Giant Holes and the question of triggered HI to H2 transition
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Overview and OQs on HI->H2 transition

- Context
- Giant (HI) loops, a ultra-short overview
- The HI/H2 relation/transition
- Identification of a molecular loop in outer region of M33
- Geometry and timescales
- Conclusions on HI H2 relation in this structure
- General conclusions and outlook

Context

•SF proceeds over contraction of molecular gas

•Very often HI reservoir is much bigger than the one of H2

•In addition any gas accretion onto galactic disks is presumably atomic

•Then, what relates HI and H2 and how can HI be turned into H2 ?

•New and much more complete sets of HI data as well as CO maps for nearby galaxies have triggered an intense activity in the field.

•Numerical and analytical models of HI/H2 relations and SF are very numerous, but most include untested assumptions and microphysics.

•To build up physical models which will also allow to extrapolate to more extreme cases (incl early universe), exploration of the details is necessary.

To explore HI H2 relation several approaches are possible:

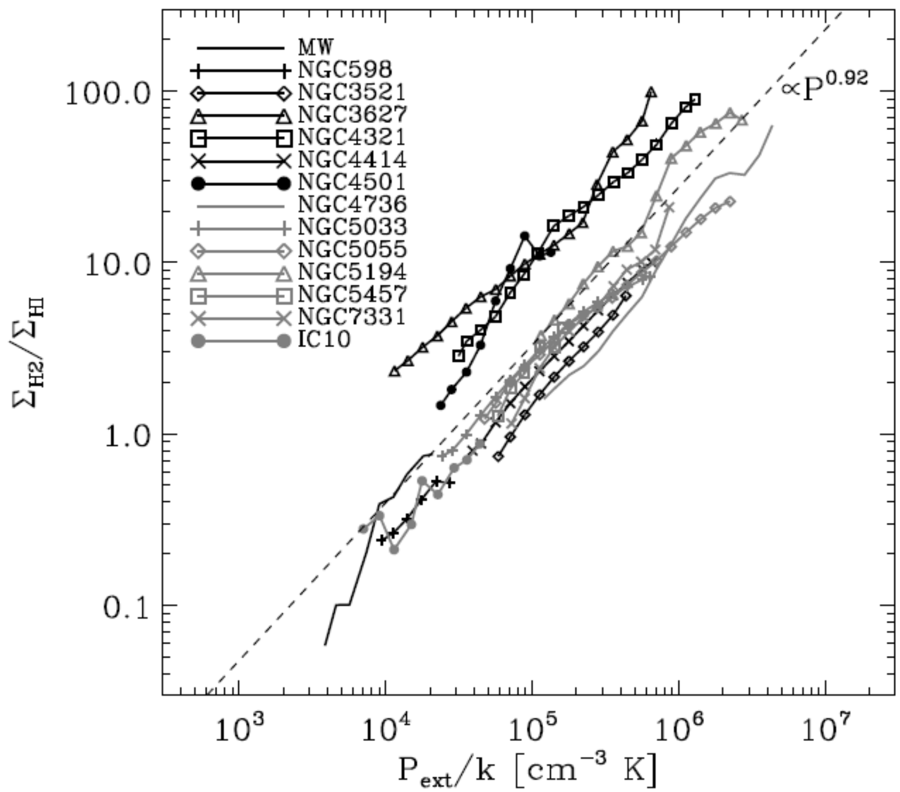
Pseudo equilibrium conditions:

- Study of PdR regions
- Large scale comparison of both phases in galactic disks (example Blitz et al 05)

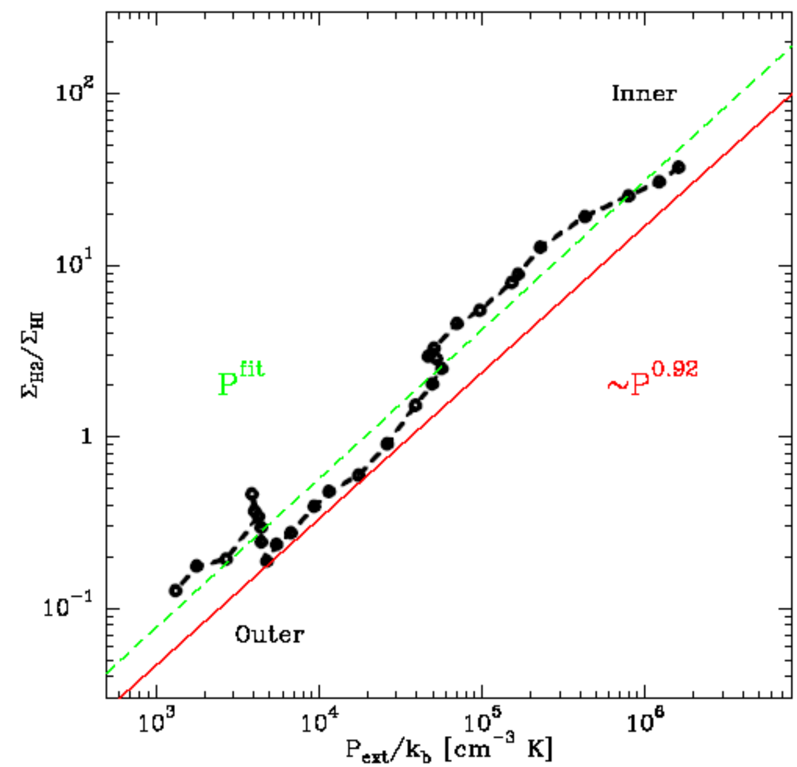
Non equilibrium conditions:

- Study of spiral arm patterns and offsets (ex. Tamburro et al 08)
- Study of shock fronts and blast waves (ex. Guillard et al 09)

