

CENSUS OF MOLECULAR GAS IN ISOLATED GALAXIES

NGC 1530

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Collaborators

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Analysis of the Interstellar Medium of Isolated GALaxies

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AMIGA PROJECT

Analysis of the interstellar Medium of Isolated GALaxies

Starts in 2003 @IAA (PI: L. Verdes-M)

Staff: Jack Sulentic (IAA), Ute Lisenfeld (Univ. Granada)

Postdocs Daniel Espada (IAA), José Sabater (IAA), Simon Verley (Univ. Granada), Gilles Bergond (CAHA), Chandreyee Sengupta (CAHA)

PhDs: Vicent Martínez (IAA), Carmen Argudo (IAA)

Software Engineers *adio-VO, archives, tools for 3D data*: Pique Ruiz del Mazo (IAA), Susana Sánchez (IAA) Víctor Espigares (IAA)

Since 2006 Coordinated project IAA-group + IRAM-30m @ Granada

+ International collaboration:

ESO (Chile), Obs. Marseille, Obs. Paris, CfA, ASIAA-Taiwan, MPIfA (Bonn), UMASS, Mc Donald Obs., Arcetri, UNAM, IAC, Kapteyn Institute, ATNF

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SUMMARY

- THE AMIGA SAMPLE:

 - Definition

 - Summary of multiwavelength results

- CO study:

 - Statistical study

 - Comparison with denser environments

 - Preliminary results for NGC 1530

- Prospects for ALMA

WHY ISOLATED GALAXIES?

Direct interaction-enhancement connection difficult to establish

Amplitude and processes not well quantified/understood

- **Pairs: SF excess but no HI deficit**

(Xu & Sulentic '91, Zasov & Sulentic '94)

- **HCGs: Morphology changes + HI depletion, not excess SF**

(e.g. VM et al '01, Iglesias-Páramo & Vílchez '99, Bitzakis et al '10)

- **AGN Activity Frequency**

(e.g De Robertis et al '98, Krongold et al '03, Miller et al '03, Best et al '05)

- **Is H₂ increased by interactions? Contradictory results**

(Braine & Combes 1993, Perea et al 1997, Verdes-M et al 1998, Leon et al 1998)

DO WE NEED A NEW SAMPLE?

- Ambiguous definition of “isolated” and “normal”

FIELD galaxies (e.g. Kennicutt & Kent '83)

“NORMAL” galaxies (e.g. Boselli et al '01)

Galaxies without v data not considered companions

(Kelm & Focardi '04: isolated w.r.t. companions brighter than 15.5mag)

- Or if well defined:

Monochromatic observations of large samples/

multiwavelength observations of small samples

10 – 100/200 members

(Huchra & Thuan '77, Vettolani et al '86,, Márquez & Moles '99, '00,
Colbert et al '01, Pisano et al '02, Varela et al '04, Smith et al '07)

GOALS

- To **build** a catalogue of isolated galaxies:
 - Well defined (isolation, completeness)
 - Statistically significant
 - With multiwavelength information (main focus ISM)
 - Continuous vetting
- To **analyze** the catalogue:
 - Multiwavelength characterization: ISM – SF – AGN
 - Comparison with denser environments

Available at **AMIGA Virtual Observatory Interface**

amiga.iaa.es

TOPCAT, etc

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METHOD: Starting sample, continuous vetting

Amiga is a refinement of CIG:

Catalogue of Isolated Galaxies (Karachensetva 1973)

Selected from CGCG (Zwicky) with $m_{pg} < 15.7$ $\delta > -3$

• **Strength:**

▪ Size: 1050 galaxies

▪ Isolation: no similar sized galaxies (factor 4) within $40 \cdot R(\text{companion})$ -> last interaction several Gyrs ago

▪ Morphology: permits discrimination based on types.

▪ Depth: large volume to allow sampling of the OLF 10.000
-15.000 km/s

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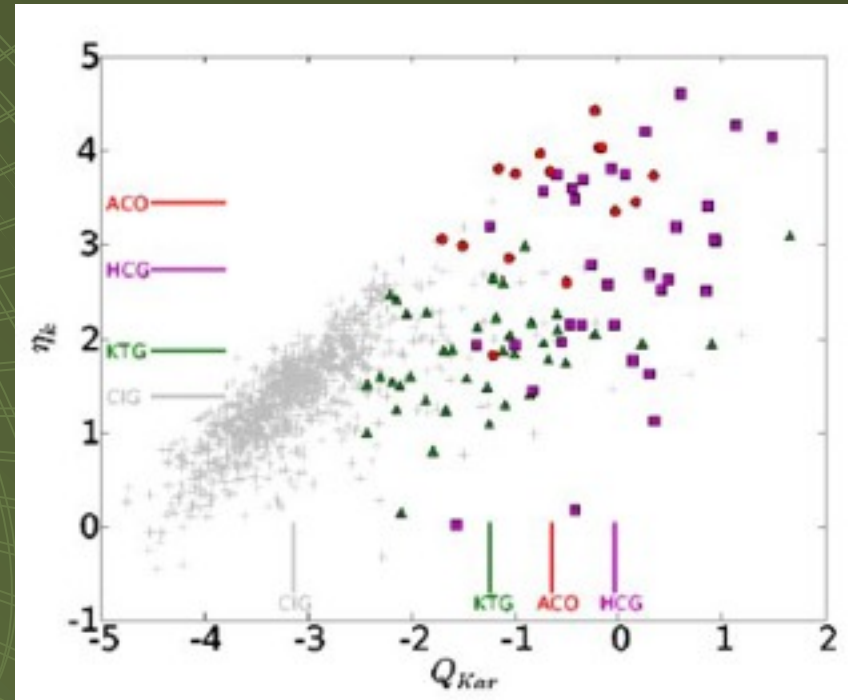
Isolation

(Verley PhD; Verley et al 2007ab, A&A)

- Karachentseva (1986): visual examination of plates
- ⑩ Our revision: POSS-I & II, $R \geq 0.5$ Mpc, $m_B < 17.5$
 - Catalog of all potential companions: 54.000
- Quantification: CIG, 41 triplets, 34 groups, 15 clusters :
 - Local number density η_K
 - Tidal force estimation Q

Final revised catalogue, $n = 791$

- $Q > -2$ (1% binding forces)
- $\eta_K > 2.4$



On-going SDSS study

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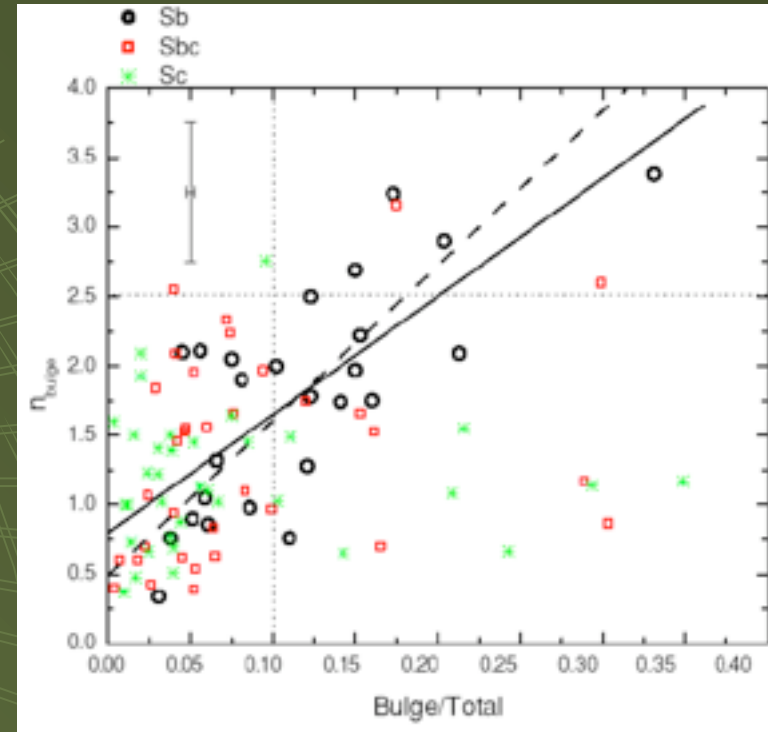
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MULTI RESULTS

- Sb-Sc dominant population
- **LOWEST VALUES** relative to any other samples of:
 - LB of both late and early types (Sulentic et al 2006)
 - Sersic index of late types
=> **pseudobulges**)
 - Optical asymmetry, clumpiness, concentration

(Durbala et al 2008, 2009)



MULTI RESULTS

- Sb-Sc dominant population
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 - Optical asymmetry, clumpiness, concentration
 - LFIR (Lisenfeld et al 2007)

- $\log(L_{\text{FIR}})$: only 2% $> 10.5 L_{\text{sol}}$
- Comparison with 2445 galaxies of CfA sample:
 $\langle \log(L_{\text{FIR}})_{\text{CfA}} \rangle =$
 $\langle \log(L_{\text{FIR}})_{\text{AMIGA}} \rangle + 0.26$

MULTI RESULTS

- Sb-Sc dominant population
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 - Optical asymmetry, clumpiness, concentration
 - LFIR
 - Radiocontinuum (disk dominated) (Leon et al 2008)
 - Nuclear activity (Sabater PhD 2009, Sabater et al 2010ab)
- radio-FIR correlation: 0% of radio excess galaxies

MULTI RESULTS

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 - Optical asymmetry, clumpiness, concentration
 - LFIR
 - Radiocontinuum (disk dominated)
 - Nuclear activity
 - HI asymmetry (Espada et al 2009, PASP)

MULTI λ RESULTS

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Lowest possible values

Nurture-free zero point

What happens with the CO?

