COMMON WARM DUST TEMPERATURES AROUND MAIN SEQUENCE STARS

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ABSTRACT

We compare the properties of warm dust emission from a sample of main-sequence A-type stars to those of dust around solar-type stars with similar Spitzer Space Telescope IRS/MIPS data and similar ages. Both samples include stars with infrared spectral energy distributions which show evidence of multiple components. Over the range of stellar types considered, we obtain nearly the same characteristic dust temperatures (~190 K & ~60 K for the inner and outer dust components respectively)—slightly above the ice evaporation temperature for the inner belts. The warm inner dust temperature is readily explained if populations of small grains are being released by sublimation of ice from icy planetesimals. Evaporation of low-eccentricity icy bodies at ~150 K can deposit particles into an inner/warm belt, where the small grains are heated to Tdust ~190 K. Alternatively, enhanced collisional processing of an asteroid belt-like system of rocky planetesimals just interior to the ice line may account for the observed uniformity in dust temperature. The similarity in temperature of the warmer dust across our B8-K0 stellar sample strongly suggests that dust producing planetesimals are not found at similar radial locations around all stars, but that dust production is favored at a characteristic temperature horizon.

MOTIVATION & BACKGROUND

- Our goal is to compare mid-IR excess characteristics in a sample of 50 A-type stars selected by 24 µm excess and followed up with IRS low-res spectroscopy (Morales et al. 2009), with a similar sample but around solar-type stars.

- We identified 19 debris disks around solar-type stars:
  - Spectral type between K0 and F5 ($M_\star$ within ~20% of $M_\odot$)
  - Excesses at MIPS 24 µm ranging between 1.1 and 4.1 × $F_\star$
  - With IRS 5-35 µm spectroscopy (low-resolution, $\lambda/\Delta\lambda \approx 100$)
  - Ages < 1 Gyr (roughly the main sequence lifetime of an A star)

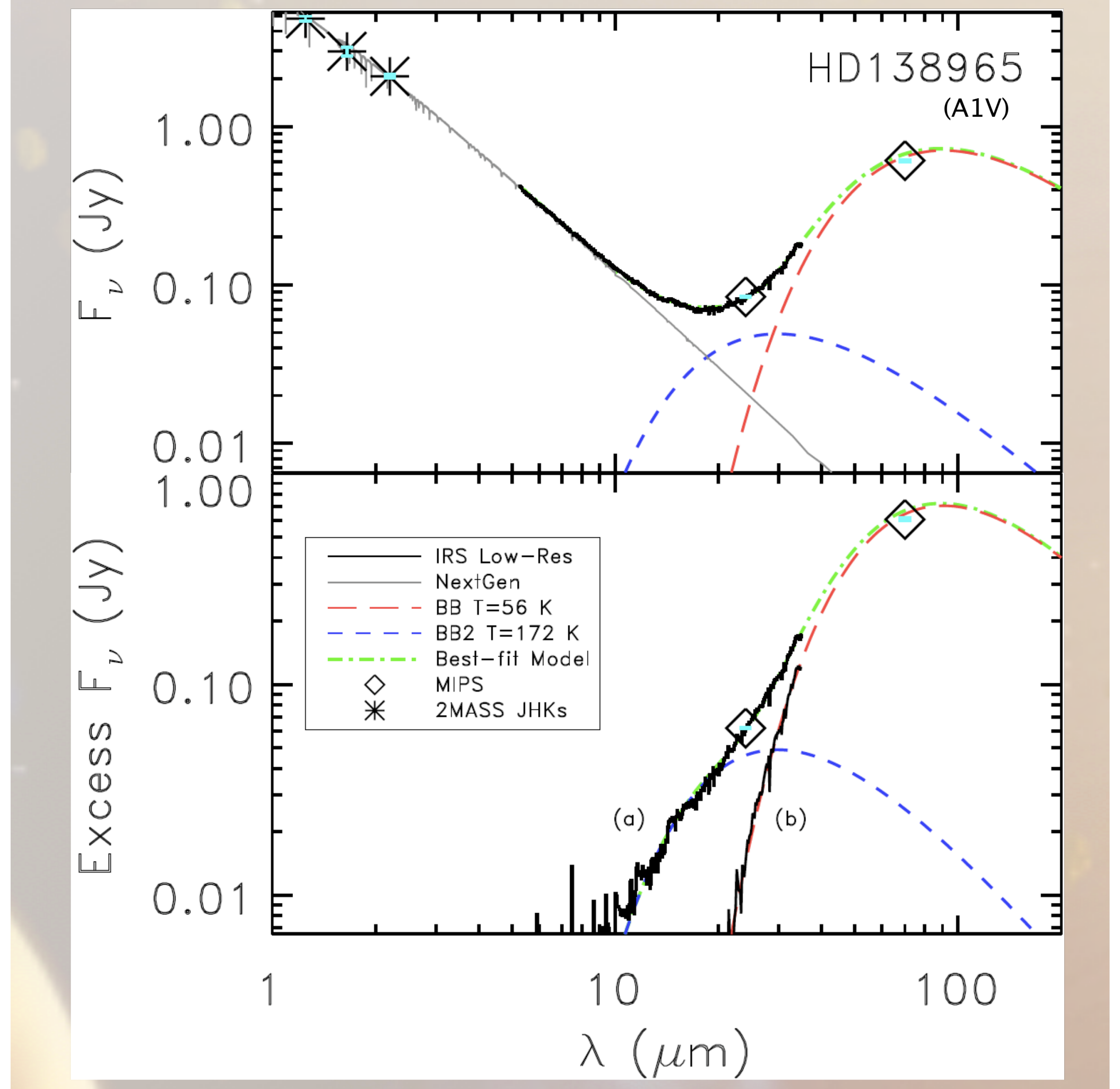
- These stars are at distances of 14 to 54 pc, range in age from 40 to 900 Myr, and 9 are also seen with MIPS at 70µm.

