A Novel Model for the Stellar IMF

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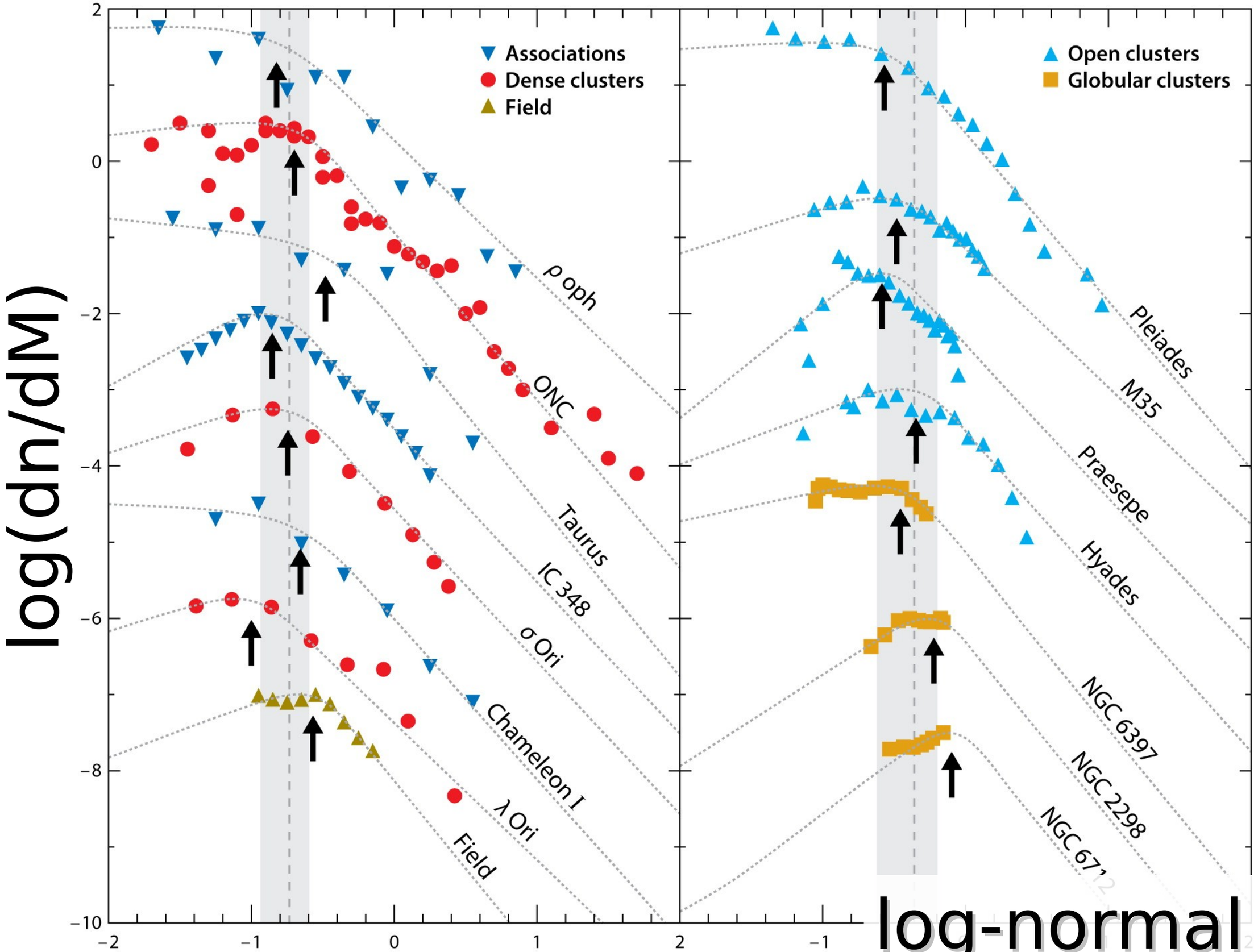
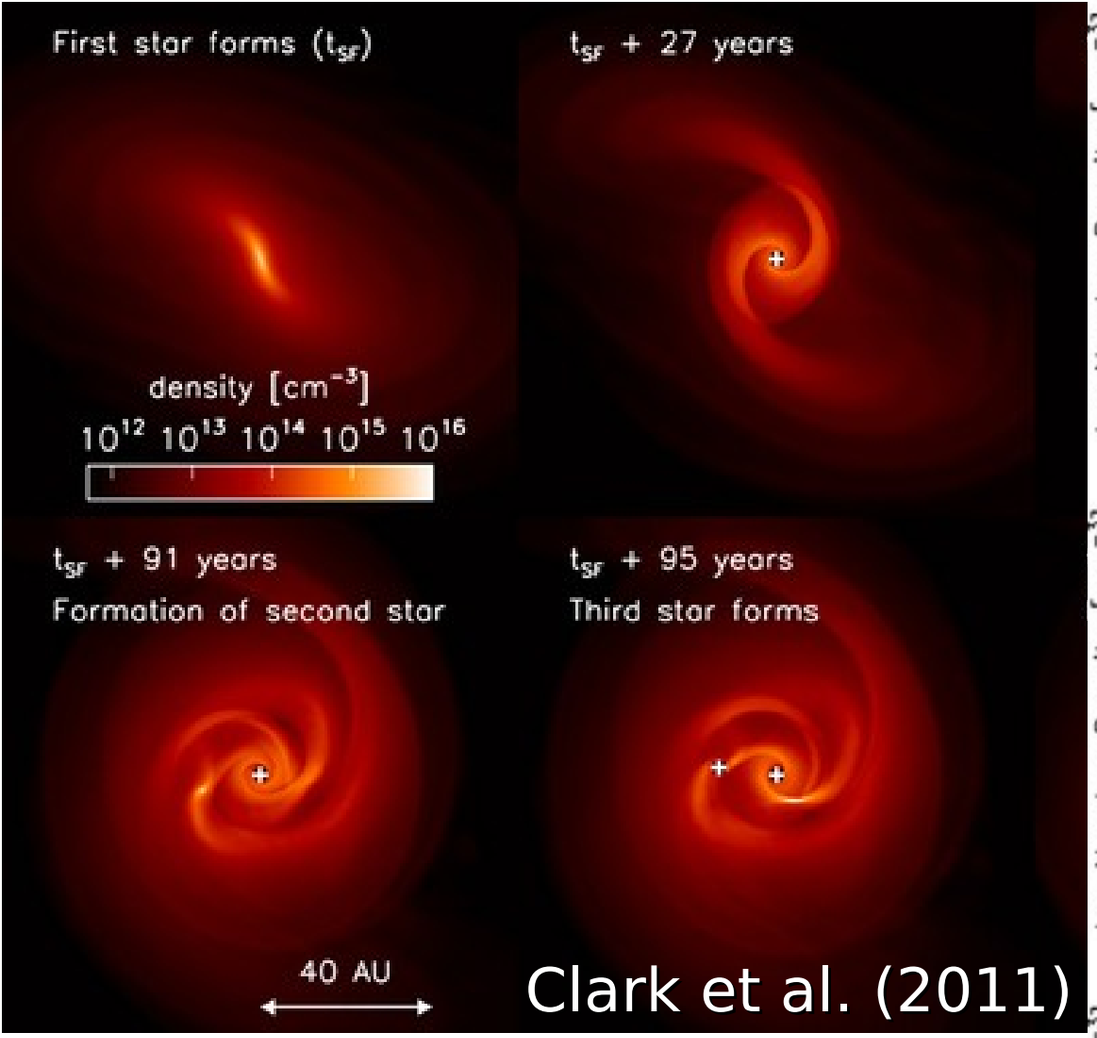
Paul Clark, Simon Glover,
Philipp Girichidis & Ralf Klessen