- HI asymmetry (Espada et al 2009, PASP)

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Molecular gas content

CO single dish

205 (276) AMIGAs

$1500 < v < 5000$ km/s

Major axis maps for ~ 20

IRAM 30M, FCRAO, Nobeyama

470h

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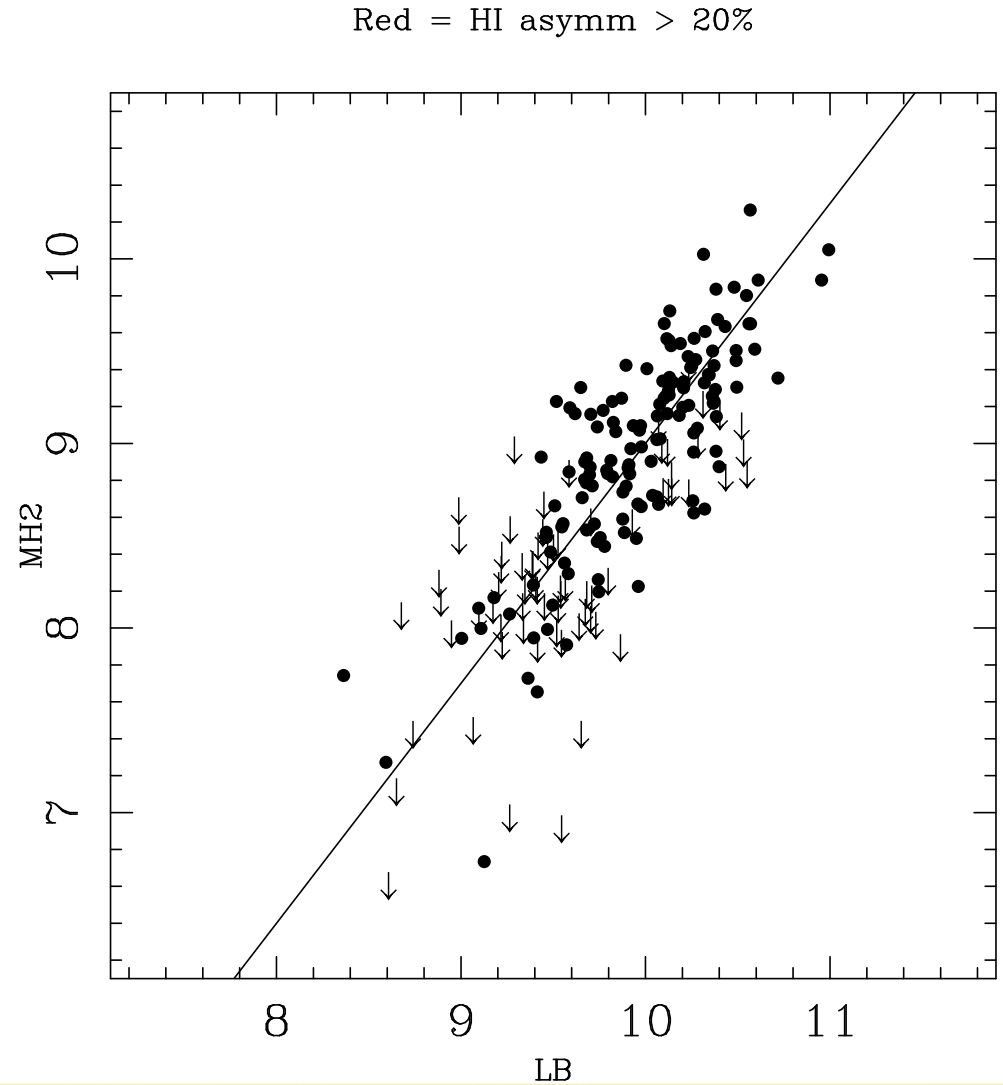
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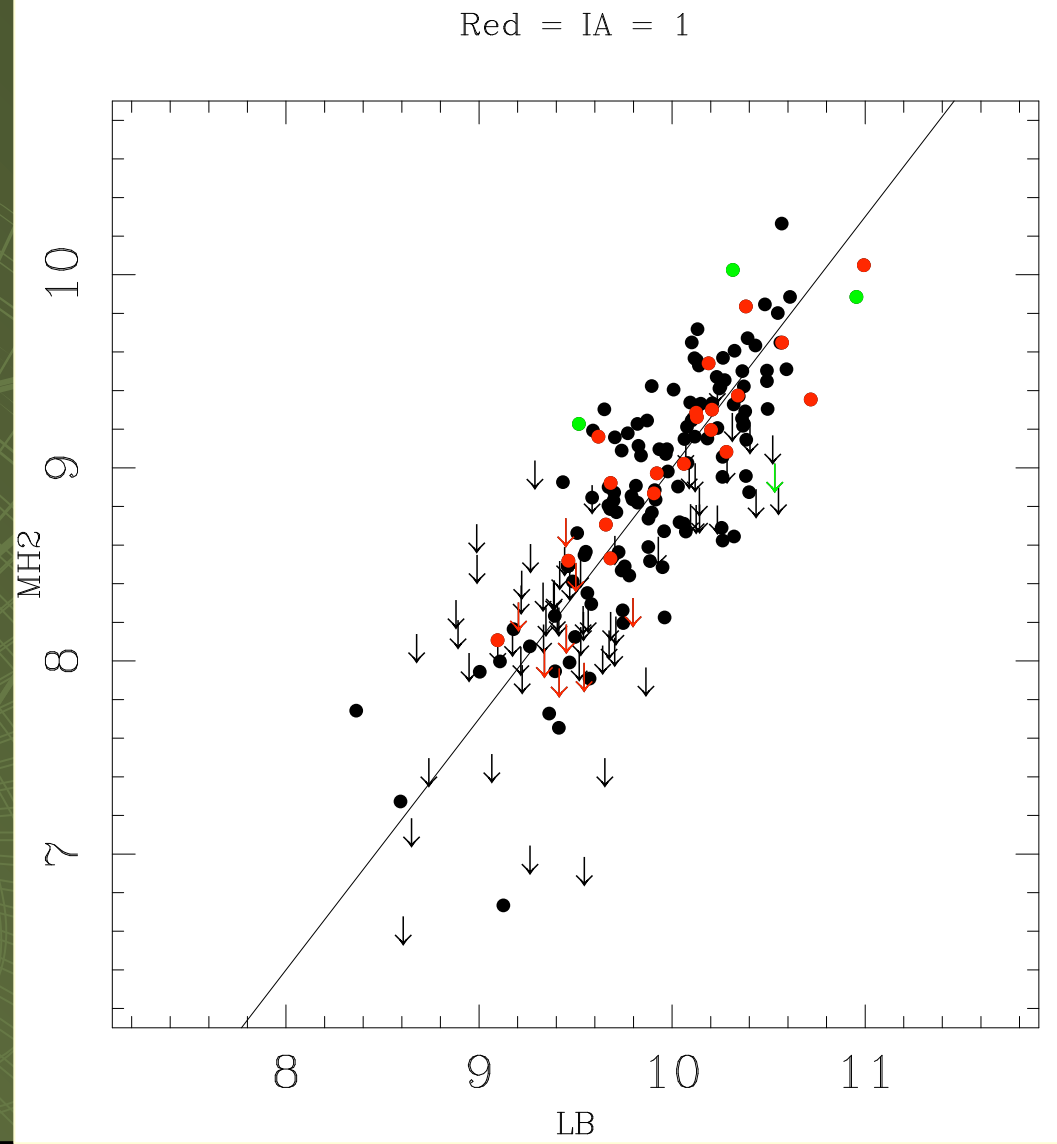
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Molecular gas content



