Dust-grain processing in circumbinary disks around evolved binaries.

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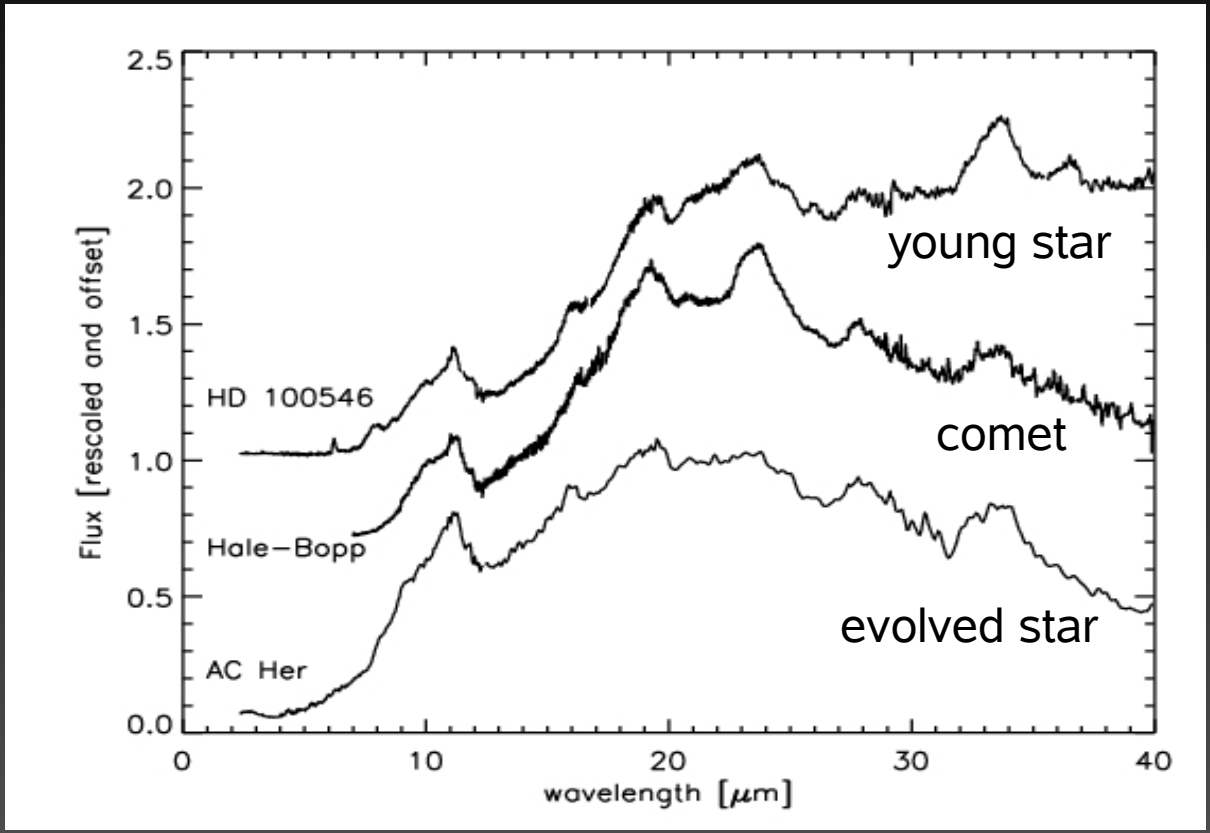
Introduction



spectra of evolved stars very similar to spectra of young stars and solar-system comets

→ different formation histories!

→ different initial dust species!

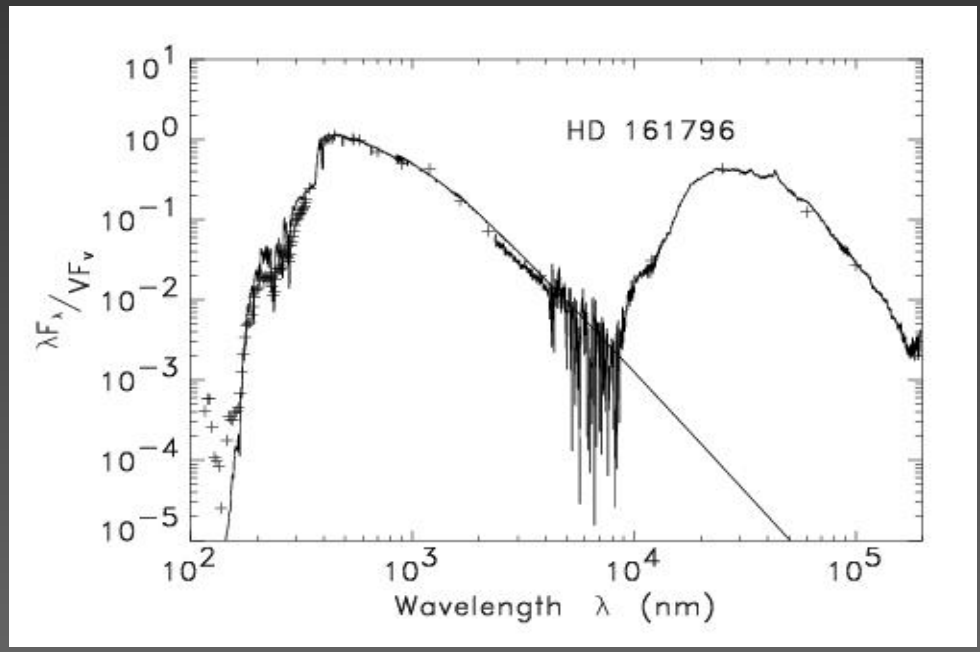
Outline

- Post-AGB sample
- Spectral energy distribution
- Mineralogy around dying binary stars
- Conclusions
- Future work

Post-AGB stars

- **post-AGB stars**: transition between AGB phase and planetary nebulae
  - spectral type: B-K (F,G)
  - double-peaked SED: cool dust from AGB outflow
  - chemical abundances: extremely rich photospheric spectra: CNO elements (dredge-up) (C-rich +s-process)

