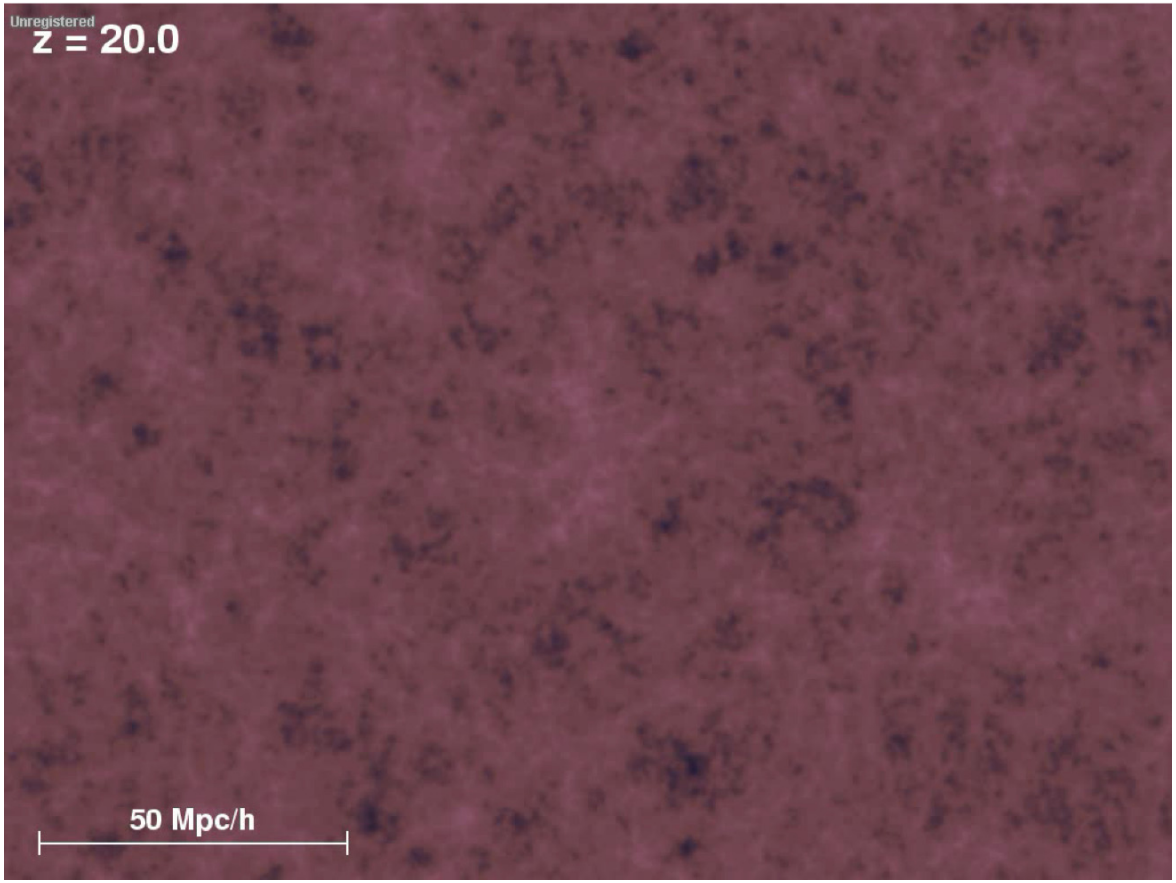
Gas and Star Formation in Galaxies: the Nearby and the Distant Universe

Prof. Alberto Bolatto

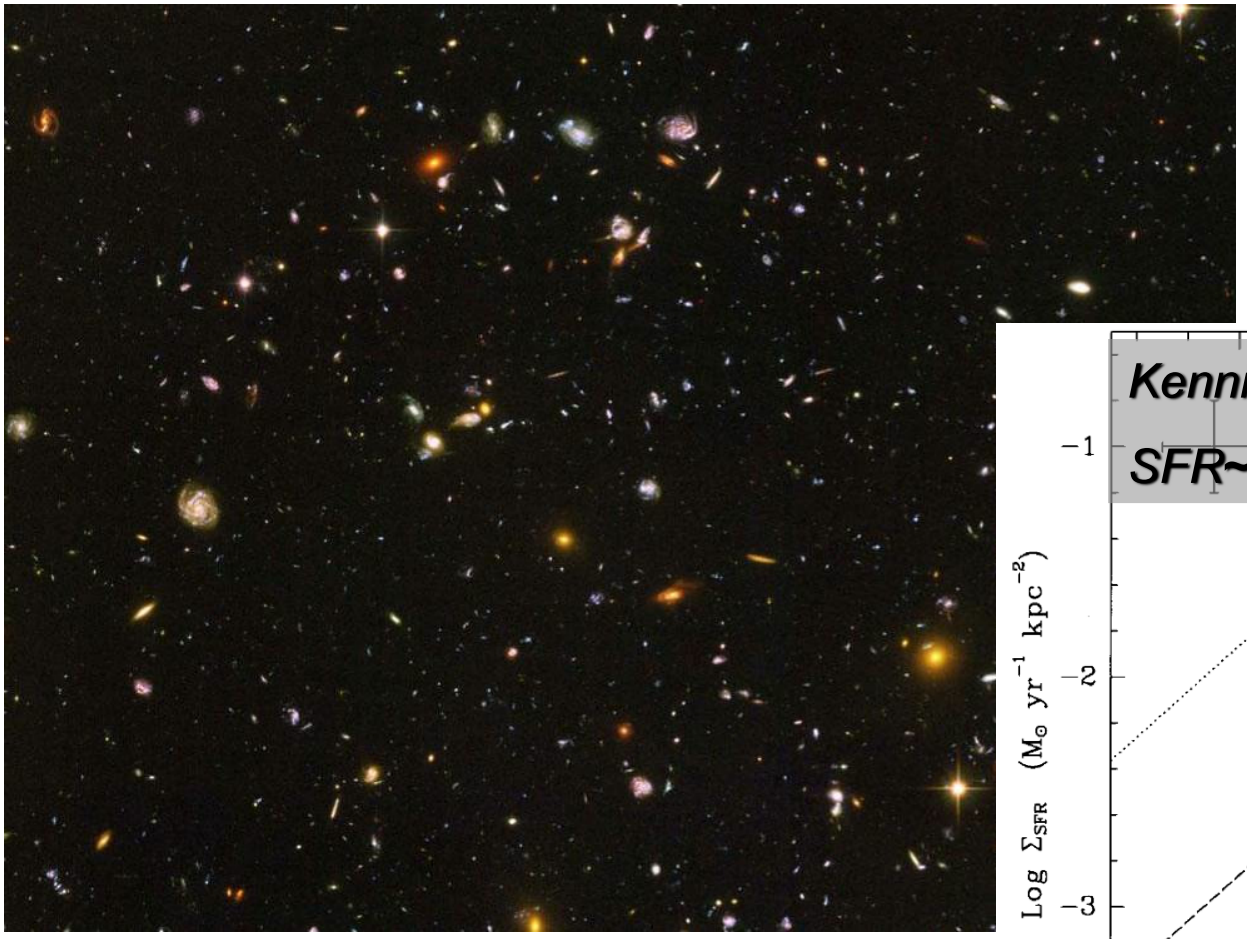
Motivation: understanding structure formation



