

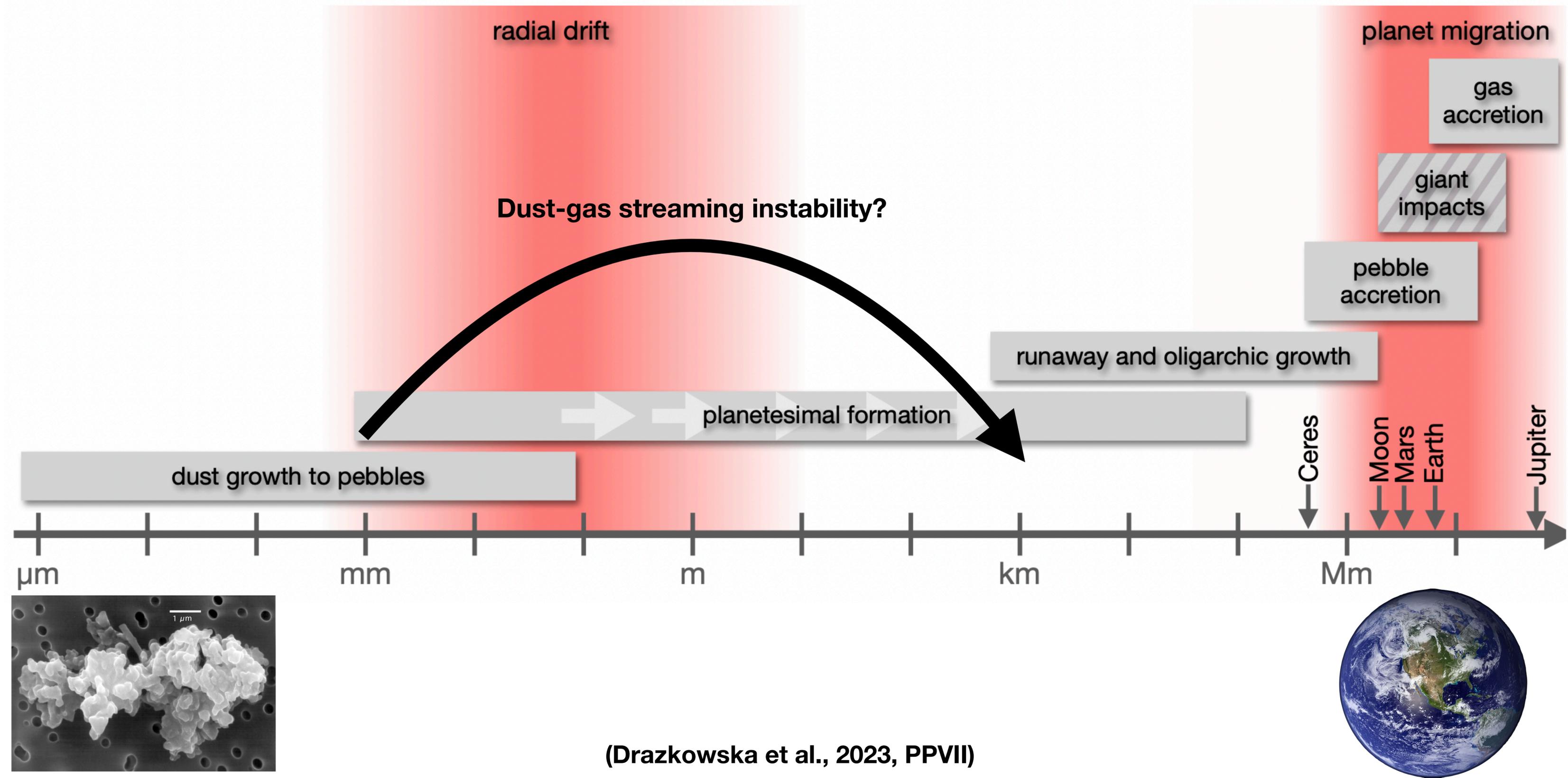
Dust dynamics in non-isothermal gas with application to planetesimal formation

