Streaming Instability: Reborn

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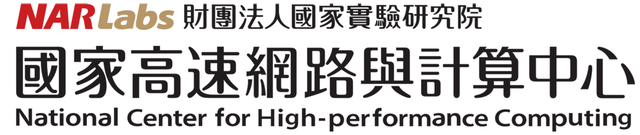
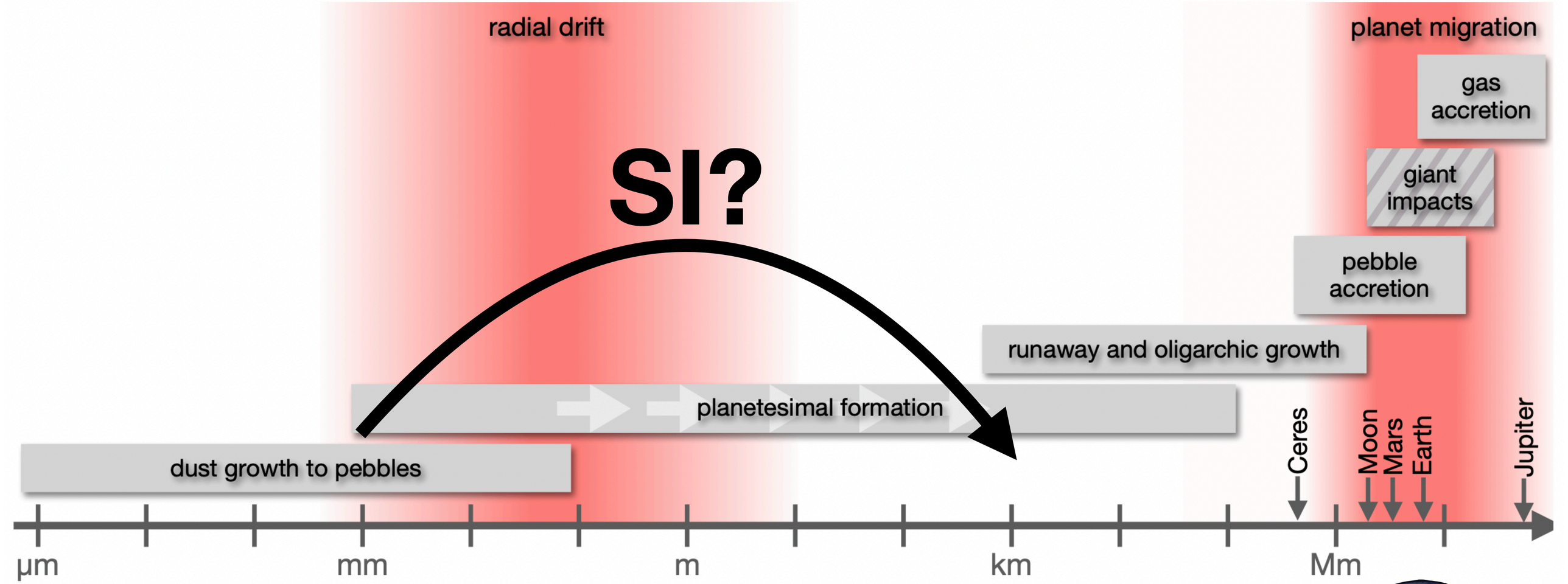
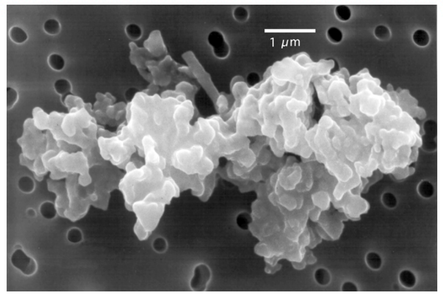
December 2023



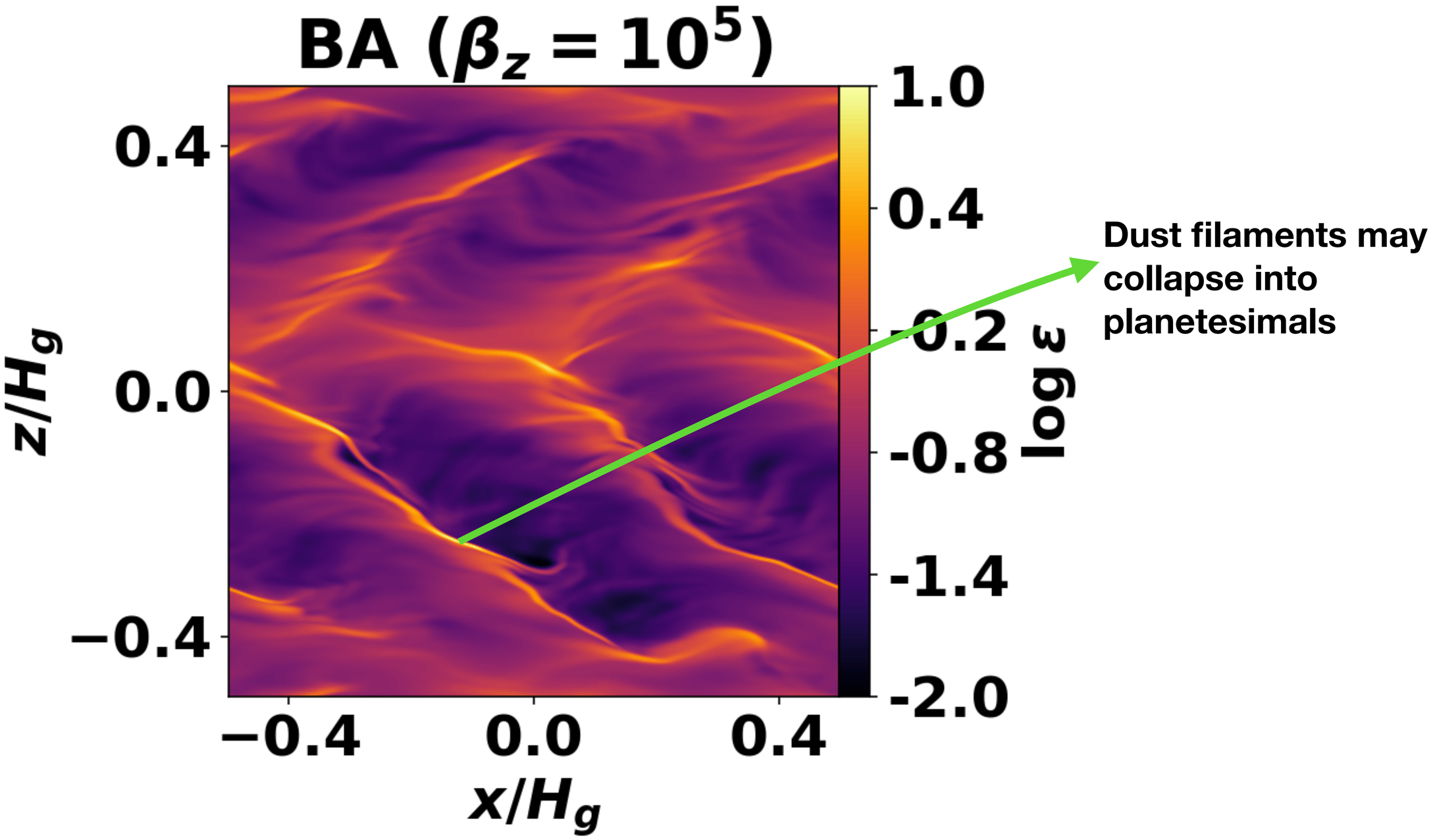
Streaming instability for planetesimal formation