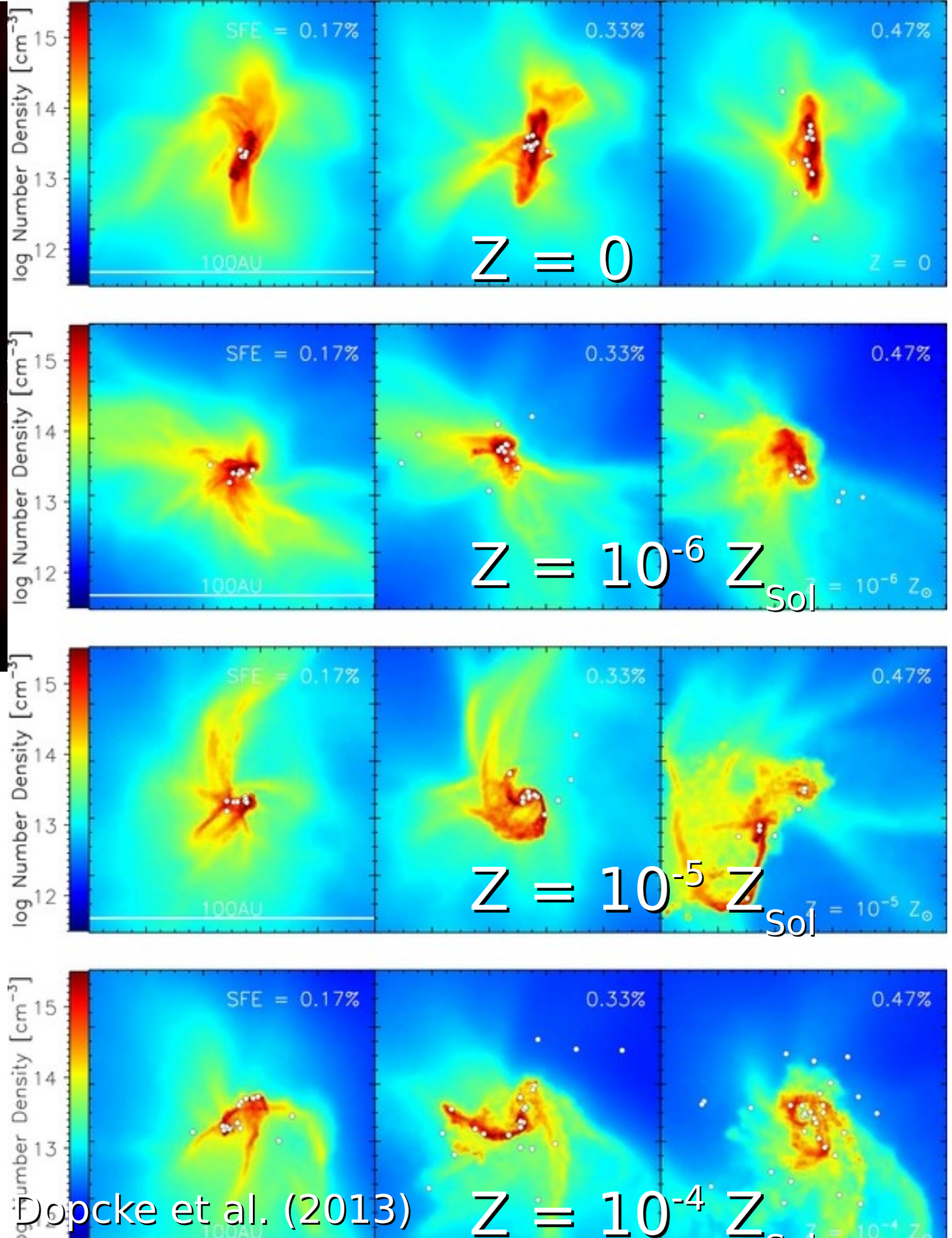
log-normal + power law

Bastian N, et al. 2010.
Annu. Rev. Astron. Astrophys. 48:339–89

M17 – ESO
Omega Nebula

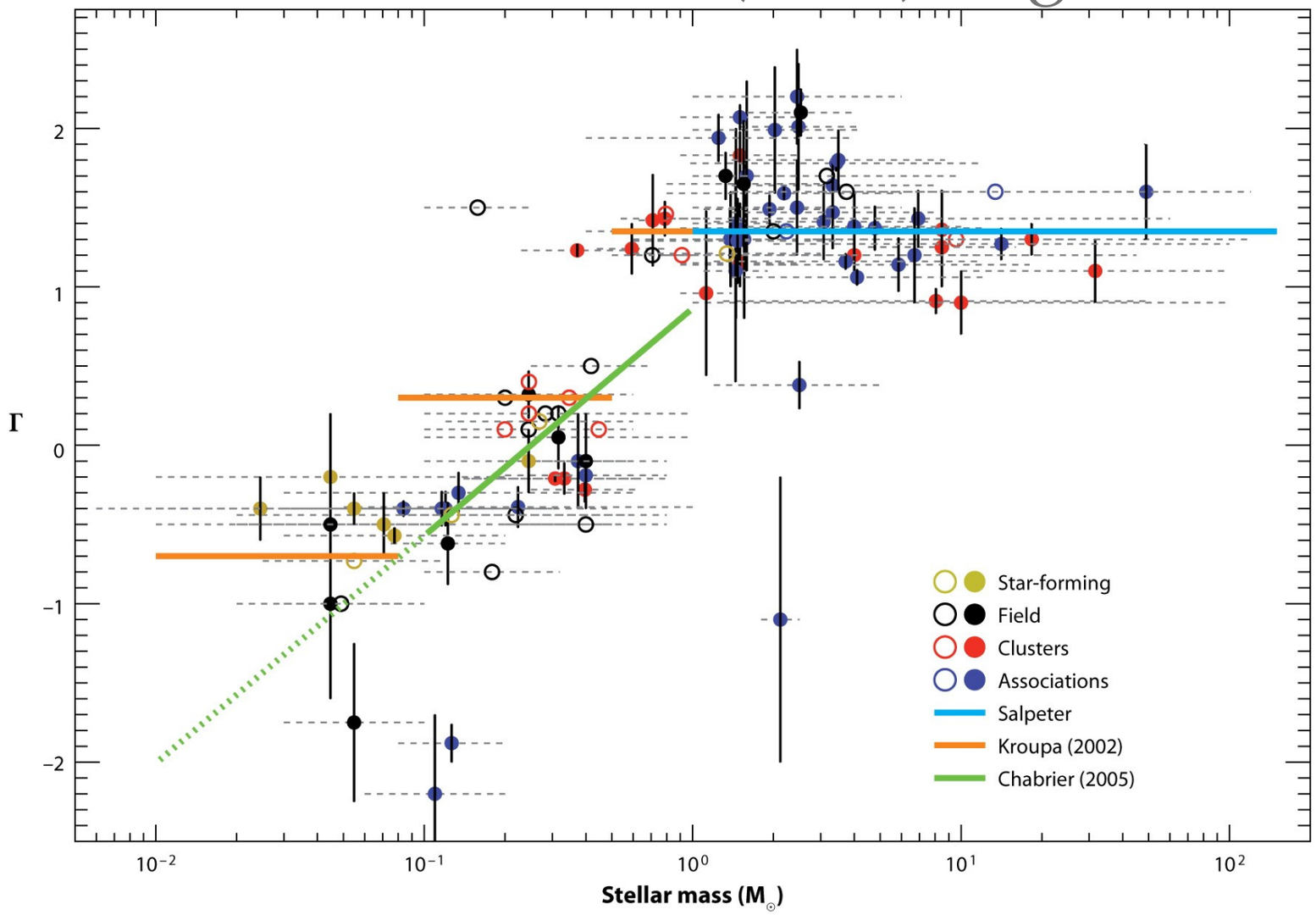


IMF Variations Metallicity