from Blitz et al 05



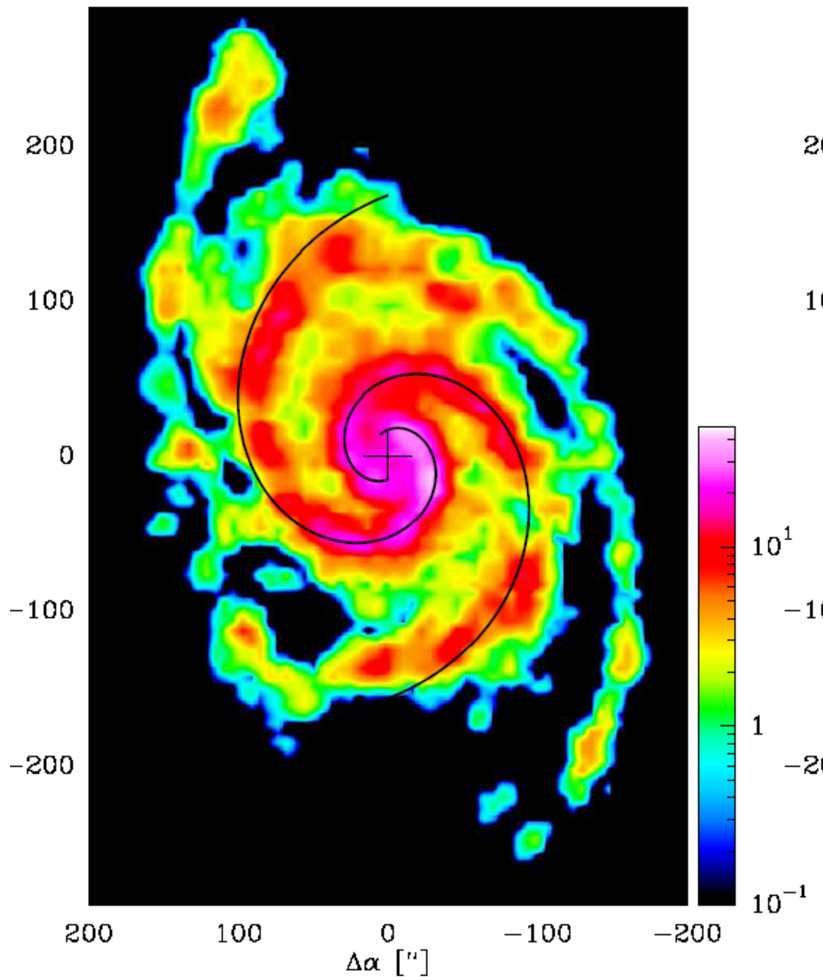
M51 Hitschfeld et al 2008



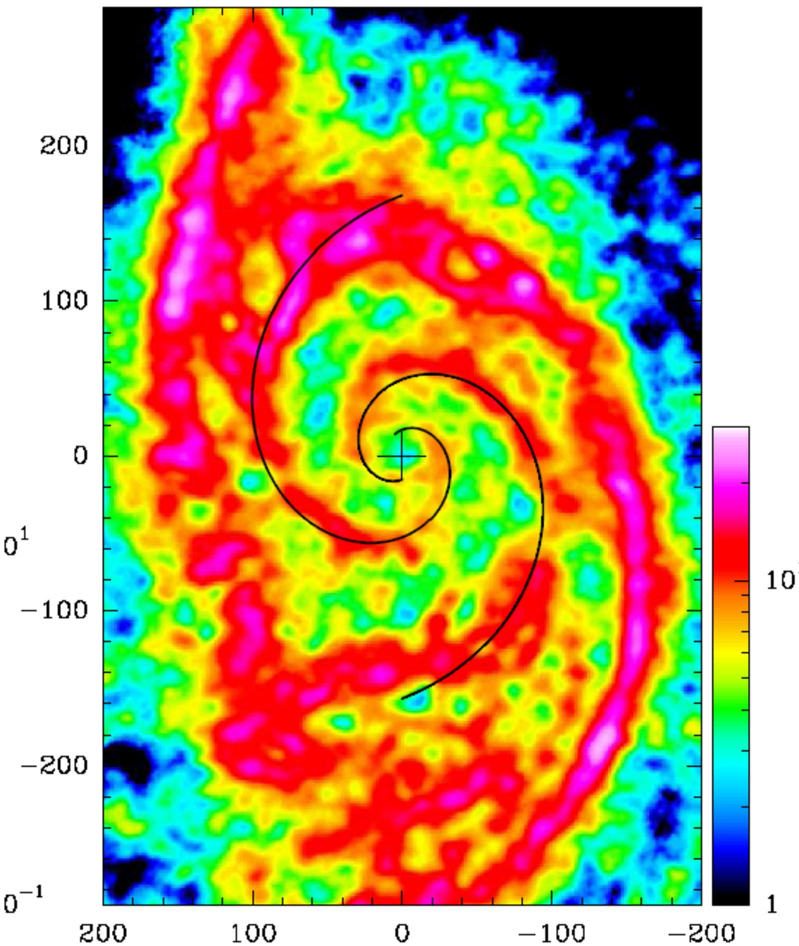
Midplane pressure if stars dominate
and “a couple” of other assumptions.

$$P_{\rm hydro} = 0.84(G\Sigma_*)^{0.5}\Sigma_{\rm gas}\frac{\sigma_{\rm gas}}{h_*^{0.5}}.$$

