PAH chemistry and IR emission from circumstellar disks

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NWO

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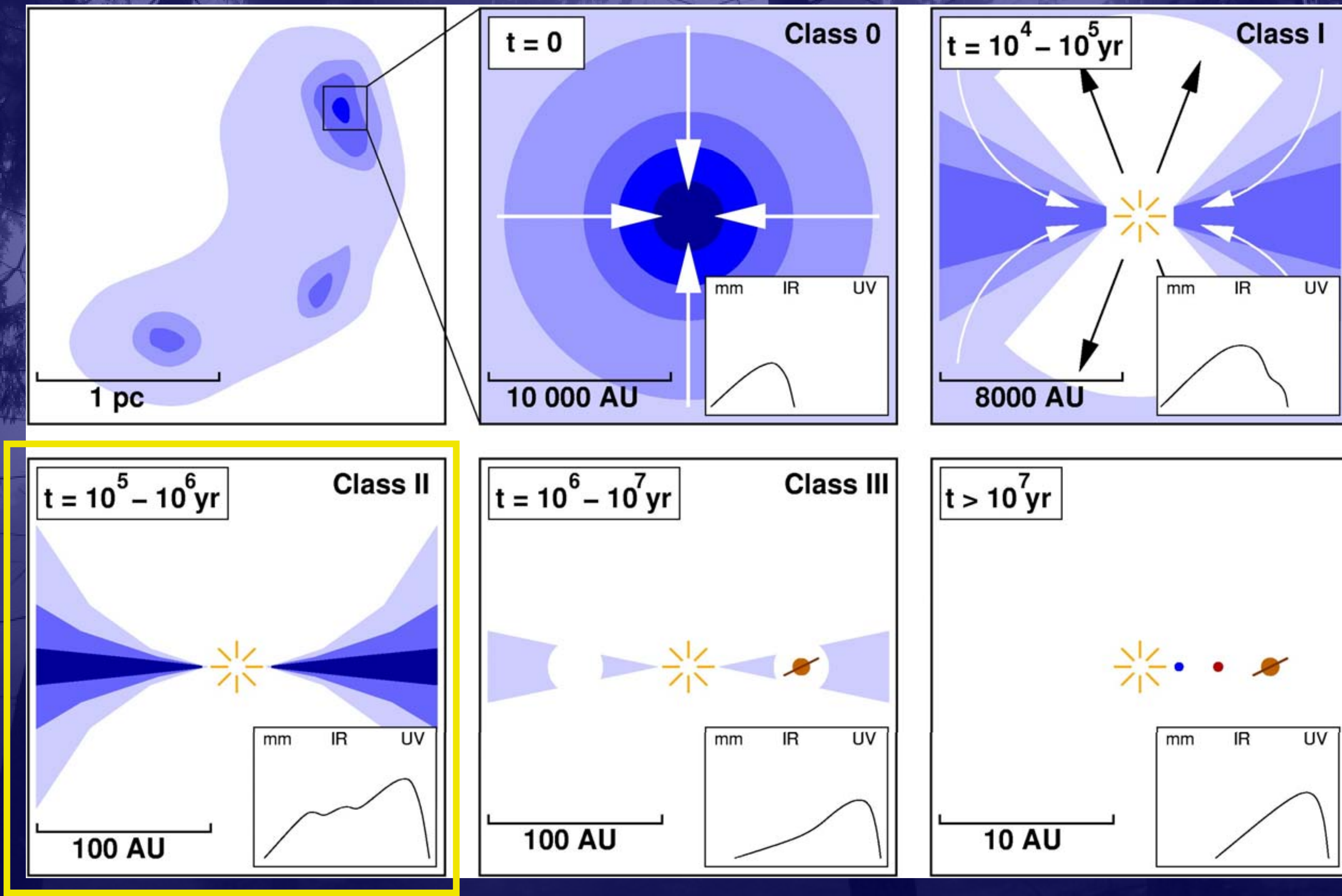
Star and planet formation

(low-mass stars)



