Millimeter dust continuum emission as a tracer of molecular gas in galaxies:

comparison of SMC and Local GMCs

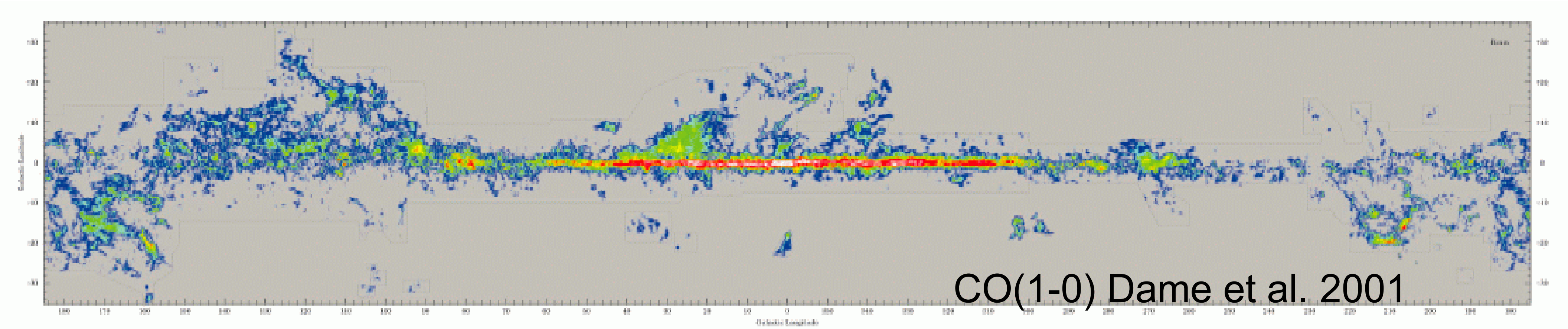
Caroline Bot

a project w/ Francois Boulanger, IAS France

& Monica Rubio, Universidad de Chile

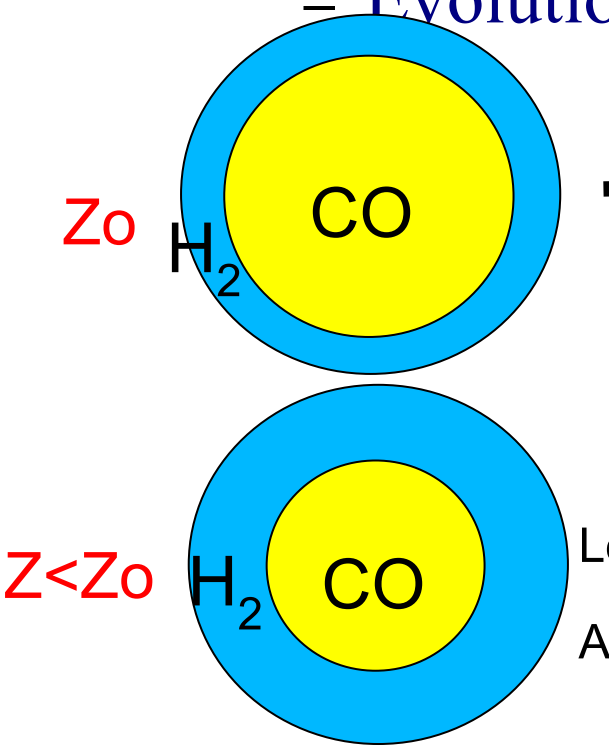
Molecular clouds

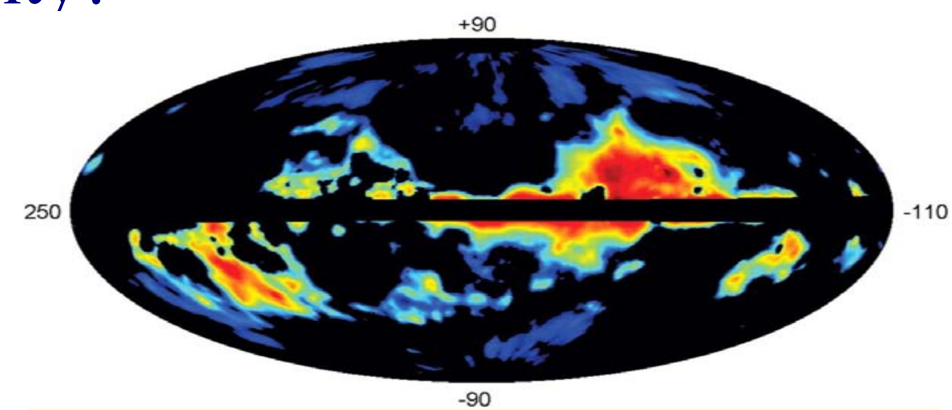
- Sites of star formation
- Most of the molecular gas is in giant molecular clouds
- PROBLEM: H_2 is quite impossible to observe directly in cold interstellar regions
- Use of tracers (CO, gamma rays, dust emission)



