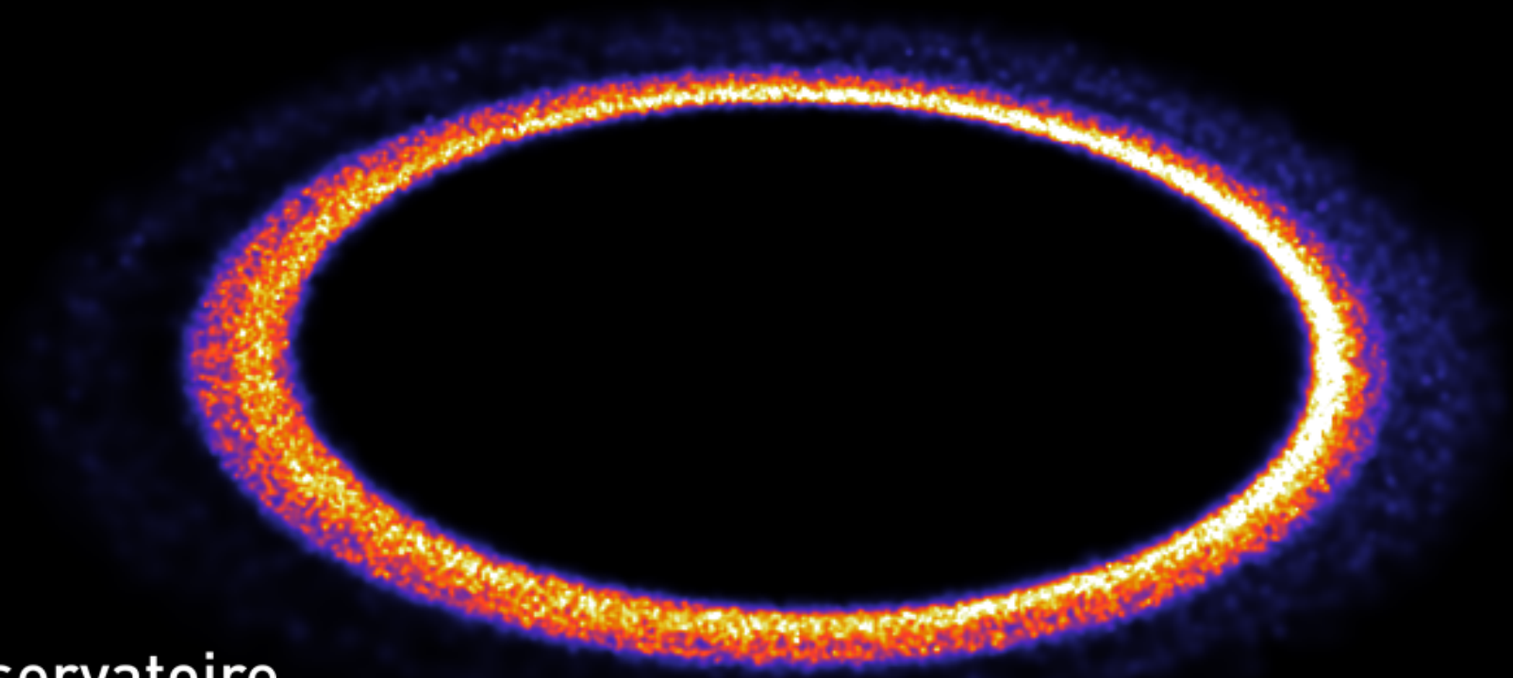
SELF-INDUCED DUST TRAPS AROUND SNOWLINES IN PROTOPLANETARY DISCS

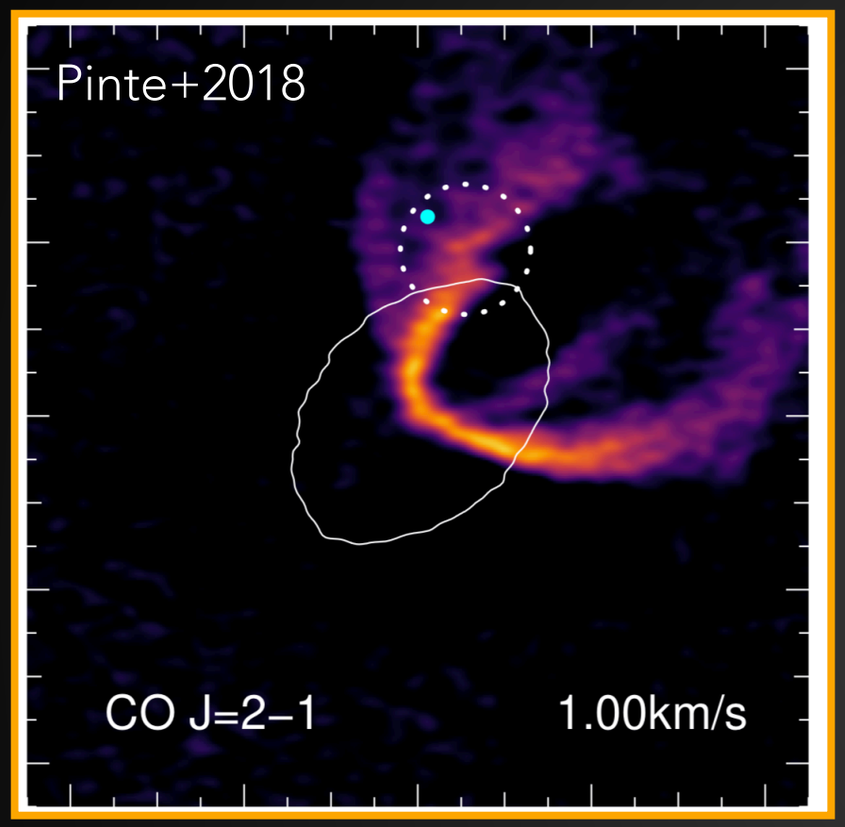


Arnaud Vericel, Jean-François Gonzalez

Centre de Recherche Astrophysique de Lyon

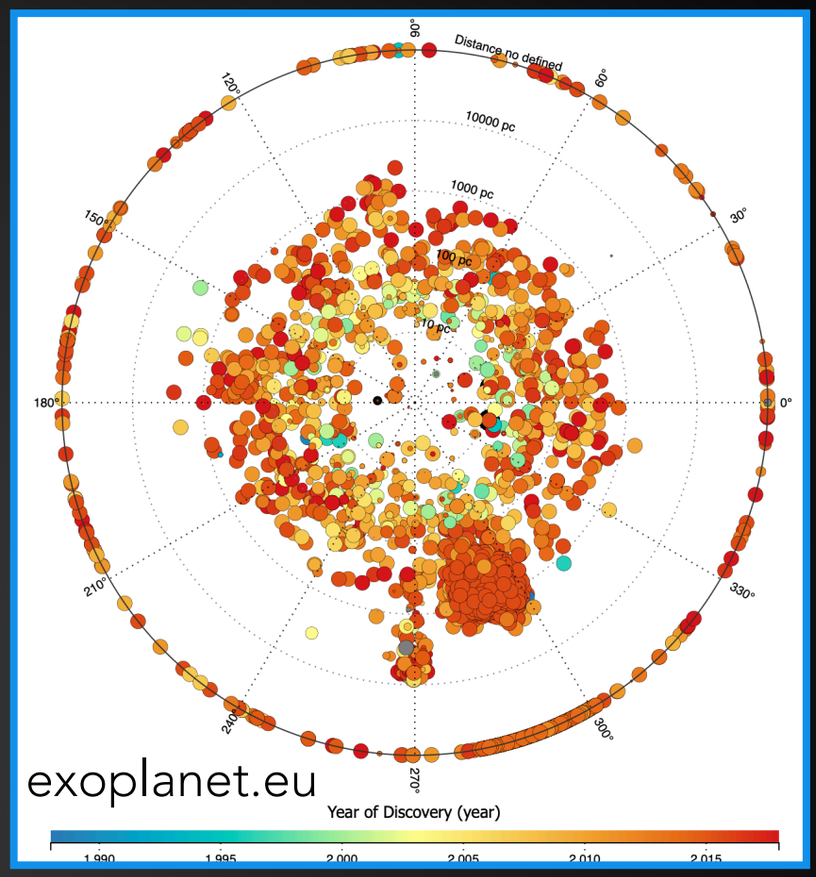
SF2A 2019, Nice

WHY DO WE CARE ?

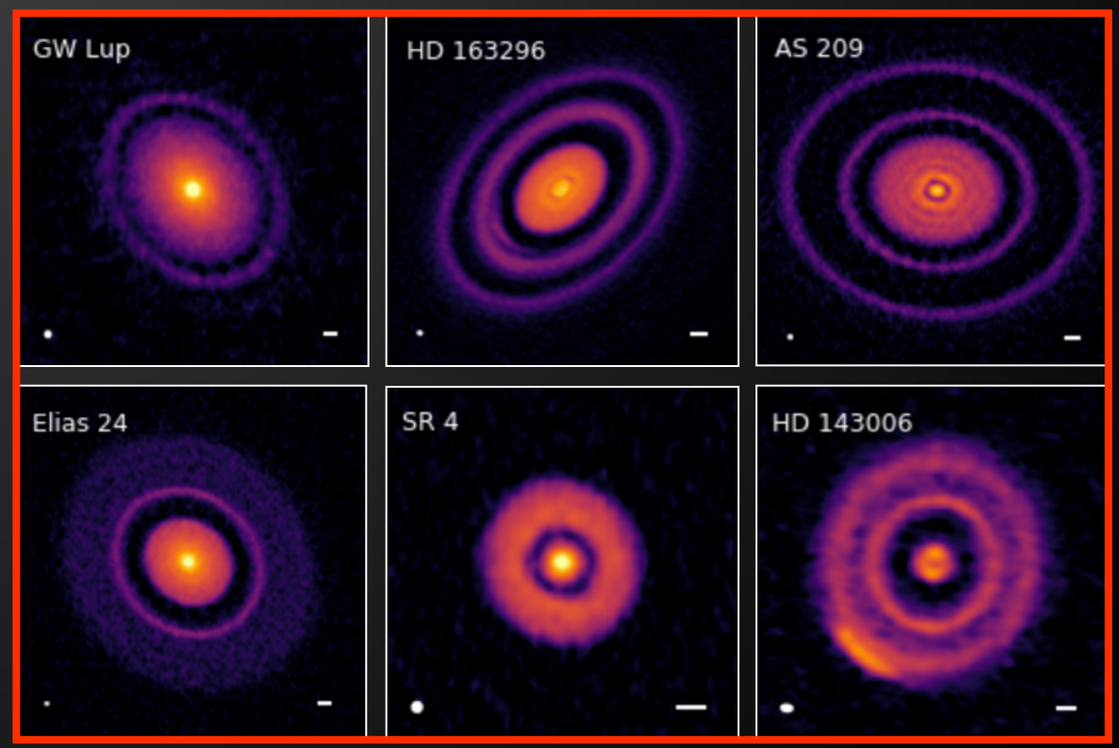


Planets during protoplanetary disc phase

Exoplanet population growing and diversified



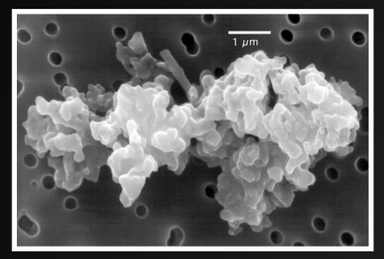
Dust structures in the mm with ALMA



Andrews+2018

...BUT!

$$\mathrm{St} = \frac{t_s}{t_k} = \frac{\Omega_k \rho_s}{\rho_g c_s} s$$



µm mm-cm m km

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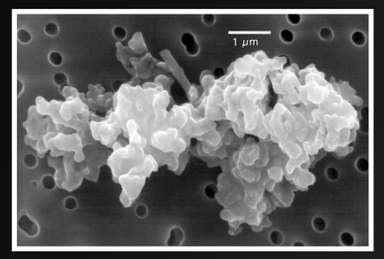
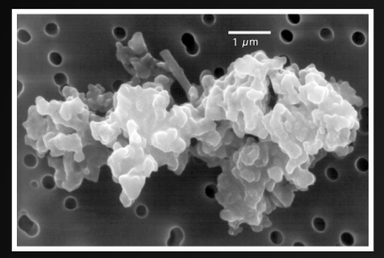


µm | mm-cm | m | km

$\mathrm{St} \ll 1$ | $\mathrm{St} \gg 1$

...BUT!



$$\mathrm{St} = \frac{t_s}{t_k} = \frac{\Omega_k \rho_s}{\rho_g c_s} s$$

µm mm-cm m km

$\mathrm{St} \ll 1$ $\mathrm{St} \sim 1$ $\mathrm{St} \gg 1$

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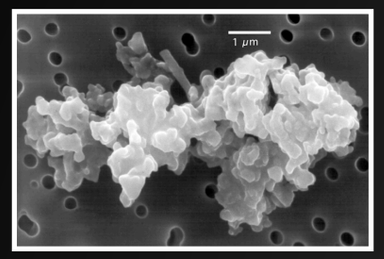
$$\mathrm{St} = \frac{t_s}{t_k} = \frac{\Omega_k \rho_s}{\rho_g c_s} s$$