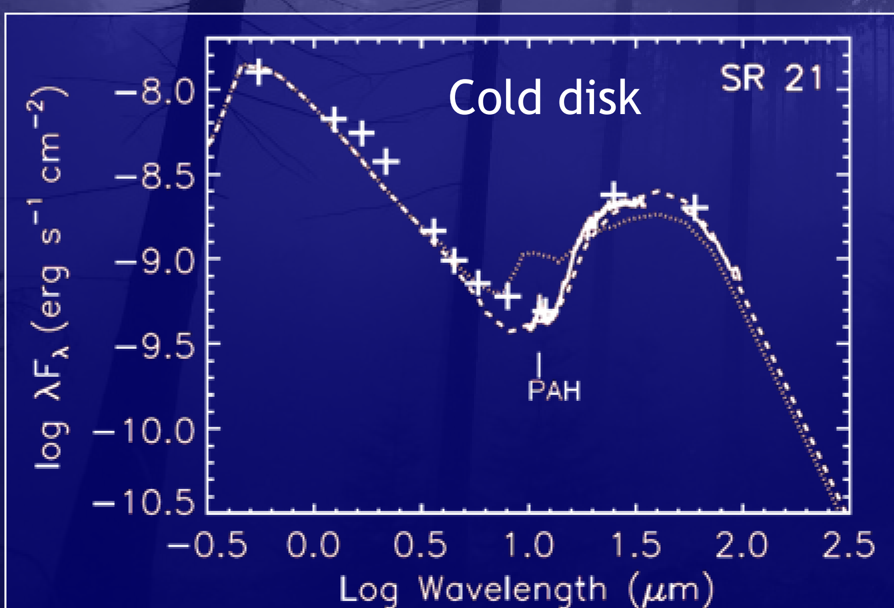
Jonkheid et al. 2006

PAH: Carbon and hydrogen

- Charge: negative, neutral or positive
- Hydrogen coverage: none to double
- Both depend mostly on density and UV intensity
- Both affect shape of PAH IR emission spectrum
- Strong UV field: carbon skeleton destroyed

PAHs observed in disks

- Spitzer is the first telescope to probe PAHs around solar-mass stars
- Detections:
  - Herbig Ae/Be: 60%
  - T Tauri: 8% (lower limit)
  - Cold disks (inner gap): almost all sources