Molecular clouds tracers

- No perfect tracer:
  - Different tracers in different environments
  - Simplified assumptions
  - Evolution with metallicity?





Lequeux et al. 1994

André et al. 2004

Grenier et al. 2005:
dark clouds= H2 without CO

- Compare in a consistent manner different tracers in different environments

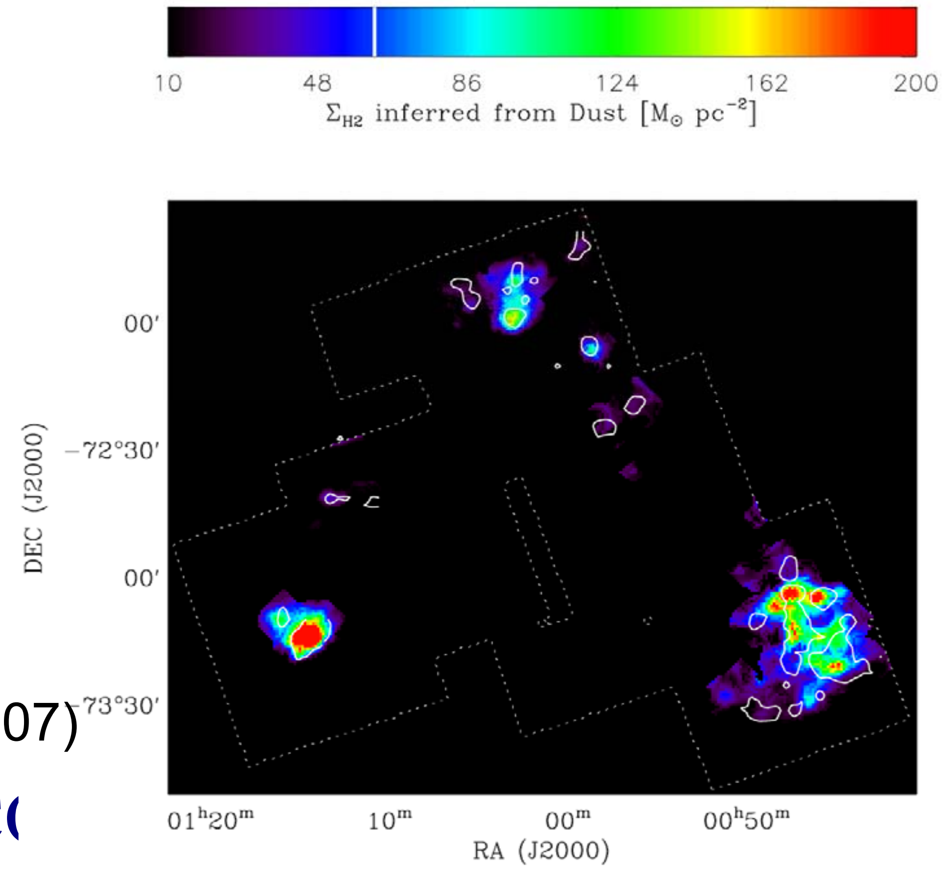
In the SMC...

