Gas flows and chemical evolution in dwarf irregular galaxies

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Star Formation in Dwarf Galaxies
Flagstaff, 20/06/2012

A toy model of galaxy formation

Physical ingredients

Diffuse gas: M_{HI}

Molecular clouds: M_c

Stars: M_*

Physical ingredients

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Molecular clouds: M_c

Stars: M_*

Physical ingredients

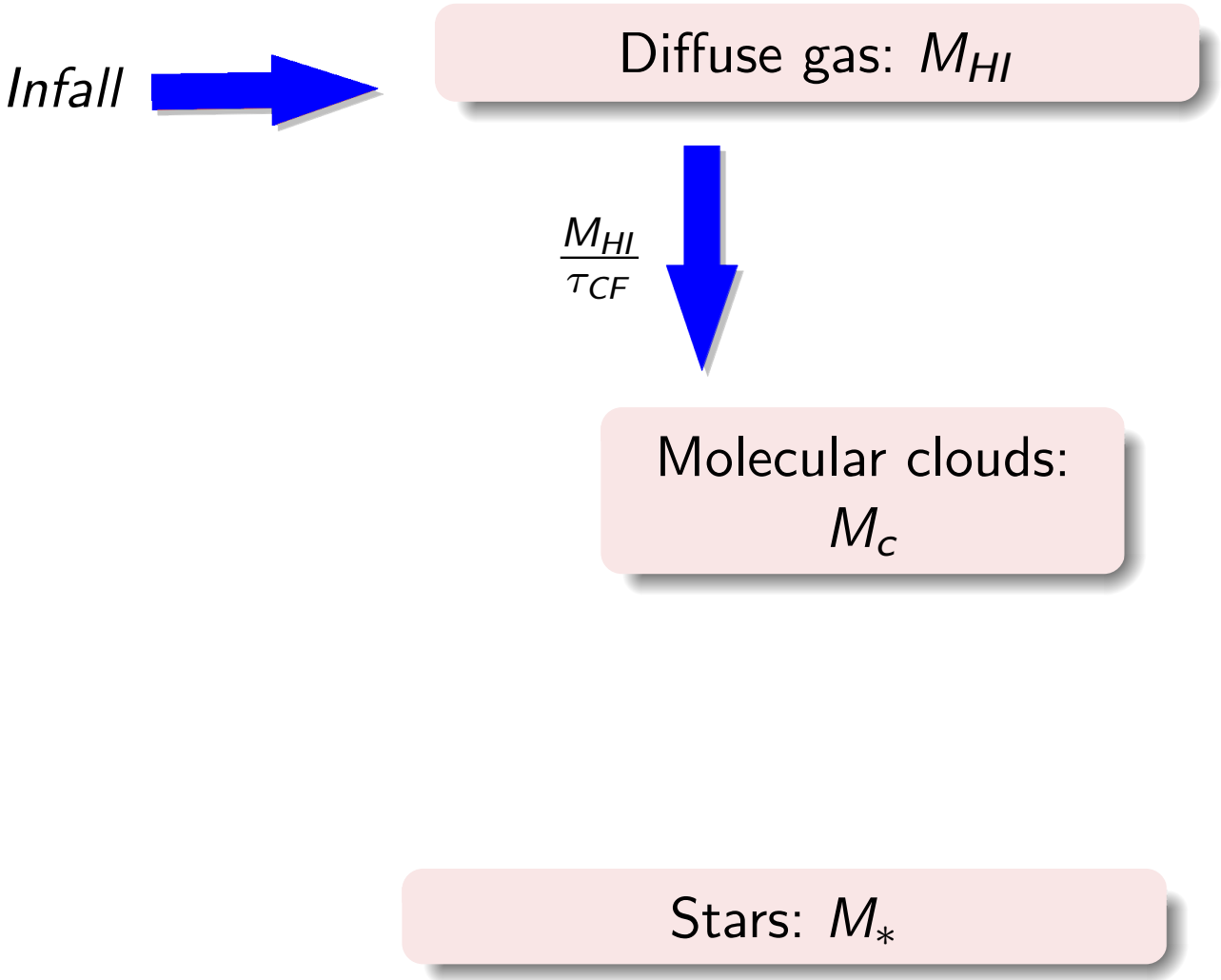
Infall 

Diffuse gas: M_{HI}

Molecular clouds: M_c

Stars: M_*

Physical ingredients



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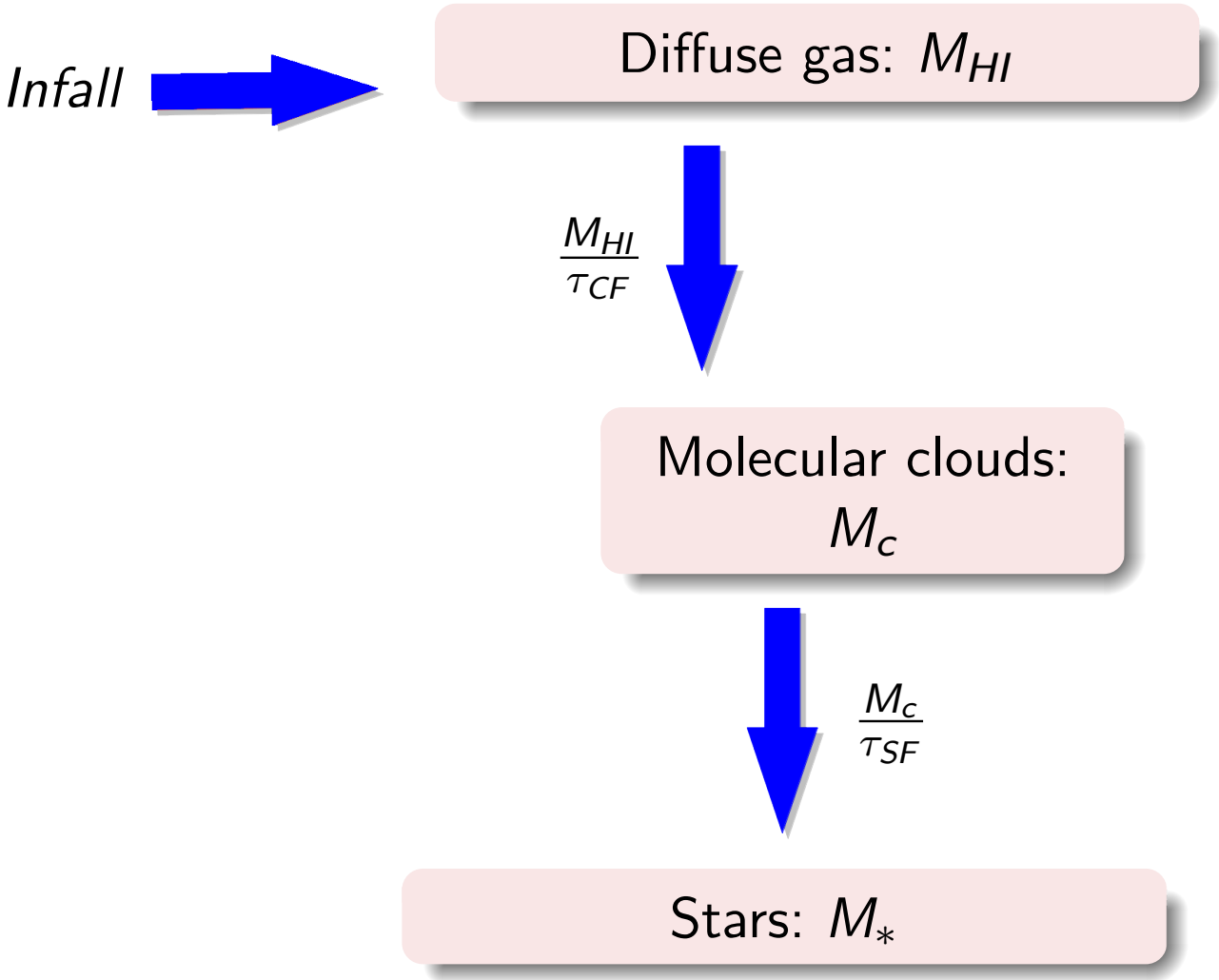

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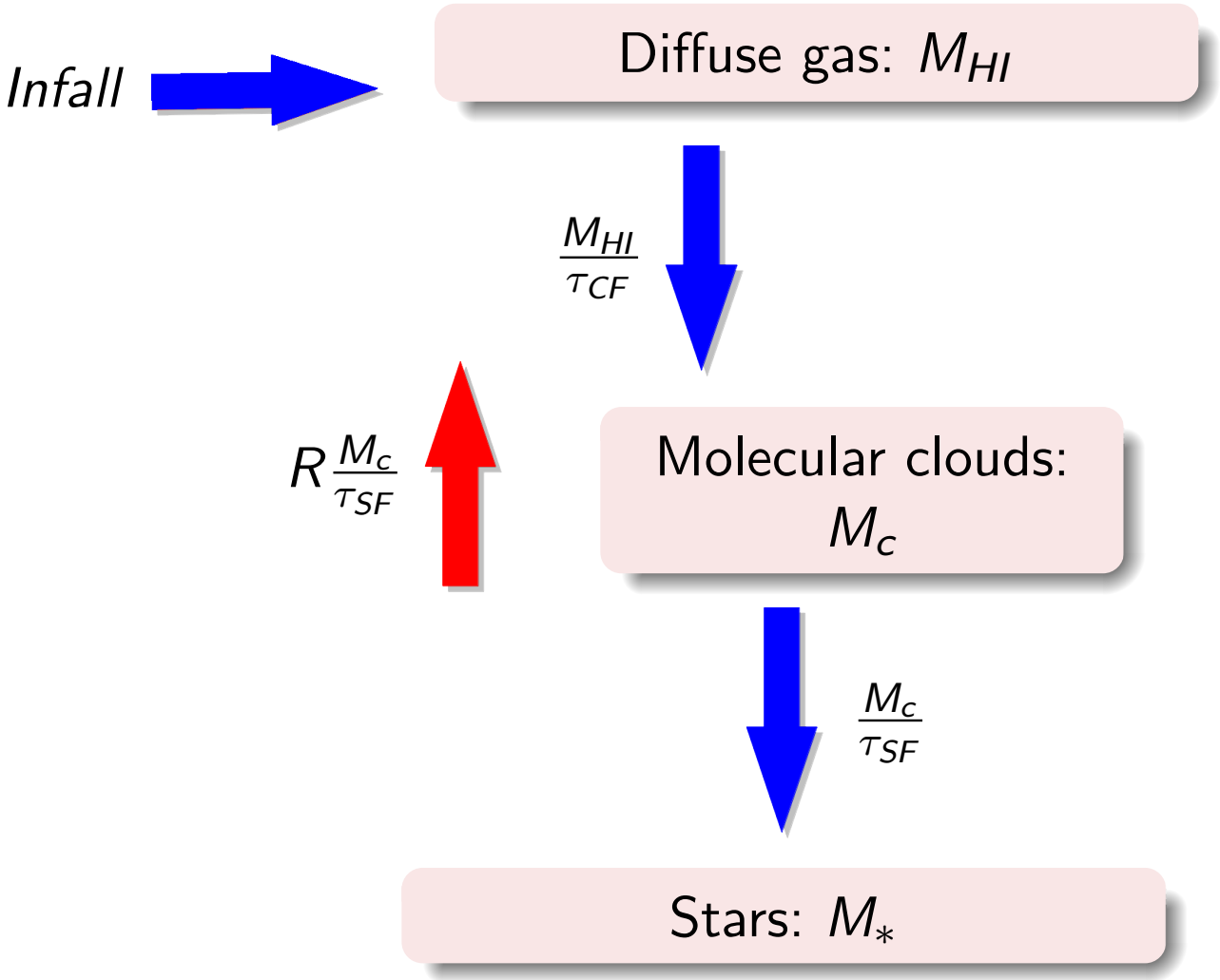