M51 CO
Hitschfeld et al 08
& Schuster et al 07

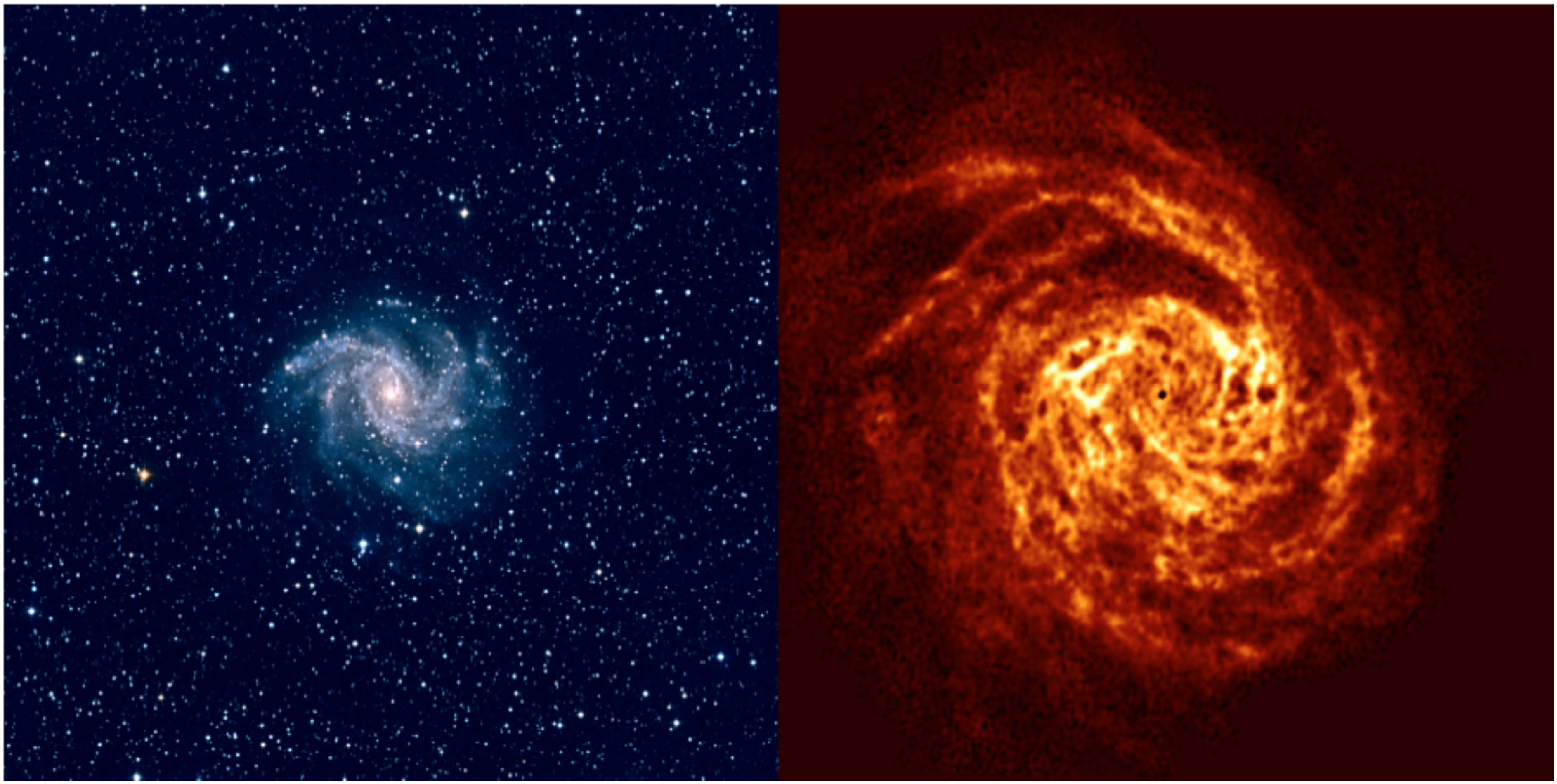


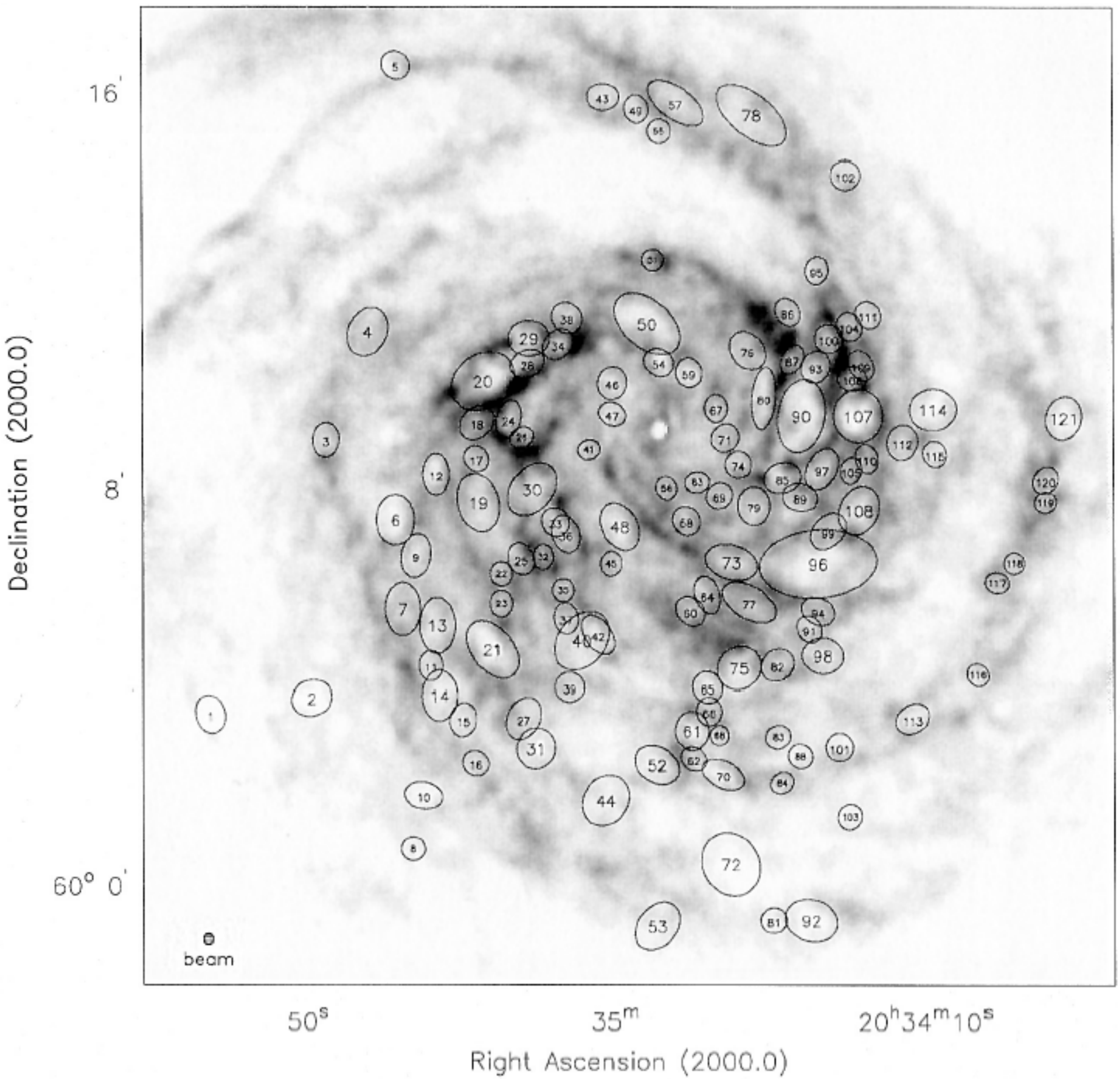
M51 HI from Walter et al 2008



Giant (HI) loops, an ultra-short status overview

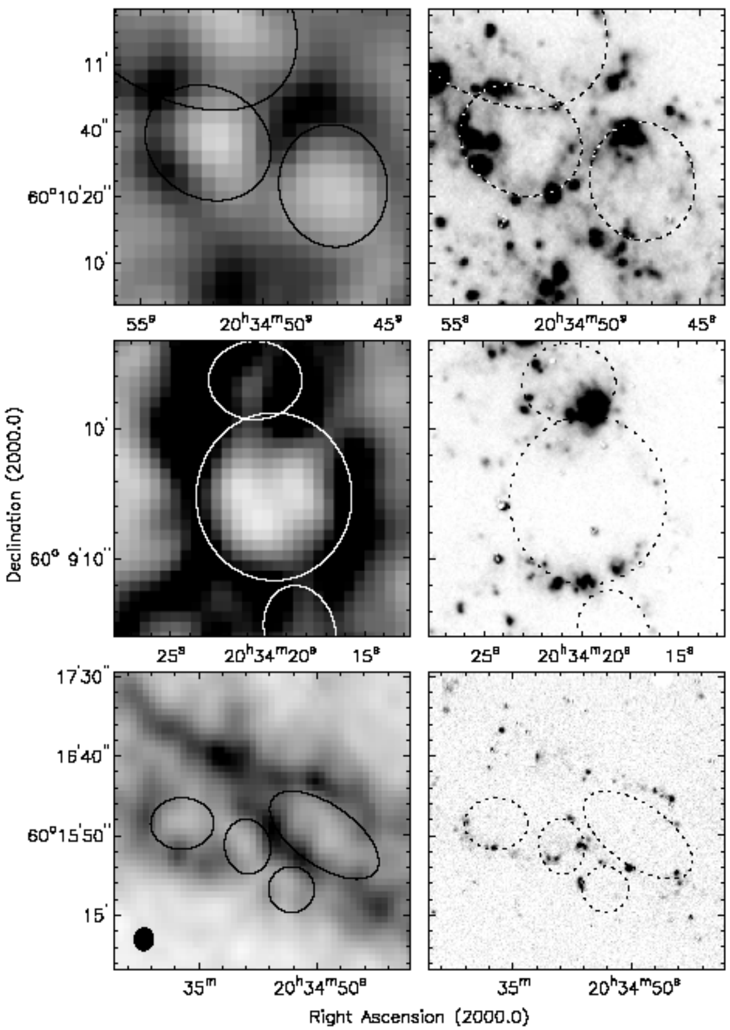
NGC 6946, Boomsma et al 2008

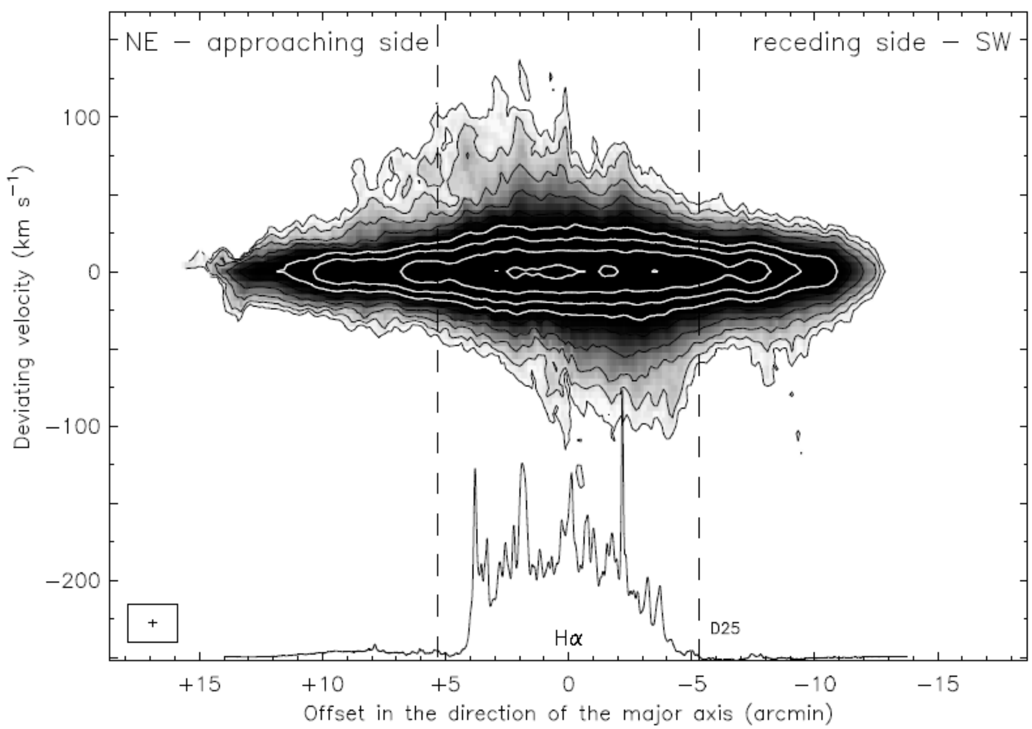


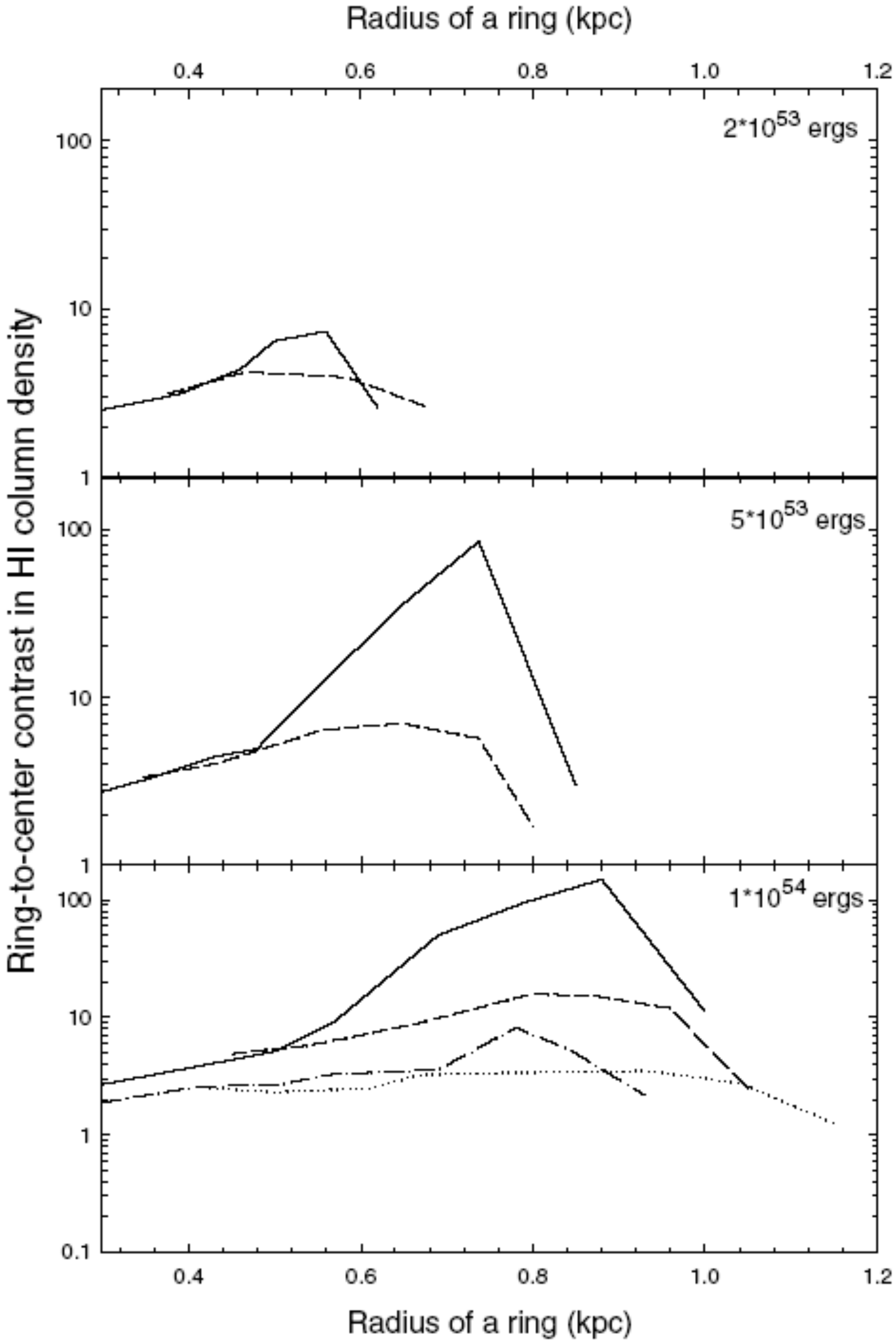


16'
8'
60° 0'
Declination (2000.0)
beam
50s
35m
20h34m10s
Right Ascension (2000.0)