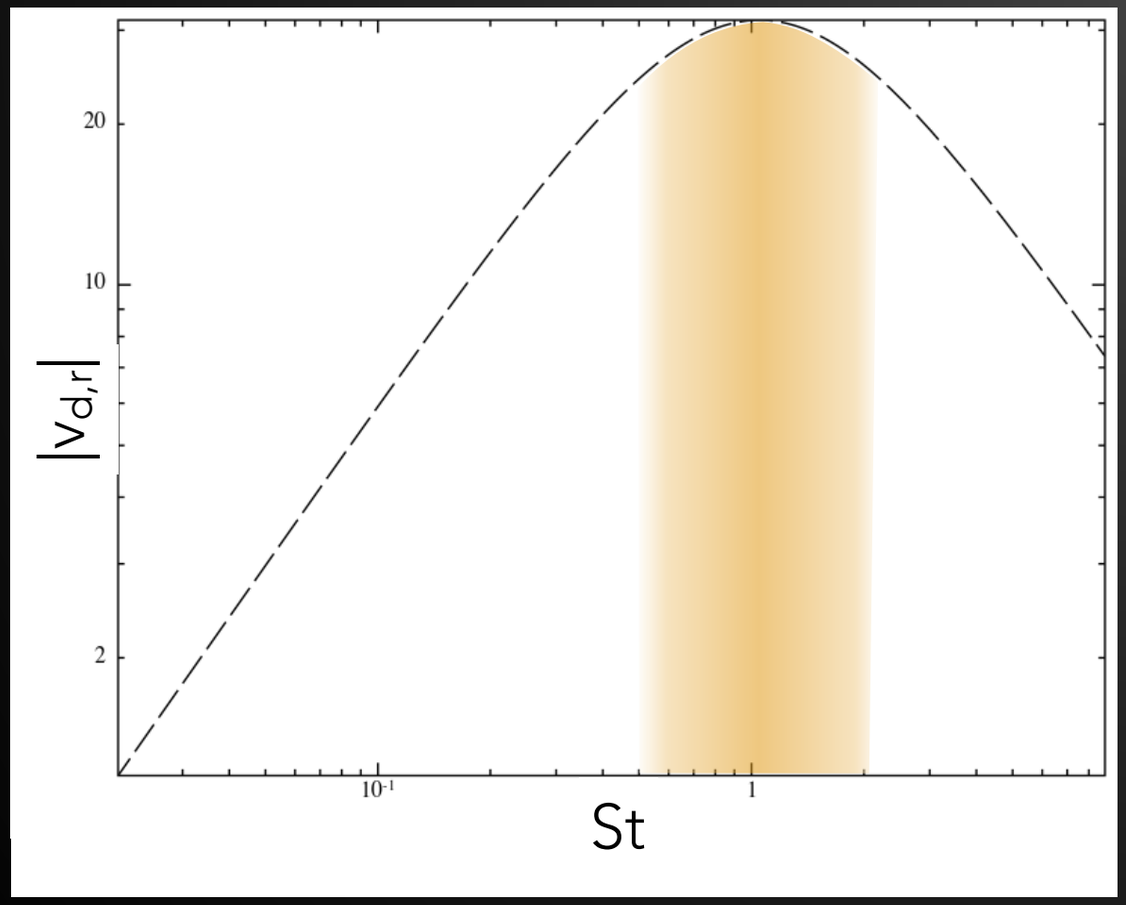


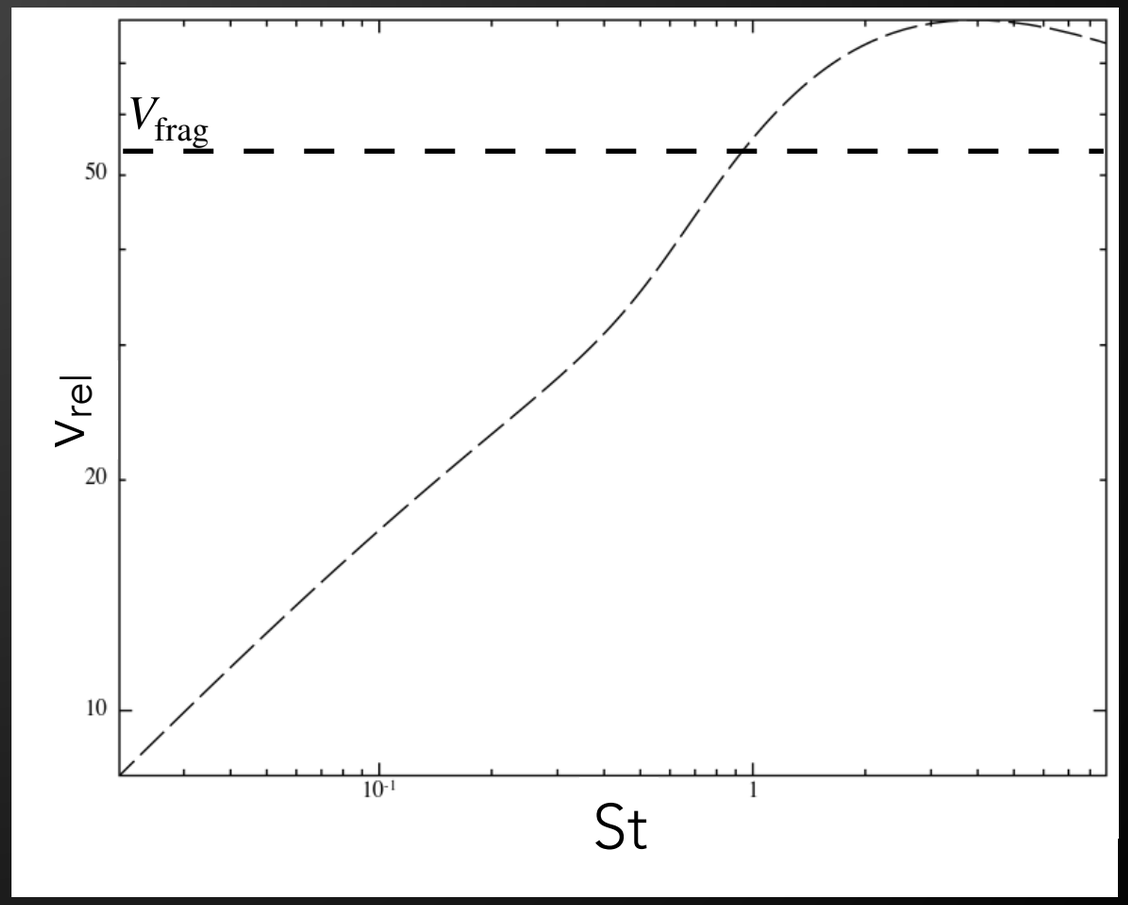
µm | mm-cm | m | km

$\mathrm{St} \ll 1$ | $\mathrm{St} \sim 1$ | $\mathrm{St} \gg 1$

"Radial drift barrier"

"Fragmentation barrier"





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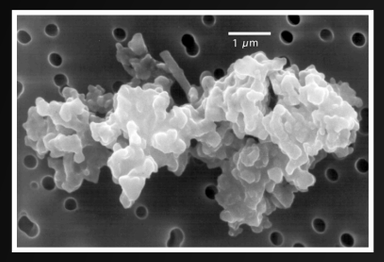
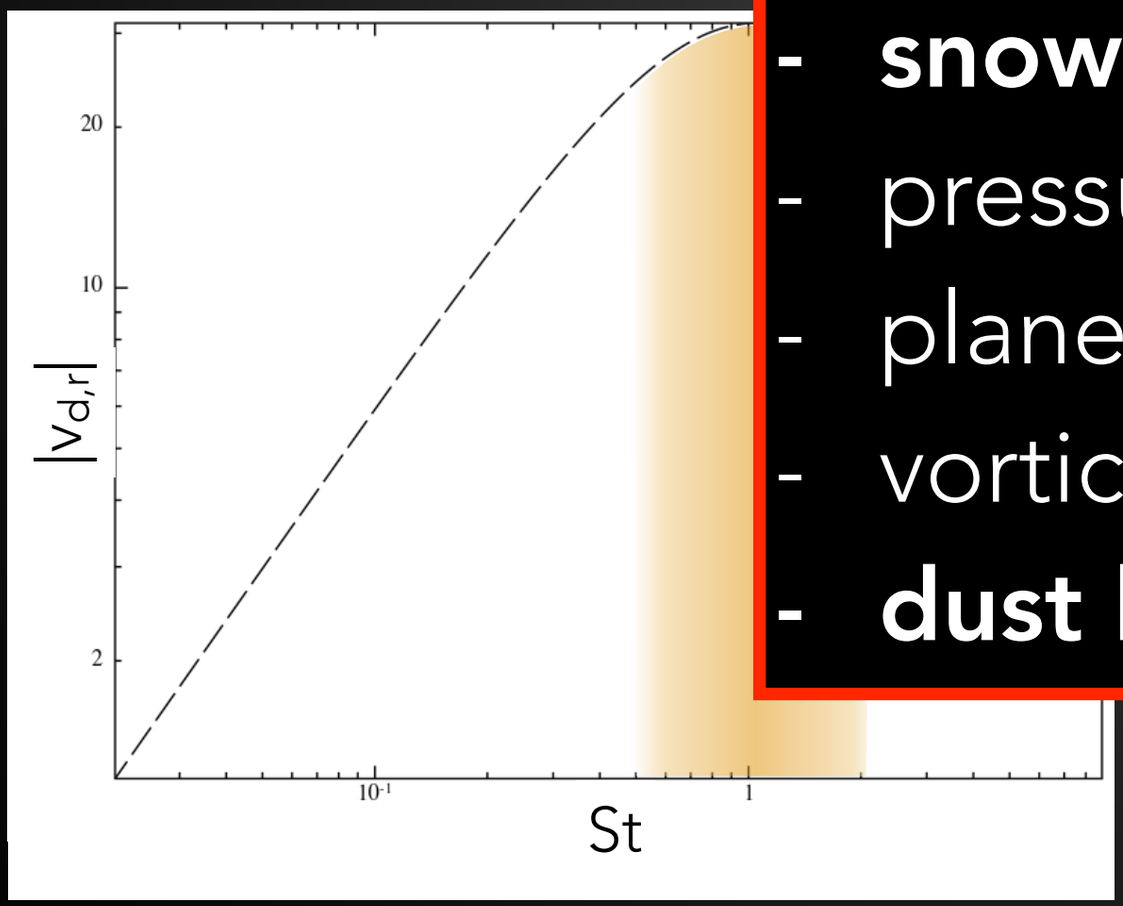
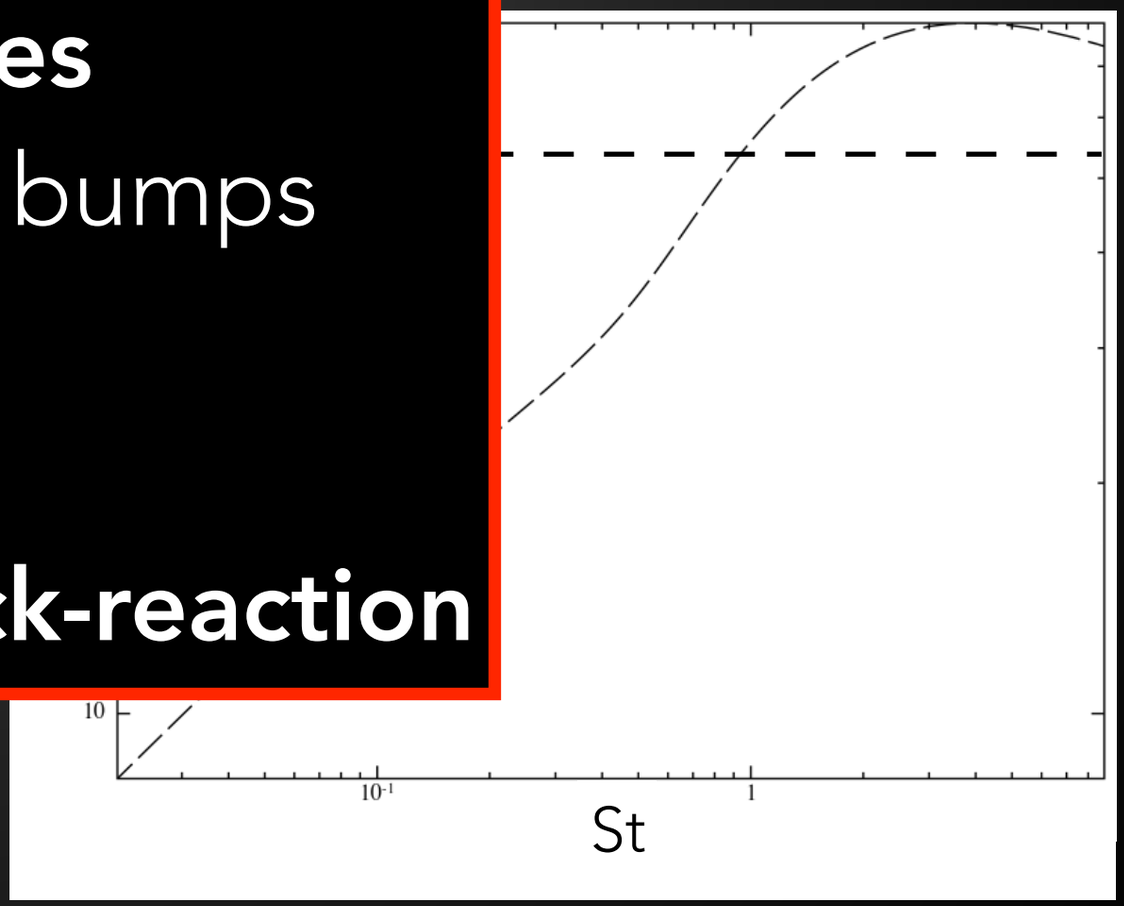


"Radial drift bar ntation barrier"