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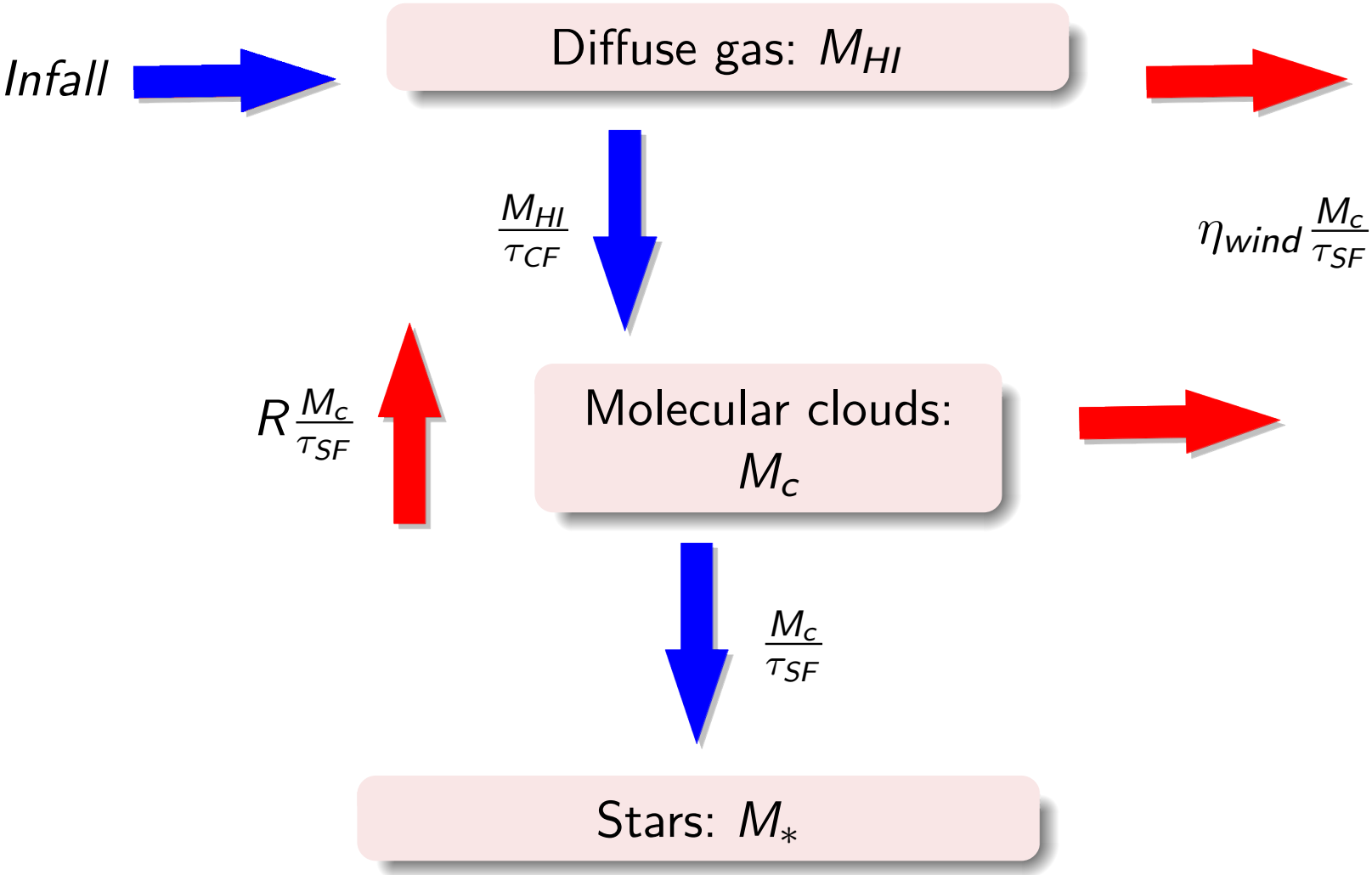