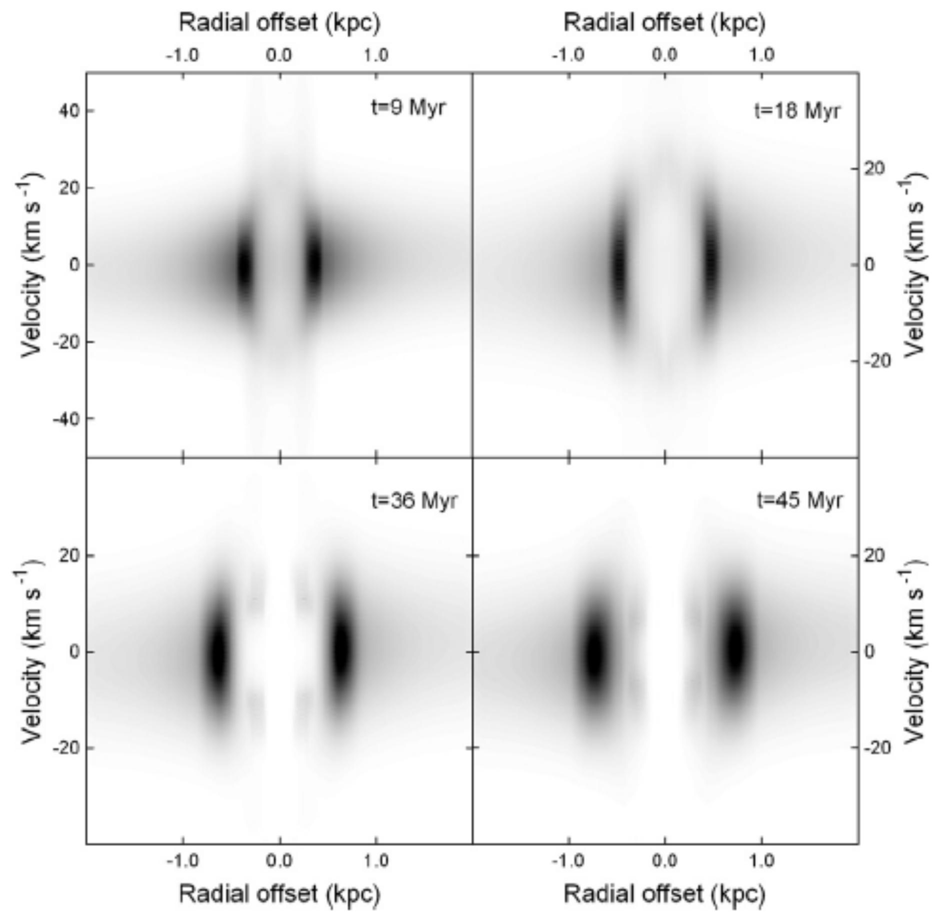
Are HI loops due to HV cloud impacts or collective SN blasting ?







Vorobyov & Shantanu 05 find that
PV diagrams of HV cloud impacts do not
reproduce observed PV diagrams of loops



H2 Formation:

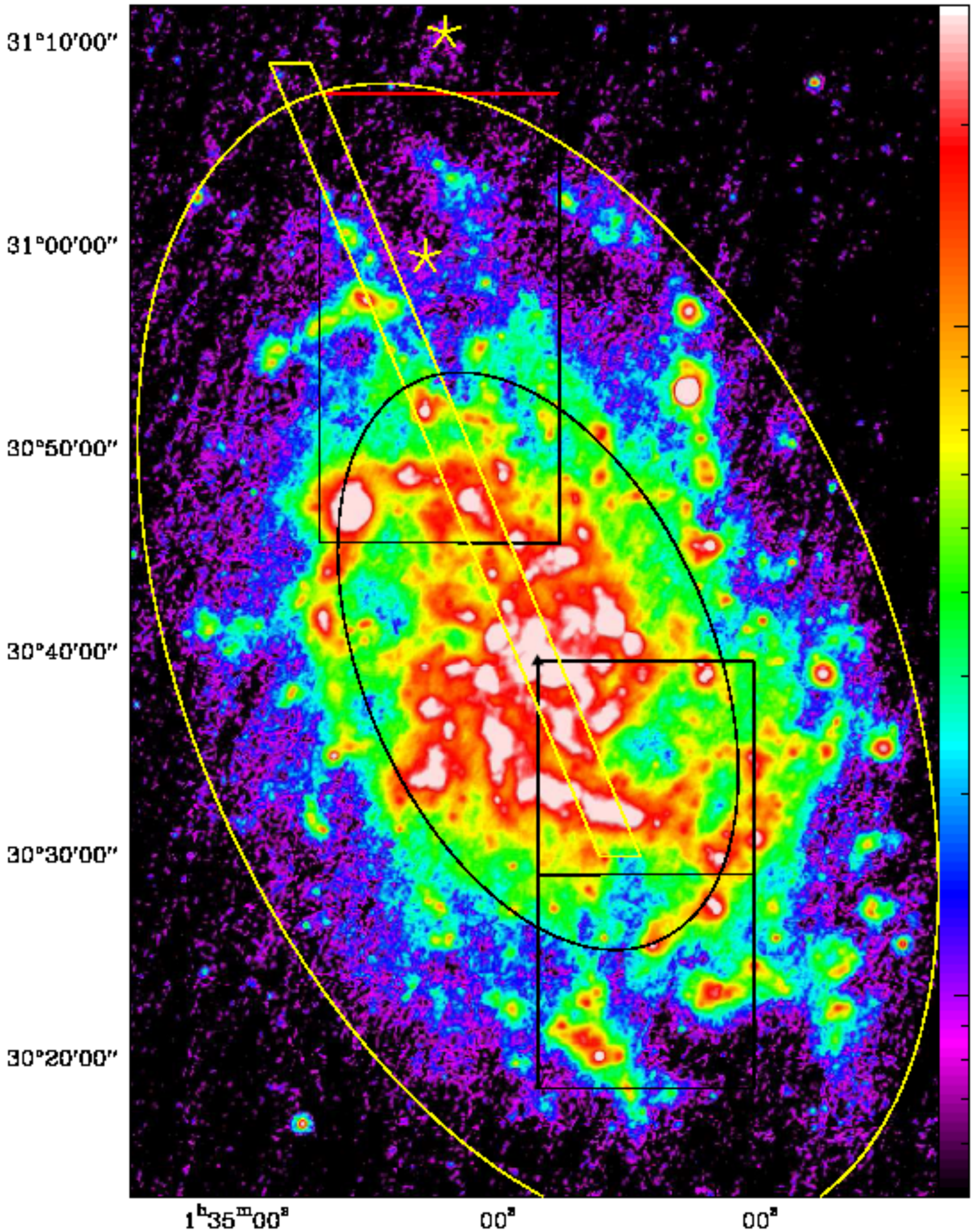
•For almost all cases in the local universe local universe H2 formation on cold dust grains is dominant. *Langmuir-Hinshelwood process see for ex. Tielens & Allamandola 87.*