V. Springel et al.,
Millenium Simulation

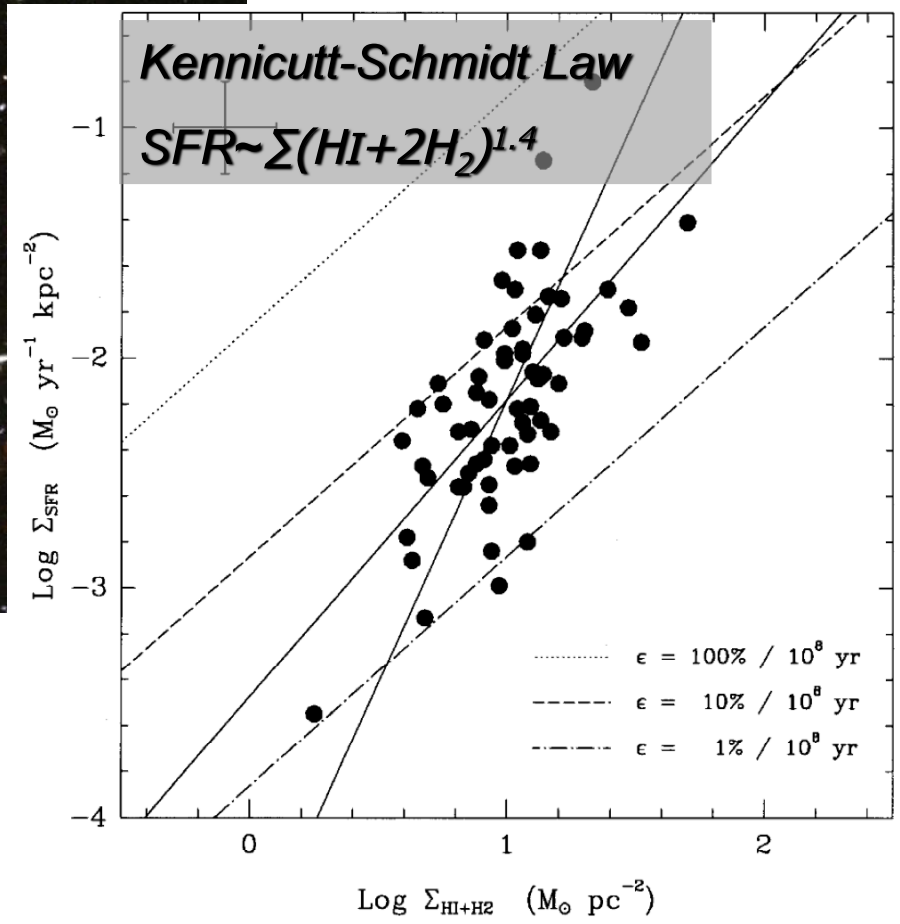
Dark matter (gravity)

Structure formation in the Universe: Light



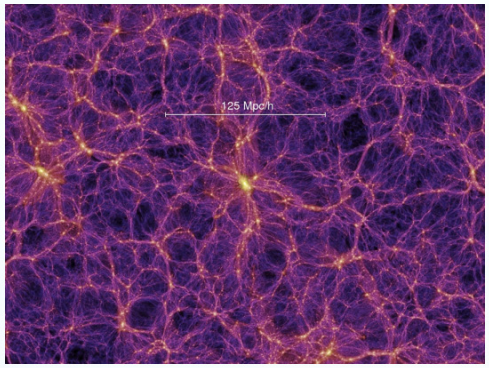
Hubble UDF

Kennicutt (1989,1998)



Dark matter (gravity) → HI → H_2 → stars → observable structure (astrophysics)

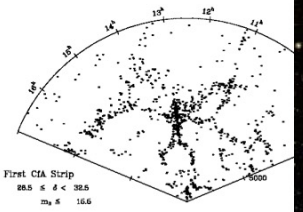
The evolution of structure in the universe