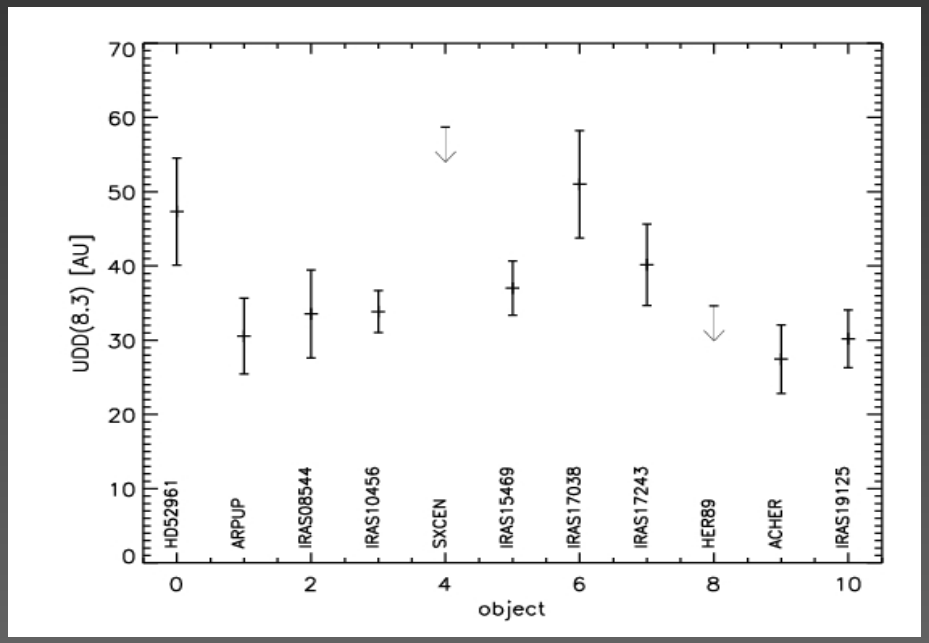
→ for single star evolution!

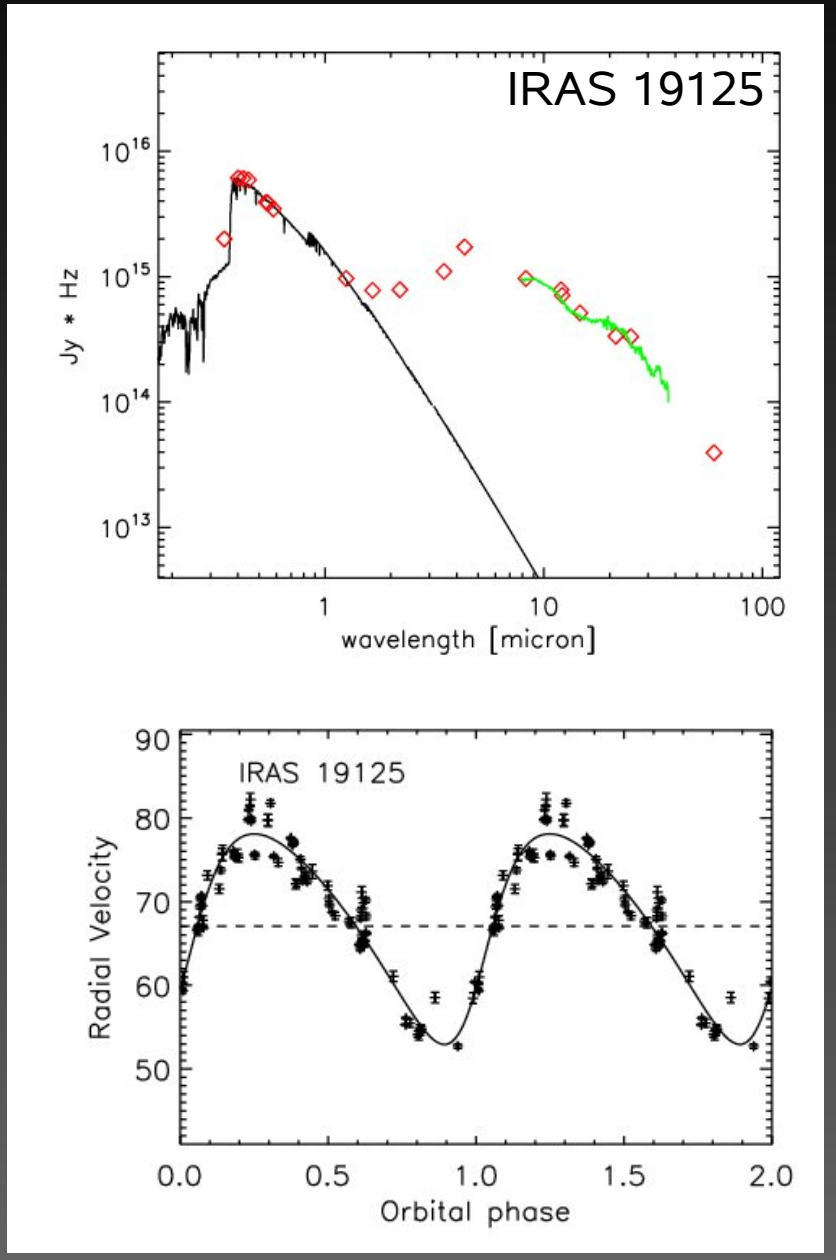


Post-AGB stars

- selection on broad IR-excess
  → hot dust
- what we observe:
  - large grains (submillimetre slope)
  - binarity (radial velocity monitoring)
  - compact CE (interferometry)

