Can Grain Growth Explain Transition Disks?

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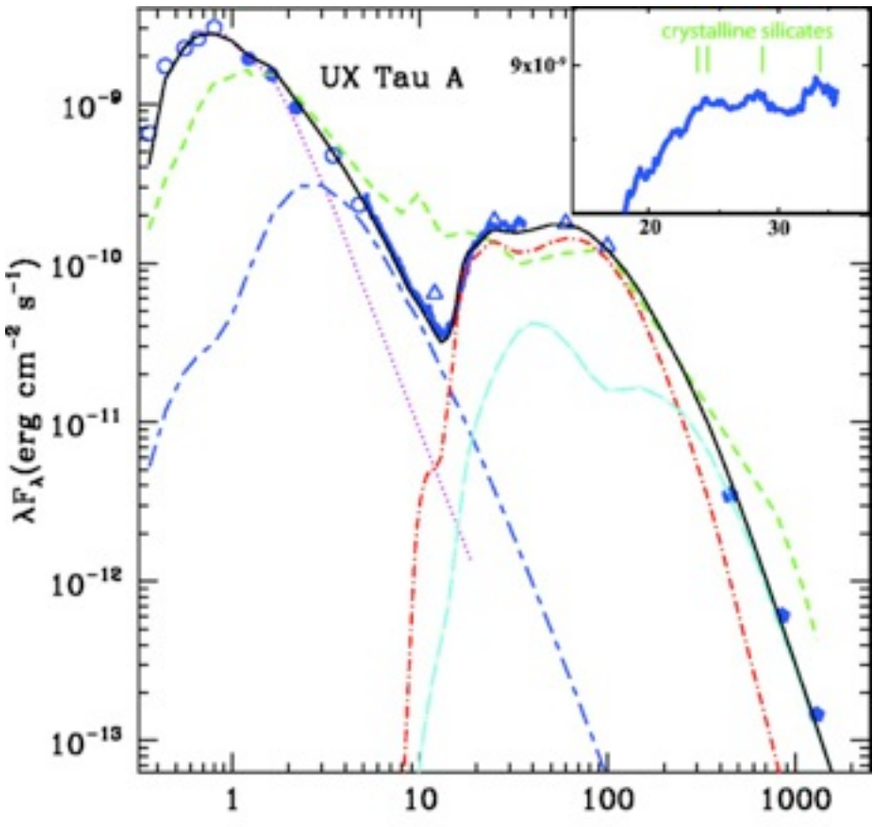
EC/LMU