- Resolve GMCs
- Lower metallicity
- In SMCB1#1
  - $M_{mm}(H_2) >> M_{CO}(H_2)$

Rubio et al. 2004

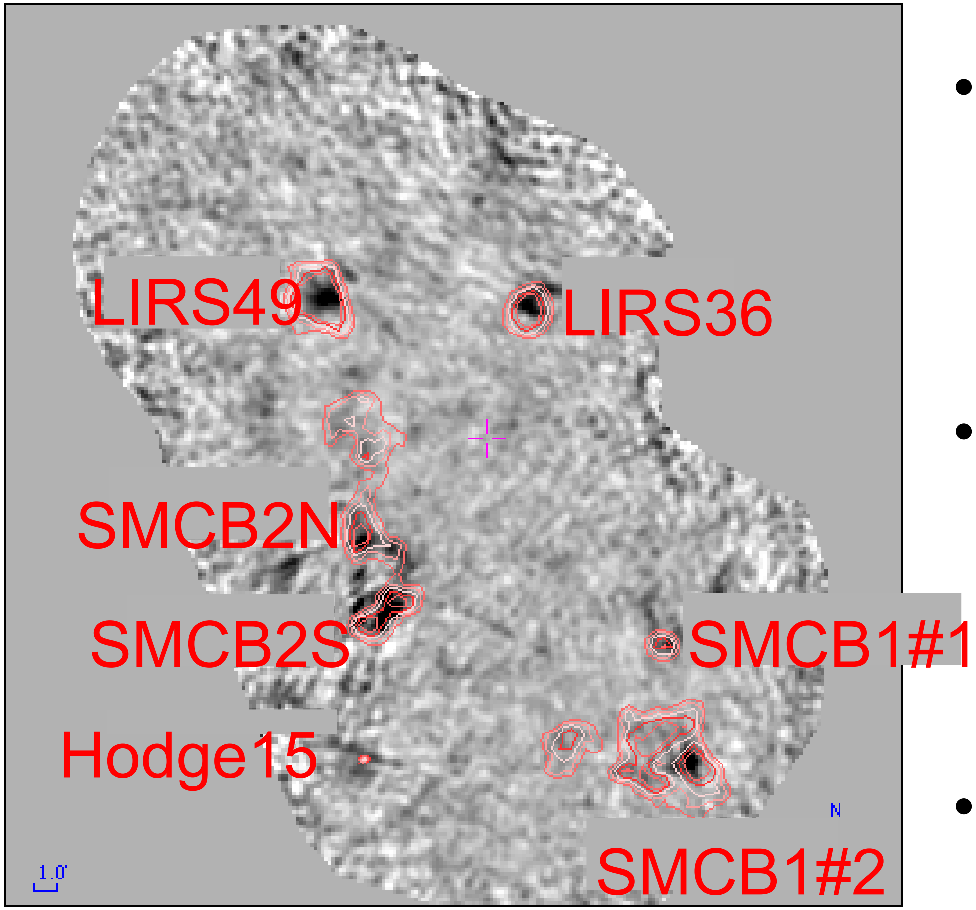
- General trend in the SMC?
- S3MC+NANTEN

Leroy et al. (2007)

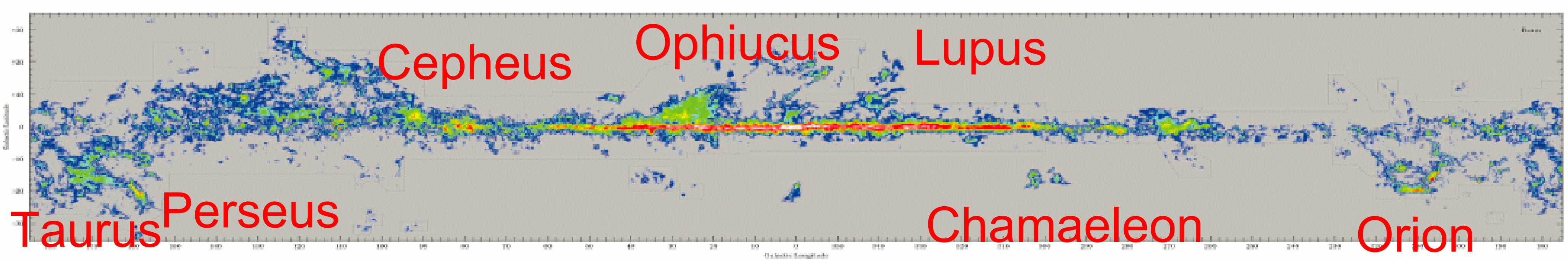


  - H_2 larger than predicted by C(
  - But IR dust emission biased by temperature
- Is there the same difference in our Galaxy?
- How do we understand it?

