National Aeronautics and Space Administration

The Uber Catalogue of Debris Disk Architectures—from Debris Disks to Exoplanetary Systems

P.I.: Farisa Y. Morales ([1]Jet Propulsion Laboratory, California Institute of Technology; 3262)

Co-Is: Geoffrey Bryden[1] (3262)**, Bryana Henderson**[1] (3227)

Program: Spontaneous Concept Program

Project Objective:

Our objective was to carry out a rigorous exploratory exercise to extract spectral feature information from the existing *Spitzer*/IRS 5-35 *μm* spectroscopic data from 49 two-belt planetary debris disks (Fig. 1), using a stacking technique, in order to explore the relationship between the inner-warm asteroidal dust and the outer-cold Kuiper-like material detected and spatially resolved by Herschel/PACS.

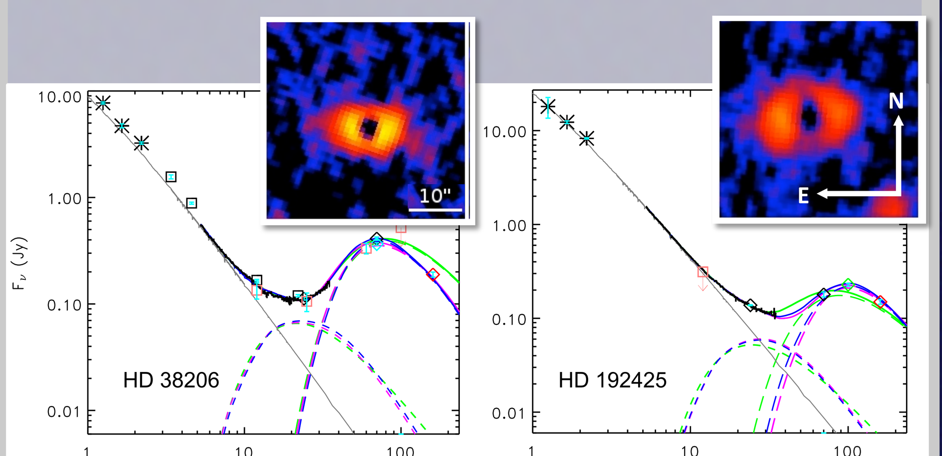

Figure 1. Sample SEDs for 2 two-belt debris system in our sample—HD 38206 (A0V) and HD 192425 (A2V). Both have SED best modeled with two thermal components, and both have outer cold belts spatially resolved by Herschel. Blue, magenta and green profiles correspond to icy, rocky and blackbody grains respectively, as modeled by Morales et al. (2016). Both debris systems are best fit with inner-rocky-grains and outer-icy-particles.

FY19 Results:

We χ^2 fit the spectral energy distributions (SEDs) of the 49 two-belt debris disk systems, using realistic grain properties, and disaggregated the flux emission from the stellar photosphere and the contribution of each population of realistic grains (i.e., cold icy dust, small warm rocky grains, and the large warm rocky grains).

We then added all 49 spectra (figure 2), using a weighting technique, while subtracting the different contributions; i.e., first from the star, then from each of the different grain populations, and ultimately leaving the flux contribution of the small ($a < a_{\mathrm{BOS}}$) populations of grains only—smaller than those ejected our of the system by radiative blow-out.