0
na

RED:
ASYMMETRIES, TAILS
GREEN:
DISTORTED OBJECTS



AMIGA

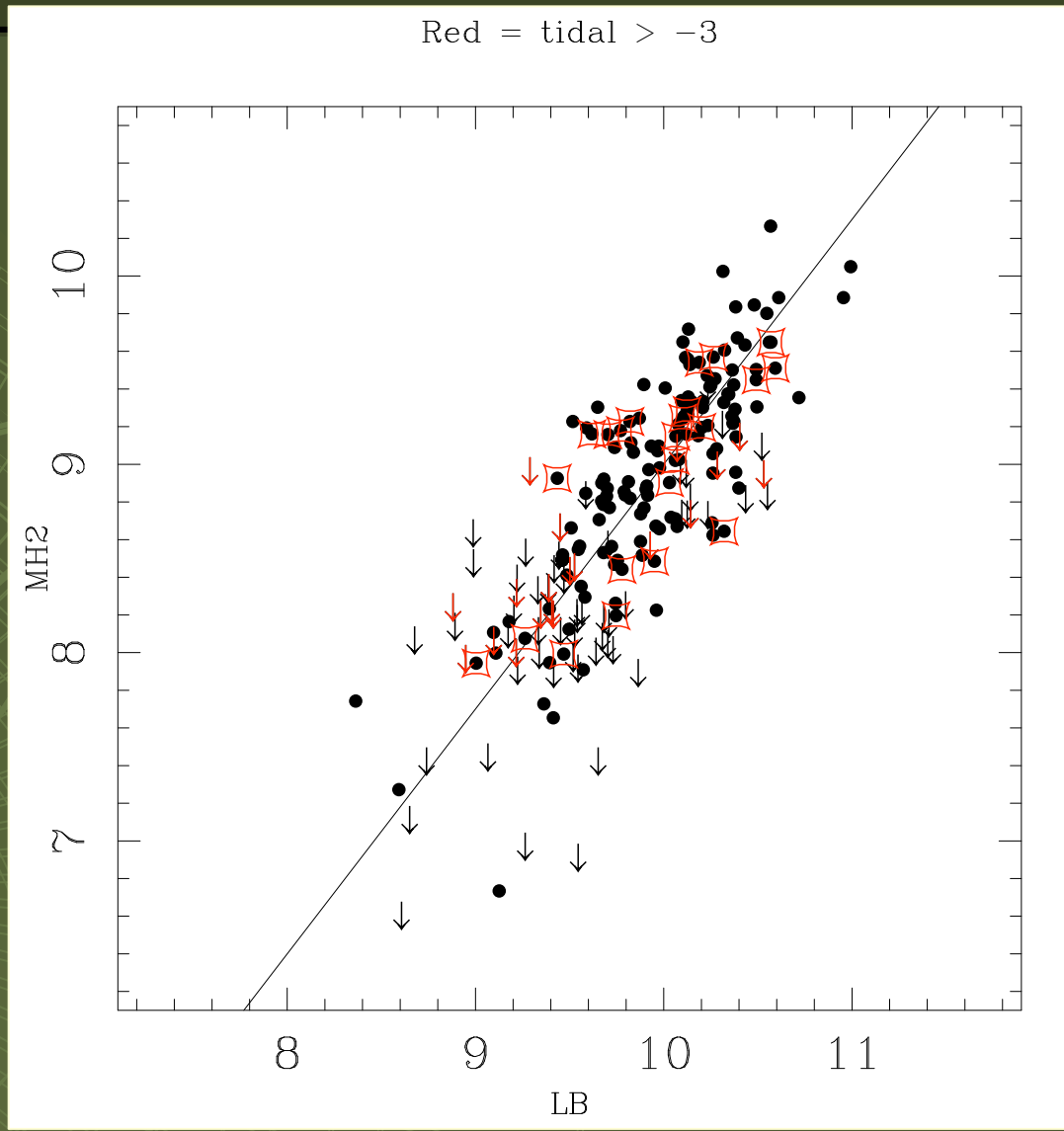
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□ TIDAL FORCES $> 10^{-3}$



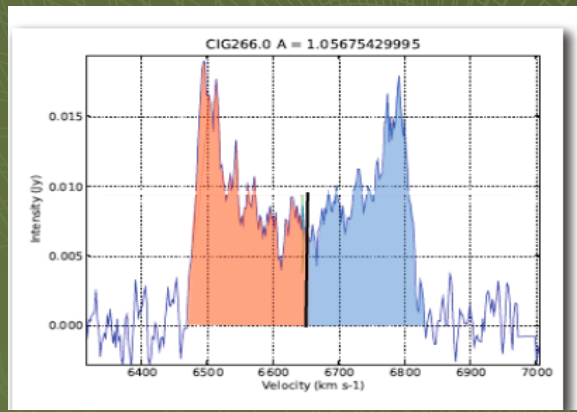
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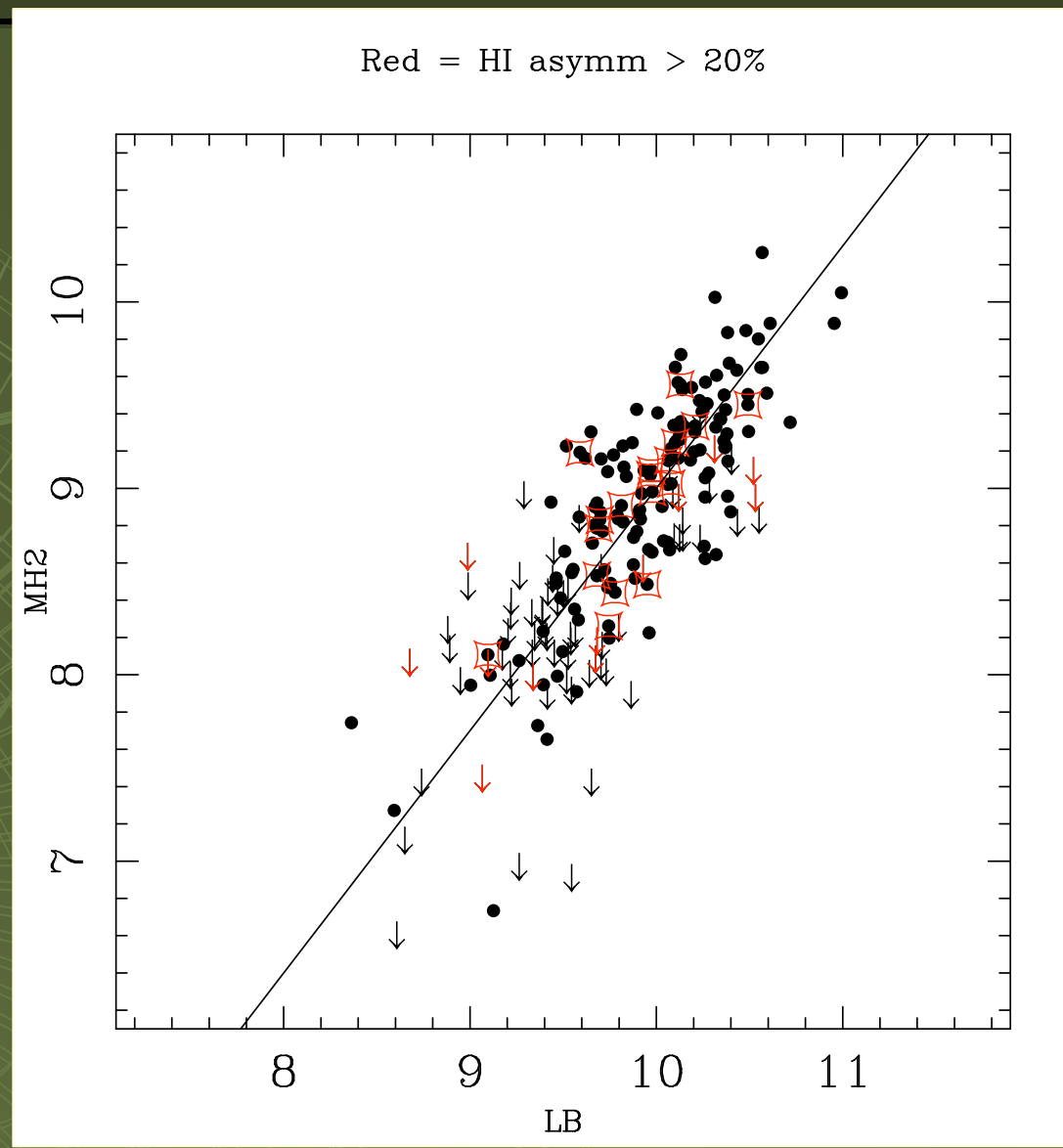
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□ HI ASYMMETRIES $> 20\%$



Single dish: for 910 CIG
Espada et al (2010)