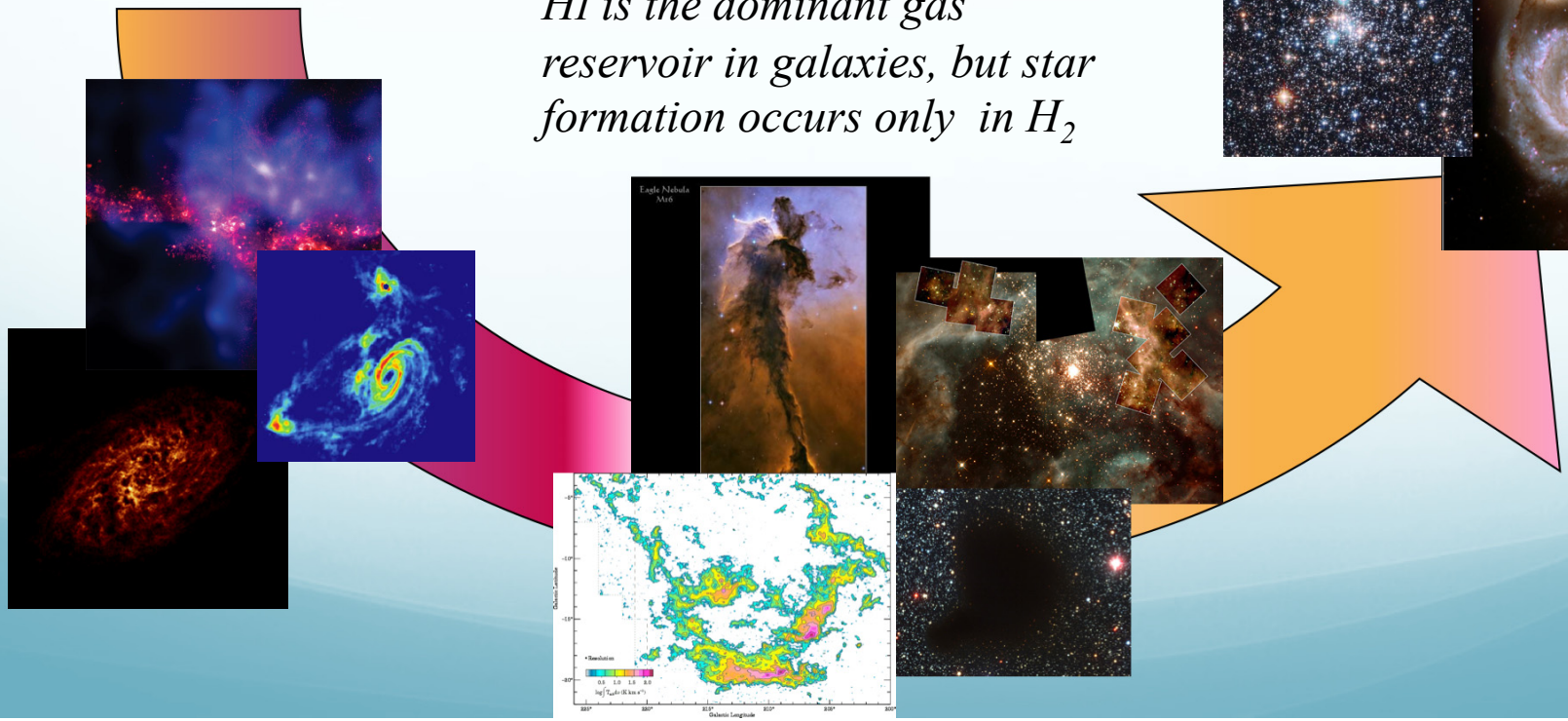


Stars form in Giant Molecular Clouds (GMCs)

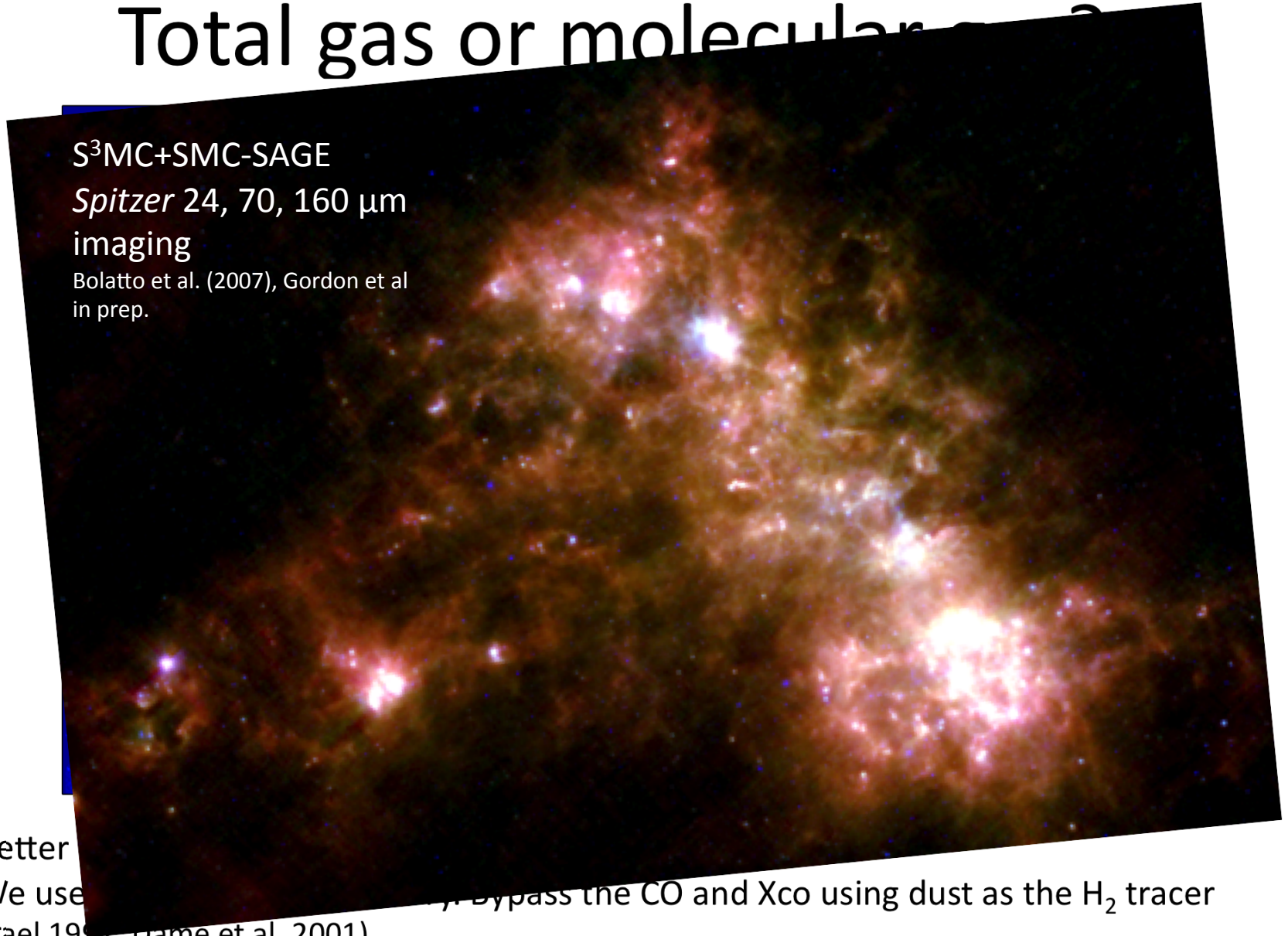
Molecular transitions are necessary to radiate the heat of contraction

