Gas and Molecular Dynamics in Galaxies

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A brief message from our sponsor

1. *Authors: Proofread!*
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Introduction

1. What's the point?
2. Correlation between CO and H_2
3. It's dusty in here
4. Molecular content vs. galaxy type
5. Effect on galaxy structure

What is the point?

- Most abundant element: H_2
- H_2 content determines star formation rate
- How do we determine gas content of galaxies?
  - H_2 is hard to see
  - CO traces H_2
- Spirals vs Ellipticals

CO and H_2 lines

- Carbon Monoxide
  - Molecular rotation: ~1.3mm
- Hydrogen
  - 21cm spin flip transition

CO, dust and H_2

- Emperical fit
- CO and H_2 column densities similar
  - CO transition "strength"
  - H_2 density
- Dust lanes and CO arms
  - star forming shells and chaotic motion

Dust and CO

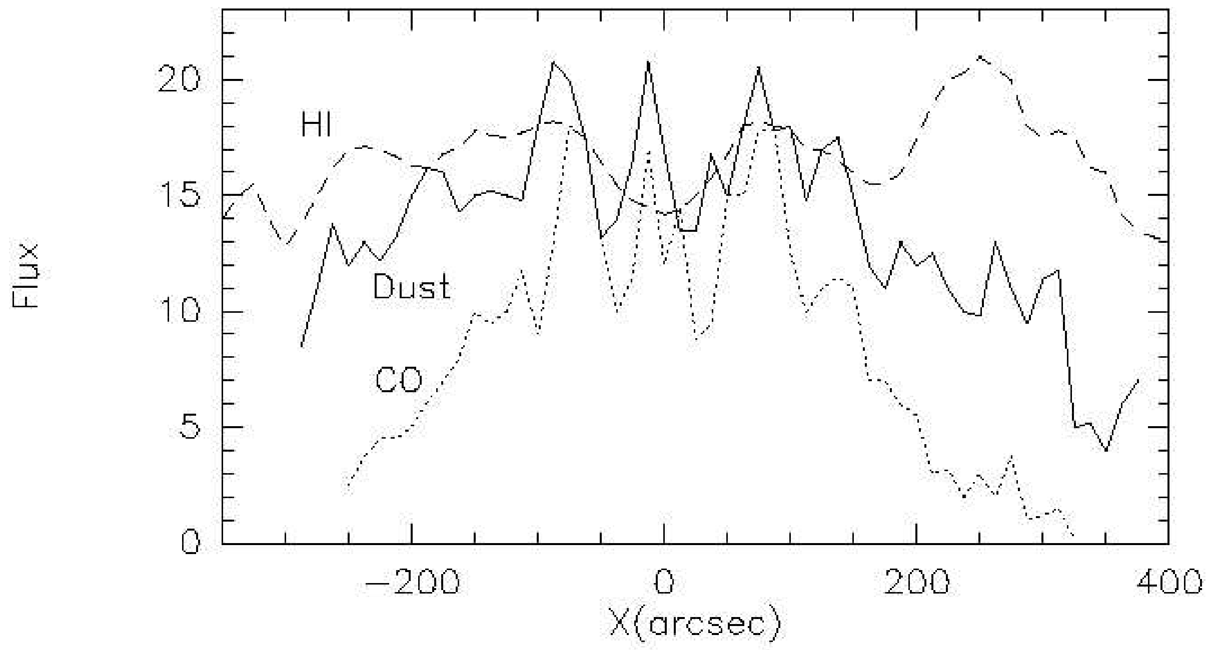

Figure 2. Dust emission radial profile in NGC 4565, compared to the CO and HI profiles, from Neininger et al (1996).