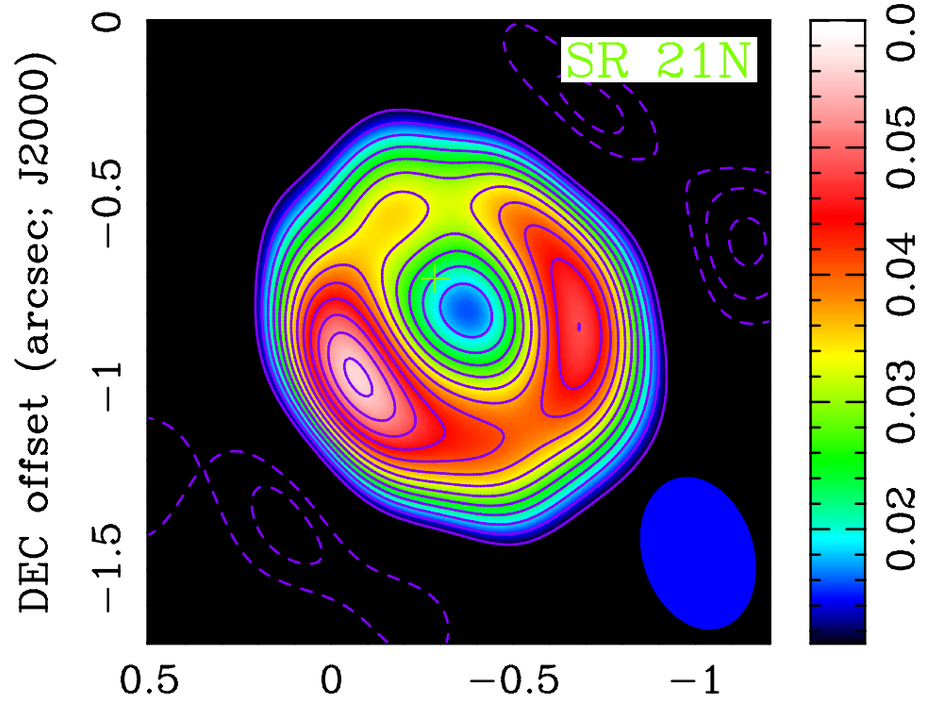
17.09.2012

Planet Formation and Evolution 2012

– Features of Transition Disks –



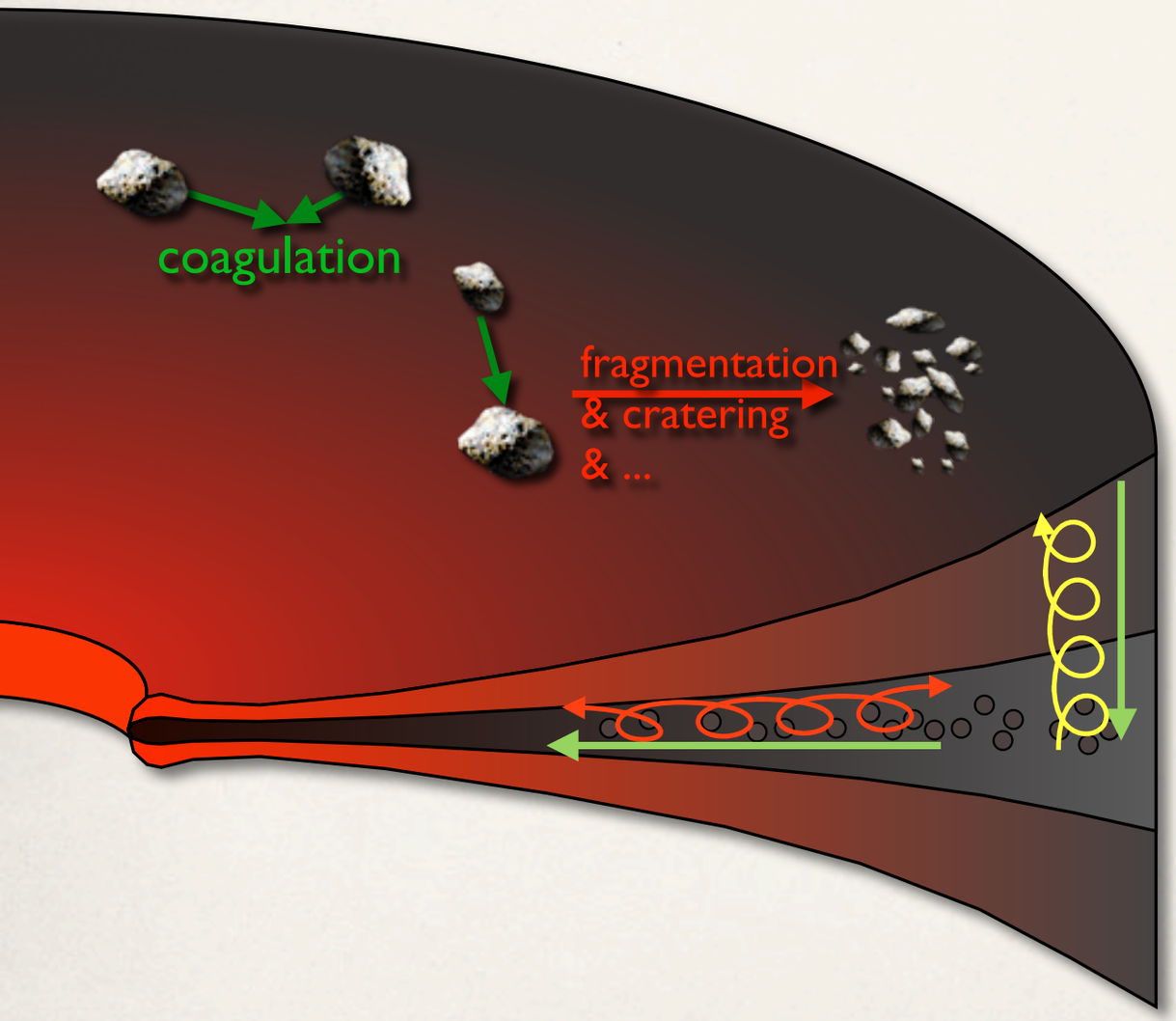
Espaillat et al. 2007



Brown et al. 2009

+ wide range of accretion rates!

– Dust Evolution in a Nutshell –



- **Vertical Evolution**
  turbulent mixing, settling, dead zones, …

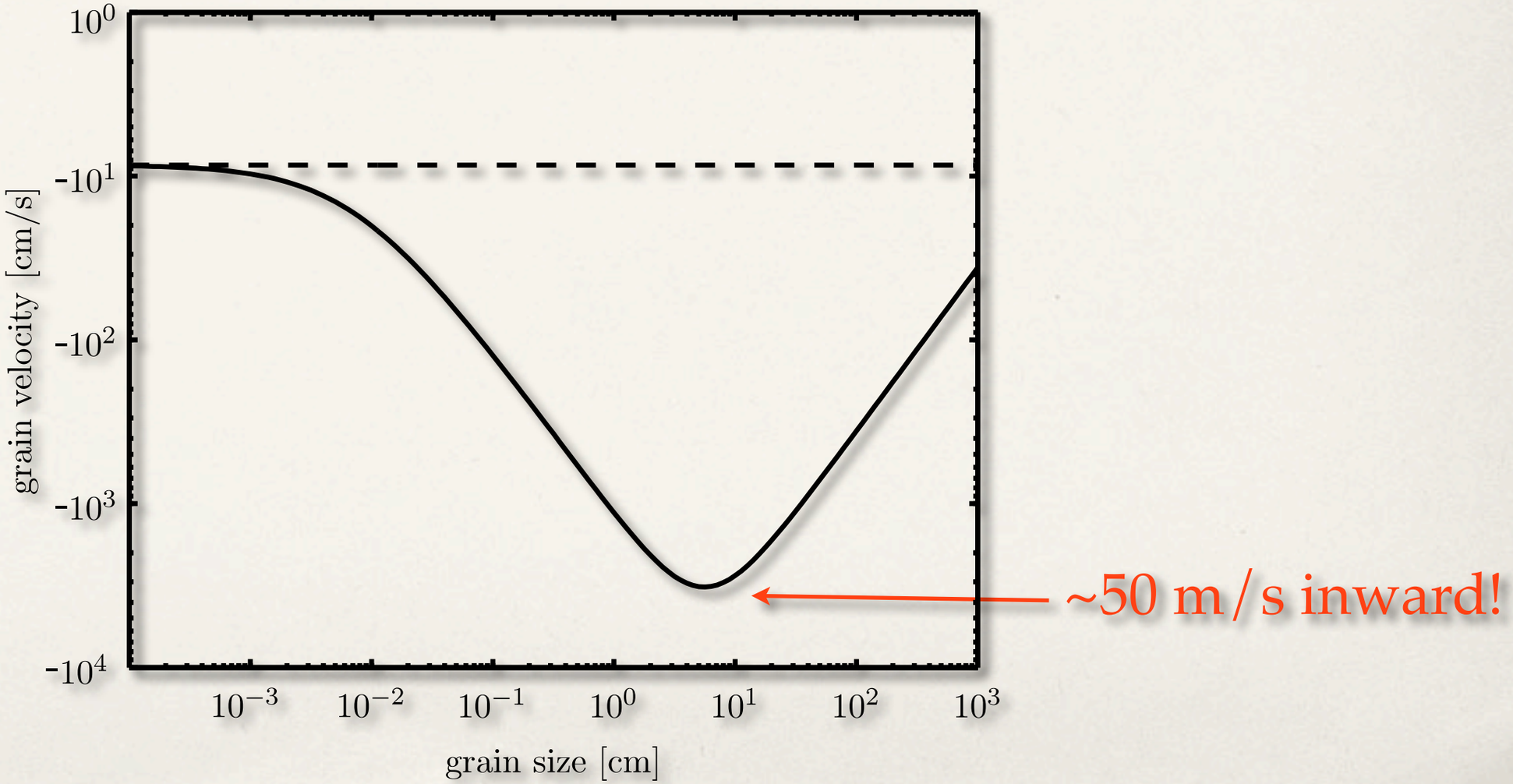
- **Radial Evolution**
  radial drift, radial mixing, gas drag, turbulent concentration, pressure traps, photophoresis,...

- **Dust Size Evolution**
  sticking, bouncing, fragmentation, compaction, erosion, evaporation, condensation, ...

  For bouncing, charging, porosity:
  see talks by Zsom, Windmark, or Okuzumi

– Dust Evolution in a Nutshell –

- Rule 1: the larger the grain, ...
  - ... the larger its *inward drift velocity*
  - ... the larger the *turbulent collision velocity*



