NEW HIGH-RESOLUTION OBSERVATIONS OF MOLECULAR GAS TOWARDS THE CENTER OF SPIRAL GALAXIES

Observations and numerical simulations

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We discuss the major results from a study of the molecular gas distribution and dynamics in the nuclear disks (**ND**) of a limited sample of nearby spirals: NGC891, NGC5907, NGC4565, NGC4013, NGC4321, M82, NGC3626 and NGC3593. The main objective is to search for observational evidences of secular evolution along the Hubble sequence in spirals and to study the specific role of bars in the process.

The 1–0 and 2–1 lines of ^{12}CO, observed with the 30m single-dish and Bure interferometer, are the best tracer of neutral gas in **ND**. High-resolution and sensitivity requirements are fulfilled to study **ND**, typically of sizes r$\sim 100 - 500pc$.

Major axis position-velocity diagrams of edge-on spirals in the sample allows to trace the CO rotation curves and possible deviations. **ND** stand out as a distinct mass component, in addition to bulge, disk and halo. **ND** masses range from 1-5$\times 10^9 M_{\odot}$ and their signature is imprinted on the steepen CO rotation curves (with no HI counterpart). Rapidly rotating **ND** are studied in the edge-on's NGC891(García–Burillo and Guélin, 1995), NGC5907 (García–Burillo*et al.* 1997) and NGC4013(Gómez de Castro and García–Burillo, 1997). **ND** host nuclear bars: evidences are discussed and modelled using bar-driven orbits. Bar signatures include: existence of forbidden velocities, strong streaming motions, lack of axisymmetry and out of the plane gas orbits connected to peanut bulges (see NGC4013).

Observations and models underline *secular evolution of rotation curves in spirals*: bars drive inwards gas by gravitational torques, changing mass distribution during galaxy lifetime. **ND** witness the intensity of these gas mass accretion episodes. In its trip towards the nucleus gas shifts from high energy x_1 orbits to lower energy x_2 orbits. When the fraction of mass in the **ND** reaches a minimum threshold a dynamically decoupled bar instability

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develops. *Bars within bars* are a powerful mechanism to drive gas to the inner 100 pc of spirals.

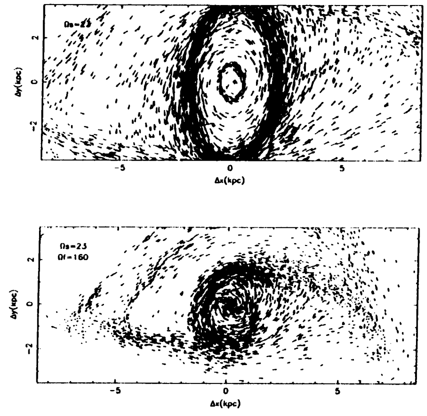

Figure 1. We display the particle orbits for molecular clouds in the region where the bar instability develops, as they are seen, firstly, **a(top):** from the frame rotating at Ω=23 kms^{-1}kpc^{-1}, for the solution of a single slow pattern and **b(bottom):** from the frame rotating at Ω=23 kms^{-1}kpc^{-1} for the best-fit solution of a double pattern.

As an example we have studied the feasibility of a two independent patterns scenario in the disk of the double barred face-on spiral M100 (García–Burillo*et al.* 1997, submitted). Using the Bure array we mapped the ^{12}CO(1–0) emission in M100's **ND**. Molecular gas is distributed in a two spiral arm structure starting from the end points of a nuclear bar (r = 600 pc) up to r = 1.2 kpc, and a central non–resolved source (r <100 pc). The kinematics of the gas indicates the existence of a steep rotation curve (v_{rot}=180 km s^{-1} at $r \sim$ 100 pc) and strong streaming motions characteristic of a trailing spiral wave inside corotation.

Interpretation of the CO observations is made in the light of a numerical model of the clouds hydrodynamics. Ballistic simulations analyse the gas response to a gravitational potential derived from a K plate. We found the best fit solution consisting of a fast pattern (Ω_f=160 kms^{-1}kpc^{-1}) for the nuclear bar (with corotation at R^F_{COR}=1.2 kpc) decoupled from the slow pattern of the outer bar+spiral (Ω_f=23 kms^{-1}kpc^{-1}) (with corotation at R^S_{COR}=8-9 kpc). Corotation of the fast pattern is overlapped with the oILR of the slow pattern, allowing an efficient fuelling of molecular gas towards the nucleus.

References

García–Burillo S., Guélin M., 1995, A&A, 299, 657
García–Burillo S., Guélin M., Neininger, N., 1997, A&A, 319, 450
Gómez de Castro, A.I., García–Burillo S., 1997, A&A, 322, 381
García–Burillo S., Sempere, M.J., Combes, F., Neri, R., 1997, A&A, submitted