Radial and local Kennicutt-Schmidt laws

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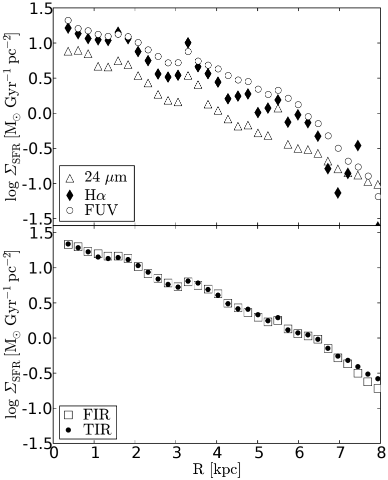
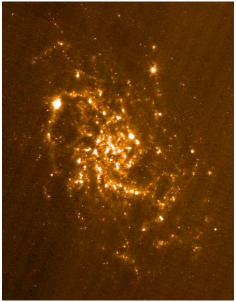
Dust and star formation in M 33

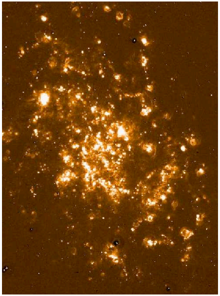


$$\mathrm{SFR(FIR)} = 13 \times 10^{-44} L(\mathrm{FIR})\ [\mathrm{erg\ s^{-1}}]$$

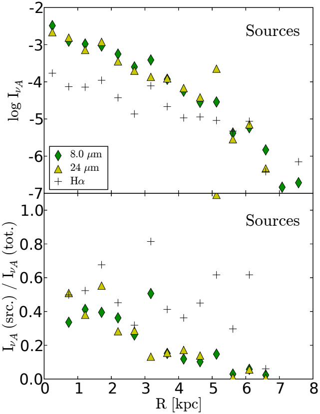
Dust and star formation in M 33



24 μm



Hα



24 μm: high diffuse fraction powered by evolved stars

The Kennicutt-Schmidt law of star formation
Schmidt 1959, ApJ, 129, 243; Kennicutt 1998, ApJ, 498, 541

$$\Sigma_{\mathrm{SFR}} \propto \Sigma_{\mathrm{gas}}^{n}?$$

Questions:

- SFR: Hα, UV, bolometric?
- Gas: molecular (H_2), atomic (HI), total (H_2 + HI)?
- At which spatial resolution does it hold? Radially? Locally?
- Does the SFR correlates better with Σ_{gas} or ρ_{gas}?
- How important is the fitting method in determining n when dispersion is high?

Multiwavelength data

Gas:

- H I — Deul & van der Hulst 1987 Westerbork
- H_2 — Corbelli 2003; Heyer et al. 2004 FCRAO

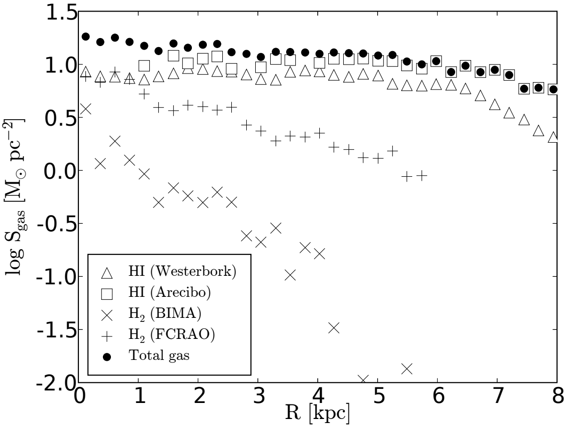
SFR:

- Optical: Hα — Hoopes & Walterbos 2000 KPNO
- Ultraviolet: FUV — Gil de Paz et al. 2007 GALEX
- Infrared: IRAC+MIPS — Verley et al. 2007 *Spitzer*

Resolution $45''$ given by the CO map

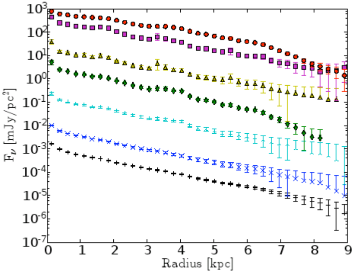
Atomic, molecular, and total gas in M 33

