Planet formation in action

The role of dust trapping in transitional disks

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Sterrewacht
Leiden
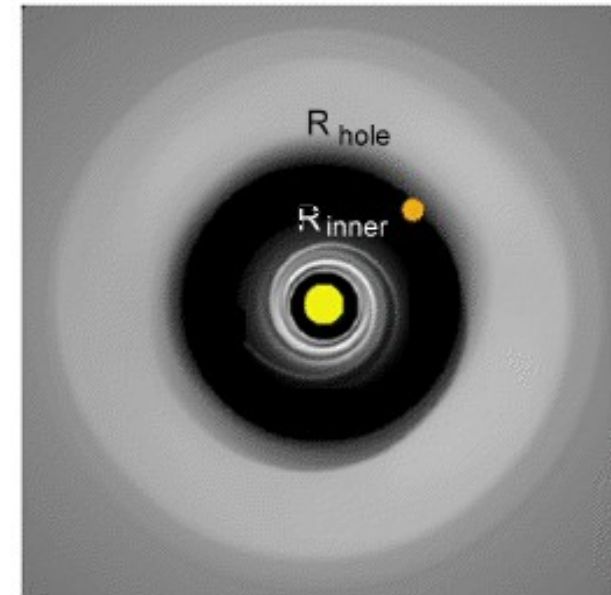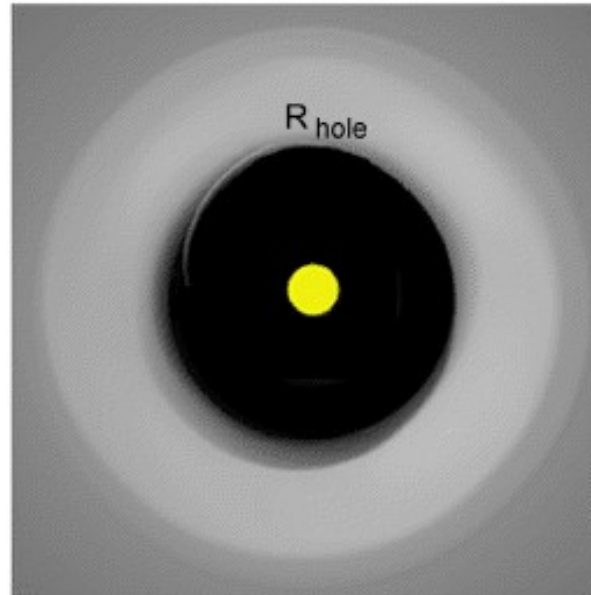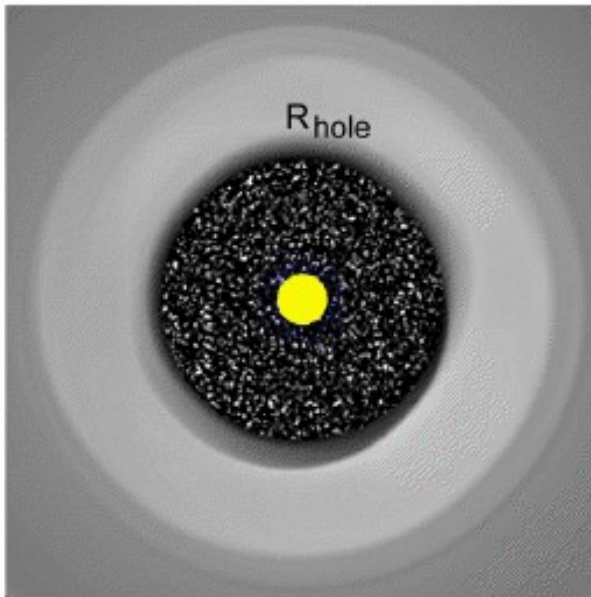
Transitional disks

- Dust hole: mechanisms

Grain growth   Photoevaporation   Stellar companion
                                          Forming planet?
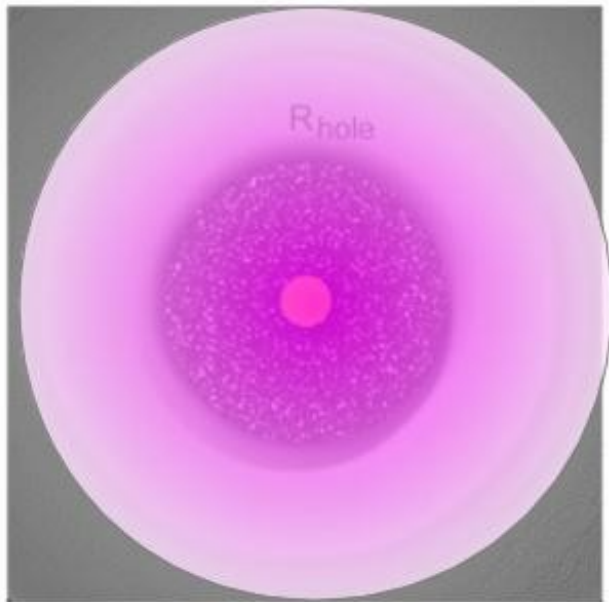

⇒ **What about the gas?**
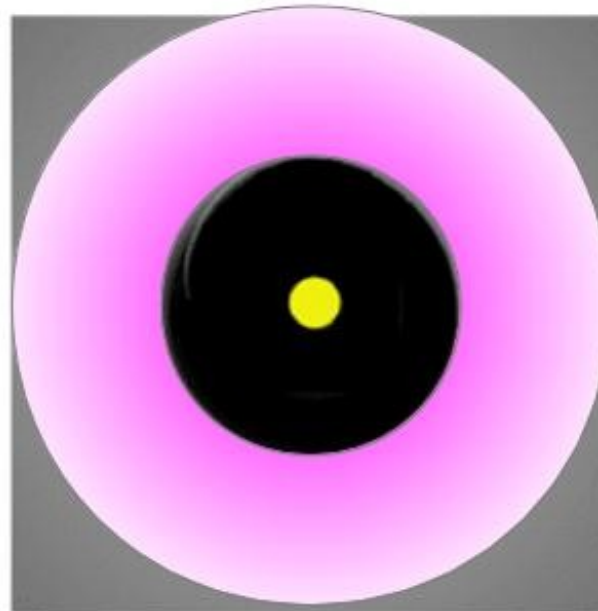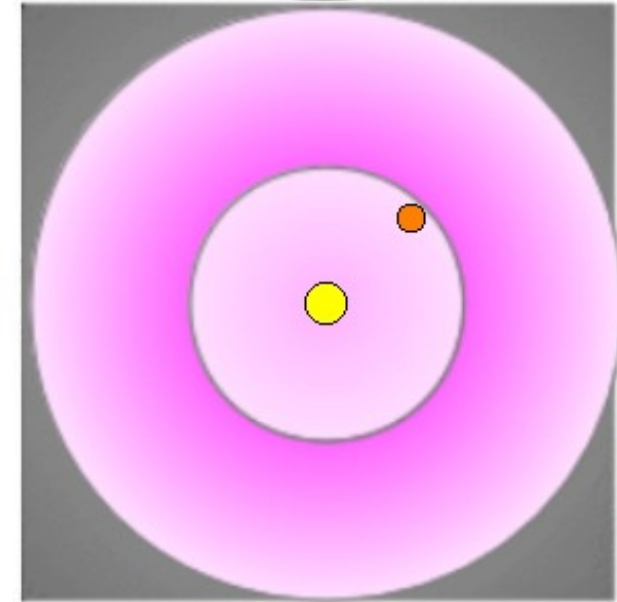
Transitional disks