The Data



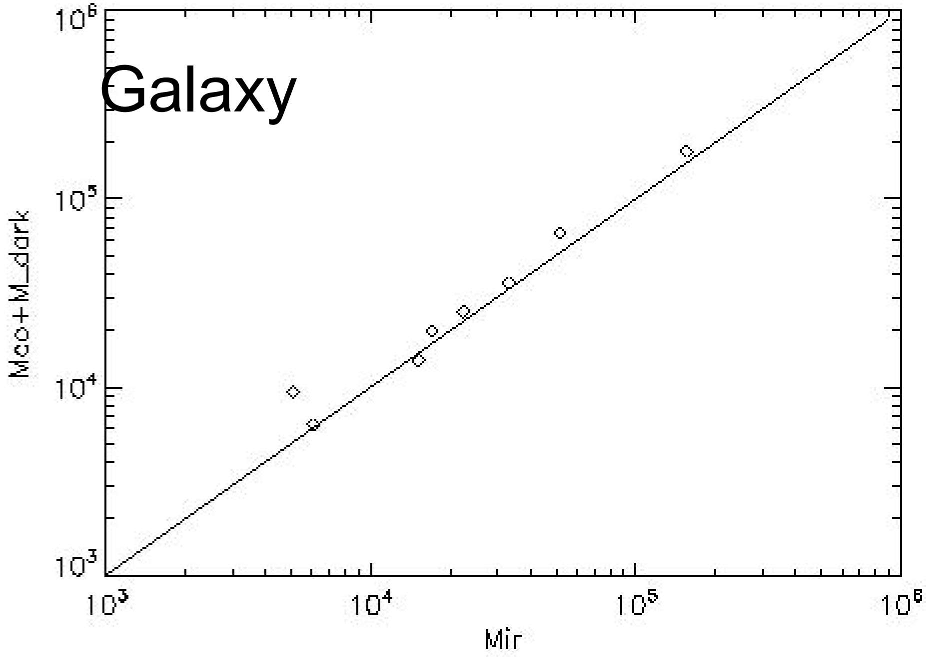
- SMC:
  - SEST SIMBA & CO data (M. Rubio)
- Galaxy:
  - FIRAS
  - CO (Dame et al. 2001)
- Same linear resolution