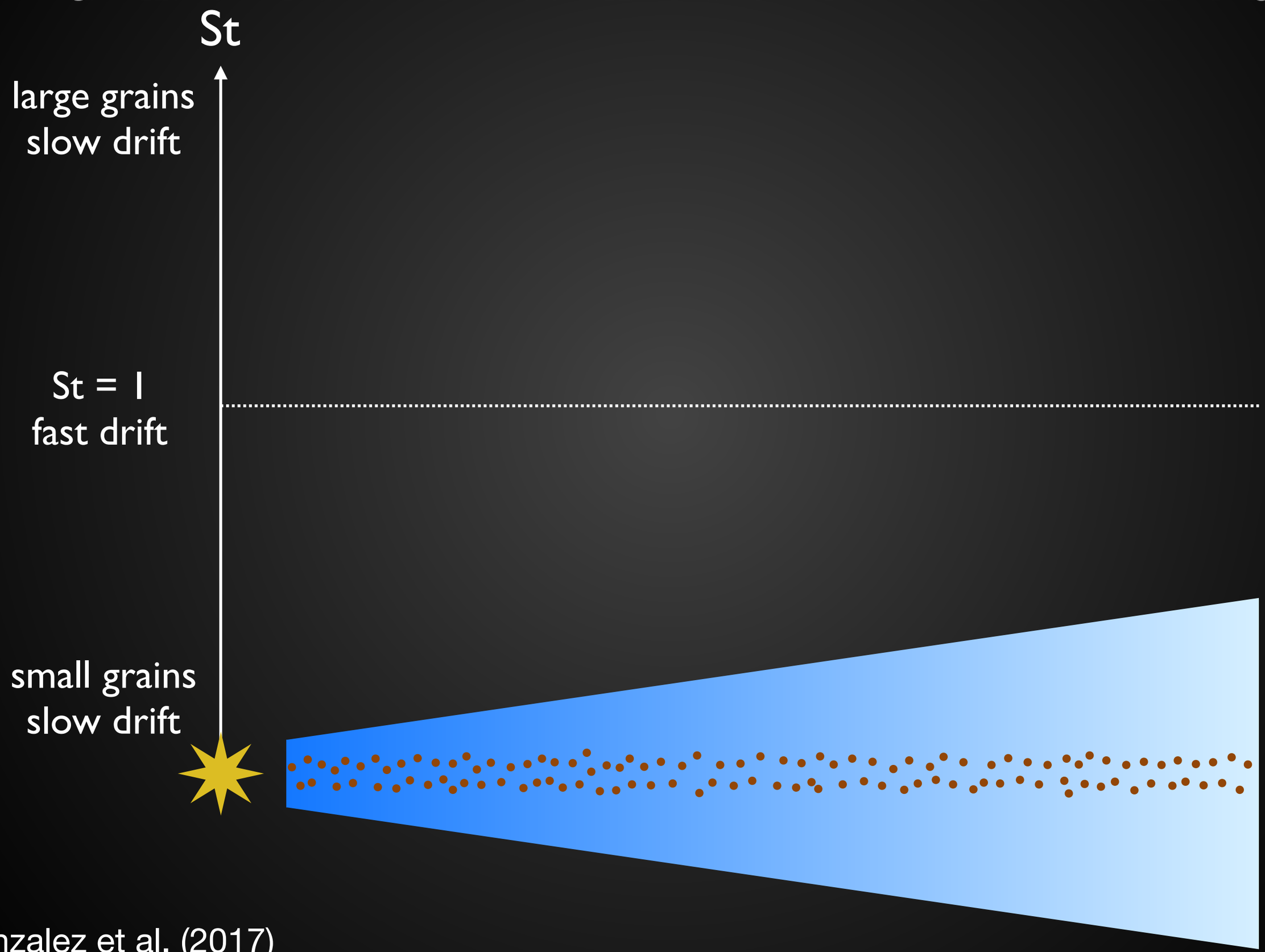
Need dust traps:

- dead zones
- **snow lines**
- pressure bumps
- planets
- vortices
- **dust back-reaction**



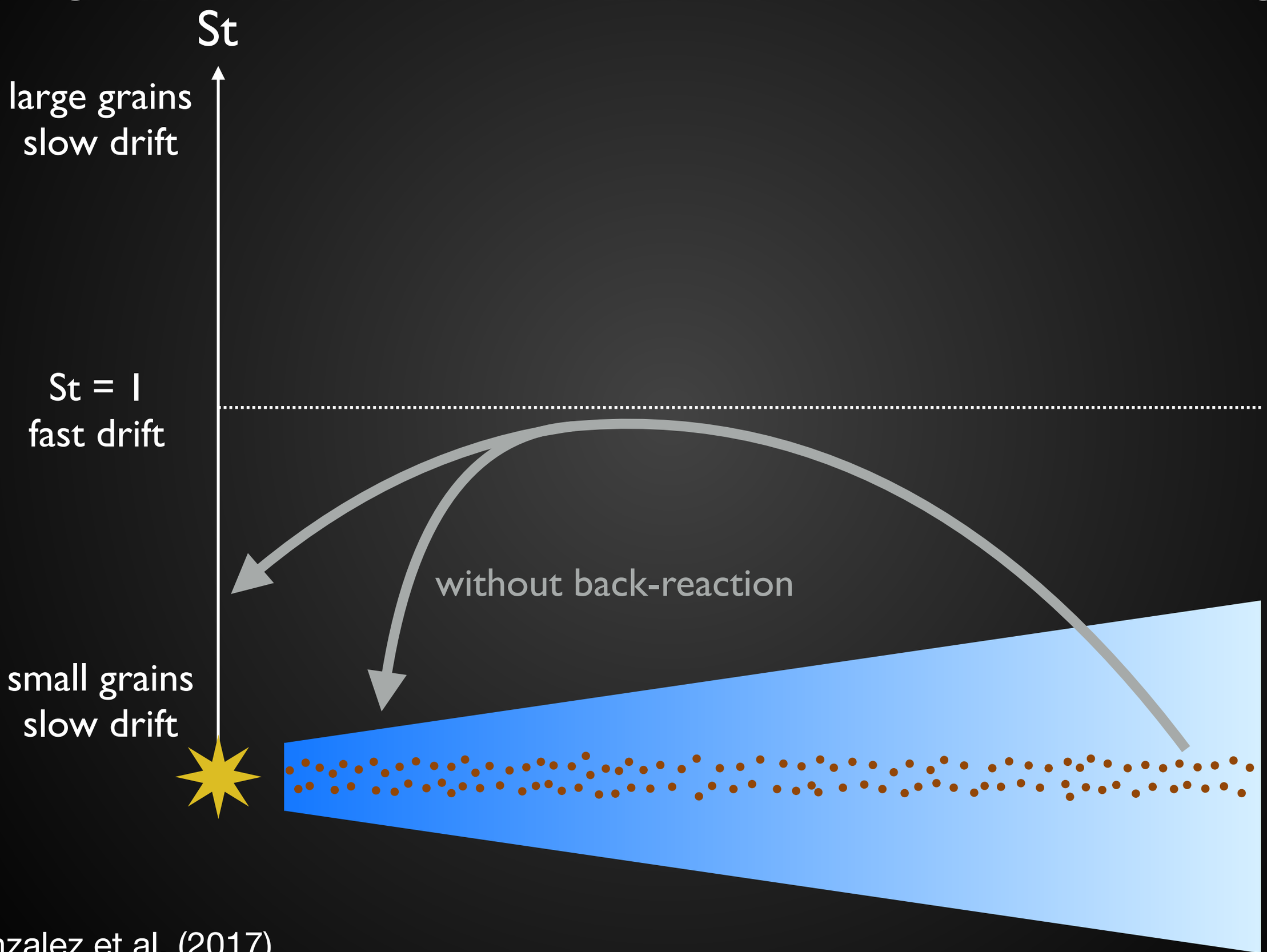


SELF-INDUCED DUST TRAP



Gonzalez et al. (2017)

SELF-INDUCED DUST TRAP



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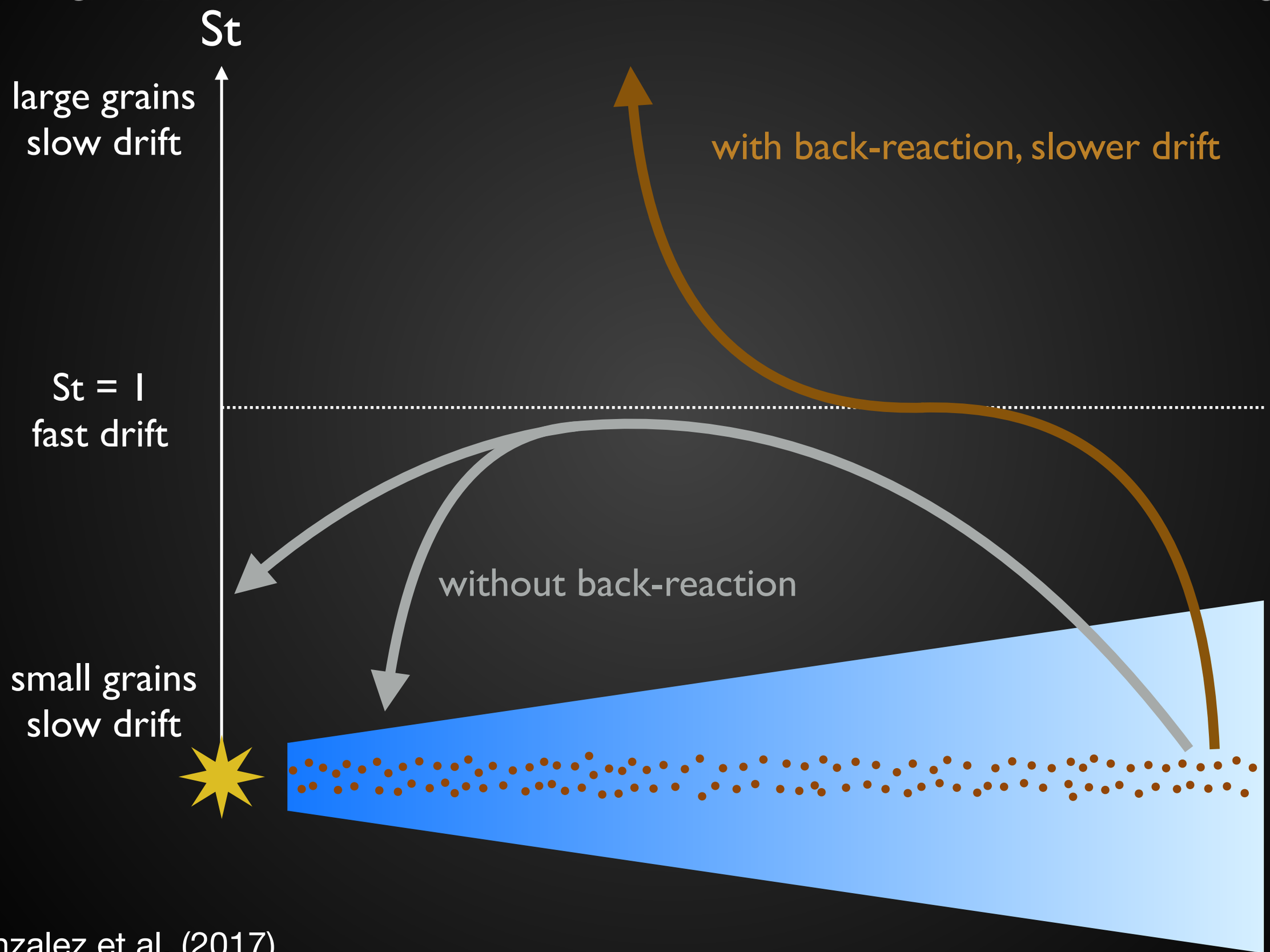

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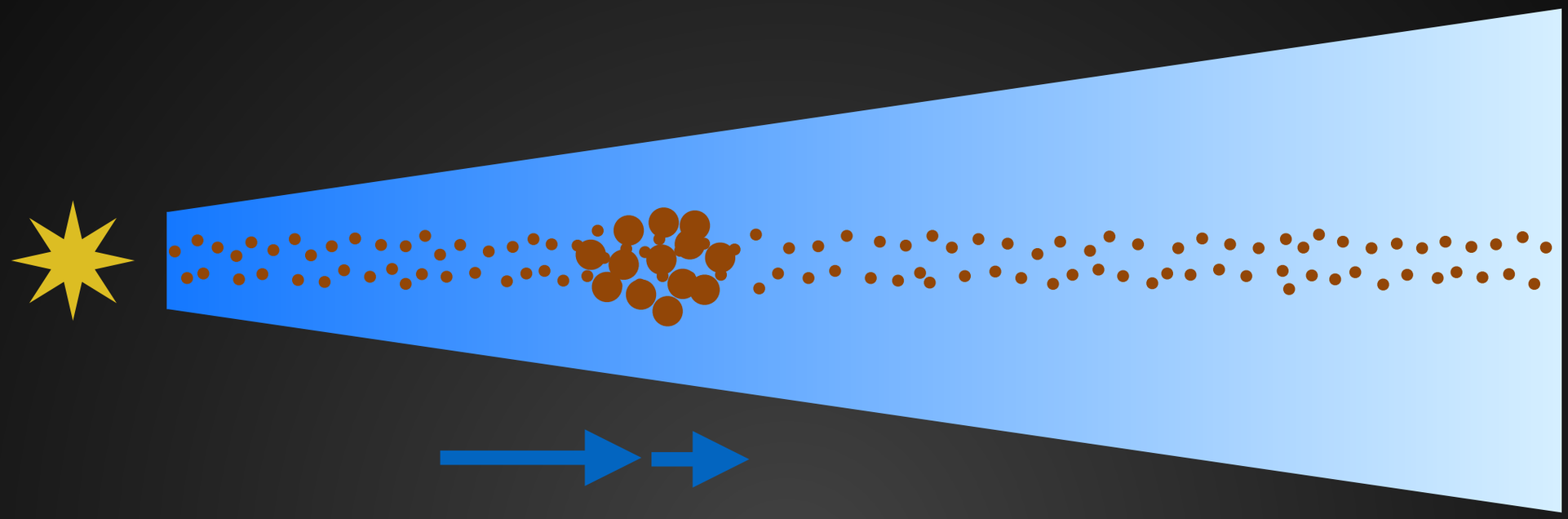

Gonzalez et al. (2017)