Log-normal + Power Law

- Salpeter (1955): $\Phi(\log M) = \dfrac{dN}{d\log M} \propto M^{-\Gamma}$
- Miller & Scalo (1979): log-normal



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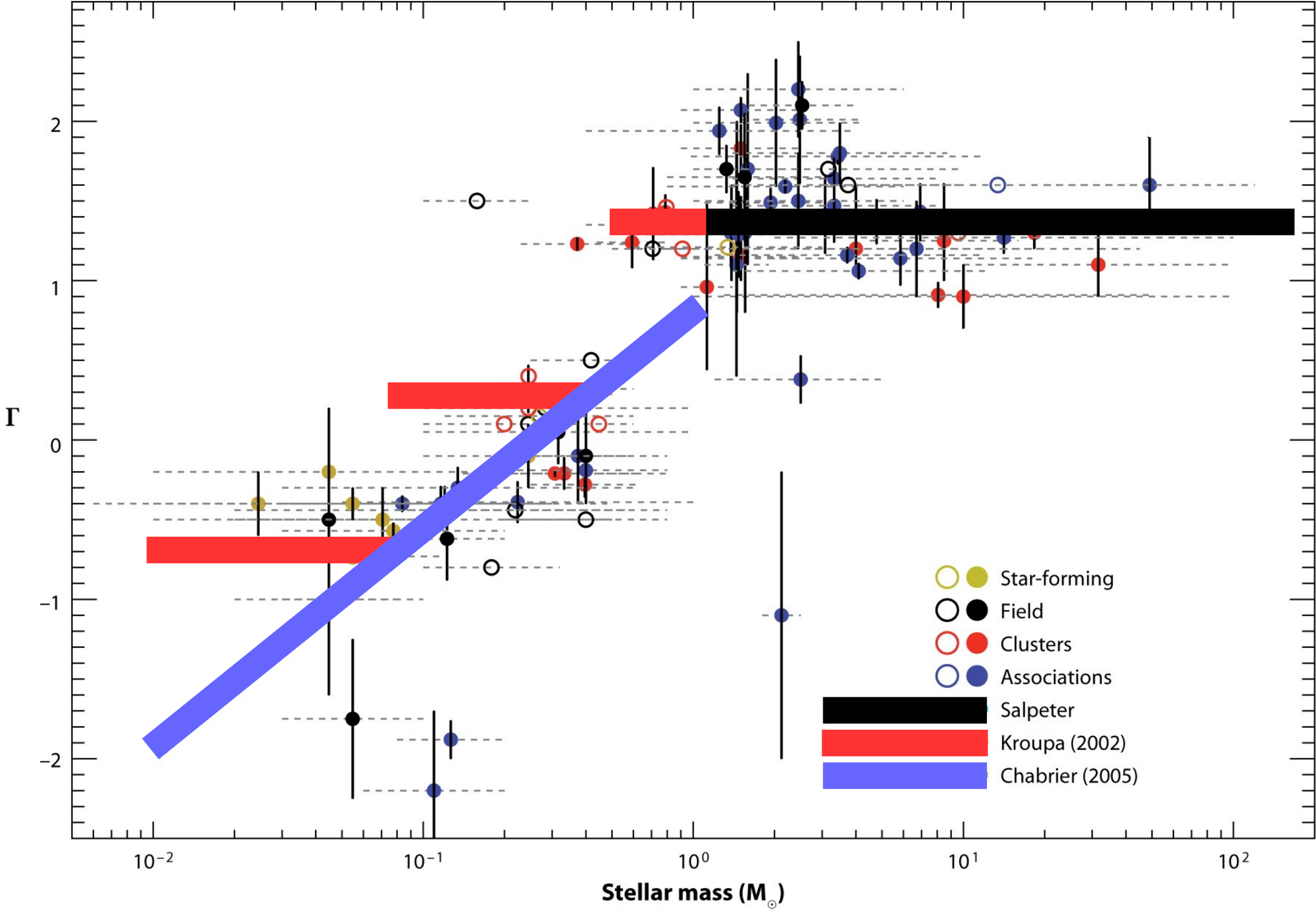