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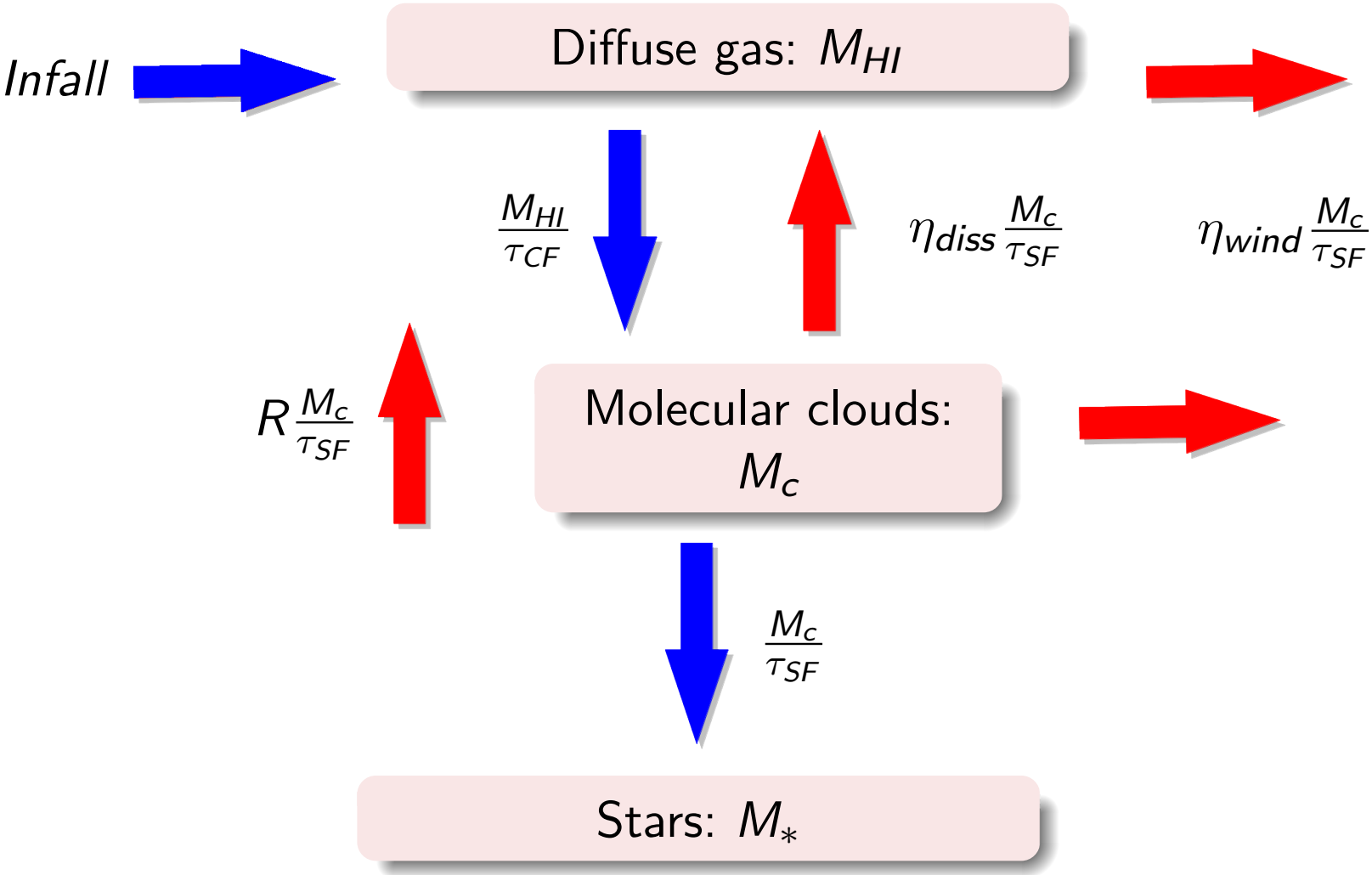

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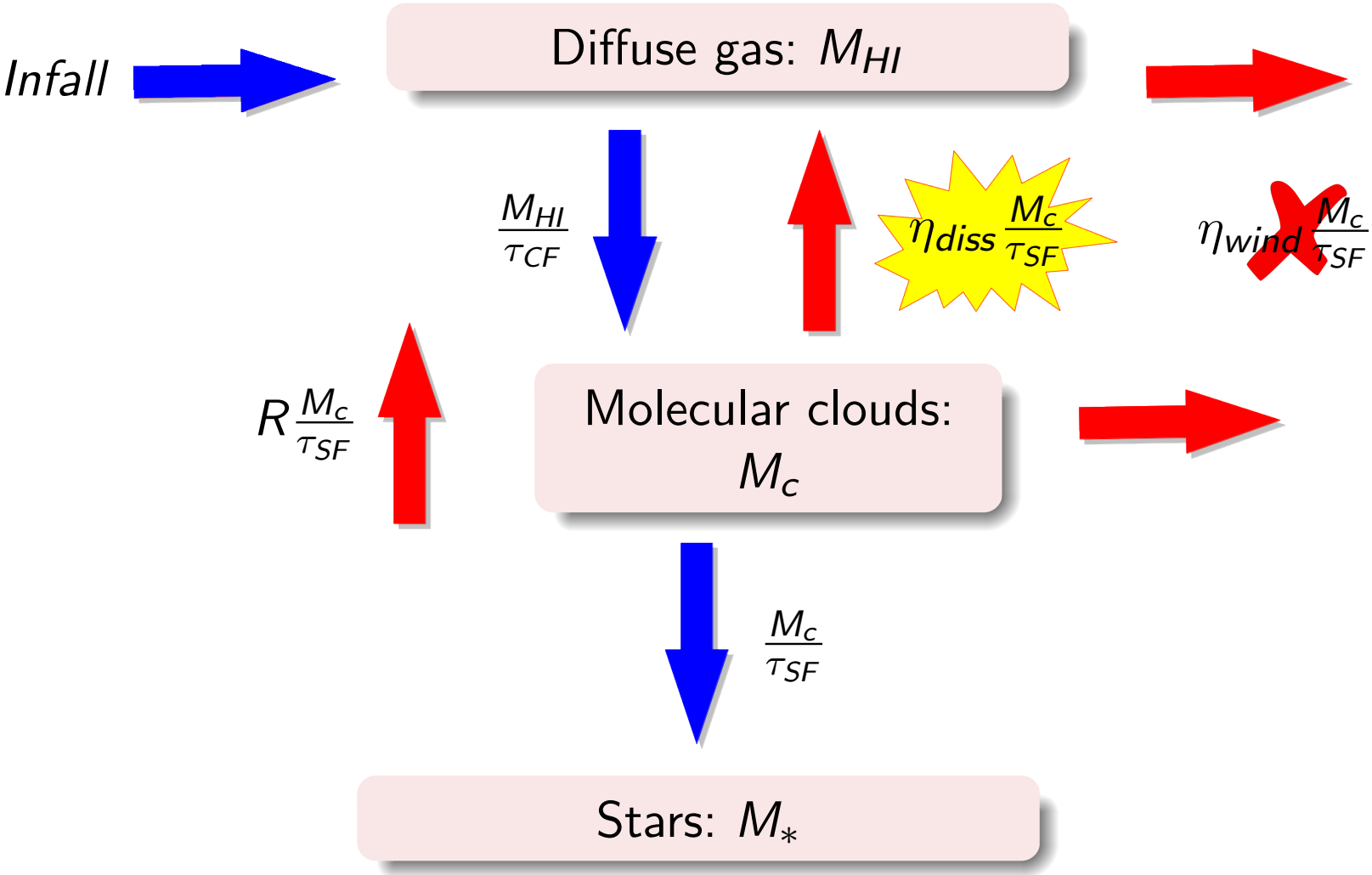