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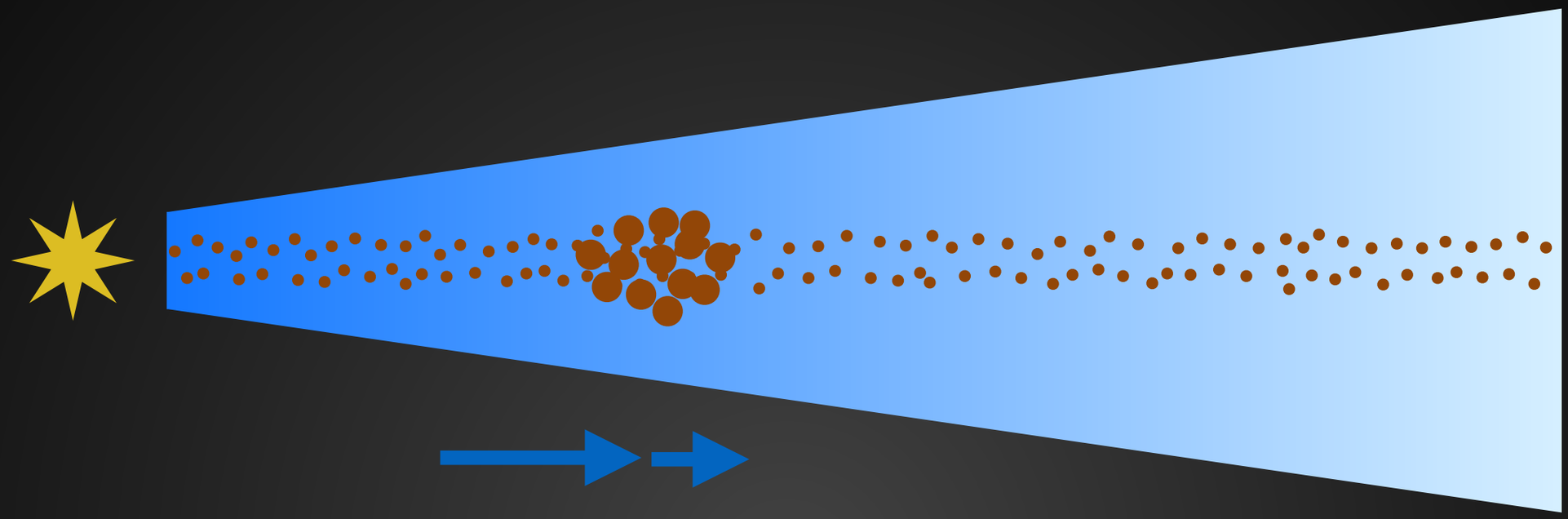

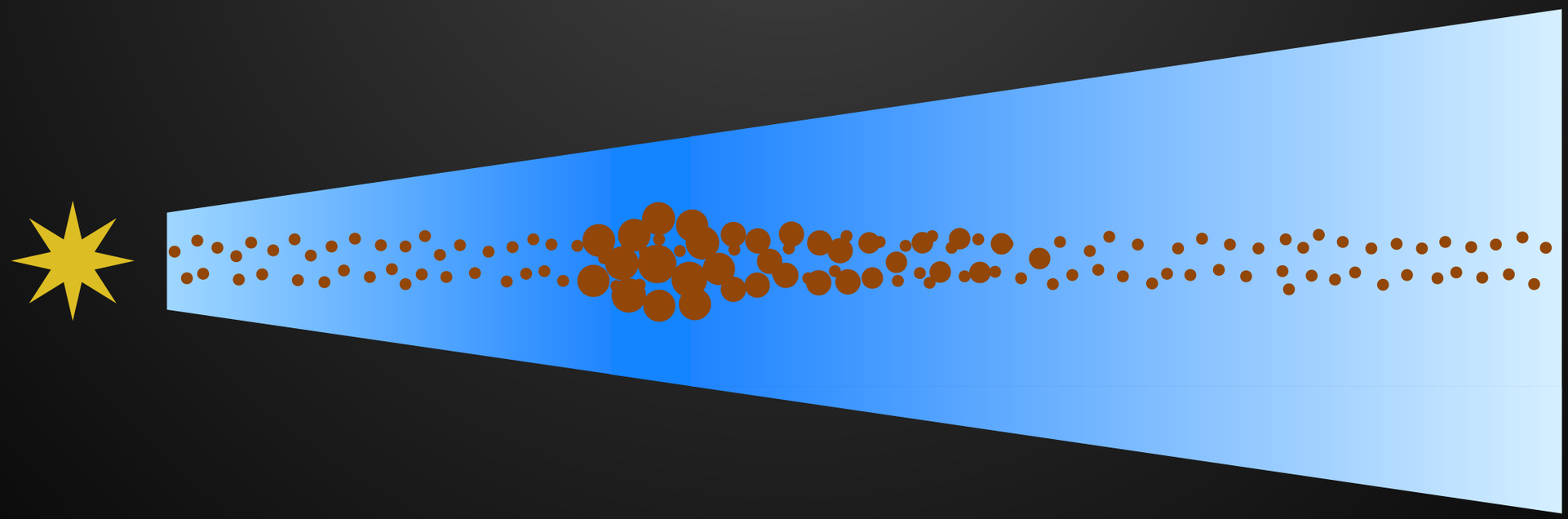

Gonzalez et al. (2017)

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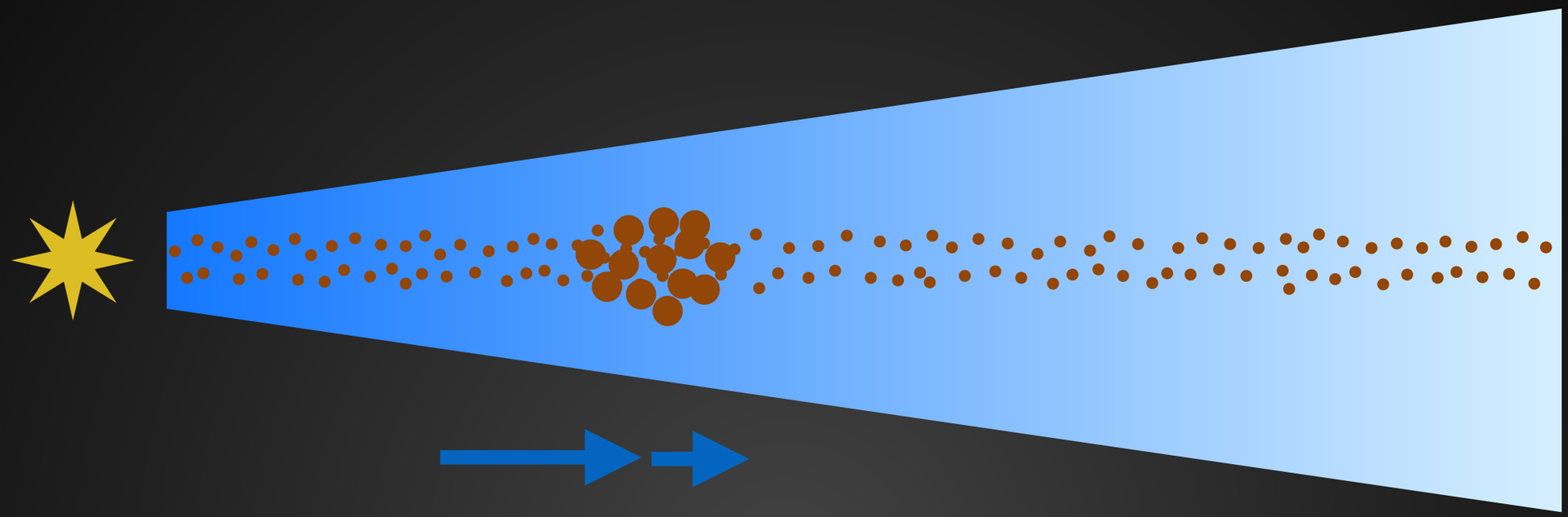

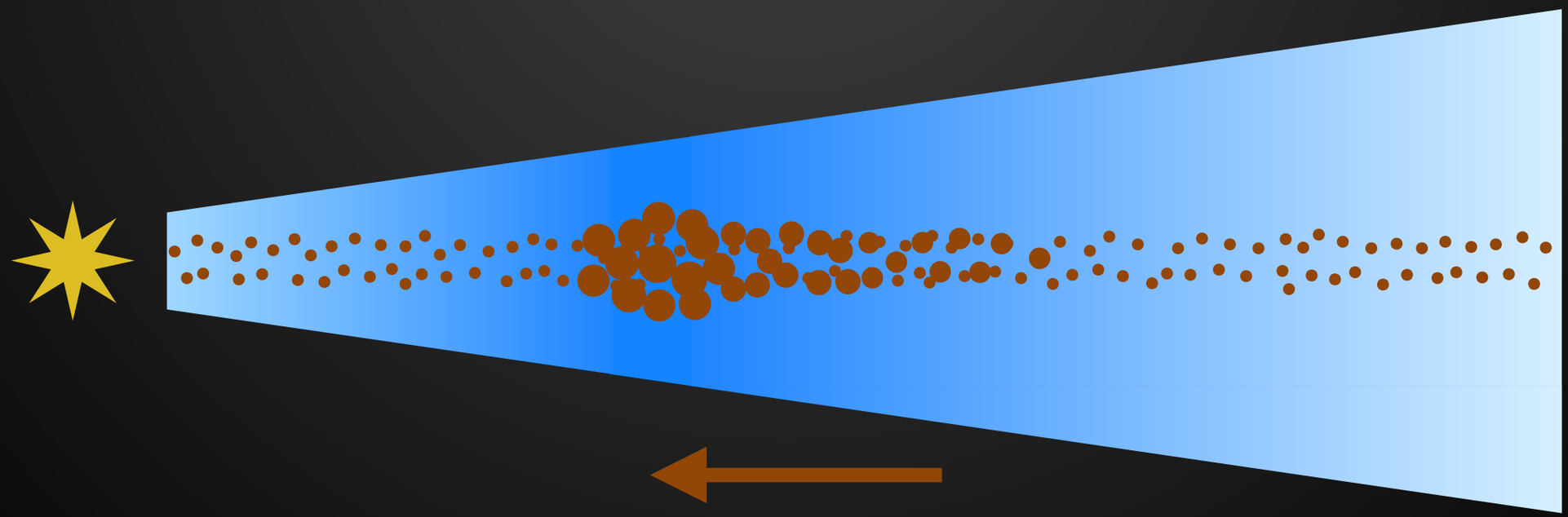

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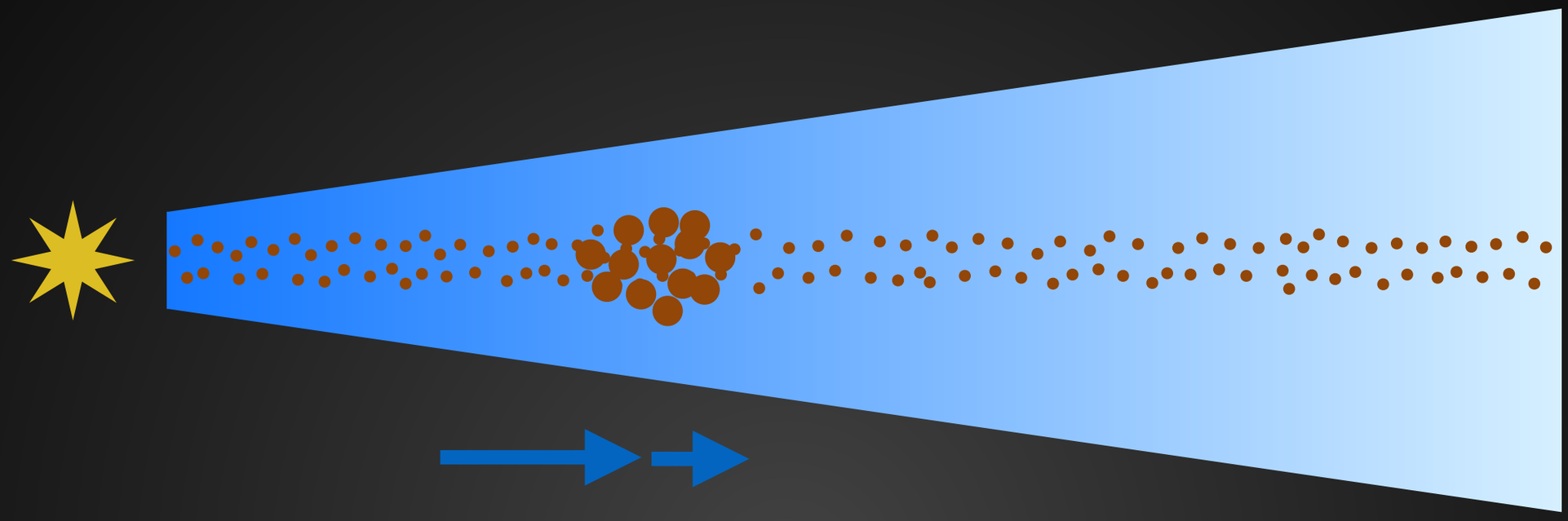
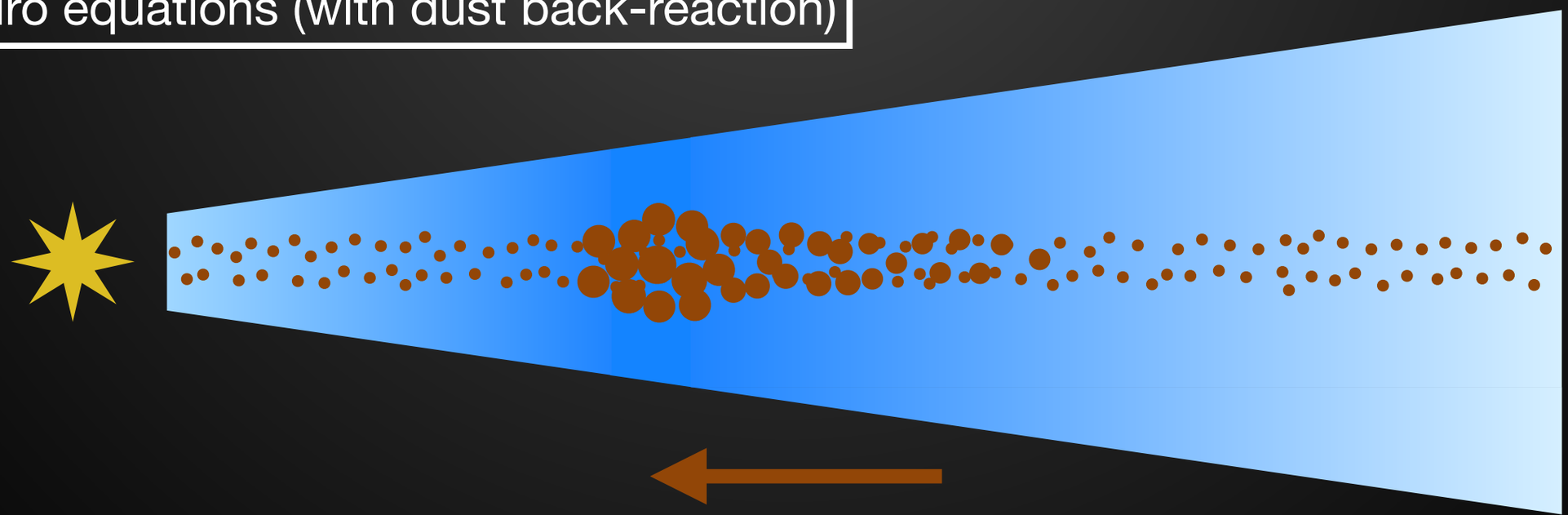