• Recent models relax dust temperature conditions due to grain surface structure (Td 10-40 K). *Chang et al 2005, Hornekær et al 2003*

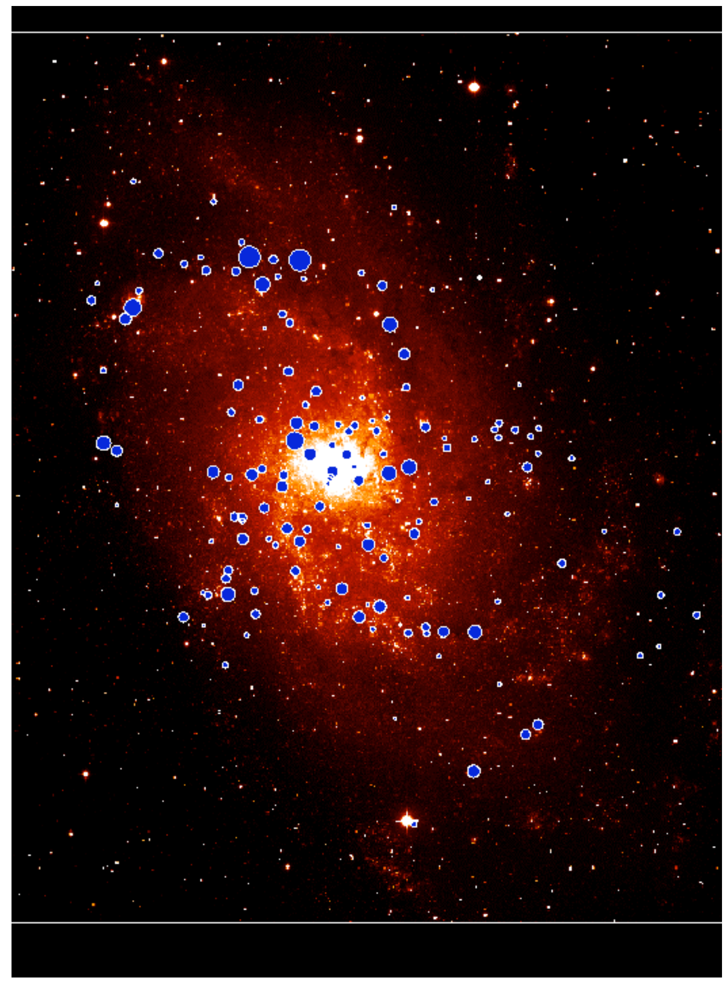
• Grain surface H2 formation rates are proportional to dust fraction, gas temperature and density (=Pressure).

•Formation timescales are ~ 10^7 years for thermal pressure of 10^4 K cm^3. (*ex Guillard et al 09)*

•Exact formation rate depends on dust model.