- ## Dust hole: mechanisms

Grain growth   Photoevaporation   Stellar companion
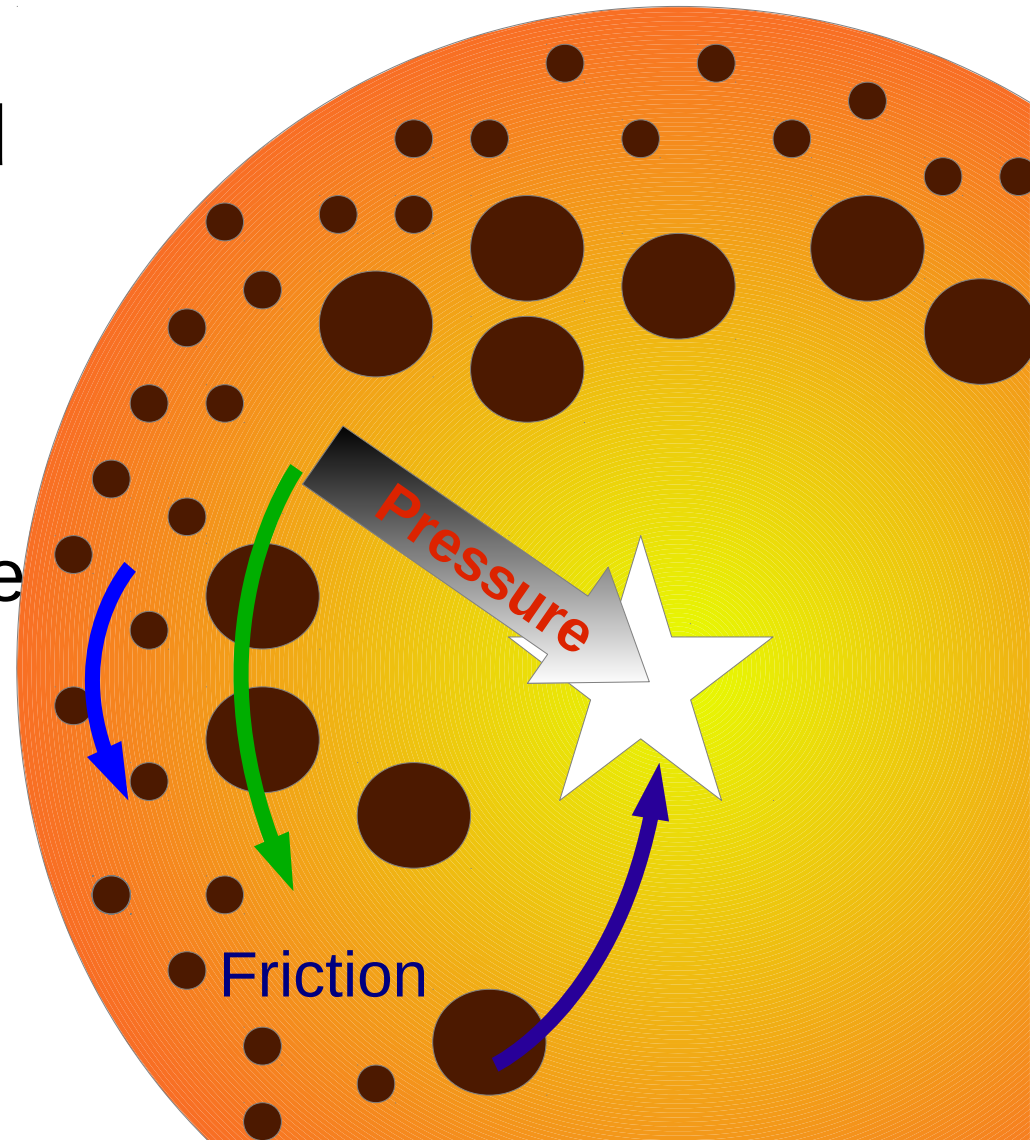Forming planet?