Lyon SPH code:
3D gas+dust (two-fluid)
growth and fragmentation
solve hydro equations (with dust back-reaction)

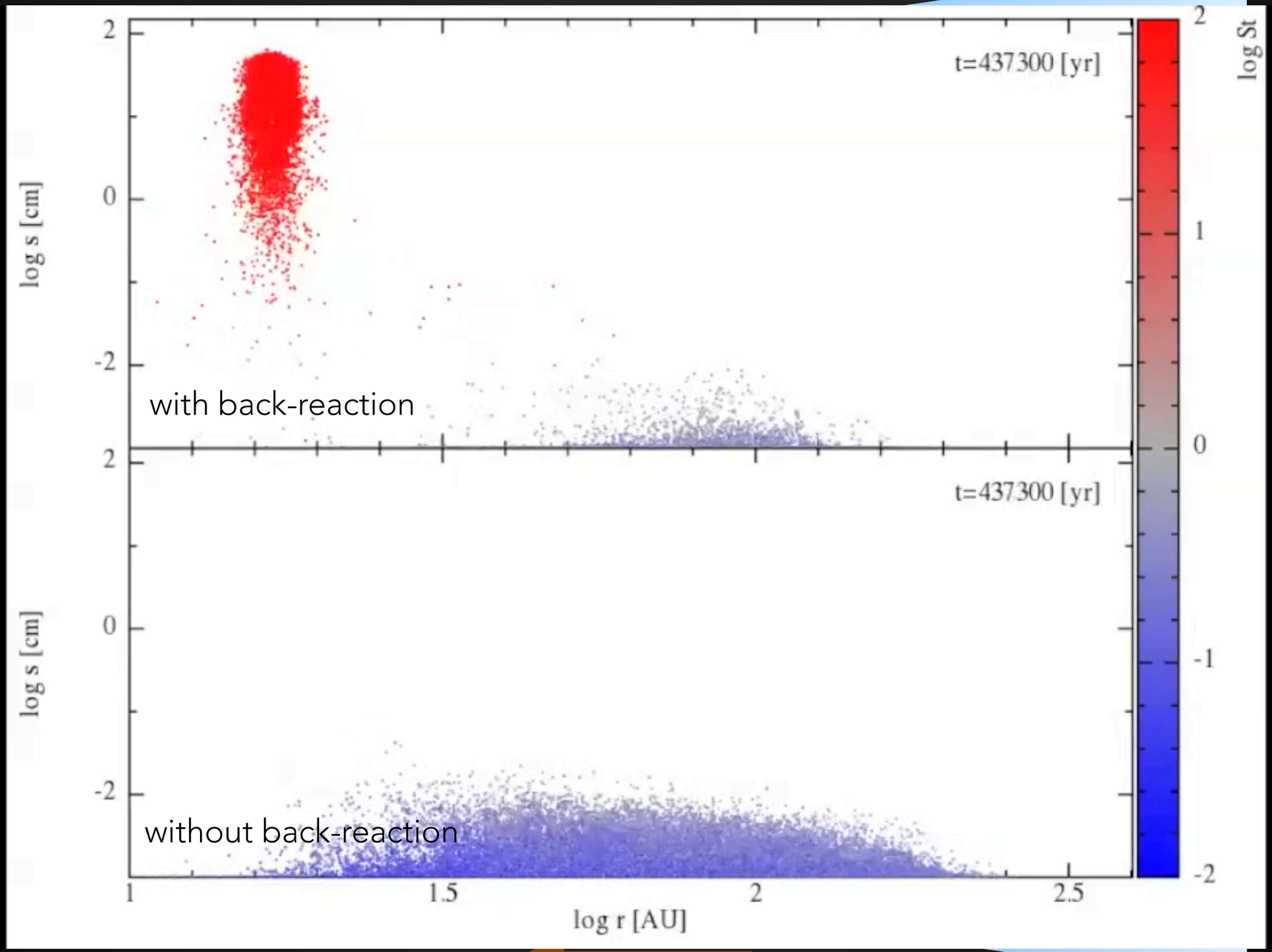
Barrière-fouchet et al. (2007)
Laibe et al. (2008)
Gonzalez et al. (2015)



Gonzalez et al. (2017)

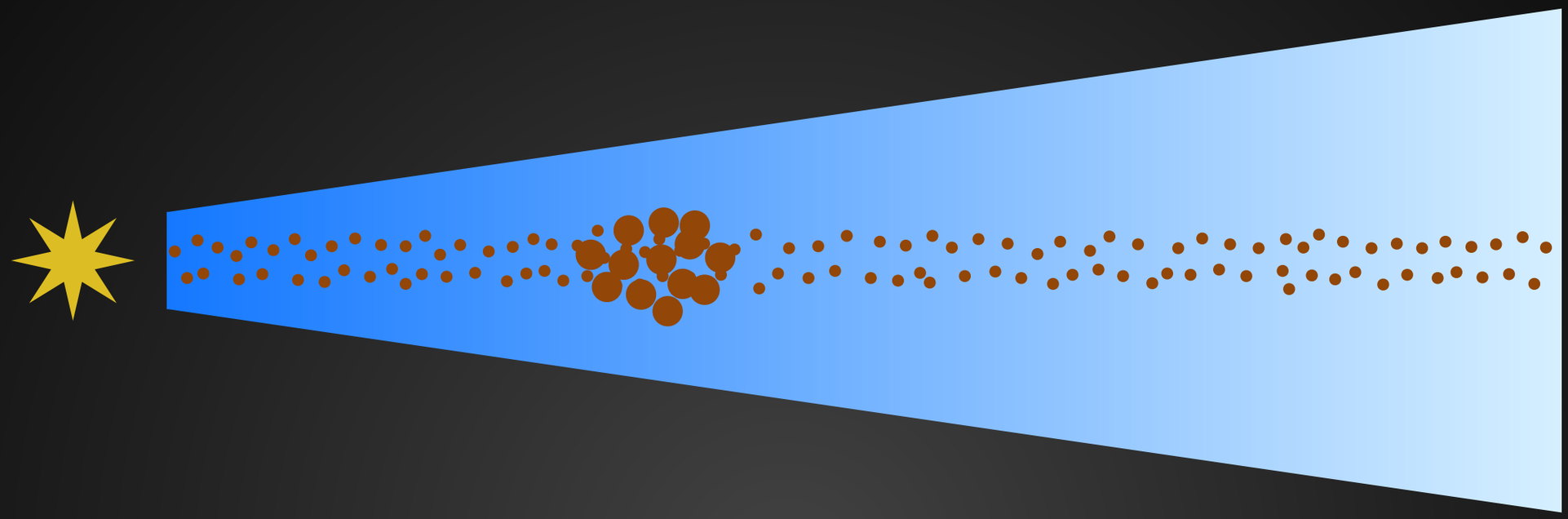
SELF-INDUCED DUST TRAP

$V_{\mathrm{frag}} = 15\ \mathrm{m\,.\,s^{-1}}$

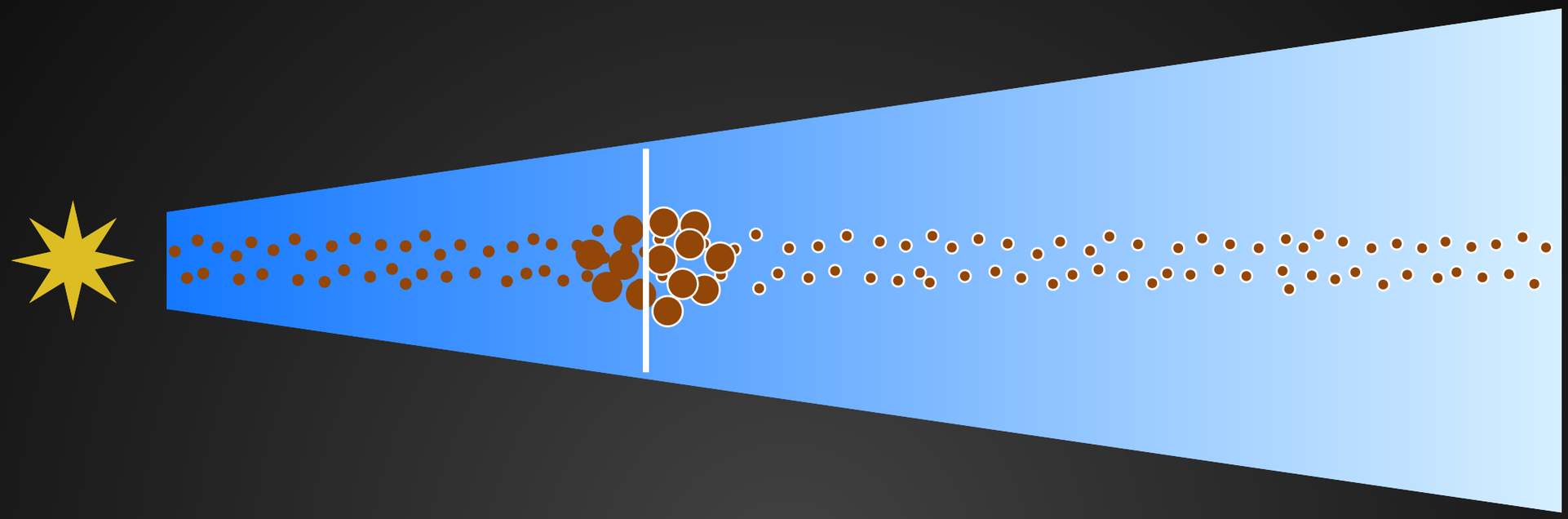


Gonzalez et al. (2017)

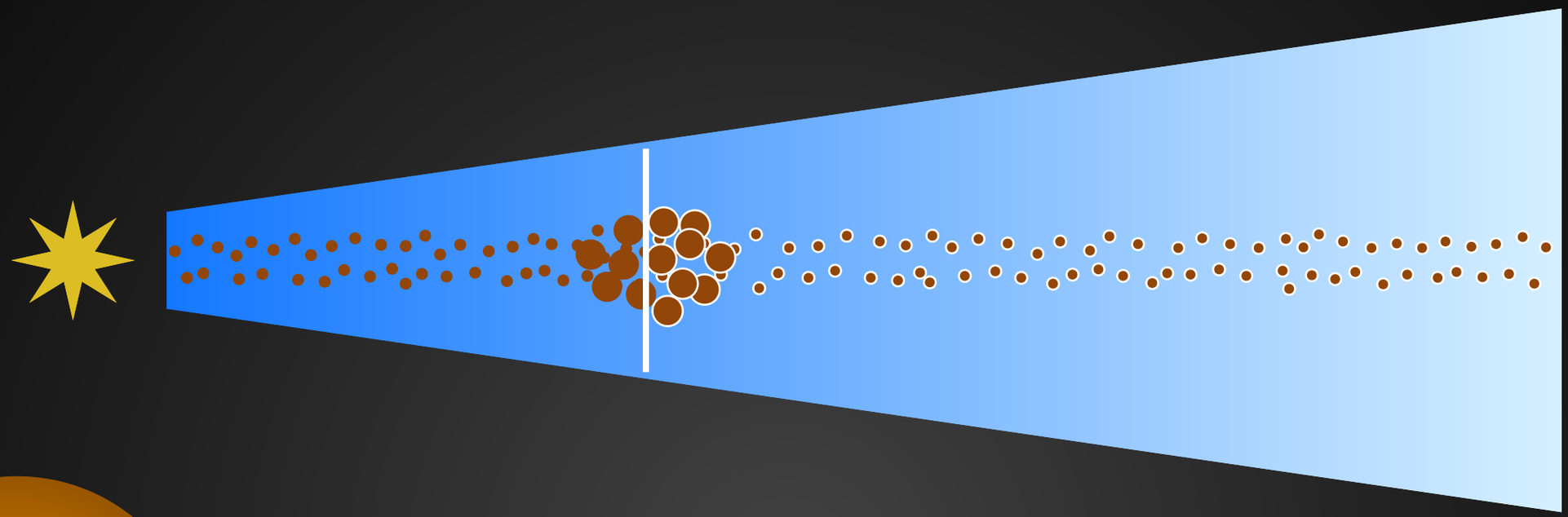
SNOW LINES ?



SNOW LINES ?



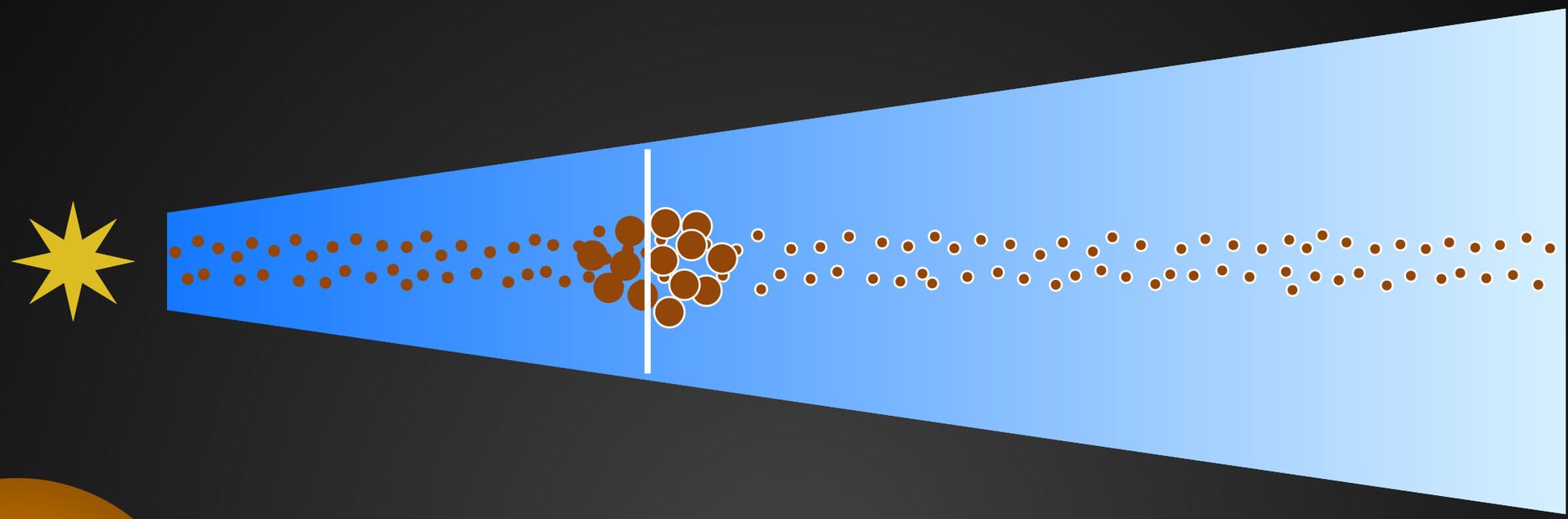
SNOW LINES ?



