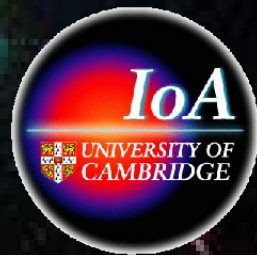


The Star Formation Law: Overview and Issues

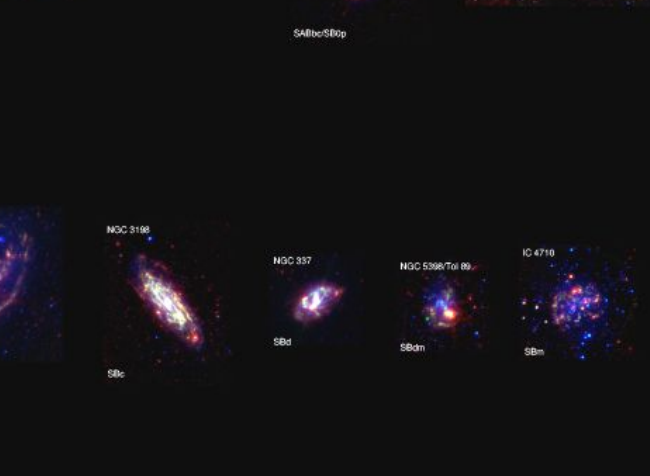
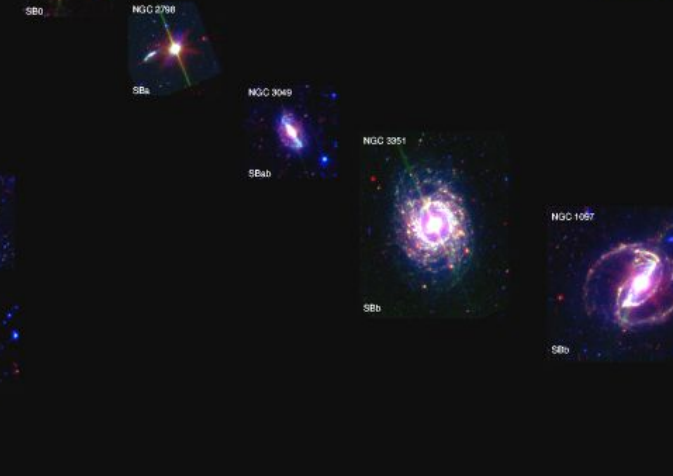
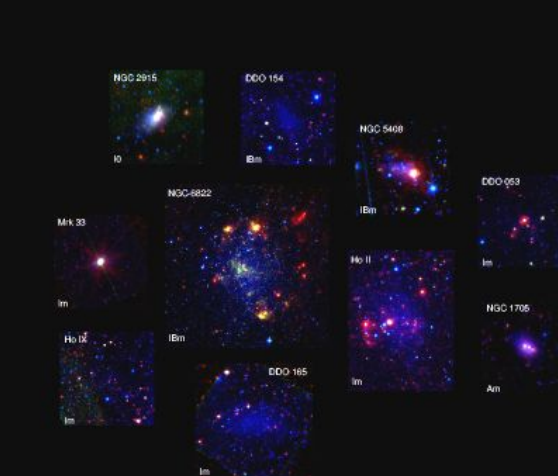
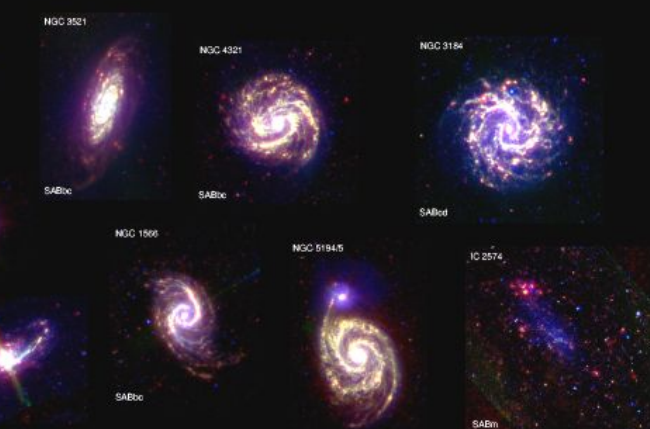
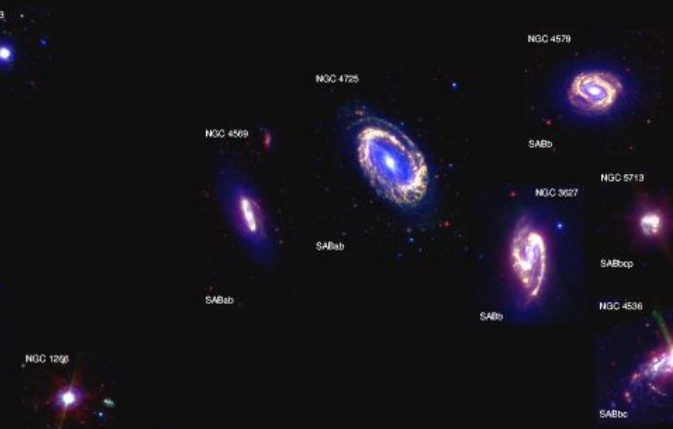
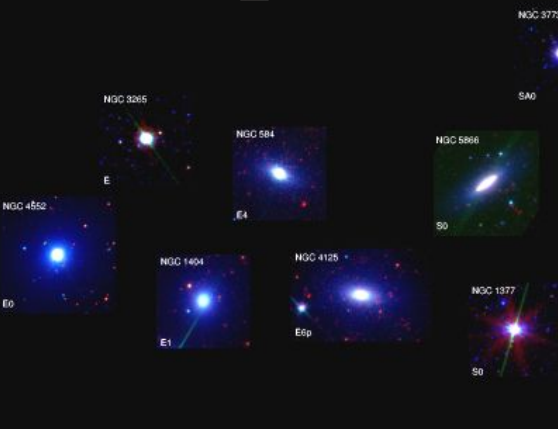
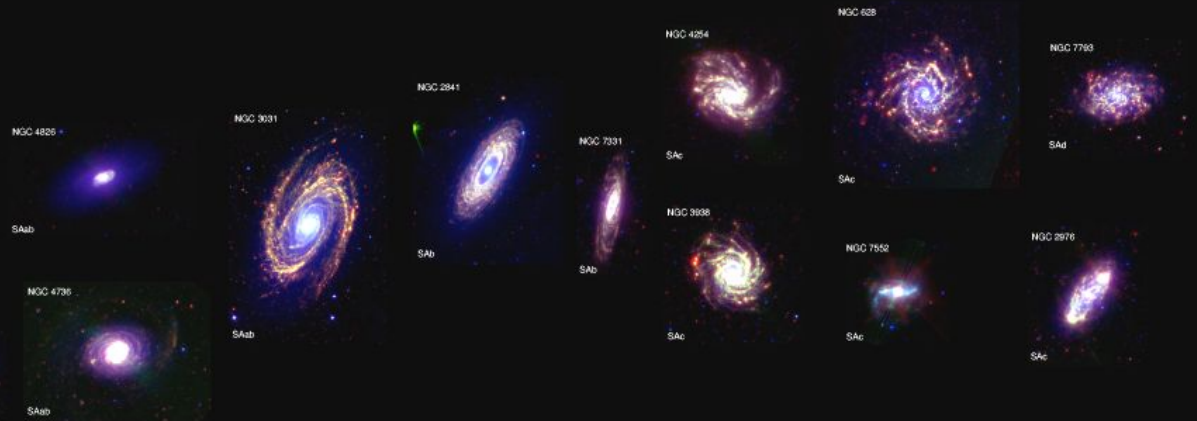
Robert Kennicutt