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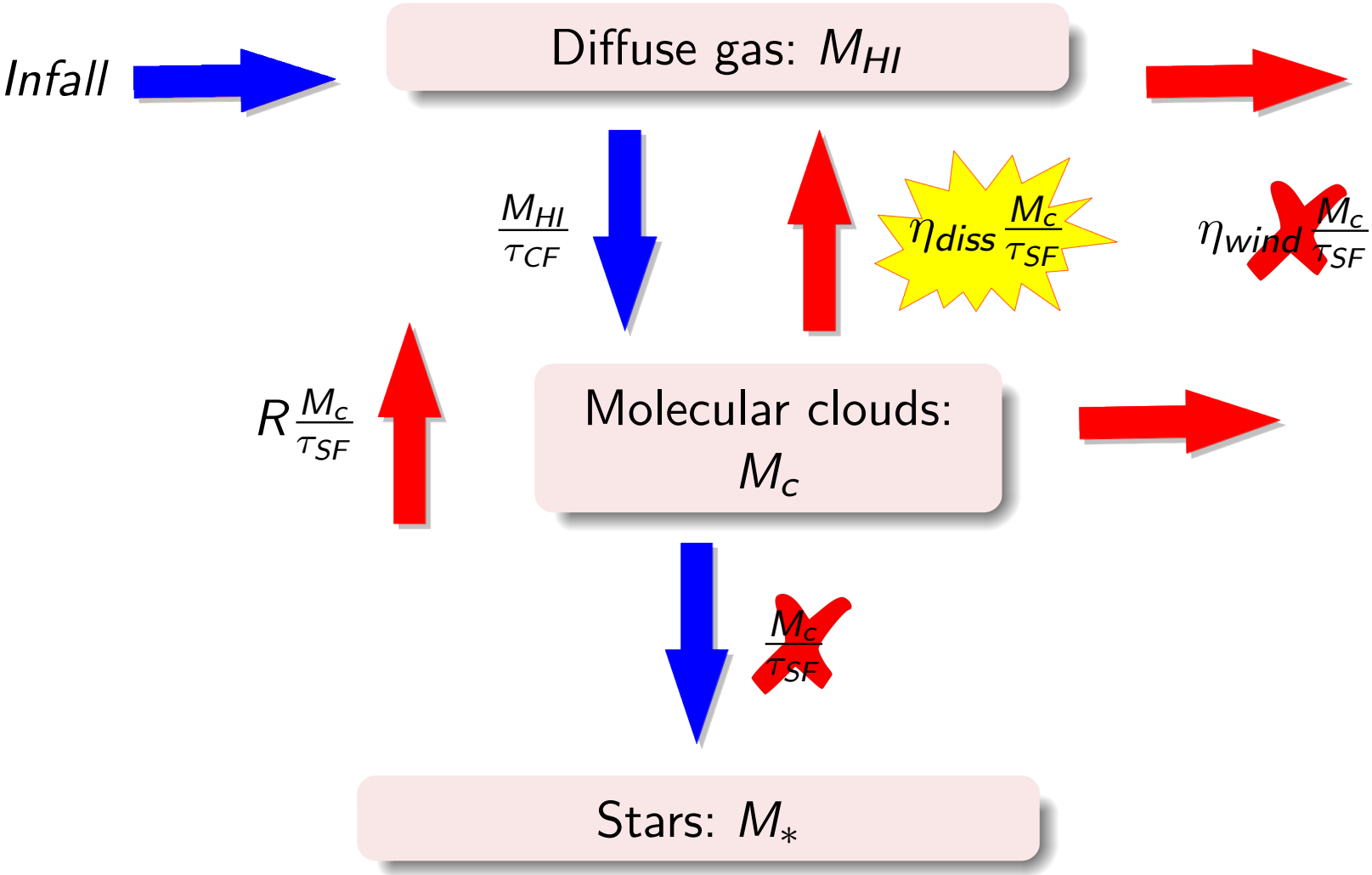
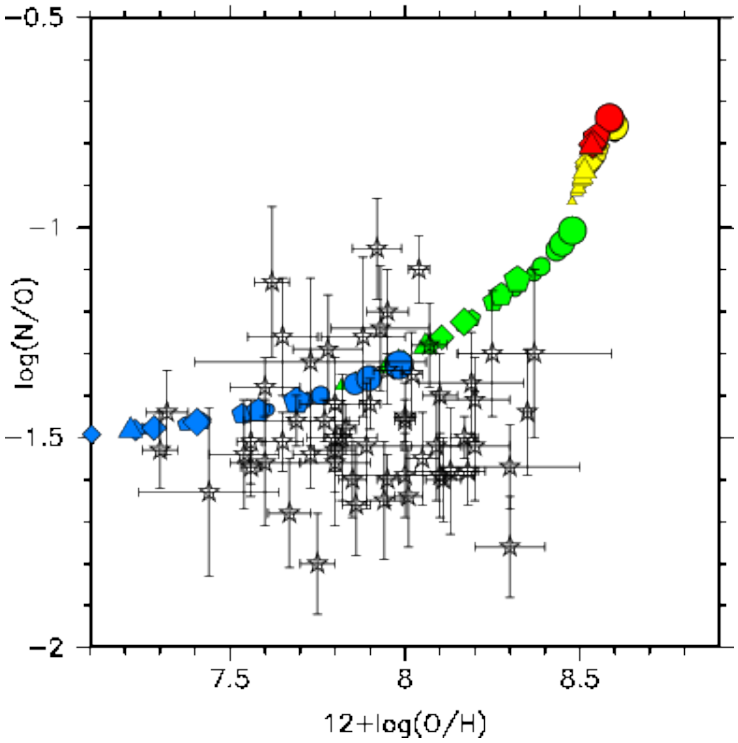


