

Dust *composition* in disks

The impact of mid-IR interferometers

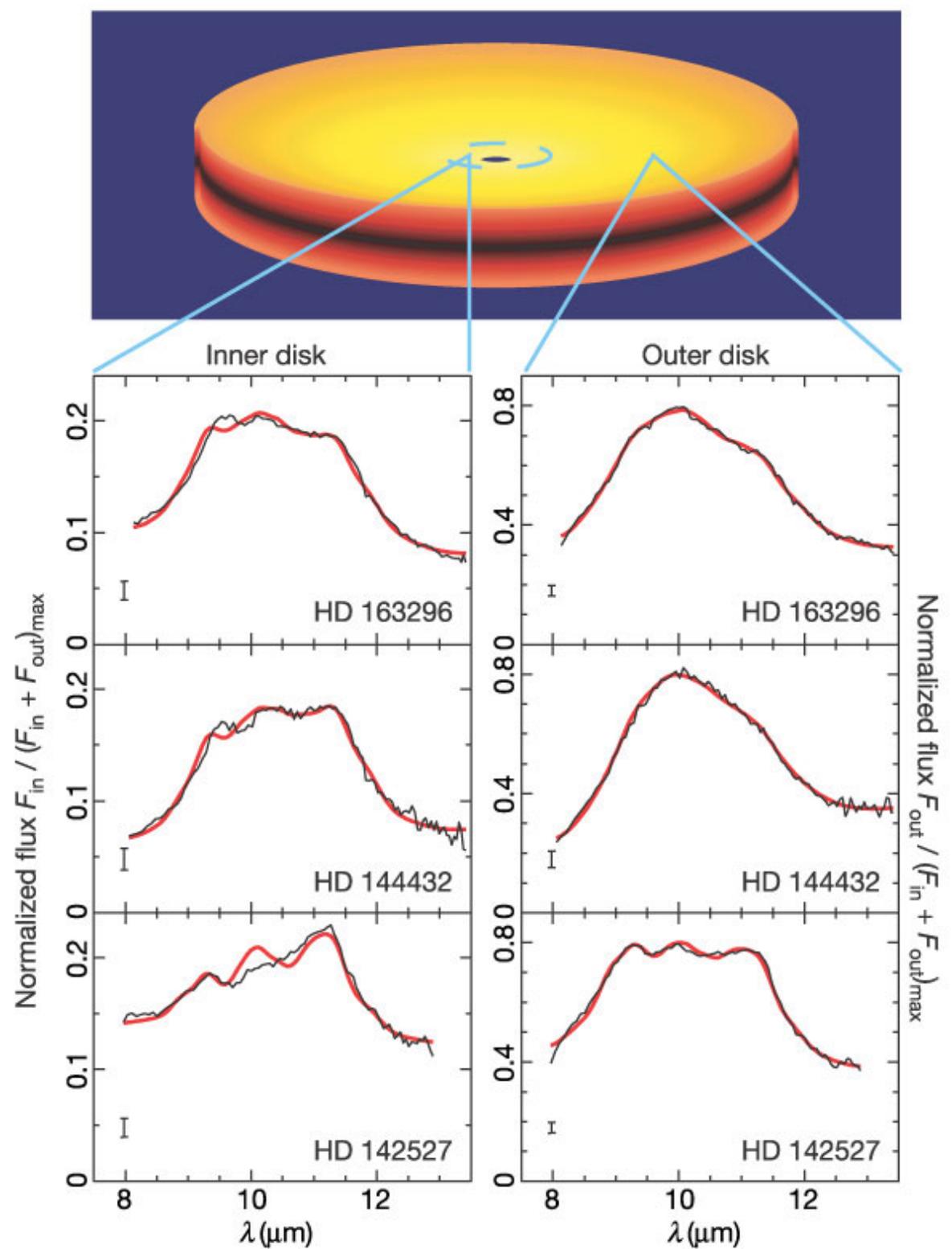
Bram Acke & Roy van Boekel

Interferometry and dust composition

- Focus on **disk geometry** (disk extent, flared disk vs flattened, disk gaps)
- **Mineralogical** analyses are scarce, mid-IR interferometry is not used to its full potential in this respect

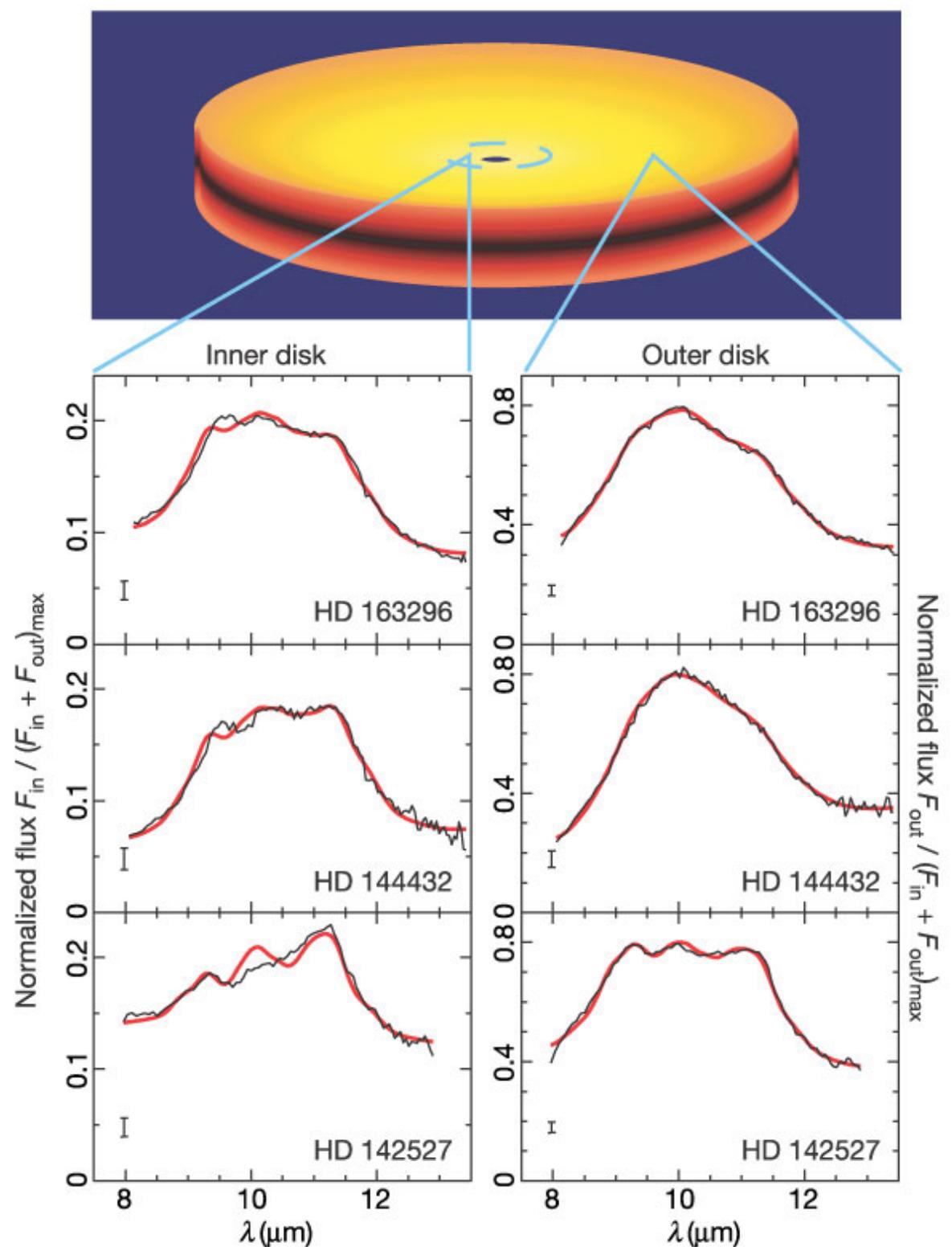
van Boekel et al. 2004,
Nature 432, 479

First-order approach:
“correlated spectrum” =
inner-disk spectrum”