Institute of Astronomy
University of Cambridge



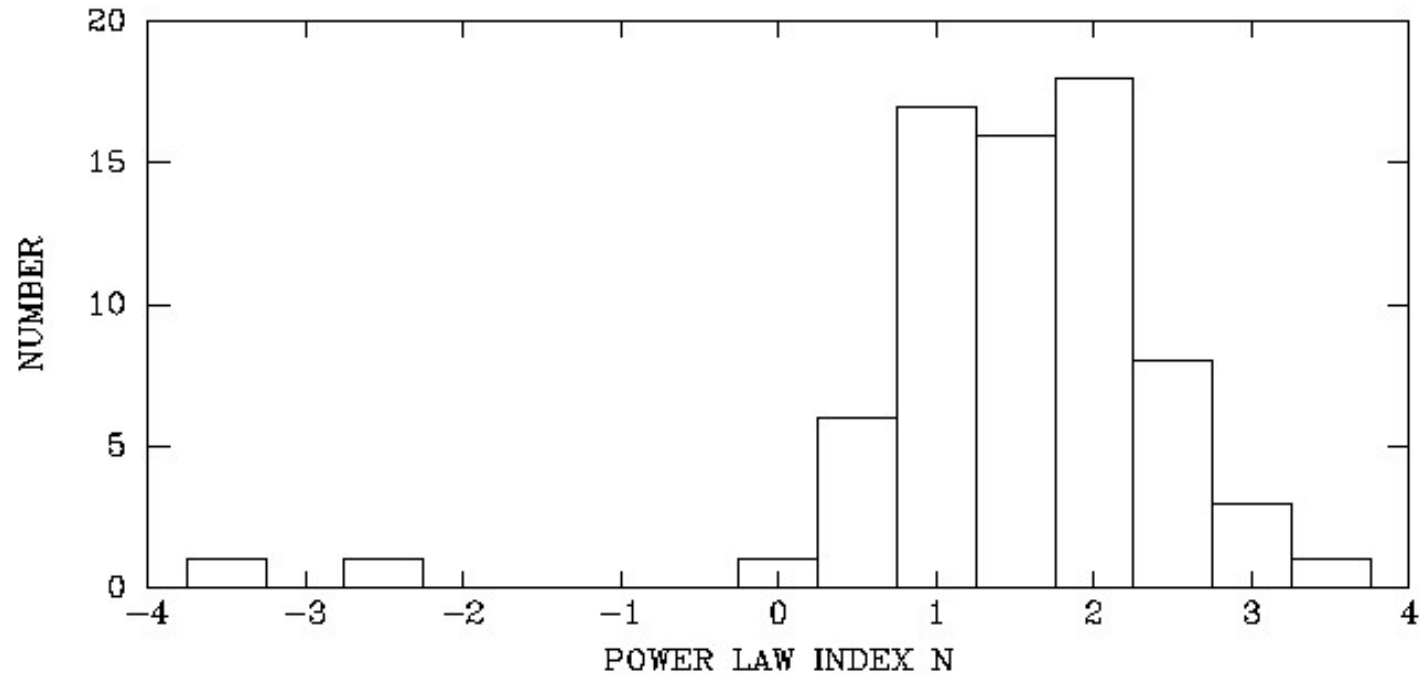
Outline

- Background
- Recent results: integrated SF law
- Issues and questions