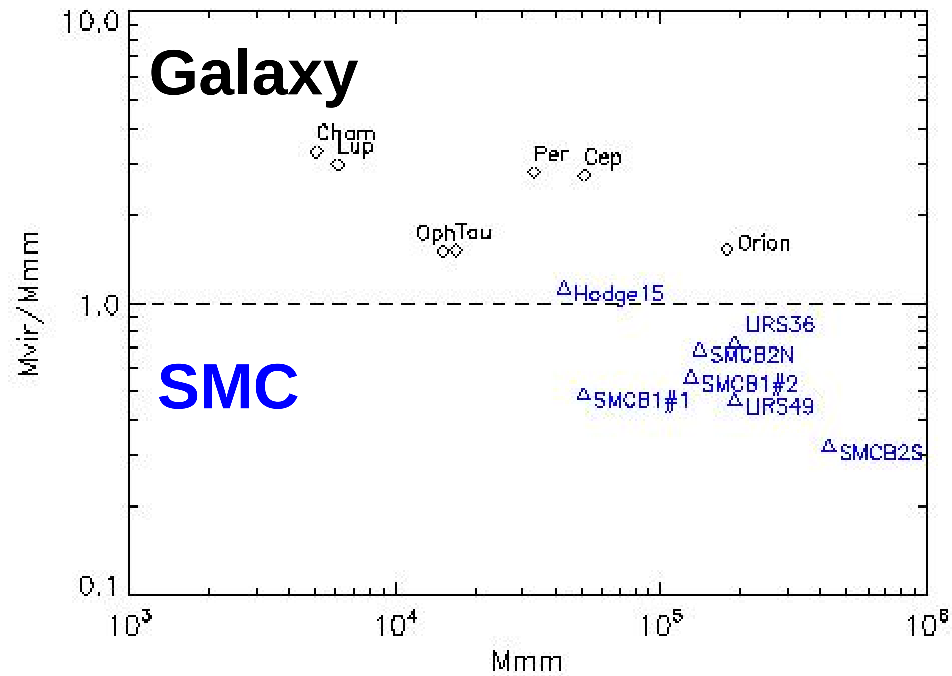


Molecular gas masses

- From millimeter dust emission
  - corrected from free-free, CO(2-1) and dust in HI
  - T_{dust}=15K (weak assumption)
  - $N_H = cst \,.\, I_\lambda \,.\, (x_d^{ref}/x_d^{region}) \,/\, \varepsilon_H^{ref}$
  - $(x_d^{SMC}/x_d^{local})=0.17$
  - ε_H^{ref}: emissivity of dust in molecular gas
    - computed in the molecular ring
    - ~2x diffuse medium value (Boulanger et al., in prep.)
    - grain-grain coagulation effects
- Virial masses: $M=190\Delta V^2 R$ (MacLaren 1988)
- M_{dark} from γray analysis (Grenier et al. 2005)

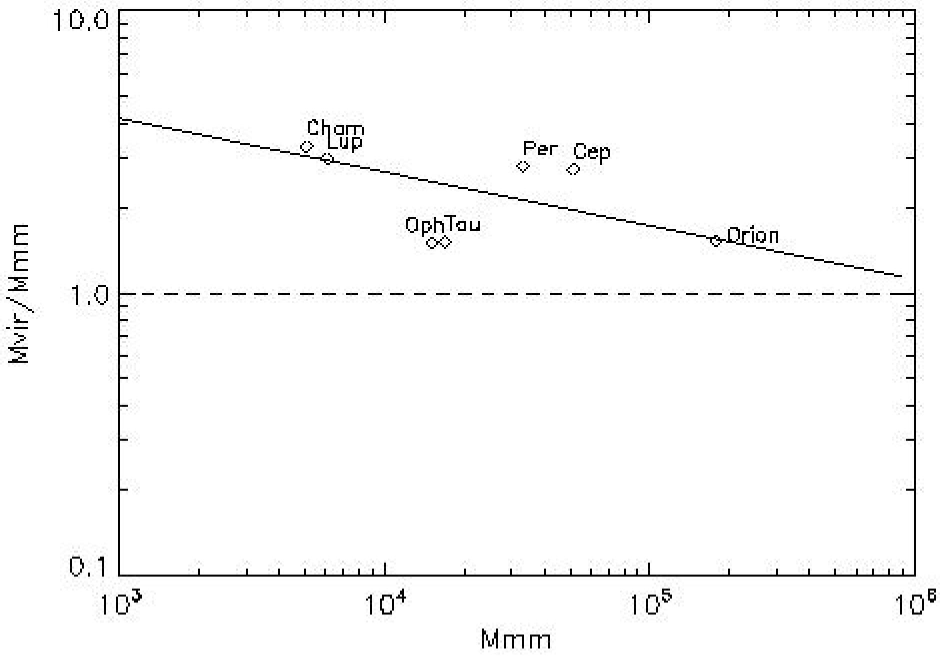
Results

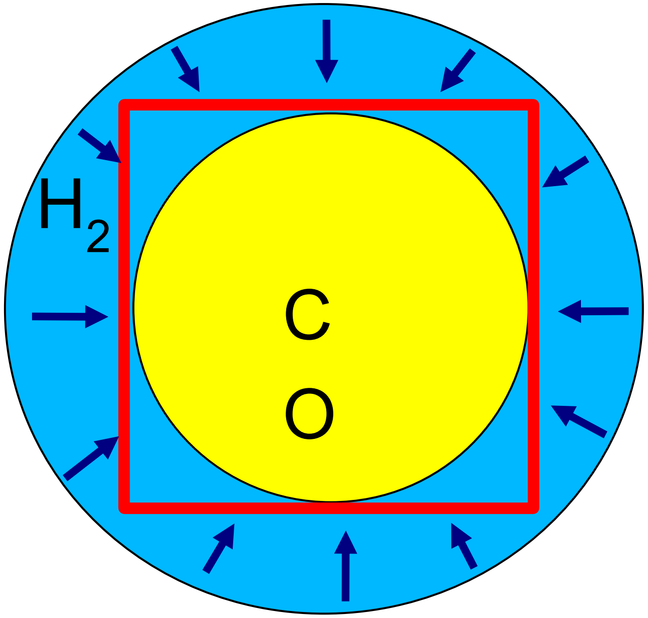




- $M_{mm} \approx M_{dark}+M_{CO}$
  - M_{mm} = true M_{H2} if the dark gas is H_2 without CO
- In our Galaxy: $M_{vir} > M_{mm}$
- In the SMC: $M_{vir} < M_{mm}$