=> **Planet disk interaction: dust trapping!**
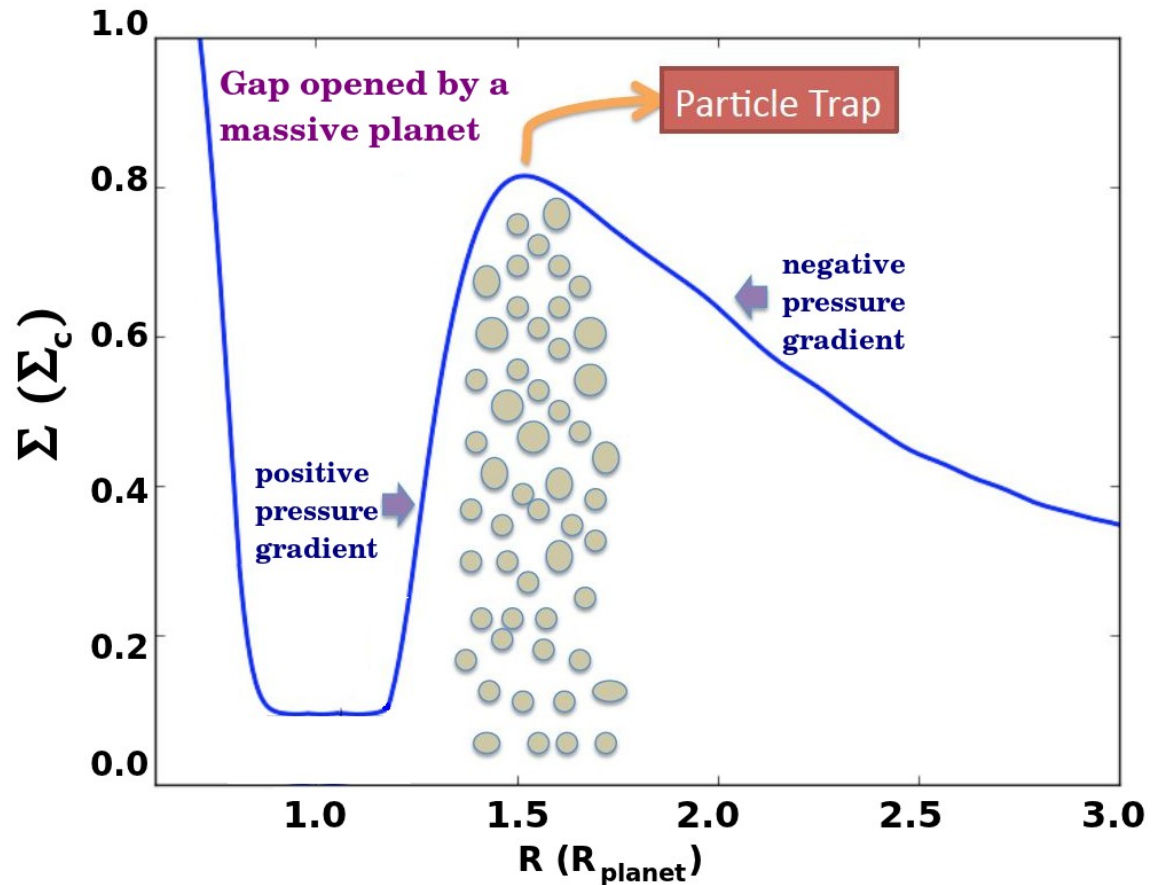
Dust trapping

- Dust growth in a normal disk

  - Radial drift problem

- Dust can not grow beyond millimeter sizes?

- Two dust properties:

  - Large particles move towards high pressure

  - Small particles move with the gas

  => Pressure bump?
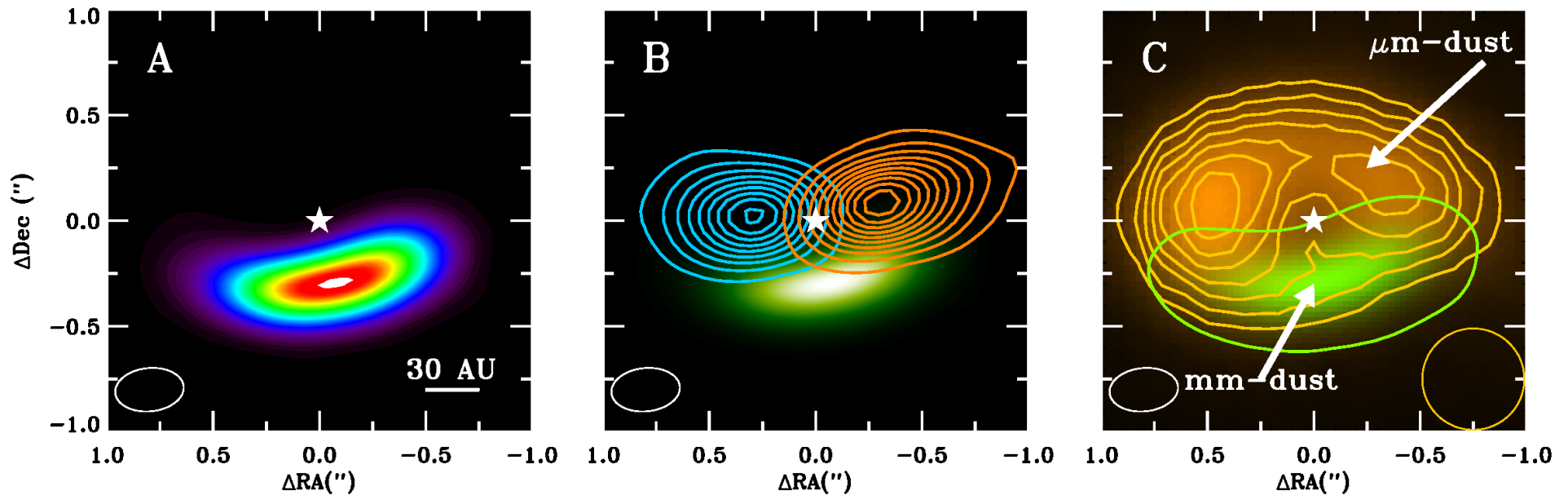
Dust trapping

- Planet generates a radial pressure bump in gas

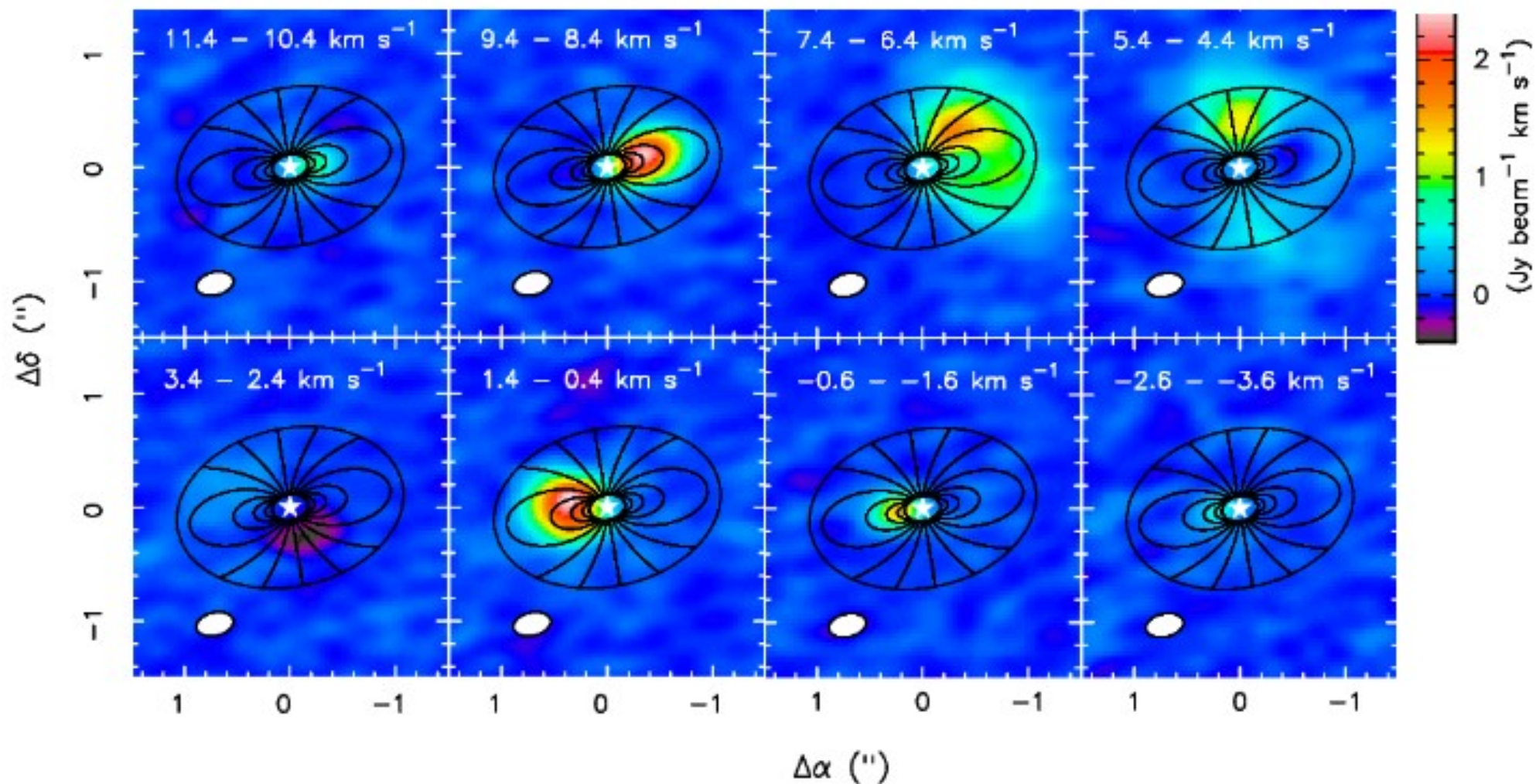- Large dust will be trapped

- Potential vortex formation

- Dust trap => different distribution gas and mm-dust

Pinilla et al. 2012

Oph IRS 48

- ALMA Cycle 0 Band 9 observations

- Asymmetry in mm-dust vs full gas disk ring
  => evidence dust trap!
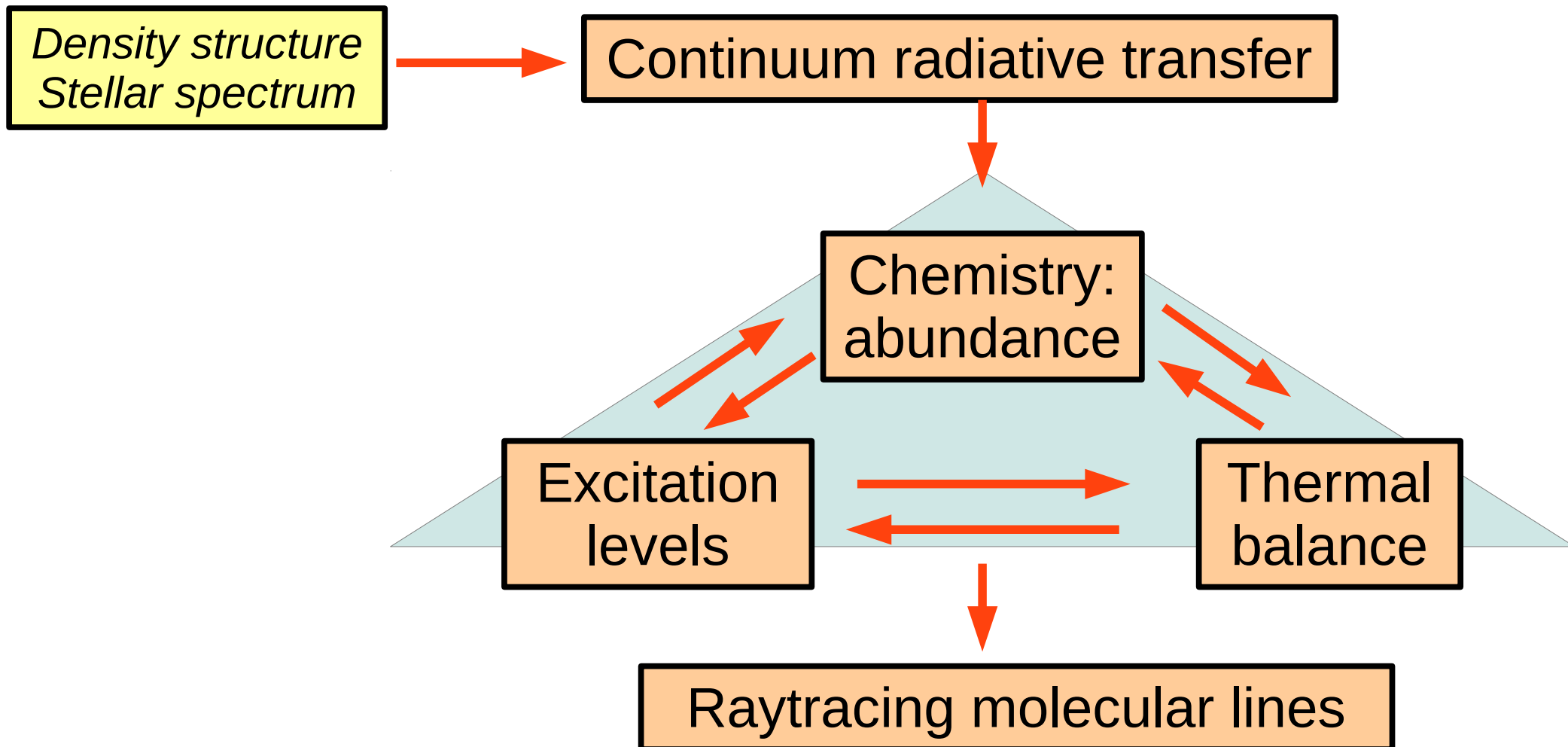