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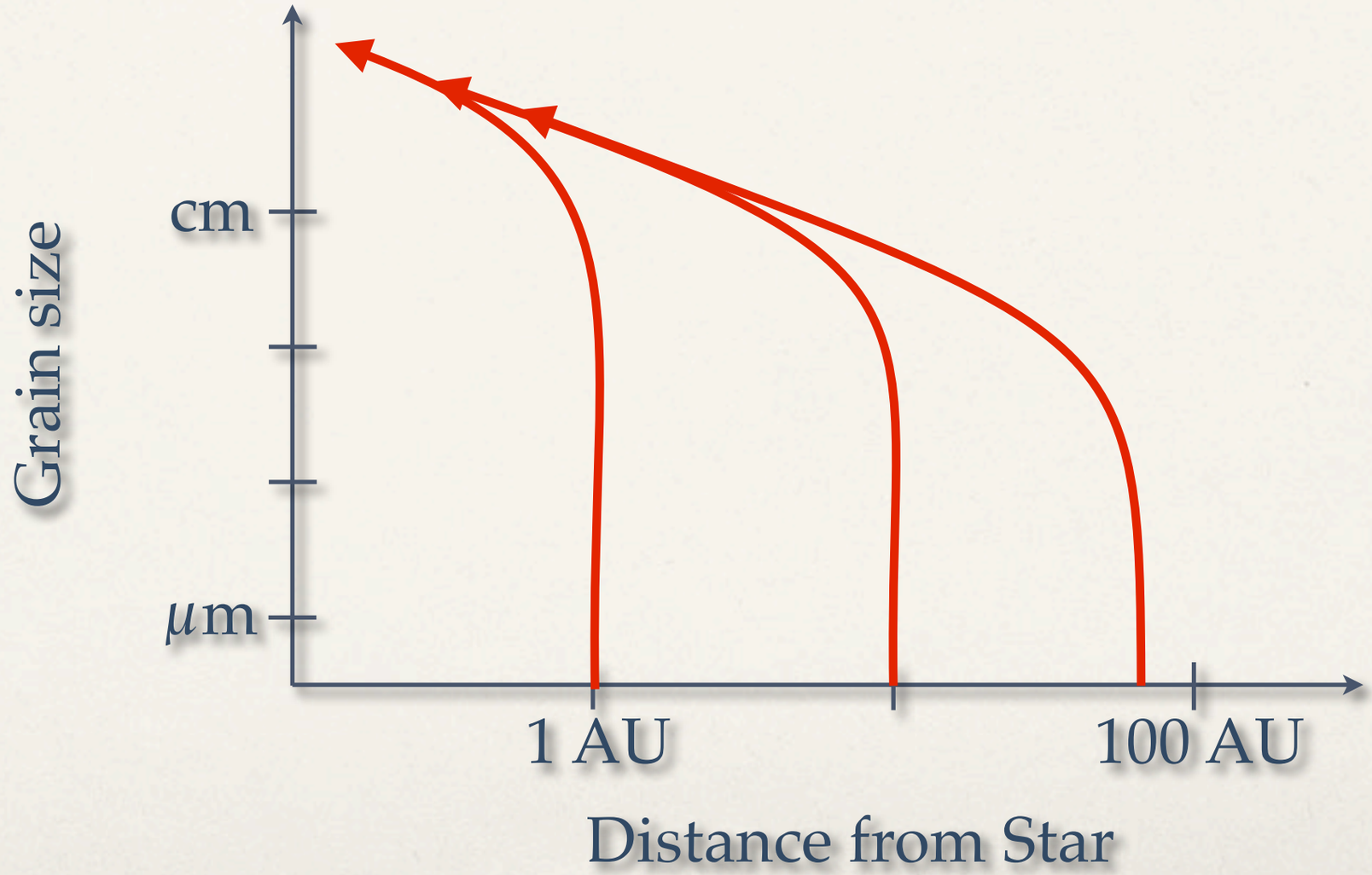
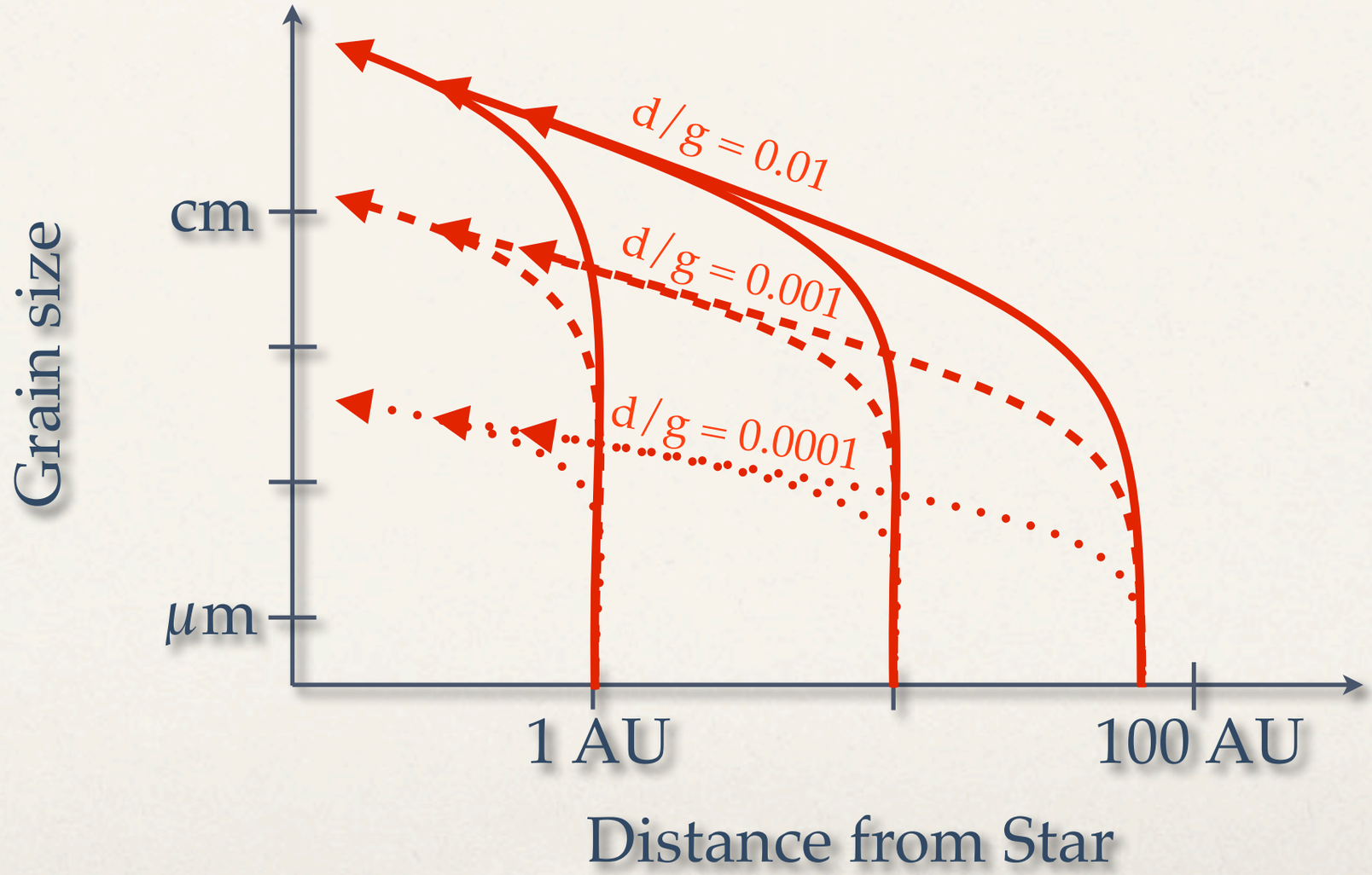