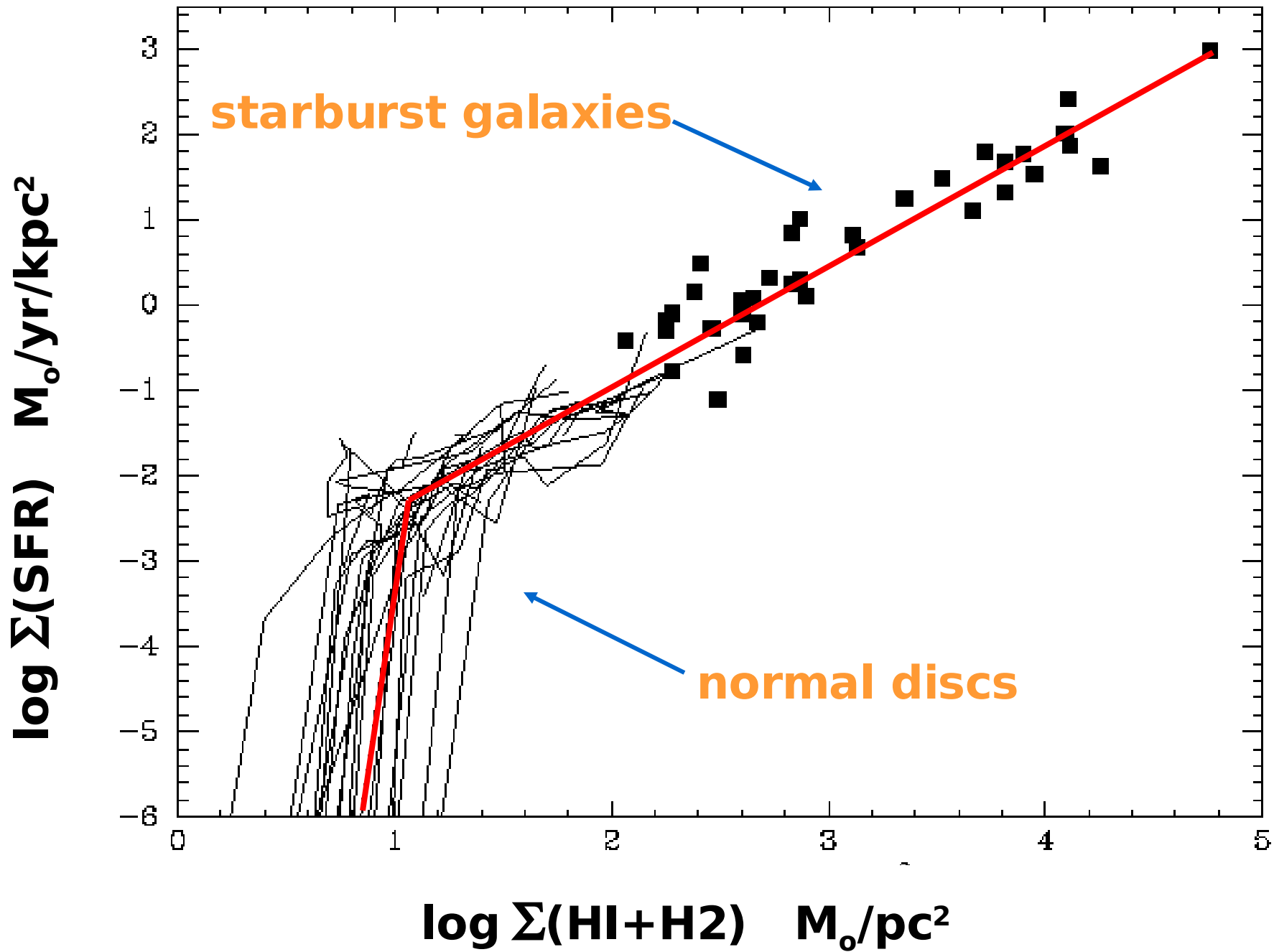


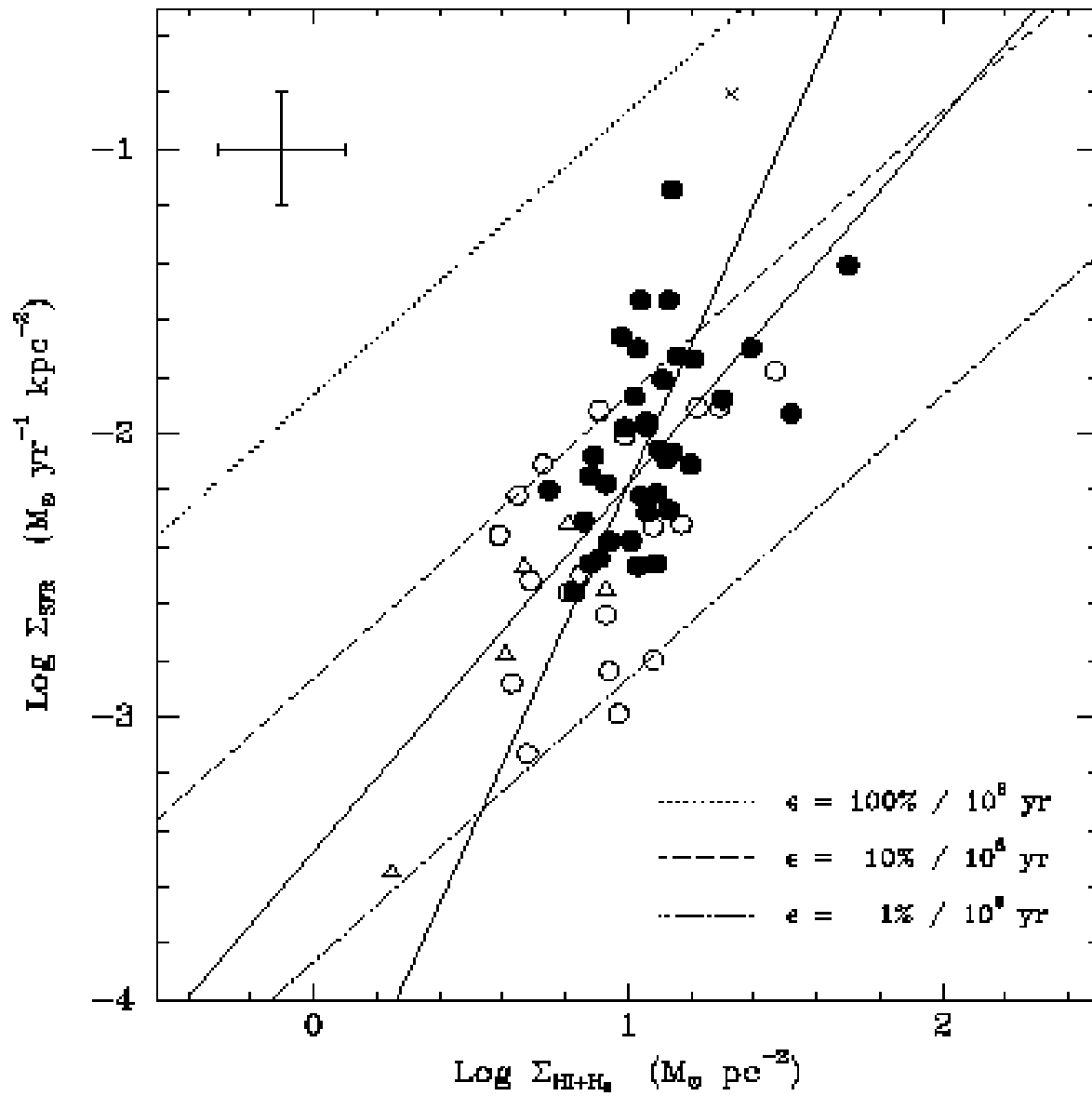
Schmidt Law

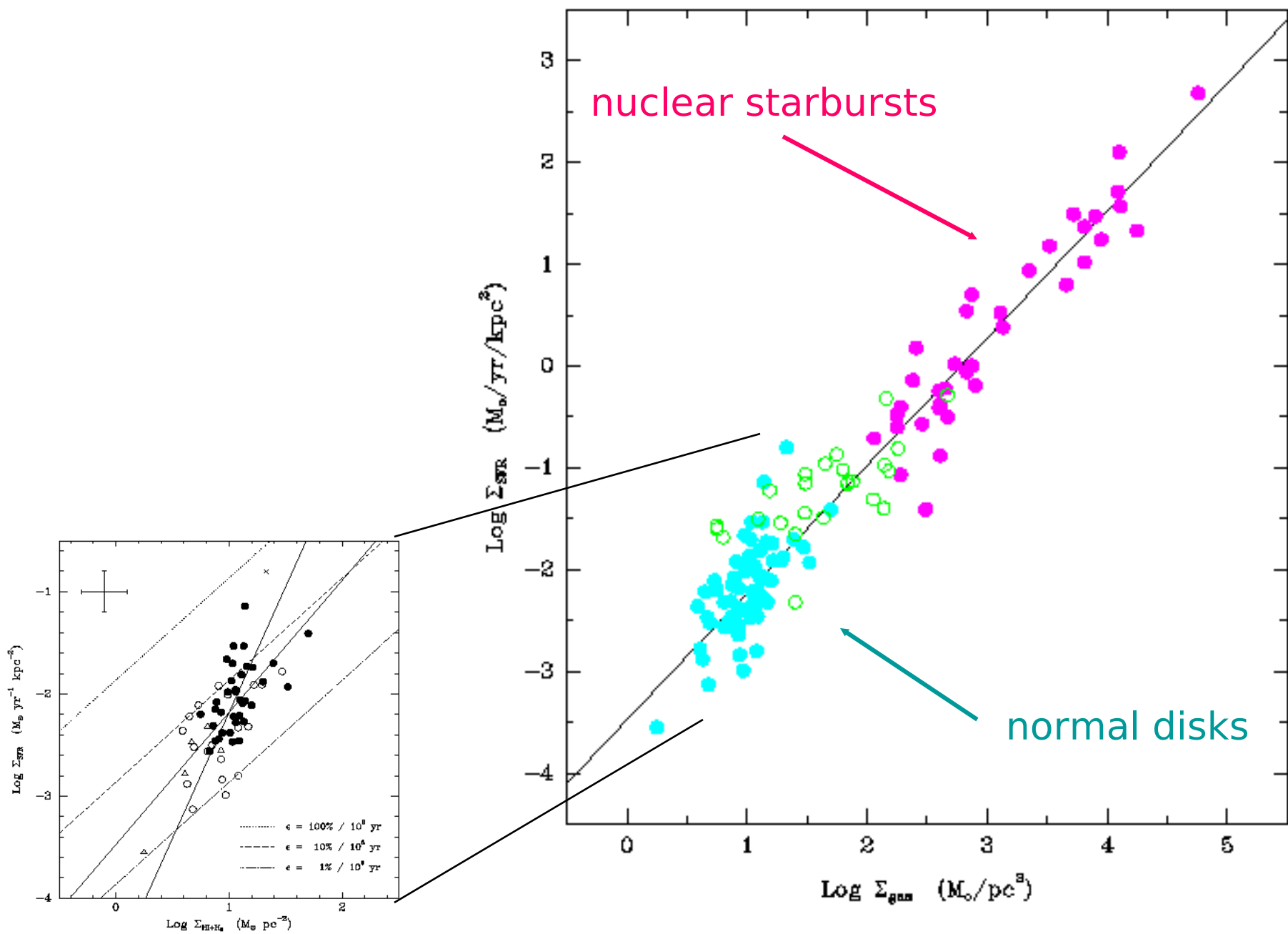
- Schmidt 1959, ApJ, 129, 243
- Schmidt 1963, ApJ, 137, 758