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January 2024

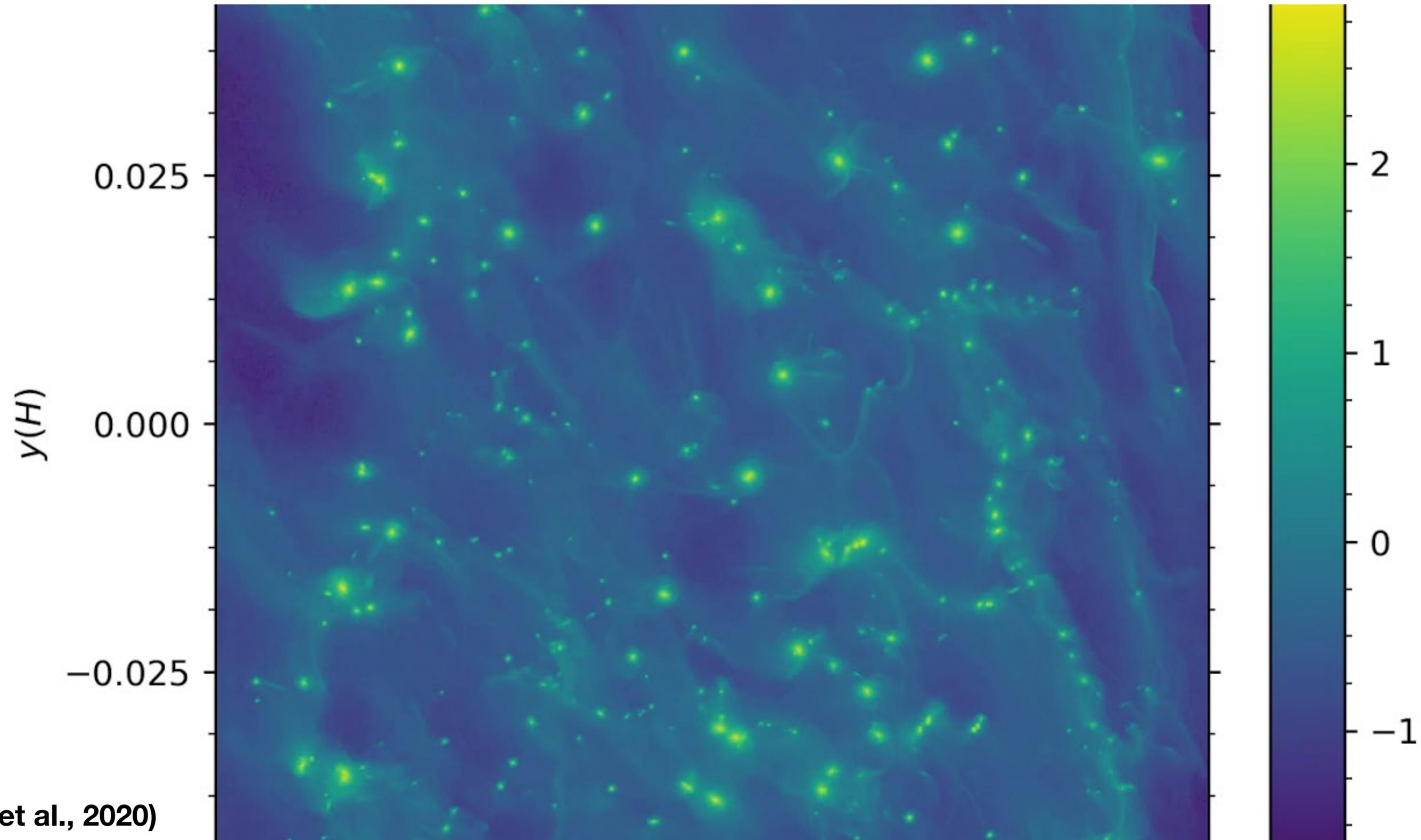


The road from dust to planets



(Drazkowska et al., 2023, PPVII)

Planetesimal formation via the streaming instability



(Nesvorný et al., 2020)

Our group's extensions to the streaming instability

- **turbulence**



Chen & Lin (2020)

- **vertical structure**



Lin (2021)

- **magnetic fields**



**Lin & Hsu (2022), Hsu & Lin (2022),
Wu, Lin et al. (2024)**

- **thermodynamics**



Lehmann & Lin (2023), Lin & Lehmann (in prep)

Non-isothermal gas-dust interaction: why?