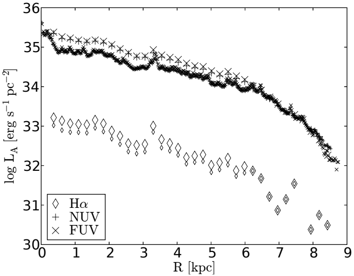
Verley et al. 2009, A&A, 493, 453



Infrared, ultraviolet, and optical radial profiles

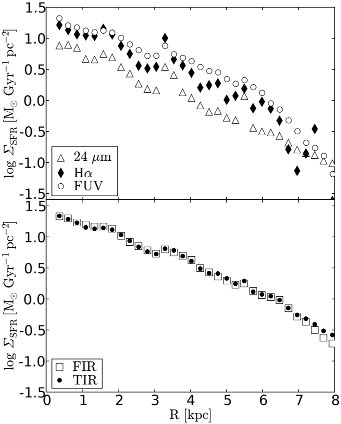
Verley et al. 2009, A&A, 493, 453





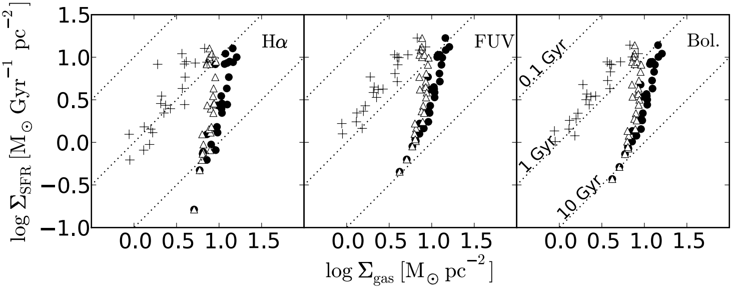
Multiwavelength SFR across the disk in M 33

Verley et al. 2009, A&A, 493, 453



$$SFR = 0.45 \pm 0.10\ M_\odot\ yr^{-1}$$

The radial Kennicutt-Schmidt law in M 33



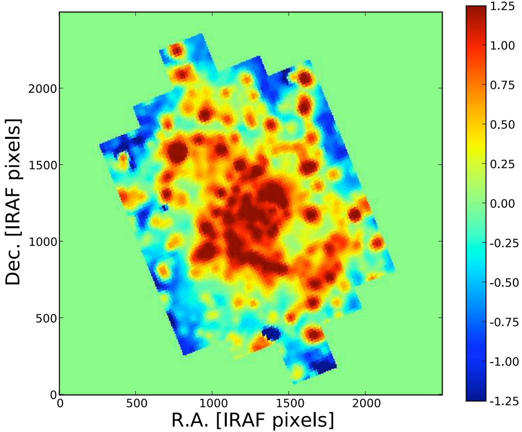
Kennicutt-Schmidt indexes:

Hα: $n_{H_2} = 1.3 \pm 0.2$ $n_{H_{tot}} = 3.6 \pm 0.3$

FUV: $n_{H_2} = 1.1 \pm 0.1$ $n_{H_{tot}} = 2.9 \pm 0.2$

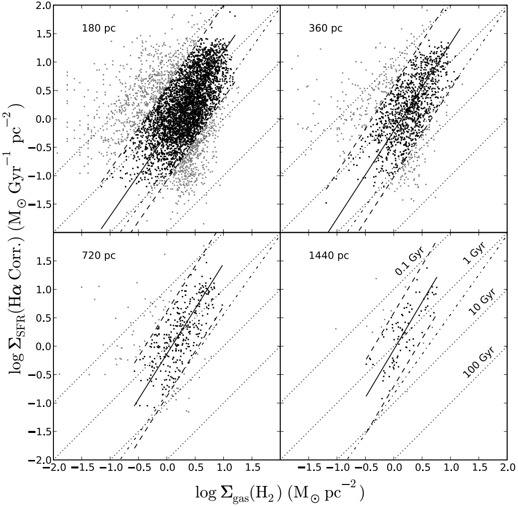
The local Kennicutt-Schmidt law in M 33

Resolution: 180 pc



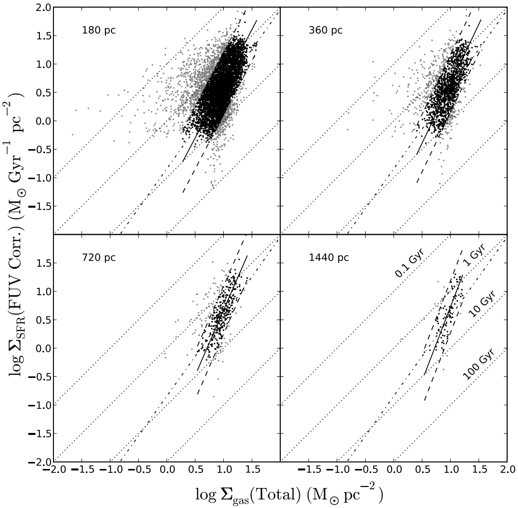
The local Kennicutt-Schmidt law in M 33

First fitting method



The local Kennicutt-Schmidt law in M 33

First fitting method



The local Kennicutt-Schmidt law in M 33

First fitting method

Results:

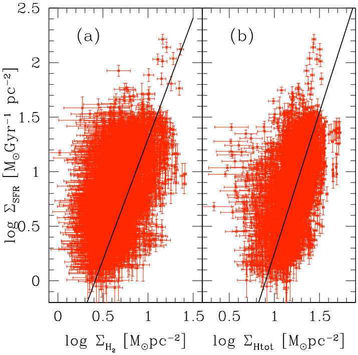
- $n_{\mathrm{H_2}} \sim 1.1 - 1.6$, $n_{\mathrm{H_{tot}}} \sim 2 - 4$
- n higher for the Hα with respect to FUV or bolometric
- n marginally increases as the resolution gets coarser
- Initial r increases as the resolution gets coarser (0.2 to 0.6)