(Drazkowska et al., 2022, PPVII)

Streaming instability of dusty gas



The SI is both simple and complex

Abstract interpretation

- Resonance between dust-gas drift and inertial waves (Squire & Hopkins 2018)

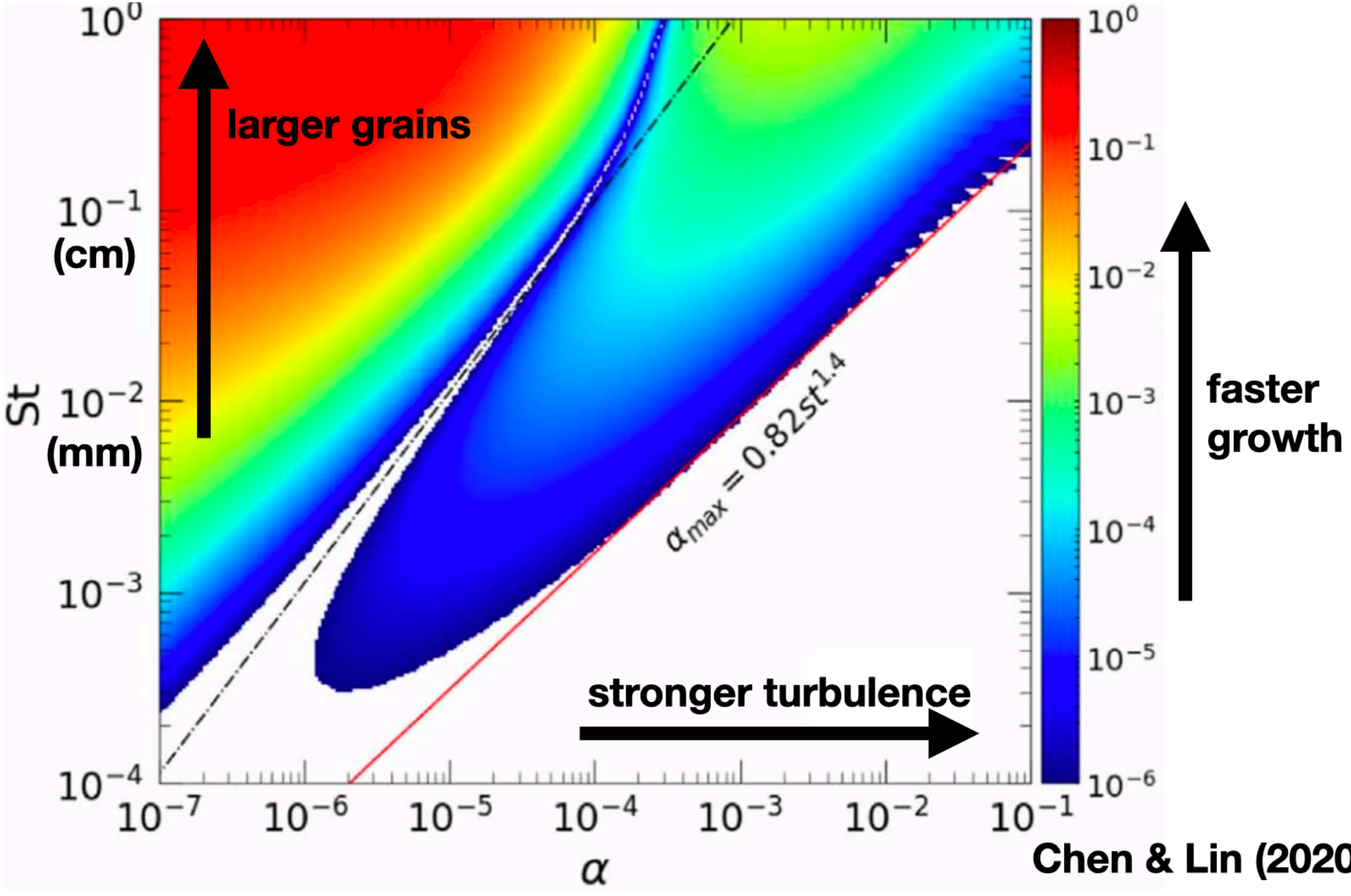
Simple ingredients

- Mutually interacting dust and gas in rotation + relative drift
- But PPDs are much more