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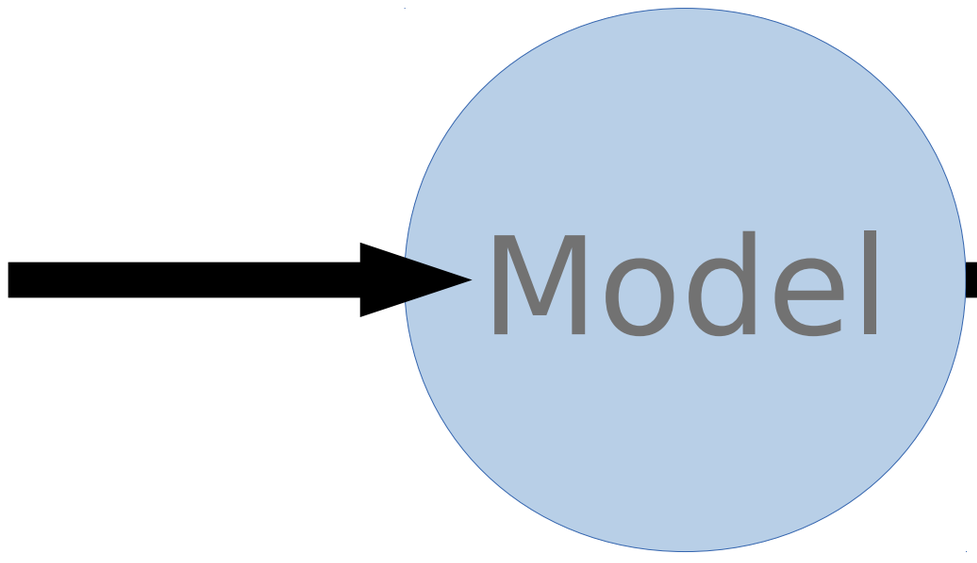
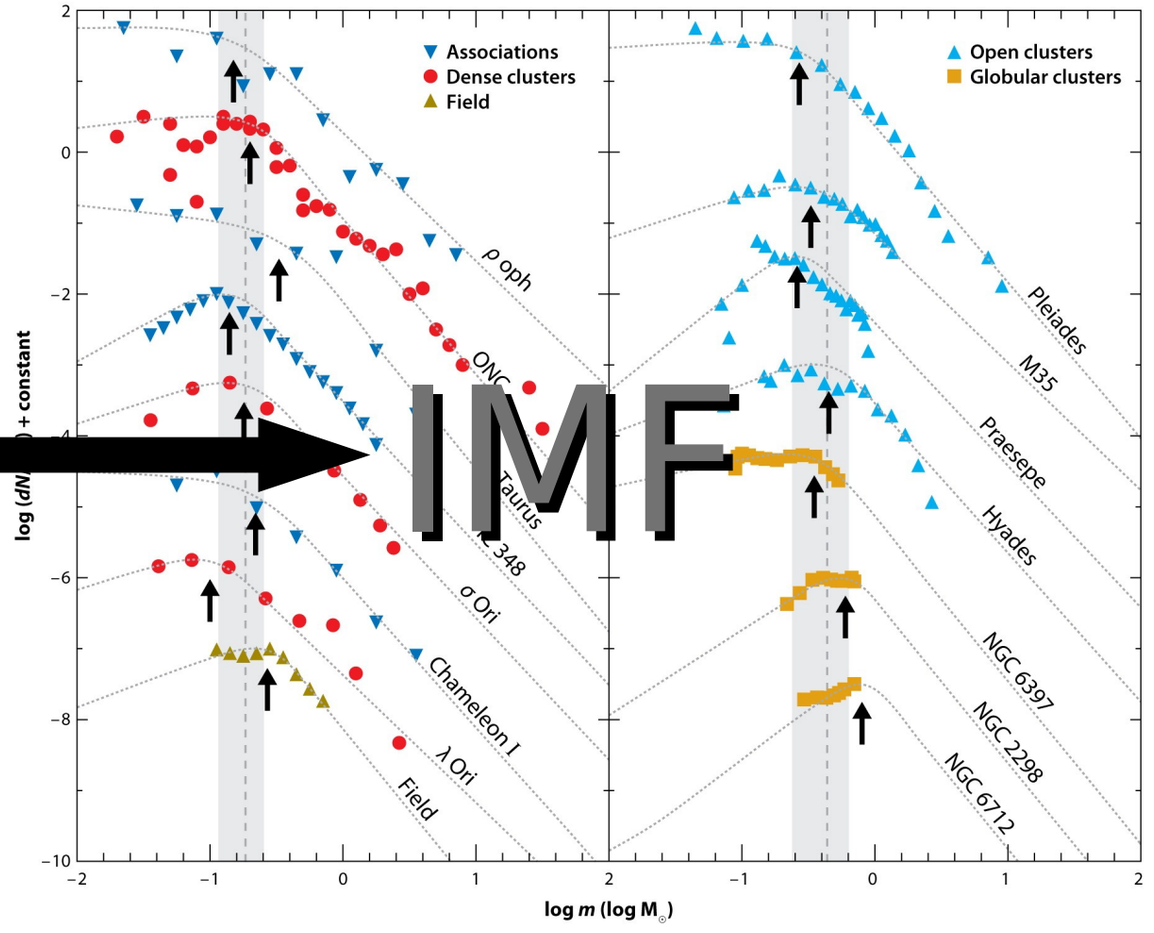
This Model