– Dust Evolution in a Nutshell –

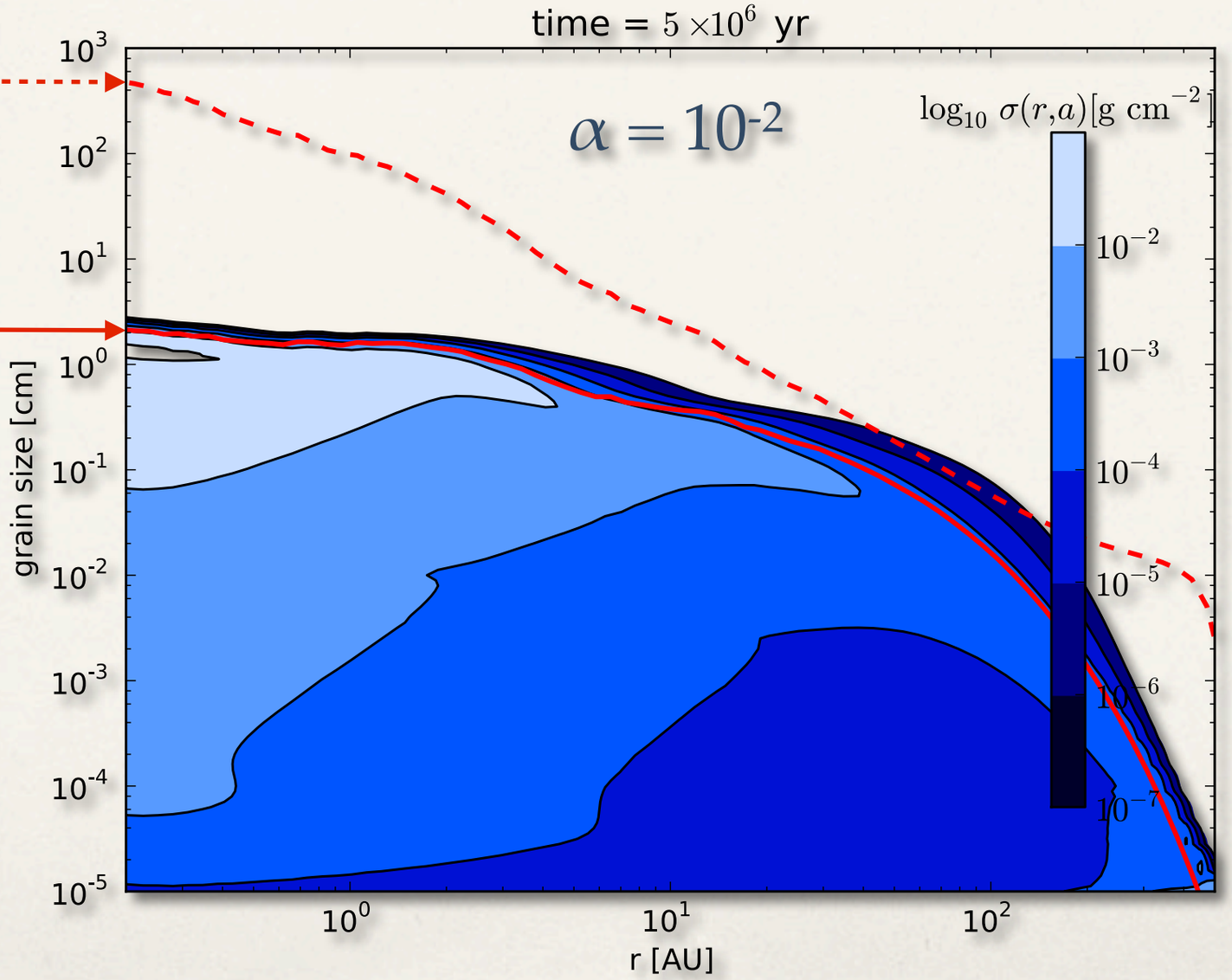
- Rule 2: lower dust-to-gas ratio = slower growth



– Applying the Rules –

fragmentation barrier (impact velocity too high)

drift barrier (scales with Σ_{dust})



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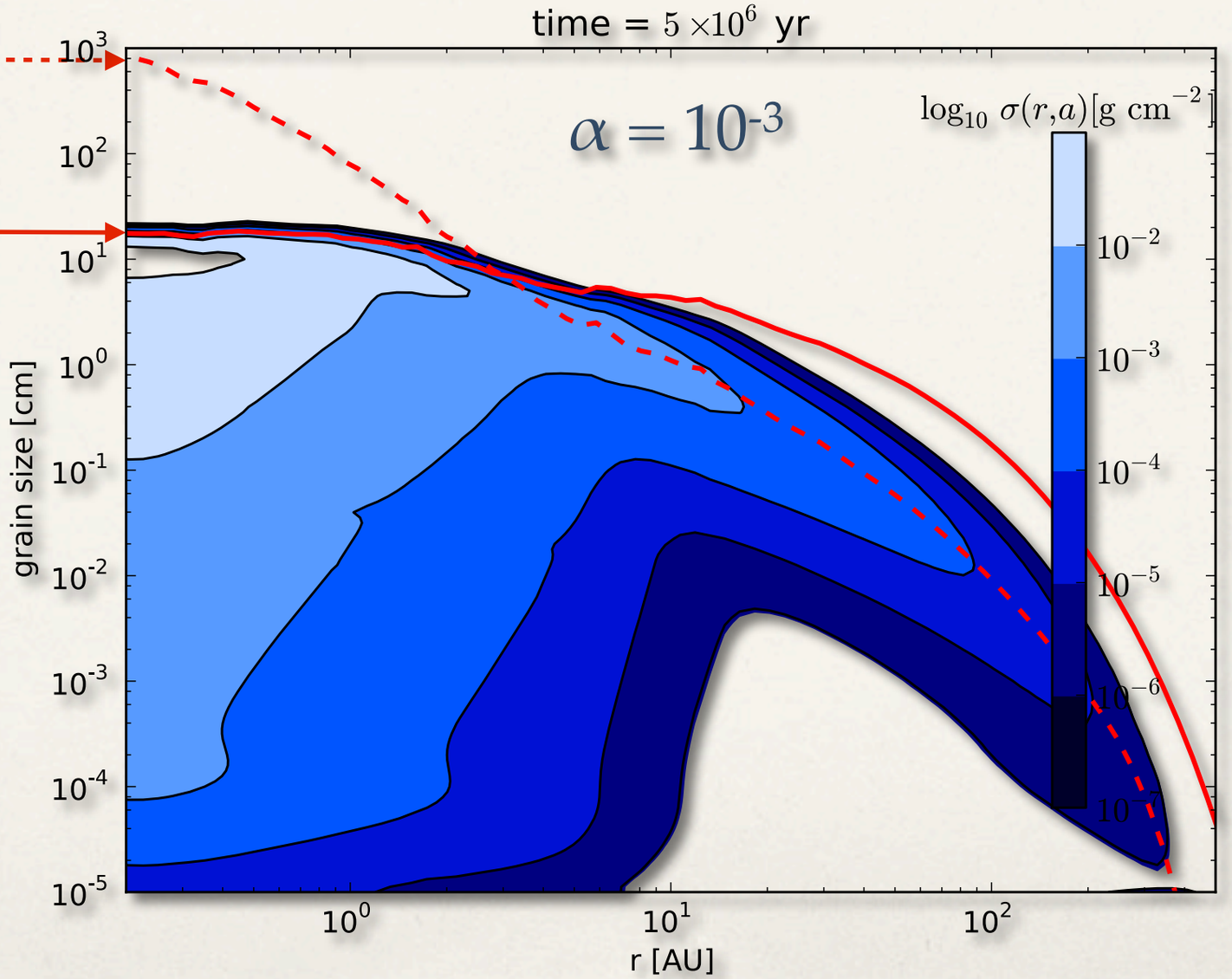

