The Physics of Planets

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Streaming instability

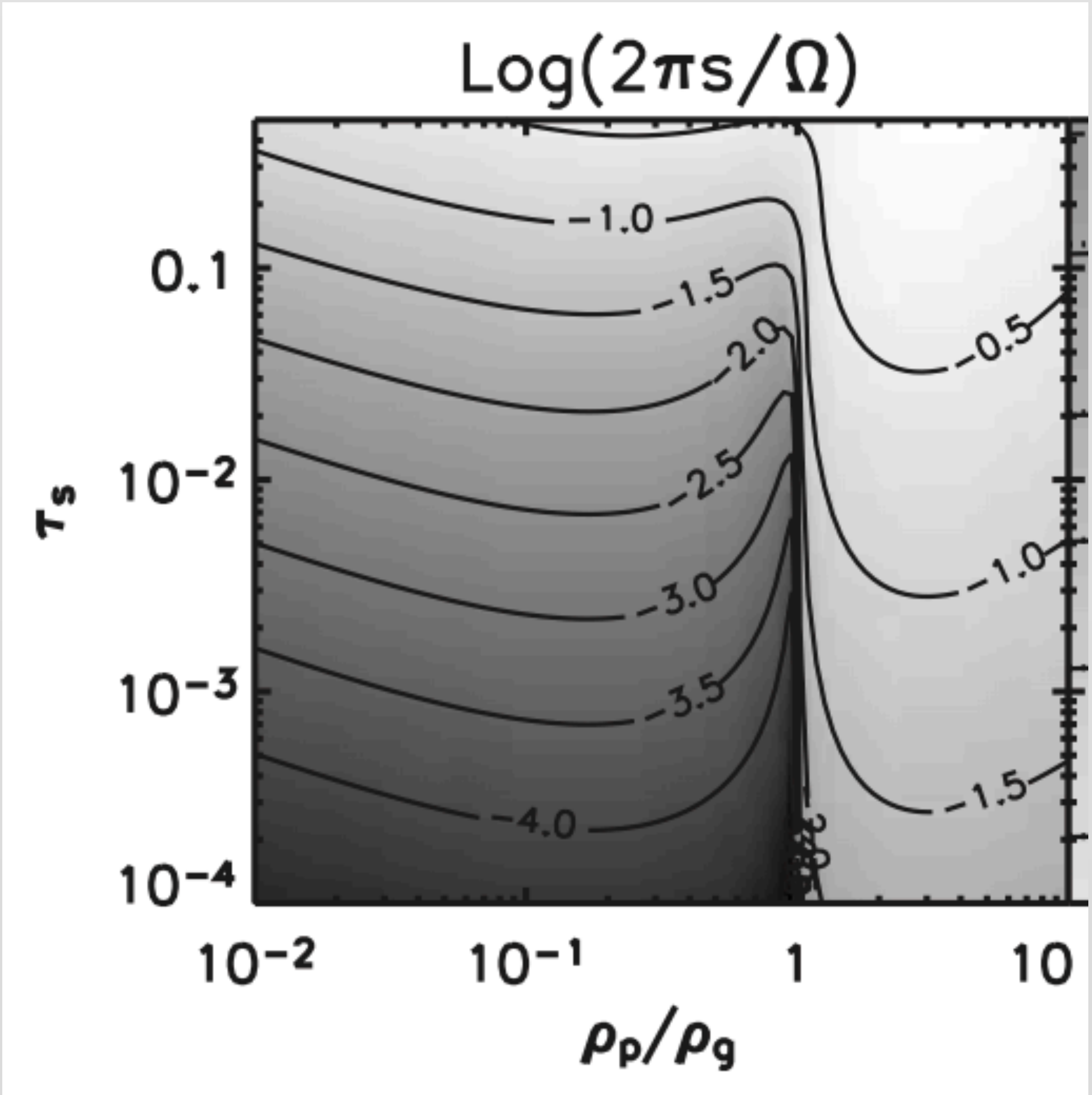
Numerical questions:

- does the instability saturate with particle over-densities large enough to trigger gravitational collapse?
- what happens when collapse occurs?

