# MID-IR SPECTRA OF DUST DEBRIS AROUND A & LATE B TYPE STARS: ASTEROID BELT ANALOGS & POWER-LAW DUST DISTRIBUTIONS

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## 1. ABSTRACT

Using the Spitzer/IRS Low-Res modules covering 5 to 35 µm, we observed 52 main-sequence A and late B type stars previously seen from Spitzer/MIPS photometry to have excess emission at 24 µm. While prominent spectral features are not evident, we observed a striking diversity in the overall shape of the spectral energy distributions (SED). Most IRS excess spectra are consistent with blackbody emission, suggestive of dust located at a single orbital radius. The typical $T_{dust}$ of ~200 K corresponds to an orbital radius of ~10 AU. Thirteen stars however, have dust emission that follows a power-law flux distribution, $F_\nu = F_0\,\lambda^\alpha$, with $1.0 \le \alpha \le 2.9$. The warm dust in these systems must span over a greater range of orbital locations. The large number of warm systems tells us that there is still activity in the terrestrial planet zones of both types. All of the stars have also been observed with Spitzer/MIPS at 70 µm, with 27 of the 50 sources detected (S/N > 3). Most 70 µm fluxes are suggestive of a cooler, Kuiper belt-like component that may be independent of the asteroid belt-like warm emission detected at the IRS wavelengths. 14 of 37 sources with blackbody-like fits at IRS wavelengths are detected at 70 µm. The 13 objects with IRS excess emission fit by a power-law model, however, are all detected at 70 µm.

## 2. MOTIVATION / BACKGROUND

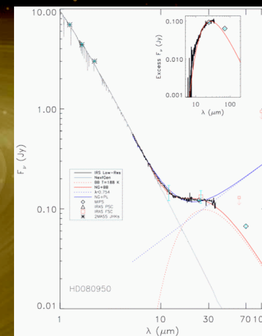
•By studying the SED profiles of debris disks it is possible to probe the underlying planetary systems. We can learn about their structure, composition, dust distribution, and evidence of associated planets.

• Stars were selected for spectroscopic follow-up based on their 24 µm fluxes ranging from 1.2 to ≥4x the photosphere.

• We considered stars with MIPS 70 µm detections or upper limits.

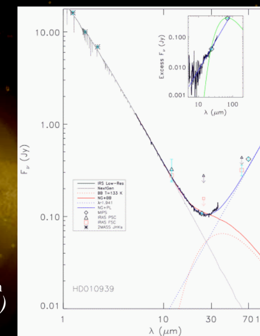
• We $\chi^2$ fitted a NextGen stellar photospheric model plus, either a single temperature blackbody or a power-law, to the IRS data.

## 3. RESULTS



**I. Example of IRS excess well fit by a blackbody:**

- HD 80950 (A0V), V = 5.9 mag
- Distance: 80.8 pc, Age: 80 Myrs
- $F_{24} / F_{*,24} = 4.26$
- $T_{dust} \approx 190$ K → $D_{dust} \approx 15$ AU
- $L_{IR}/L_* \approx 1.2\text{e-}04$
- $M_{dust} \ge 2.5\text{e-}03\,M_{Moon}$
  - *($a_{blow\text{-}out} \approx 6.2\,\mu m$)*
- $T_{PR} / T_{COLL} = 58.5$



**II. Example of IRS excess well fit by a power-law:**

- HD 10939 (A1V), V = 5.03 mag
- Distance: 57.0 pc Age: 320 Myrs
- $F_{24} / F_{*,24} = 1.6$
- Power Law, λ^1.9
- $L_{IR}/L_* \approx 9.1\text{e-}05$
- $M_{dust} \ge 0.2\,M_{Moon}$
- $(T_{PR} / T_{COLL})_{15\mu m} = 0.6$
- $(T_{PR} / T_{COLL})_{35\mu m} = 3.3$

### Dust Luminosity Ratios

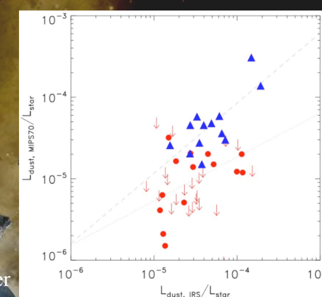
• $L_{dust}/L_*$ are extrapolated out to 55 µm for the warm components, and longward of 55 µm for the 70 µm contribution.

• Red circles are systems well modeled by a single-temperature blackbody at IRS wavelengths, that are also detected at 70 µm.

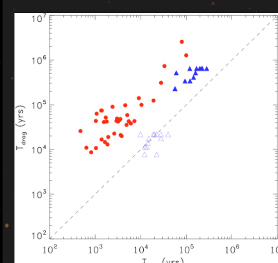
• Blue triangles are debris exhibiting power-law excess flux distributions at IRS wavelengths (all seen at 70 µm).

• Down arrows are blackbody at IRS with upper limits at 70 µm.

• A 2-d KS statistical test makes clear power-law debris disks differ significantly (>98 %) from the blackbody population.



### Timescales



• Solid red circles represent collisionally dominated rings (these sources are best fit by a single-temperature blackbody at the IRS wavelengths).

• Blue triangles are systems with power-law excess SEDs; (solid & open for distances corresponding to 35 & 15 µm emission respectively).

• Below the diagonal, P-R drag removes dust more rapidly than collisions ($T_{PR} < T_{COLL}$).

• Transition to a tenuous region where P-R becomes increasingly important appears to be close to or straddled by the IRS observations for sources best fit by a power-law.

## 4. CONCLUSIONS

• The 5-to-35 µm IRS spectra fall into two distinct groups: blackbody-like spectra and power-law spectra.

• Disks dominated by warm material are not rare as previously thought (e.g. Smith et al. 2008; Rhee et al. 2008); Of the 37 systems we find are best fit with blackbodies, 32 (86%) have $T_{dust} \ge 150$ K.

• Large (≥10 µm) rocky not icy ($T_{dust} > T_{Ice\ Sublimation}$) grains inferred due to lack of spectral features.

• Overall, the observed blackbody (I) and power-law (II) thermal profiles reveal debris distributed in a variety of radial structures that do not appear to be correlated with spectral type nor stellar age.

• By analogy with our solar system, IRS may be sampling material in an asteroidal zone while MIPS 70 µm radiation is due to an outer region similar to the Kuiper belt.

• Detailed modeling will be the next step to investigate if power-law spectra may be planet-poor systems where material is free to migrate radially.

**AKNOWLEDGMENTS**

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Background Image by NASA/JPL-Caltech