HI is the dominant gas reservoir in galaxies, but star formation occurs only in H_2





Total gas or molecular [illegible]



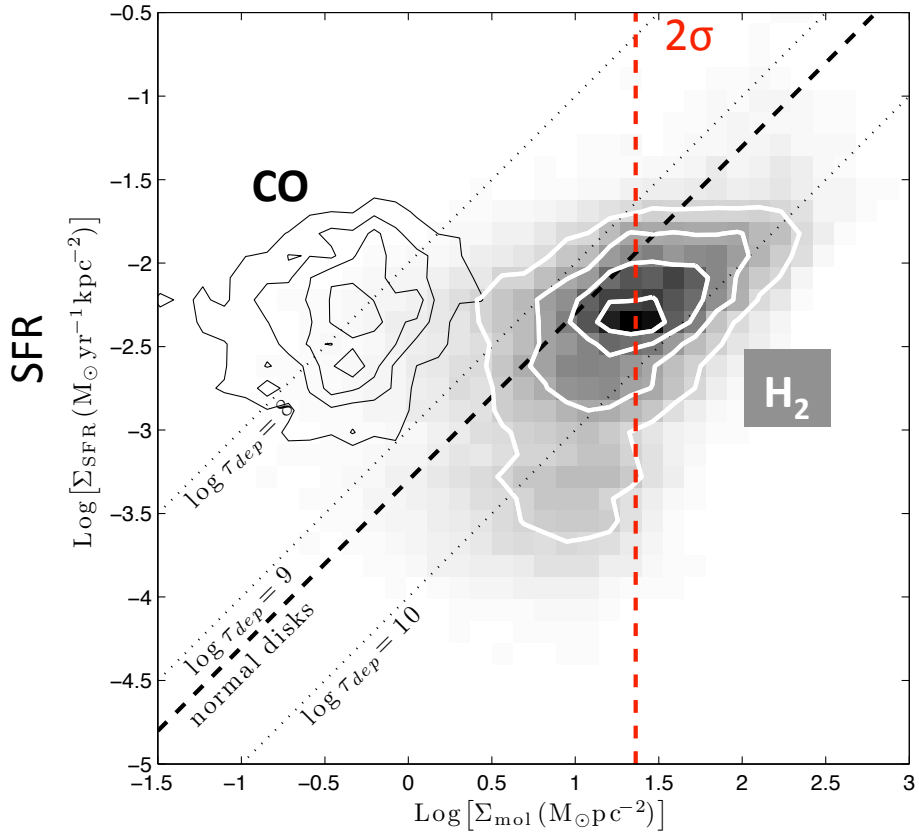
- Better [illegible]
- We use [illegible]. Bypass the CO and Xco using dust as the H_2 tracer

(Israel 1997, Dame et al. 2001)

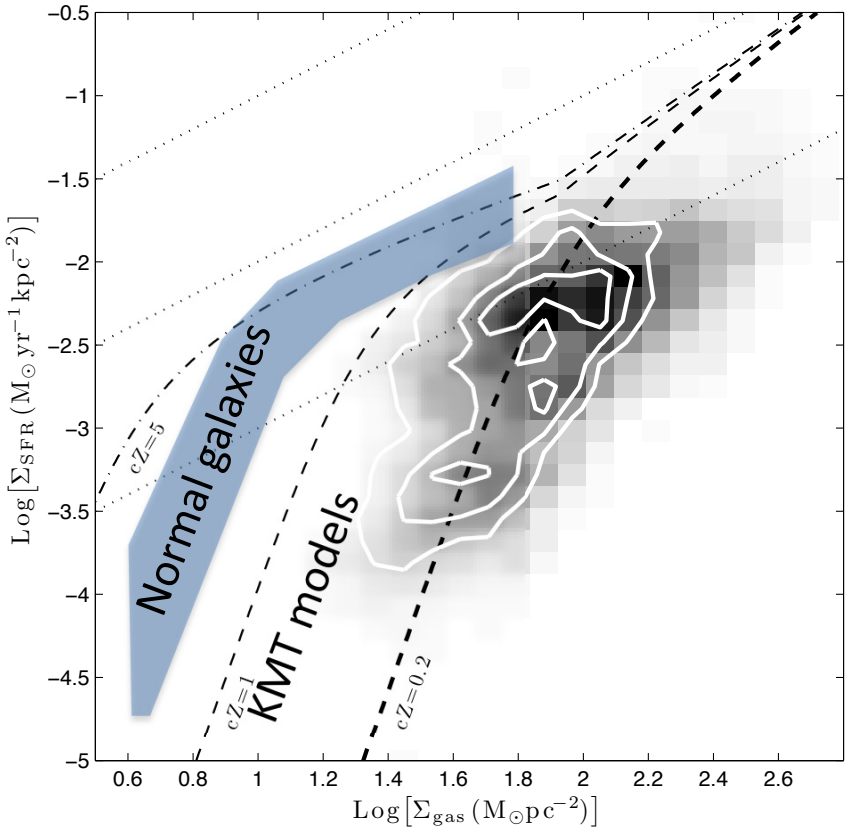
Leroy, Bolatto, et al. (2007, 2009,2010); Bolatto, Leroy, et al. in prep.