Require: two fluids with mutual aerodynamic interactions, rotation, self-gravity for collapse part

Most simulations use a particle representation of the solids, and include vertical stratification… different from *Youdin & Goodman (2005)* analytic work

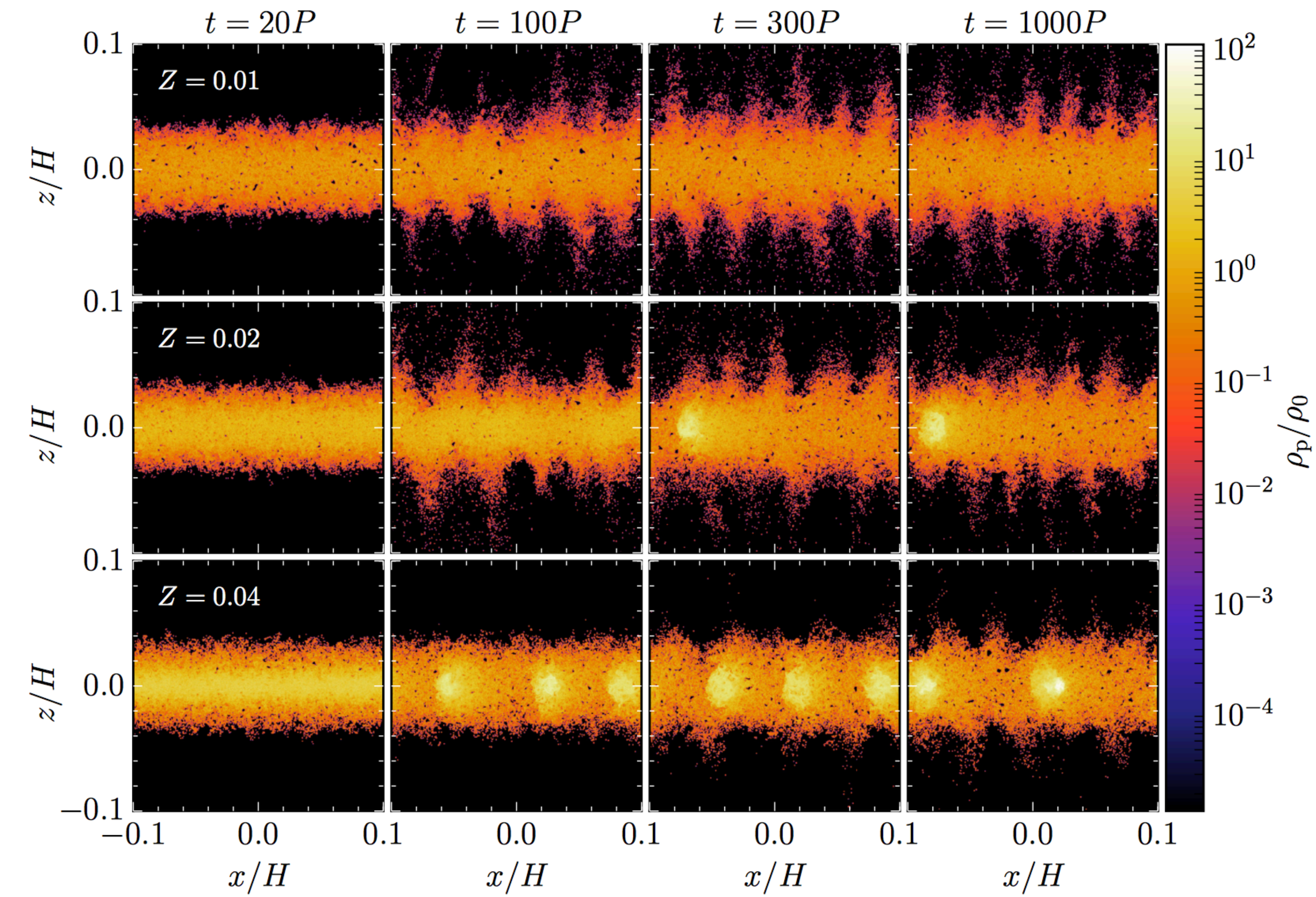
Original *Johansen et al. (2007)* simulations included gas phase turbulence, many more recent simulations do not