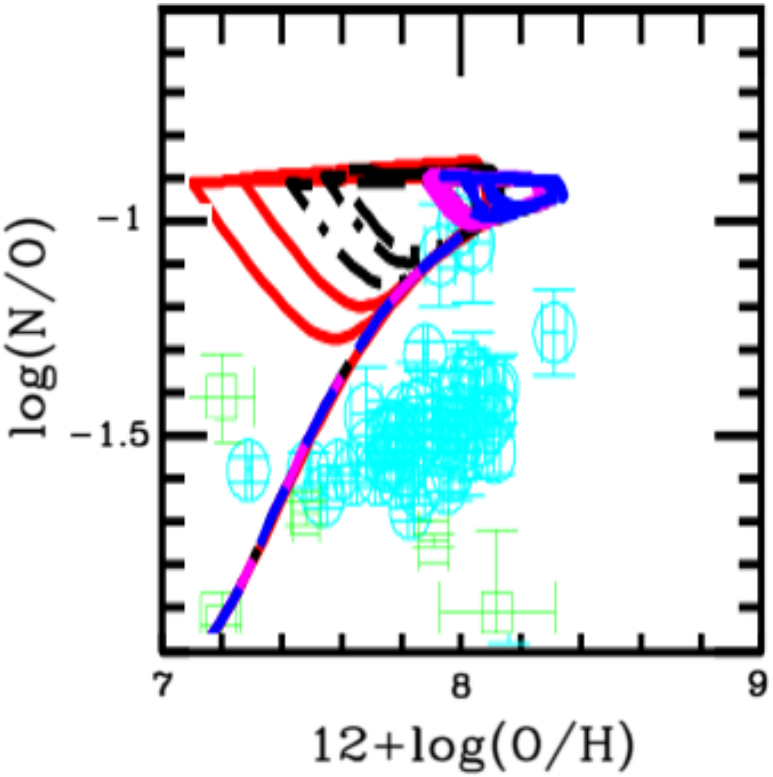
The (chemical) case for weak winds

Nitrogen-to-oxygen ratio

$\eta_{wind} = 0$



$\eta_{wind} \sim 2$



Photodissociation feedback

Gas-rich dwarf galaxies

$$\eta_{wind} \sim 2$$

Gas-poor dwarf galaxies

$$\eta_{wind} \sim 10$$

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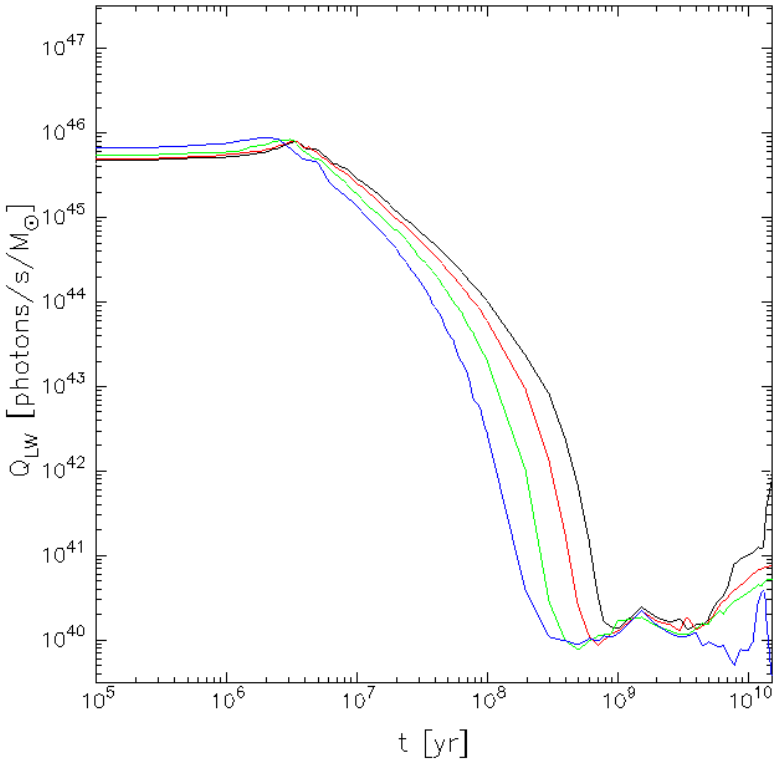
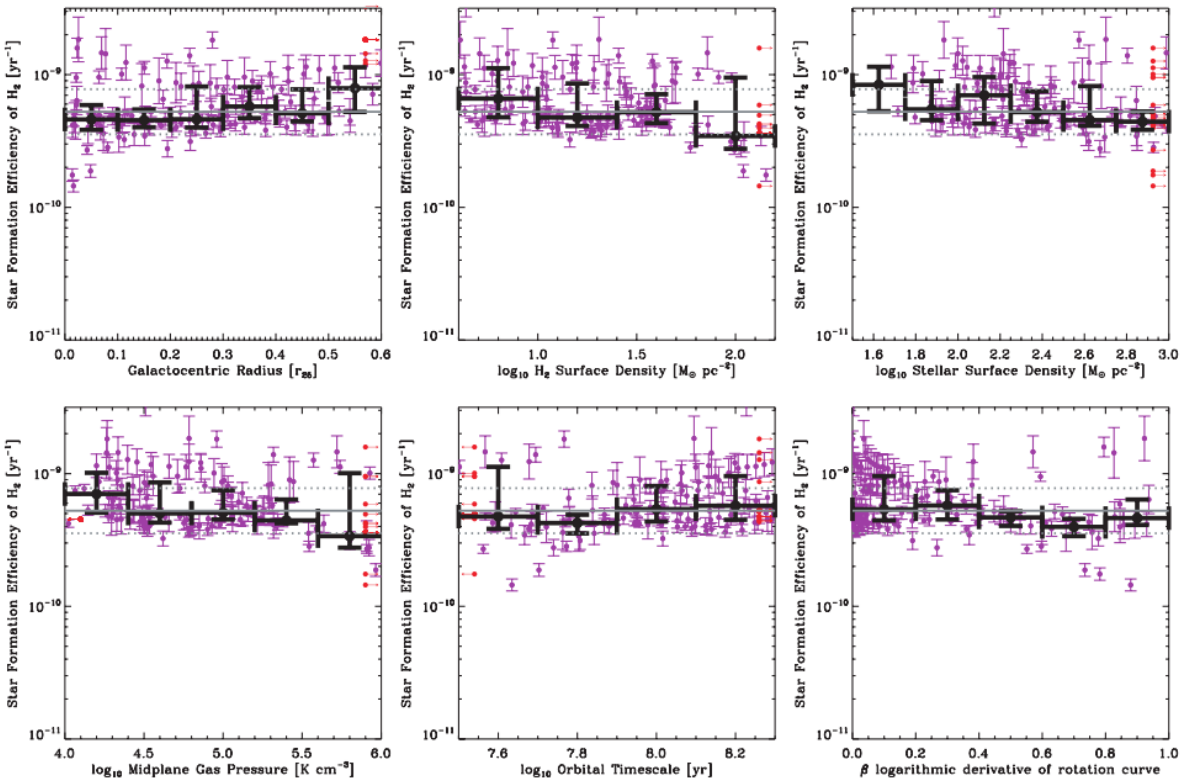