→ **dust in stable geometry: disk !**



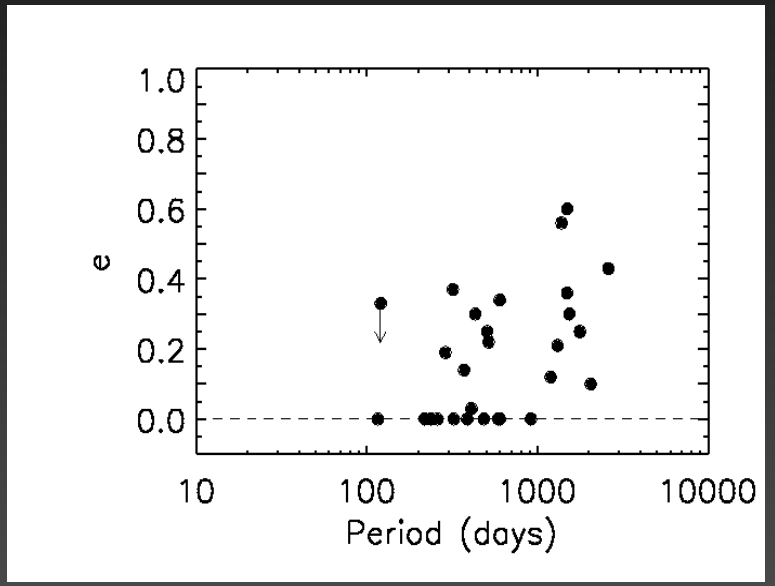


Post-AGB Sample

- **21 confirmed or suspected post-AGB binaries:**

  - orbital parameters 17/21
  - P_{orb}= 100-2000 days
  - e= 0.0-0.6

  ↔ circularisation expected!



- strong interaction during which circumbinary disk may be formed

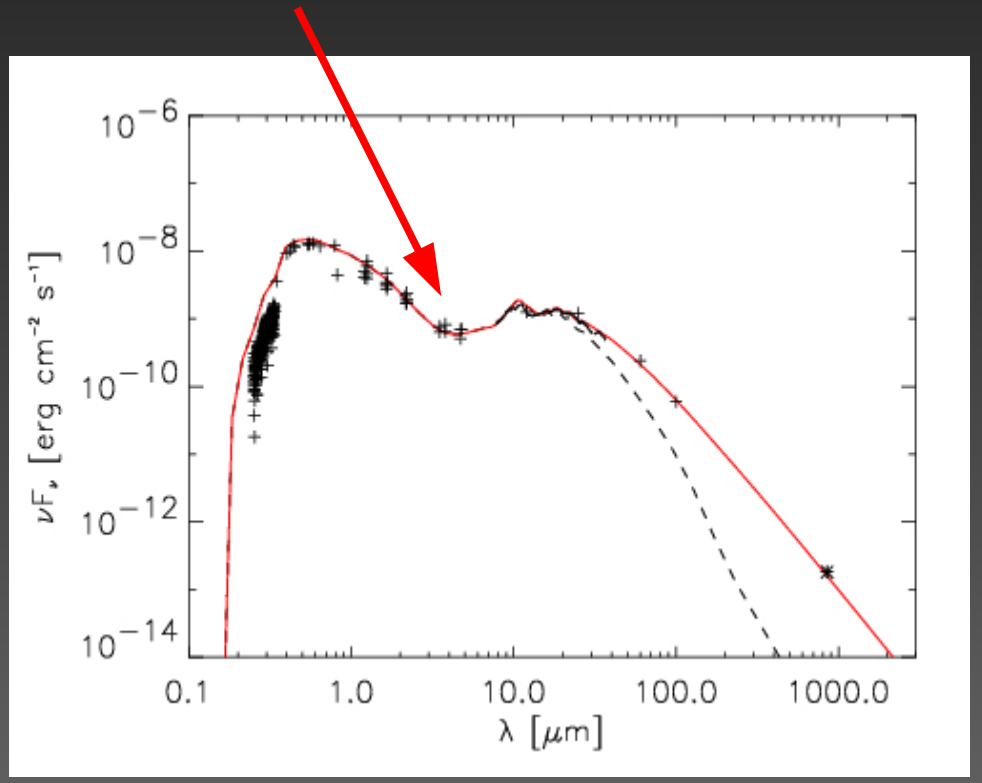
- circumbinary: orbits < sublimation radius

Spectral Energy Distribution

- SED fitting using 2D radiative transfer passive homogeneous disk model (Dominik & Dullemond, A&A, 2004)
- dust excess near sublimation temperature (~ 1500K)
- submillimetre flux points to large grains
- dust settling for large grains

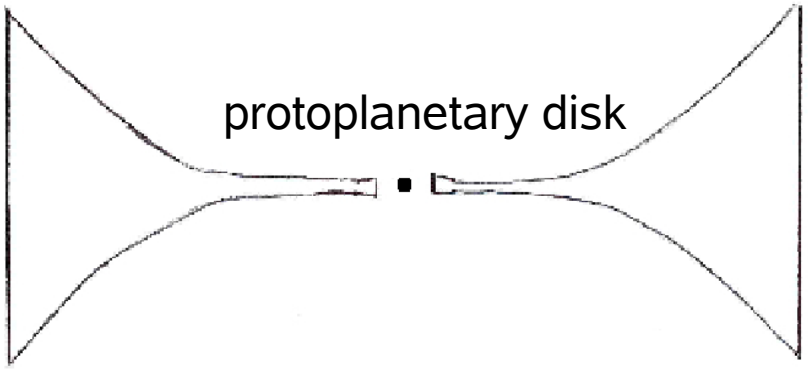
→ **inhomogeneous disk of small grains with cool midplane of large grains**

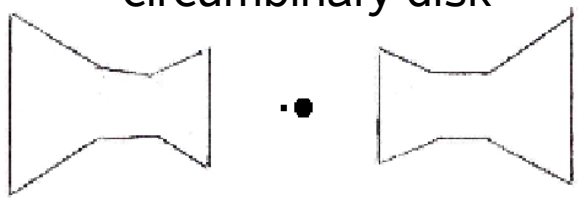
(Gielen et al. 2007, A&A, 2007)