- **Small dust: heating/cooling, ionization**
- **Large dust: dynamical interaction with gas:**
 - **Non-isothermal gas instabilities + dust**
 - **Streaming instabilities + gas heating/cooling**

Boussinesq shearing box

- **Gas**: incompressible but with cooling and/or thermal diffusion (Latter & Papaloizou, 2017)

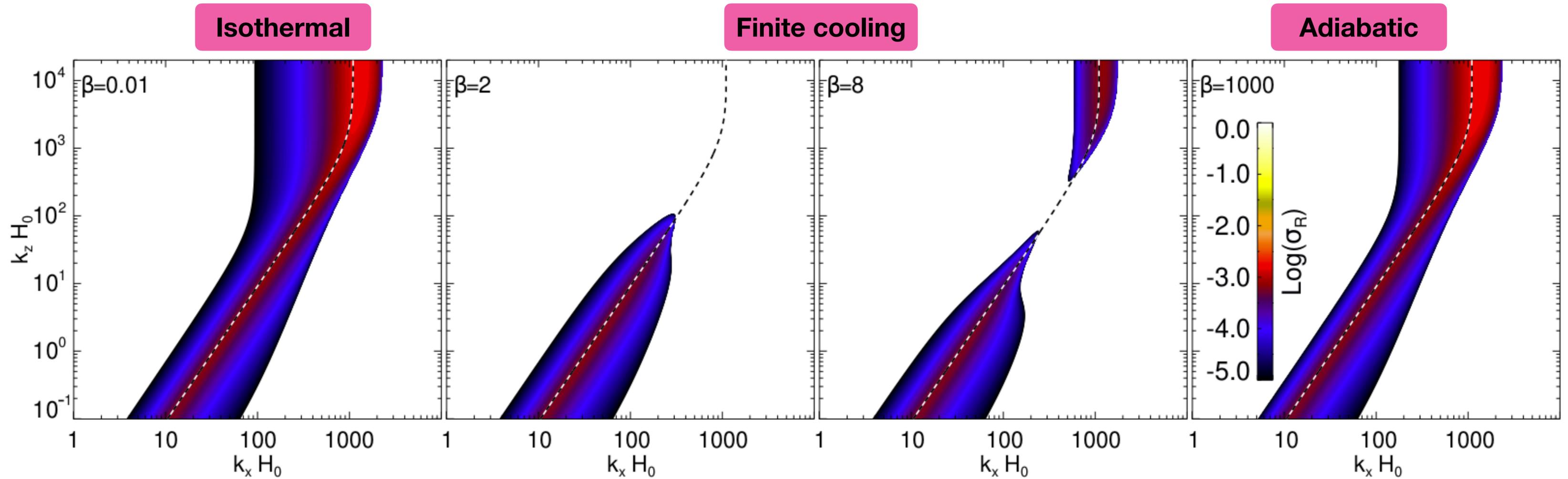


Radial buoyancy
 N_R^2

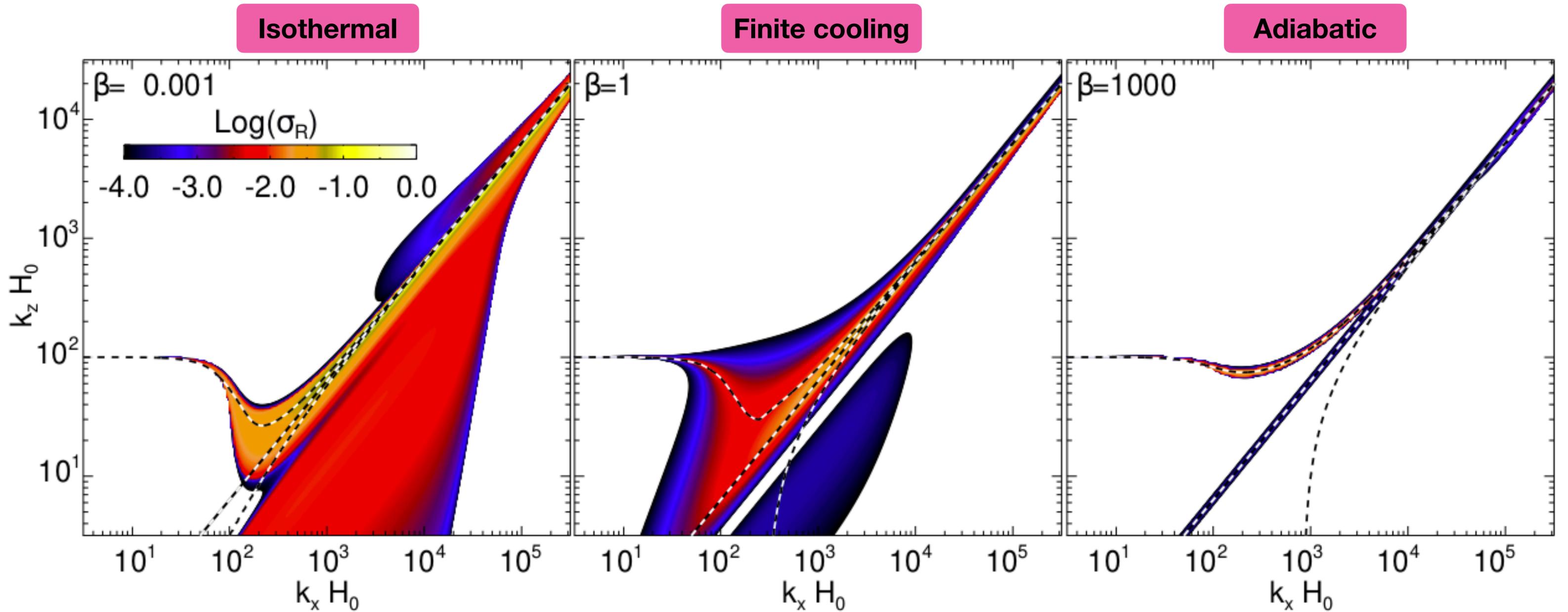
Vertical buoyancy
 N_z^2

- **Dust**: added as a pressureless fluid, coupled through drag (Lehmann & Lin, 2023)

