Crystalline forsterite as a signpost of planet formation in the disk of HD100546

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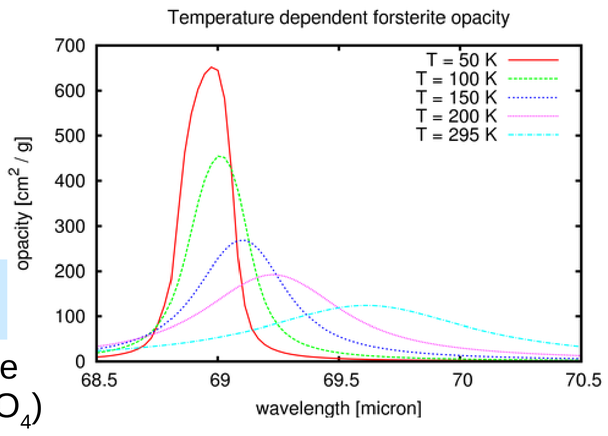
Introduction

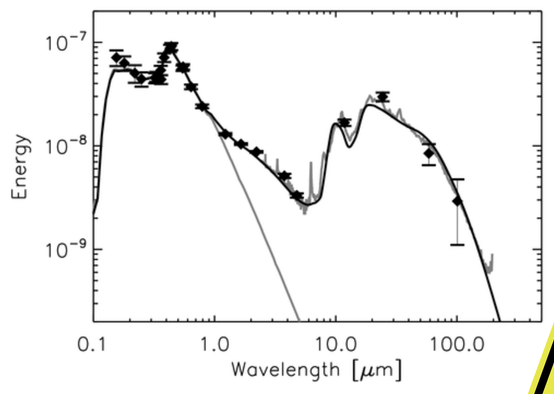
Dust crystals are commonly found in protoplanetary disks, though weak or no correlations are found between disk crystallinity and evolutionary status. We zoom in on the spatial distribution of crystalline forsterite in the disk of HD100546 using Herschel observations and 2D radiative transfer models. We find a correlation between the spatial distribution of forsterite and the disk gap that is likely caused by a proto-planet.

Forsterite



- Crystalline silicate
- Iron-poor (Mg_2SiO_4)
- Frequently found in disks and comets
- Absent in the ISM
- Spectral features over a broad wavelength range
- Shape of 69 μm feature is temperature dependent

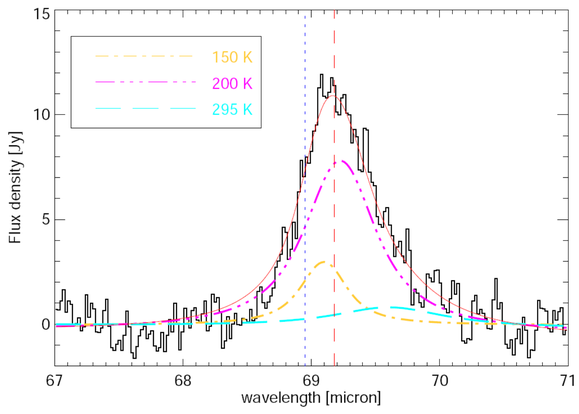
HD100546



- 2 M_{sol} Herbig star
- Prominent disk gap (~4-13 AU)
- Strong forsterite features

Herschel observations

- HD100546 observed as part of DIGIT key program
- 69 μm feature spectrally resolved
- Warm forsterite dominates feature **shape**
- But overpredicts mid infrared features in an optically thin analyis



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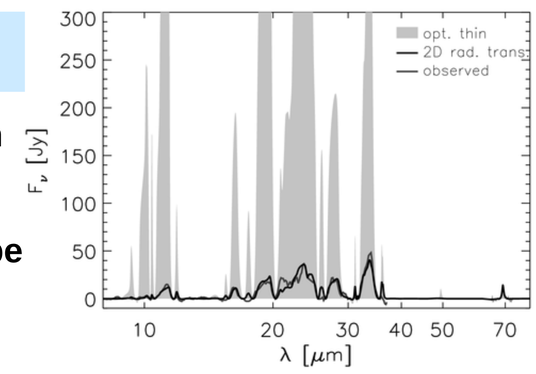
Optically thin analysis