Relations for H_2 and total gas

Molecular Gas



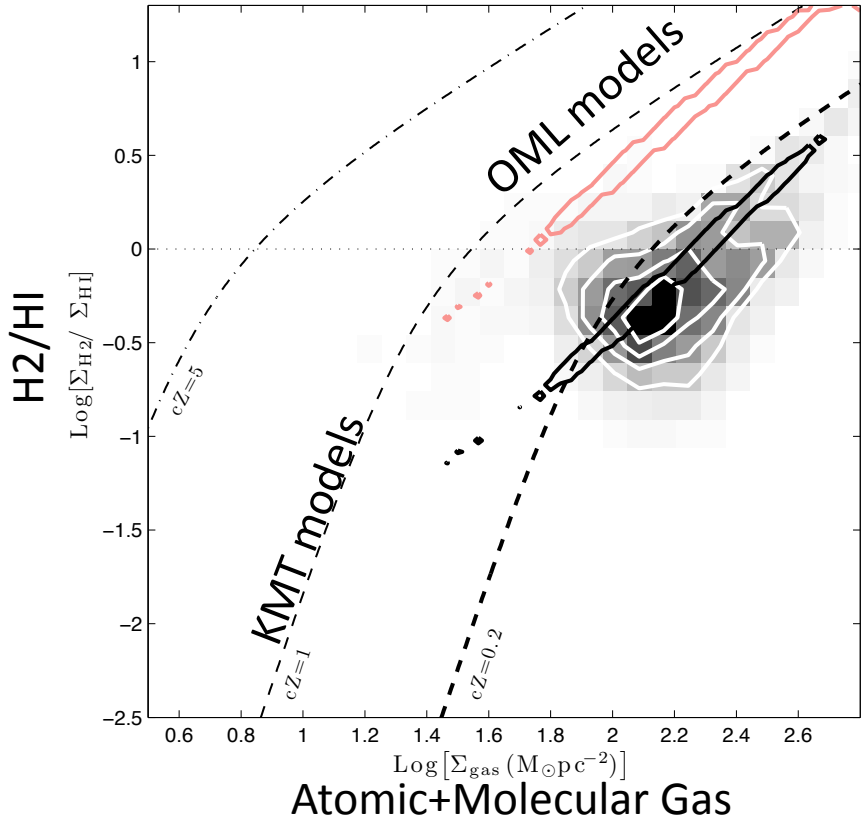
Atomic+Molecular Gas

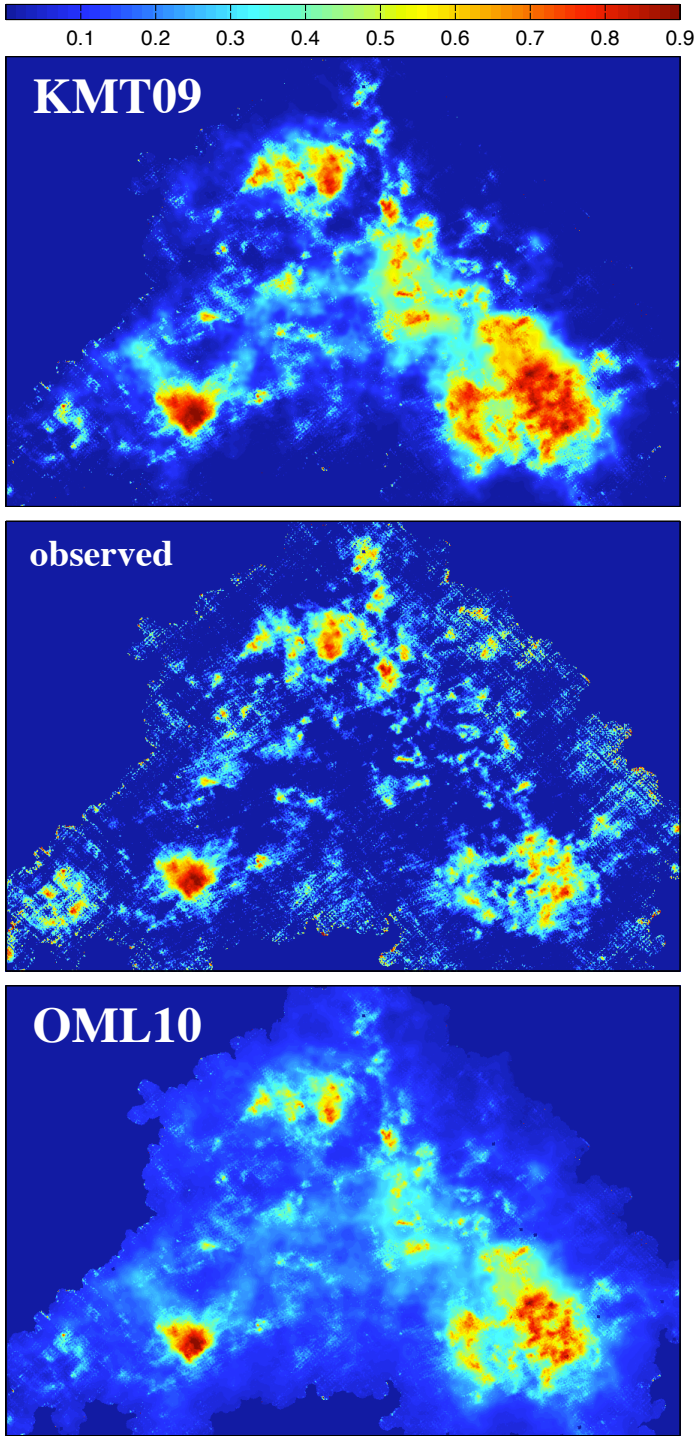


- The SMC is "normal" in H_2 vs. SFR
- The SMC is vastly underperforming in total gas vs. SFR (explains Wolfe & Chen 2006)
- KMT09 models where HI➔H_2➔SFR fit the data reasonably well

Krumholz, McKee, & Tumlinson (2009)