Extensions to the SI

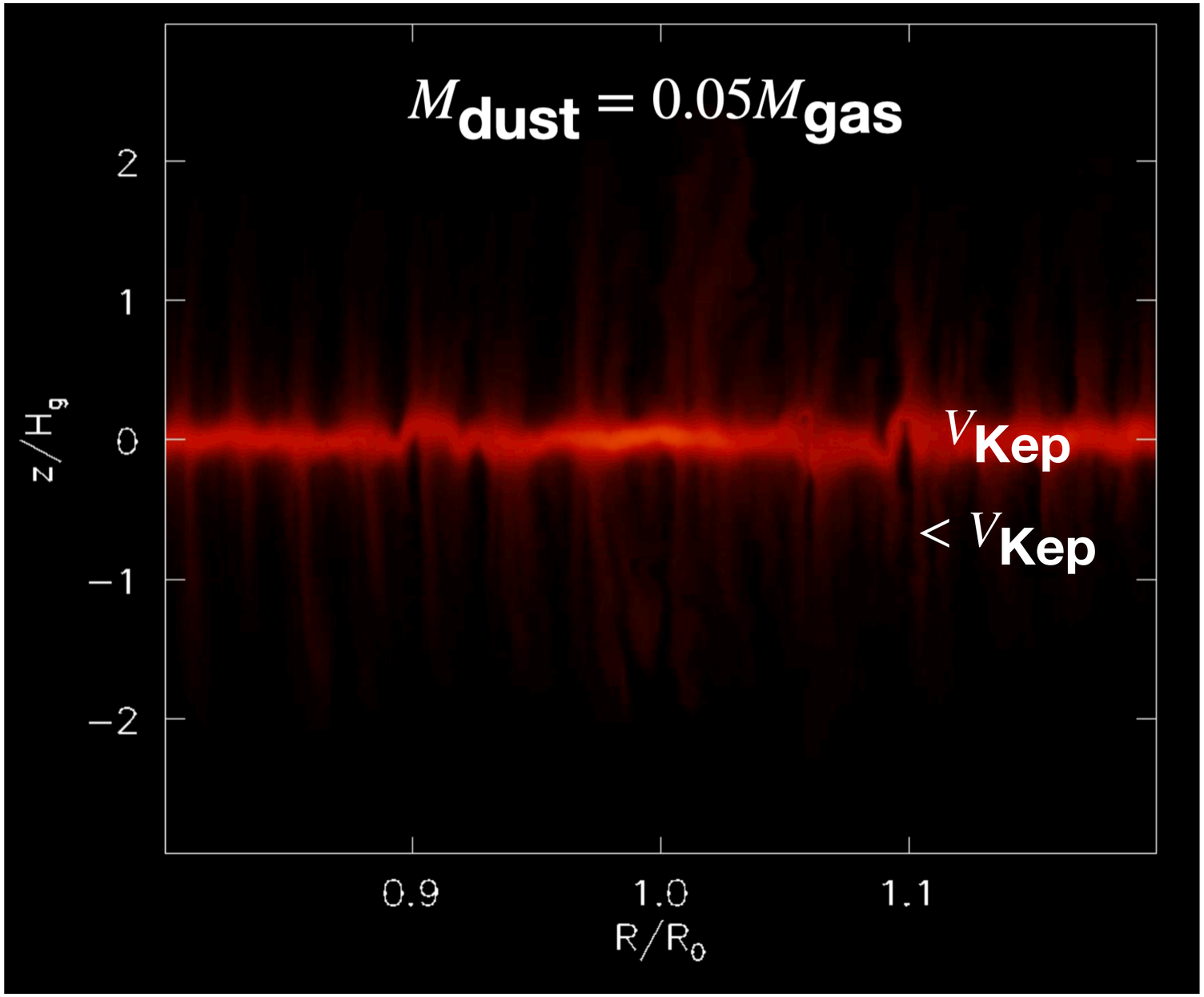
- turbulence → Chen & Lin (2020)
- vertical structure → Lin (2021)
- magnetic fields → Lin & Hsu (2022), Hsu & Lin (2022), Wu, Lin et al. (accepted)
- thermodynamics → Lehmann & Lin (2023)

Streaming instability is easily killed by turbulent viscosity



Chen & Lin (2020)