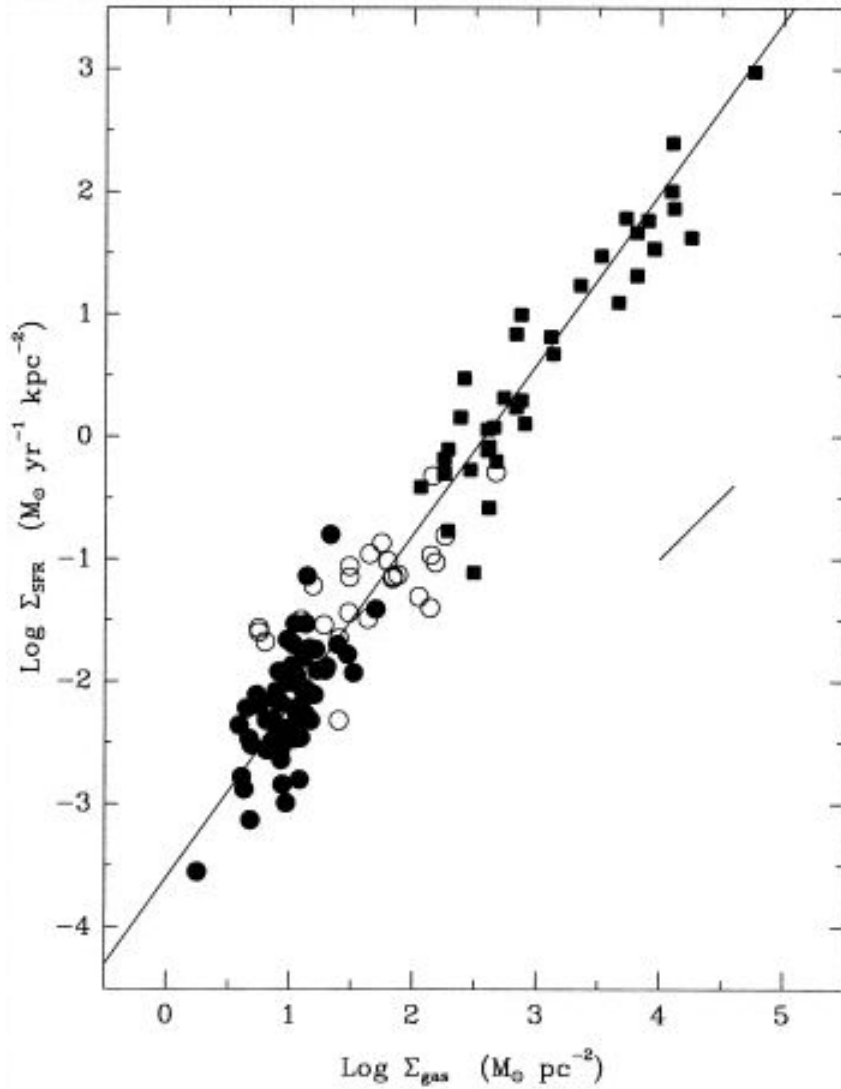


Kennicutt 1997, in The ISM in Galaxies (Kluwer)