Streaming instability + radial buoyancy

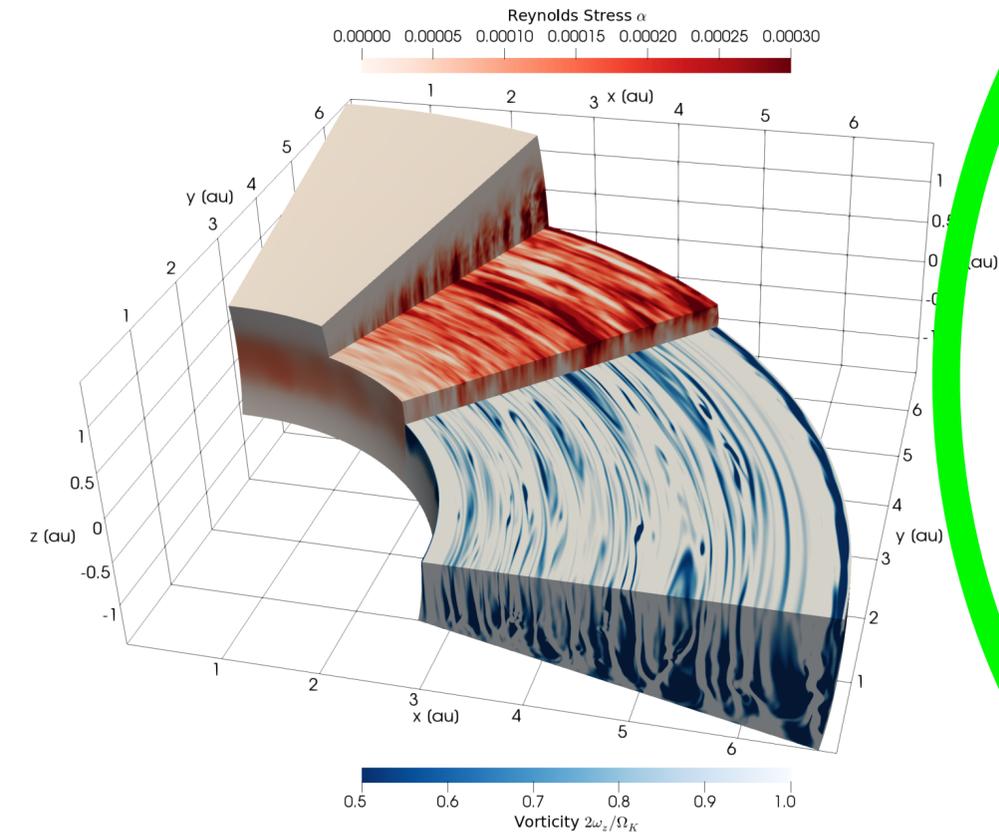


“Dust settling” instability + vertical buoyancy



Thermo-hydrodynamic instabilities in PPDs

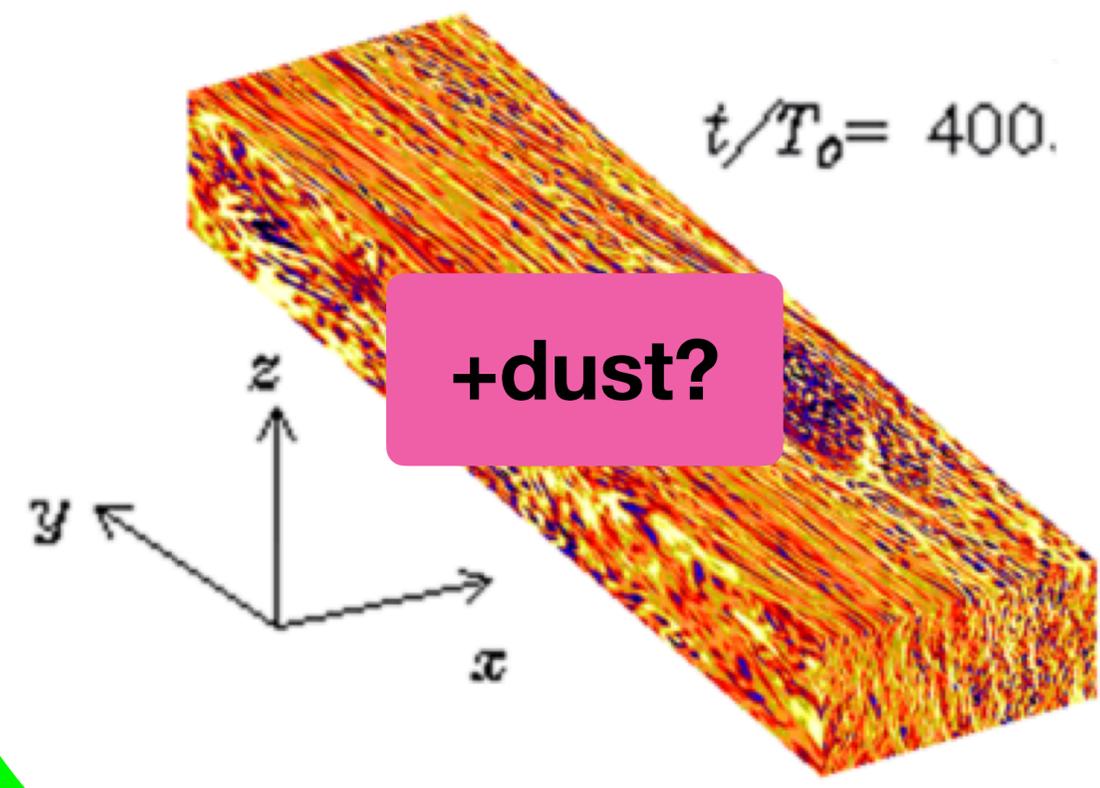
Vertical shear instability



Pfeil & Klahr (2020)