Stratified dust layers

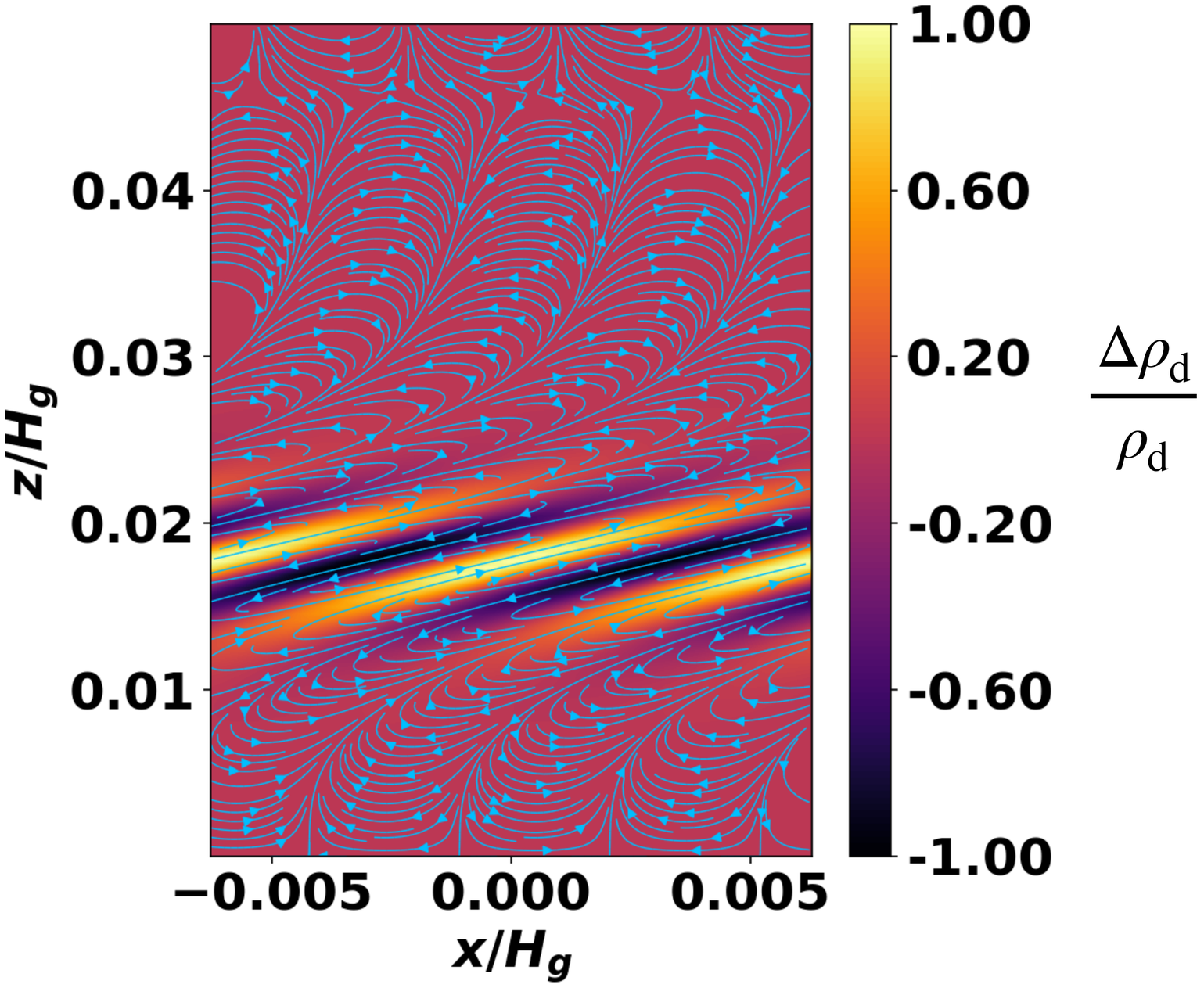


$$\frac{\partial \Omega}{\partial z} \neq 0$$

Lehmann & Lin (2022)

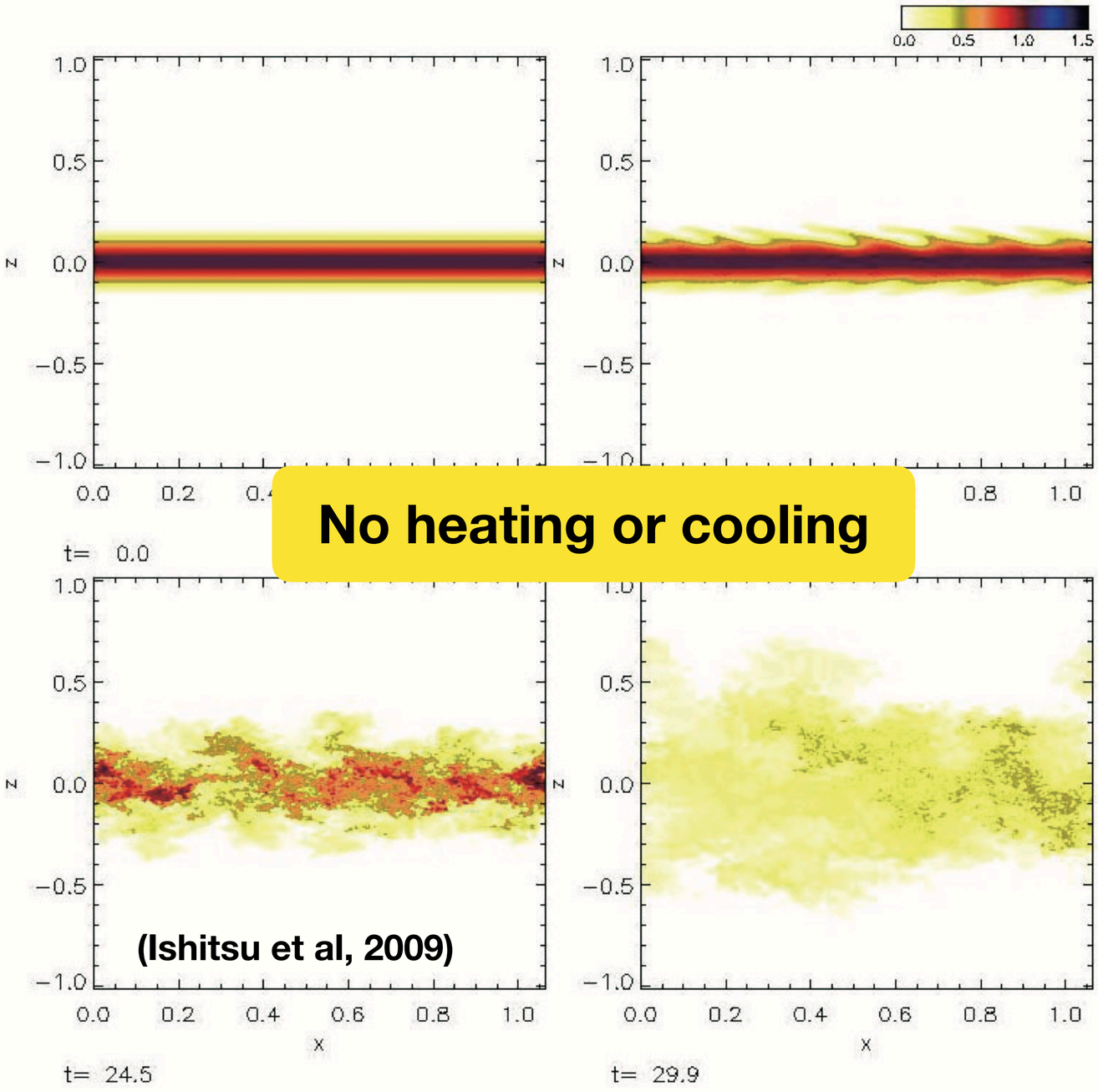
“Vertically shearing SI” in stratified disks