- Semi-analytical model for the IMF
- 4 free parameters:
  - Mi: Initial Mass
  - $\dot{M}$: Accretion Rate
  - $\dot{n}$: Fragmentation Rate
  - α: accretion power

Mi
$\dot{M}$
$\dot{n}$
α





This Model

Mi = Initial Mass

$\dot{n}$ = fragmentation rate

$\dot{M}$ = accretion rate

$$M_{acc} = \dot{M}*t - Mi$$

t = 0

Mi

t = 1

$M_i + M_{acc}$

Mi

t = 2

$M_{11} + M_{acc}/2$

$Mi + M_{acc}/2$

Mi

$$M_{acc} = \dot{M} * t - Mi$$

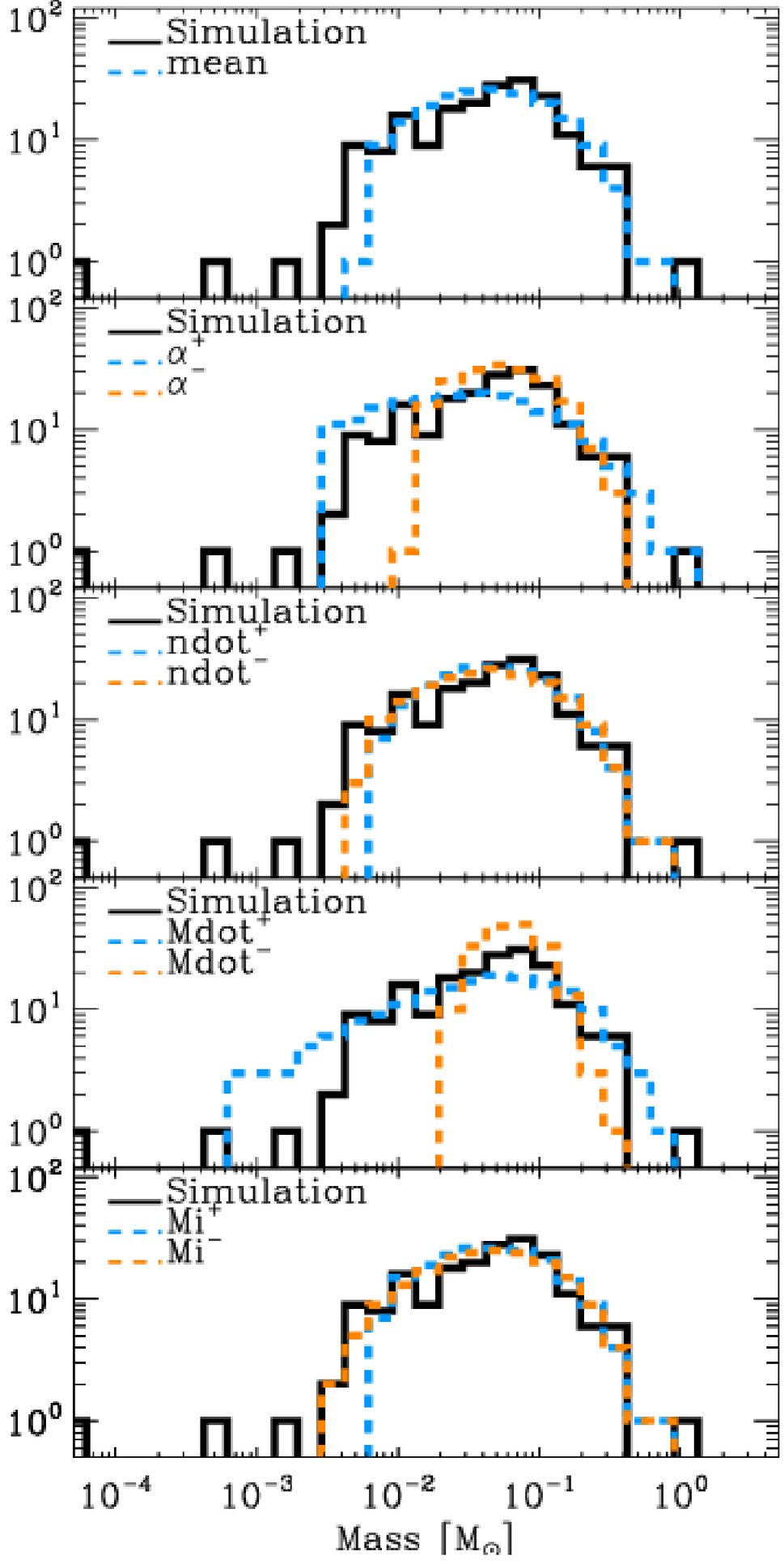
$$\frac{M_{acc} M_1}{M_1 + M_2} \qquad \frac{M_{acc} M_2}{M_1 + M_2}$$

$$\frac{M_{acc} M_1^{\alpha}}{M_1^{\alpha} + M_2^{\alpha}} \qquad \frac{M_{acc} M_2^{\alpha}}{M_1^{\alpha} + M_2^{\alpha}}$$

- Mi: Initial Mass
- $\dot{M}$: Accretion Rate
- $\dot{n}$: Fragmentation Rate
- α: accretion power