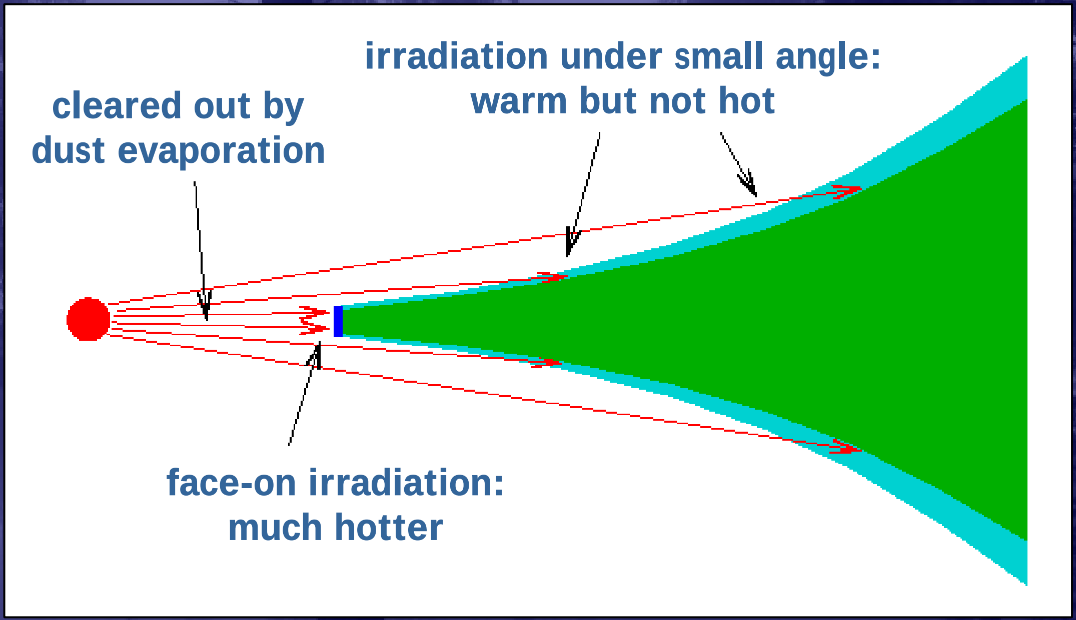


Abundances in disks are 10-100x lower than in ISM

Acke & van den Ancker 2004
Geers et al. 2006
Brown et al. submitted

Disk structure

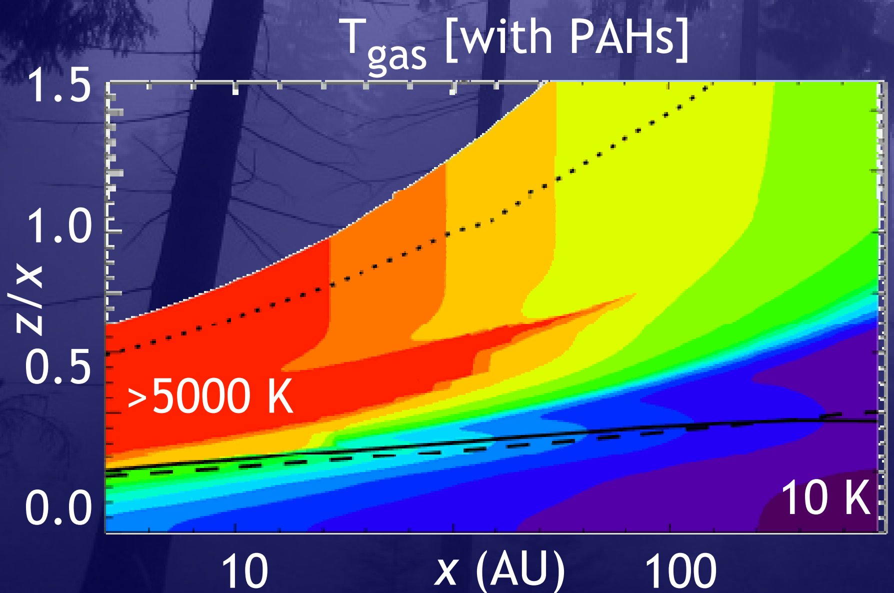
- Flaring disk
- Dust evaporation sets inner radius
- Puffed-up inner rim
- PAH IR emission mostly from surface

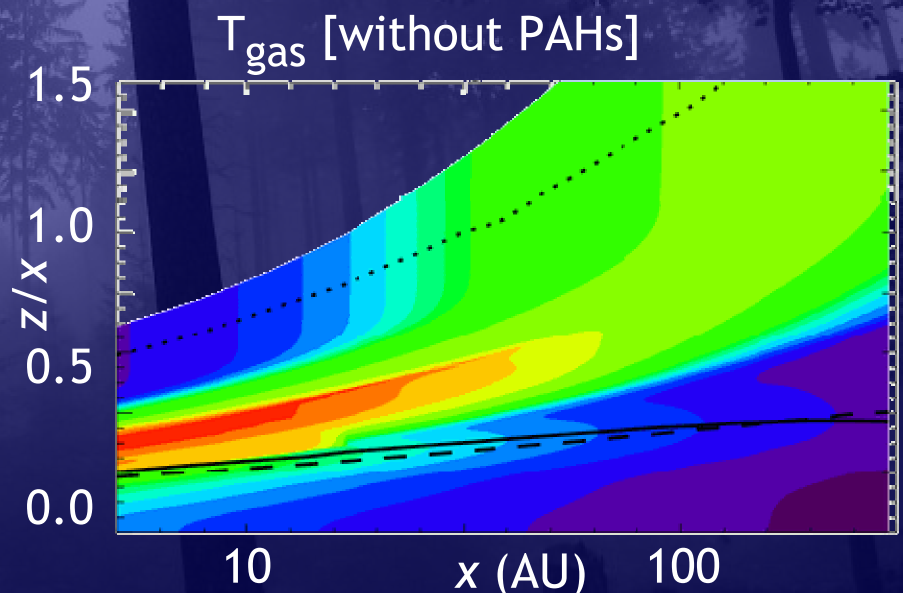


Natta et al. 2001
Dullemond, Dominik & Natta 2001

Why study PAHs in disks?