$s_{\mathbf{grow}} \sim \Omega$



Lin (2021)

Vertically shearing SIs grow fast but…

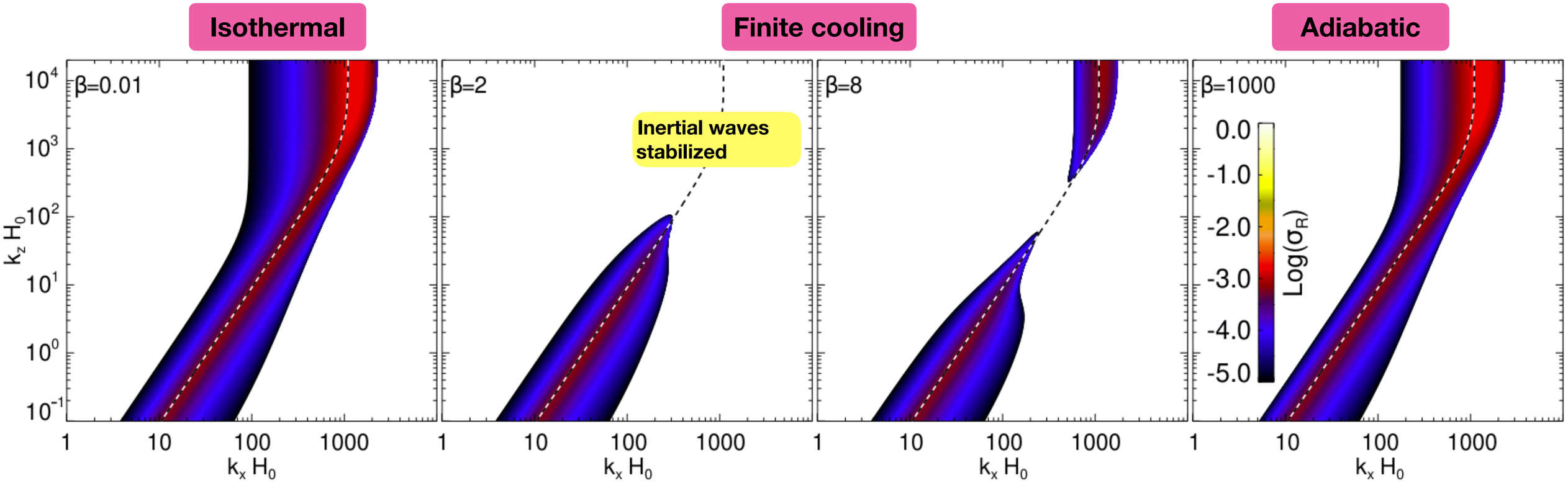


No heating or cooling

(Ishitsu et al, 2009)

dust layer dispersed

SI + radial buoyancy $N_R^2 > 0$



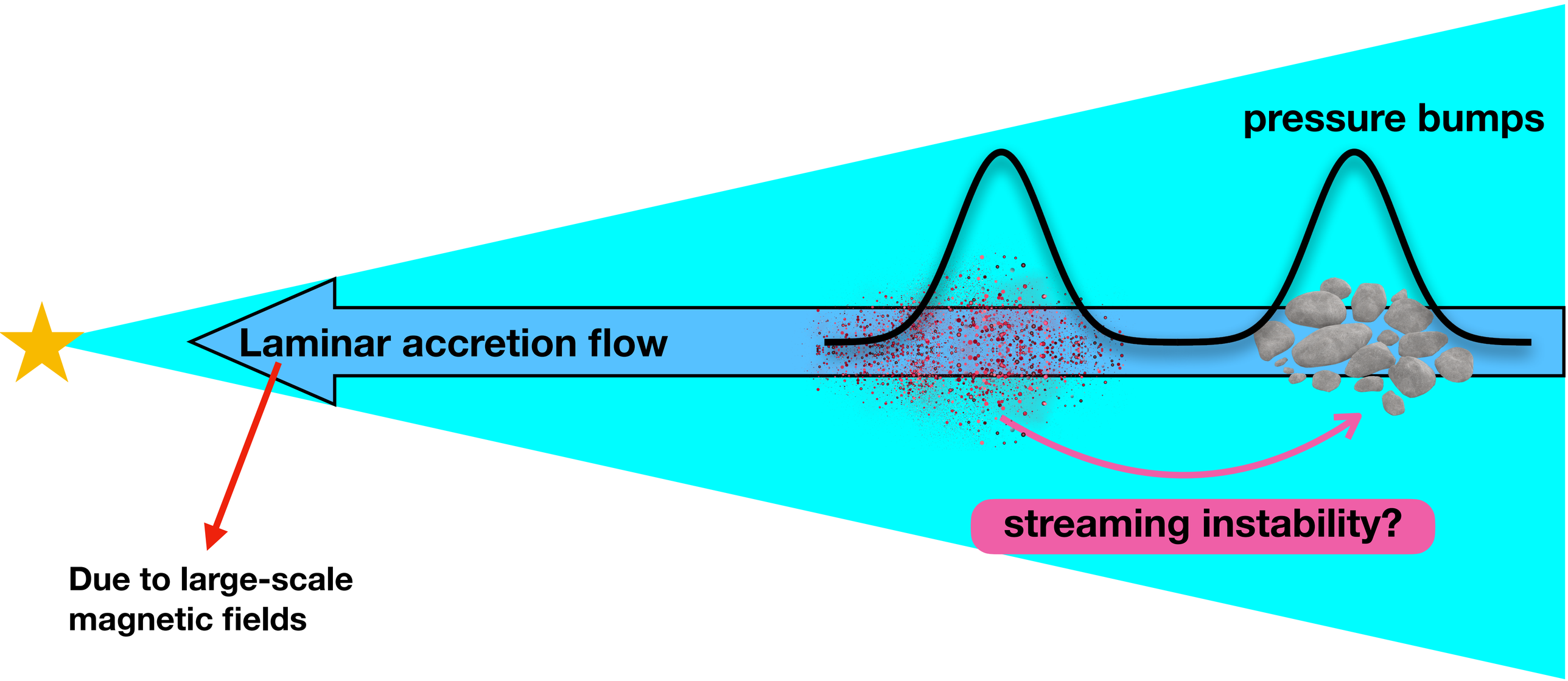
Lehmann & Lin (2023)