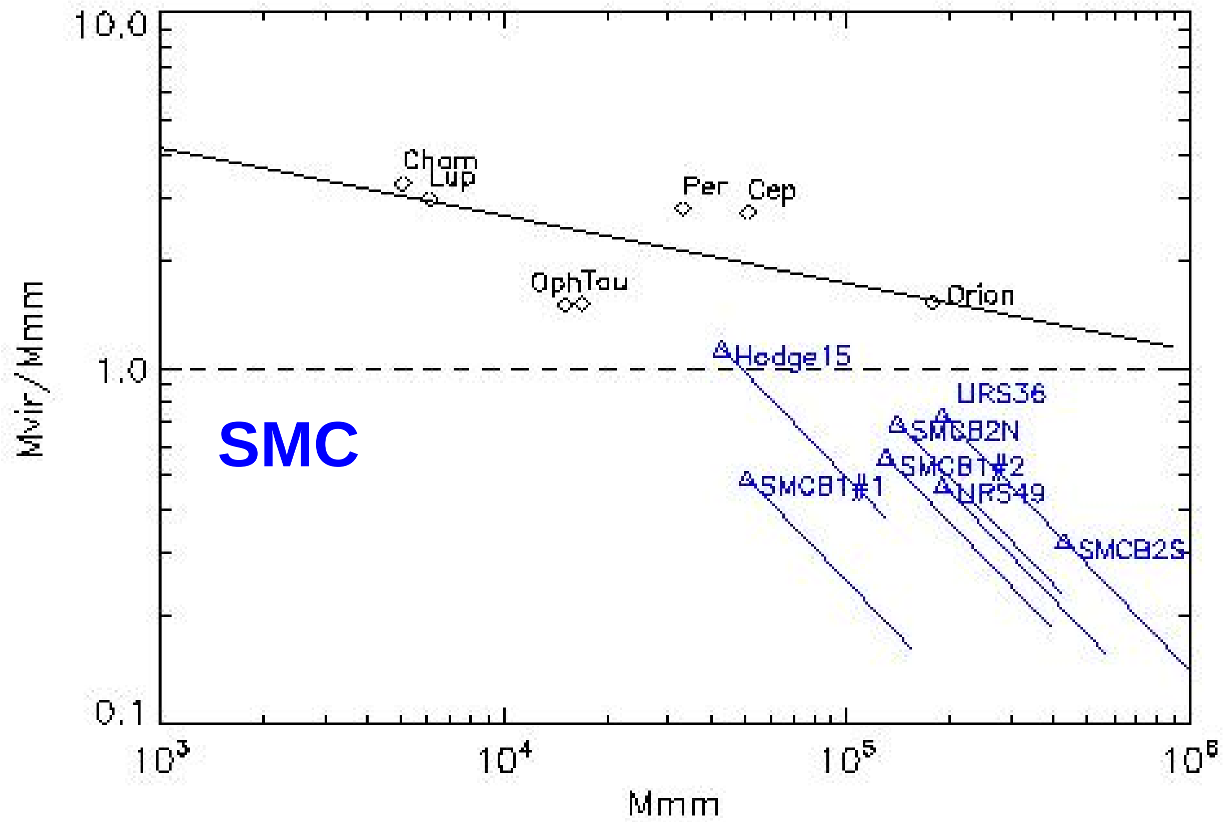
Interpretation





- In our Galaxy: $M_{vir} > M_{mm}$
  - Outside pressure effect
  - Solomon et al. (1987)