Modeling Simulations

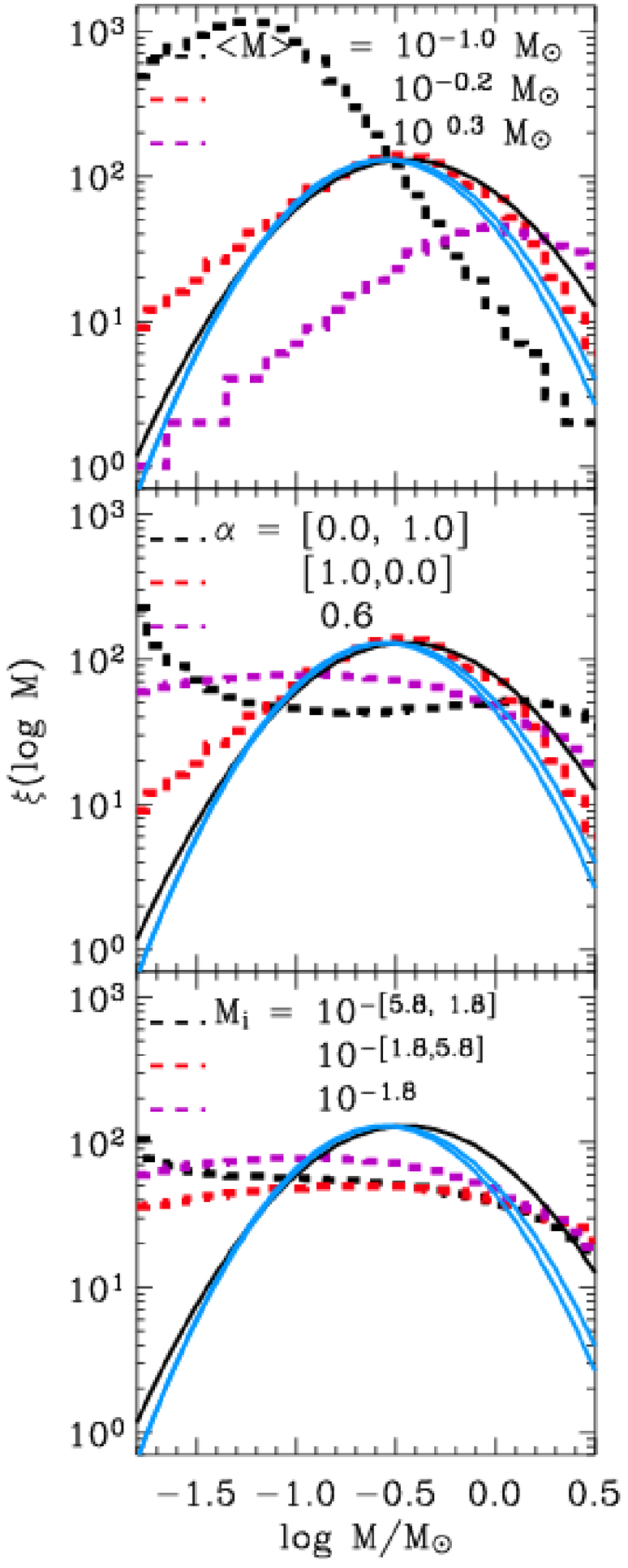
- Grid-based hydro simulations by Philipp Girichidis
- Mi, dM/dt, dn/dt, and α from simulations
- "-" e "+" indicates values lower (μ-σ) and above (μ+σ) the average



10^2
10^1
10^0
Simulation
α^+
α^-
10^2
10^1
10^0
Simulation
ndot^+
ndot^-
10^2
10^1
10^0
Simulation
Mdot^+
Mdot^-
10^2

Modeling Observations

- Observations from da Rio+2012
- Values from observations of the Orion Nebula Cluster
- M_{tot}, age, and n_{tot}: dM/dt, dn/dt



10^3

10^2

10^1

10^0

$\xi(\log M)$

α = [0.0, 1.0]

[1.0,0.0]