So far, not so good

- turbulence
- vertical structure
- thermodynamics

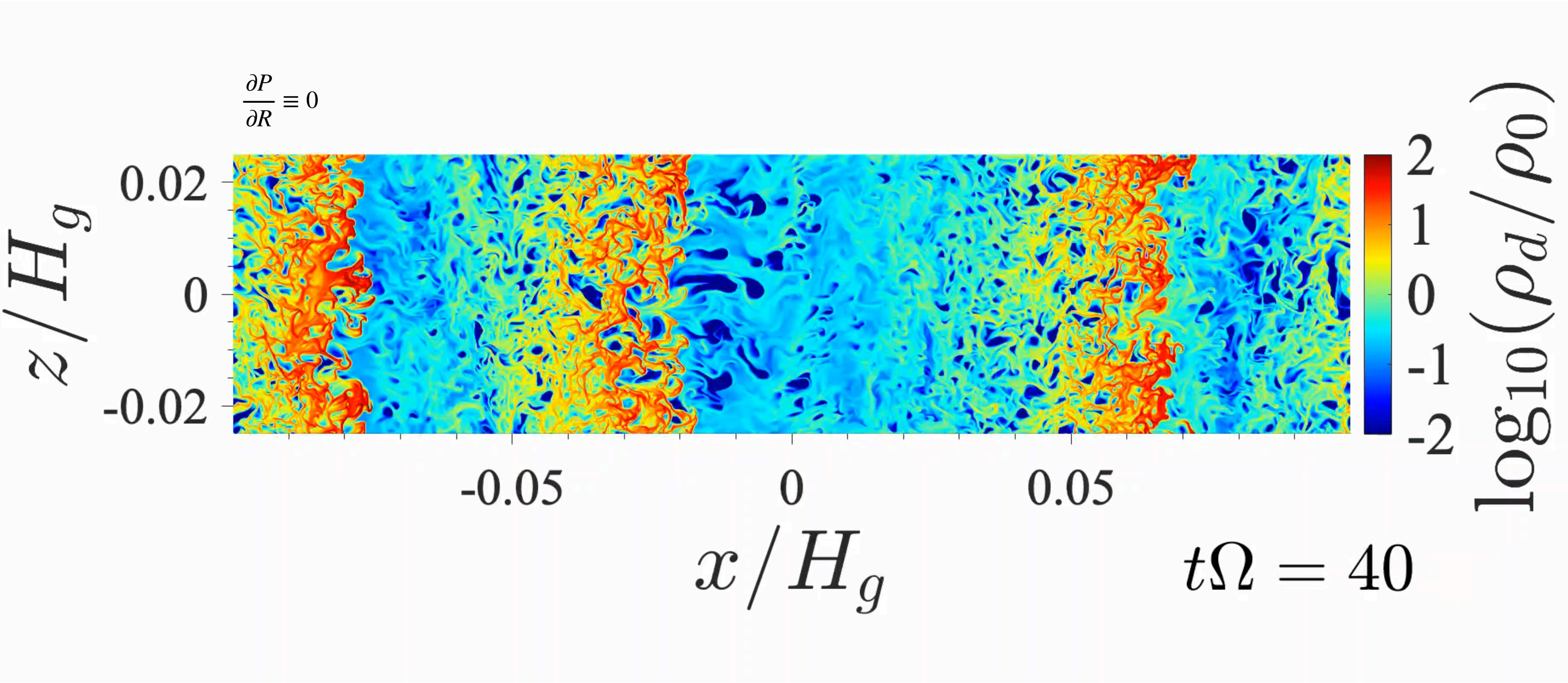
SI weakened

What about magnetic fields?