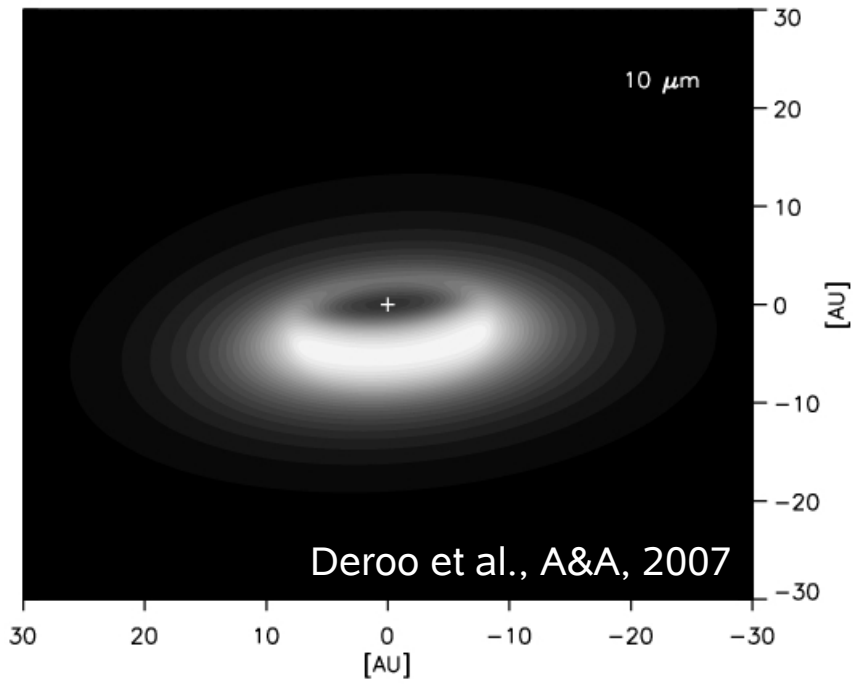


SED modelling

- typical disk sizes: 5AU-300AU
- flared disks with puffed up inner rim
- SED modelling gives an inclination range
  → combined with mass function binary system:
  companions likely unevolved main sequence stars



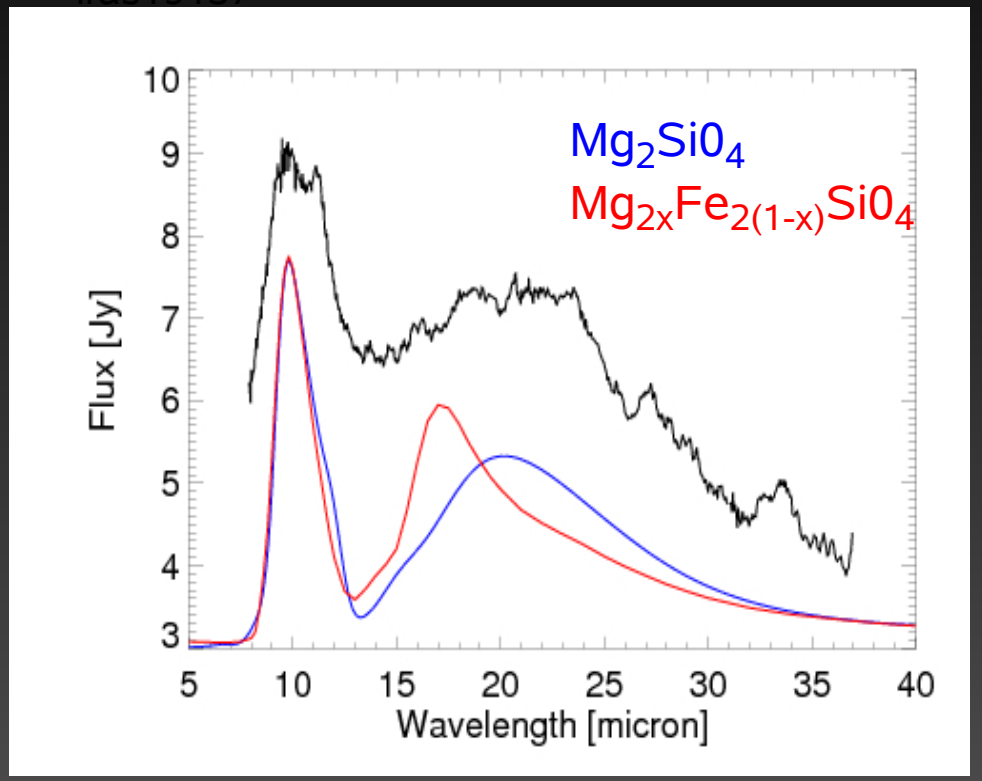




Mineralogy

- dust oxygen rich (silicates) and highly crystalline
  - forsterite (Mg_2SiO_4)
  - enstatite ($MgSiO_3$)