Cons:

- CO below detection threshold included
- No correlation coefficient after iterations

The local Kennicutt-Schmidt law in M 33

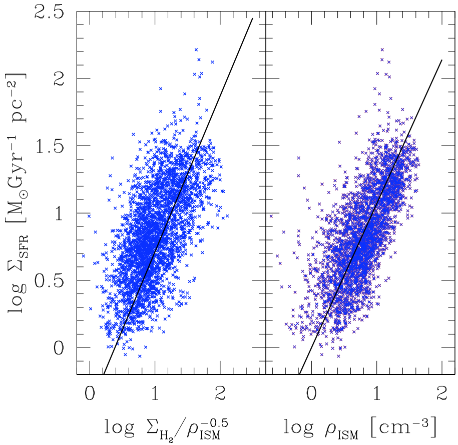
Second fitting method



Second fitting method

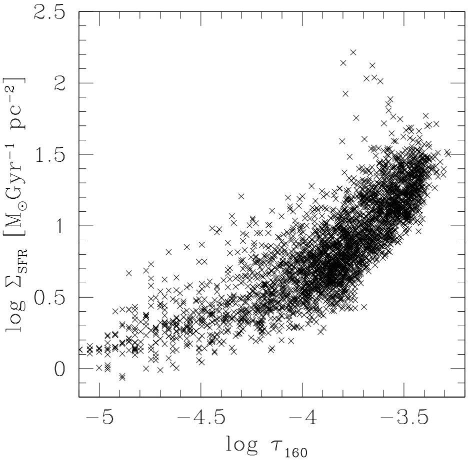
- Best spatial resolution: 180 pc
- FCRAO CO flux above 2σ noise
- Errors in gas surface density, FUV SFR density as well as extinction corrections
- $n_{H_2} = 2.22 \pm 0.07$, $r = 0.42$
- $n_{H_{tot}} = 2.59 \pm 0.05$, $r = 0.43$

Improving the correlation between gas and SFR



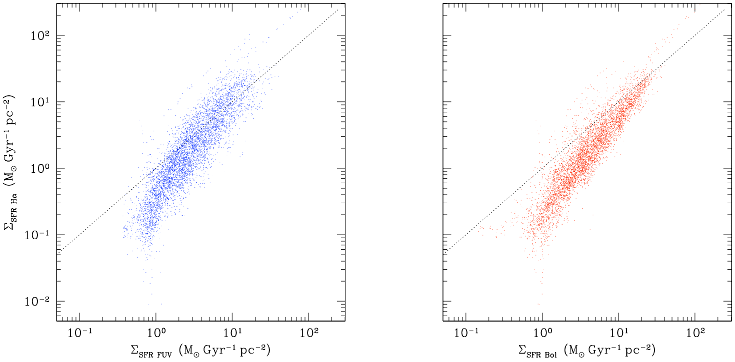
- $\log \Sigma_{SFR} - \log(\Sigma_{H_2}/\rho_{ISM}^{-0.5})$: $n = 1.16 \pm 0.04$, $r = 0.62$
- $\log \Sigma_{SFR} - \log \rho_{ISM}$: $n = 1.07 \pm 0.02$, $r = 0.71$

Correlation between dust optical depth and SFR



$\log \Sigma_{SFR} - \log \tau_{160}$: $n = 1.13 \pm 0.02$, $r = 0.81$

Hα as a SFR tracer on a local scale



Hα: Incompleteness of IMF for low luminosity regions

Conclusions

Radially and locally:

- Hα KS indices always higher than FUV and bolometric
- Incompleteness of IMF for low luminosity regions

Radially, rings of 240 pc:

- $n_{\mathrm{H_2}} = 1.1 \pm 0.1$; depletion time $\sim$1 Gyr
- $n_{\mathrm{H_{tot}}} = 2.9 \pm 0.2$; depletion time $\sim$0.5 to 10 Gyr

Conclusions

Locally, from 180 to 1440 pc:

- high dispersion, fitting methods
- recursive fit $n_{\mathrm{H_2}} = 1.1$
- bivariate regression $n_{\mathrm{H_2}} = 2.22 \pm 0.07$, $r = 0.42$
- bivariate regression $n_{\mathrm{H_{tot}}} = 2.64 \pm 0.07$, $r = 0.43$
- $\log \Sigma_{\mathrm{SFR}} - \log \rho_{\mathrm{ISM}}$: $n = 1.07 \pm 0.02$, $r = 0.71$
- $\log \Sigma_{\mathrm{SFR}} - \log \tau_{160}$: $n = 1.13 \pm 0.02$, $r = 0.81$

Open questions

- Why is there such a high dispersion in the KS law in M 33 with respect to M 51?
- What are the better scales to test the KS law?
- Is the gas density the best quantity to be involved in the KS law?