BARE SILICATE CORE

sticks poorly: $V_{\mathrm{frag}} \sim 1\ \mathrm{m\,.\,s^{-1}}$

SNOW LINES ?



BARE SILICATE CORE

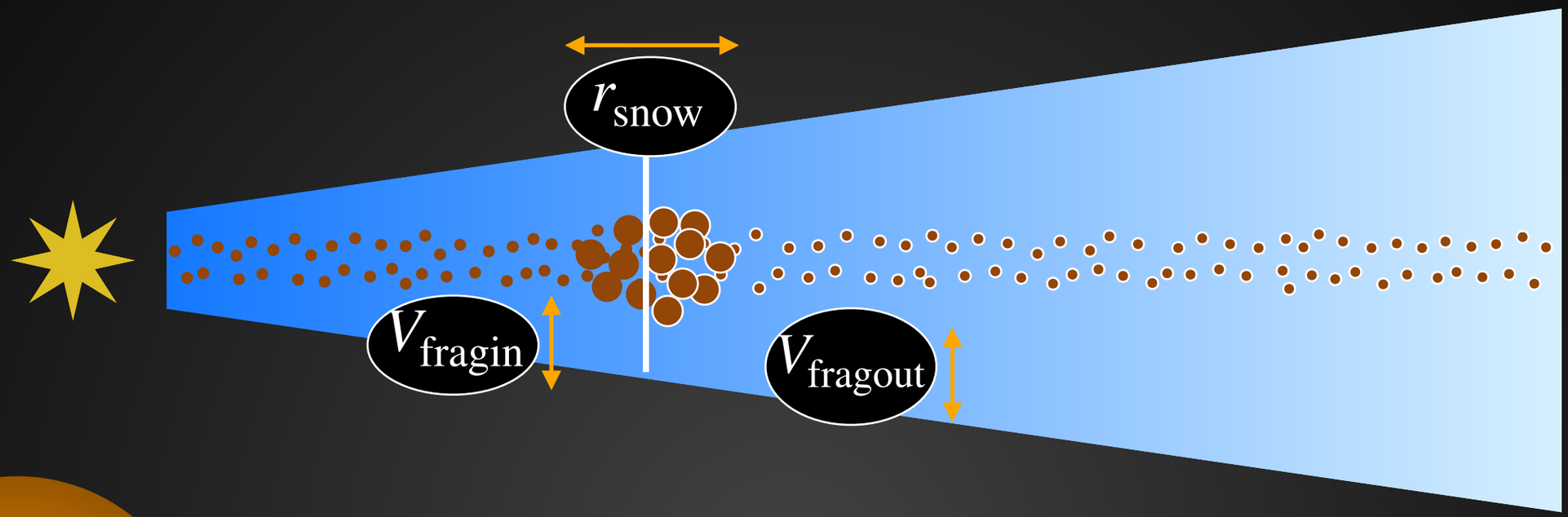
sticks poorly: $V_{\rm frag} \sim 1\ {\rm m\,.\,s^{-1}}$

SILICATE CORE + H_2O MANTLE

sticks well: $V_{\rm frag} \sim 15 - 20\ {\rm m\,.\,s^{-1}}$

Blum & Wurm 2008, Yamamoto+2014,…

SNOW LINES ?



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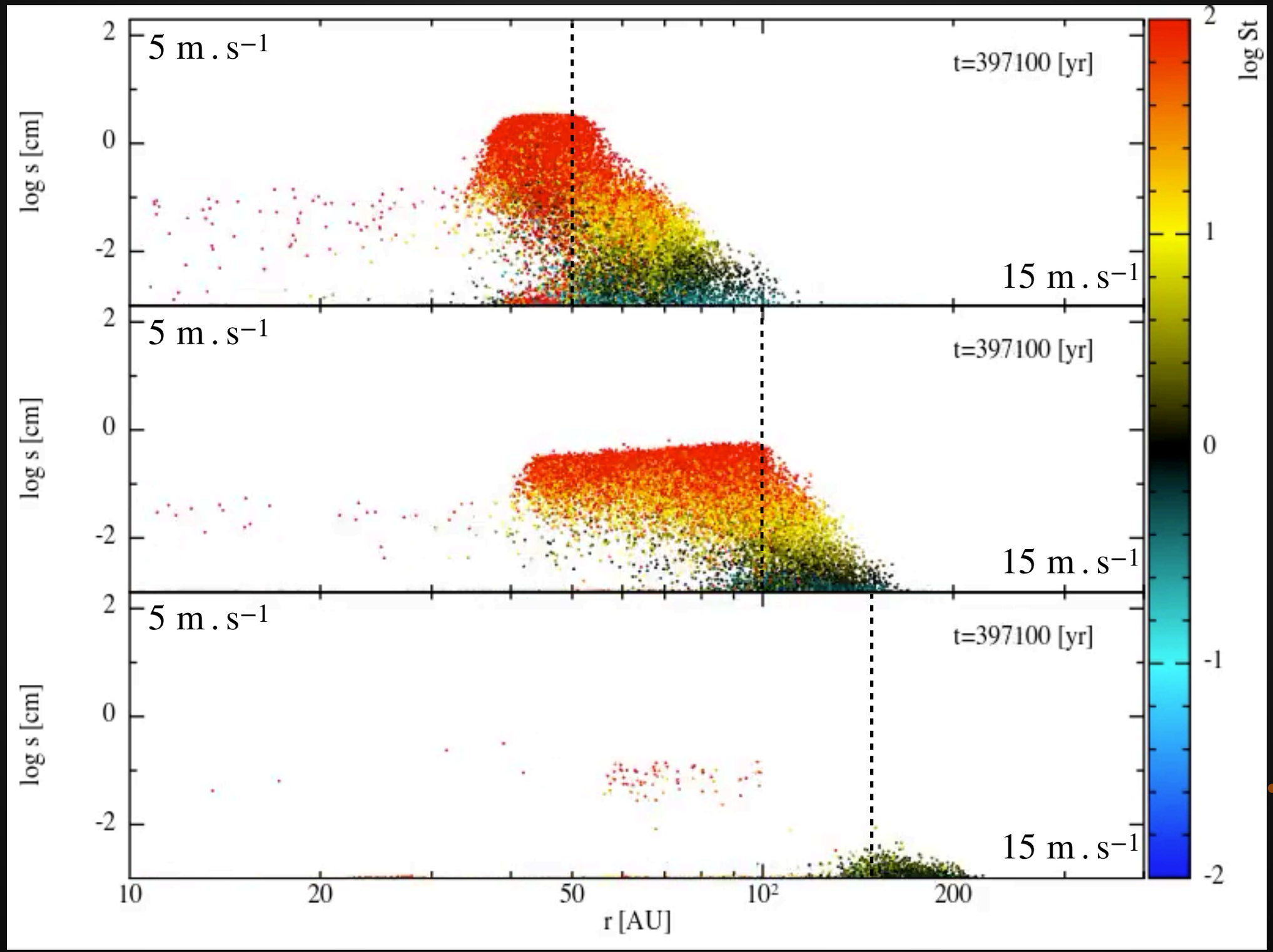
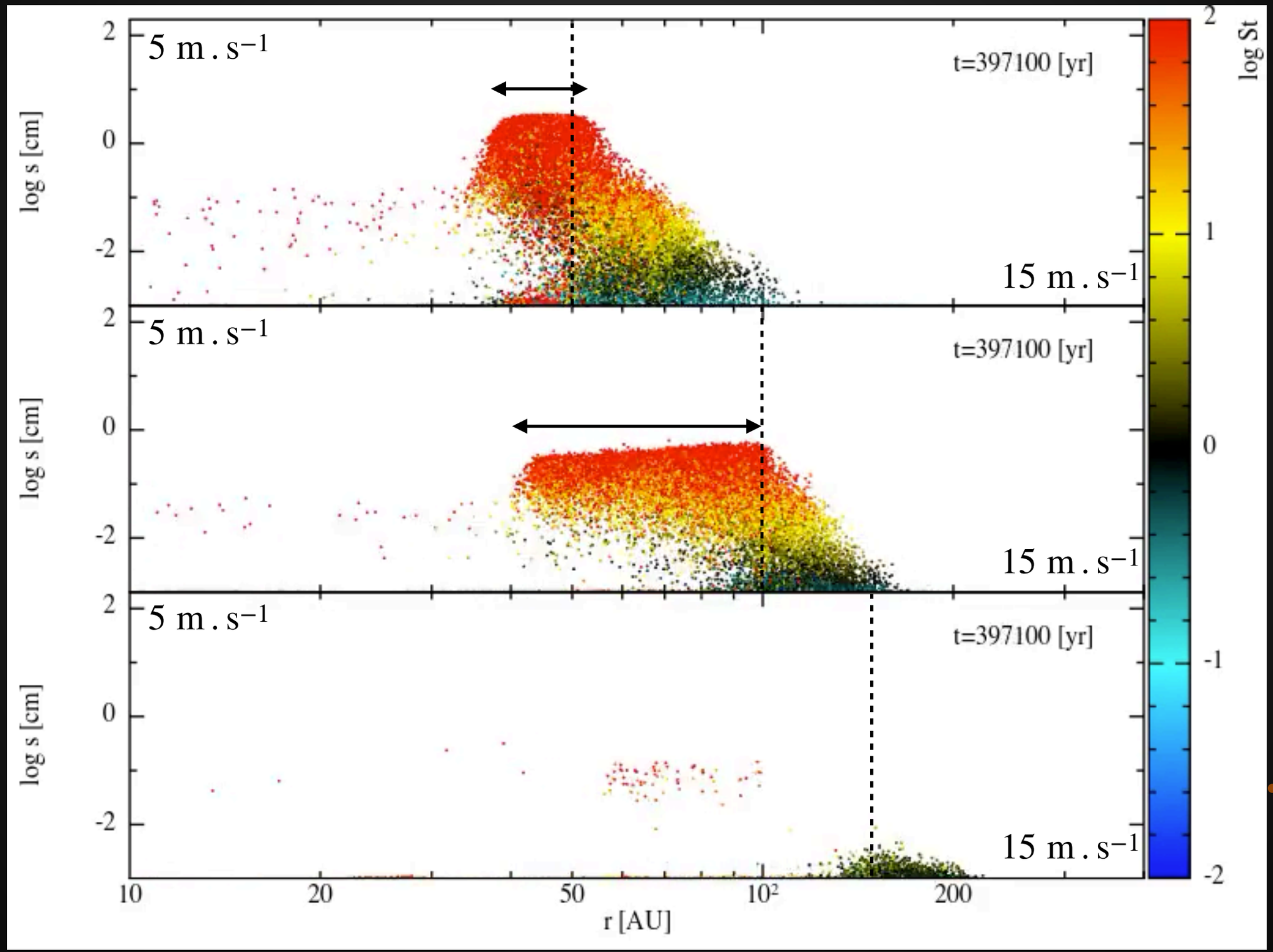
Blum & Wurm 2008, Yamamoto+2014,…

SNOW LINE POSITION



Vericel & Gonzalez (in prep)

SNOW LINE POSITION



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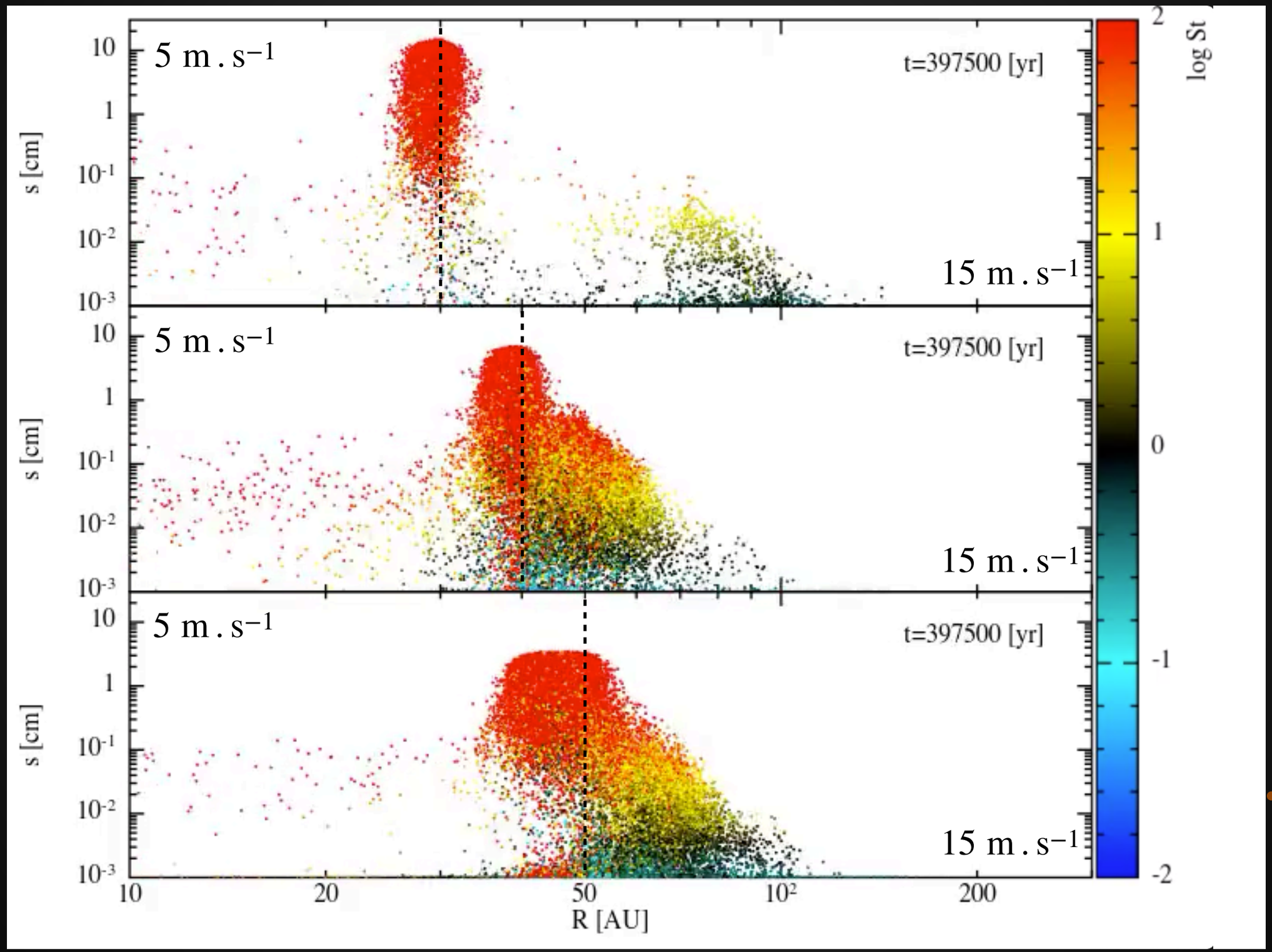