Molecular gas content

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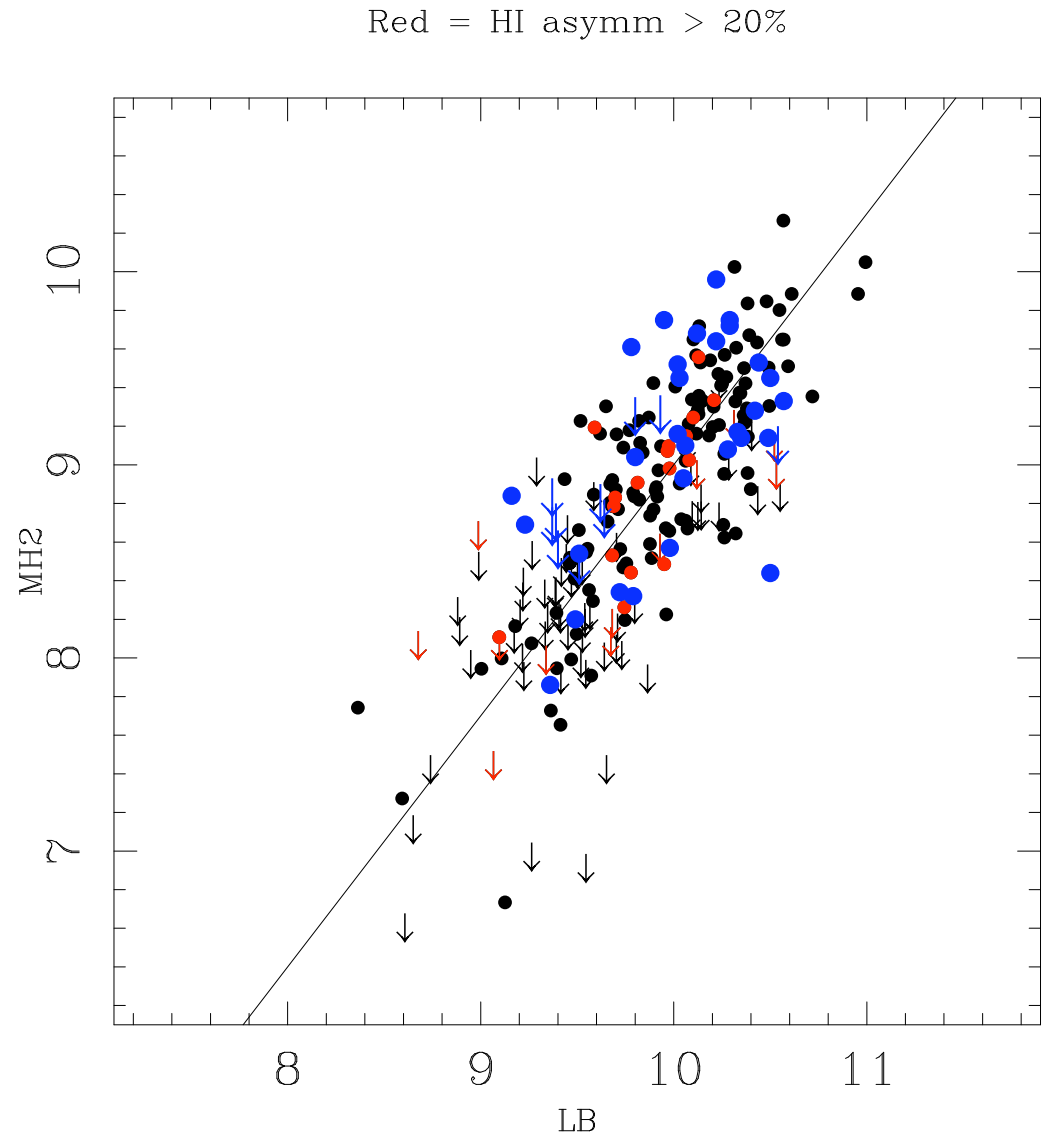
HI ASYMMETRIES >20%

Hickson Compact Groups

CO @ 30m

83gal@20HCGs

(PhD V. Martínez)



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No enhancement in

- Weakly interacting pairs

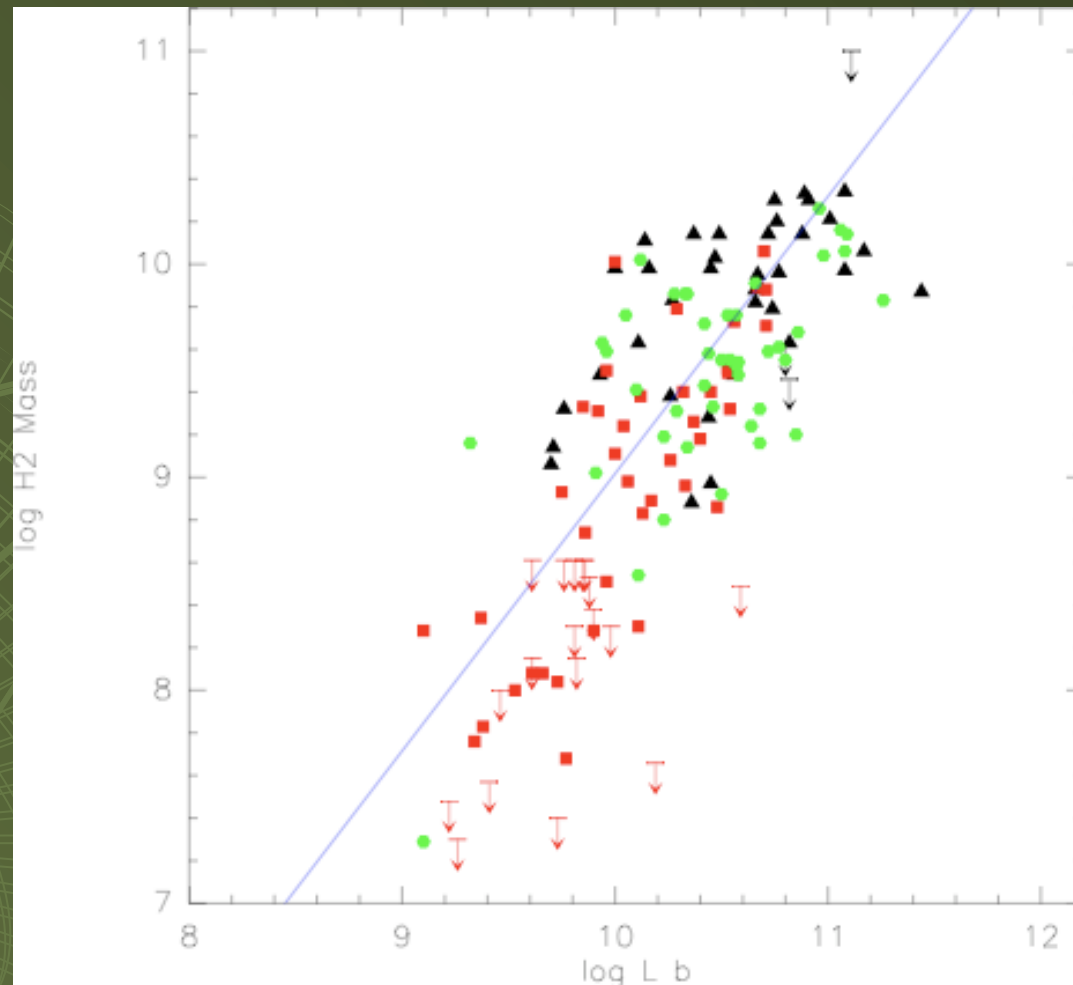
(Solomon & Sage 1988)

- ▲ Strongly interacting pairs

(Sanders et al 1991)

- Virgo galaxies

(K&Y 88, Bosselli et al 1995)



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SB(rs)b

$v = 2461 \text{ km/s}$

Intense nuclear SB

Archetypal strongly barred

Bar = 15 kpc

1 arcs = 180 pc

< 1% binding forces:

internally generated bar



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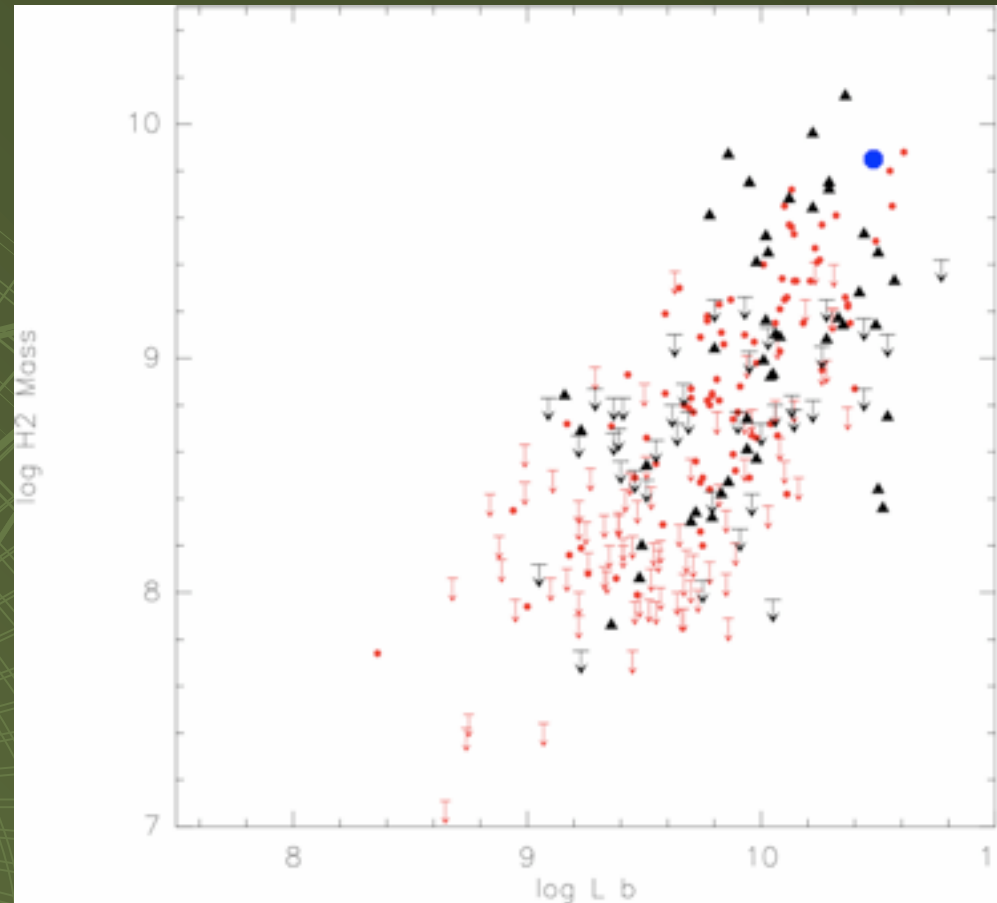
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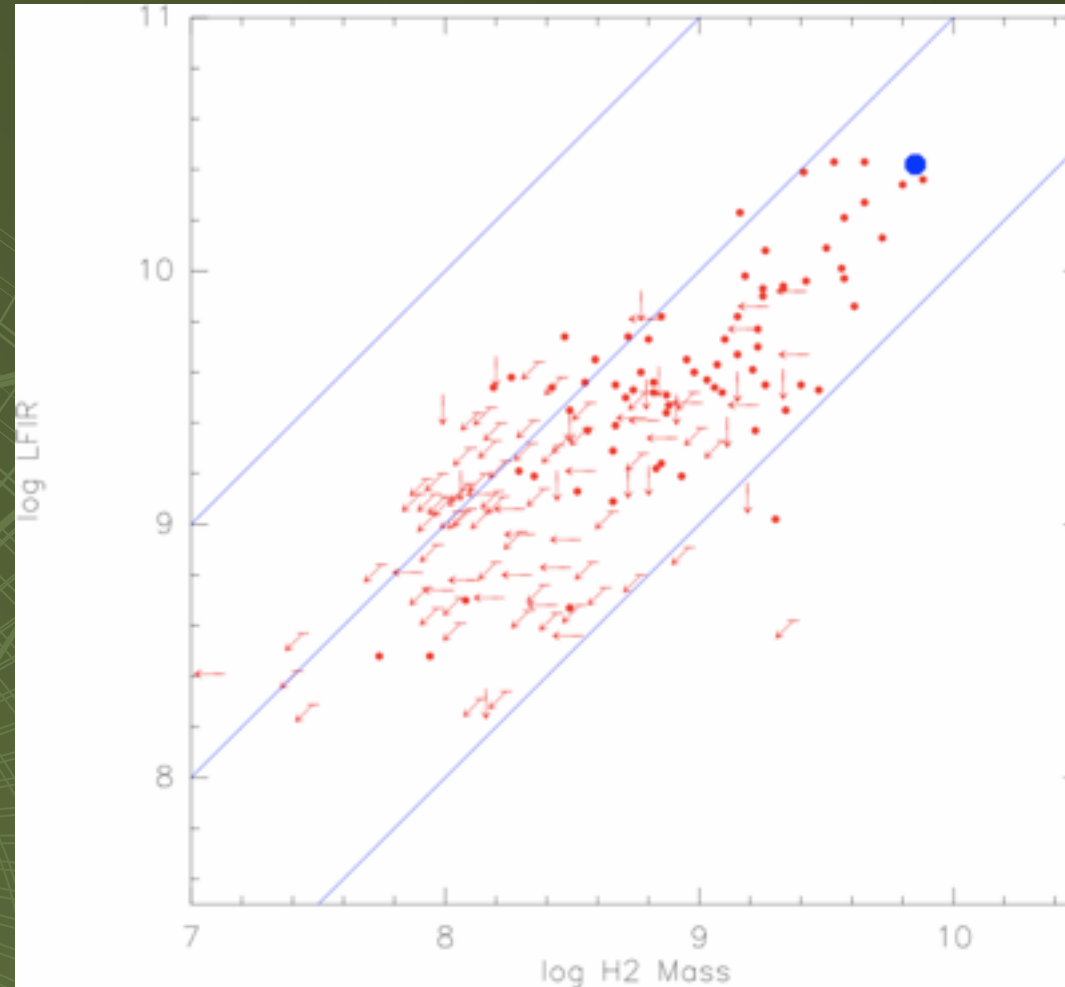
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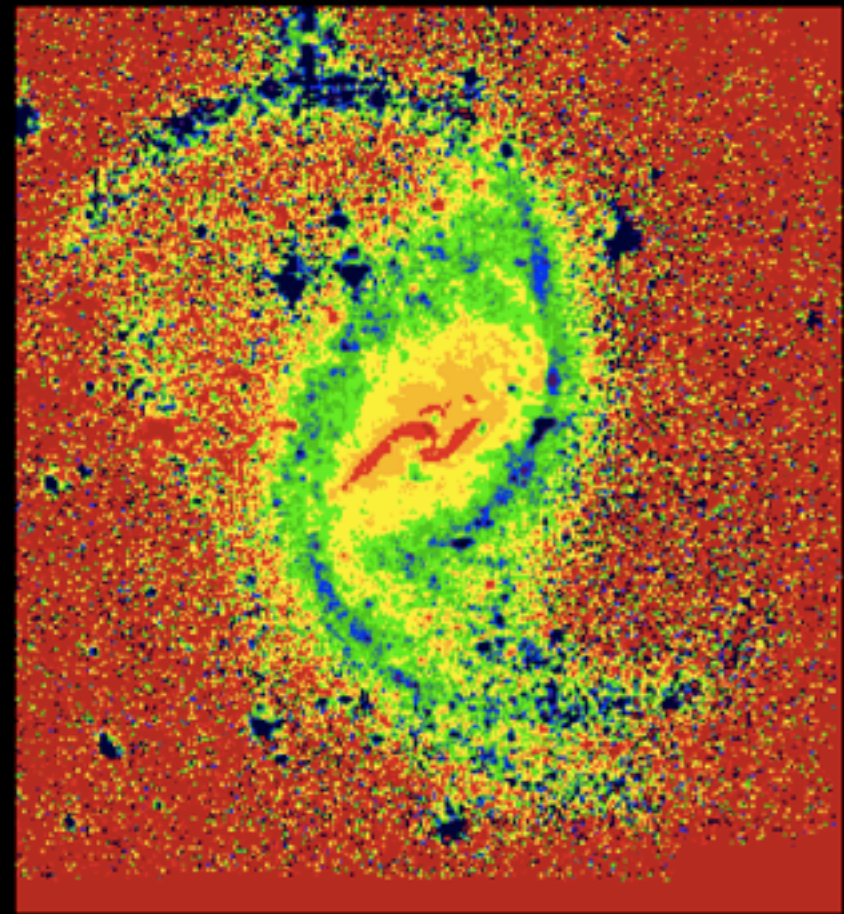
NGC 1530

2 dust lanes, leading edges
(Regan et al 1995)

CO(1-0) PdB resol 3.5"
(Reynaud & Downes 1998)

Gas moving towards the center of
the galaxy, 100 km/s (Reynaud
2001)