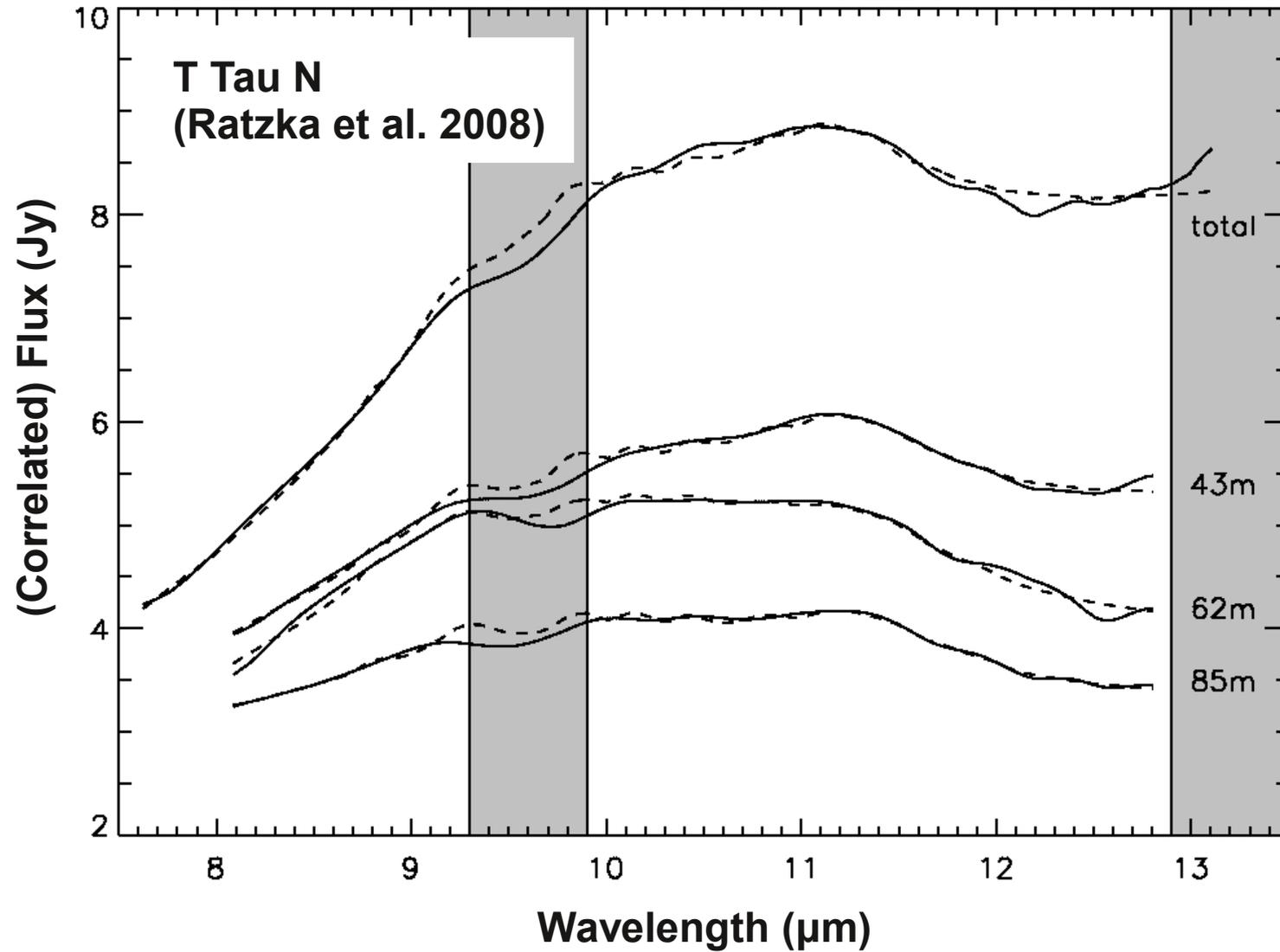


van Boekel et al. 2004,
Nature 432, 479

- High **crystallinity** in the inner disk (>50%)
- Small grains depleted in inner disk



Others have followed this approach



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Ratzka et al. 2008, Schegerer et al. 2008,2009:

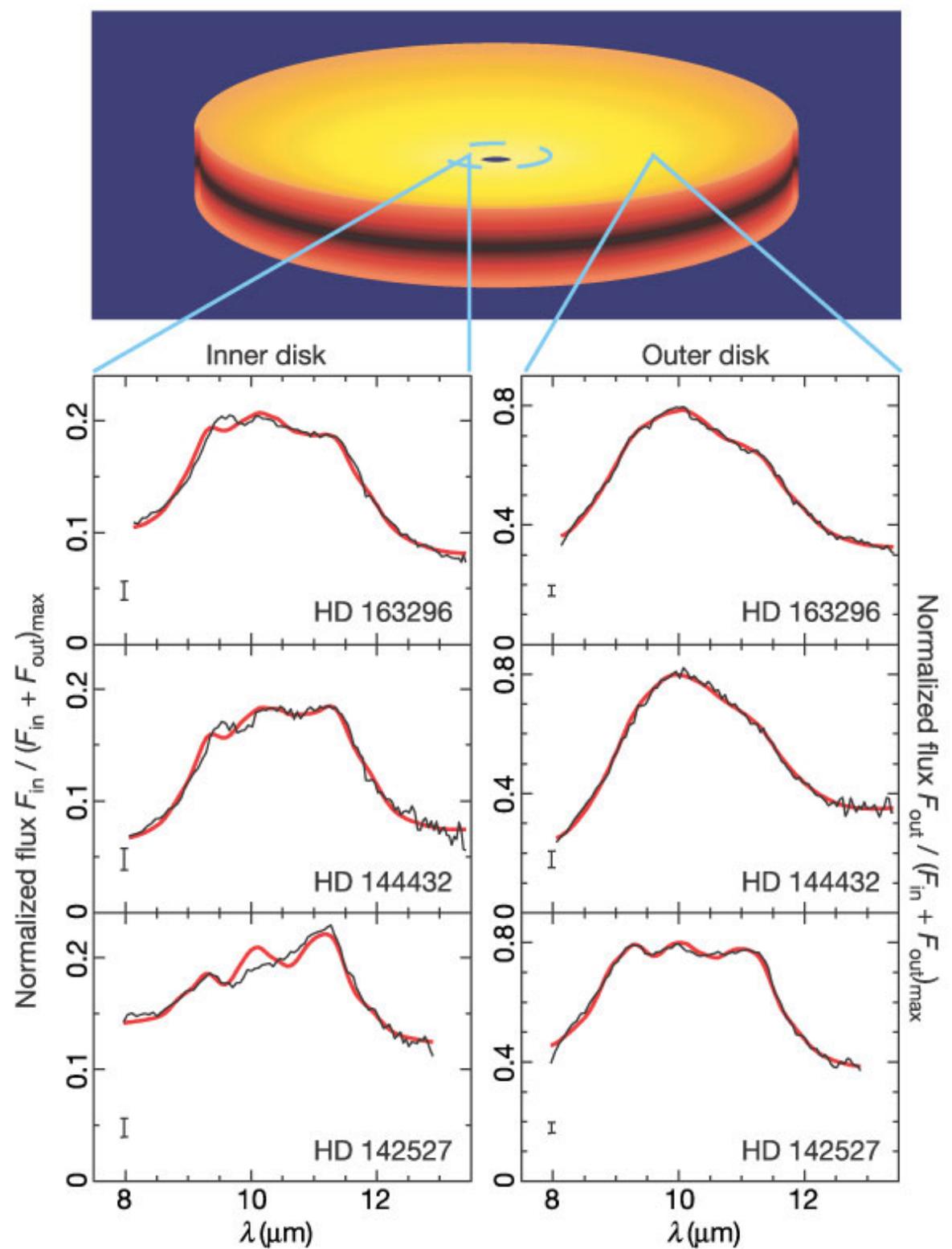
Similar to Herbig Ae stars:

T Tauri disks show an **outward decrease** of

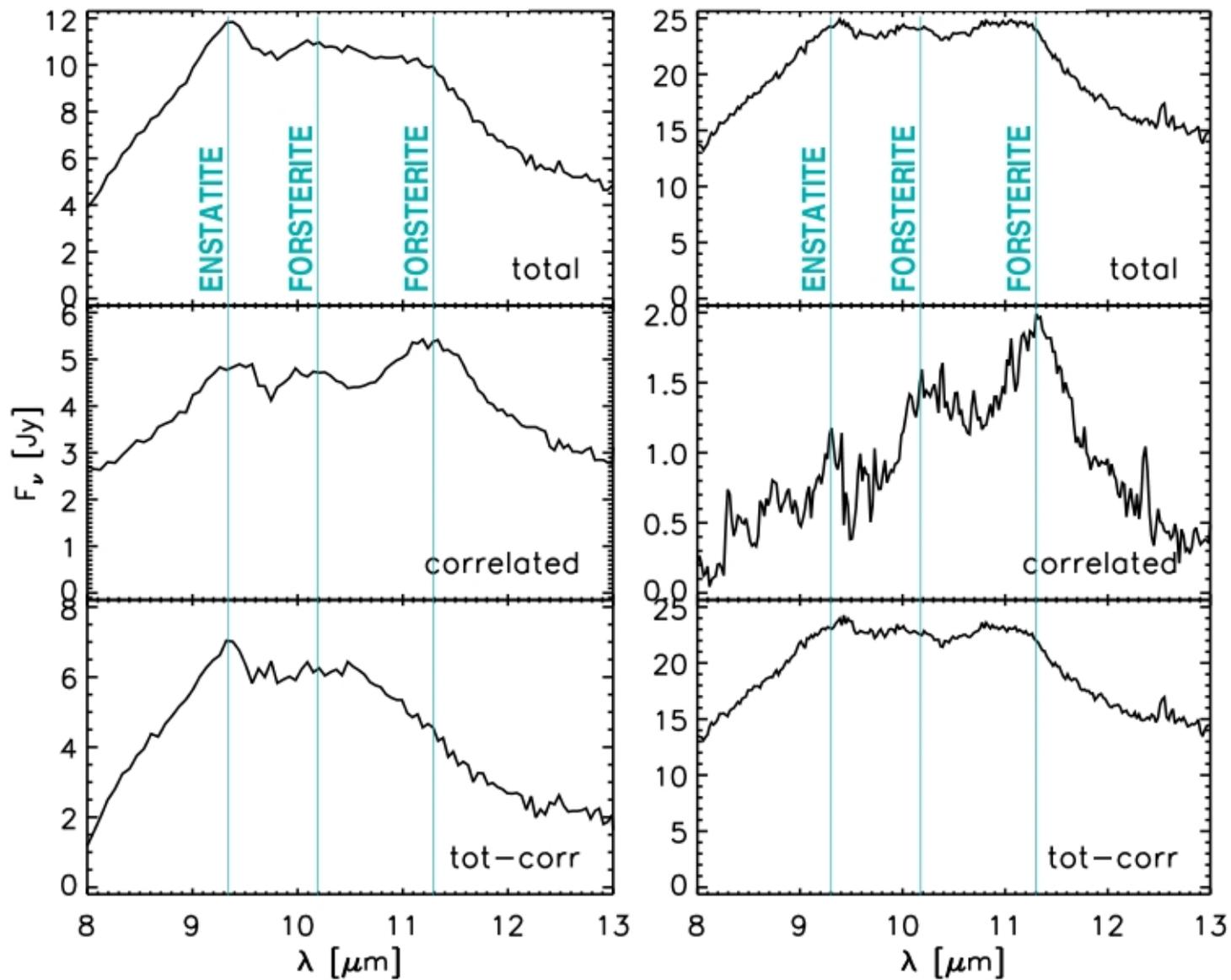
- crystallinity
- large (1.5 μm) vs small (0.1 μm)
amorphous grain contribution

van Boekel et al. 2004

Forsterite (Mg_2SiO_4) to
Enstatite (MgSiO_3) ratio
is higher in inner disk



van Boekel et al., unpublished

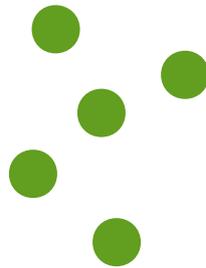


Crystallinity + mineralogy gradient

Inner disk:

Gas-phase condensation at high T

→ pure **forsterite** (Mg_2SiO_4)