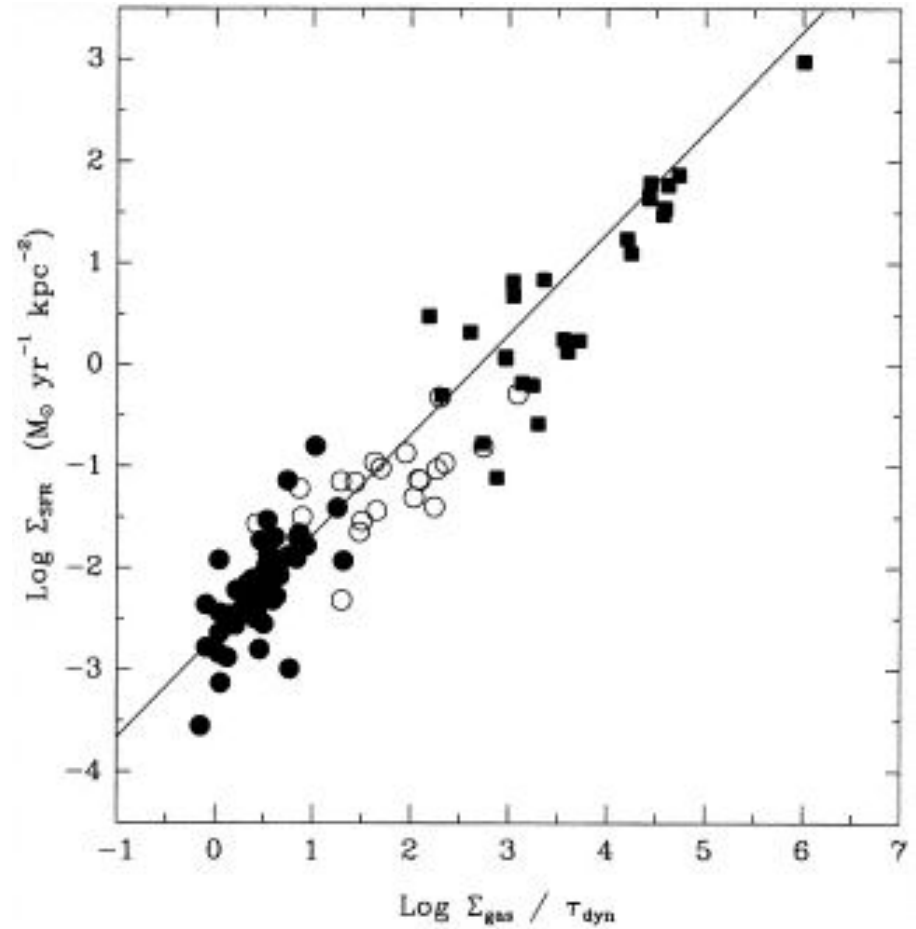








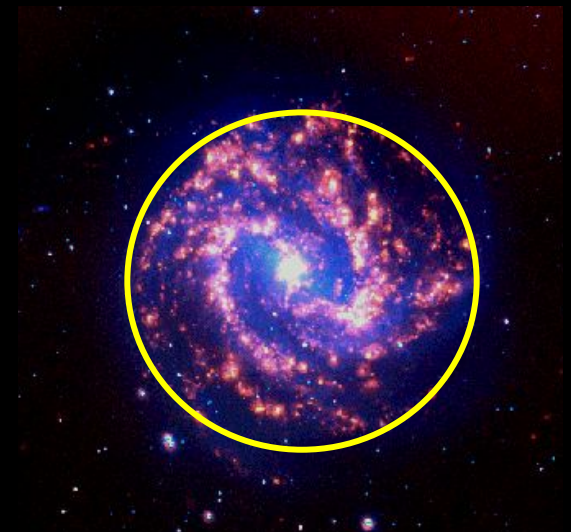
Schmidt surface density law



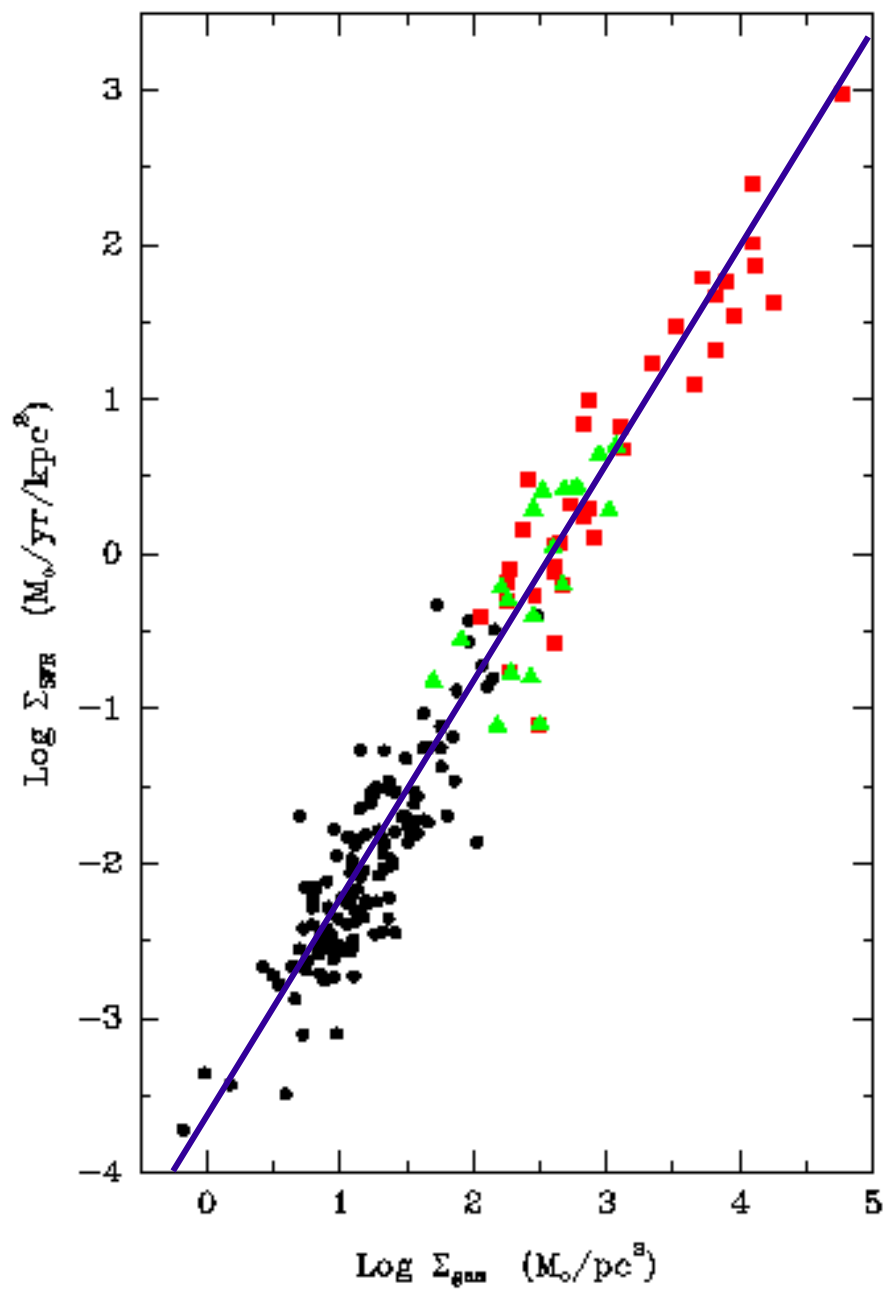
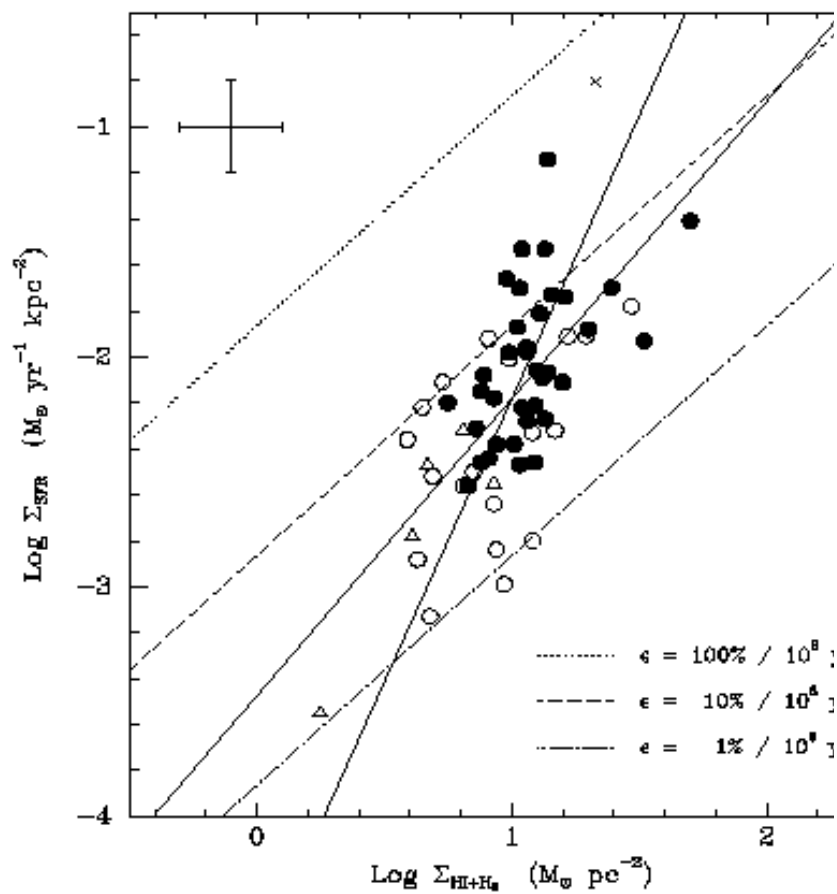
Silk $\Sigma\Omega$ law

Schmidt Law Revisited

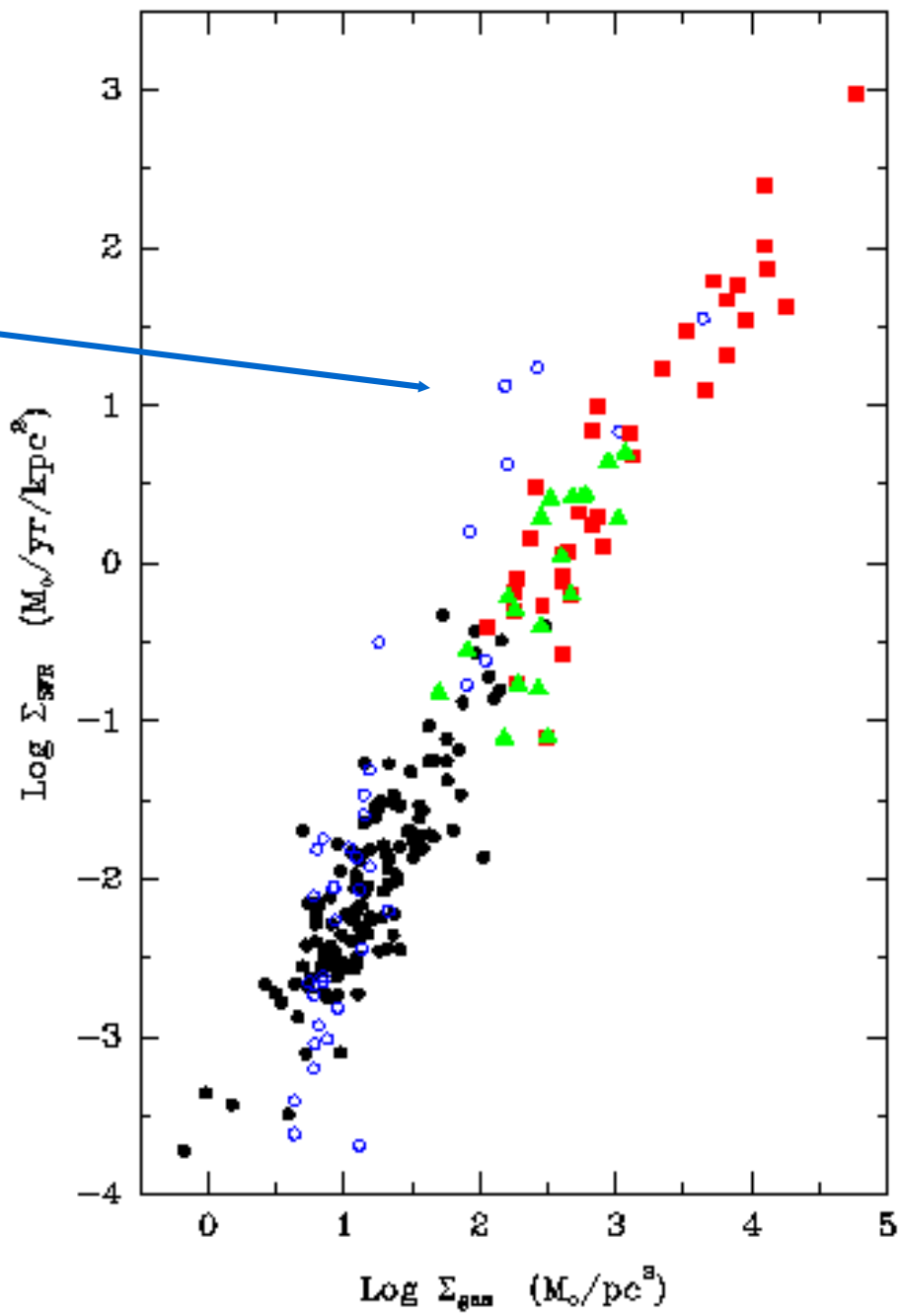
- analyze galaxies with spatially-mapped star formation ($H\alpha$, $P\alpha$, FIR), HI, and CO
- enlarged, diversified samples
 - normal galaxy sample 3x larger
 - larger ranges in gas and SFR densities
 - large subsamples of circumnuclear starbursts, low-metallicity galaxies incorporated
- densities averaged within active SF regions
- explicit corrections for [NII], extinction
- point-by-point analysis of SINGS + BIMA SONG galaxies