Molecular fraction and pressure

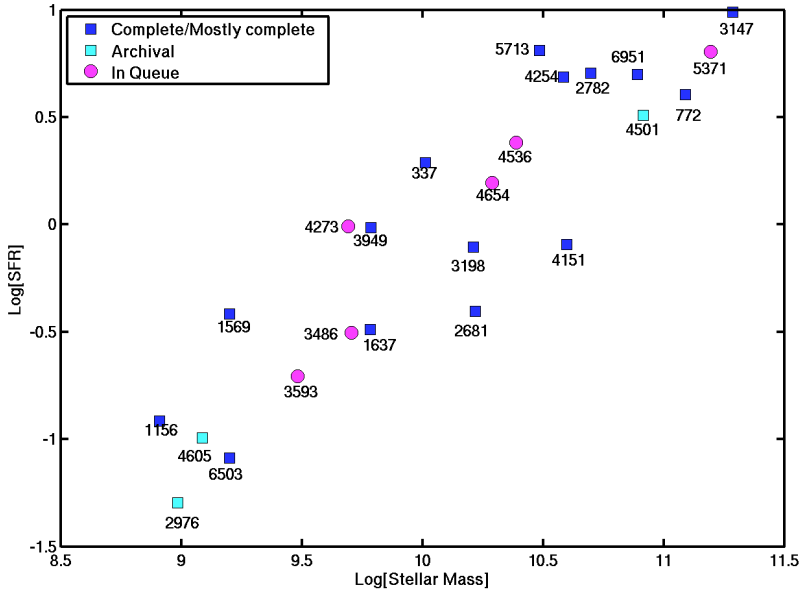


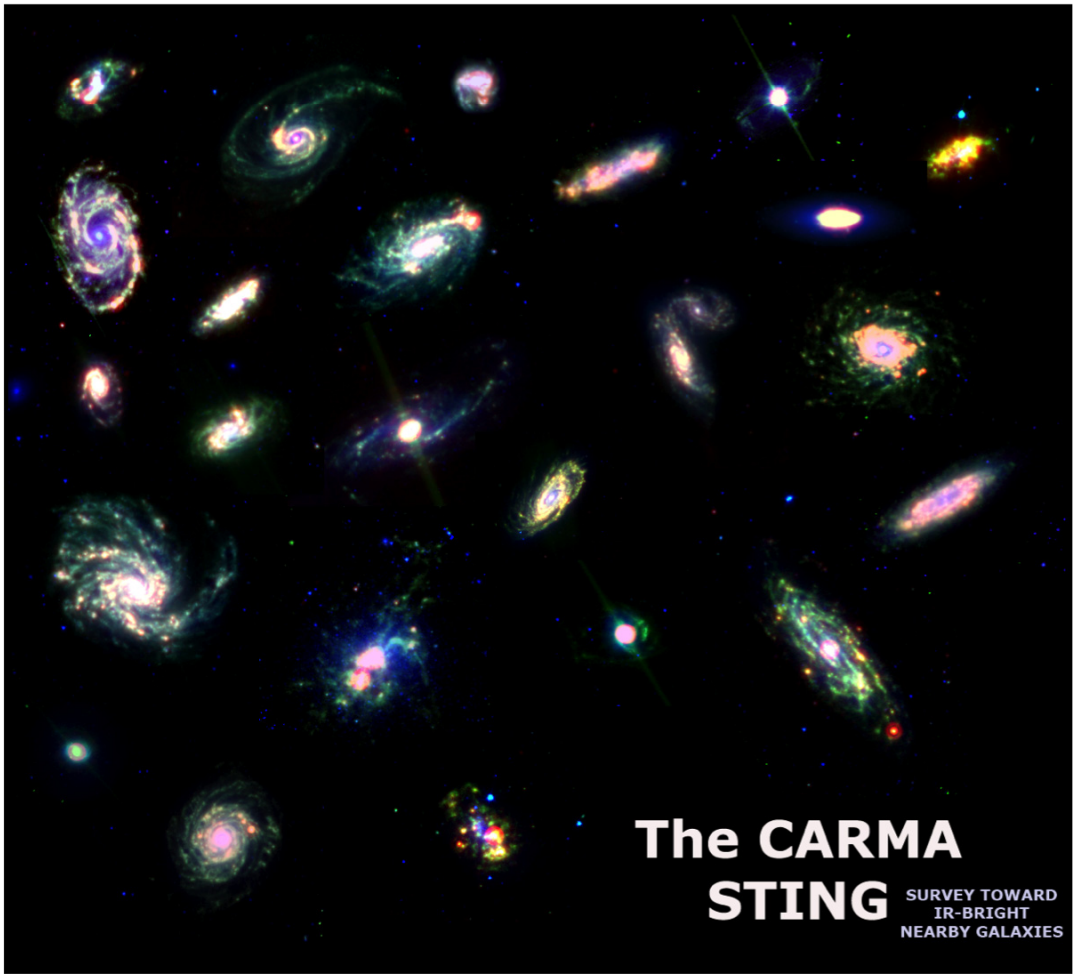


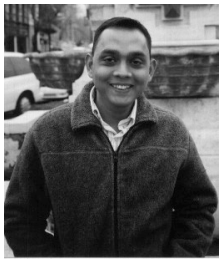
- Data are fit extremely well by OML10, after accounting for the effect of Z_d on UV propagation
- The core of OML10 is thermodynamic pressure equilibrium. It reproduces the pressure relation of BR06 very well

Elmegreen (1993); Blitz & Rosolowsky (2004,2006); KMT09; Ostriker, McKee, & Leroy 2010