- Tracers of warm upper layer
- Effects on chemistry
  - e.g. charge exchange, H_2 formation
- Heating via photoionization



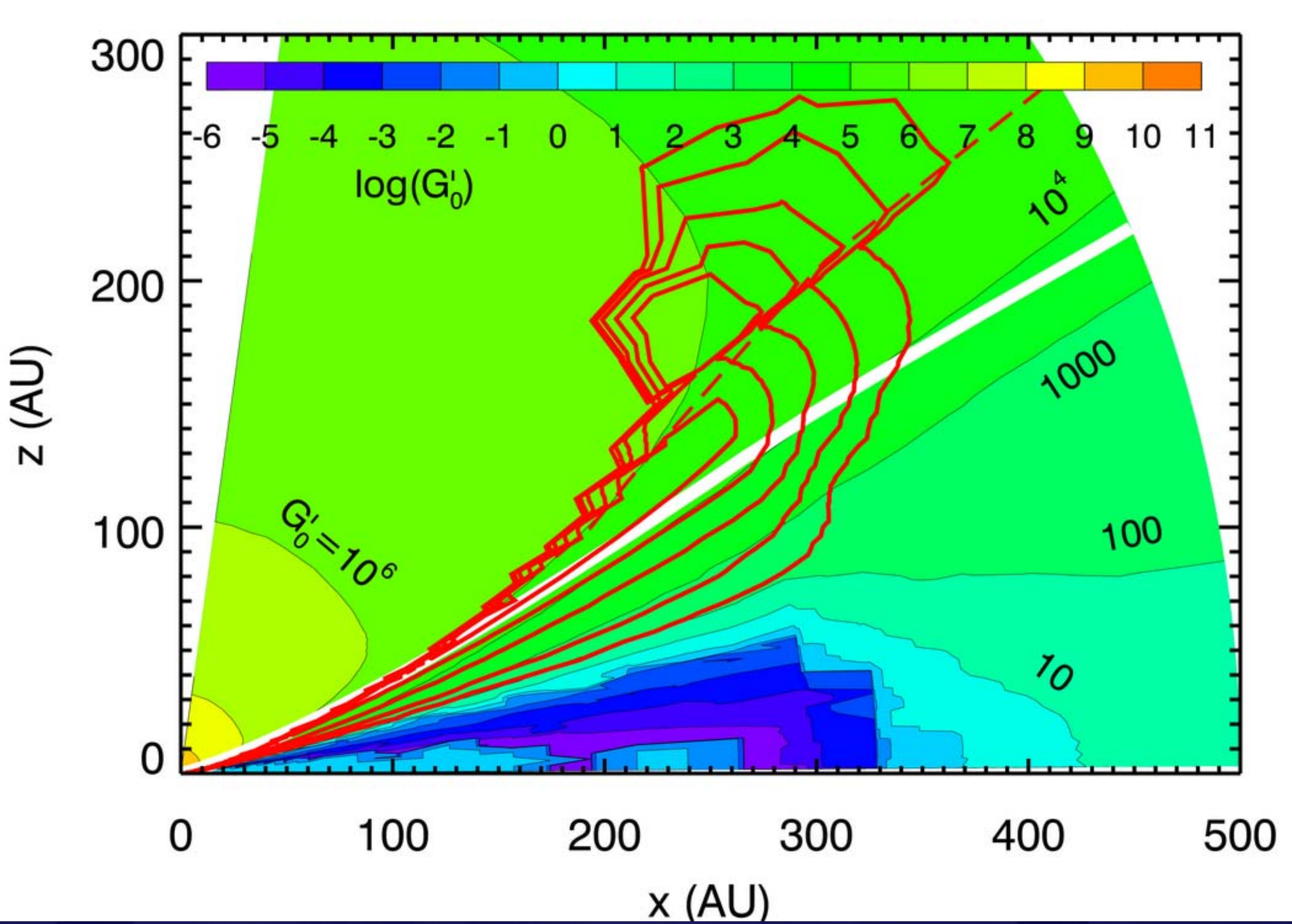


Jonkheid et al. 2006; Kamp & Dullemond 2004

Modelling PAHs in disks

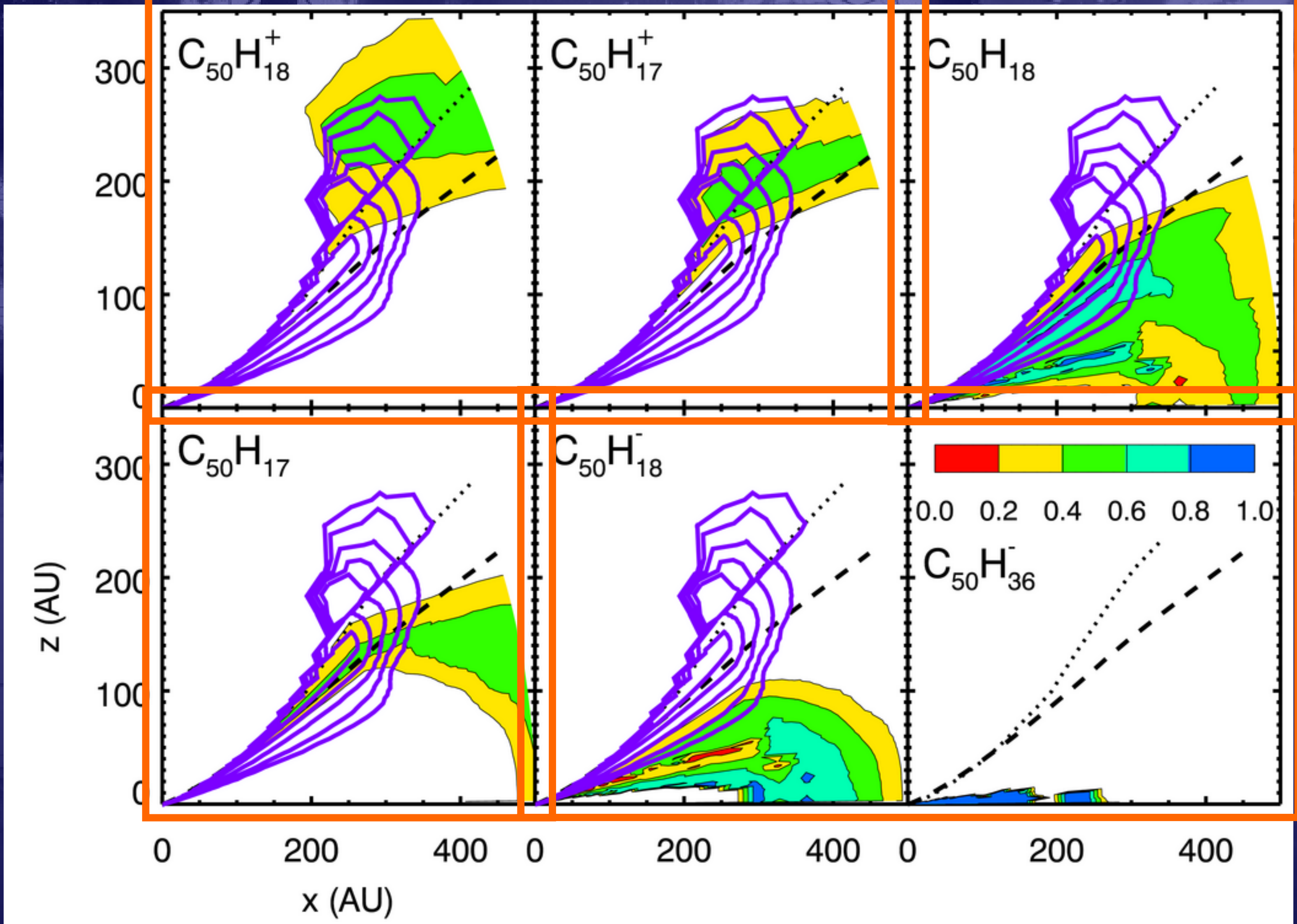
1. Standard static disk model creates density, temperature, radiation field
   Dullemond, Dominik & Natta 2001
2. Calculate PAH chemistry: charge and hydrogen content as function of position
3. Calculate PAH excitation (including multi-photon) and IR emission
4. Create spectrum (SED) or image