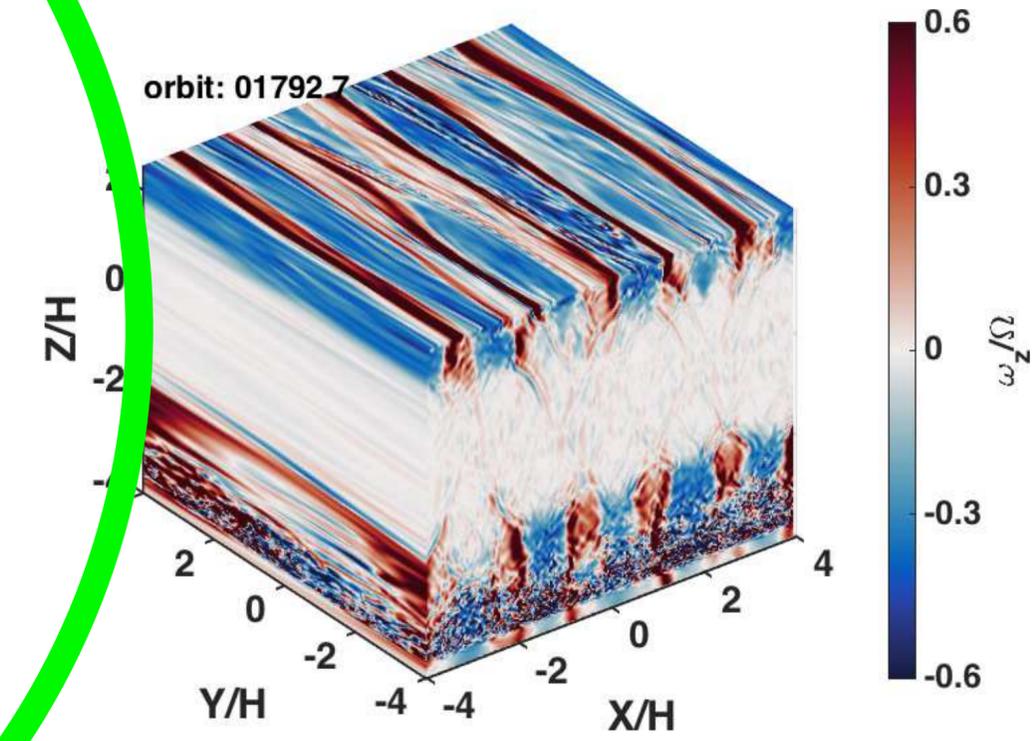
Lin & Youdin (2015)
Cui & Lin (2021)

Convective overstability



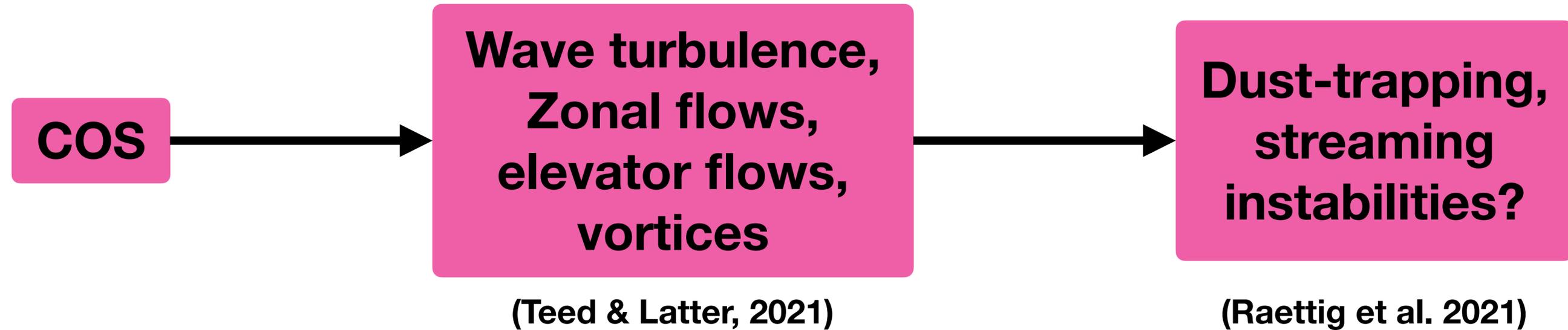
Lyra (2014)