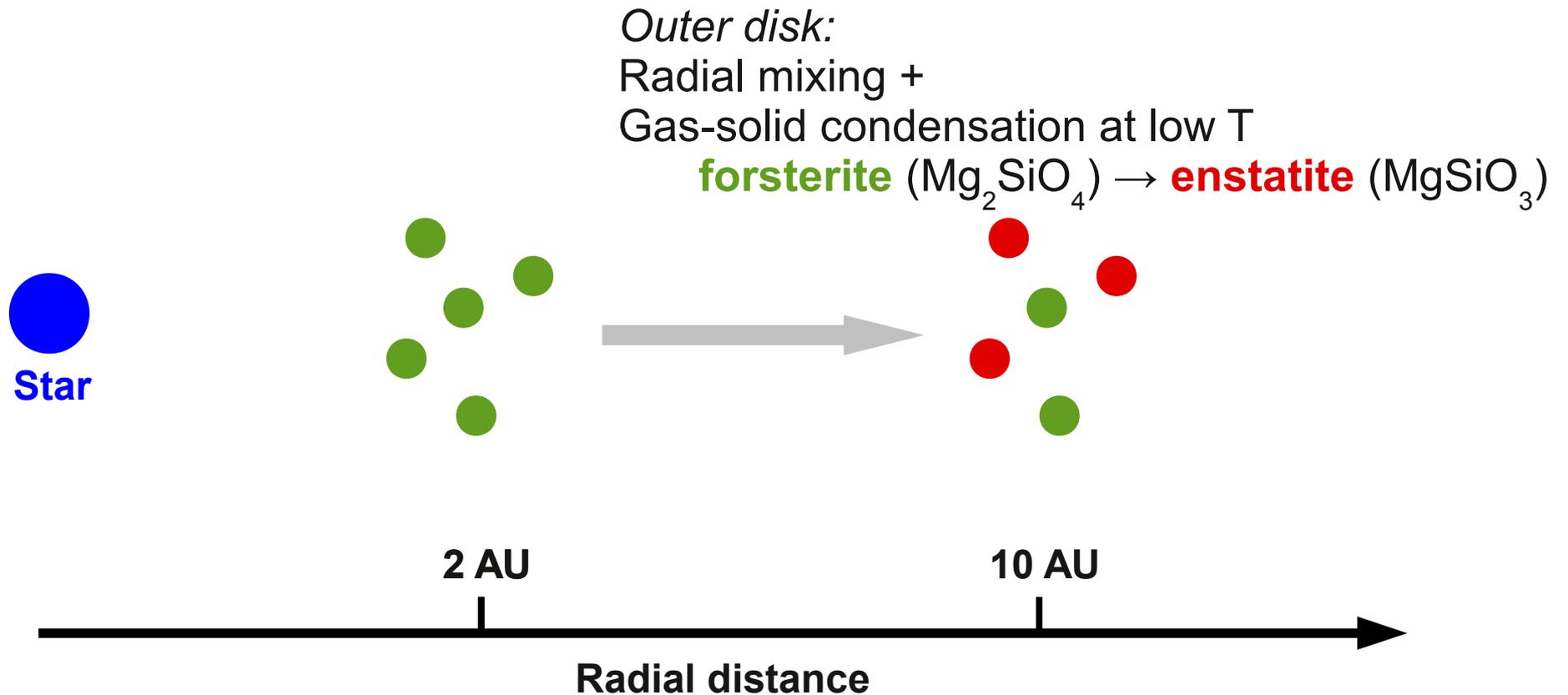


2 AU

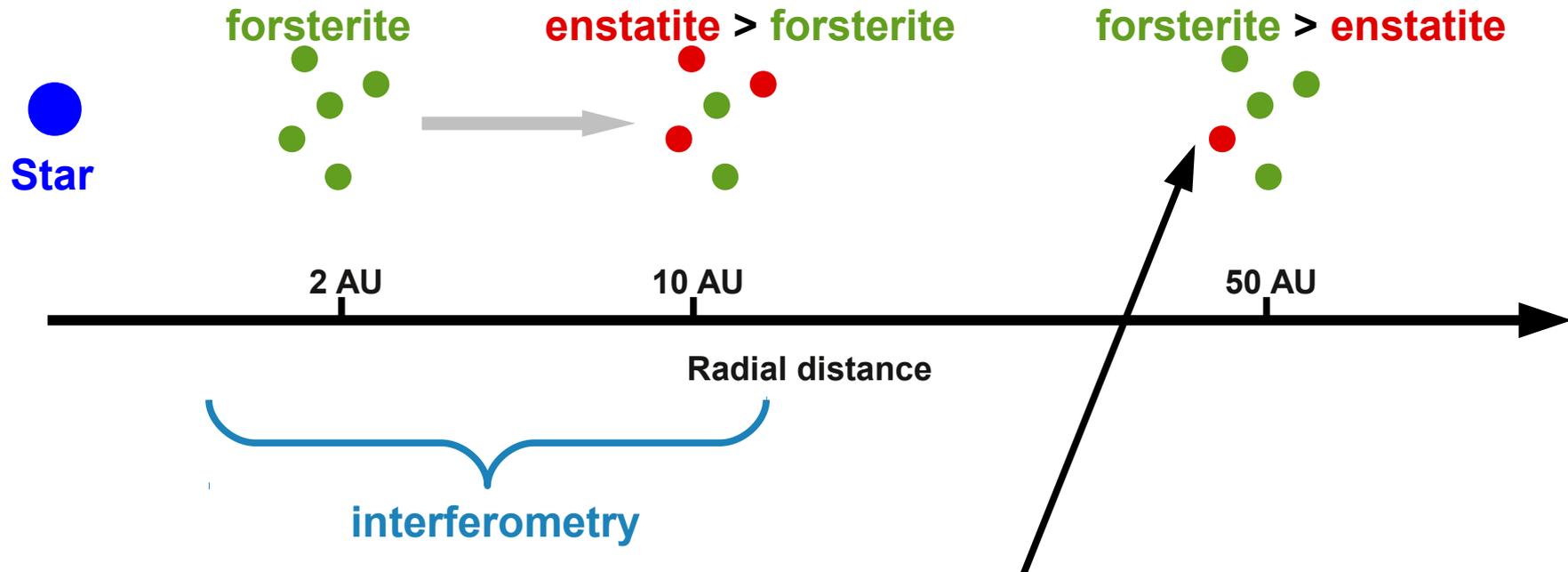
Radial distance



Crystallinity + mineralogy gradient



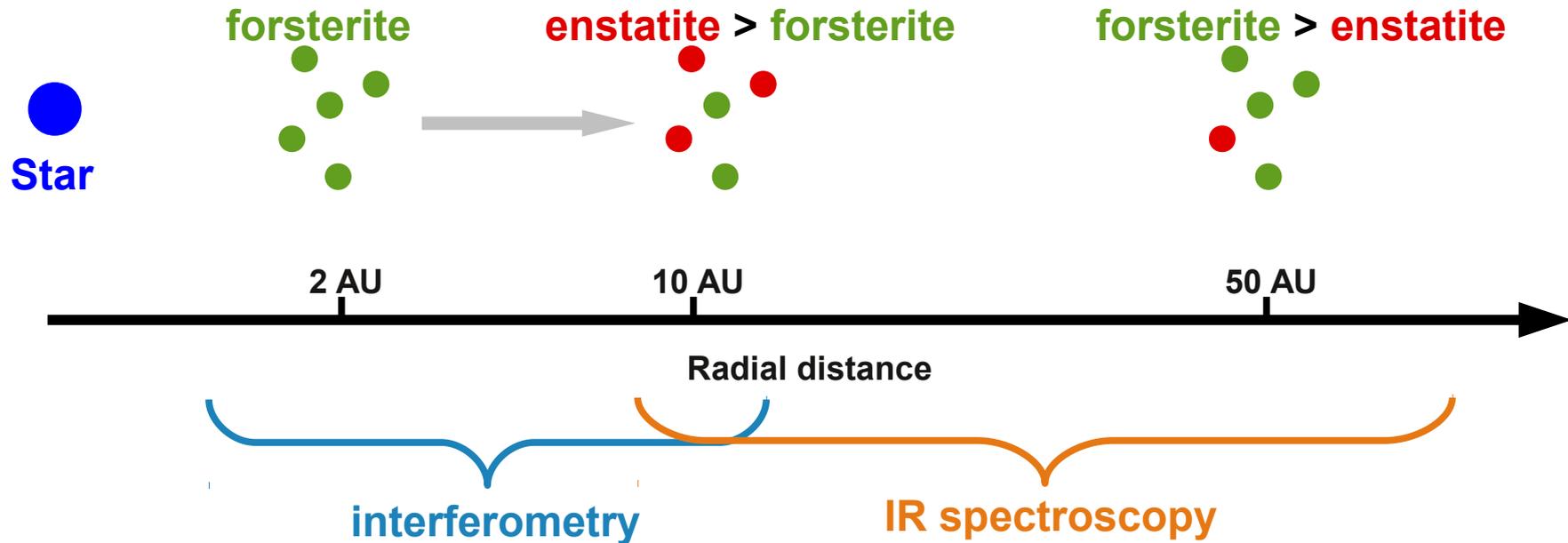
Crystallinity + mineralogy gradient



Juhász et al. 2010, based on Spitzer IRS spectra:

“Inner disk (short λ) enstatite > forsterite
Outer disk (long λ) forsterite > enstatite”