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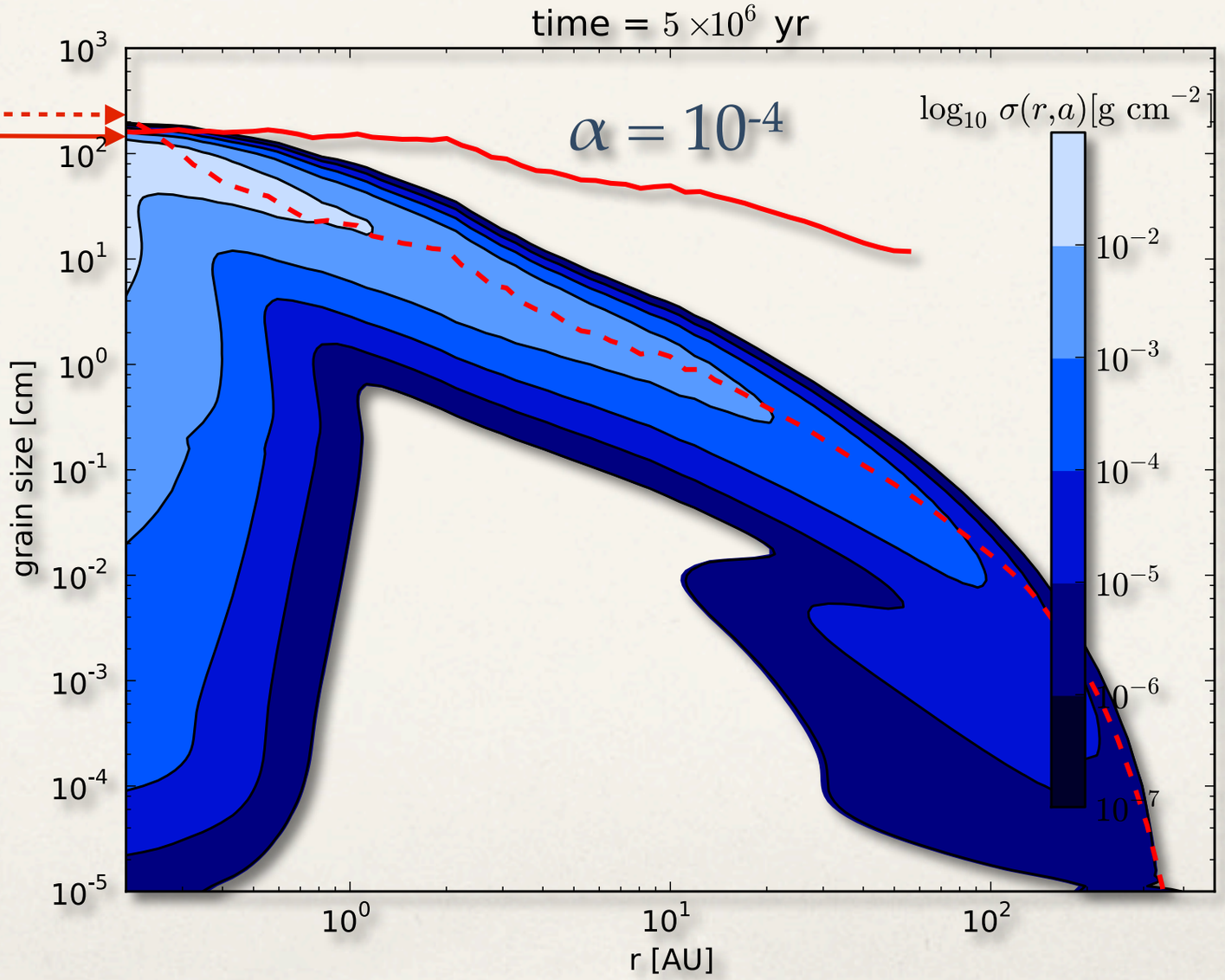

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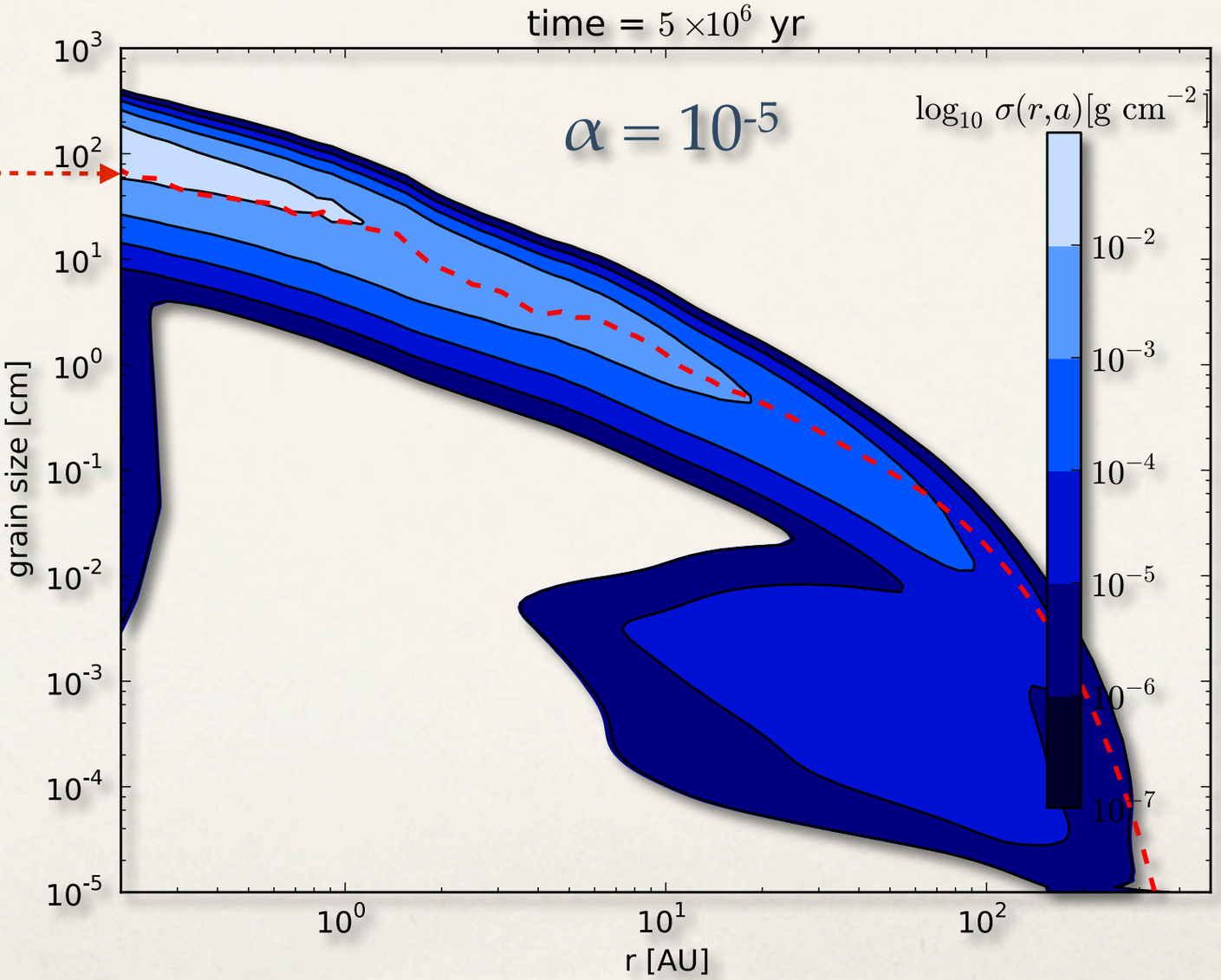