- We χ^2 fit the mid-IR data out to MIPS 70 µm by combining a NextGen model for the stellar photosphere and one or two blackbody components.

- This approach allows consistent comparison of the results from star to star without invoking the complexities of the disk geometry and the grain optical properties.

RESULTS

Close to half (46%) of the SEDs in our sample (24 A-type + 8 solar-type systems), which make up 86% of those seen also at MIPS 70 µm, are best described by a two-belt model, with evidence of radially separated inner and outer components.



Bottom figure. (a) photosphere-subtracted and (b) photosphere+warm component-subtracted dust emission fluxes versus wavelength.

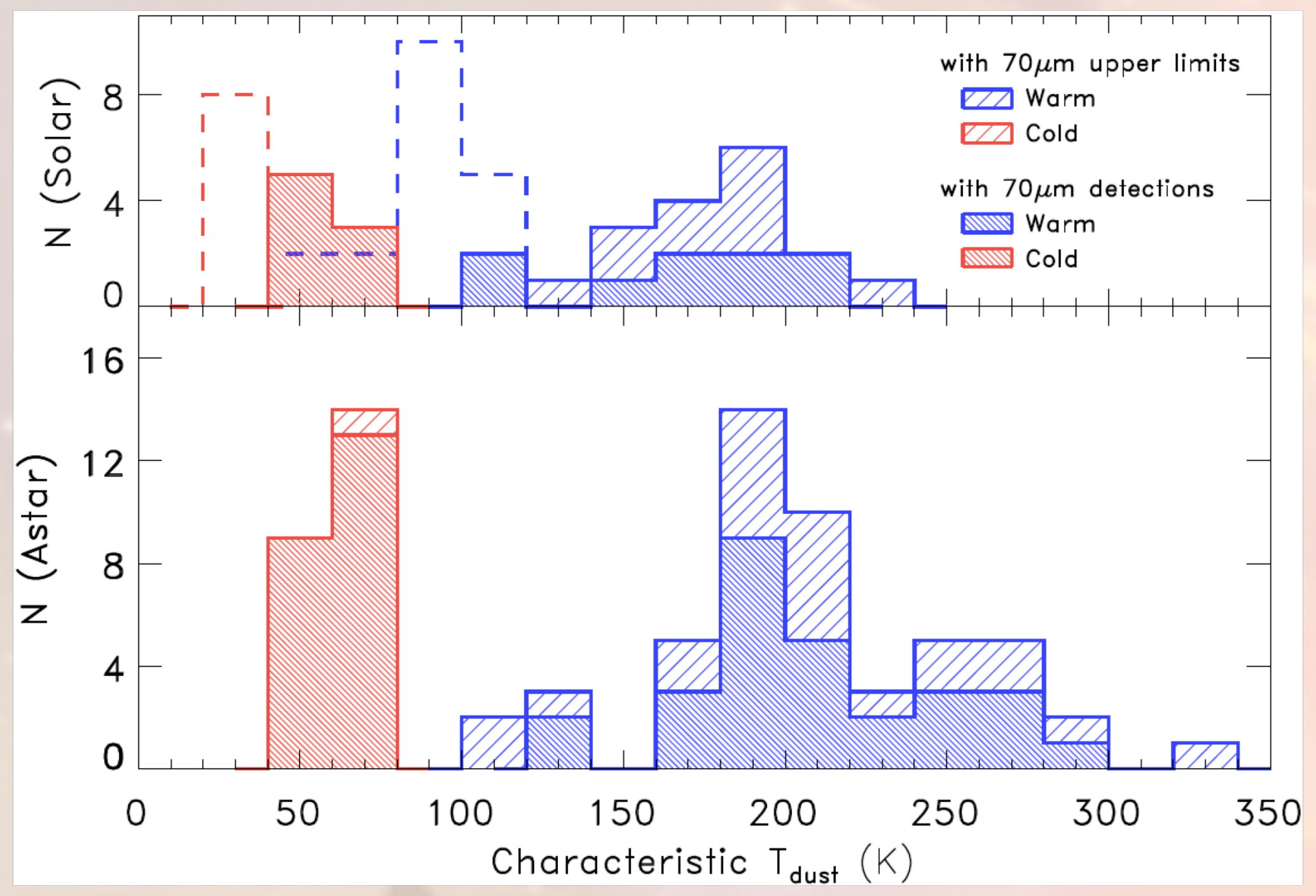


Figure. Dust characteristic temperatures for 19 solar-type (top) and 50 A-type sources (bottom) in bins of 20 K. Dashed lines are expected temperatures if the dust around the solar-type stars were at the median A-sample radial positions (~12 AU).

- Accros the B8 thru K0 spectral types considered, we find median T_{warm}~190 K and Kuiper-like components of T_{cold}~60 K.

- Warm T_{dust} distribution shows no bias toward systems without 70 µm detections.

Debris Systems		Spectral Types	Age [Myr]	$L_d/L_\star$	T_{warm} [K]	T_{cold} [K]	t_{coll} [10^3 yr]	$M_{min,in}$ [10^{-8} $M_\oplus$]
19 Solar	Range:	K0V–F5	40–900	4.2×10^{-5}–9.0×10^{-3}	99–220	47–68	0.04–3	1–2000
	Median:	G0	270	2.2×10^{-4}	177	58	0.3	9
50 A-type	Range:	B8–A7	5–1000	7.9×10^{-6}–2.0×10^{-3}	98–324	48–78	0.5–250	17–29000
	Median:	A0	100	7.2×10^{-5}	203	62	8	700

- **The uniformity in warm dust is clearly inconsistent with dust-producing planetesimal belts present at similar orbital radii across our B8-K0 stellar sample ➔ a factor of 100 in $L_\star$ would produce 3x variation in T_{warm}.**