Work in progress



metal-poor dwarf galaxies



Empirical Questions: Schmidt Law

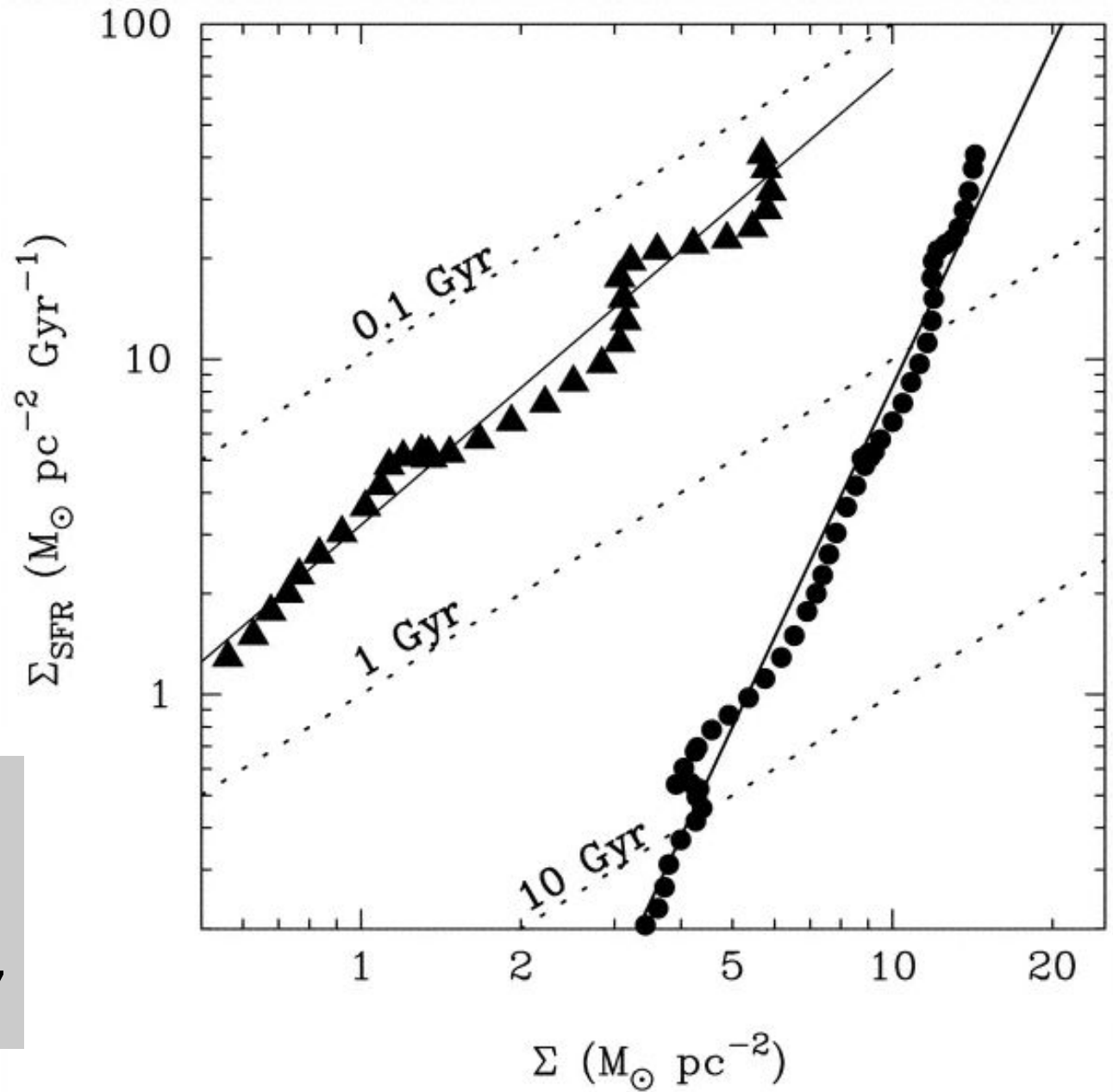
- **Is the correlation really this good?**
 - What is the slope, and is it invariant?
 - Does SFR surface density scale most tightly with gas density?
 - Is the scatter driven by a second parameter(s)?
- **Limits of applicability?**
 - upper or lower density limits?
 - limiting physical scales?
- **Is the global Schmidt law the product of a more fundamental local SF scaling law?**

More Empirical Questions: Schmidt Law

- Does the SFR surface density correlate most strongly with total gas density (i.e., pressure, self-gravity dominant) or with the H_2 surface density alone (i.e., formation/presence of molecular material dominant)?
- Is the linear correlation of infrared luminosity with dense gas luminosity (e.g., HCN) universal? Are there limits to this relation?