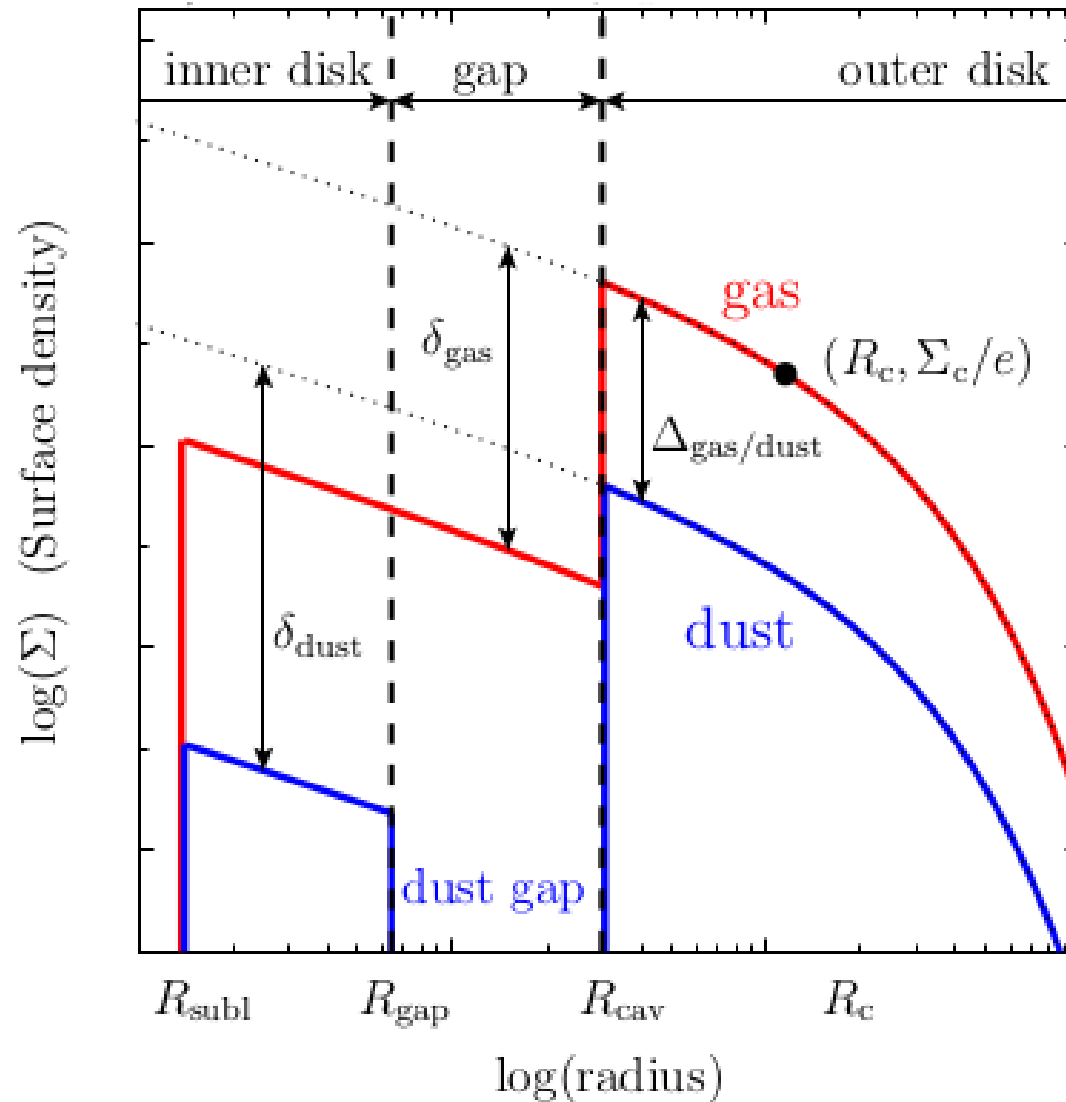Van der Marel et al. 2013

ALMA observations

Gas modeling

- Analysis gas distribution: **DALI** (Bruderer 2013)

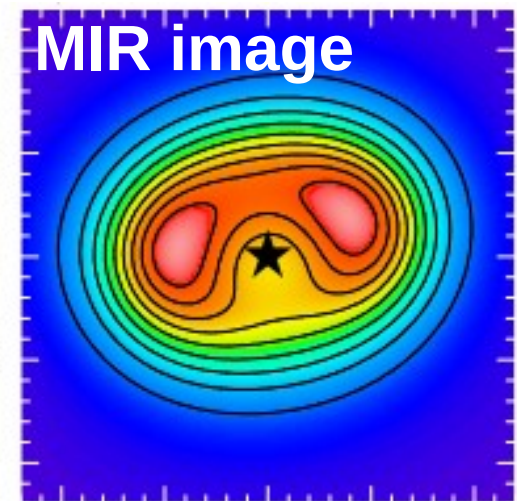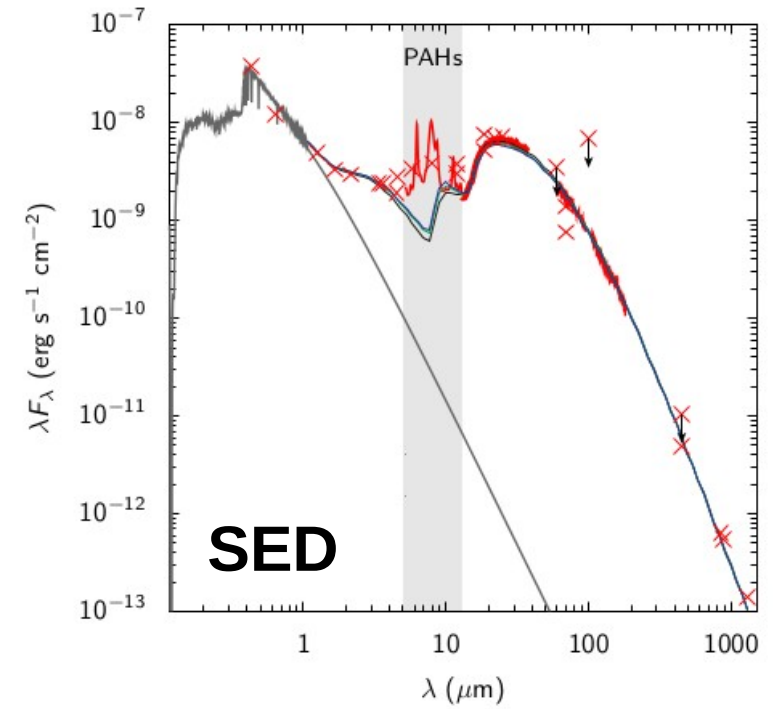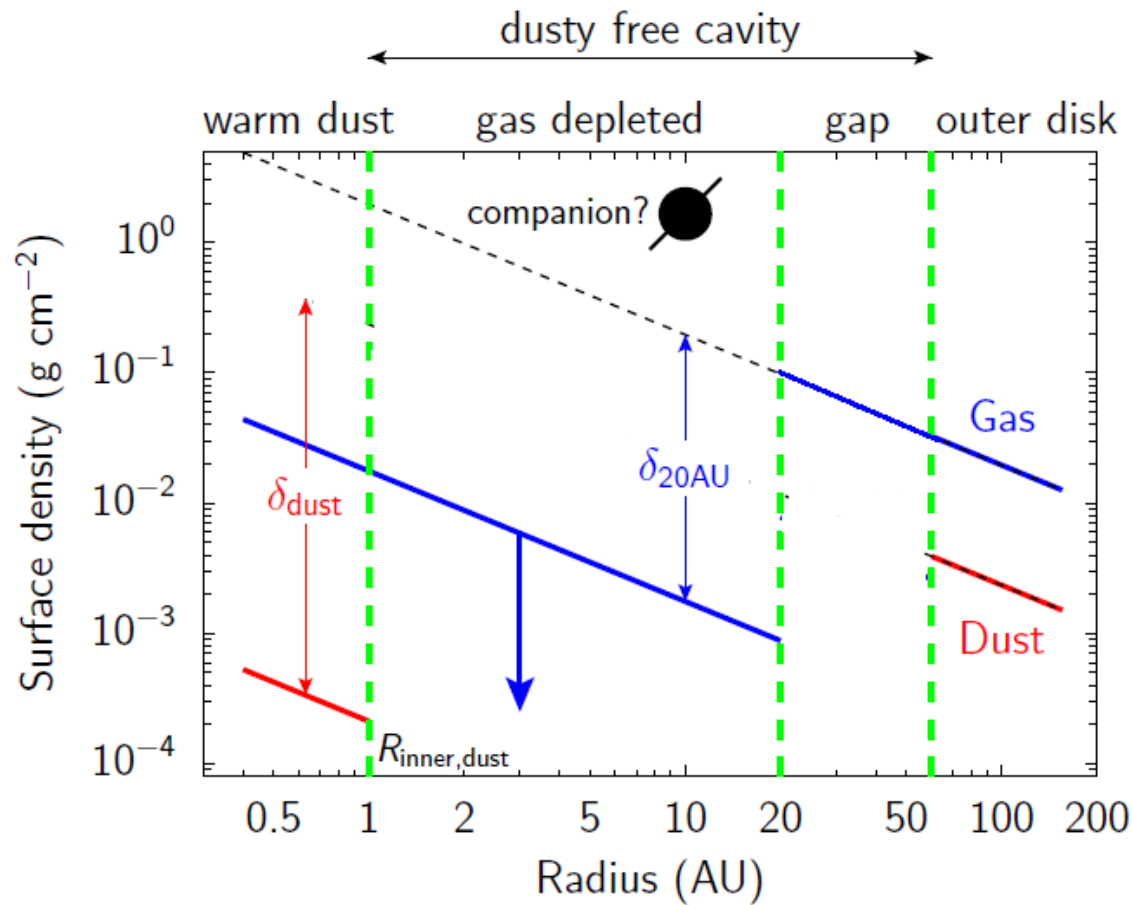- Particularly useful for transition disks: complex heating