Radiation field and PAH emission



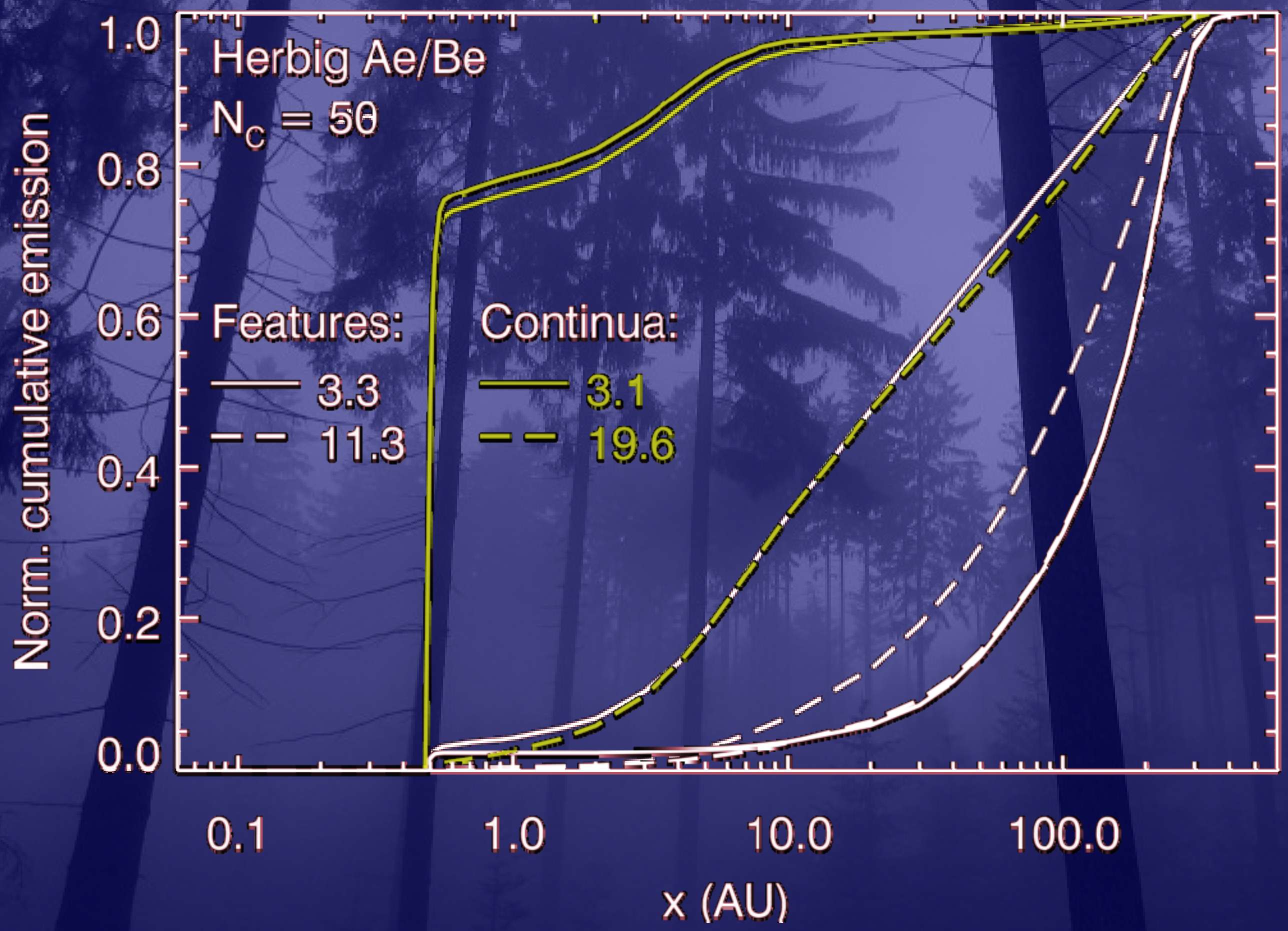
- N_C = 50 in Herbig disk, R_{disk} = 300 AU
- Destruction for $G_0 \gtrsim 10^5$
- Emission mostly from surface layers

Distribution in disk



- N_C = 50 in Herbig disk
- Disk surface: positive ions
- Main disk: neutral
- Midplane: negative ions