NGC891: dust and CO emmission

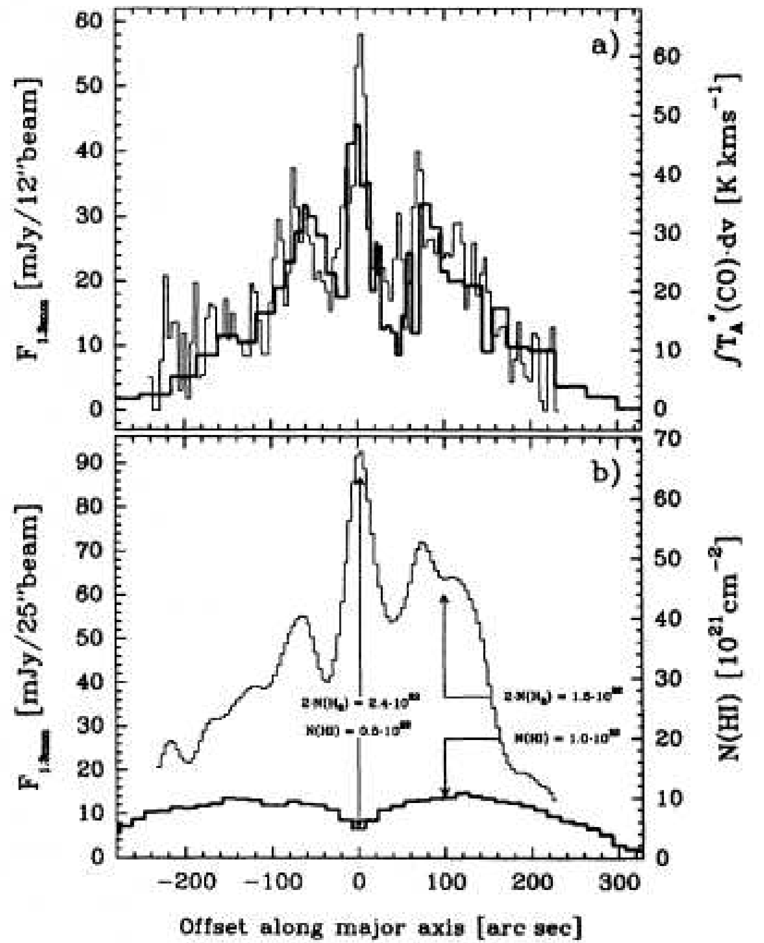

Fig. 2. a) The λ1.3mm continuum emission and the ^{12}CO (2-1) integrated line intensity along the major axis, observed with a 12″ angular resolution. Abscissa, the apparent distance from the center