$$\eta_{diss} \sim 300$$

$$\tau_{SF} \sim 2 \text{ Gyr}$$



Why is it irrelevant?

Equations

Diffuse gas

$$\dot{M}_{HI} = Infall - \frac{M_{HI}}{\tau_{CF}} + \left(R + \eta_{diss} - \eta_{wind,HI}\right) \frac{M_c}{\tau_{SF}}$$

Molecular clouds

$$\dot{M}_c = \frac{M_{HI}}{\tau_{CF}} - \left(1 + \eta_{diss} + \eta_{wind,c}\right) \frac{M_c}{\tau_{SF}}$$

Stars

$$\dot{M}_* = \left(1 - R\right) \frac{M_c}{\tau_{SF}}$$

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Steady state

Molecular clouds

$$\dot{M}_c = -\frac{M_c - M_{c,0}}{\tau_{c,0}}$$

$$M_{c,0} \equiv \frac{\tau_{c,0}}{\tau_{CF}} M_{HI}$$

$$\tau_{c,0} \equiv \frac{\tau_{SF}}{1 + \eta_{diss} + \eta_{wind,c}}$$

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$$\leq 10 \text{ Myr}$$

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$$\sim \frac{1}{2\, n_{dust}\, R_{dust}} \frac{300}{1}$$

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$$\tau_{HI,0} \equiv \tau_{CF}\, \frac{1 + \eta_{diss} + \eta_{wind,c}}{(1 - R) + \eta_{wind,HI} + \eta_{wind,c}}$$

$$\sim \frac{1}{2\, n_{dust}\, R_{dust}} \frac{300}{1} \sim \frac{100 \text{ Gyr}}{\frac{n_H}{\text{cm}^{-3}}\, \frac{Z}{Z_\odot}}$$

Does it make any sense?

Model predictions

Star formation

$$\tau_{HI} \equiv \frac{M_{HI}}{SFR} \sim \frac{100\ \mathrm{Gyr}}{\frac{n_H}{\mathrm{cm}^{-3}}\ \frac{Z}{Z_\odot}}$$

$$\tau_* \equiv \frac{M_*}{SFR} = \frac{M_*}{M_{HI}}\ \tau_{HI}$$

Gas density

- Pressure equilibrium
- Scaling relations

Metallicity

$$Z \sim y_{eff}\ \ln\left(\frac{M_{HI}+M_*}{M_{HI}}\right)$$

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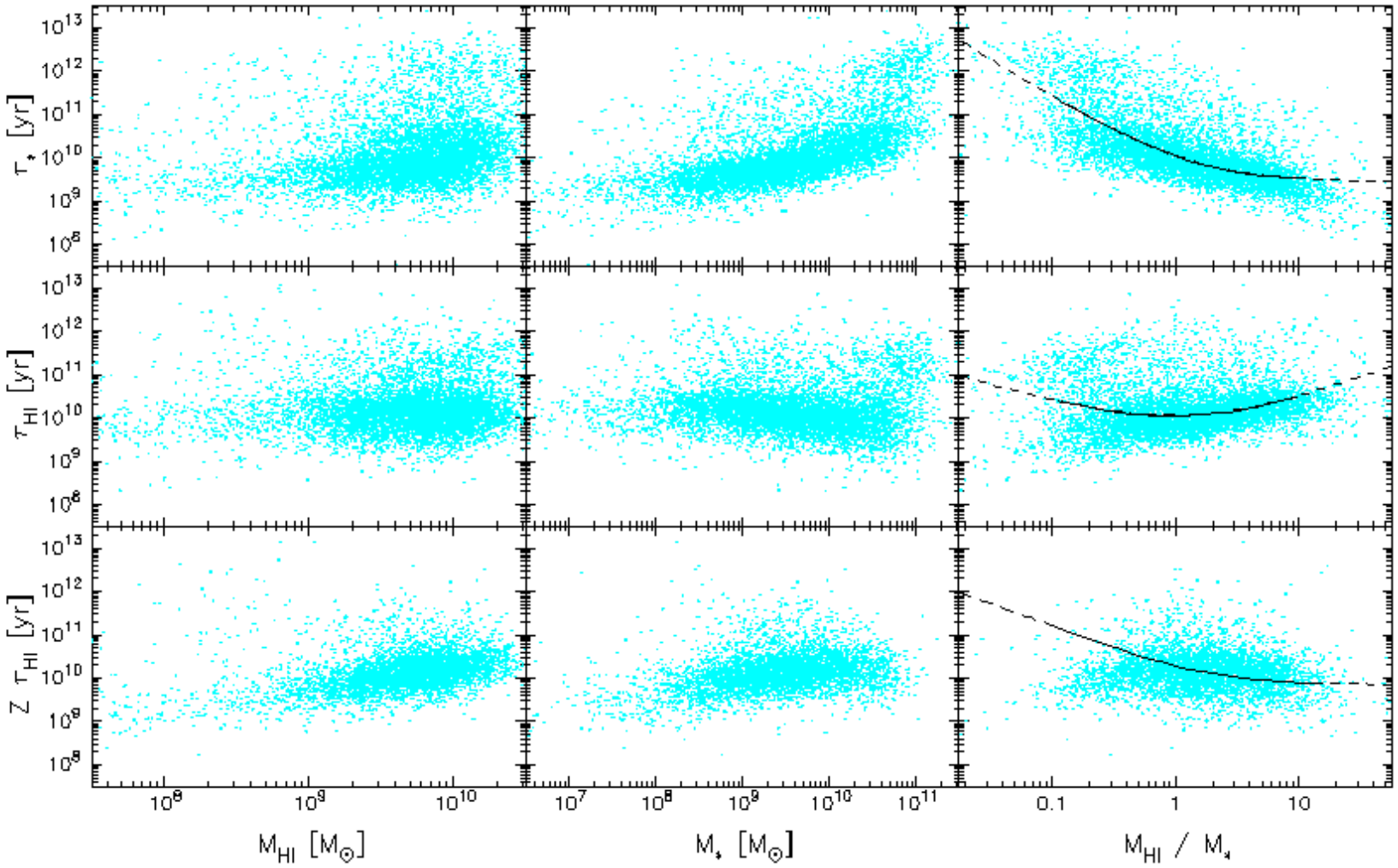