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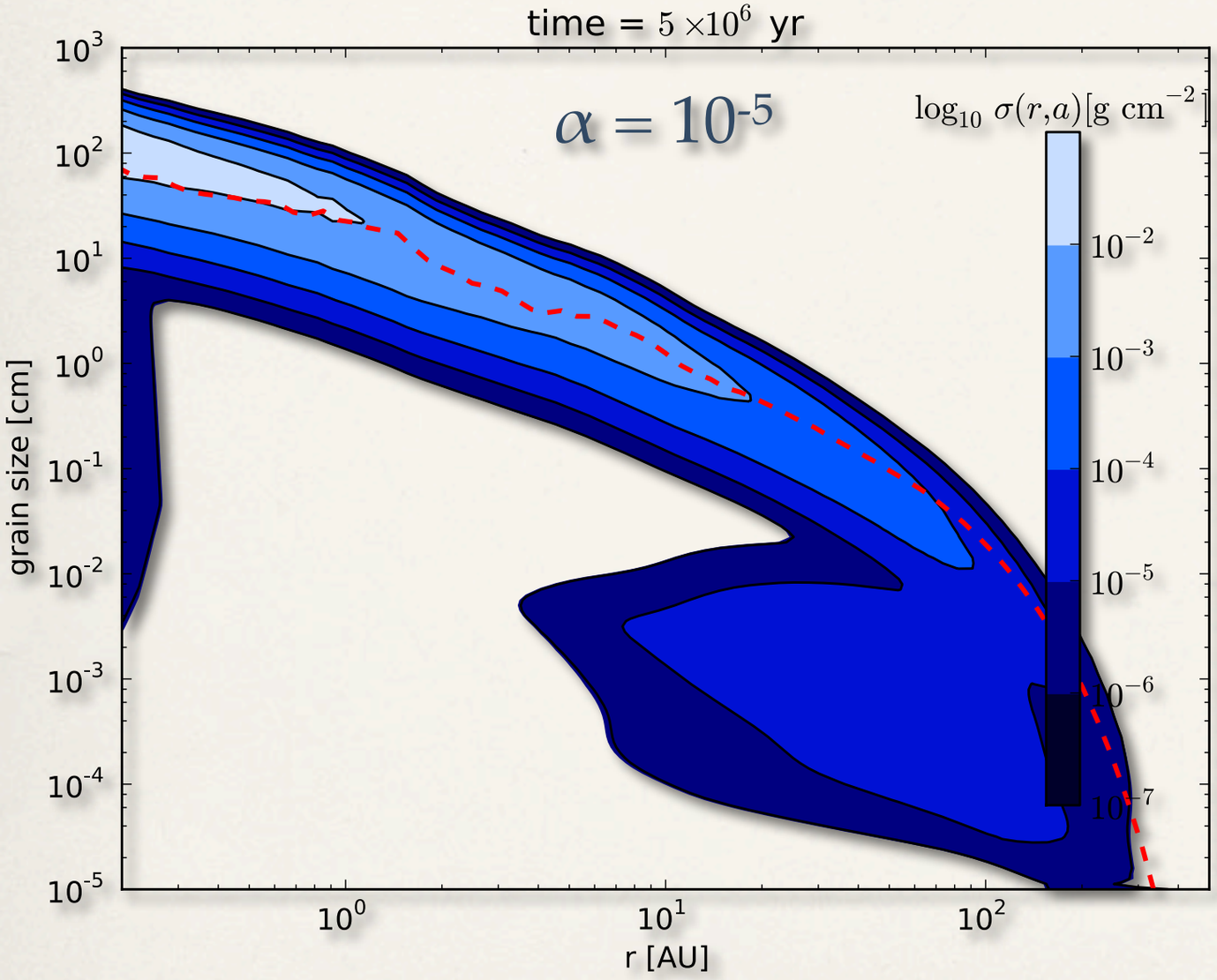
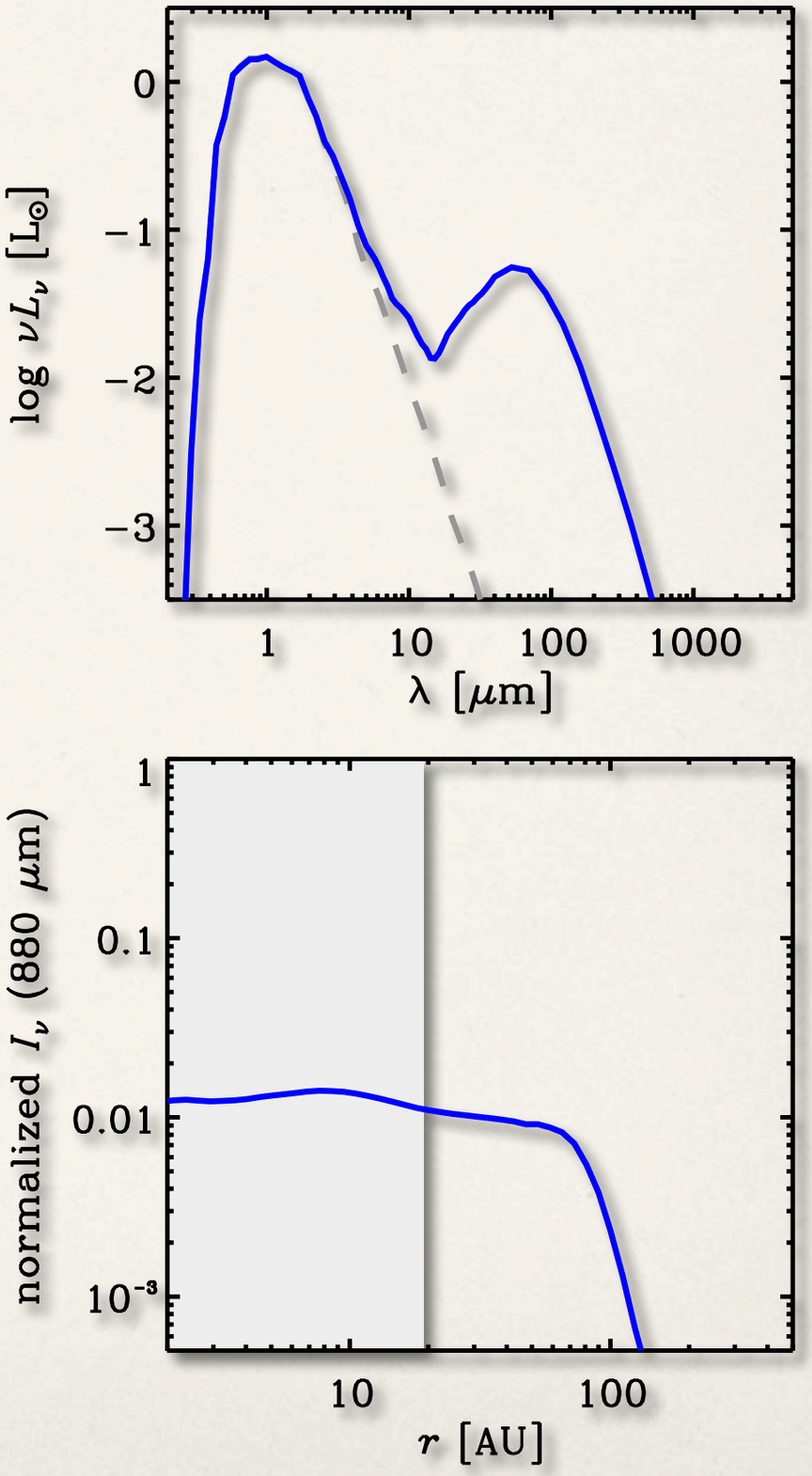
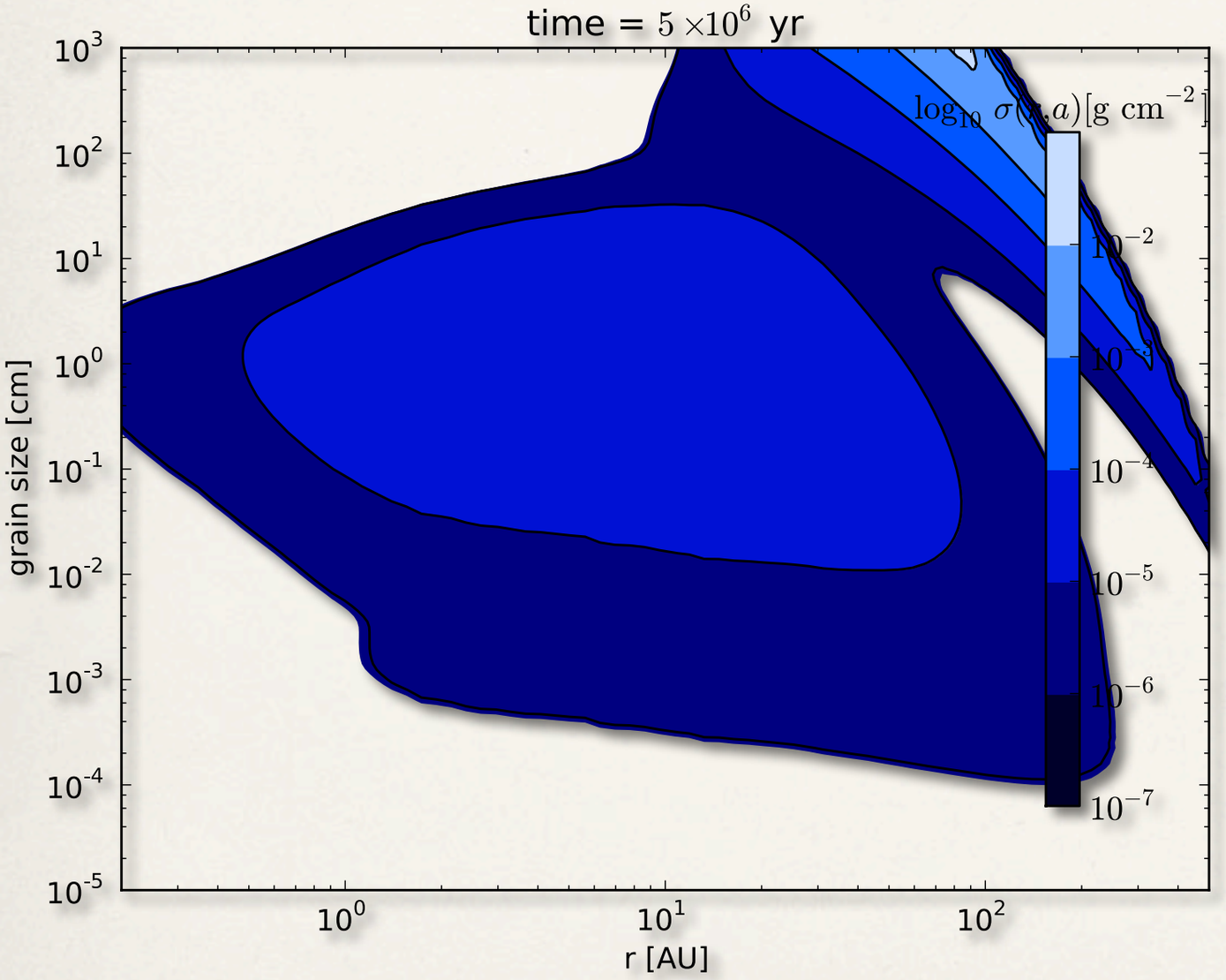