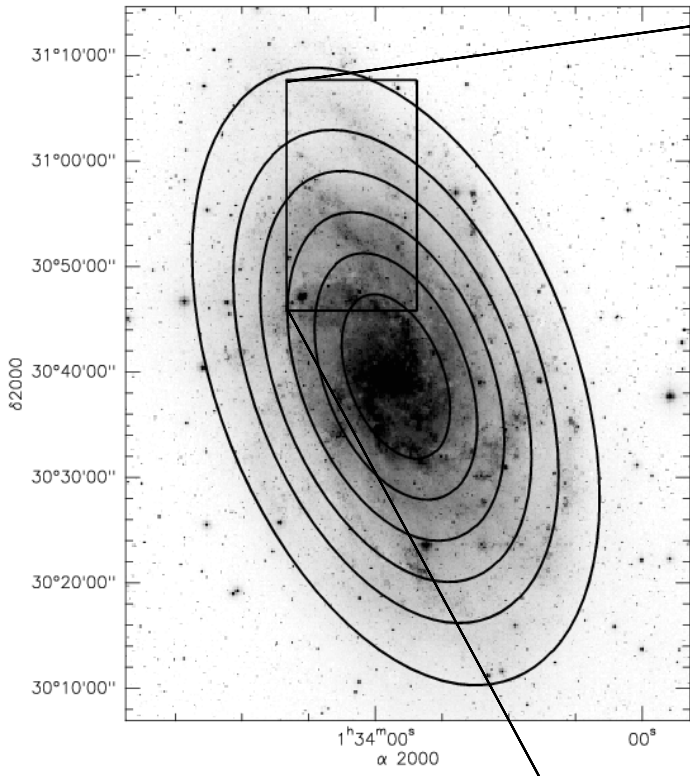


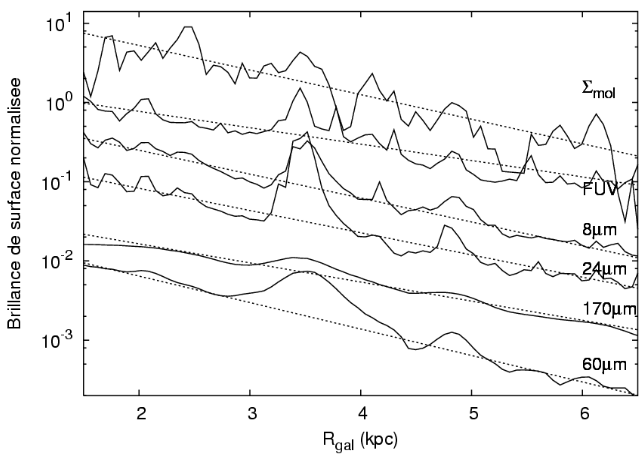
Spitzer 70μm, Tabatabaei 07



BIMA, Engargiola et al 03

Northern Field, Gardan et al 07

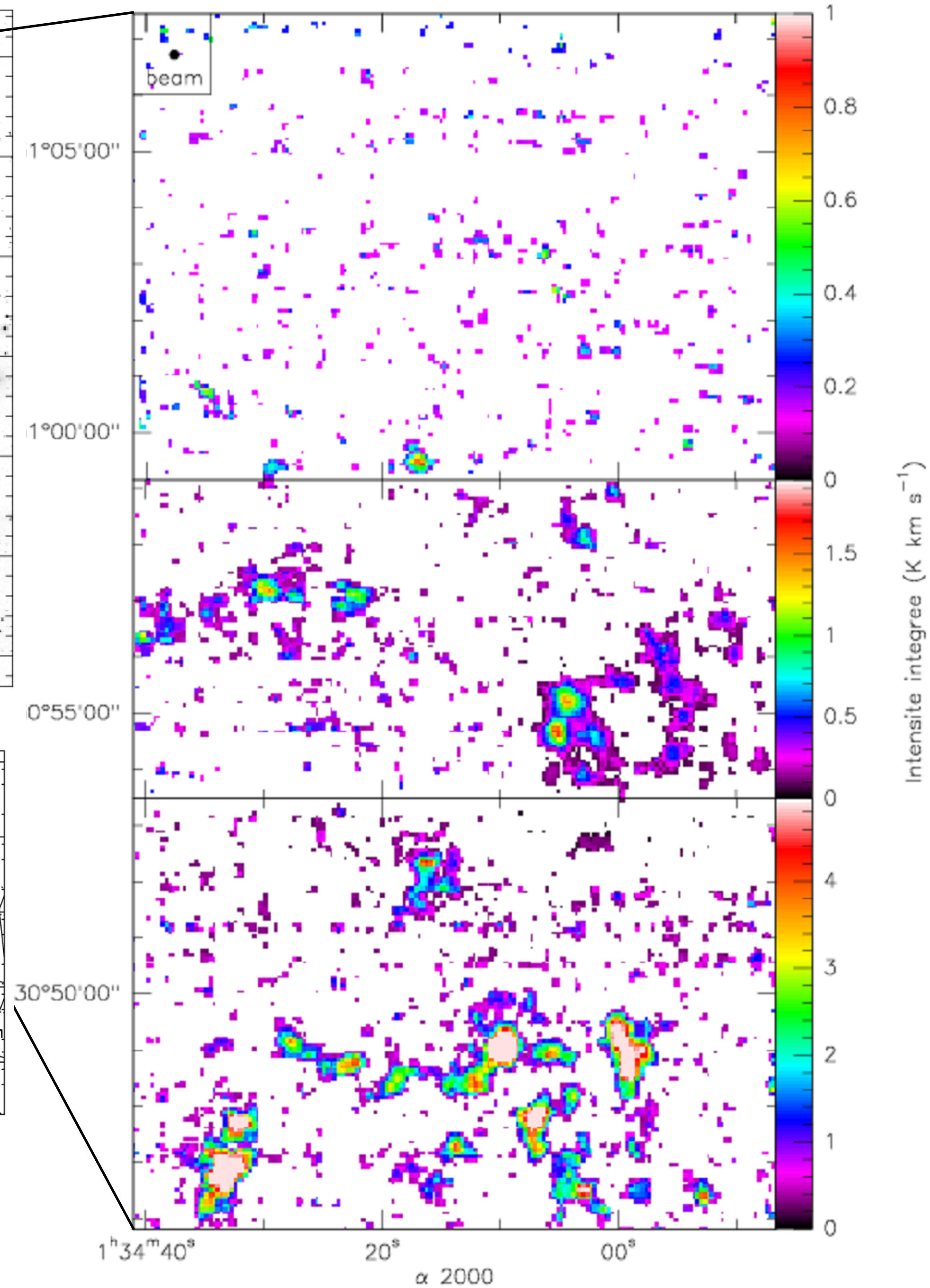


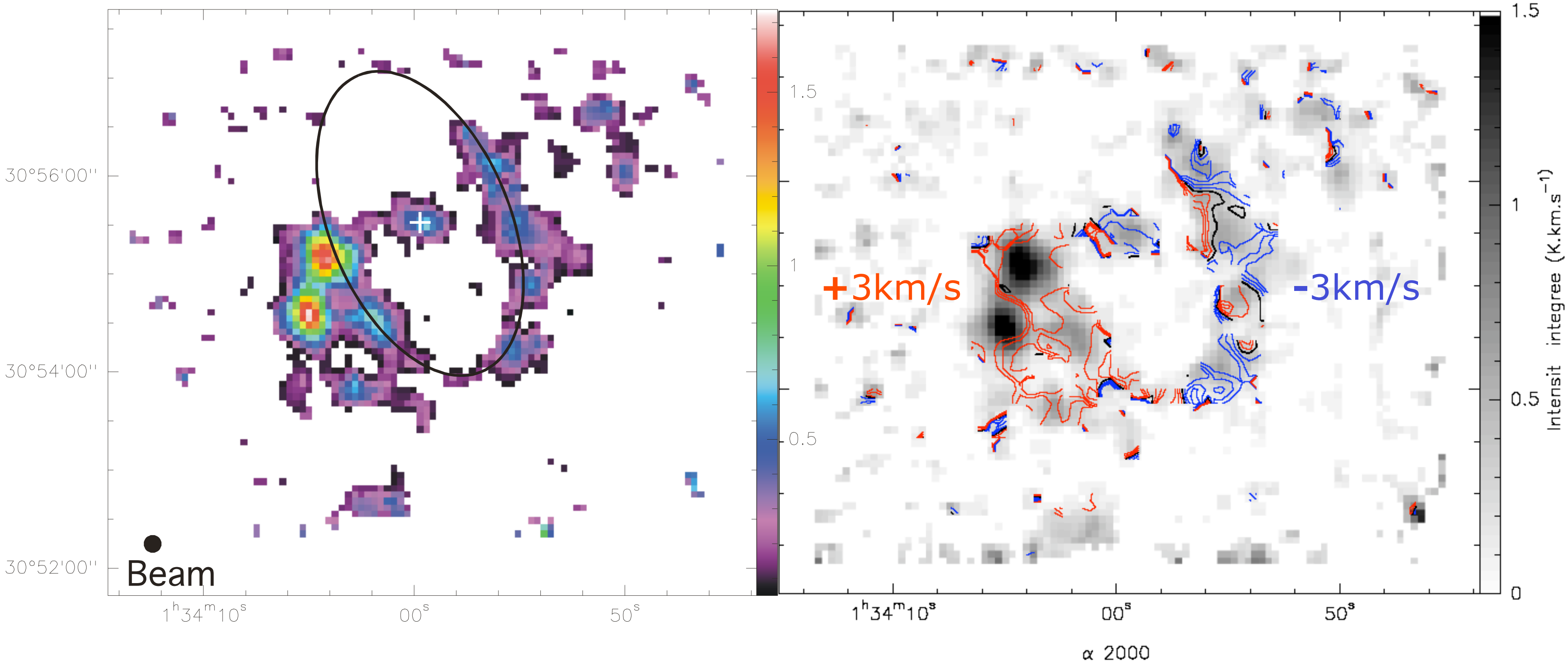


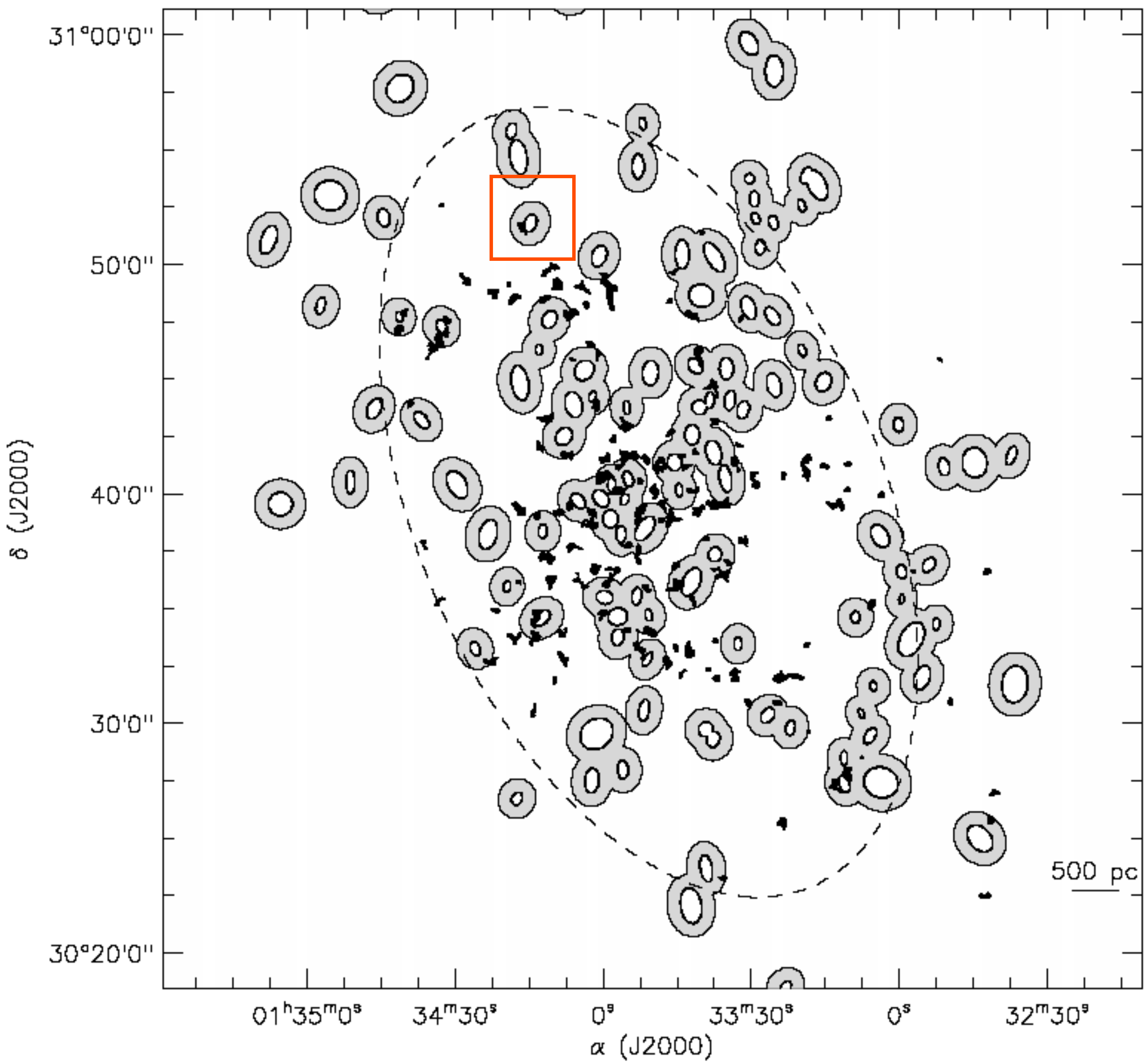
Azimuthally averaged CO emission in comparison with FIR, MIR and FUV.