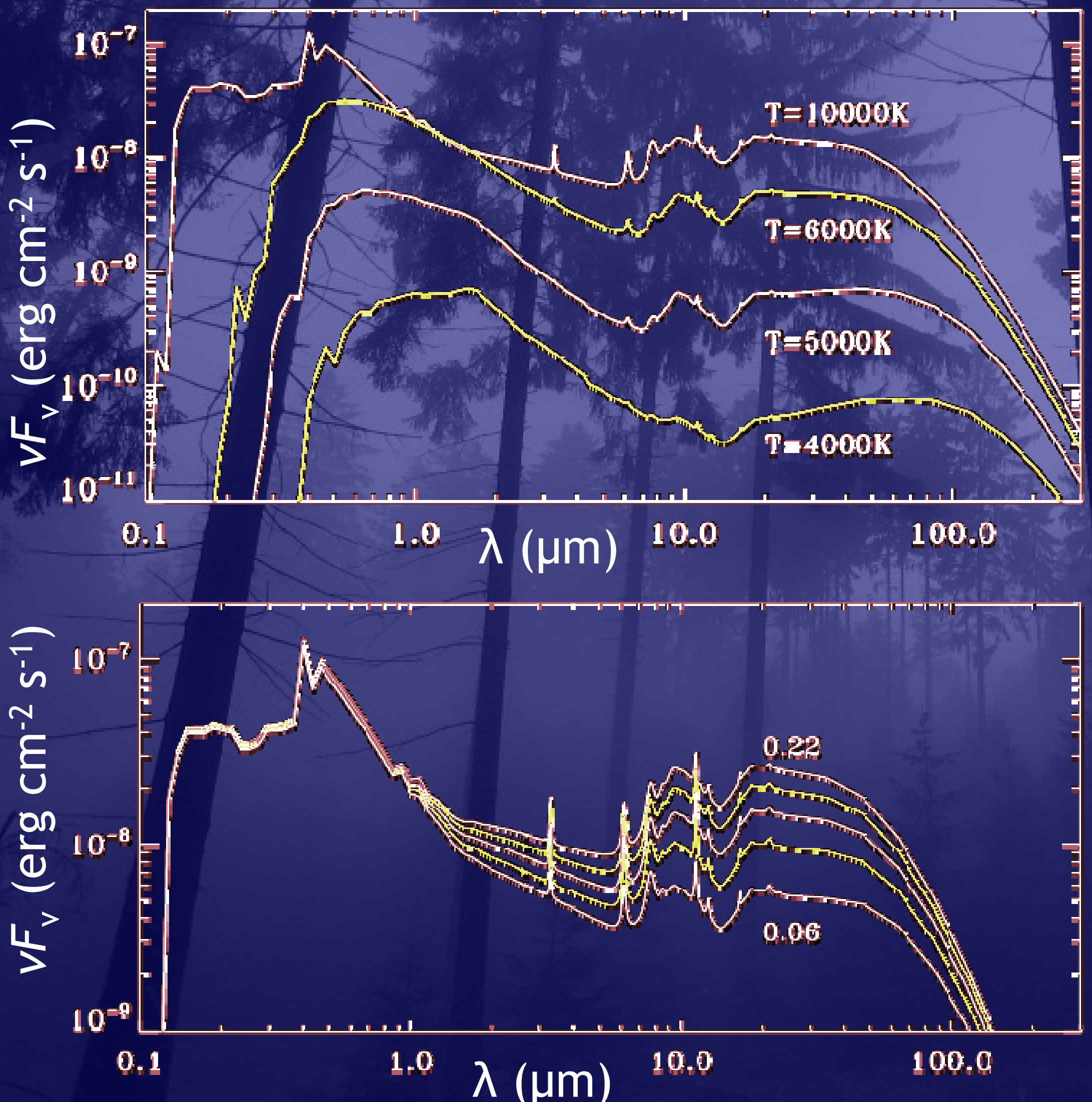
Spatial extent of features



- N_C = 50 or 96 in HAeBe disk
- PAHs destroyed in inner disk: features very extended with respect to continuum
- Features less extended for larger PAHs

Observed spatial profiles show PAH emission on a scale of tens of AU: better match with N_C = 96 than with N_C = 50