Inner spiral



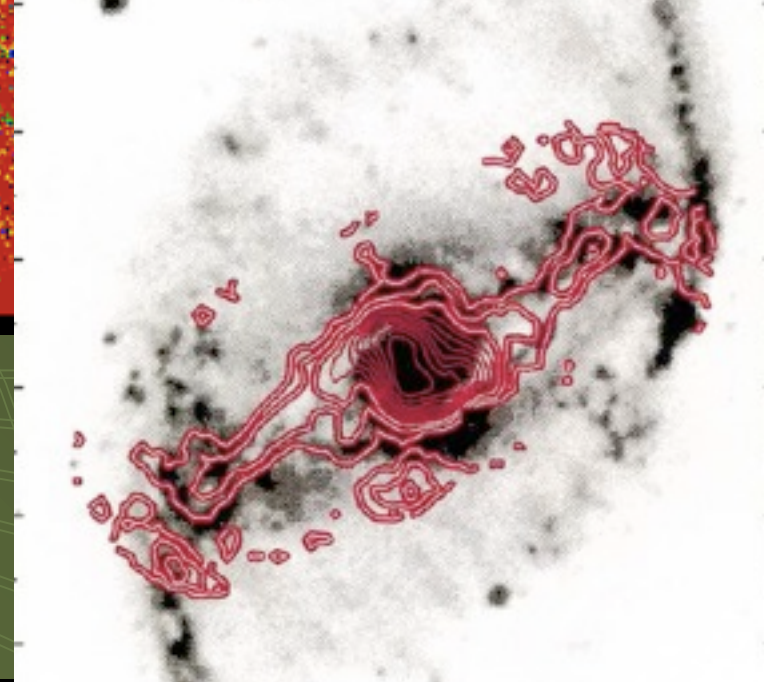
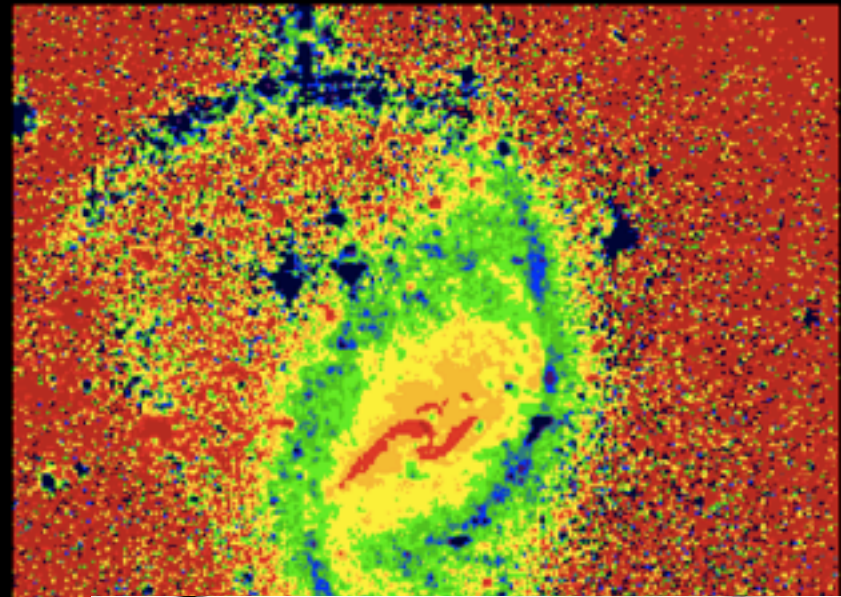
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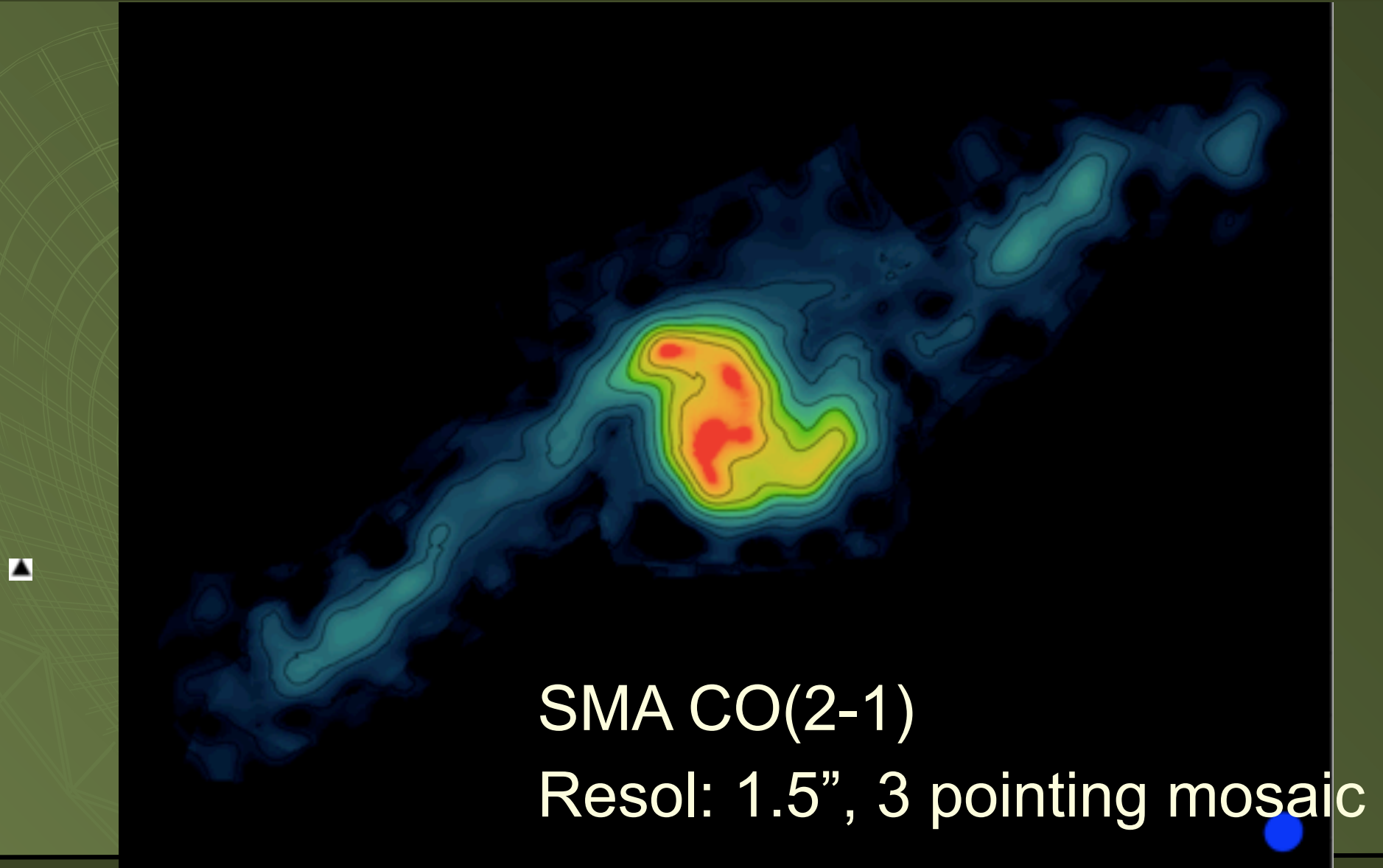


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SMA CO(2-1)

Resol: 1.5", 3 pointing mosaic

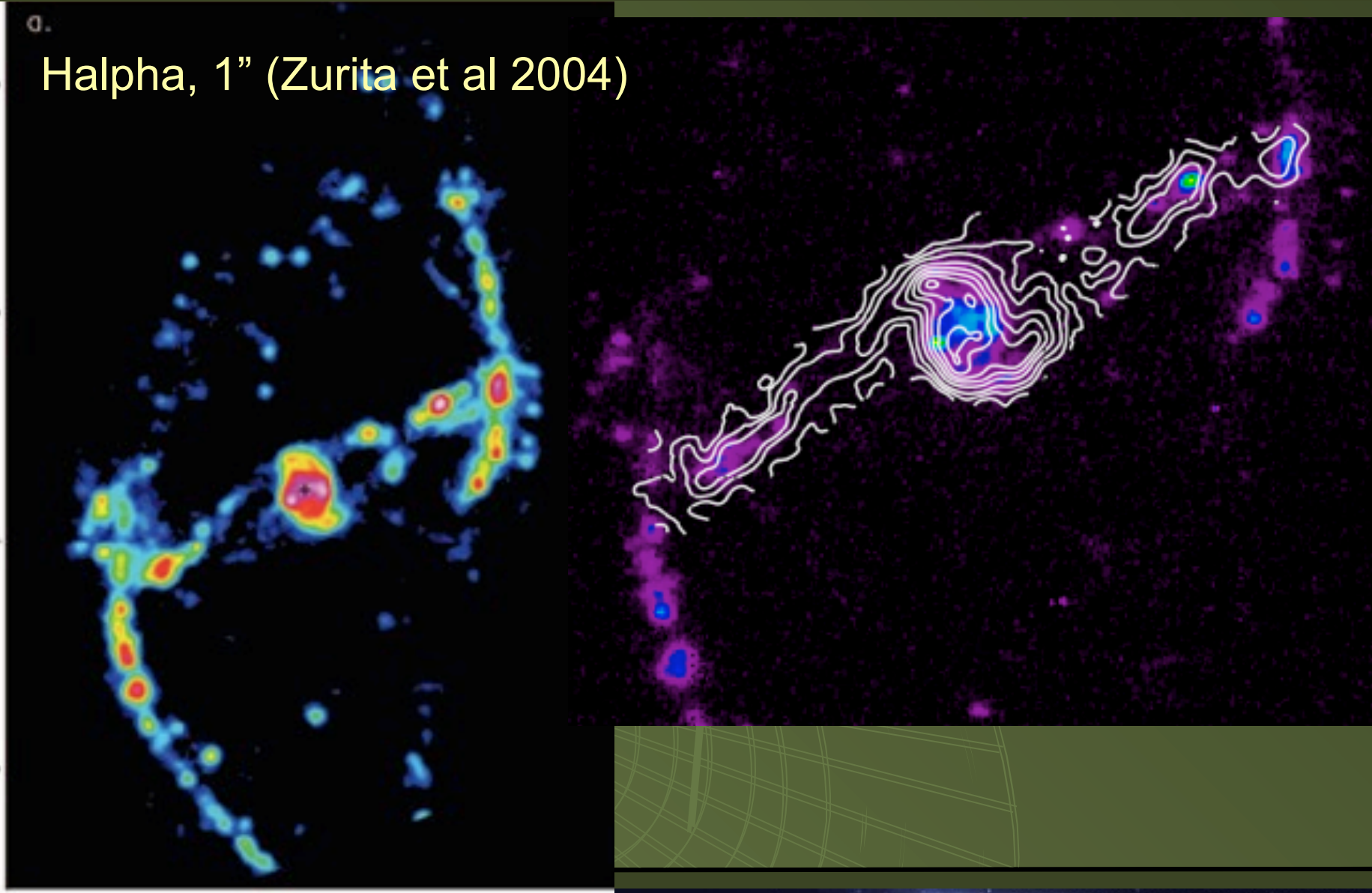
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NGC 1530

a.