M33 V

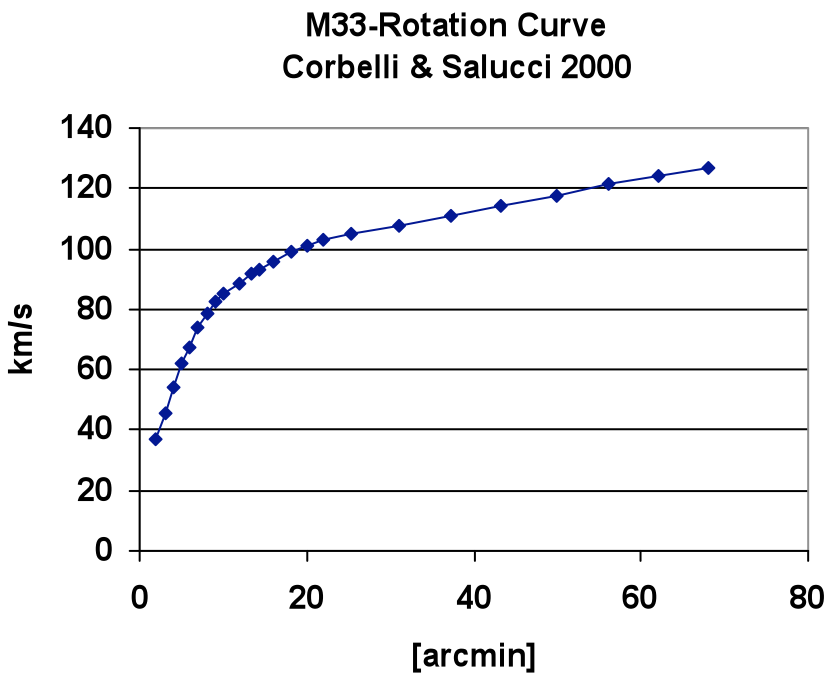
30m HERA CO(2-1)

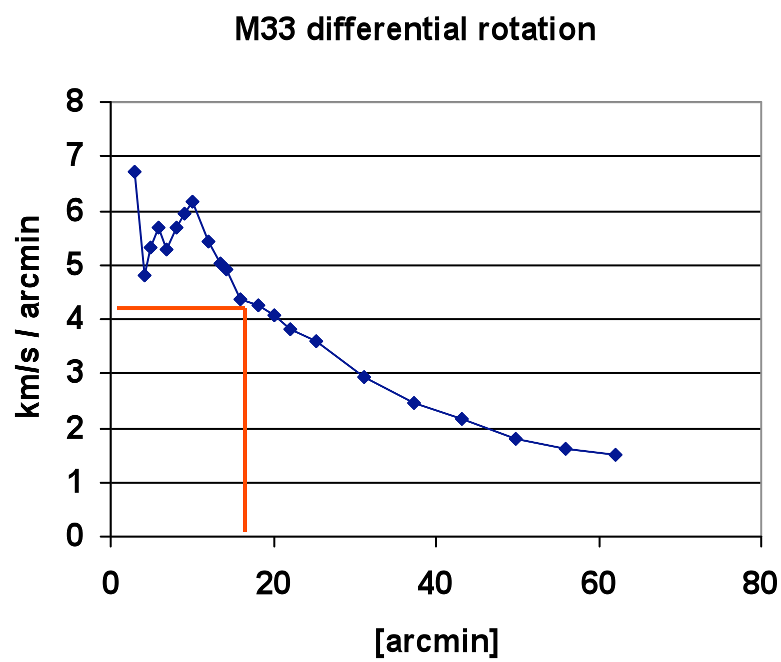



30°56'00''
30°54'00''
30°52'00''
Beam
1h34m10s
00s
50s
1.5
1
0.5
+3km/s
-3km/s
α 2000
Intensit integree (K.km.s−1)
0
0.5
1
1.5



Engargiola et al 2003 : BIMA CO and Westerbork HI loops (Deul andHartog 90)

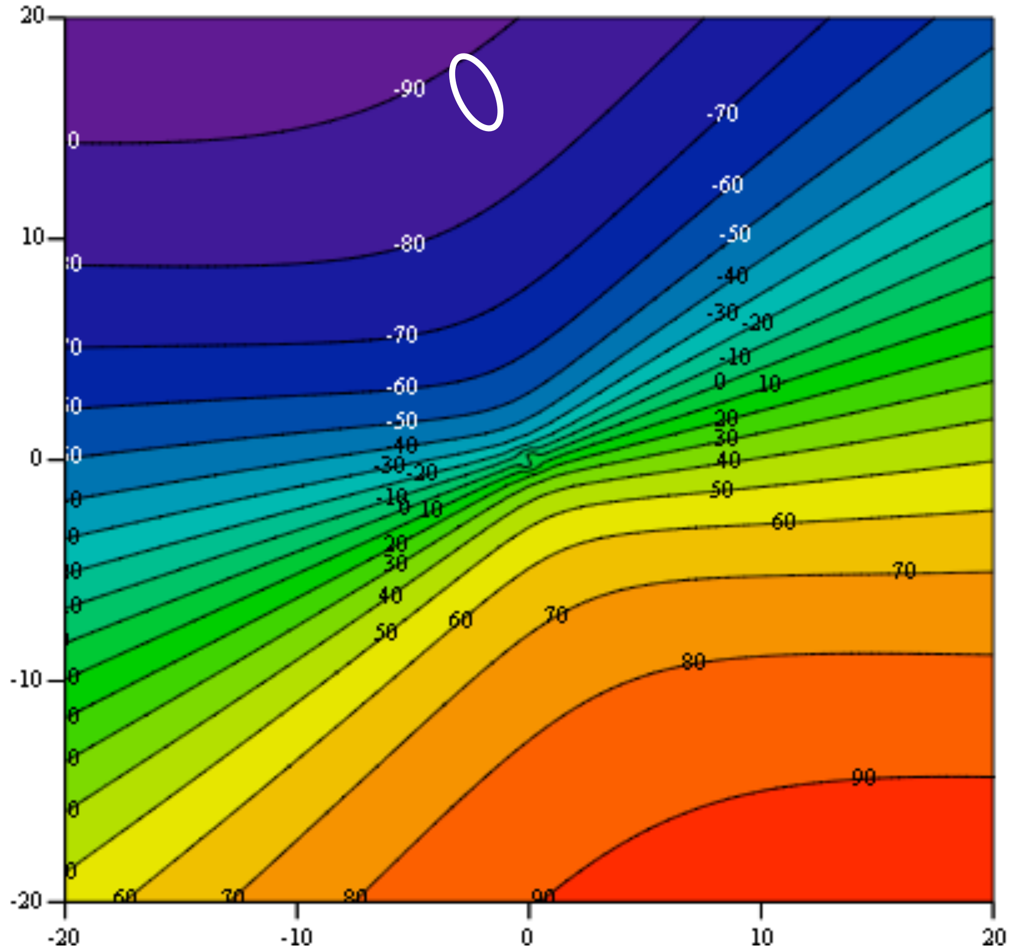




At galactocentric radius (deproj.) of loop (R=16.6 armin) differential rotation is ~4.3km/s arcmin.