Crystallinity + mineralogy gradient

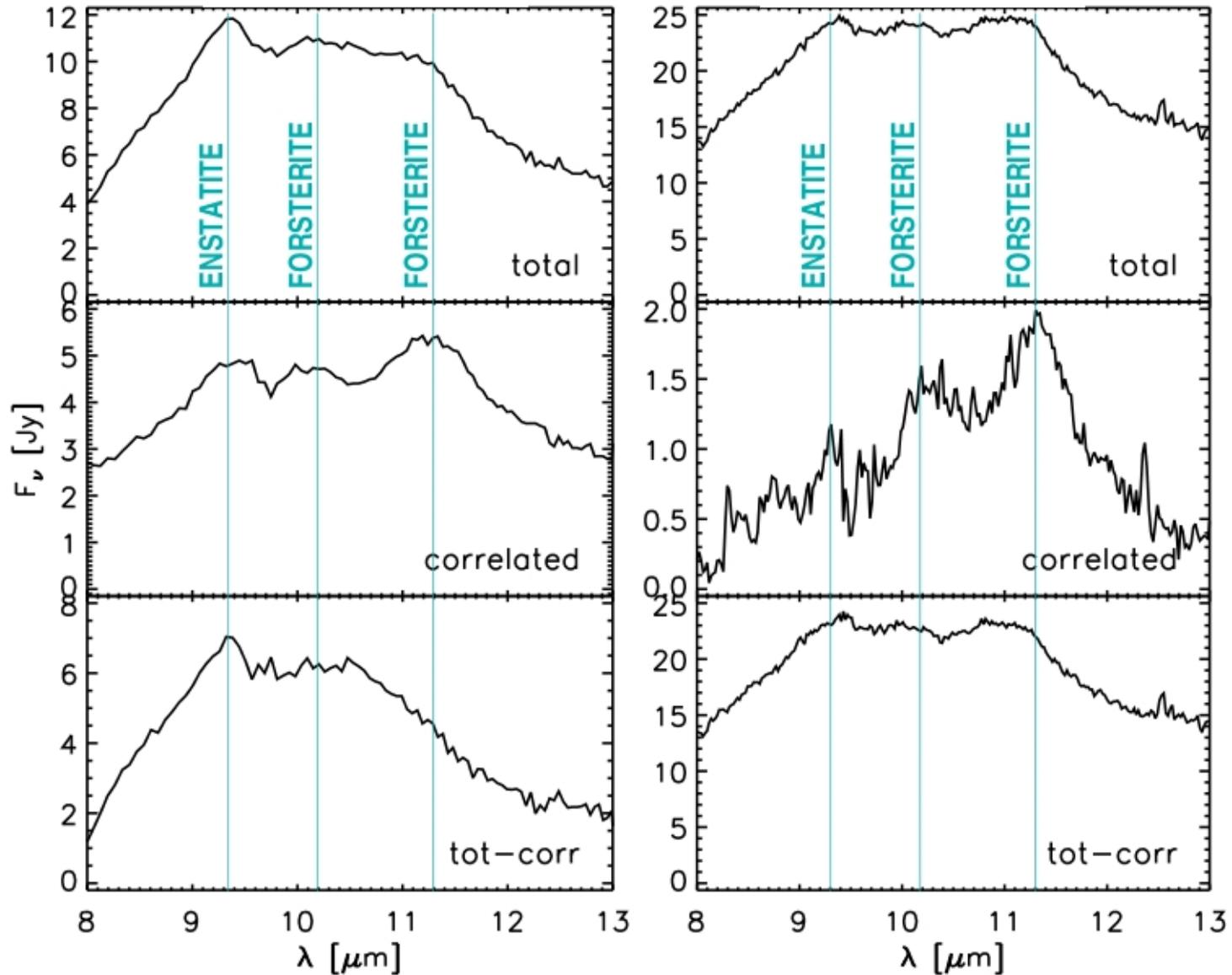


Juhász et al. 2010, based on Spitzer IRS spectra:

“Inner disk (short λ) enstatite > forsterite
Outer disk (long λ) forsterite > enstatite”

- inner disk: gas-gas + gas-solid condensation (Gail 2004)
- outer disk: shock heating \rightarrow forsterite (Fabian et al. 2000, Harker & Desch 2002)
- episodic crystal formation in surface layers during accretion outbursts (Ábrahám et al. 2009)

However: Correlated flux spectrum \neq inner disk spectrum*



* Roy's defence: "this is approximately correct for flared disks"

**The next step:
radiative transfer + spectroscopy + interferometry**

HR 4049 (Acke et al., in prep.)

evolved binary with circumbinary disk

- primary star

 - A-type giant

 - photosphere *depleted in iron* (λ Bootis star)

 - iron dust in disk?

- secondary star invisible

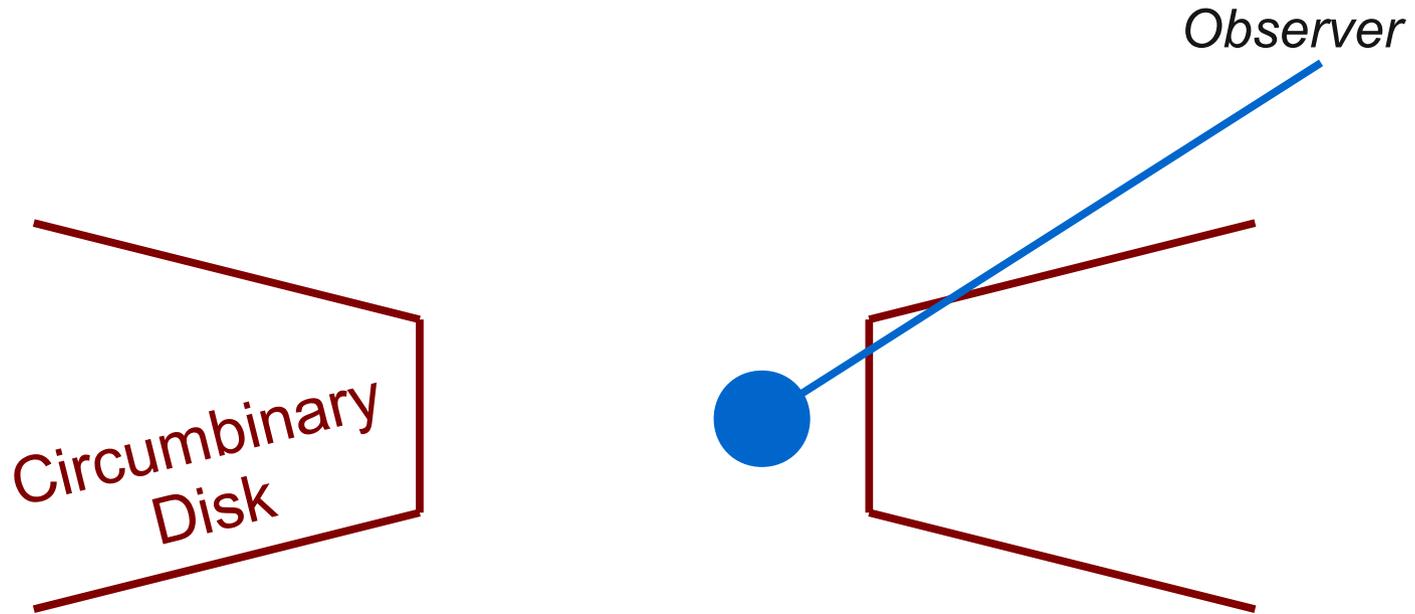
- featureless IR spectrum

 - (apart from molecular line emission+PAHs+diamond)

Metallic iron? Amorphous carbon?