- amorphous 20µm feature shifted to right
  → Mg-rich amorphous silicate dust

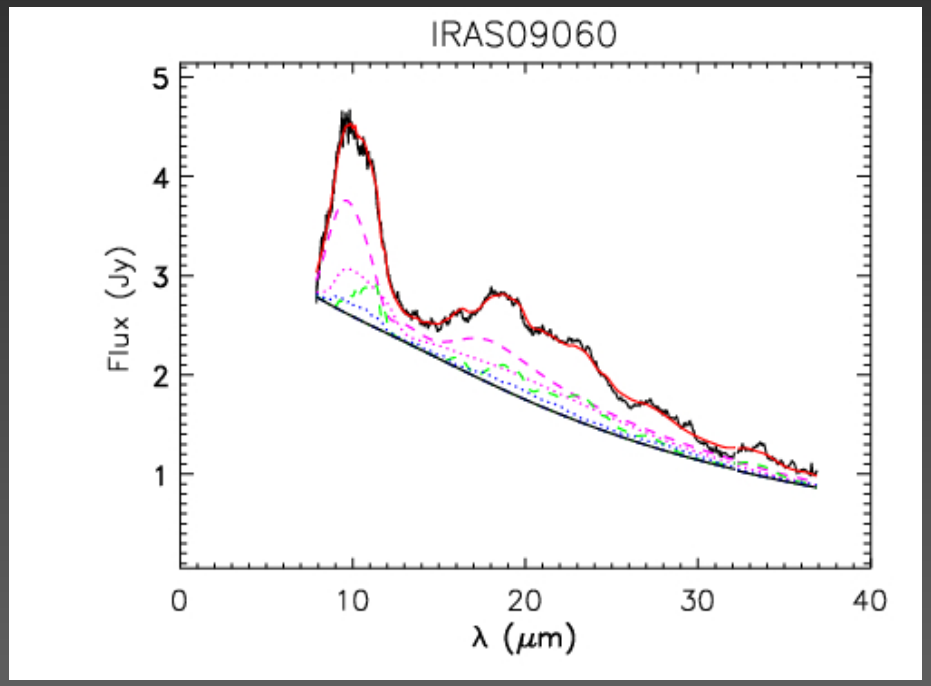


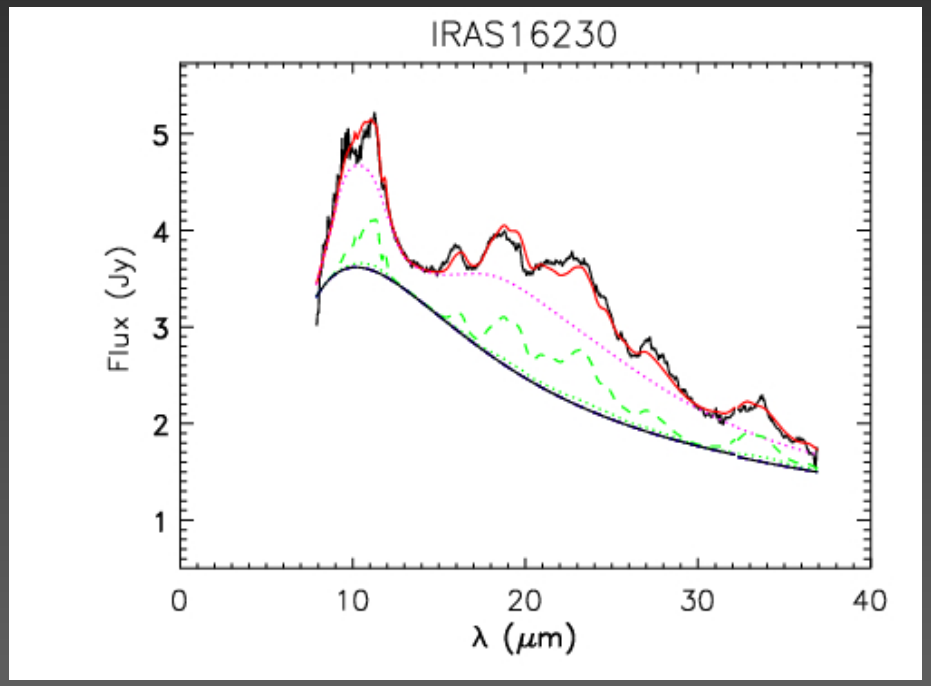
- amorphous + crystalline dust Mg-rich stellar photospheres depleted in iron } where is the iron ?

→ metallic iron ?

Full spectral fitting

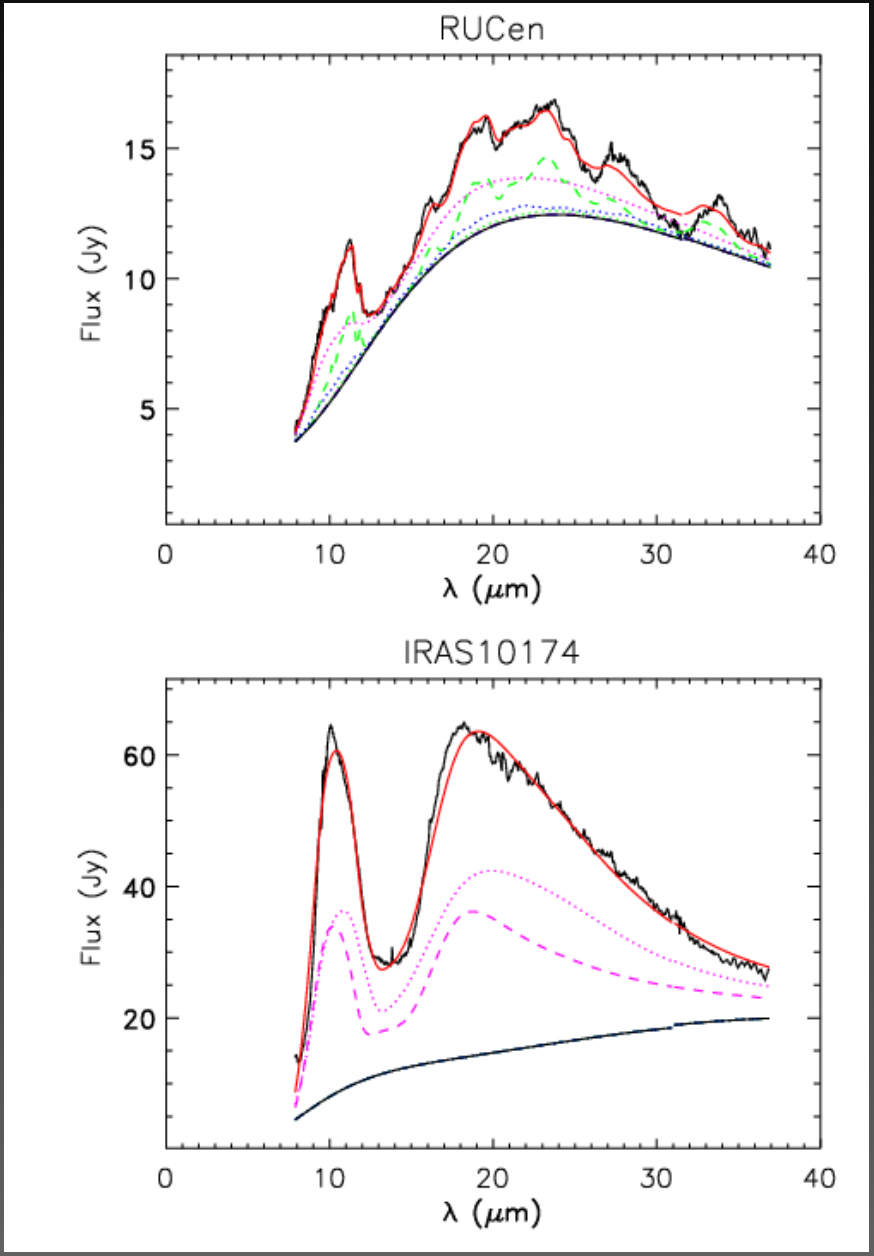
- Mg-rich amorphous and crystalline silicate dust in GRF approximation (very irregular grains)
- large grains: 2 μm + 4 μm
- 2 dust temperatures: both hot and cool dust temperatures needed to fit spectrum