Gas modeling

Input: axisymmetric density model with density drops
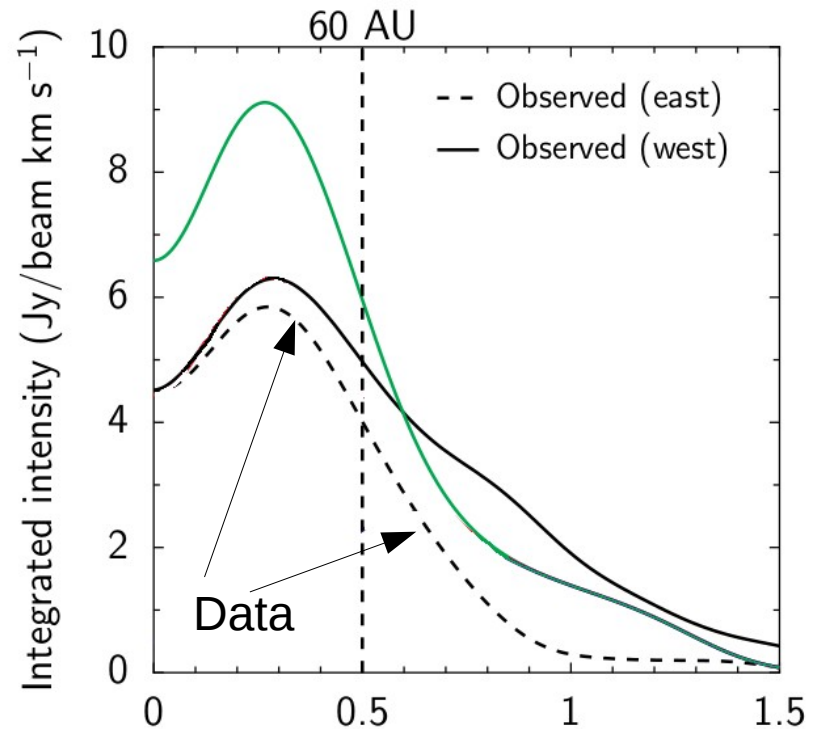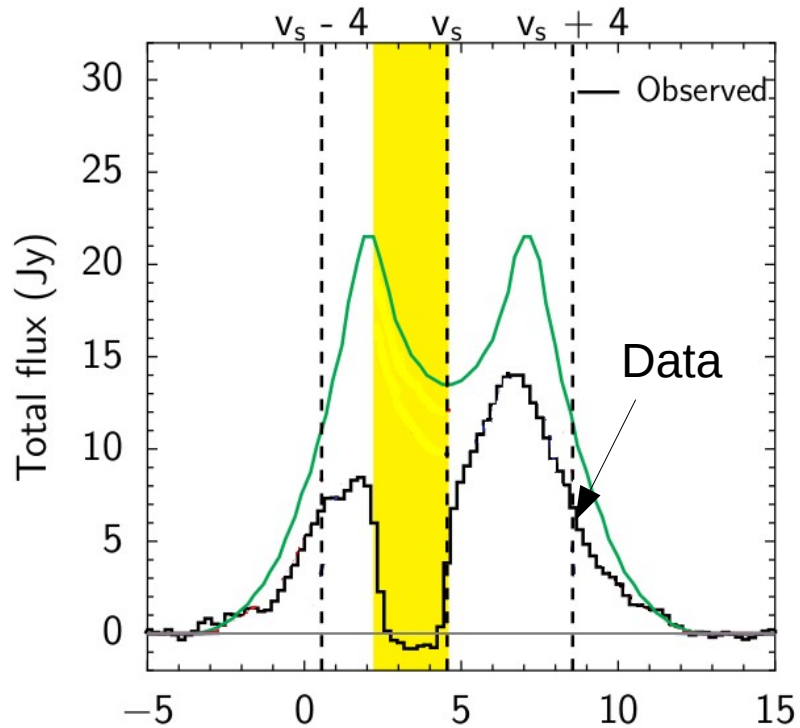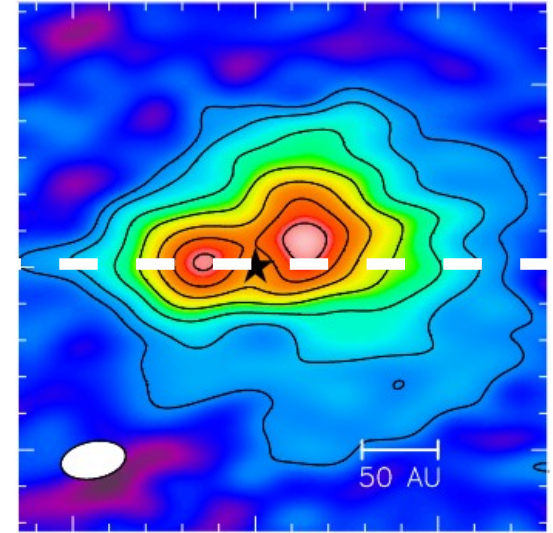
Gas modeling