0.6

10^3

10^2

10^1

10^0

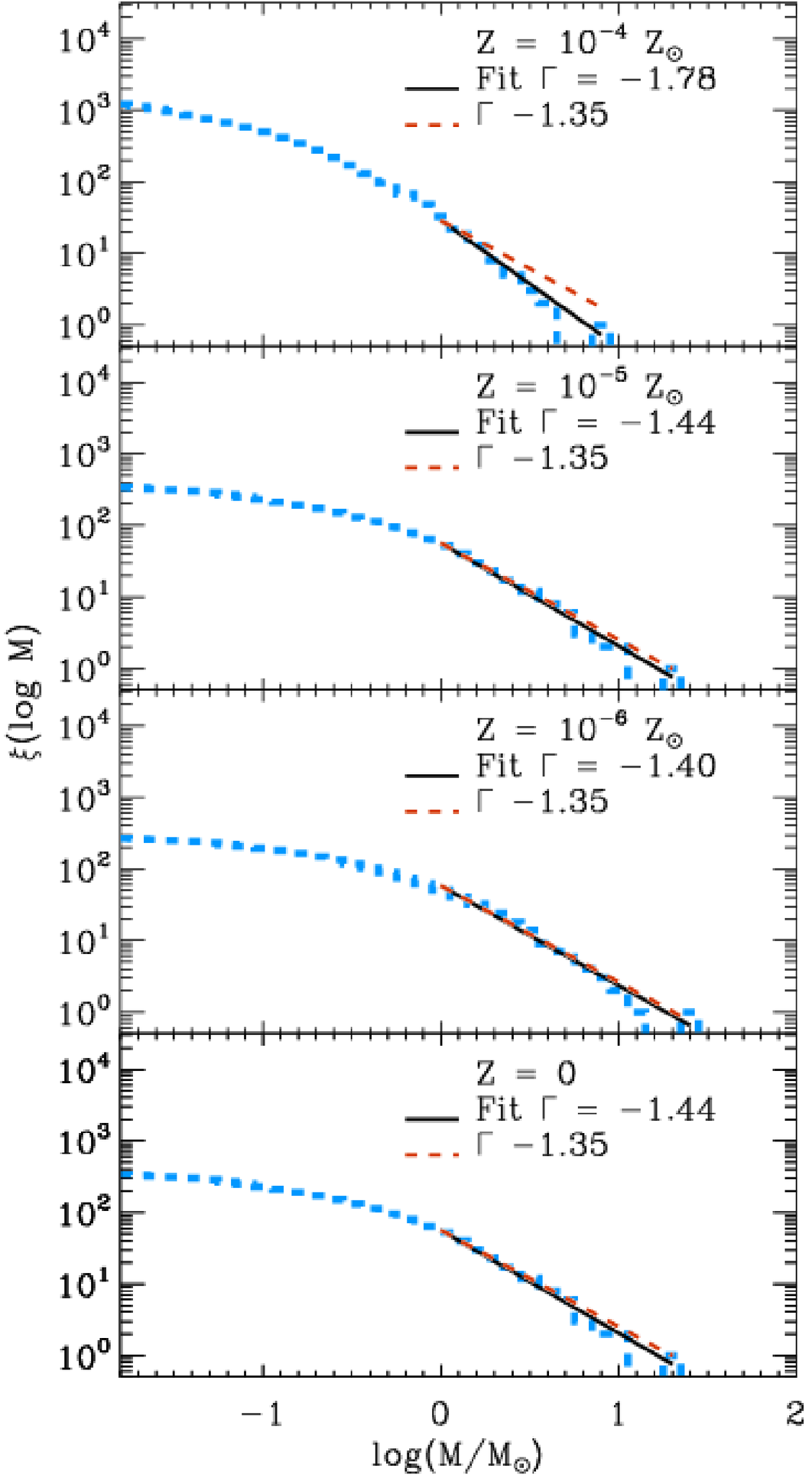
$M_i = 10^{-[5.8,\ 1.8]}$

$10^{-[1.8,5.8]}$

$10^{-1.8}$

Evolving Simulations

- Evolve simulations of different metallicities
- Slope grows with metallicity (bottom heavy for higher mettalicities).



Conclusions

- This model is simple (4 free parameters);
- Permits to reproduce and analyze simulations and observations;
- Permits to evaluate the influence of theoretical parameters on the IMF.

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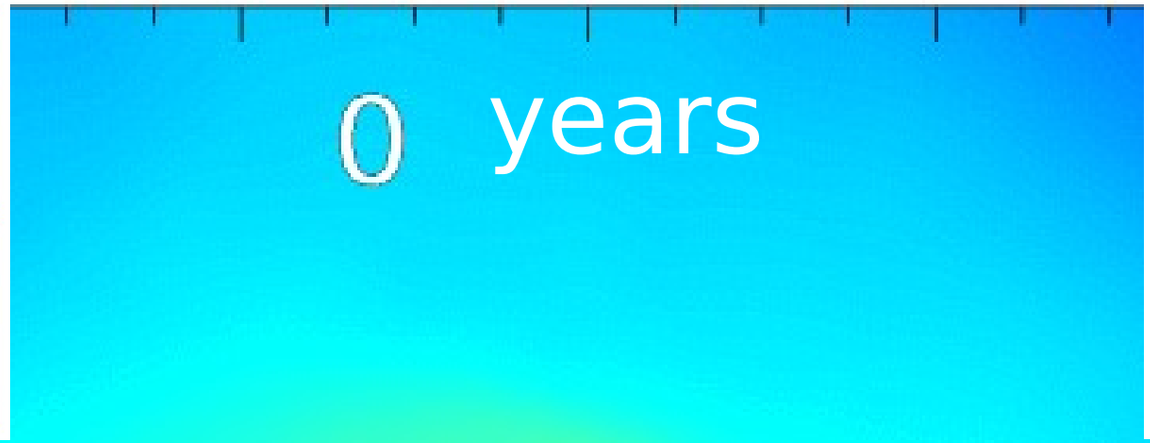
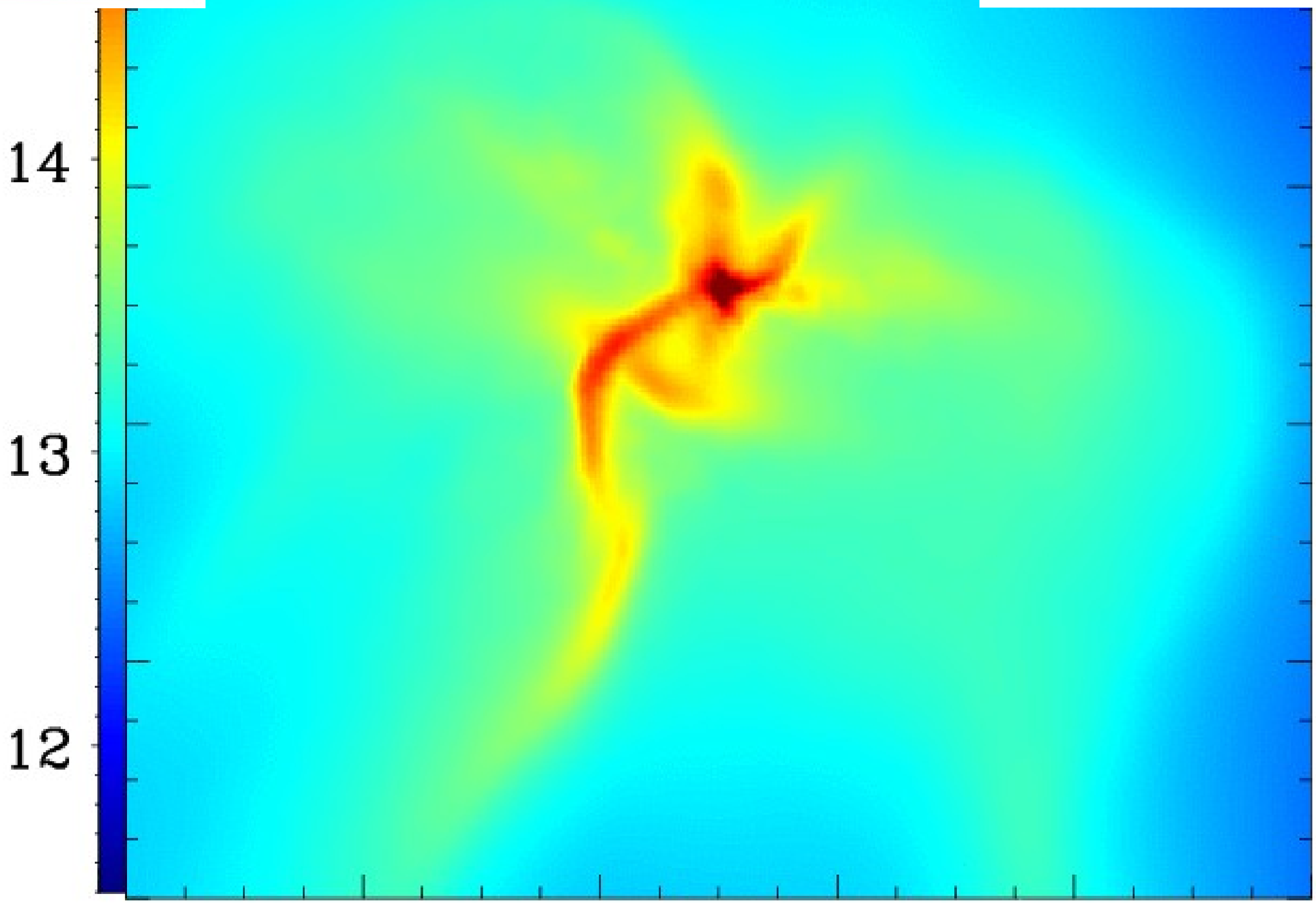
PRIFYSGOL CAERDYDD