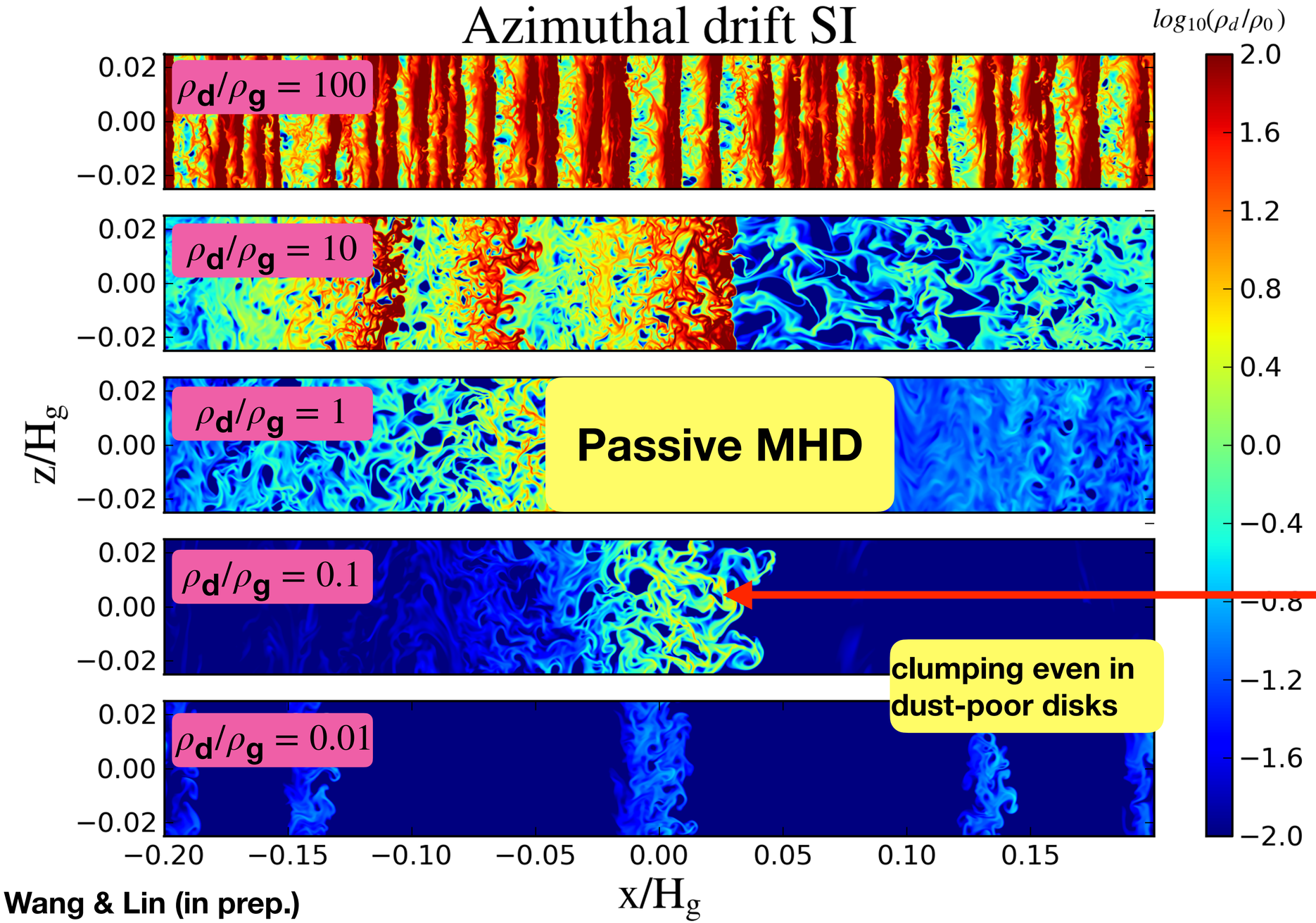
(e.g. Riols et al. 2020, Cui & Bai 2021)

Nonlinear evolution of the SI in accreting disks



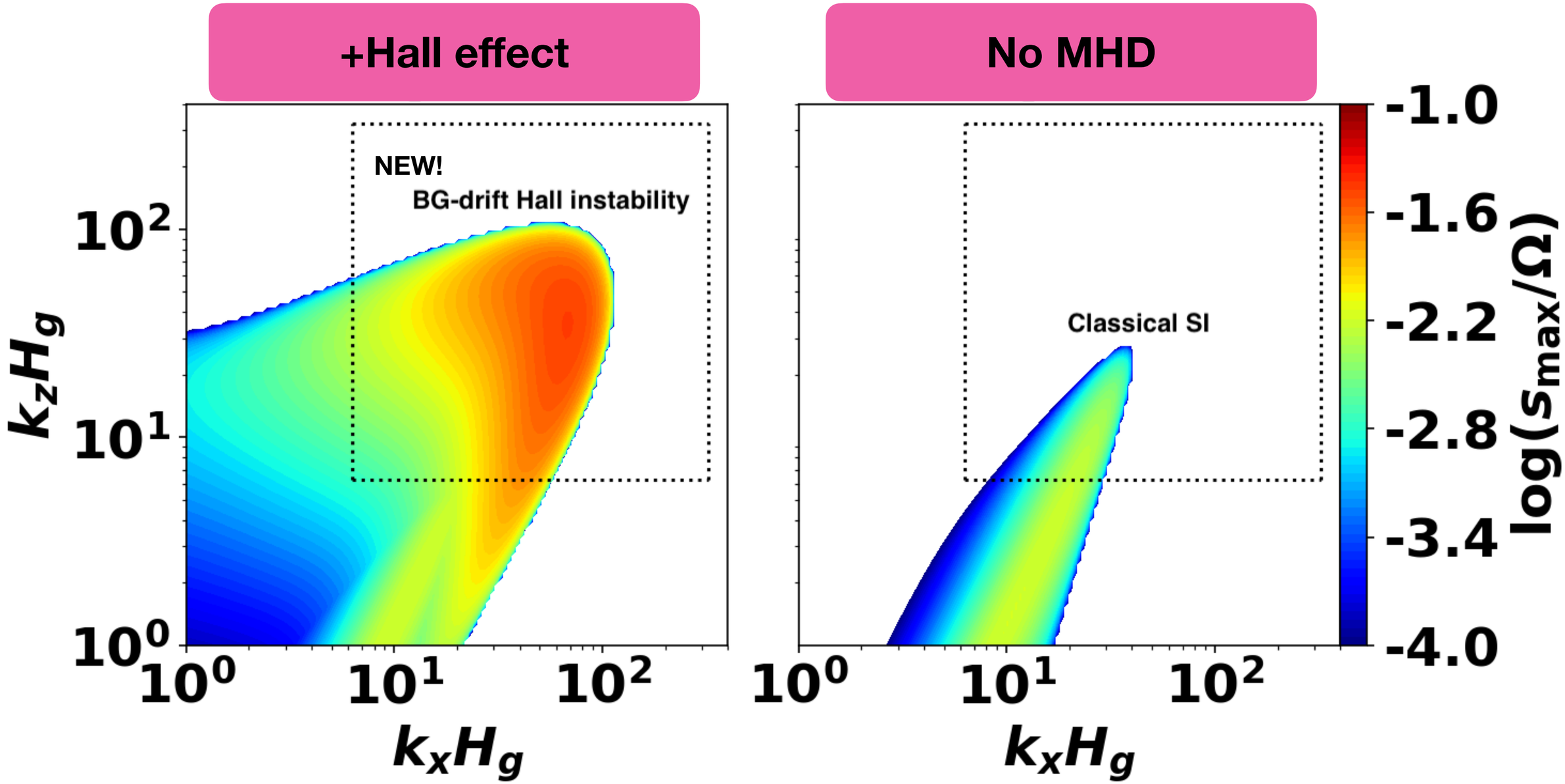
Lin & Hsu (2022), Hsu & Lin (2022)