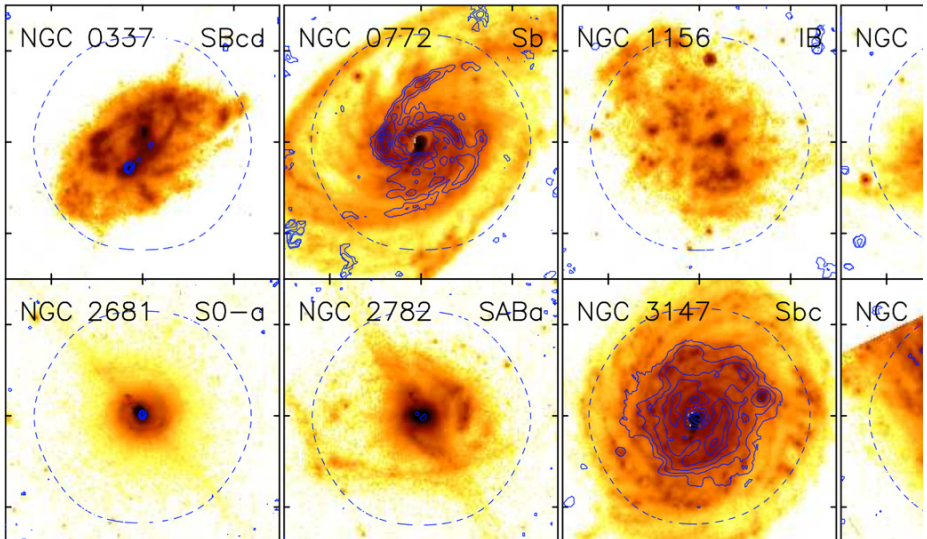
Molecular Gas in the Blue Sequence

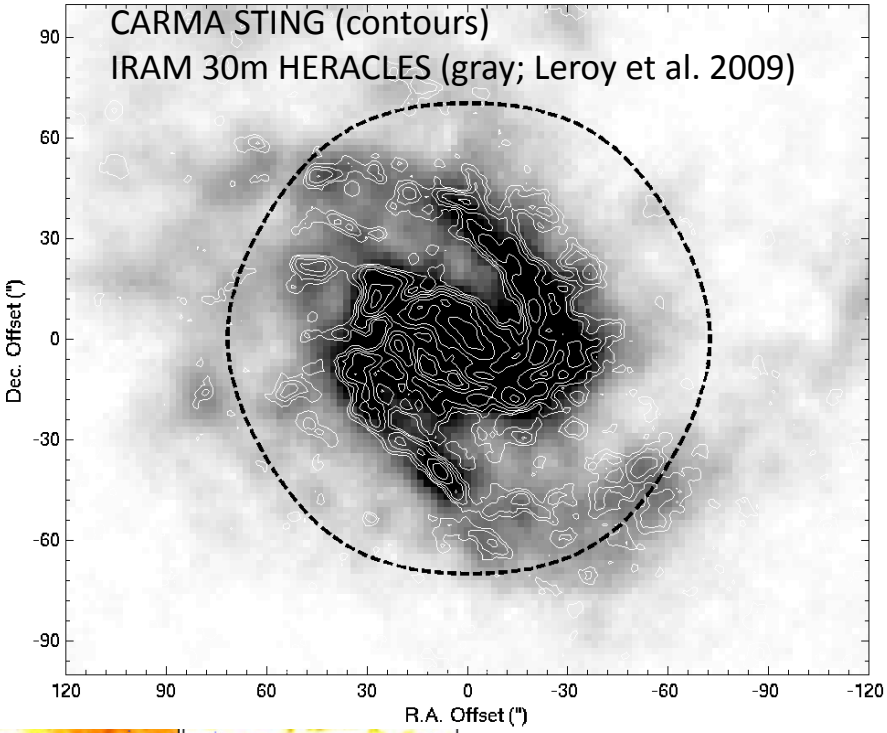






STING



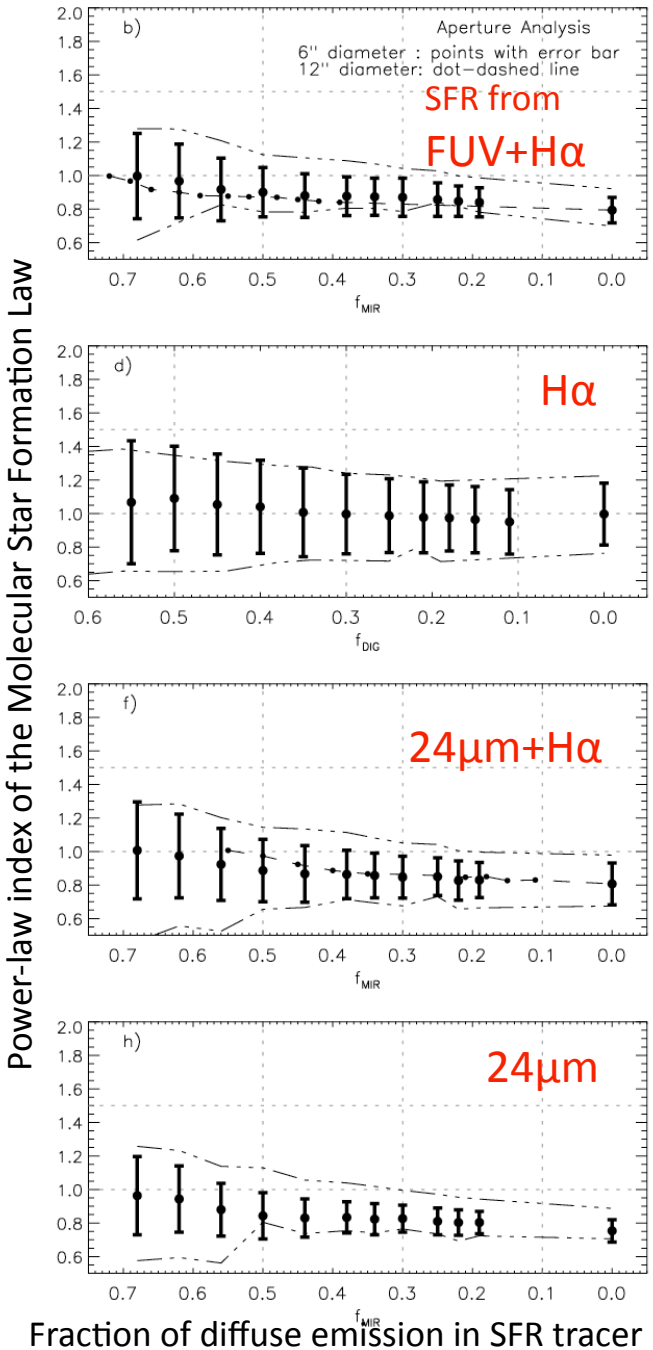


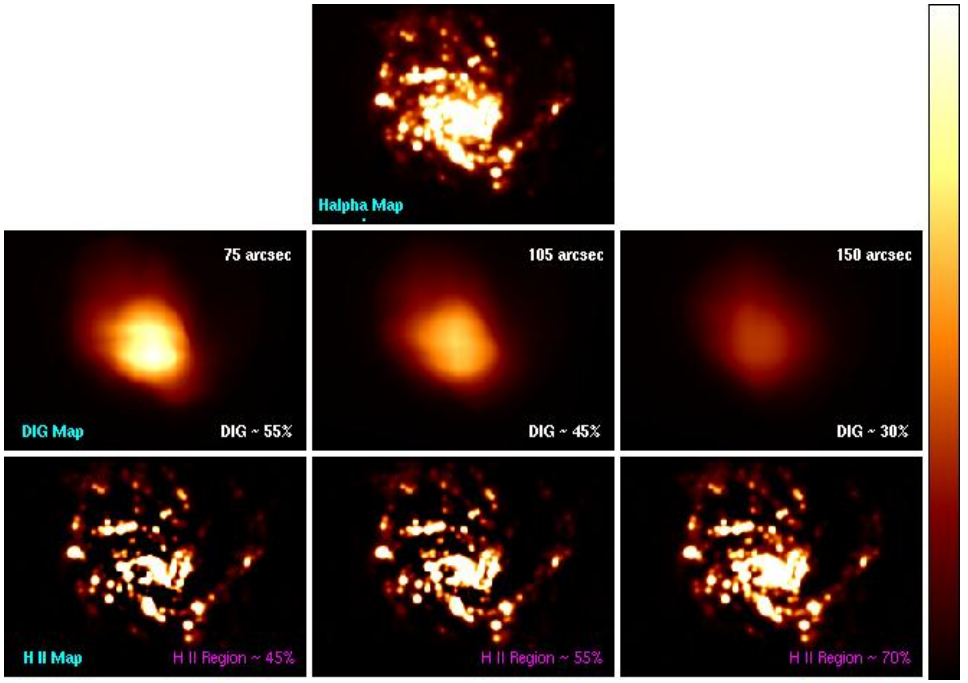
Is the relation between gas and SFR nonlinear or linear?

(Rahman, Bolatto, Wong, Leroy, Rosolowsky, Blitz, et al. 2010)

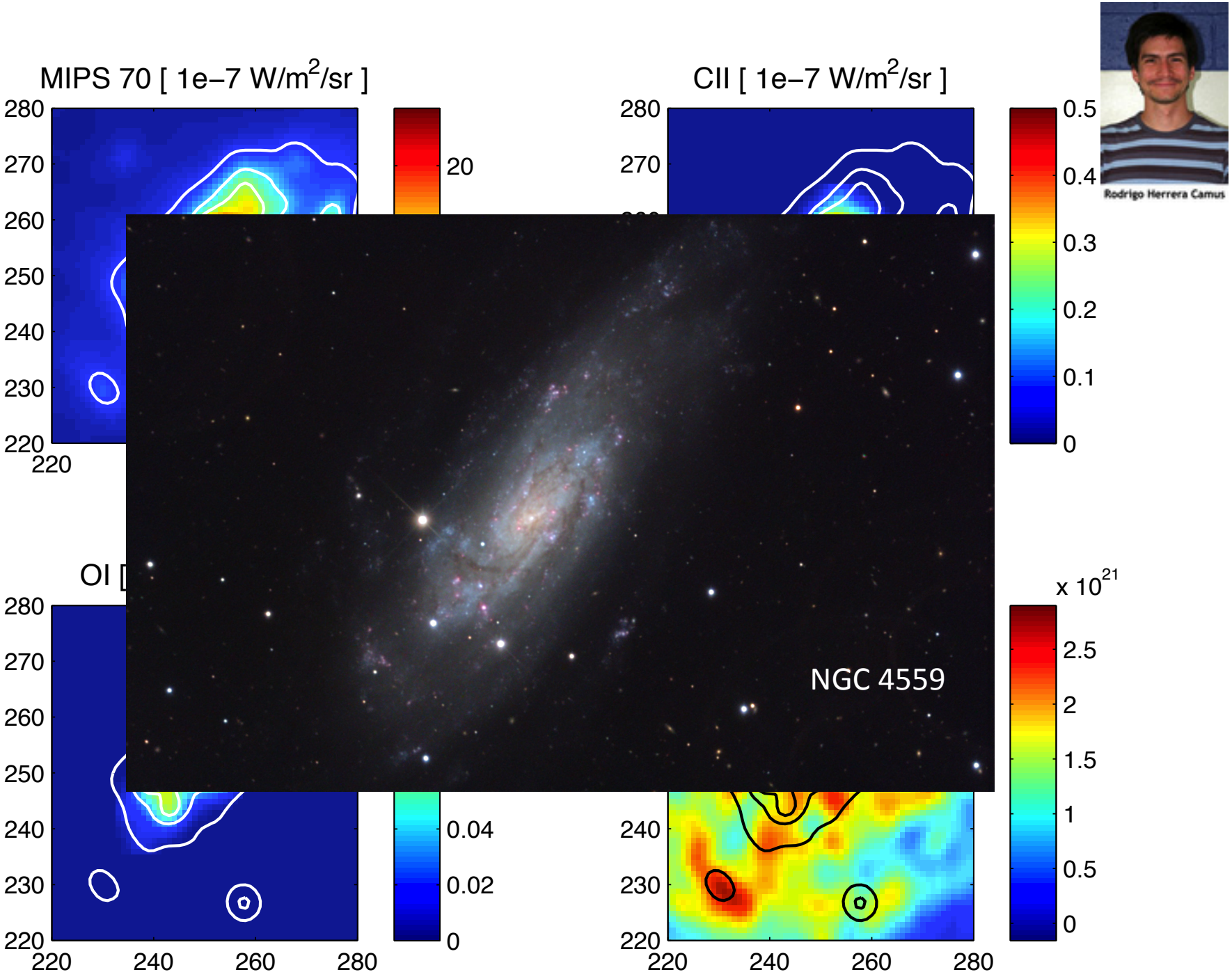
The Star Formation Law in NGC 4254

(Rahman et al., 2010)





- We show how to robustly measure the index irrespective of SFR tracer, diffuse emission contamination, and fitting method.
- The molecular SFL is approximately linear in NGC4254


MIPS 70 [1e−7 W/m2/sr]
CII [1e−7 W/m2/sr]
OI [
NGC 4559
Rodrigo Herrera Camus
x 10^21

Opportunities for students

- CARMA STING (Nearby Galaxies)
  - Star formation law (PI)
- KINGFISH (Nearby Galaxies)
  - FIR spectroscopy and imaging
  - Submm spectroscopy just approved (col)
- HERITAGE (Magellanic Cloud science)
  - FIR spectroscopy just approved (PI)
- IRAM LP (z~1-2 Medium Redshift)
  - EVLA program ongoing (PI)
  - z~3 GRB massive host (PI)
- ALMA!
  - Early science call in 5 months
  - Partnership with PUC