Galaxy type

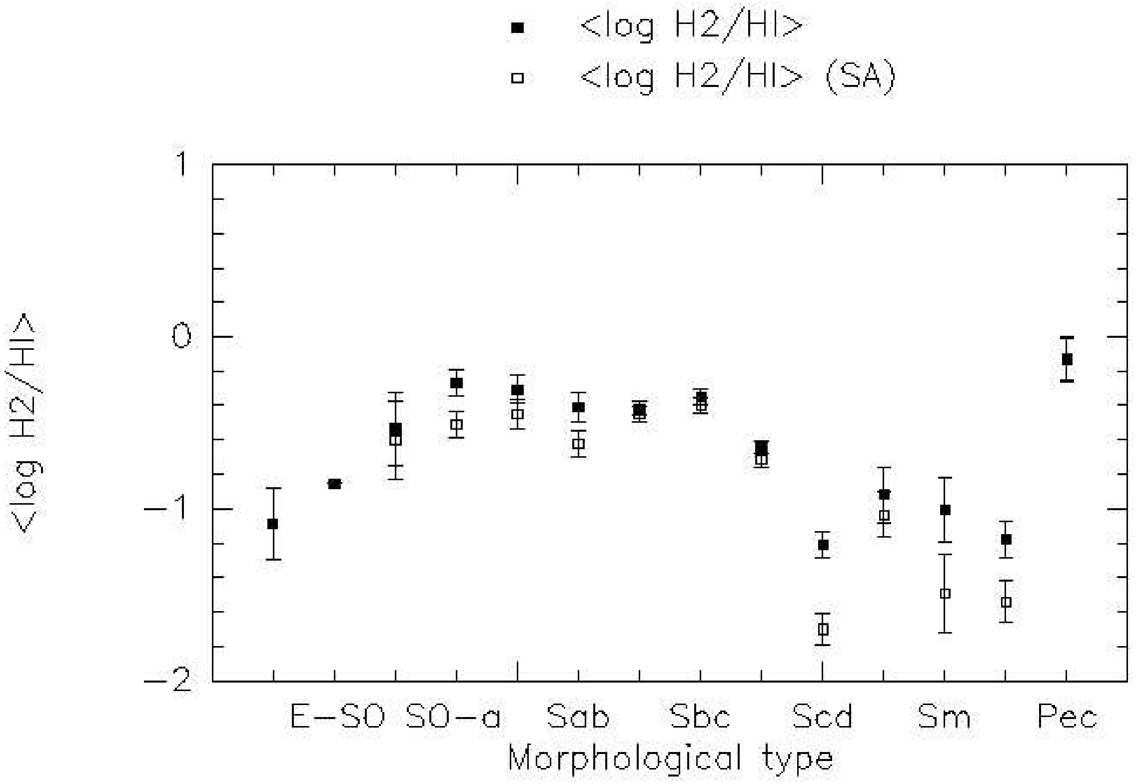

Figure 1. H_2/HI mass ratio in galaxies as a function of morphological type; full squares: mean values with upper limits treated as detections; empty squares: mean values with upper limits taken into account using the survival analysis (SA), from Casoli et al (1998).

Combes 1999

Importance of bar

- Drives of gas and dust
  - molecular gas and dust to center
  - Feeder of AGN and/or starburst
- Linblad resonance
  - Nuclear, Inner, Outer
  - Pattern speed
  - Orbital frequency
  - Oscillation frequency of the potential

Linblad resonance

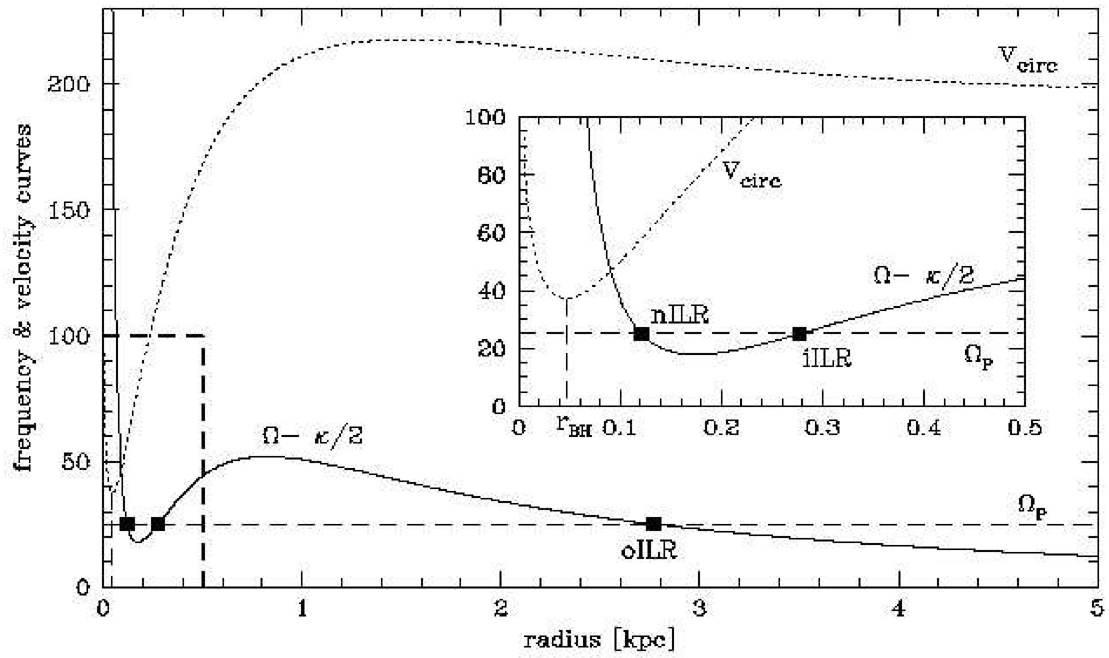

Fig. 2. Velocity and frequency curves for a potential with 3 ILRs. The circular velocity ($v_{\rm circ}$) is drawn with dotted line, the frequency curve is solid. The constant pattern speed Ω_P is marked with the horizontal dashed line. Positions of the three ILRs: nuclear (nILR), inner (iILR), and outer (oILR) are marked with squares. A close-up of the inner region is shown in the insert, where the sphere of influence of the $10^7 M_\odot$ MBH has roughly the radius $r_{\rm BH}$.