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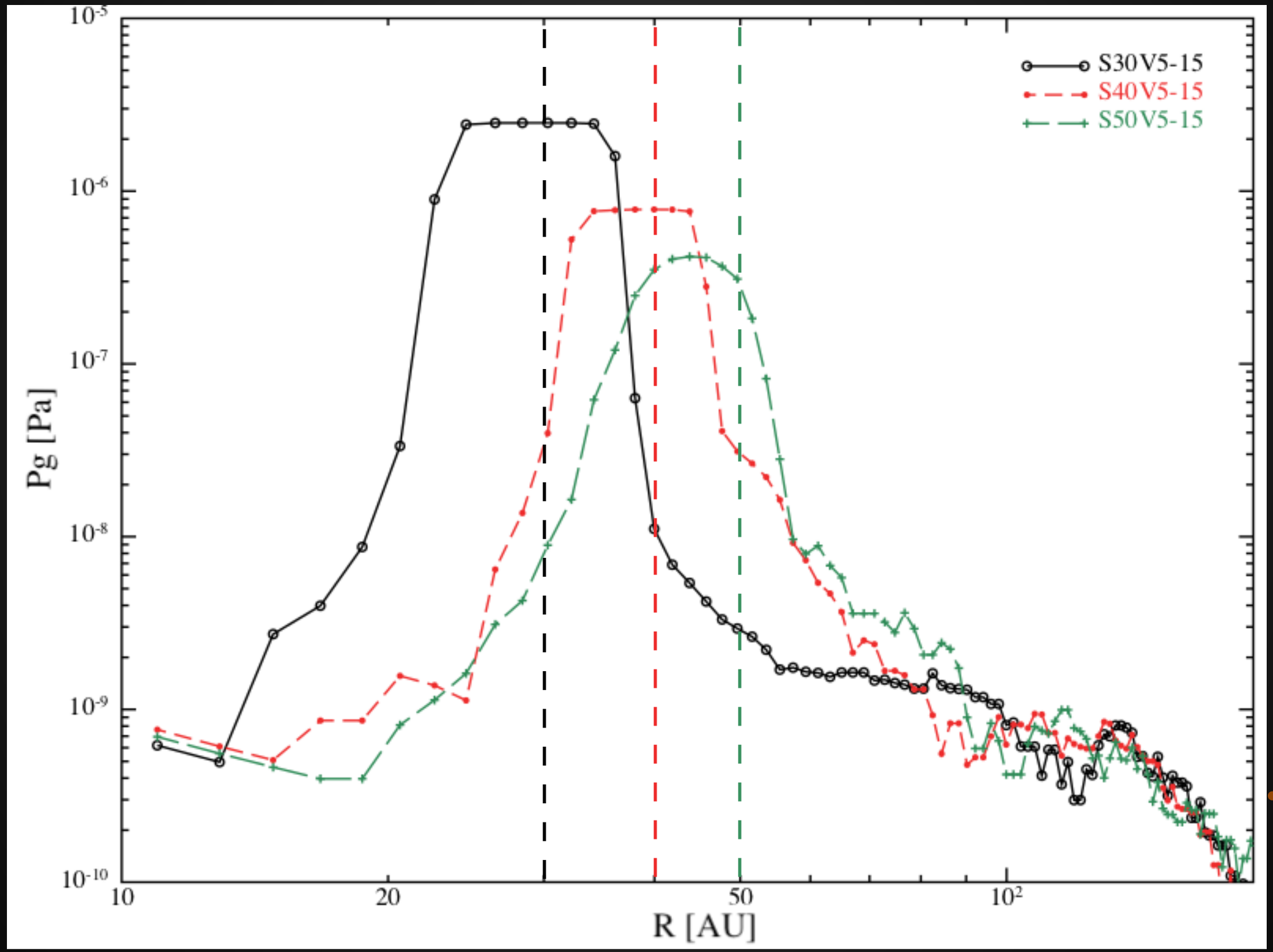
SNOW LINE POSITION



Vericel & Gonzalez (in prep)

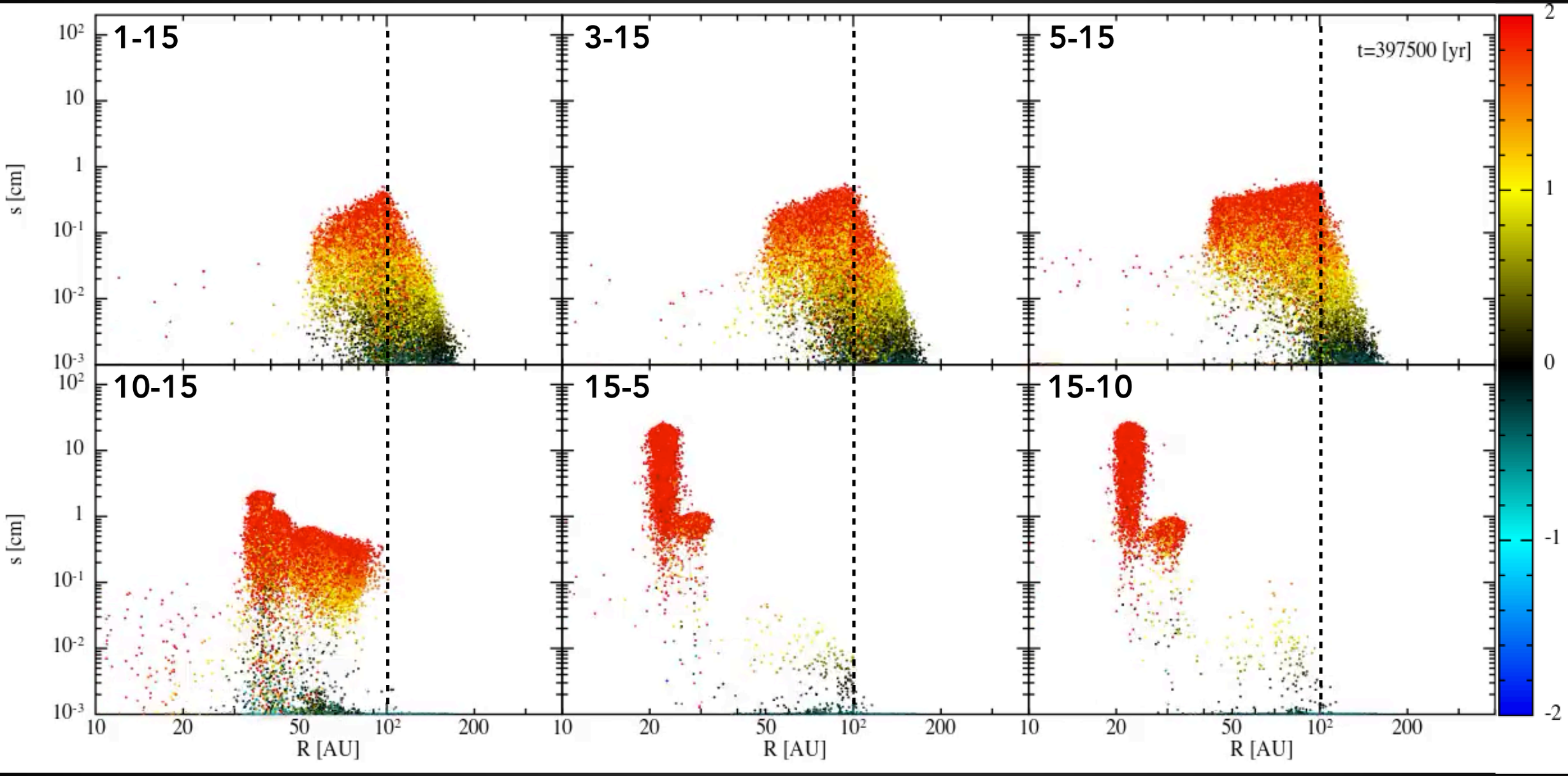
CO SNOW LINE

$T_{\rm subli}({\rm CO}) \sim 20$ K

$$T \propto r^{-q} \rightarrow r_{\rm snow} \propto T_{\rm subli}^{-1/q}$$

Vericel & Gonzalez (in prep)

CO SNOW LINE



$T_{\mathrm{subli}}(\mathrm{CO}) \sim 20$ K

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Vericel & Gonzalez (in prep)

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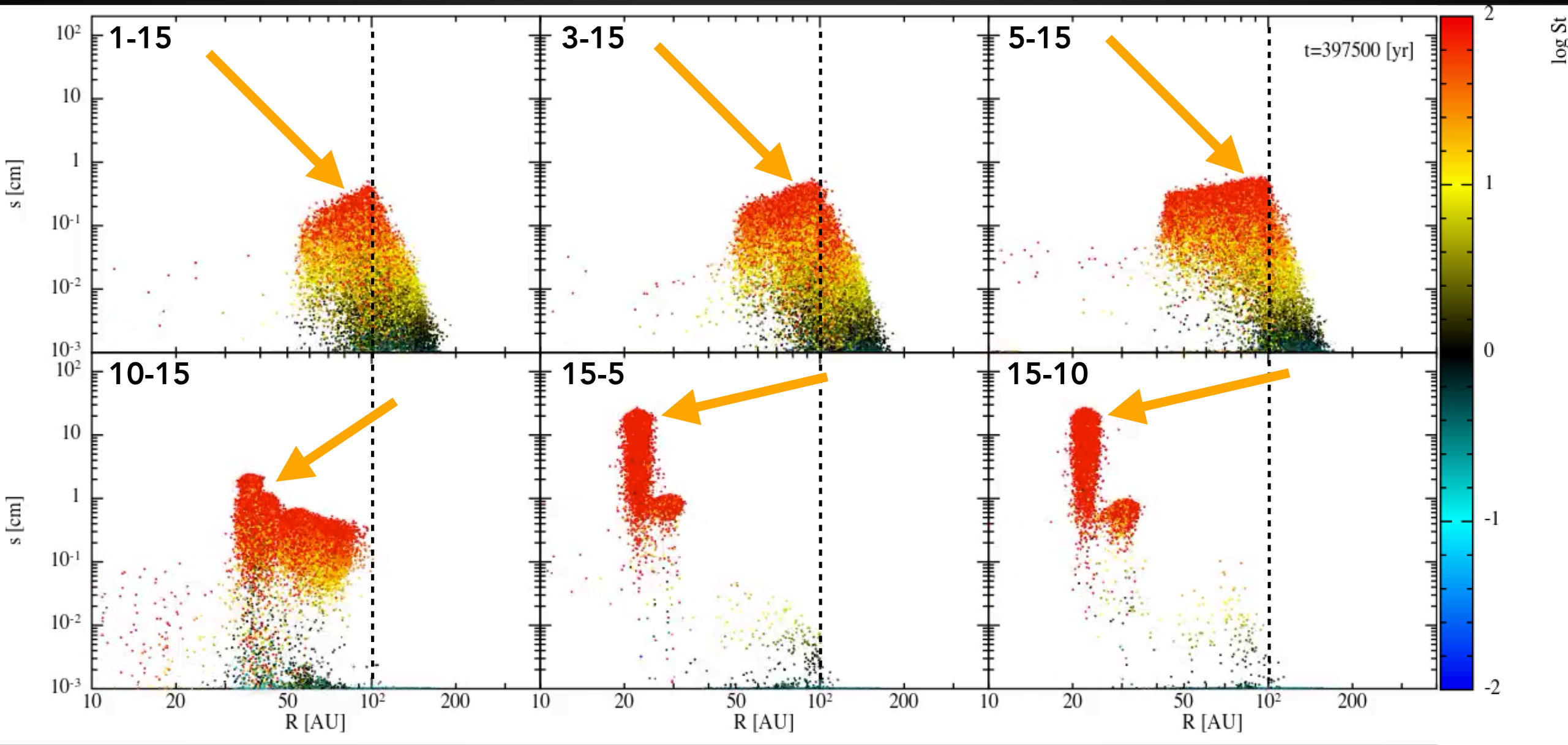