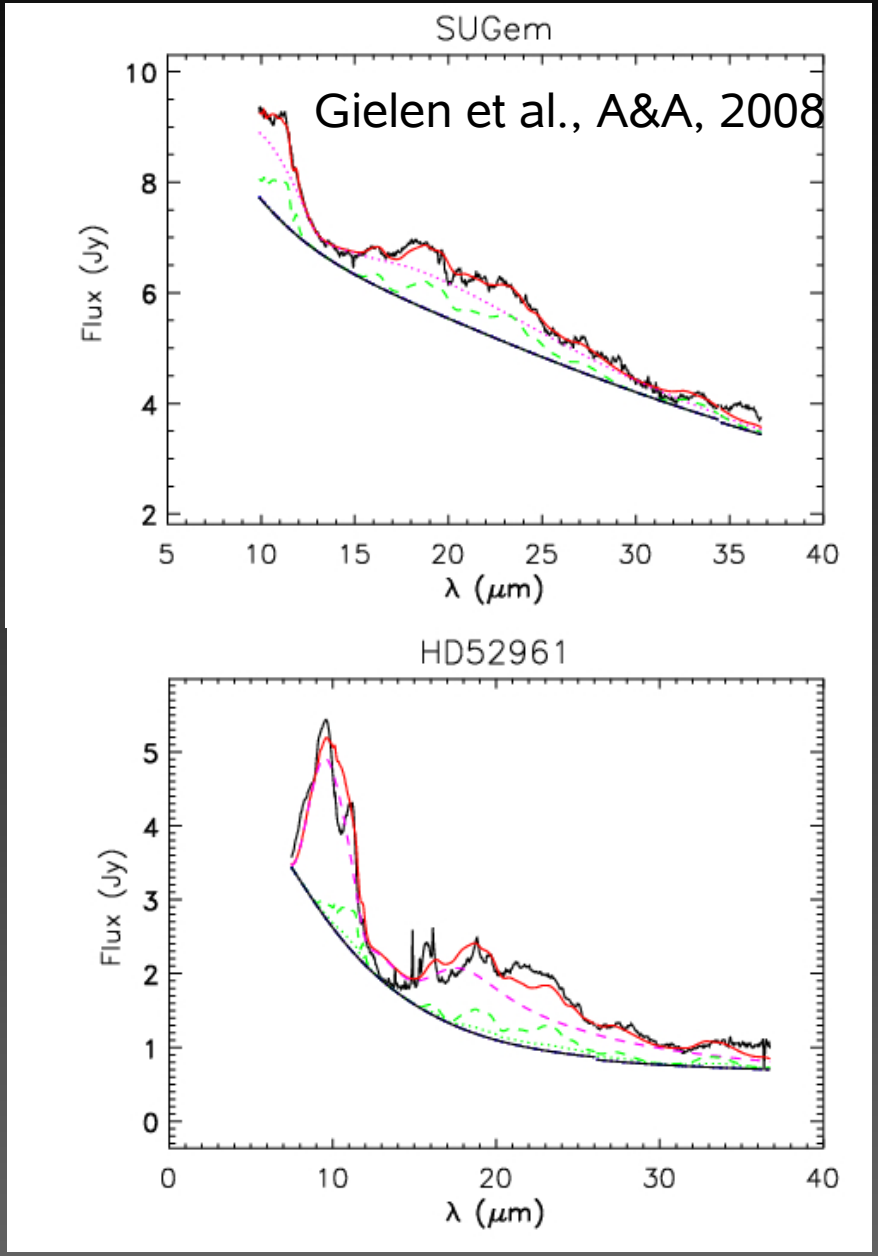




Gielen et al., A&A, 2008

Full spectral fitting





Comparison young stars

(van Boekel et al. A&A, 2005, Bouwman et al. A&A, 2001)

- **grain sizes:**
  post-AGB + Herbig: very small fraction small grains (0.1μm)

  → efficient removal smallest grains
  → large grains at disk formation?