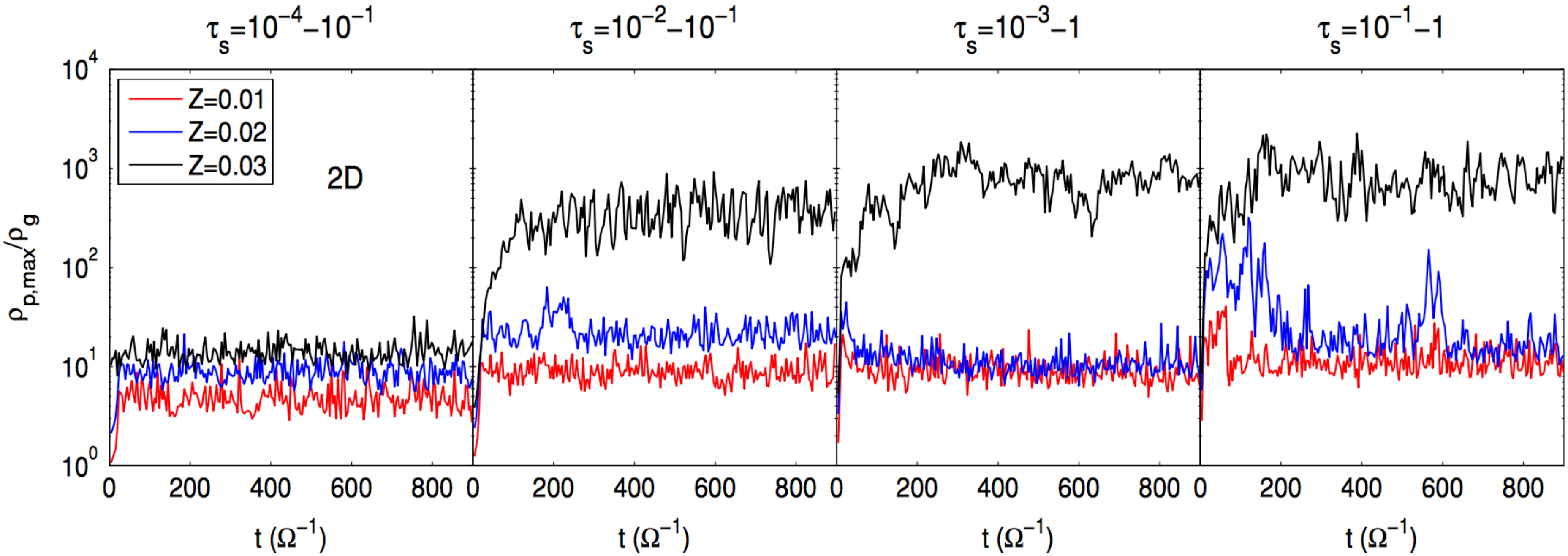
Youdin & Goodman (2005)