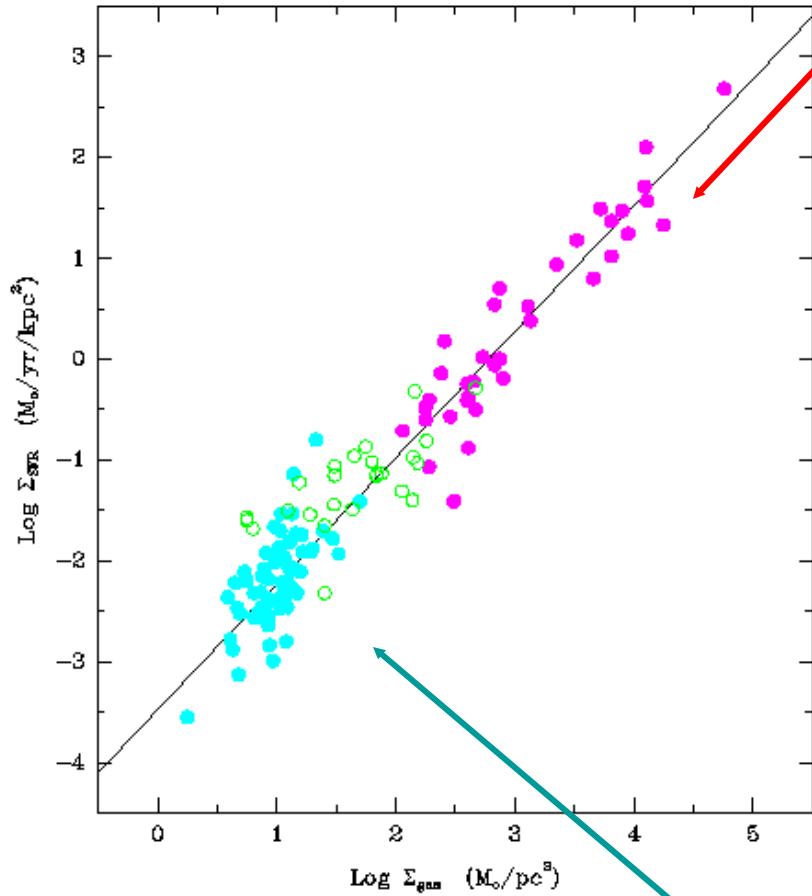
M33

Heyer et al. 2004,
ApJ, 602, 723

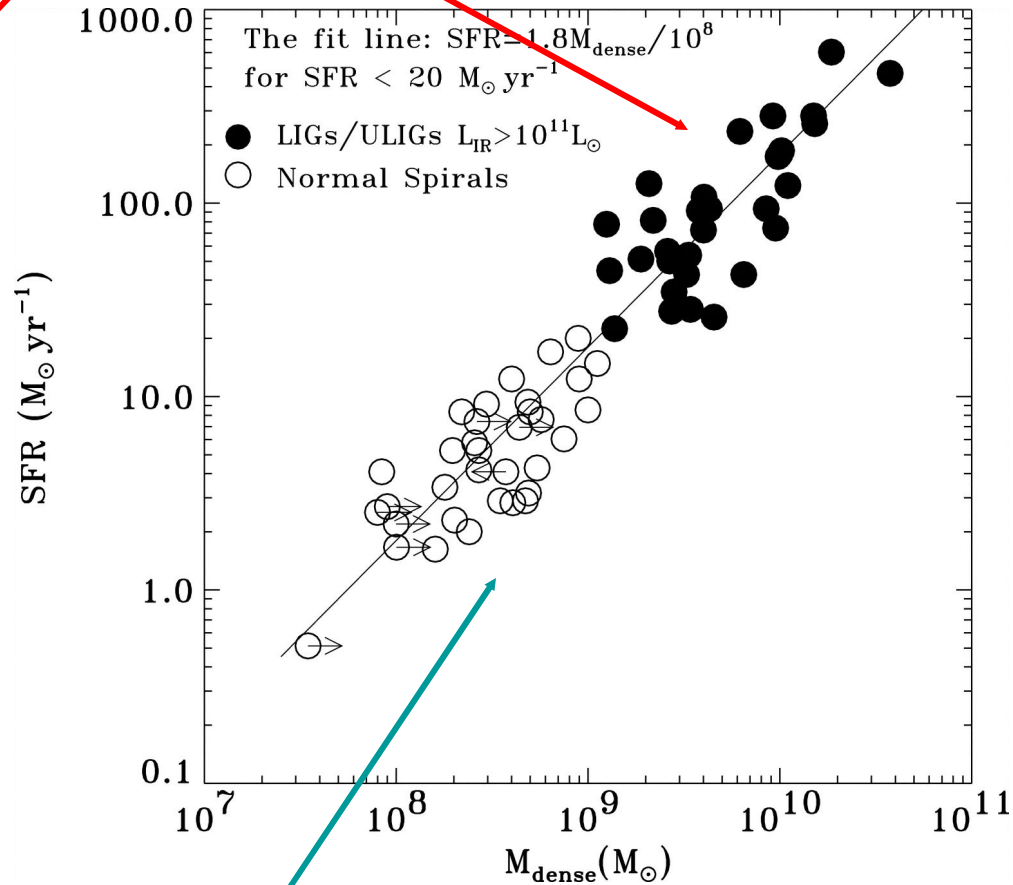


Patterns, Scaling Laws

starbursts



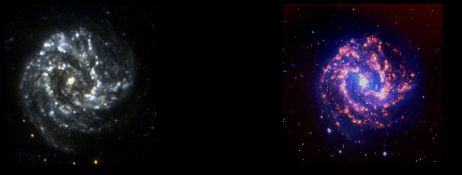
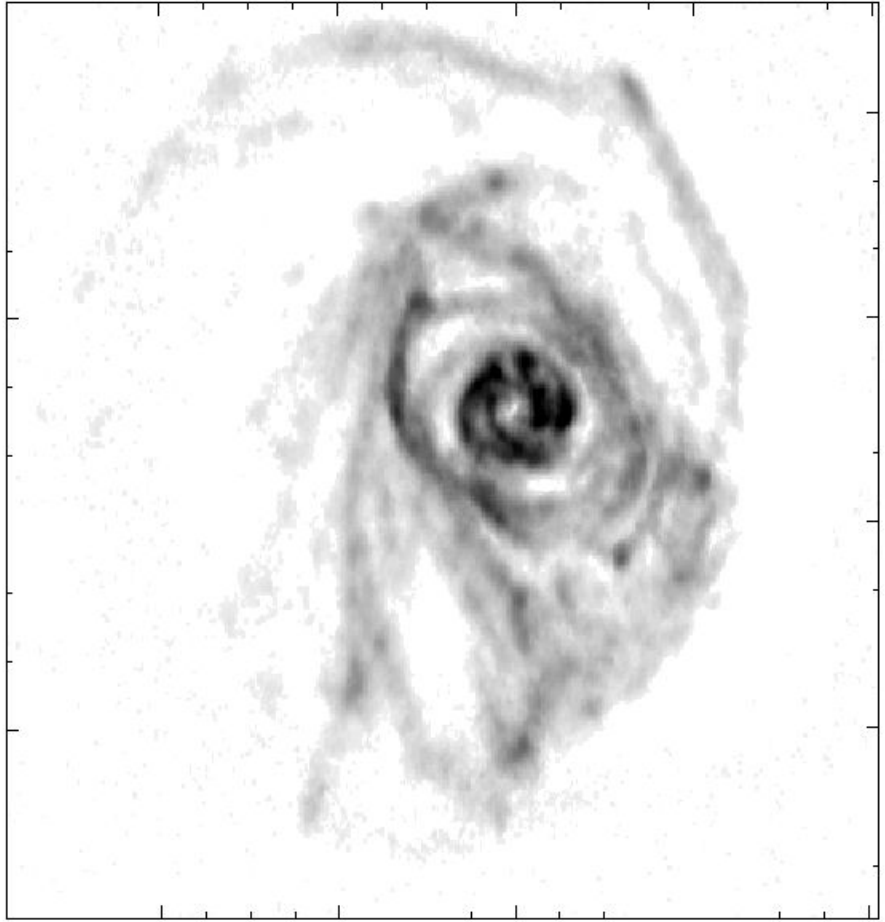
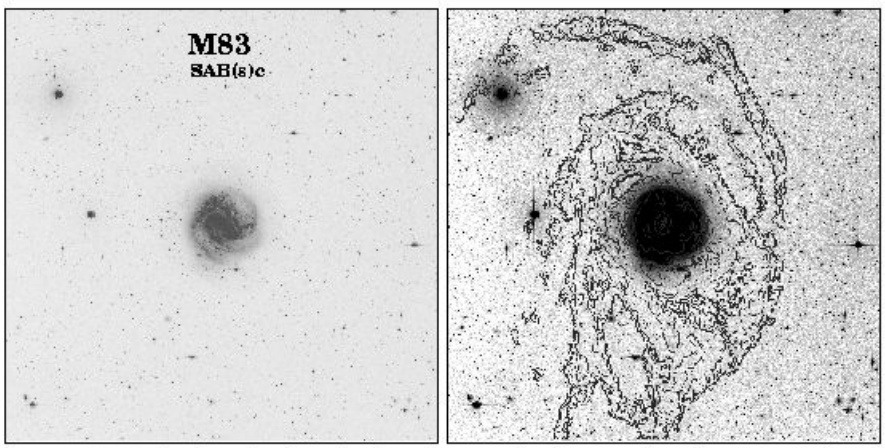
normal galaxies