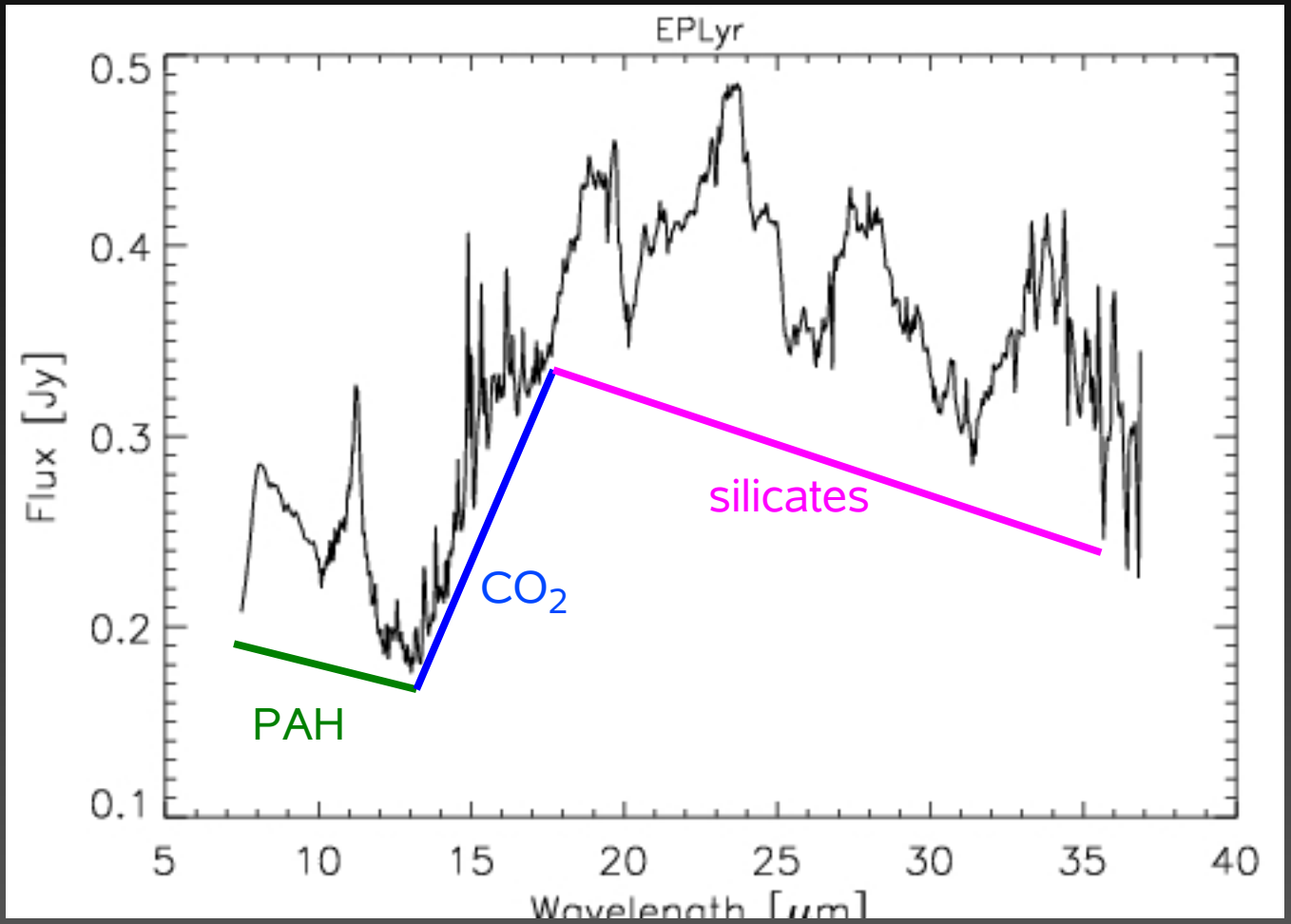
- **crystallinity:**
  post-AGB: mass frac. crystalline grains ≈ 30% (10-60%)
  Herbig: mass frac. crystalline grains < 35%

  → different crystallisation process?

- **forsterite/enstatite:**
  post-AGB: all sources forsterite dominant species (50-90%)
  Herbig: correlation crystallinity and enstatite fraction

  → difference in initial dust species?

Mixed chemistry: EP Lyr



Gielen et al. A&A, 2008b (in prep)