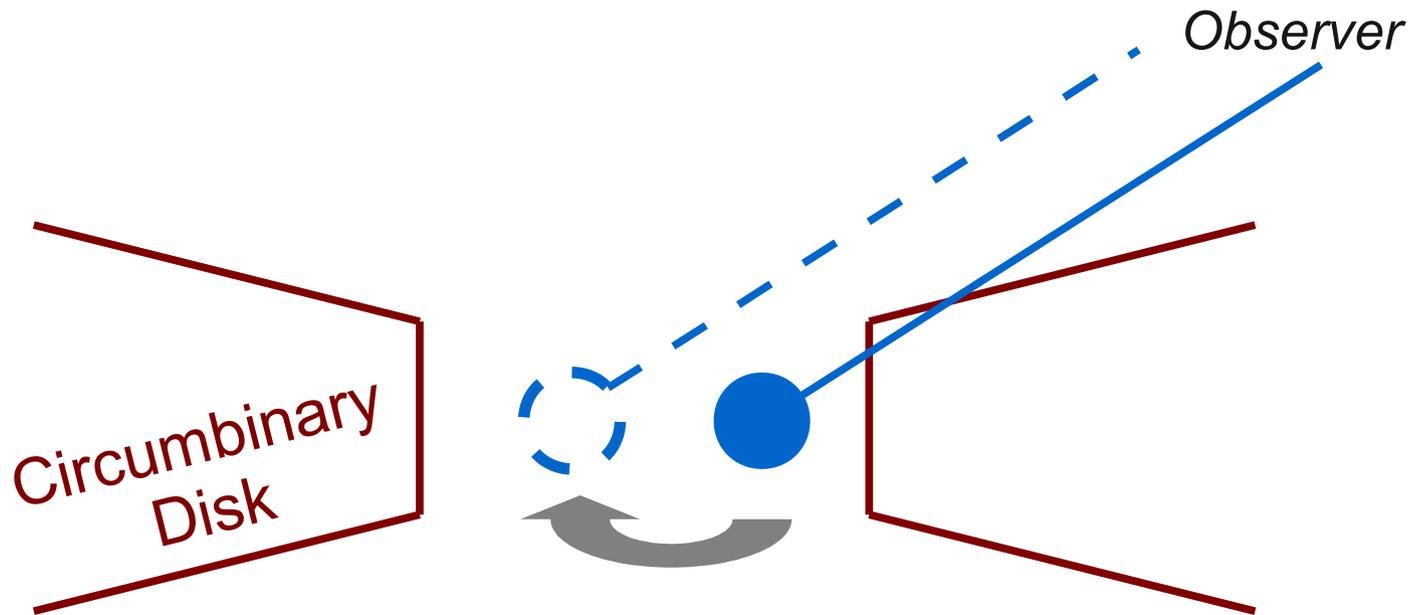
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At visual wavelengths



HR 4049

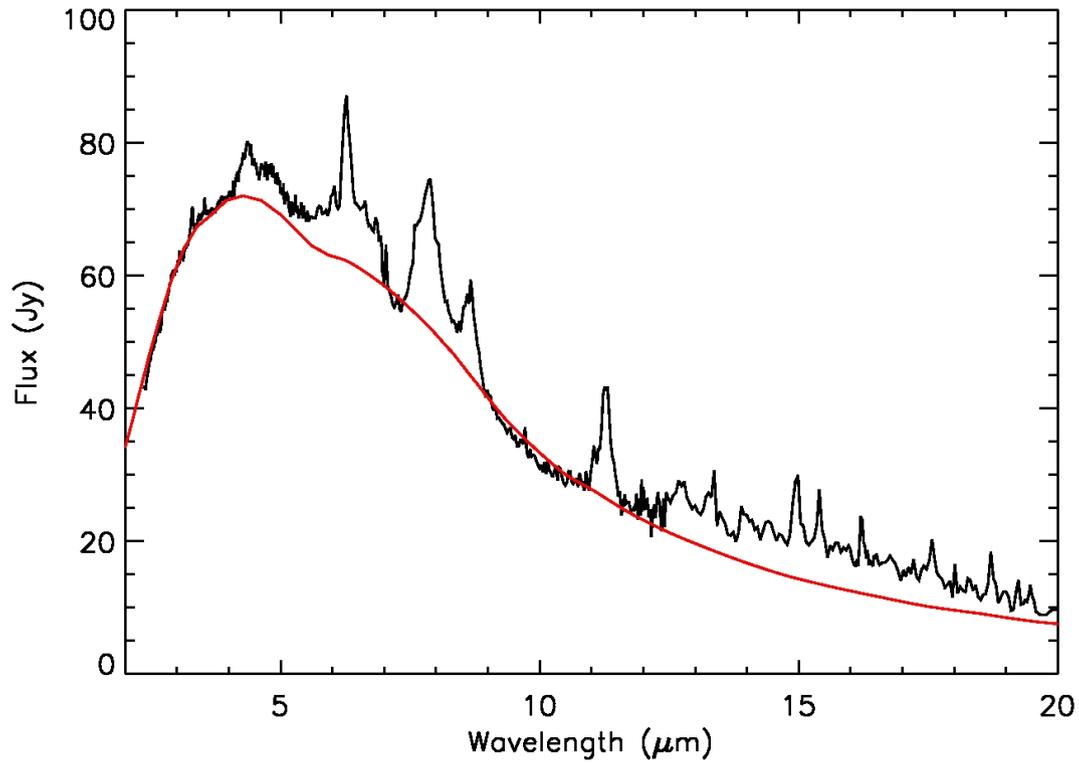
At visual wavelengths



Variable extinction in line of sight
due to circumbinary dust:

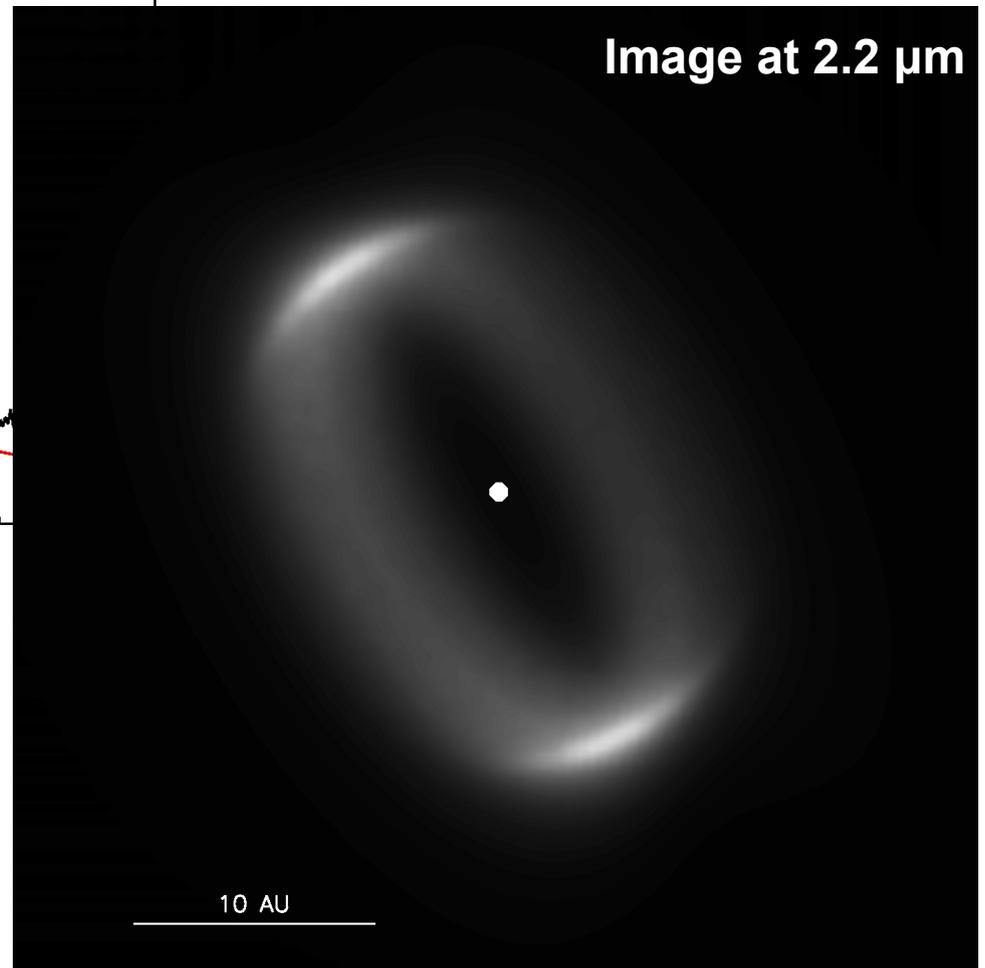
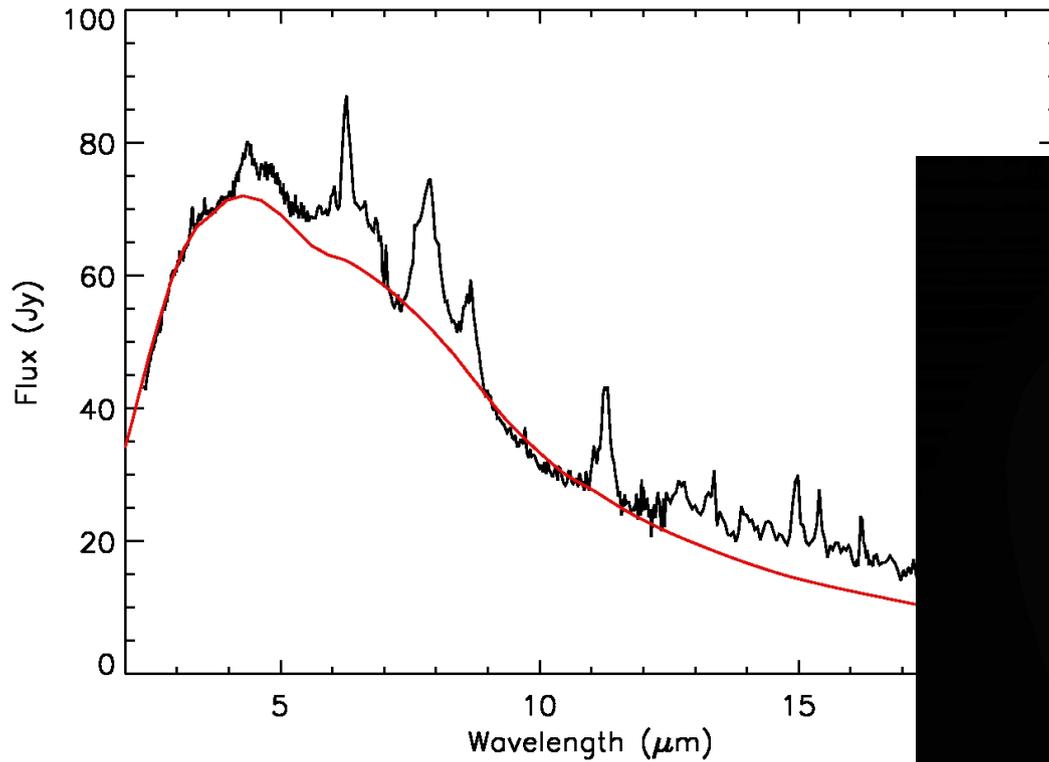
- *Very small dust particles*
- *No silicates; iron, carbon possible*

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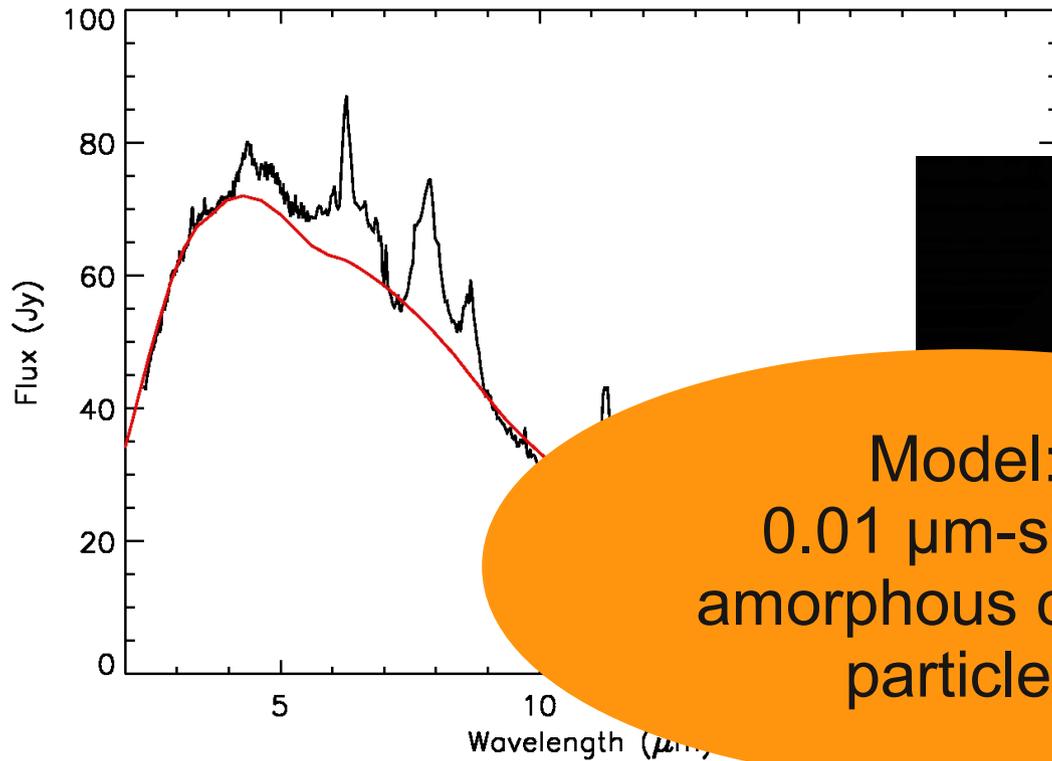
Good agreement between model
and observed spectrum

HR 4049



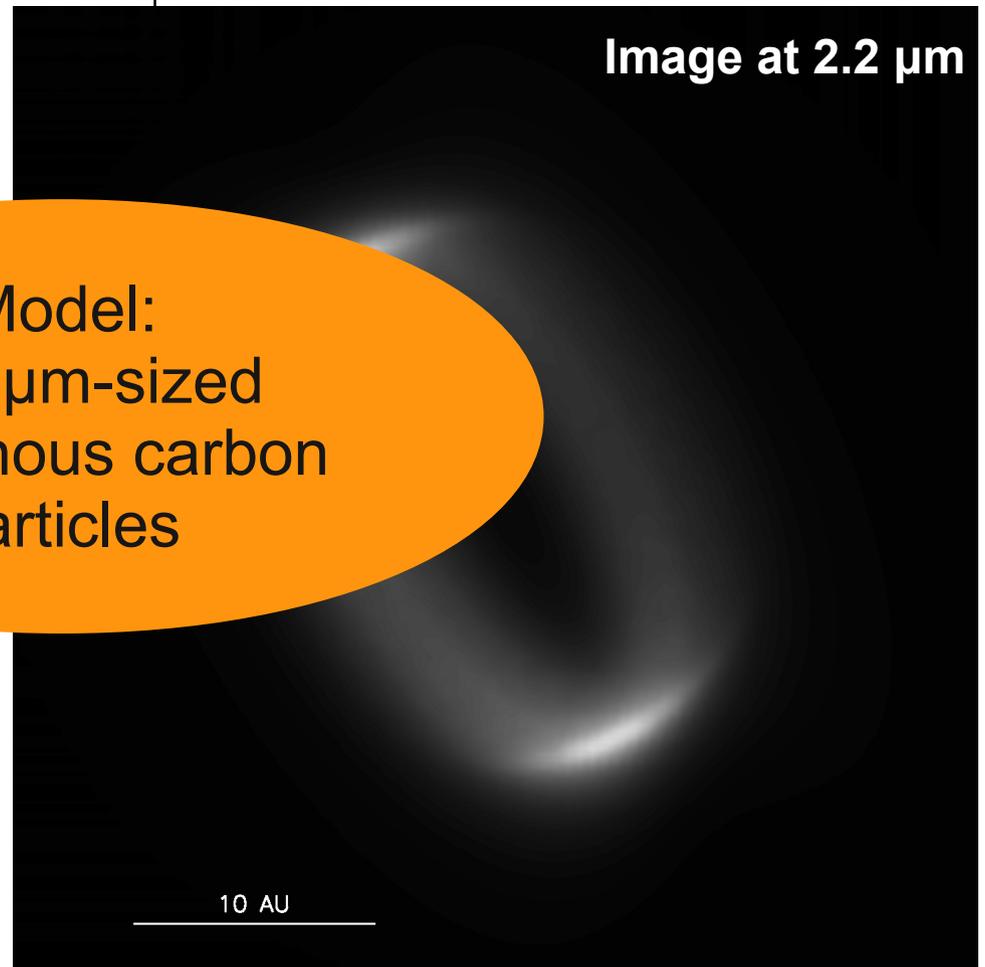
Good agreement between model
and observed spectrum
...and between model and
observed interferometry

