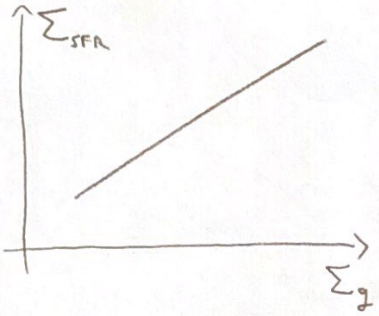
# Thu discussion on turbulence generation & dissipation in SF gals

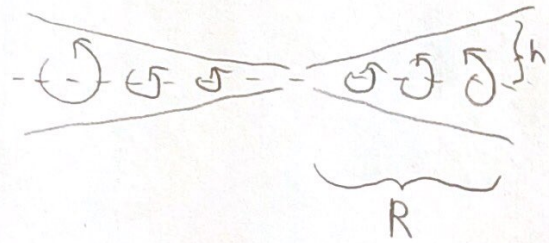
KS relation: (simplified)




$$t_{depl} = \frac{\Sigma_g}{\Sigma_{SFR}} \sim 1\,\mathrm{Gyr}$$

$$\Sigma_{SFR} = \varepsilon_{ff}^{disc} \frac{\Sigma_g}{t_{ff}^{disc}} \Rightarrow \varepsilon_{ff}^{disc} \sim 1\%$$

Equilibrium model:




neglect: multiphase, chemistry, ...

$$\begin{cases} W \approx G \Sigma_g \Sigma_{disc} \\ P_{turb} \approx \bar{\rho}\, c_T^2 \end{cases} \Leftarrow \quad \dot{e}_{in} = \dot{e}_{diss}$$

"steady state"

## SF-driven turb.:

$$\dot{e}_{in} \approx \frac{\Sigma_{SFR}}{h} (P_*/m_*)\, c_T \qquad [\text{SNRs merge w/ ISM at } v_{SNR} \approx c_T]$$

$$\dot{e}_{diss} \approx \frac{\bar{\rho}\, c_T^2}{h/c_T} \qquad [\text{always}]$$

$$\Rightarrow P_{turb} \approx \Sigma_{SFR} (P_*/m_*), \quad \overset{P_{turb} \approx W}{\Rightarrow} \quad \boxed{\Sigma_{SFR} \approx \underbrace{\frac{G}{P_*/m_*}}_{\text{gravity/feedback}} \Sigma_g \Sigma_{disc}}$$

## Accretion-driven turb. (radial transport):

$$\dot{e}_{in} \approx \frac{\dot{M}_{acc} V_c^2}{R^2 h}$$

$$\approx \frac{(1+n)\Sigma_{SFR} V_c^2}{h}$$

$$\dot{M}_* \approx \dot{M}_{acc}/(1+n)$$

[$\dot{e}_{diss}$, $w$ are the same as in SF-driven case, so obtain KS w/ $(P_*/m_*)c_T \to (1+n)$ $(P_*/m_*) \to (1+n)$!]

$$\Rightarrow \boxed{\Sigma_{SFR} \approx \frac{G c_T}{(1+n) V_c^2} \Sigma_g \Sigma_{disc}}$$

[$Q \approx 1 \Rightarrow f_g \approx c_T/V_c$

$$\Rightarrow \boxed{\Sigma_{SFR} \approx \frac{G f_g}{(1+n) V_c} \Sigma_g \Sigma_{disc}}$$ ]

## SF efficiencies (disc-scale):

$$\varepsilon_{ff}^{disc} = \frac{\Sigma_{SFR}}{\Sigma_g} t_{ff}^{disc} = \frac{G \Sigma_{disc}}{P_*/m_*} t_{ff}^{disc} \approx \boxed{\frac{c_T}{P_*/m_*}}$$

SF case

using: $t_{ff} = 1/\sqrt{G\bar{\rho}}$; $\bar{\rho} \approx \Sigma_{disc}/h$

$$Q \sim \frac{V_c c_T}{G \Sigma_{disc} R} \sim 1$$

SNe: $P_*/m_* \sim 1{,}000\text{-}3{,}000$ km/s.

$\Rightarrow \varepsilon_{ff}^{disc} \sim 1\%$ for $c_T \sim 10\text{-}30$ km/s ✓

Accr. case

$$P_*/m_* \to (1+n)\frac{V_c^2}{c_T} \Rightarrow \varepsilon_{ff}^{disc} \approx \boxed{\underbrace{\frac{1}{1+n}}_{\sim 1} \underbrace{\left(\frac{c_T}{V_c}\right)^2}_{\sim 0.1^2}} \sim 1\% \checkmark$$

Assuming: • randomly driven SNe
• SNe drive turb. on scale $R_{SN}$ = radius when remnant vel. $= c_T$

Martizzi+15,16 showed: $\boxed{c_T \approx 10\ \mathrm{Km/s} \left(\frac{f_g}{0.1}\right)^{-2/5} \left(\frac{\Sigma_g}{100 M_\odot\ pc^{-2}}\right)^{1/5}}$, almost const.

If applies to real galaxies, accretion limit may be realized when $c_T \gtrsim 10$ Km/s

Disc wants to maintain $Q \sim 1$, $\Rightarrow c_T \sim f_g V_c$

$f_g \nearrow \Rightarrow$ grav. inst. drives turb.

<u>Implications</u>: • $\varepsilon_{ff}^{disc}$ largely decoupled from cloud-scale $\varepsilon_{ff}^{cloud}$
• " not universal (depends on galaxy properties)

<u>Questions</u>: • Can we unambiguously (in sims or obs.) determine SF vs. accretion contributions?
• In SF case, is turb. excited by SNe in vol.-filling medium or GMC disruption?