for NGC2782. This analysis allows us to establish whether the gas flows into the central region and feeds the AGN down to the resolution limit of our images. In NGC 2782, the torques are negative and the gas there is certainly fueling the circumnuclear region, and in a second step should fuel directly the AGN.

SFR



Molecular hydrogen surface density (Σ_{H2}) derived from ^{12}CO(1-0) NUGA observations for NGC 2782 (top panel) and NGC 5953 (bottom panel).

Star formation rate surface density (Σ_{SFR}) derived from combined 8 μm IRAC and FUV GALEX emissions for NGC 2782 (top panel) and NGC 5953 (bottom panel).

Kennicutt/Schmidt law derived for NGC 2782 (top panel) and NGC 5953 (bottom panel). The solid blue line corresponds to the best-fit OLS bisector regression, while the black dotted line is the Kennicutt (1998) formulation. Constant SF efficiencies are shown as green dashed lines, assuming a gas-depletion time of 10^8 yr.

DETAILS:

We derived the Σ_{SFR} using the formula:

Σ_{SFR} [$M_\odot$ yr^{-1} kpc^{-2}] = 3.2 x 10^{-3} I_{24} [Myr ster^{-1}] + 8.1 x 10^{-2} I_{FUV} [Myr ster^{-1}] (Bigiel et al. 2008, Leroy et al. 2008)

To use the above relation for SFR, we assumed $I_8 = I_{24}$.
This is a conservative assumption since I_8/I_{24} = 0.1-1 (Dale et al. 2005).
We avoided use of the MIPS 24 micron images because they provide very little spatial information for the bright almost unresolved sources at that wavelength.

Results

Our data for NGC 2782 and NGC 5953 show that the distribution of molecular gas does not correlate locally with the SFR, at least for NGC 2782. These galaxies are circumnuclear starbursts, forming stars at a roughly constant efficiency of 10%.

At resolutions of 230-300 pc we measure KS power-law slopes of ~1.1+/-0.1, and 1.2+/-0.15 over ranges in Σ_{H2} of 10-800 $M_\odot$ pc^{-2}. These spatially resolved KS power-law slopes of order unity are lower than the canonical KS slope of ~1.4-1.5 for galaxy disks, but consistent with the shallower ones recently found in the HERACLES survey. Whether these are the exception or the rule in LLAGN and starbursts will be investigated in our statistical study of the NUGA sample.

Acknowledgement

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To know more:

Kennicutt, 1998, ARA&A, 36, 189
Dale et al. 2005, ApJ, 633, 857
Kennicutt et al. 2007, ApJ, 671, 333
Bigiel et al. 2008, AJ, 136, 2846
Leroy et al. 2008, AJ, 136, 2782
Hunt et al. 2008, A&A, 482, 133, NGC 2782, NUGA IX
Casasola et al. 2009, in prep., NGC 5953, NUGA XIII