HR 4049

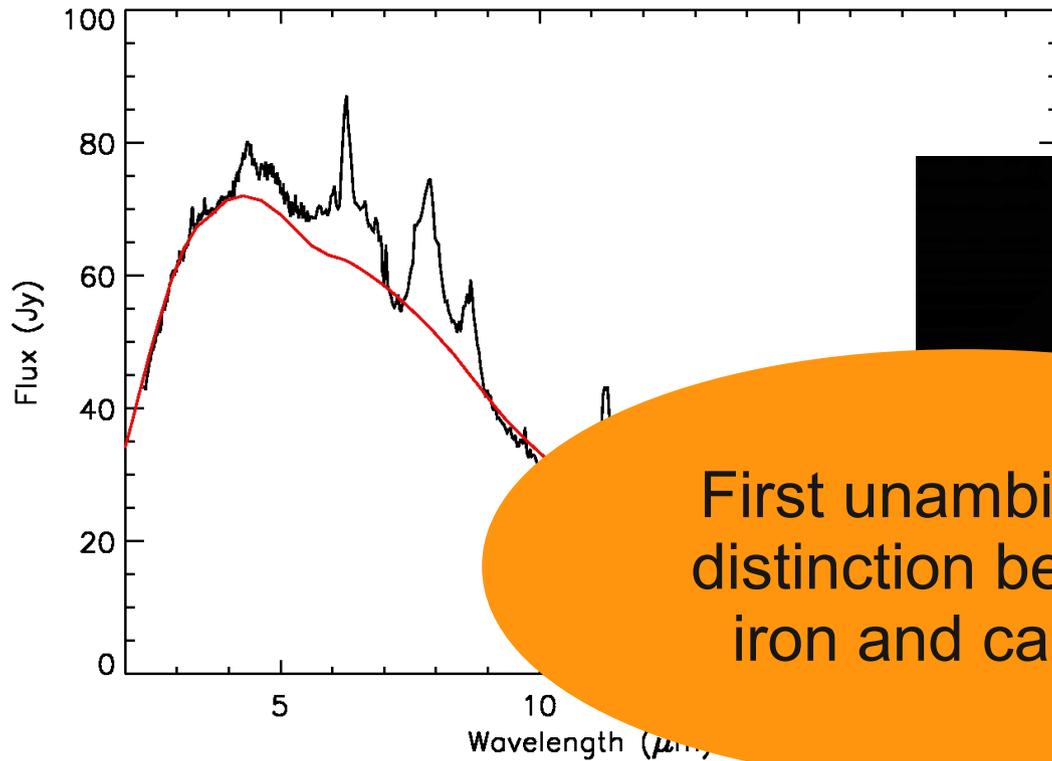


Model:
0.01 μm -sized
amorphous carbon
particles

Good agreement between model
and observed spectrum
...and between model and
observed interferometry

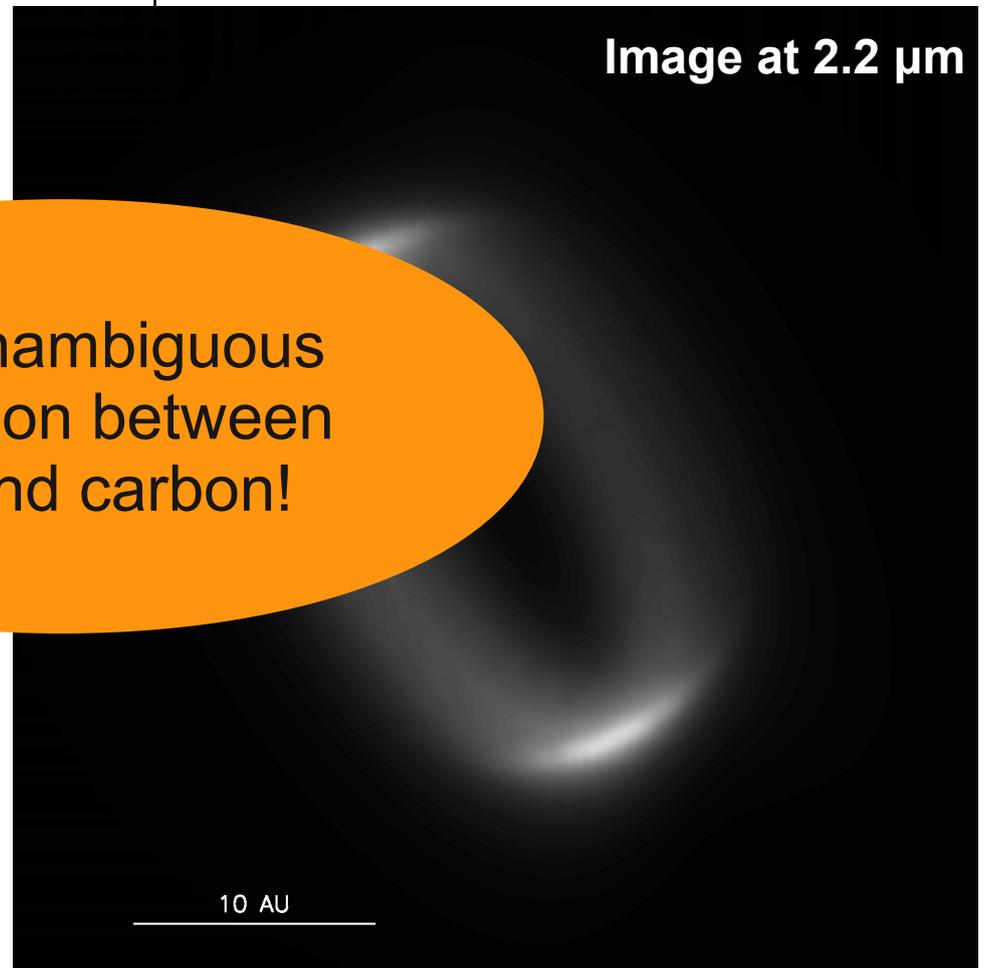


HR 4049



First unambiguous distinction between iron and carbon!

Good agreement between model and observed spectrum
...and between model and observed interferometry



Mid-IR interferometry has the power
to study dust composition. Use it!

Thank you
for listening