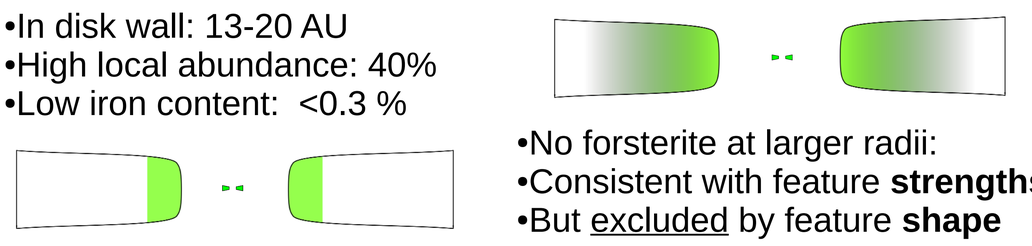
- Cold forsterite (50-70K) fits 69μm feature **strength**
- But does not fit Herschel observations

- Warm forsterite (150-200K) fits 69μm feature **shape**
- But overpredicts mid infrared features (grey area)



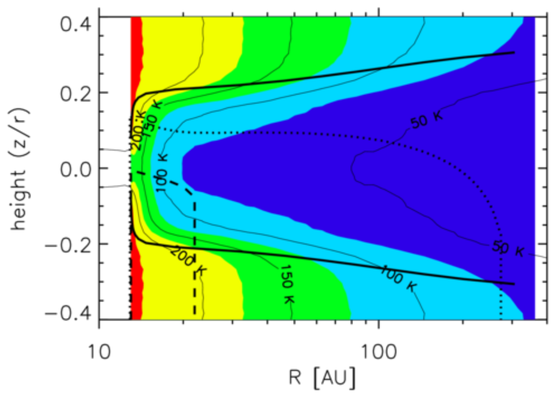
Spatial distribution of forsterite

- In disk wall: 13-20 AU
- High local abundance: 40%
- Low iron content: <0.3 %



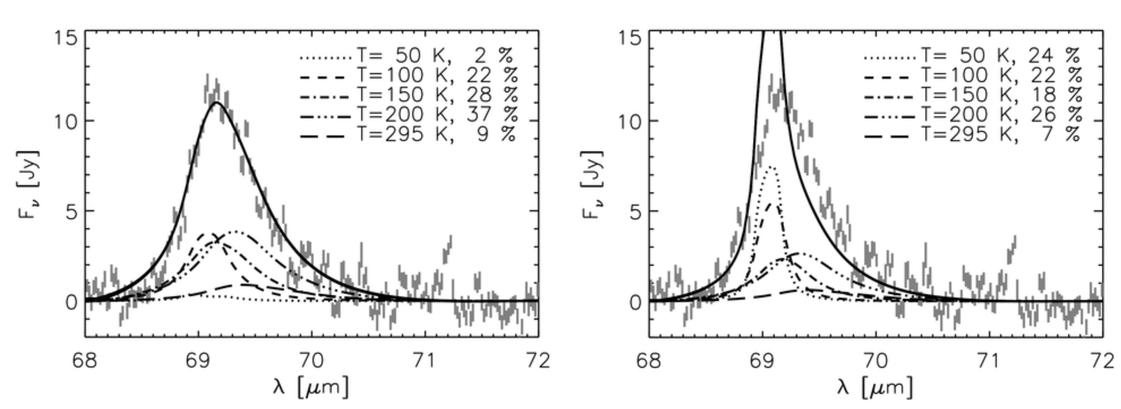
- No forsterite at larger radii:
- Consistent with feature **strengths**
- But <u>excluded</u> by feature **shape**

2D radiative transfer



- See deeper into disk at longer wavelengths (τ=1 at 11 μm (dotted) and 69 μm (dashed))
- Warm forsterite hidden from view at short wavelengths

- Both feature **strength** and **shape** explained with warm forsterite (see above and right)



Correlation between forsterite and a planet in the gap

Crystalline forsterite observed in HD100546 is spatially correlated with the disk wall at the far end of the gap. Its low iron content can be explained if it was formed in (partly) molten, differentiated planetesimals. This is supported by a lack of silica in the spectrum, which excludes most other crystallization mechanisms. We hypothesize that a forming planet in the gap could stir up these planetesimals and start a collisional cascade, releasing forsterite into the disk wall where it is observed. The wall also acts as a display case, producing strong spectral features from only a small amount of forsterite, about a tenth of an earth mass.

References:
Sturm et al. 2010
Mulders et al. (A&A submitted)

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