Mixed chemistry: EP Lyr

- **emission features at 8 and 11.3 micron**

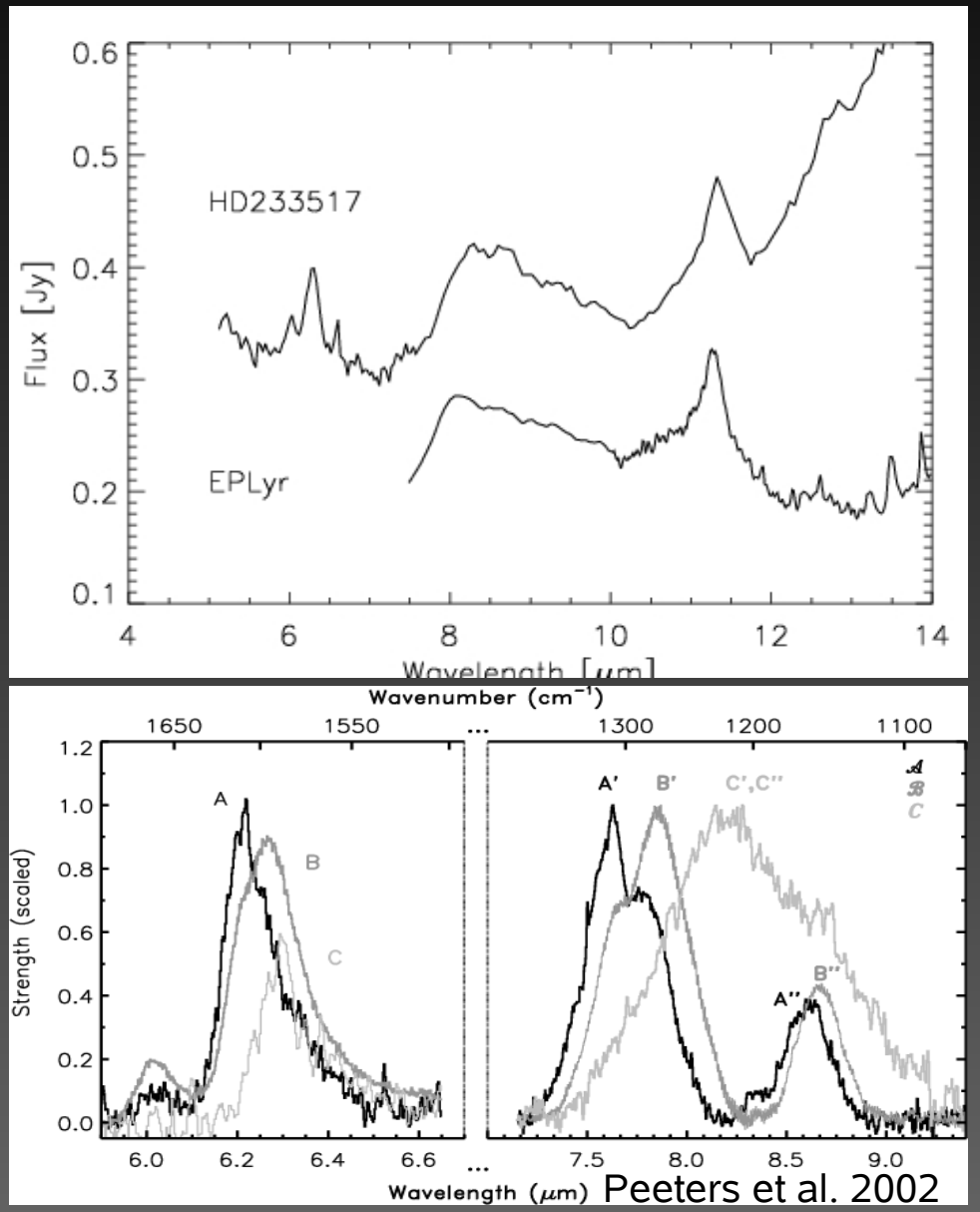
  → 'Class C' PAH features

  (Peeters et al. A&A, 2002)

- **Sloan et al. (ApJ, 2007):**

  class C PAH relatively unprocessed

- **formed in disk or outflow?**



Peeters et al. 2002

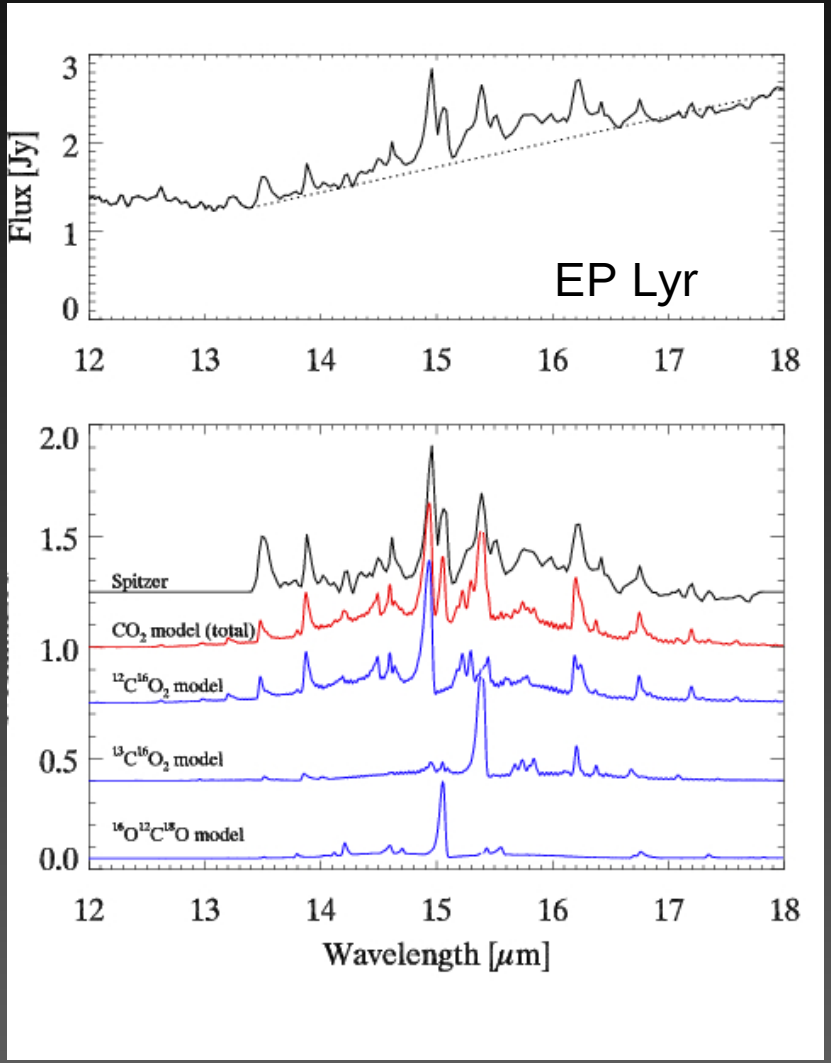
Gas diagnostics

- **CO_2 emission lines:**

  - only in HD52961 + EPLyr
  - $^{12}C/^{13}C$ good gas diagnostic

  → $^{12}C/^{13}C$ < 10: ^{12}C not enriched by 3th dredge-up during AGB evolution

  → AGB phase shortcut by binary interaction



Conclusions

- evolved stars with strong binary interaction:
  - binary orbit, highly eccentric
  - evidence for disk formation
  - unevolved companion
  - oxygen rich dust

  → formation badly understood
  AGB evolution shortcut !!
- strong grain processing in circumbinary disk
  - high degree crystallinity
  - large grains present
  - hot and cool grains
- no correlations dust characteristics and stellar parameters
- disks physiscs very similar to protoplanetary passive disks around YSO

Future Work

- interferometry to constrain disk parameters
- next modelling step: combine constraints from interferometry and mineralogy
- obtain more submillimetre data to constrain total dust mass
- explain wide variety in observed spectra
  $\rightarrow$ evolution or formation effect?
- write and defend PhD thesis