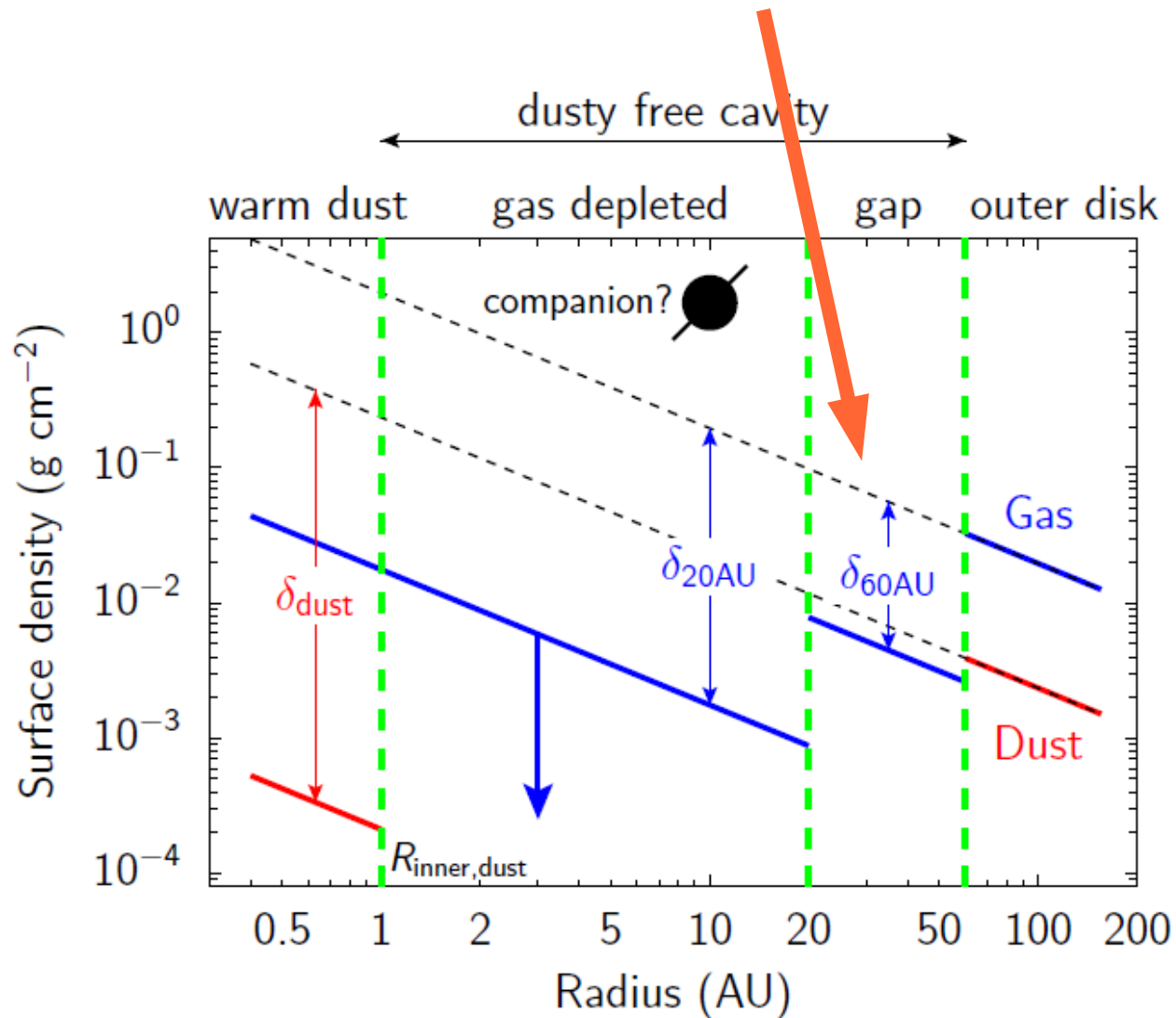First model...

...good fit to MIR dust distribution

Gas modeling

But no good fit to gas data!