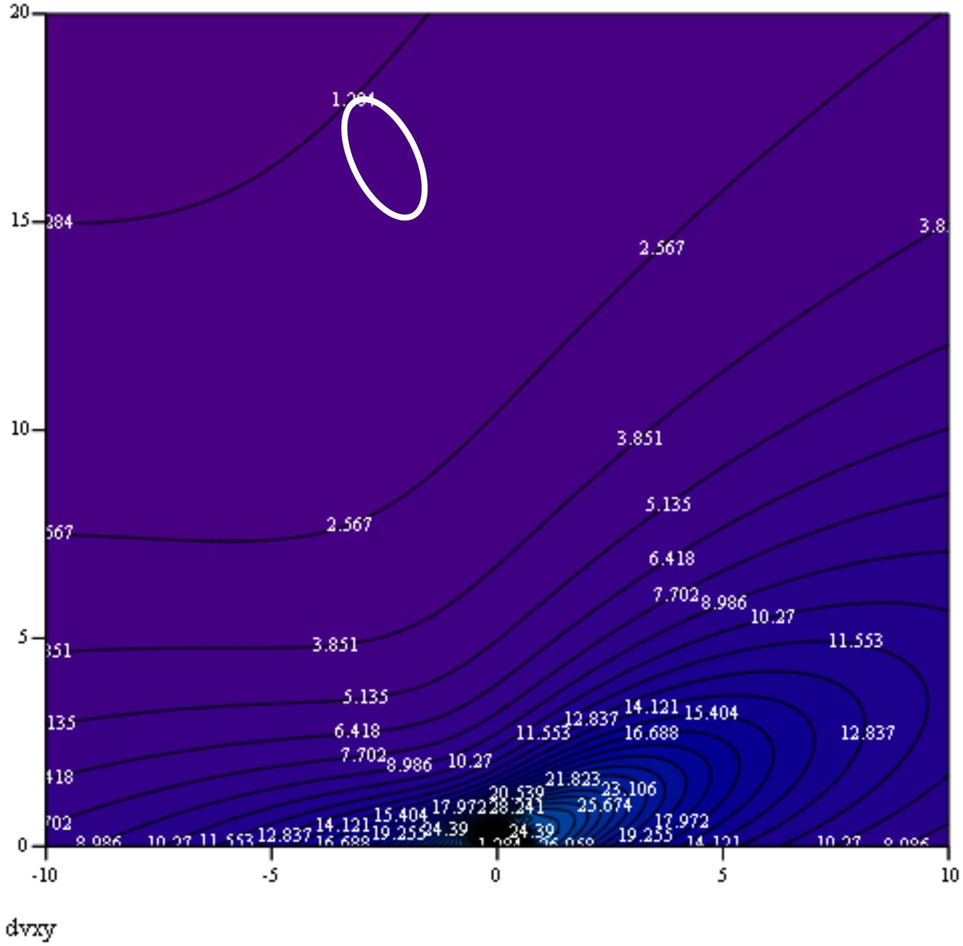
Shear of 4.3 pc/my must be compared to bubble diam of 700 pc

Global velocity field

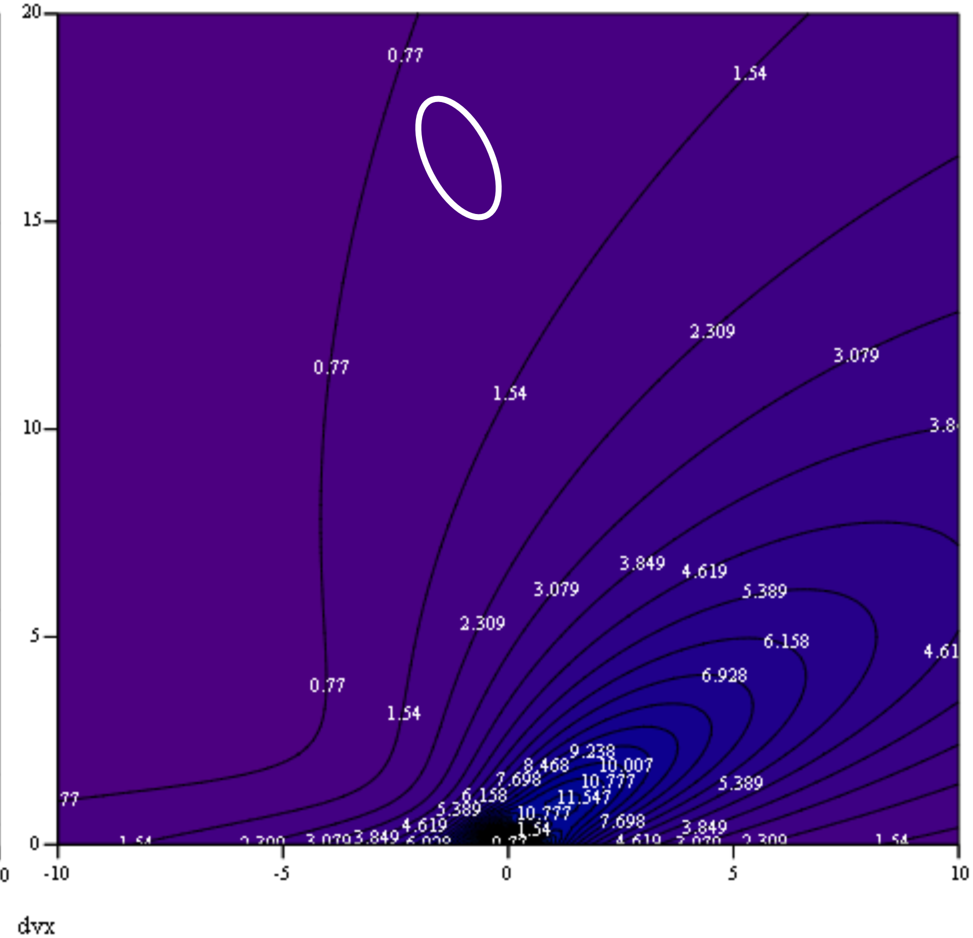


vxy

total velocity gradient



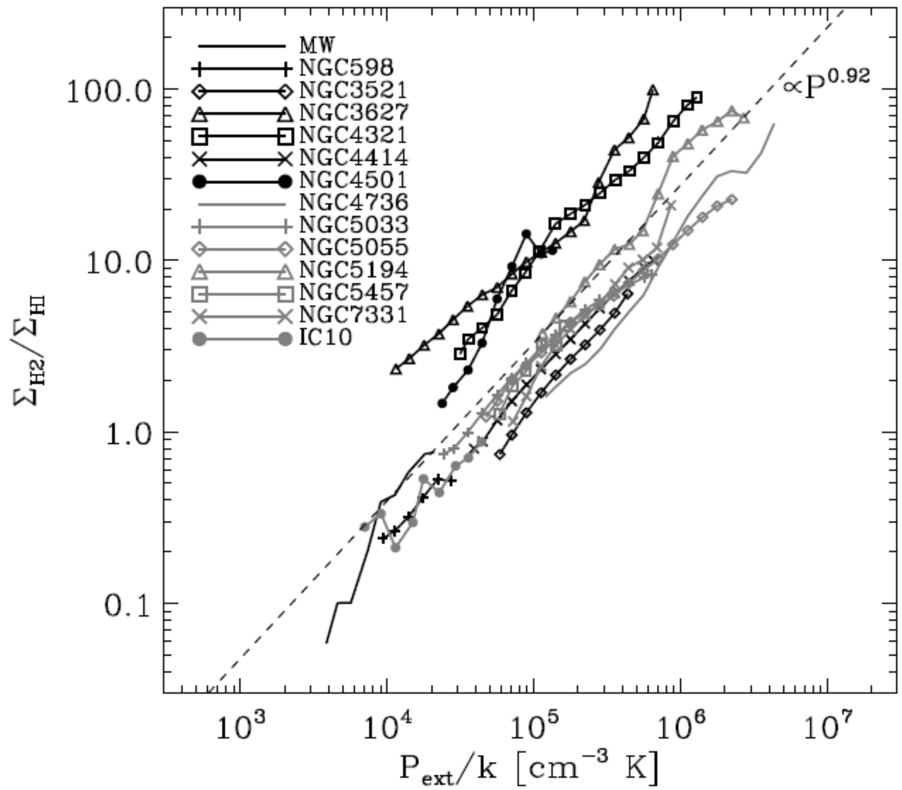
Ra velocity gradient



Velocity gradient 1.5 km/s*arcmin total and only 0.9 km/s arcmin in Ra

$$\frac{E_0}{10^{50}\,erg} = 5.3\cdot 10^7 \left(\frac{n_0}{cm^{-3}}\right)^{1.12} \left(\frac{v}{km\ldots}\right.$$

from Blitz et al 05



- First order calculations allow to deriv ergs, typical for a medium OB Ass.

- The de-projected near-perfect circula if differential rotation is taken into acc

- The dynamical time scale is of the or disperse an OB assoc.

- The expanding velocity pattern is consistent with a trailing arm orientation of M33.

- The ram pressure P_{ram}/k_b is $1.5\cdot 10^3 \cdot \left(\frac{n}{cm^{-3}}\right) cm^{-3}\cdot K$

This indicates that only for preshock densities >5cm^{-3} efficient H2 formation would take place. Formation timescale then also ok.

Summary and Conclusions

•Molecular triggered loops will only be visible with high sensitivity and in the transition region between HI and H2 dominated radii.

•For the detected loop a pre-shock HI density of > 5 cm^3 is required for an effective H2 formation.=> we likely need some HI clumpiness to make this work.

•The low numbers of loops with observed central associations remains a challenge.

•After all we understand the H2 formation timescale will be a direct measure of thermal pressure and dust fraction.

•More deep observation are required to put this preliminary result onto a better statistical basis. Comparison with results from spiral patterns should follow.