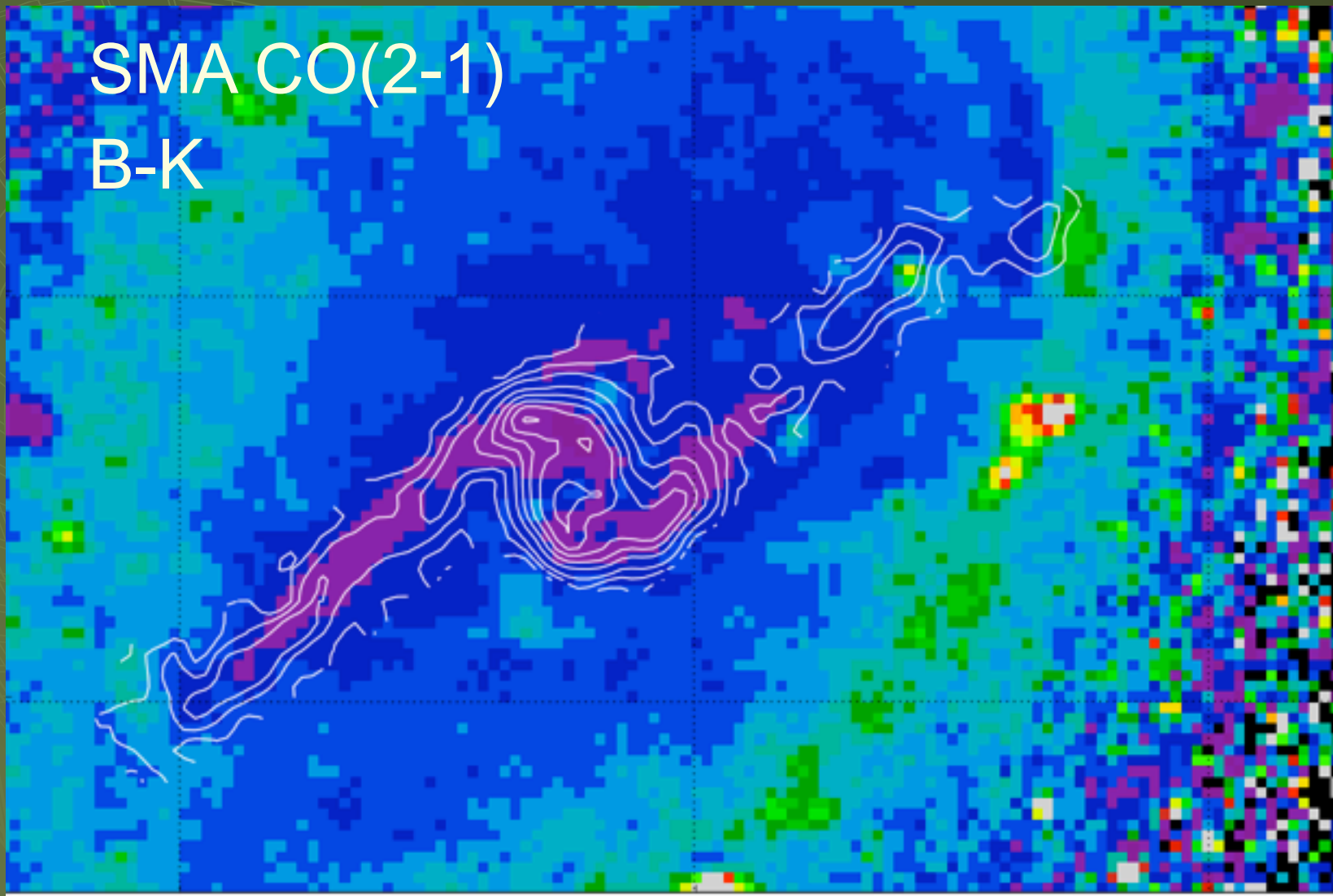
H α , 1" (Zurita et al 2004)



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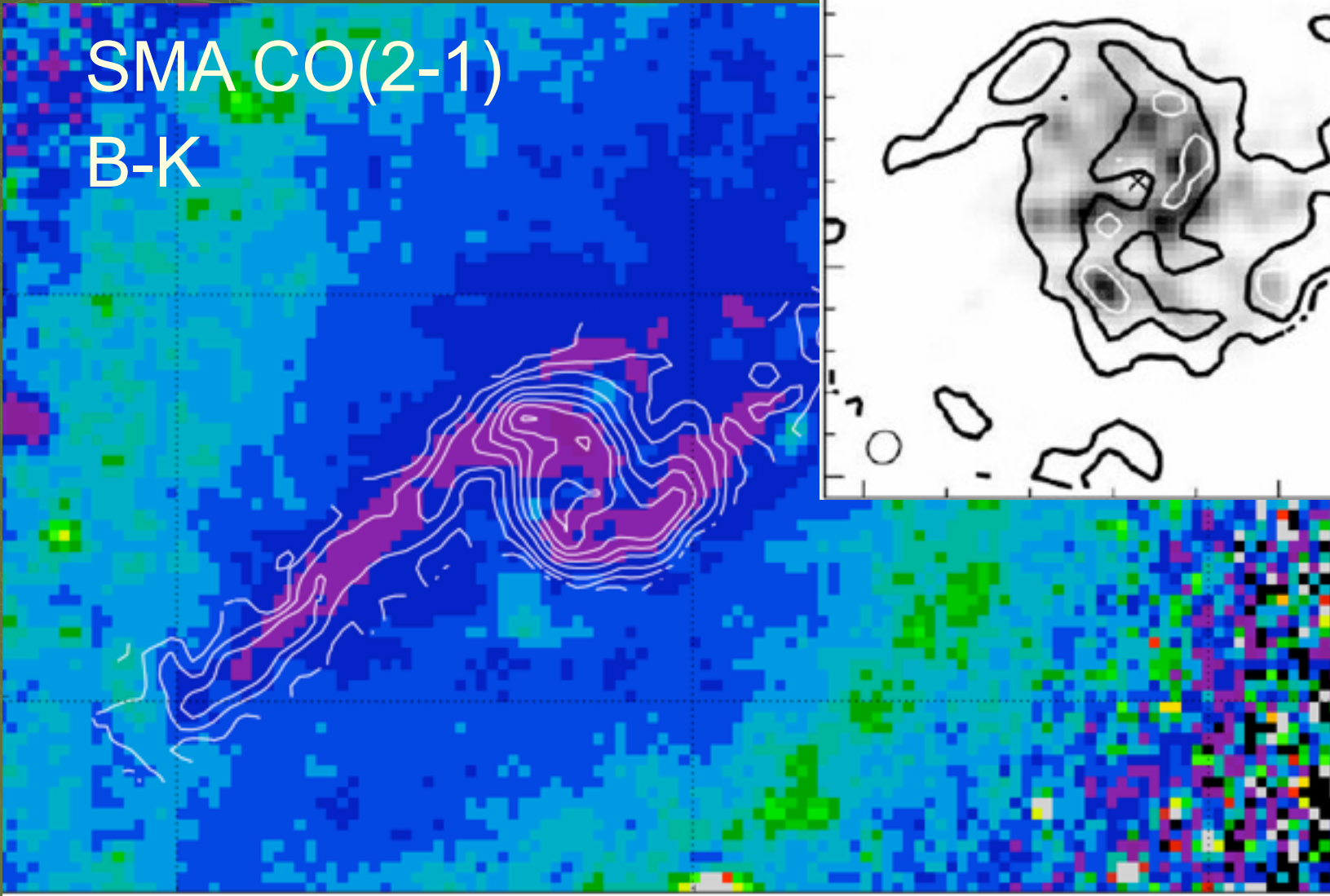
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(Reynaud & Downes 99)
20cm + CO(2-1)