Stellar temperature & Disk flaring

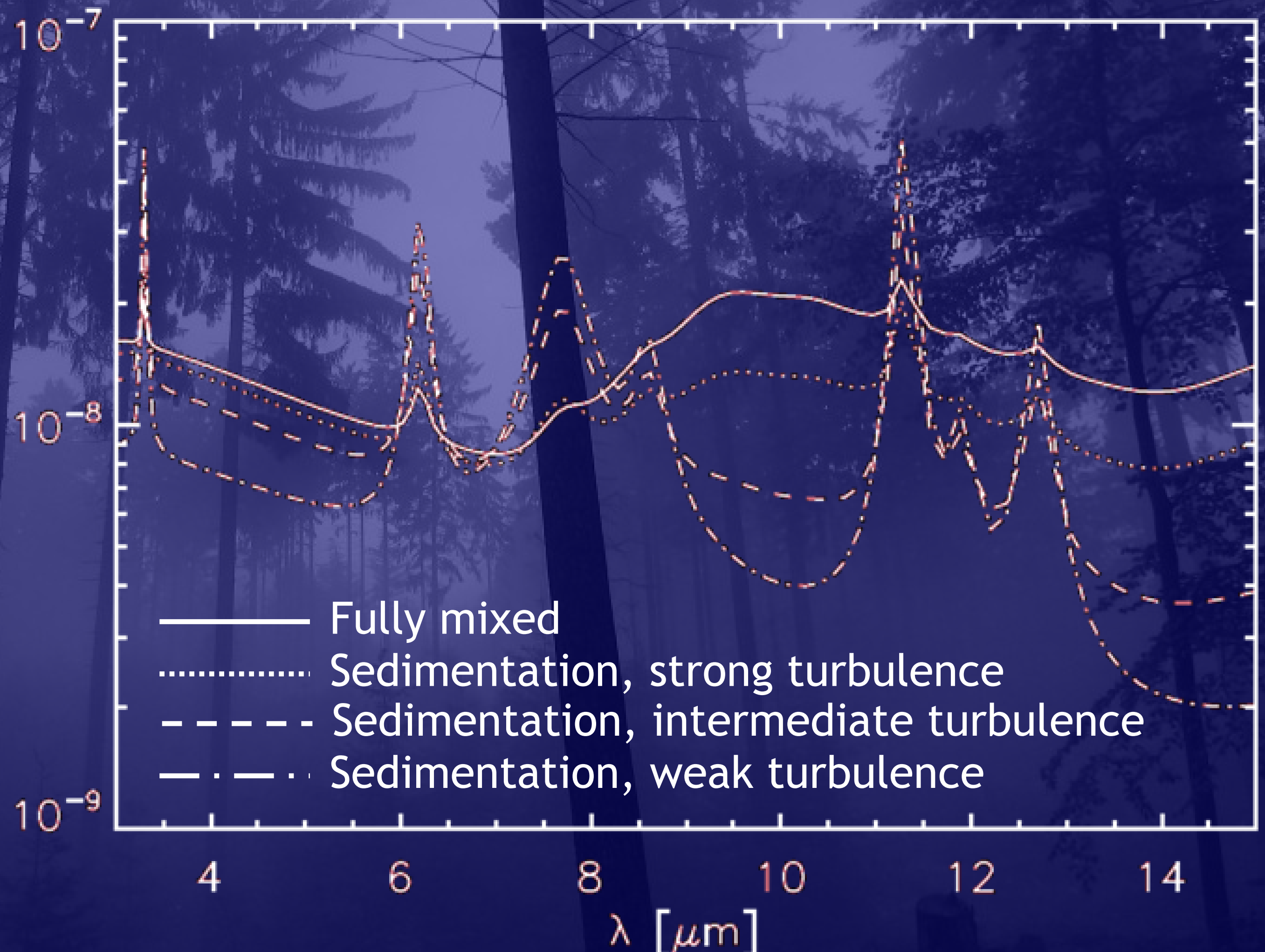


- Total flux increases with T_*, as do features
- Mid-IR flux increases with flaring angle; features almost constant

Geers et al. 2006

Sedimentation and turbulence

- Sedimentation (vertical settling) of PAHs is slower than that of larger grains
- Sedimentation enhances PAH features (as long as turbulence is not too high)



Dullemond et al. in prep

Conclusions and outlook

- PAH emission from circumstellar disks:
  - not from very small PAHs ($N_C < 50$)
  - from surface layers, spatially extended
    cf. van Boekel et al. (2004), Geers et al. (2005), Habart et al. (2006)
  - multiple charge and hydrogenation states
  - abundances 10-100x lower than in ISM
  - sedimentation can enhance PAH features

- Future work:
  - Spatially resolved observations
    Geers et al. in prep.
  - Study PAH evolution/“trail” from ISM to planet-forming zones
  - Apply model to AGNs

Thank you!

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