Spirals

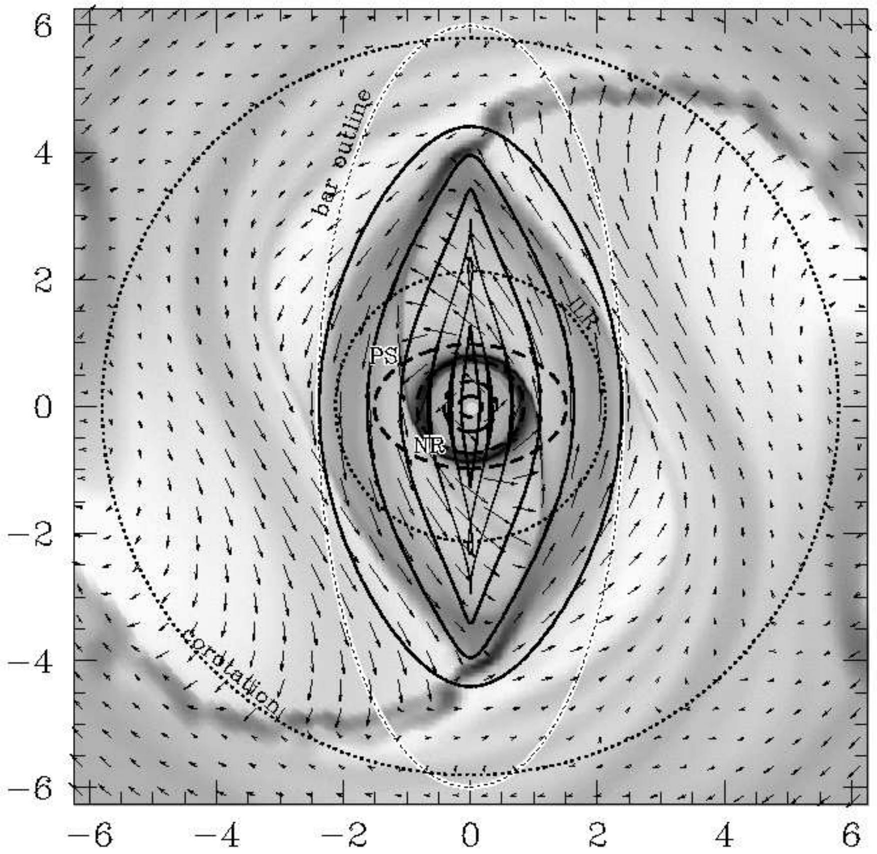

Fig. 1. A representative snapshot of the gas density and velocity field in a barred galaxy, taken after 6 rotation periods of the bar, once the main flow patterns have been established. The gas, treated as a non-selfgravitating, isothermal fluid with a sound speed of 5 km/s, responds to a fixed gravitational potential of a bar, disc and spheroid, and is modeled with an Eulerian code on a fixed grid. The density is shown in grayscale, and arrows mark gas velocity in the reference frame rotating with the bar. Dotted circles mark corotation and the ILR. Examples of x_1 and x_2 orbits are drawn with solid and dashed lines, respectively. **PS** marks the principal shock in the bar, **NR** is the nuclear

Clusters

- Cluster spirals
  - deficient in HI
  - Still contain CO - H_2?
- Starburst outside of galaxies?
  - Xu & Tuffs (1998)
  - 25kpc from neighbouring galaxies
  - Young stars - ~.7M_o/year

Redshift dependence

- High z observations
  - > 10 objects with $z > 2.2$
- Gravitational amplification
- Gas excitation uncertainty
- Infrared background
- Early starbursts?