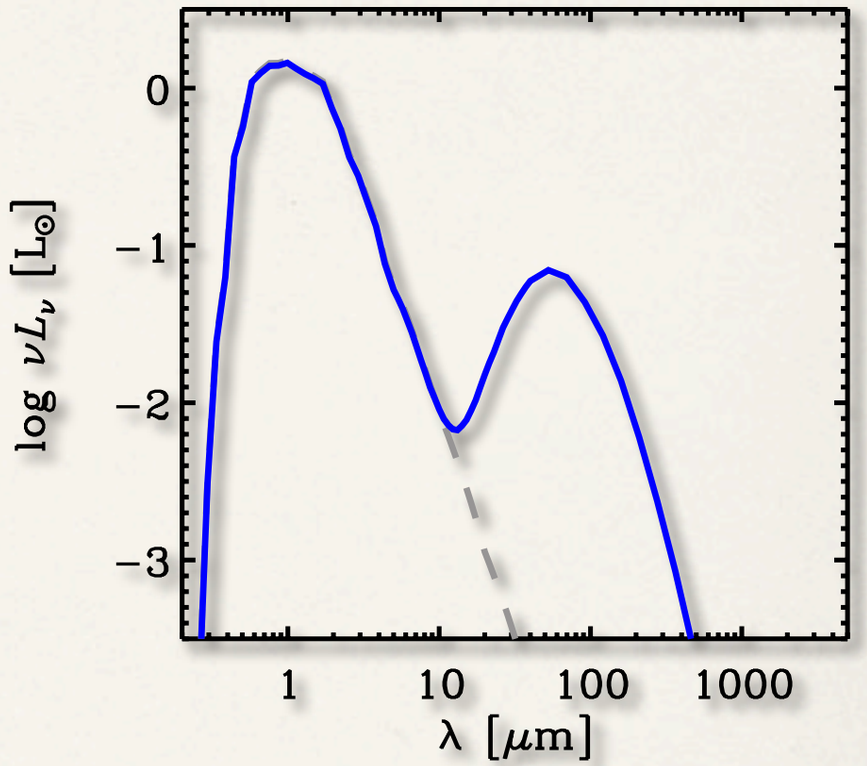


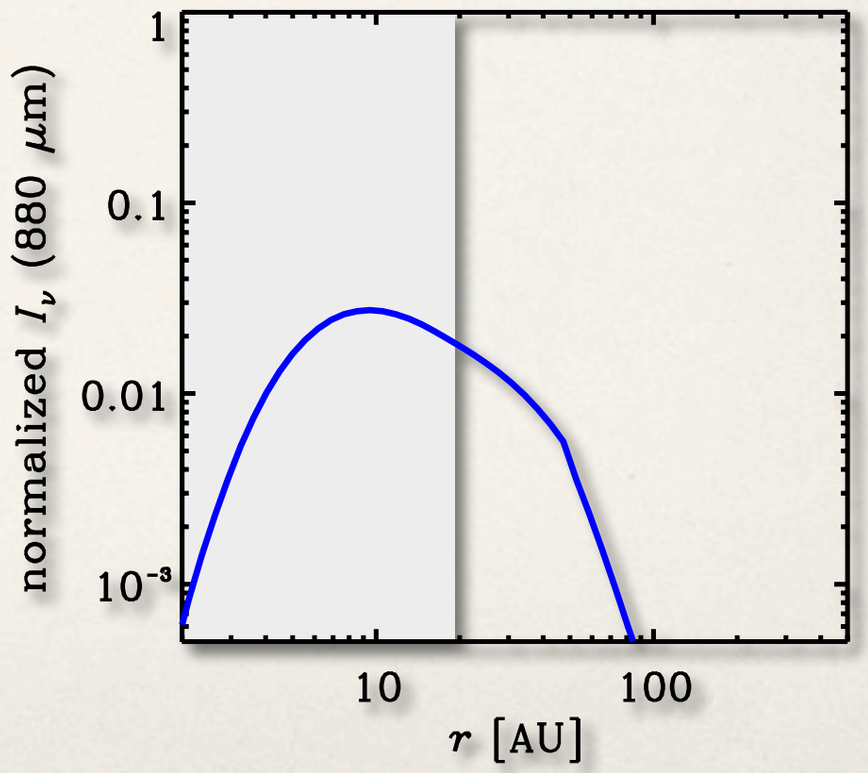
⇒ surface density profiles from first principles