SMA CO(2-1)
B-K



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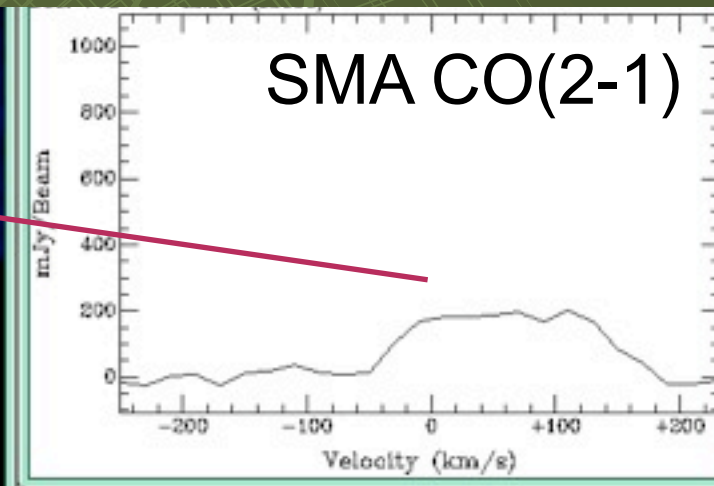
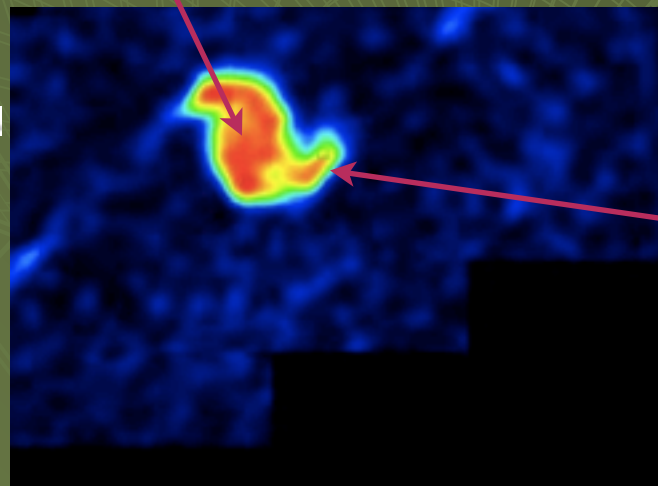
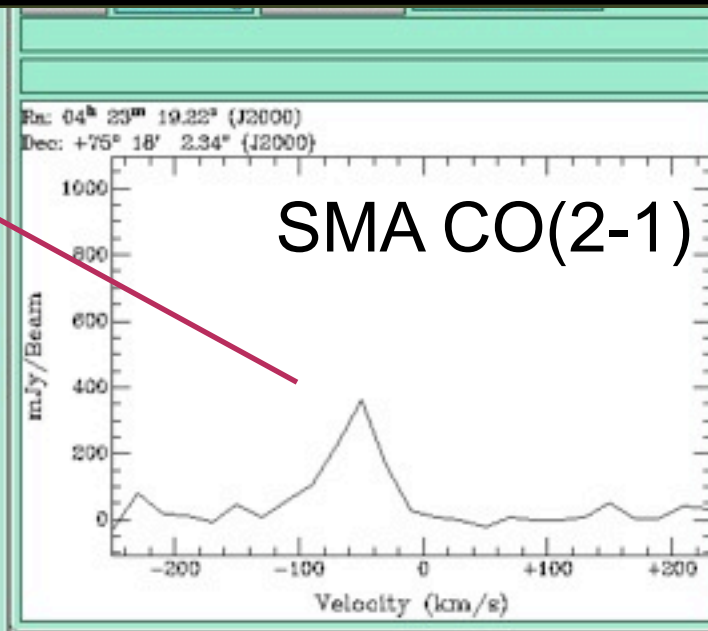
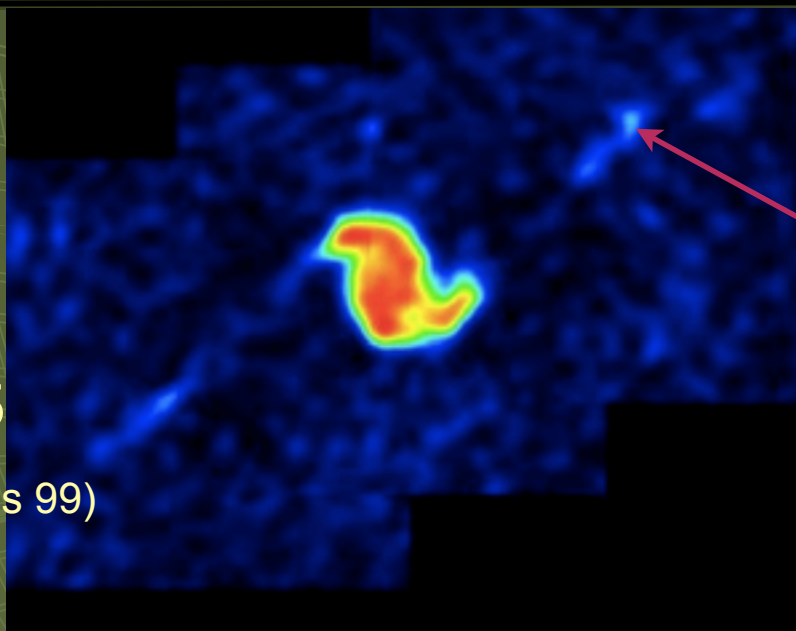
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CO/HCN < 15

(Reynaud & Downes 99)



CO/HCN > 25

(Reynaud & Downes 99)

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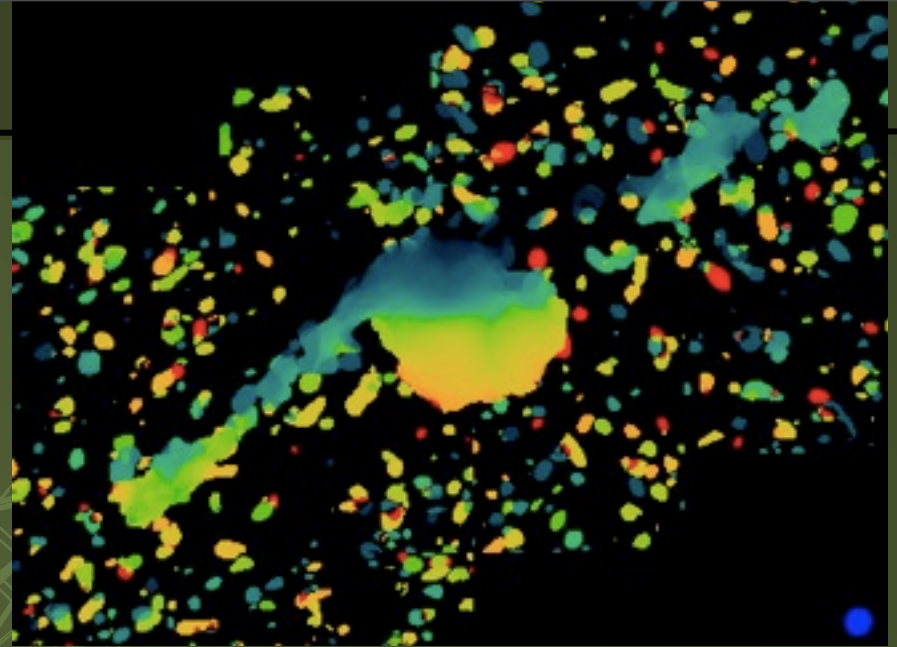
On-going work
CO(2-1)/CO(1-0) ratio
&
comparison with velocity
gradients along the bar

CO vs HCN along bar



+ Halpha : SF law

Halpha velocity gradient
(Zurita et al 2004)



Same work for full H2 range

AMIGA:

The most quiescent sample in the nearby Universe

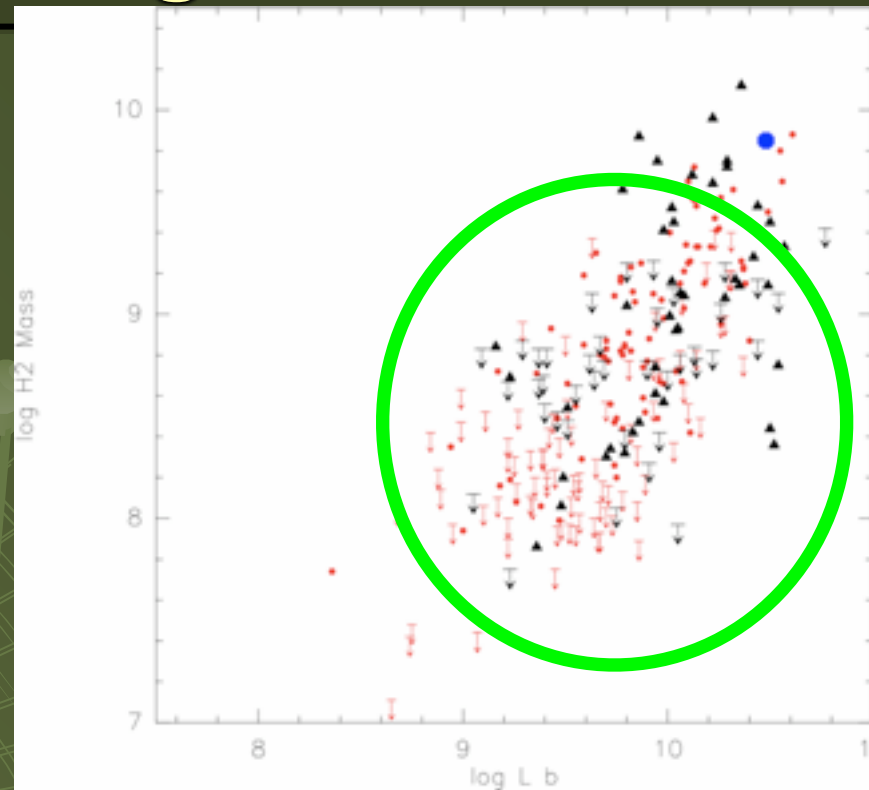
Unique for ALMA to quantify the role of the environment on secular evolution

Dec < 37, v 1500 – 5000 km/s size < 2

N = 77 galaxies.

Velocity resolution of 20 km/s beam of 1" (160 pc @ $v = 2500$ km/s)

ALMA CO(1-0) 50h



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