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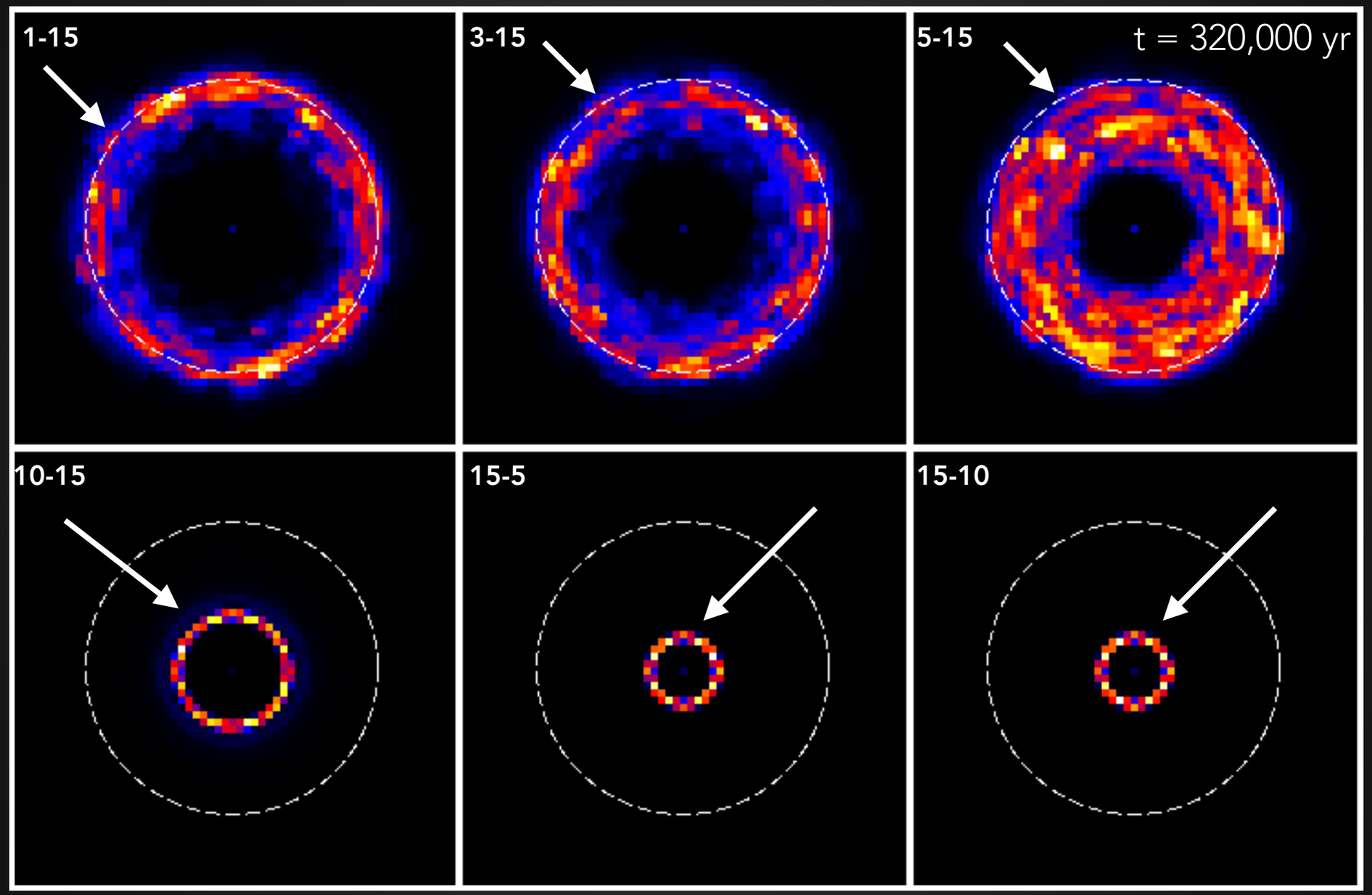
Vericel & Gonzalez (in prep)

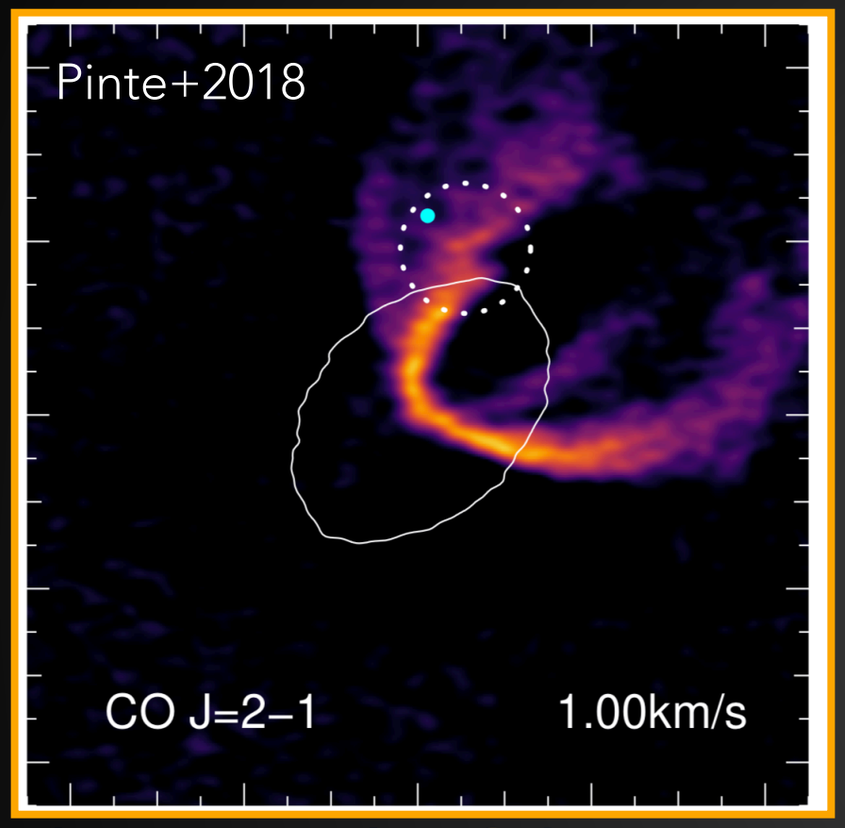
OBSERVATIONAL SIGNATURES



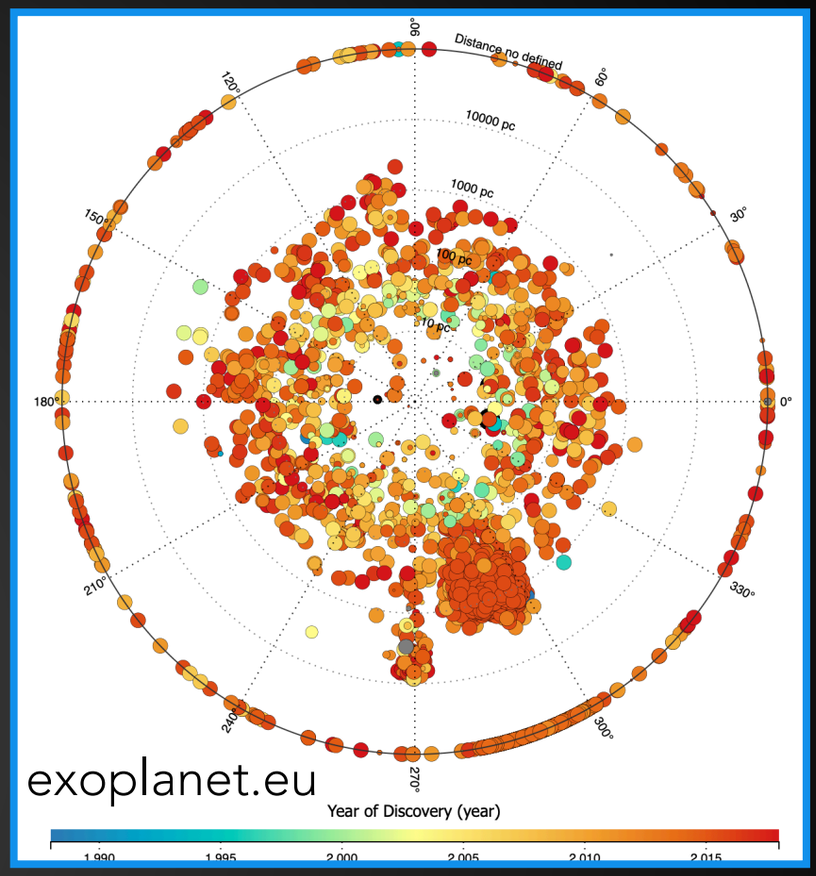
850 μm, i=0°

MCFOST (Pinte+2006)

TAKE AWAY MESSAGES

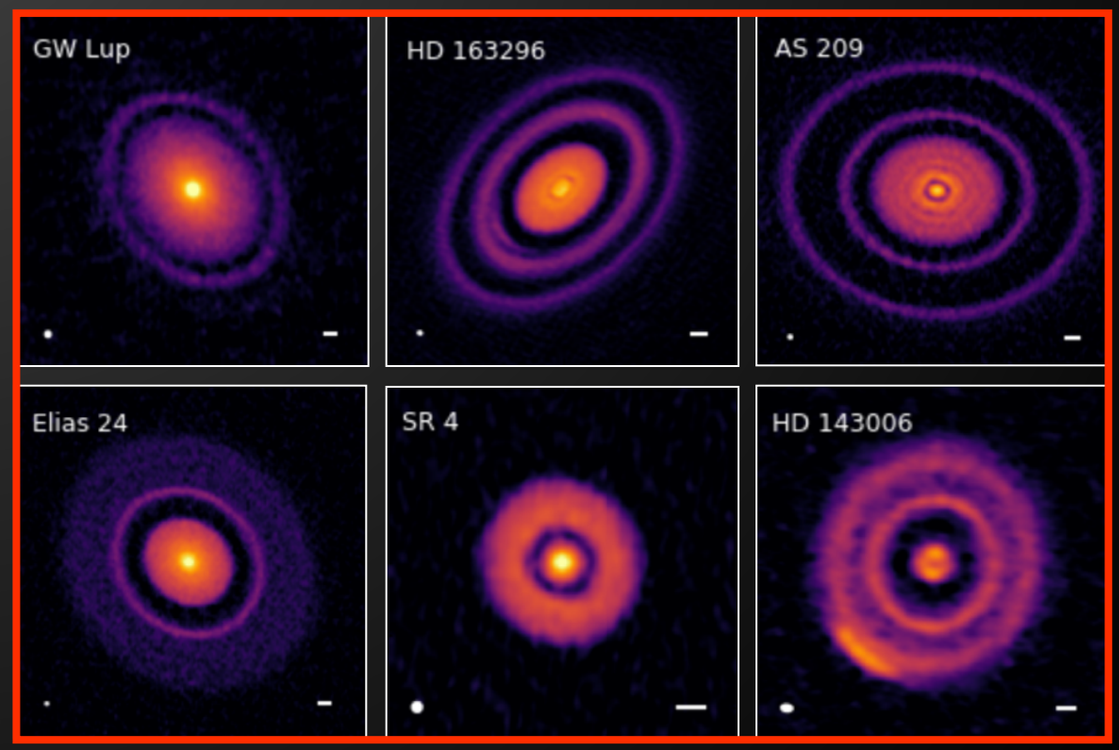


Self-induced dust trap formation is a robust mechanism, even with snowlines.



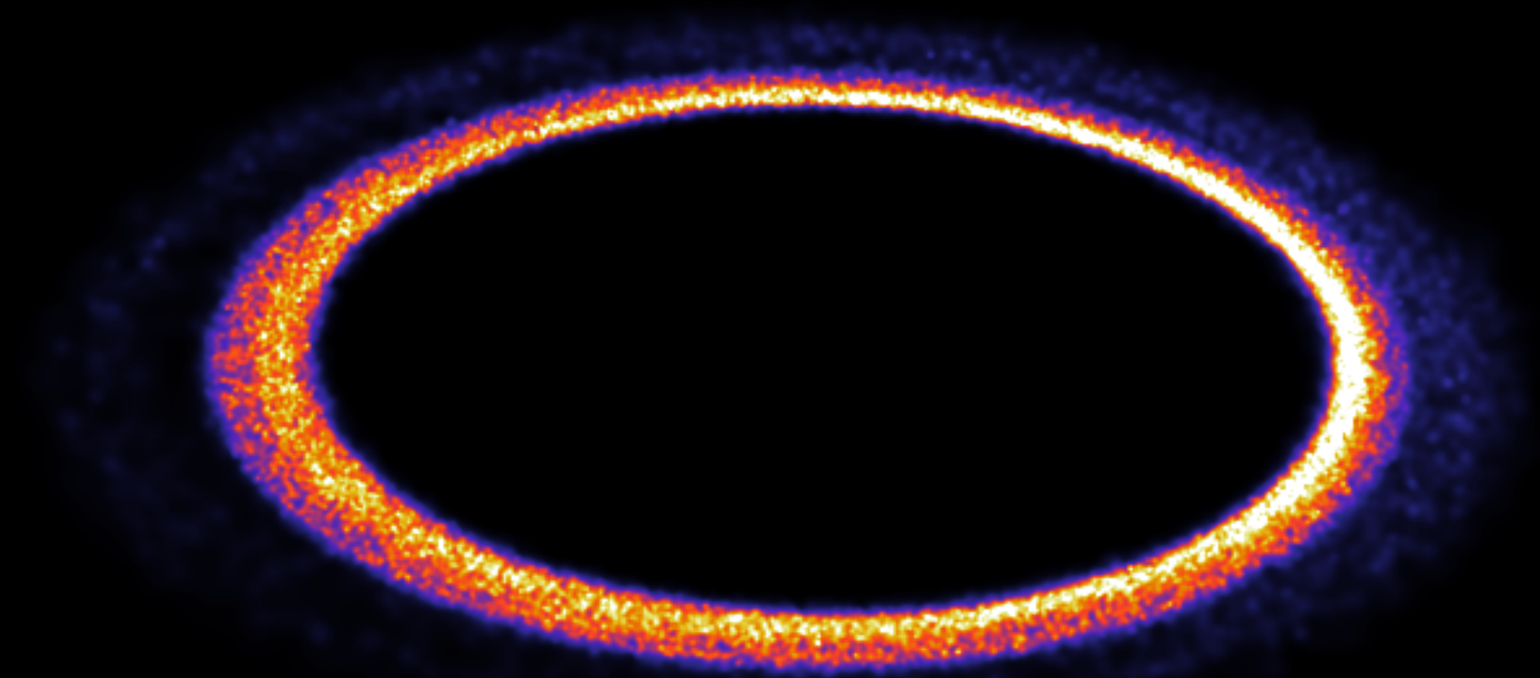
The timescale of these traps formation is of a few hundred thousand years << disc lifetime.

It could explain some of the rings/structures seen with ALMA. (in progress)



Andrews+2018

THANK YOU



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