Interpretation



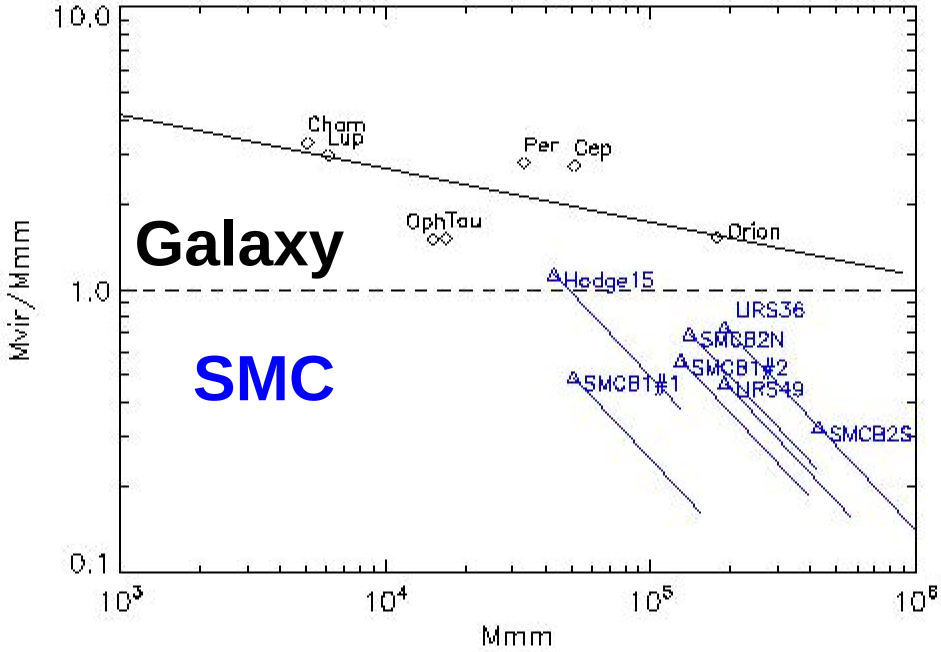
- In the SMC:

$M_{vir} < M_{mm}$ (~2)

- M_{mm} are lower limits:
  - enhanced emissivity in the SMC? (harsh environment)
  - We took high dust/gas ratios

Interpretation

- In the SMC:
  - $M_{vir} << M_{mm}$
  - Confirms Rubio et al. 2004 result on all SMC clouds of our sample
- Revisit virial theorem to understand the difference

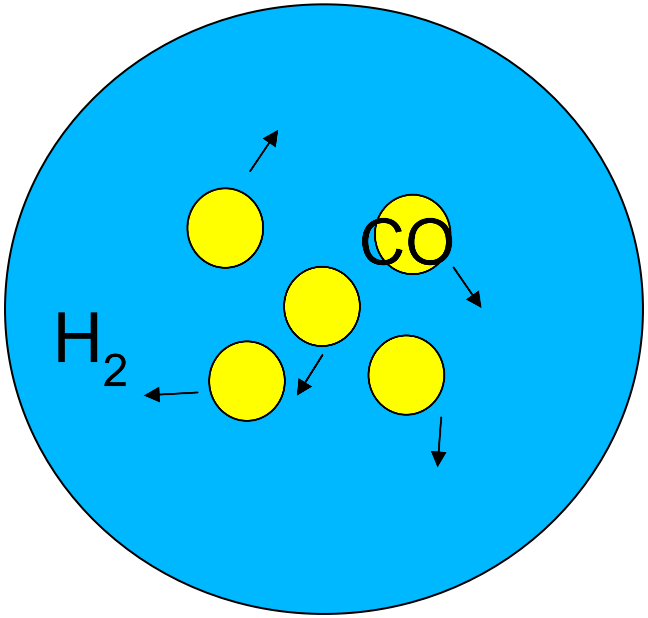


→ Partial support of the cloud by a magnetic field

Results

- Magnetic field > 15μG
  - Coherent with the densities observed if B α $n^{1/2}$ (Mouschovias 1976)

- New image of the GMCs in the SMC:
  - -CO clumps in densest regions
  - -Large enveloppes of H_2
  - -Magnetic + gravitational support



Conclusions

- Millimeter emission traces molecular gas
- Good comprehension of the Galactic clouds
  - coherence of different tracers
- In both samples: large enveloppes of H_2 and small CO clumps
- Support by a magnetic field
  - only in the SMC? -> different formation of GMCs? Effect of higher ionization?
- astro-ph/0704.3257