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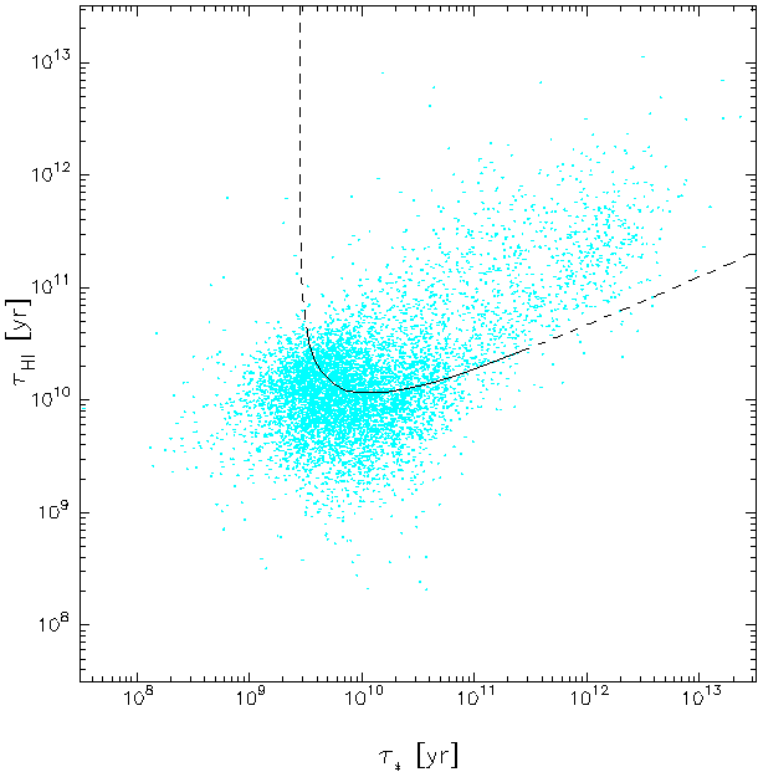

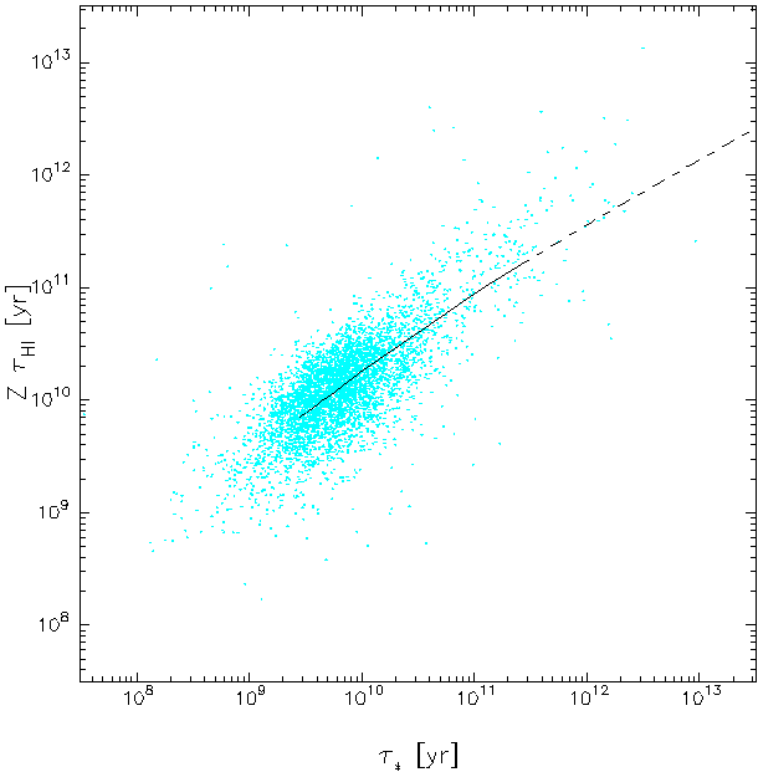

Conclusions

Weak winds?

- N/O ratio
- $\eta_{wind} \ll \eta_{diss}$

Molecular hydrogen

- $\tau_{HI,0} \sim \frac{100\ \mathrm{Gyr}}{(n_H/\mathrm{cm}^{-3})\,(Z/Z_\odot)}$
- $\tau_{c,0} \sim 10$ Myr $\Rightarrow$ steady state

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Thank you