Analytic growth rates

Wide range of unstable conditions, but growth rates can be slow

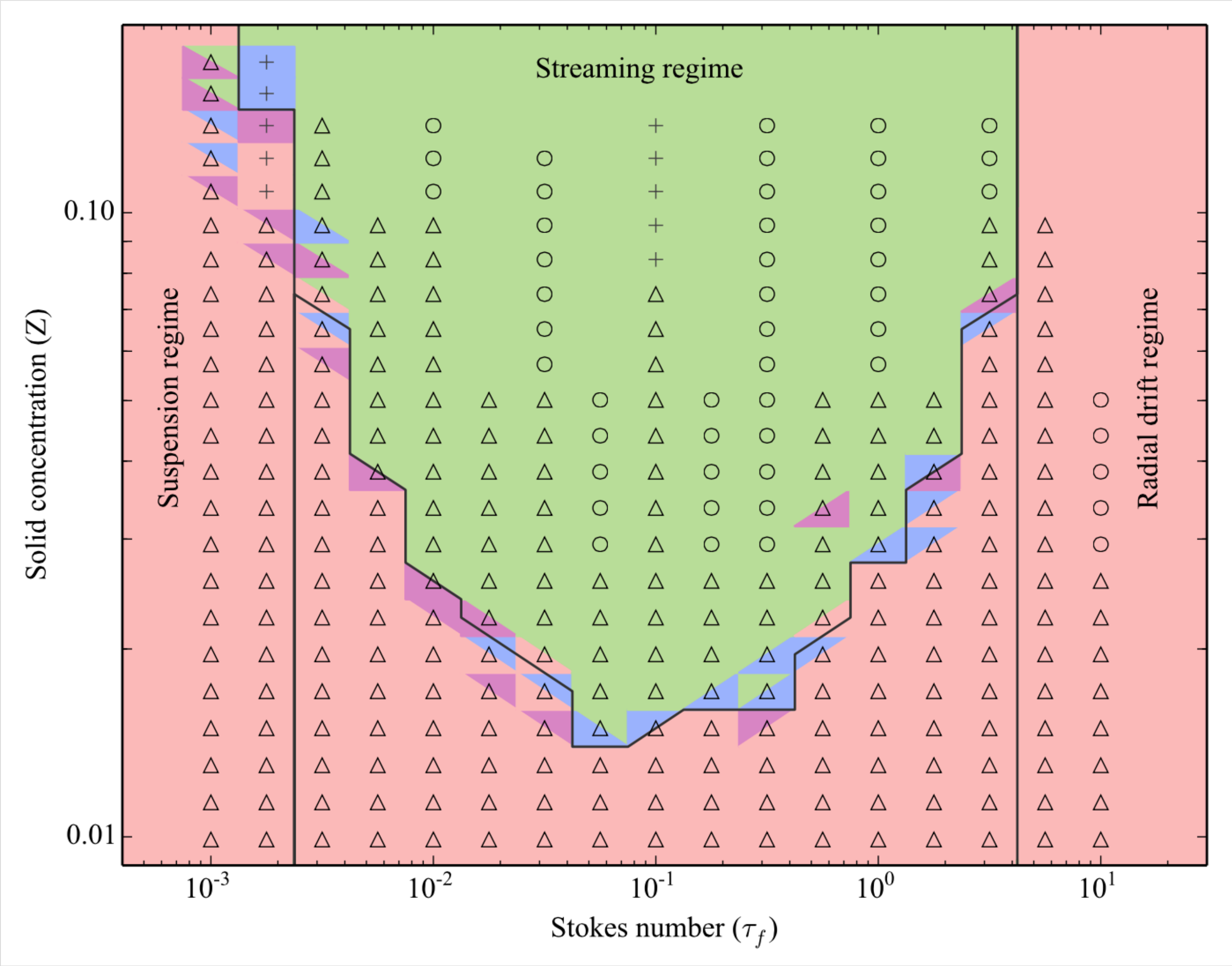


Yang et al. (2016)



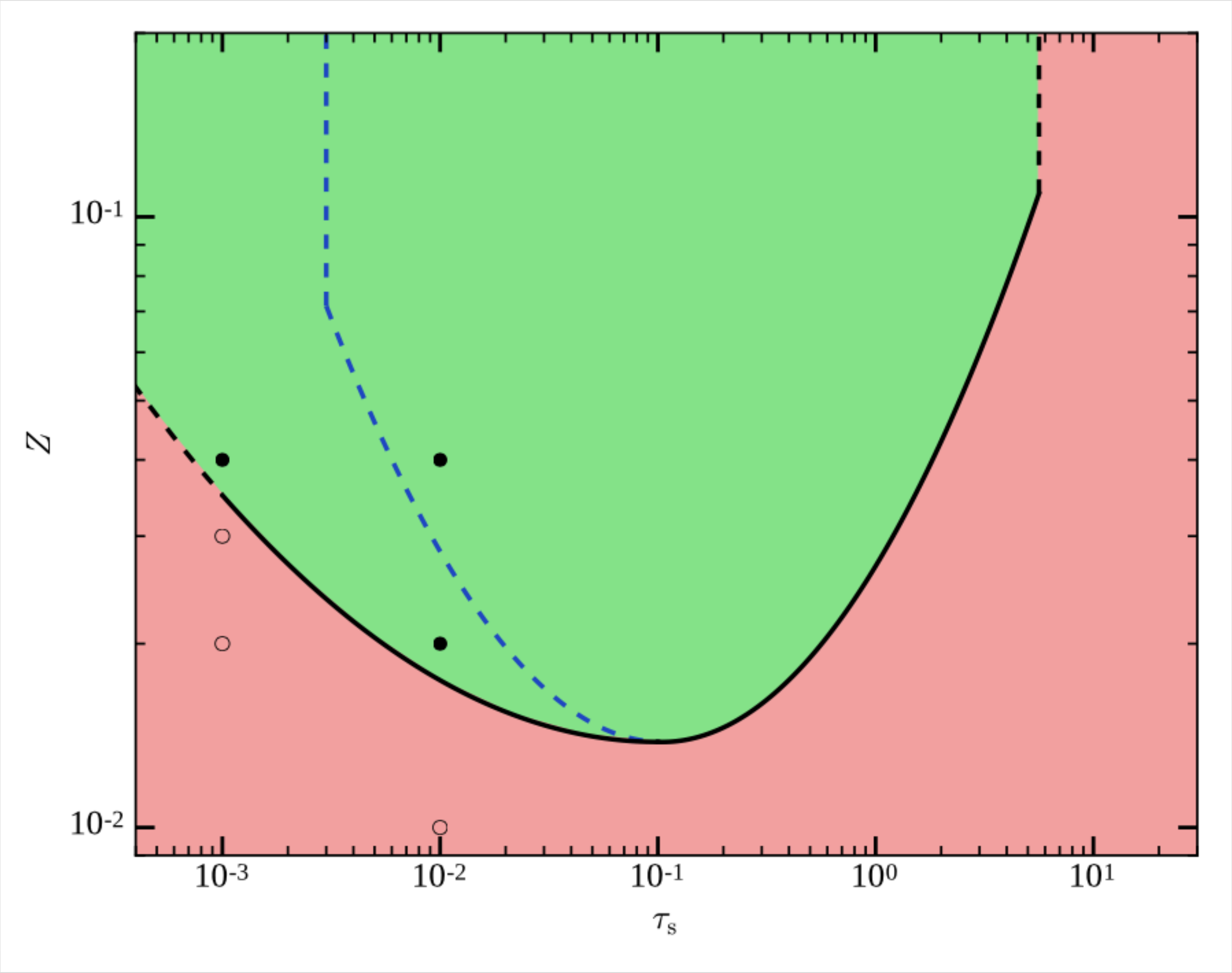
Bai & Stone (2010)