Gas modeling

Additional drop between 20 and 60 AU

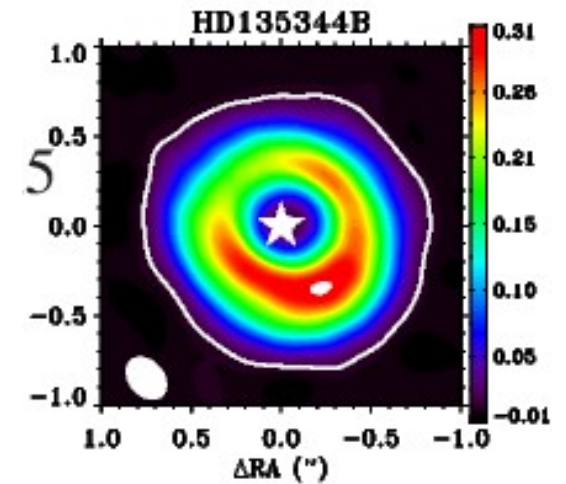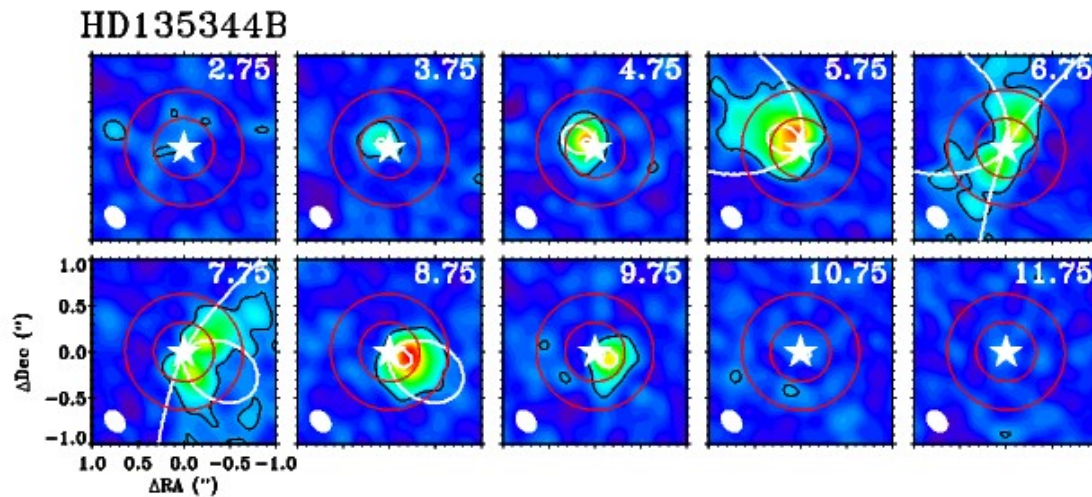# Dust trapping

- Gas **inside** mm-dust hole: evidence trapping

- Trapping: **radial** or **azimuthal**

- Density drop gas ~ **mass** of embedded planet

- Other ALMA dust traps?

  - HD142527 (Casassus et al. 2013, Fukagawa et al. 2013)

  - HD100546 (Walsh et al. 2014)

  - Others?

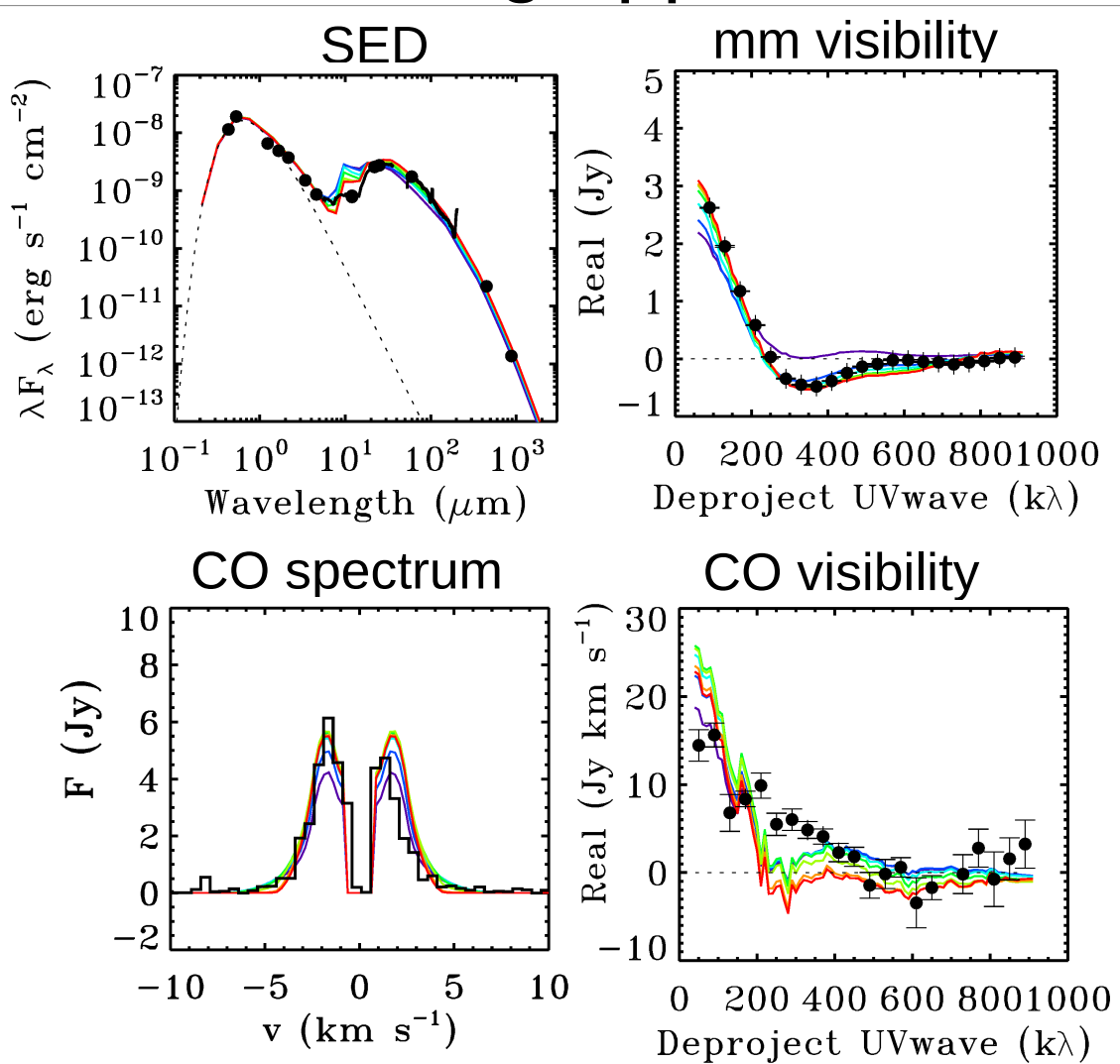   **=> modeling gas/dust of 6 transition disks**

ALMA observations

¹²CO channel maps

Continuum

ALMA observations

- ## Modeling approach

- Density/vertical structure
- Fit SED and mm visibilities
- Include info scattered light, other lines, etc.
- Fit gas distribution using CO-visibillities/spectrum/ intensity
- Constrain possible density drop inside dust hole

Van der Marel et al. in prep

Preliminary conclusions

- All transition disks observed with ALMA show gas inside dust hole

- gas density drop is 10^{-1} - 10^{-4}
dust density drop is lower ($< 10^{-6}$)

- Gas outer radius > mm-dust outer radius

- Physical model not unique, but possible

- CO isotopologues required for further constraint

Questions?