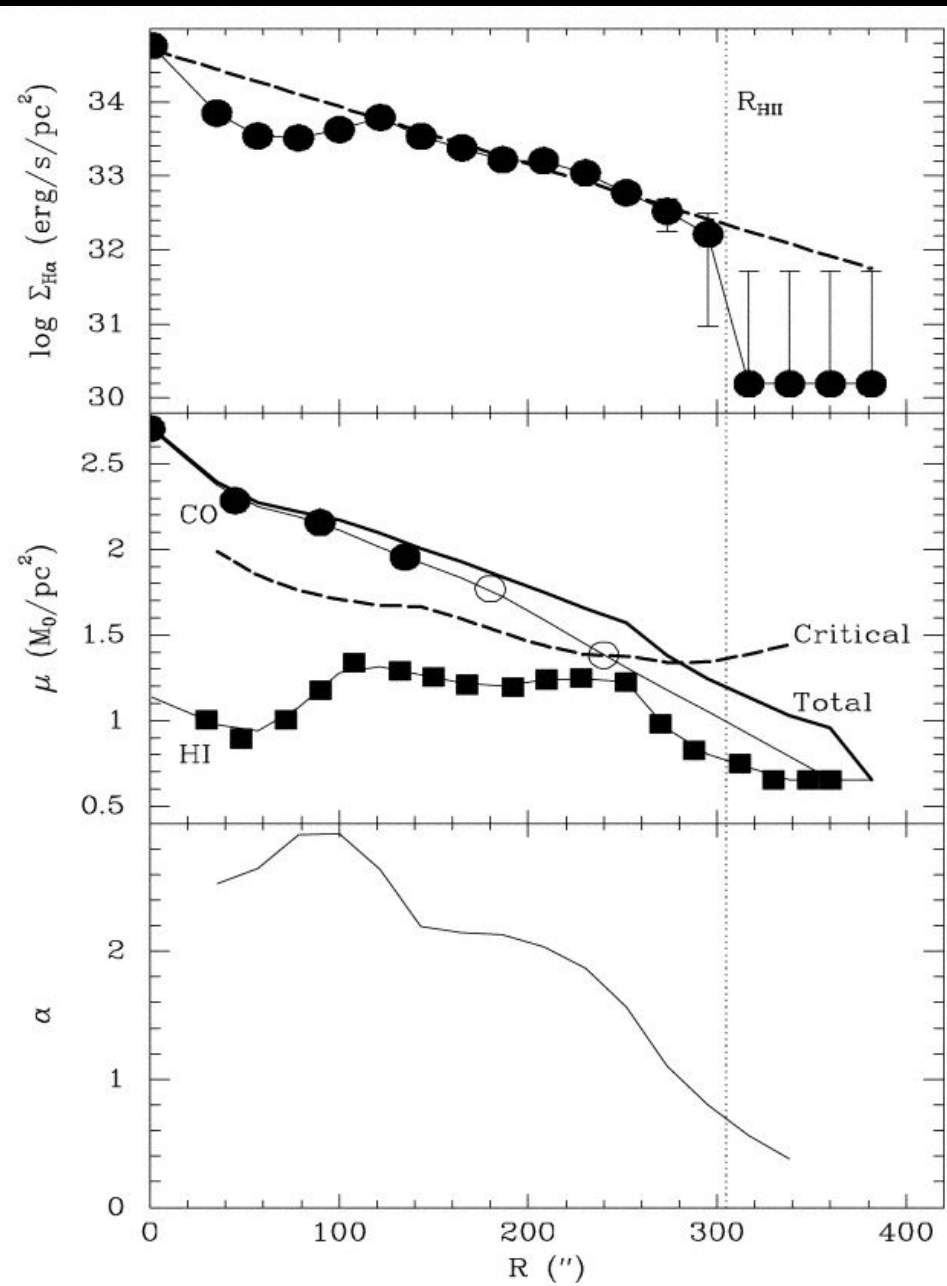


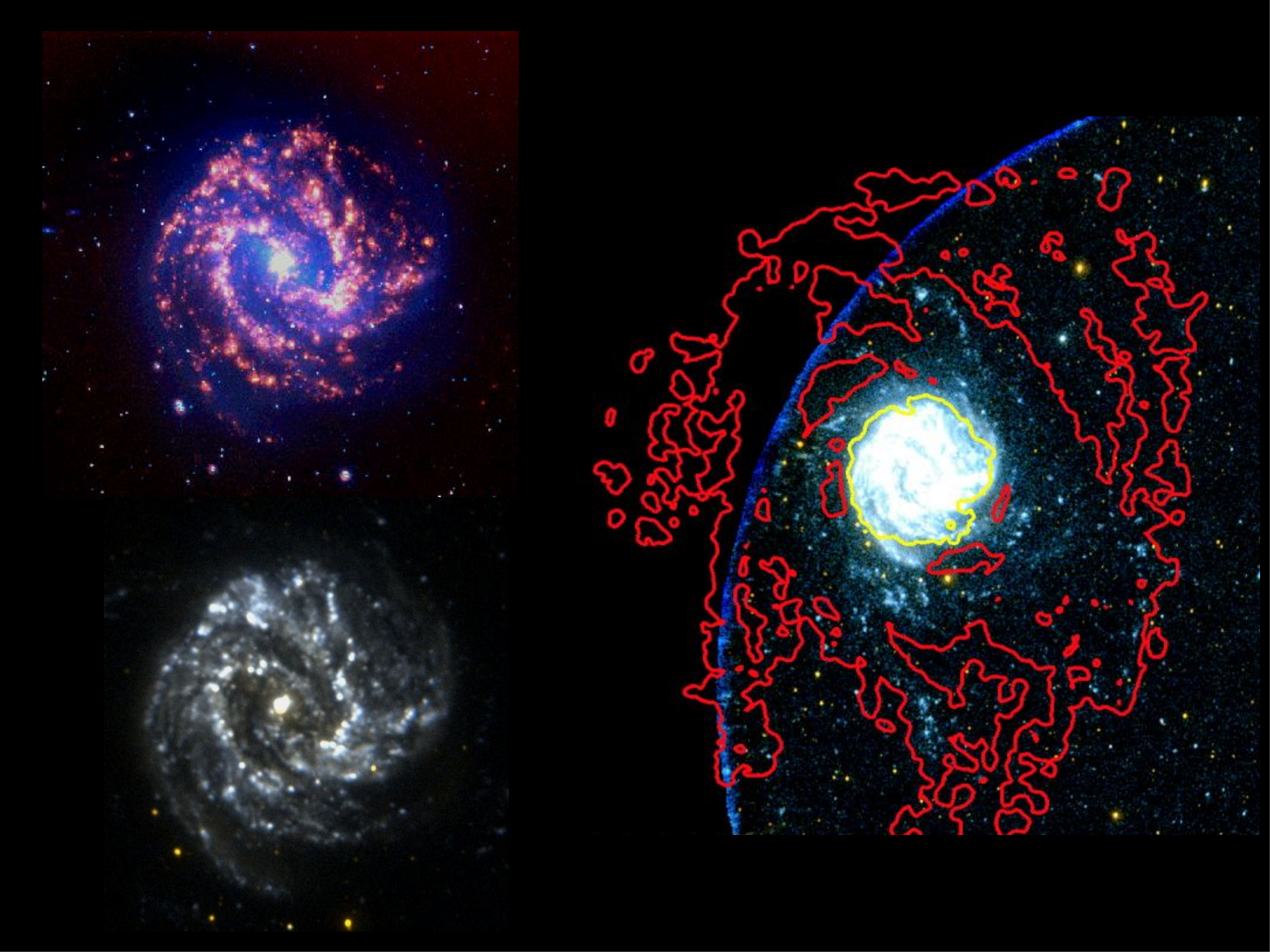
Empirical Questions: Thresholds

- Do disk thresholds seen in $H\alpha$ trace proportional transitions in the SFR?
- Do observed $H\alpha$ /UV transitions coincide with features in the HI or H_2 gas distributions, or in the stellar mass distribution?
 - Do GMCs, H_2 exhibit a threshold behavior?
- Does any SF scaling law hold below threshold?
- Does the threshold density vary radially?

M83
SAB(s)c







Physical Origins of SF Law

- Beware the treacheries of correlation vs causation!
 - For a $Q \sim 1$ disk: $\Sigma_{\text{gas}} \sim \kappa C / \pi G$
 $\kappa \propto \Omega$ so $\Sigma_{\text{gas}} \propto \Omega$
 - Likewise: $\Sigma_{\text{gas}} \propto \Sigma_{\text{tot}}$, so $P \propto \Sigma^2$
 - Also, for local Galactic ISM pressures, Σ_{crit} for self-gravitating clouds is approximately the same as Σ_{crit} for self-shielding of molecular clouds
 - And--- in SF regions much of HI may be a photodissociation product of UV radiation on H_2