Does the instability saturate at levels high enough to trigger gravitational collapse?



Carrera et al. 2015

Does the instability saturate at levels high enough to trigger gravitational collapse?



Yang et al. 2016

Outcome of collapse phase

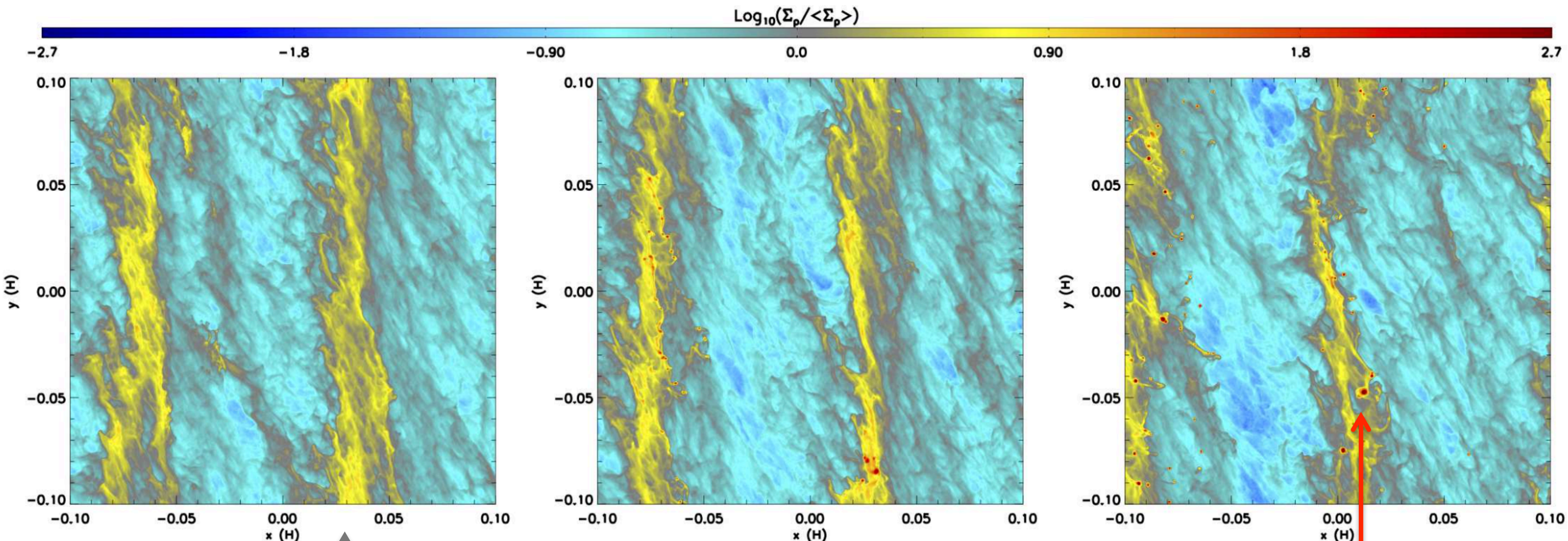
Example movie from simulations including self-gravity:

`http://jila.colorado.edu/~jasi1566/3dstreaminginsta.html`

Simon et al. (2016)

$\tau = 0.3$, $Z = 0.02$

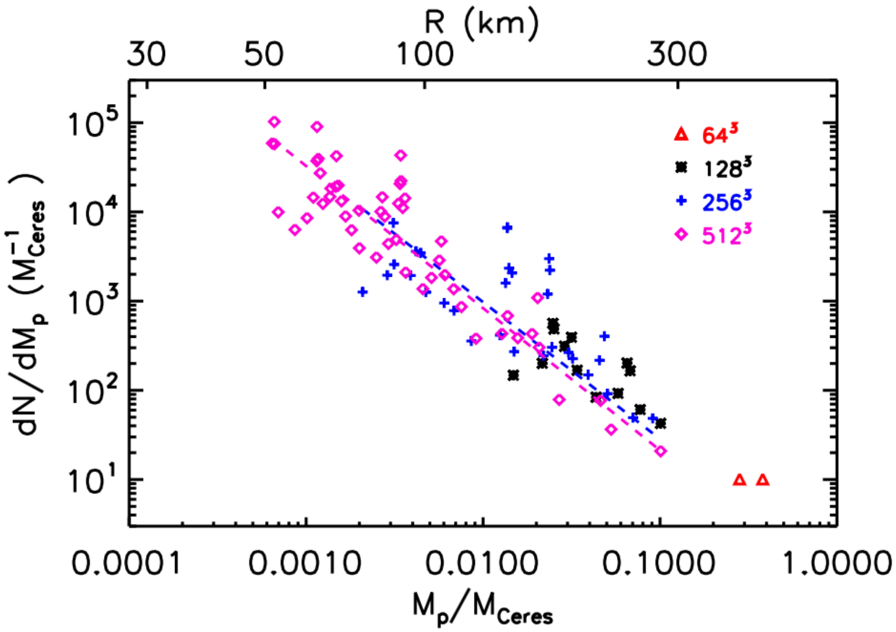
512^3 gas, 1.5×10^8 particles
nominal mass resolution
corresponds to ~0.5 km bodies

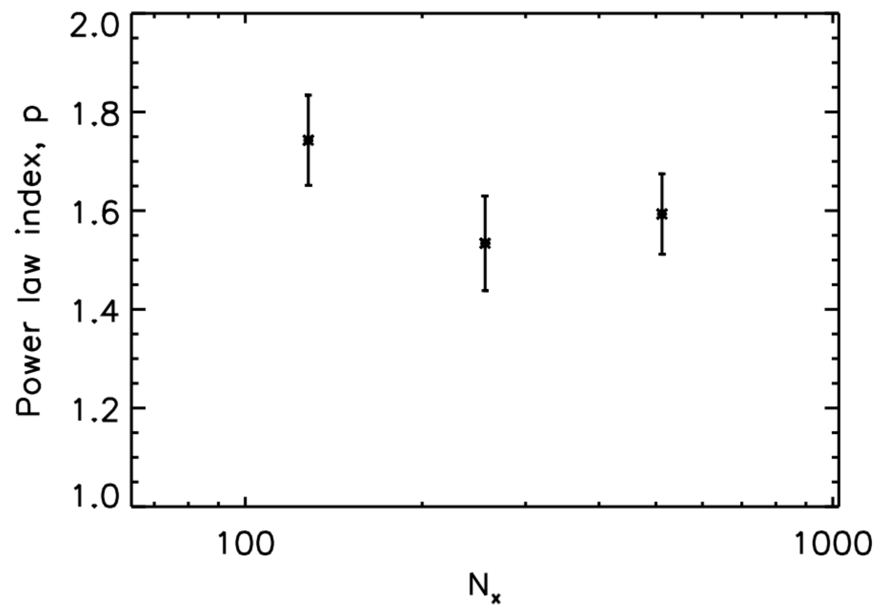


form ~axisymmetric bands
of clustered cm-sized solids

collapse
gravitationally

Initial planetesimal mass function





- mass distribution of primordial bodies consistent with a truncated power-law $dN / dm \sim m^{-1.6}$
- predict prompt formation of objects ~0.1 M_{ceres}
- consistent with *Johansen et al. (2015)*

Simon et al. (2016)