PRELIMINARY RESULTS ON EXOPLANET SEARCH

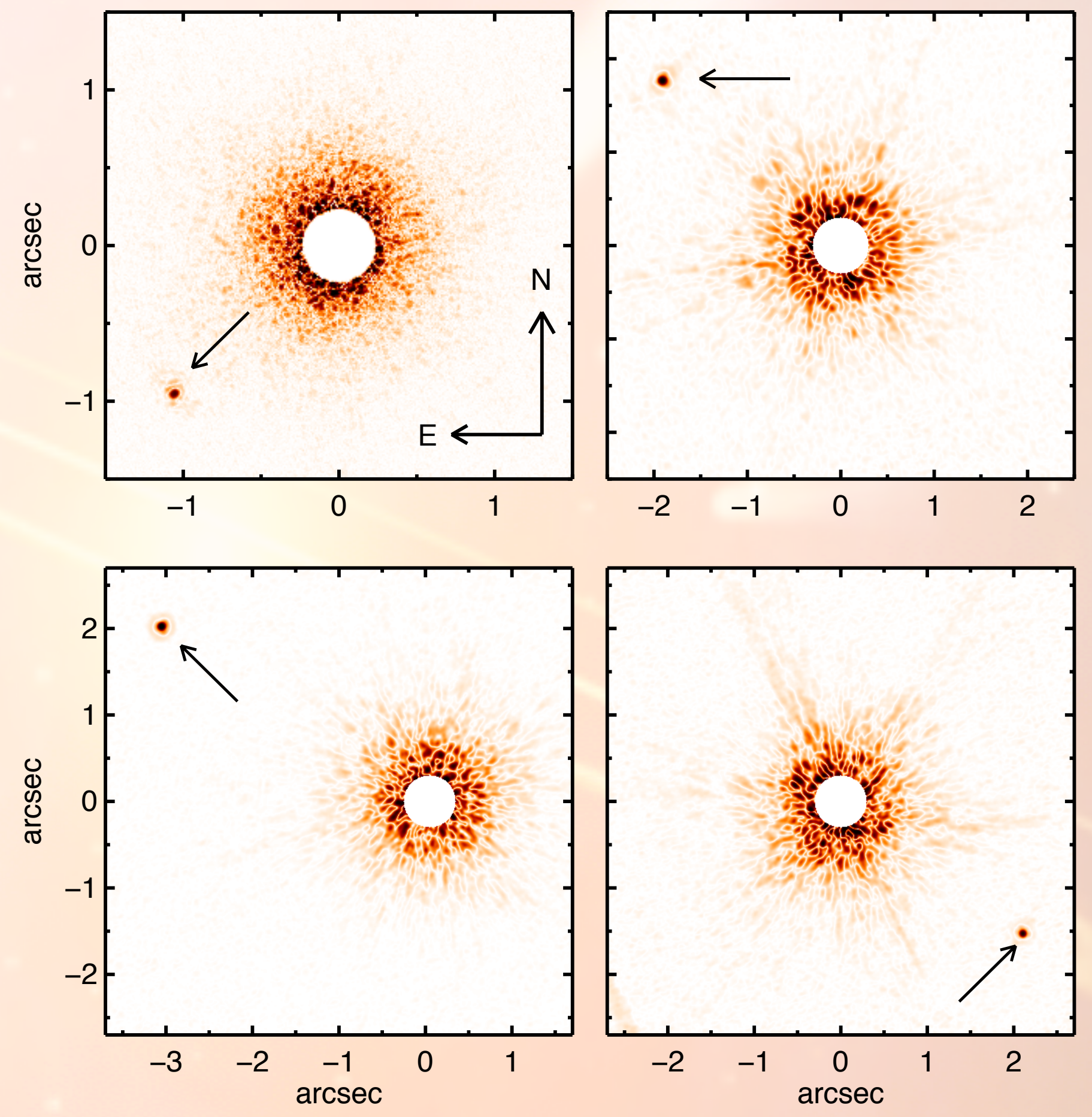


Figure. A mosaic of Keck NIRC2 Natural Guide Star AO images of four stars with debris disks as seen by *Spitzer or WISE.* Arrows indicate *candidate* planetary companions (figured prepared by Sasha Hinkley, Caltech).

- Debris disk are considered prime signposts for planetary system formation.
- Like HR 8799, β Pic, and Fomalhaut, stars known to have both debris disks and planets, we have identified six (four shown) candidate exoplanets around stars with warm dust.
- Follow-up proposed using the new P3K+ Vector Vortex Mask at Palomar's 5-m Telescope.

CONCLUSIONS

- The IR SED of 32 systems (24 A-type & 8 solar-type) is well-fit using two single-temperature blackbody curves.
- The characteristic T_{dust} (~190 K) for the inner dust component is nearly the same across the B8-K0 range of stellar spectral types.
- The range of stellar luminosities strongly suggests that the dust is not found at the same radial location around all stars, but that dust production is favored at a characteristic temperature horizon.
- We propose that, because the warm belts (91% with $T_{dust} \geq 150$ K) have a median temperature slightly warmer than that expected at the ice line, a common grain creation mechanism operates in the inner regions of the star-disk systems—possibly due to
  - **I.** Sublimation of icy planetesimals crossing the snow line (analogous to cometary disruption & outgassing of Jupiter family comets–JFCs),
  - **II. Or, (a)** collisional grinding in an asteroid belt-like system (that form at the observed temperature horizon near the ice line (Kretke & Lin, 2007)). **(b)** In addition, If giant planets preferentially form just exterior to the ice line (Pollack et al. 1996), they may then stir up the remaining reservoir of material just interior (e.g. Raymond et al. 2005, 2009).

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