SCIENCE WITHOUT BORDERS



Gustavo Dopcke

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100 AU

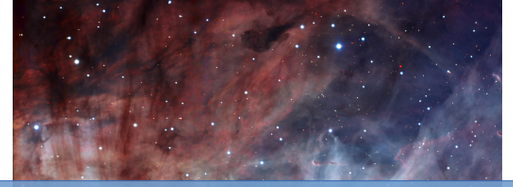
Dopcke, et al. (2013)

Models

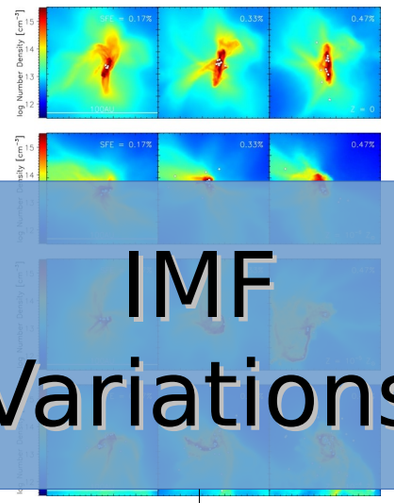
- Silk & Takahashi 79
  - Coagulation: $1 < \Gamma < 2$
- Zinnecker 82
  - Competitive Accretion: $\Gamma \sim 1$
- Klessen 01
  - Turbulence: $\Gamma = 1$
  - Turbulence-Free: $\Gamma = 0.5$

Theory

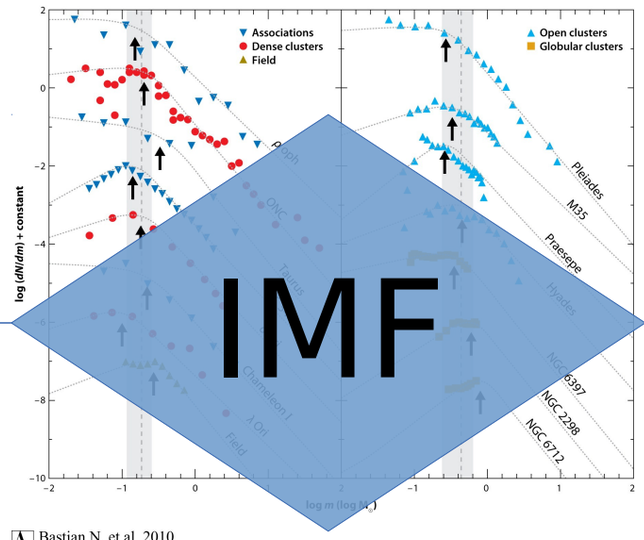
- Hennebelle & Chabrier 08
  - Supersonic turbulence: conects CMF to IMF
- Bonnell 01
  - Competitive Accretion
    - Gravitational potential
      - gas: $\Gamma = 0.5$
      - stars: $\Gamma = 1.5$



Star Formation



IMF Variations



IMF

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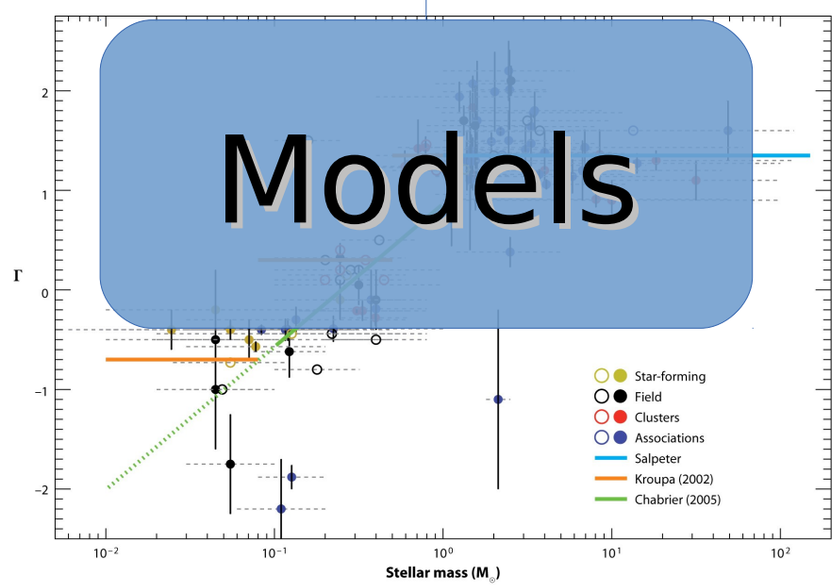

Models

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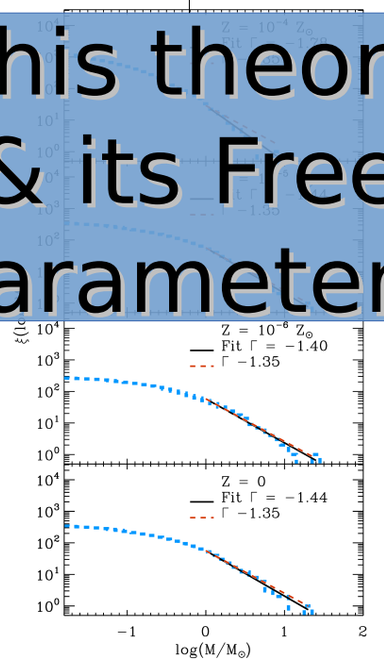

This theory & its Free Parameters

Results

- Reproduces SPH sims
- Values from simulations
- Values below (μ-σ) and above (μ+σ) average