Zombie vortex instability



Barranco et al. (2018)

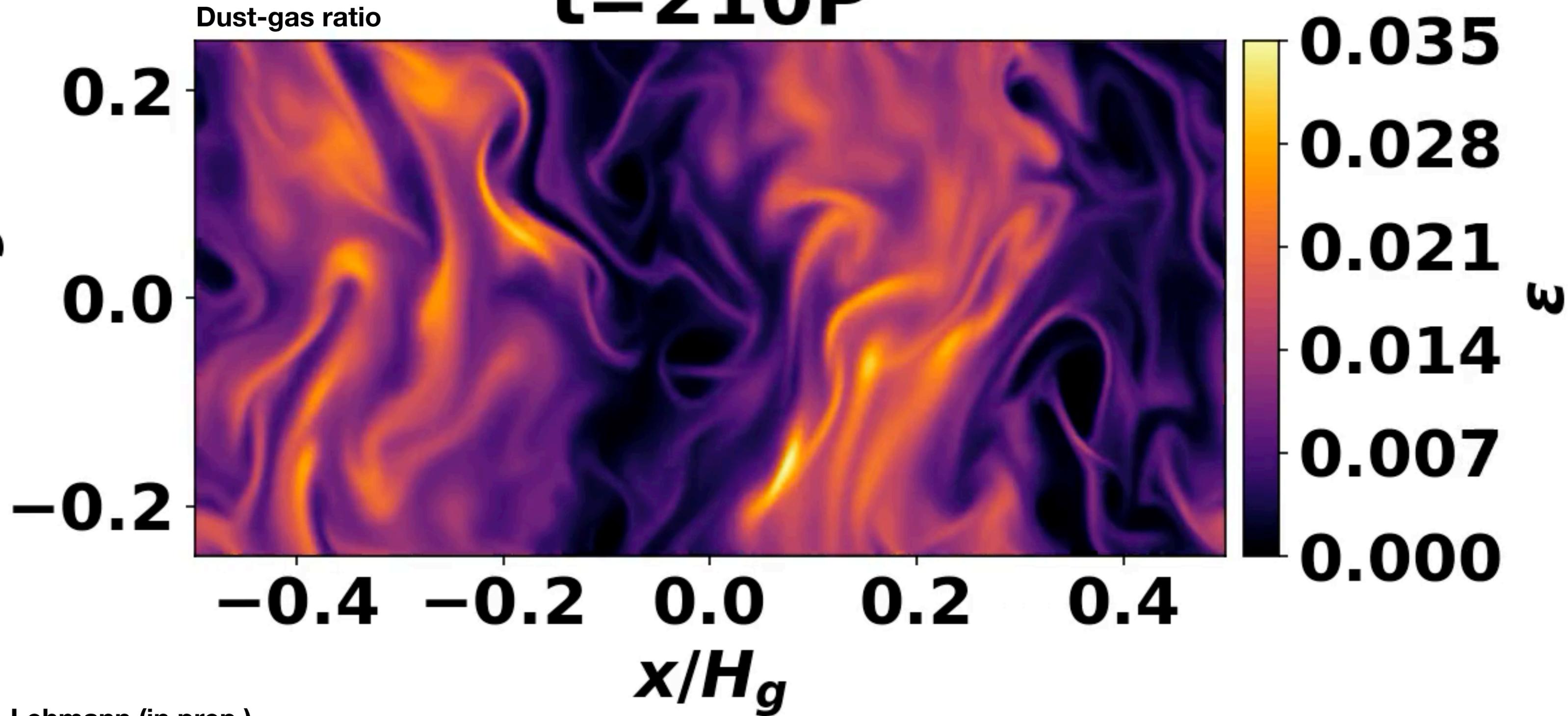
Nonlinear evolution with dust



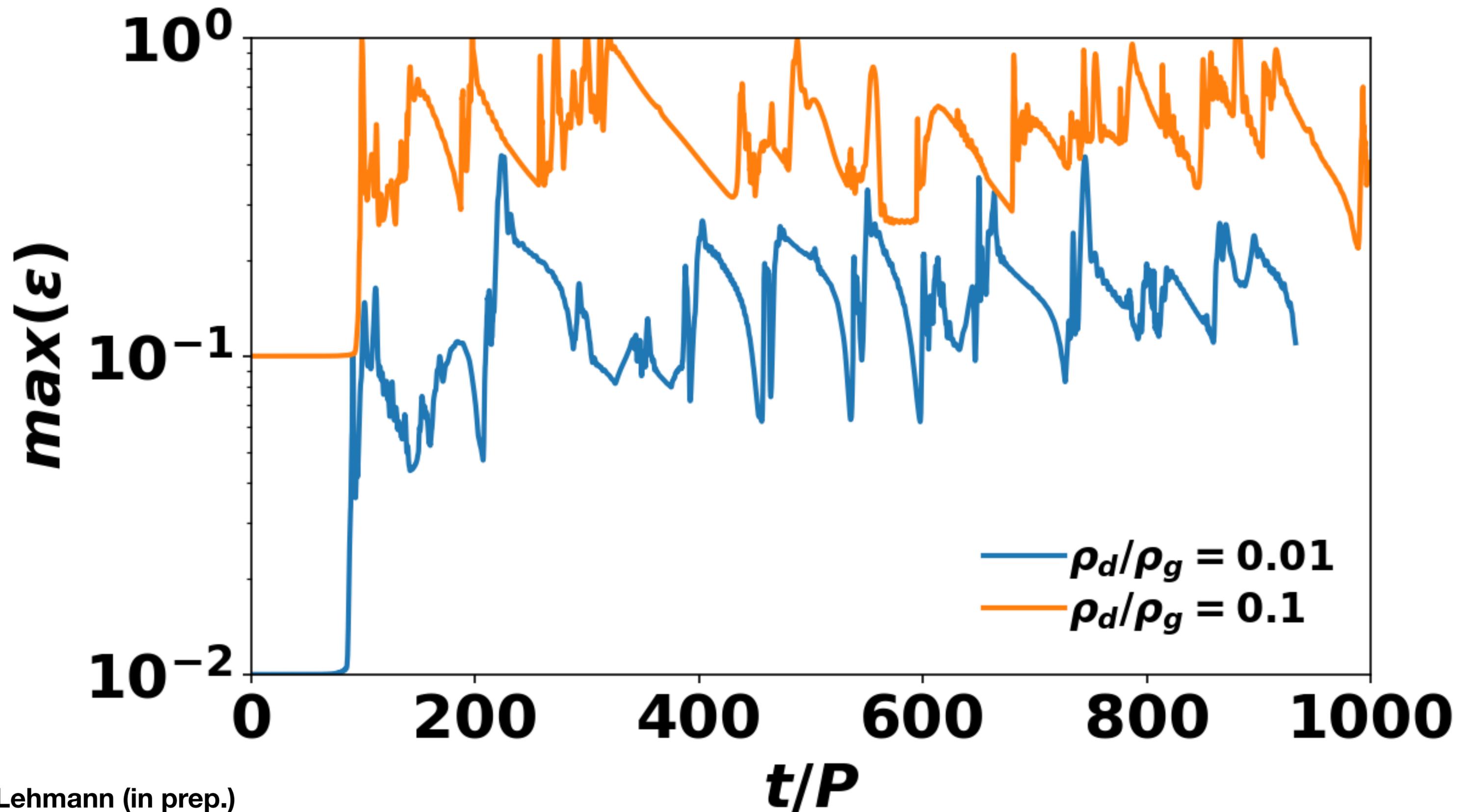
- **Dedalus** spectral code (Burns et al., 2019) to evolve the axisymmetric dusty Boussinesq equations + dissipation

Example run

$t=210P$



COS & dust feedback



Summary

- Dust-gas interaction is a key component
- Streaming instabilities are driven by gas thermodynamics;

**2024 ASIAA Summer Student Project:
Radial Convection in Protoplanetary Disks**

Streaming instabilities can be modified by dust

Thank you
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