Parameter study



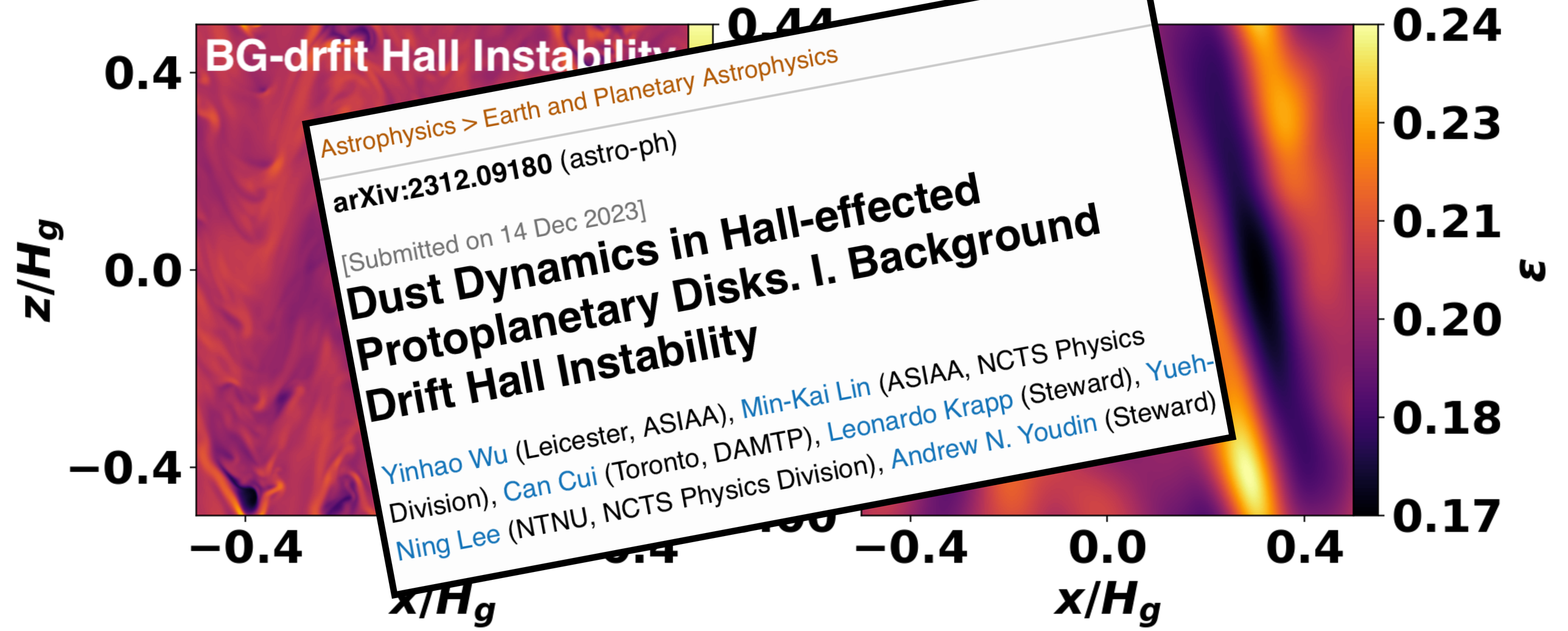
Shiang-Chih Wang & Lin (in prep.)

Live MHD & dust dynamics



Yinhao Wu, Lin, Can Cui, …, Yueh-Ning Lee, et al. (accepted)

Spectral simulations with Dedalus



Astrophysics > Earth and Planetary Astrophysics

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Dust Dynamics in Hall-effected Protoplanetary Disks. I. Background Drift Hall Instability

Yinhao Wu (Leicester, ASIAA), Min-Kai Lin (ASIAA, NCTS Physics Division), Can Cui (Toronto, DAMTP), Leonardo Krapp (Steward), Yueh-Ning Lee (NTNU, NCTS Physics Division), Andrew N. Youdin (Steward)

Yinhao Wu, Lin, Can Cui, …, Yueh-Ning Lee, et al. (accepted)

Summary

- **Kill the SI: turbulence, vertical structure, thermodynamics**
- **Revive the SI: gas accretion, magnetic fields**
- **Future: convection, coagulation, improved simulations, etc.**

Thank you

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