Birnstiel, Klahr, & Ercolano 2012

– No Drift, No Fragmentation –

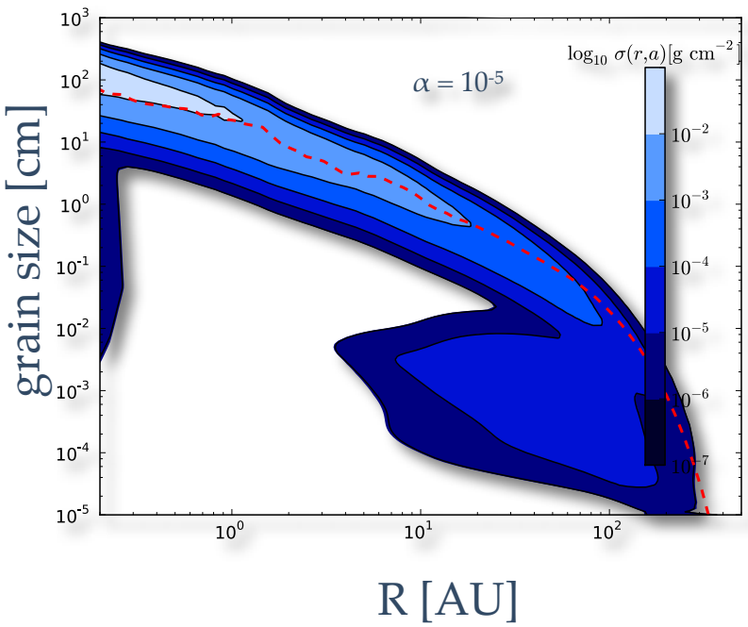




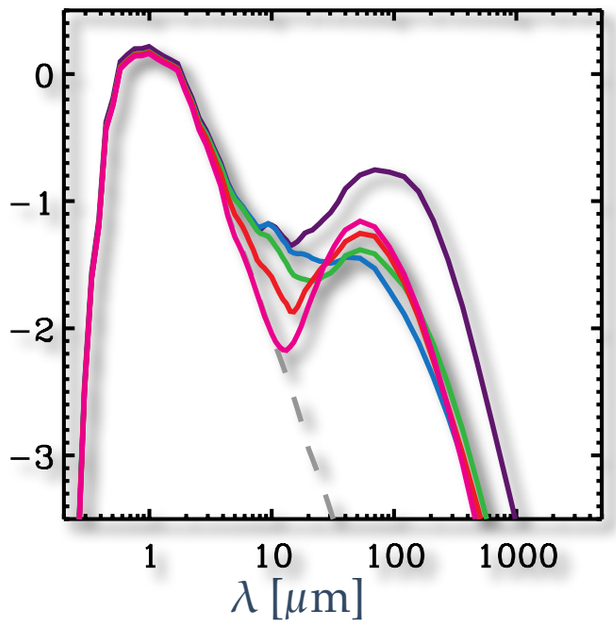


– Observations –

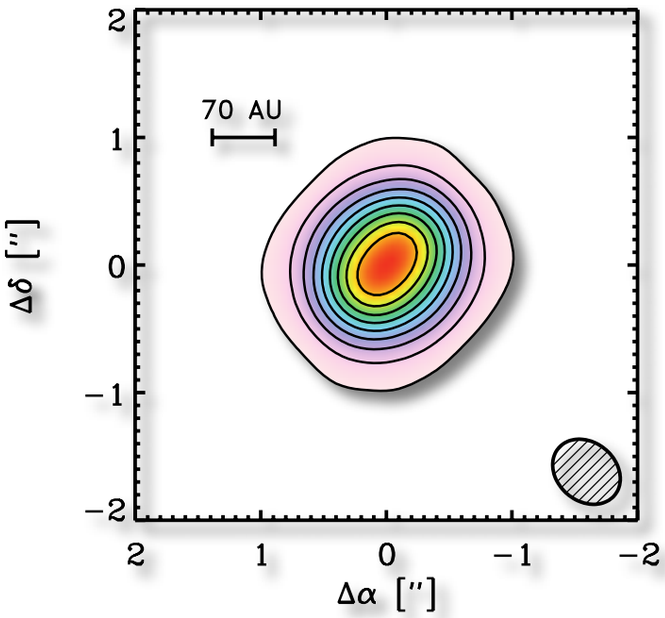
Dust Model



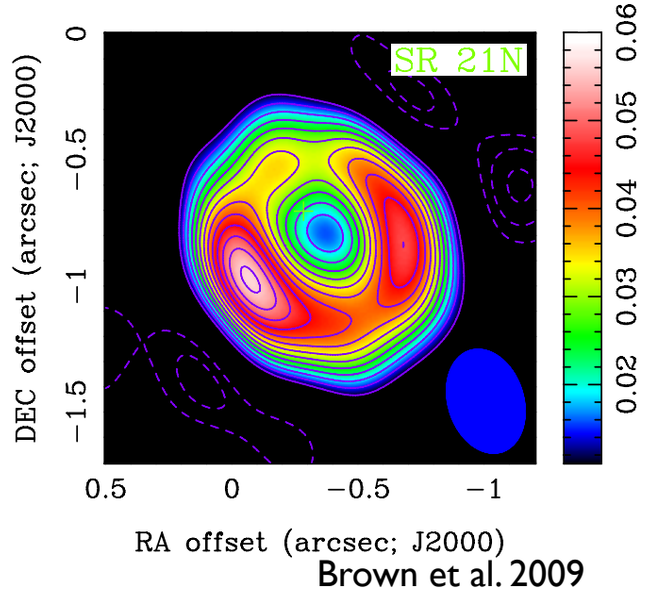
Model SED



Model Image



Observation



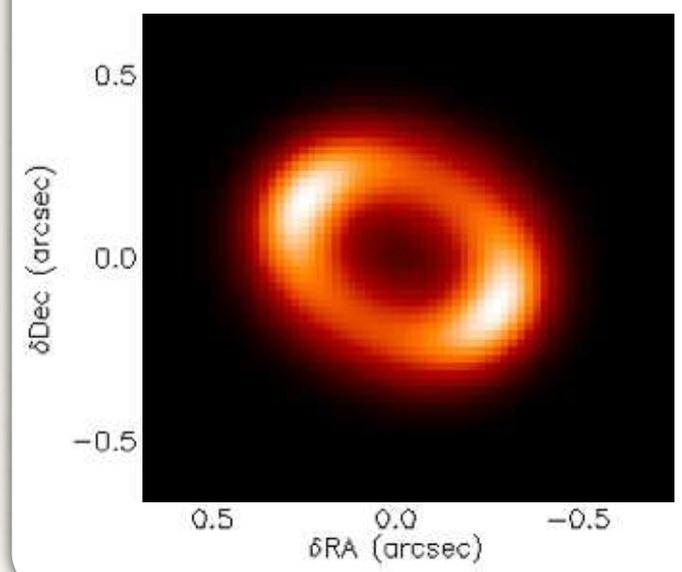
Brown et al. 2009

Summary: No!

✔ grain growth can cause IR dips in SED

✗ Large cavities cannot be explained by dust evolution *alone*

Model Image



Dust evolution
&
something else

Pinilla, Benisty, & Birnstiel 2012
see talk by Paola Pinilla