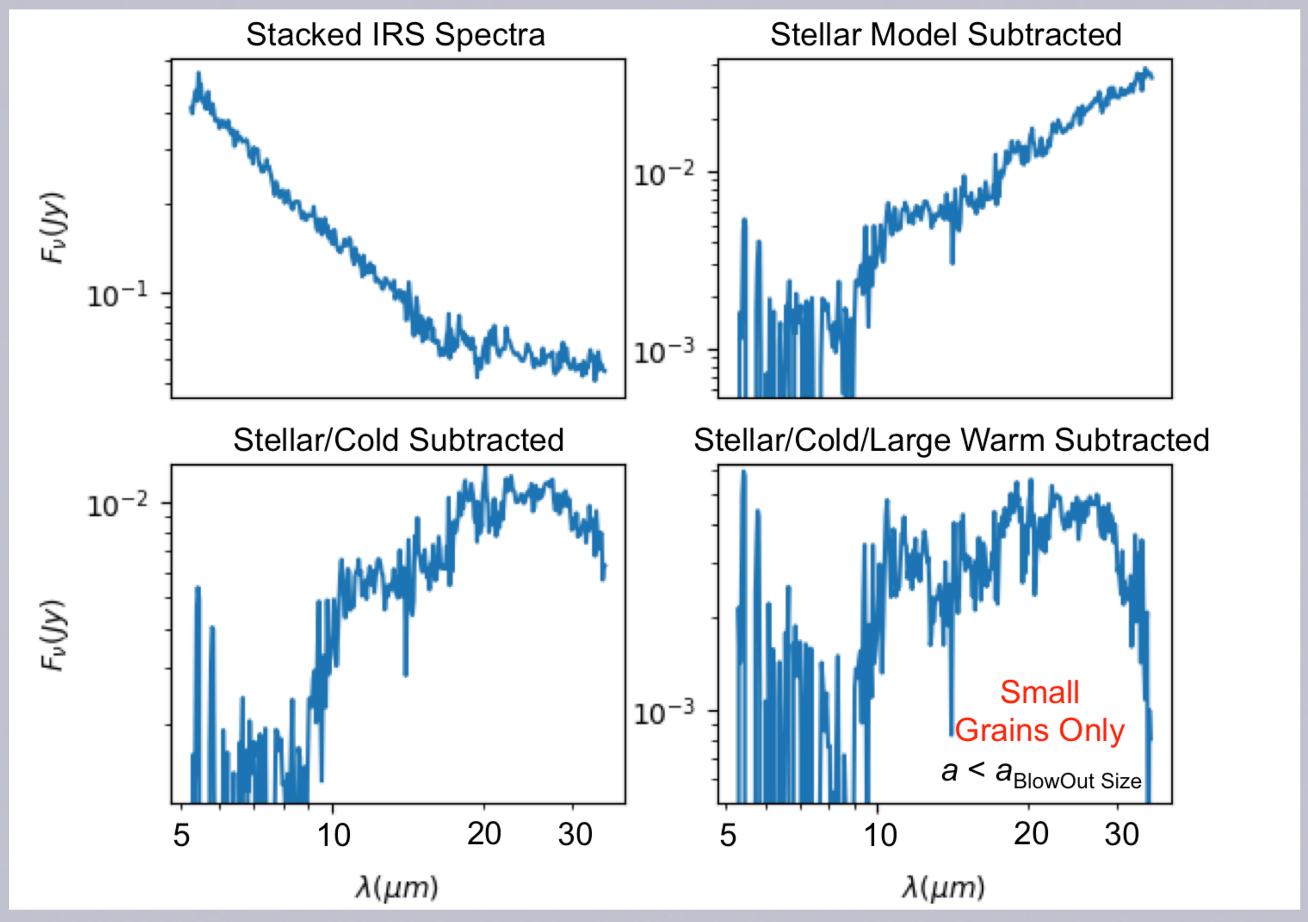

Figure 2, The figures show the stacked *Spitzer*/IRS 5-35 *μm* spectra of 49 double-belt debris disk systems. The upper-left insert shows the weighted IRS spectra. The upper-right is the star-subtracted weighted IRS spectra. The lower-left insert is the star- and cold-dust-subtracted spectra, thus showing the warm-dust only. The lower-right insert is star-, cold- and large warm grains-subtracted stacked spectra, showing the emission of the small (lower than the blowout size) population of grains, with the identifiable ~10 and ~20 *μm* Astronomical Silicate features.

Significance of Results

Our stacking analysis shows that the otherwise plain continuum spectra when analyzed individually, indeed shows clear evidence of a population of small Astronomical Silicate grains present in the terrestrial planet zones of the two-belt debris disk systems analyzed. The remaining challenge is to relate the properties of the spatially-resolved outer cold dust belts to the properties of the inner warm AstroSil population of small grains in the terrestrial planet zones.

Benefits to NASA and JPL (or significance of results) :

- The ~50 well-characterized spatially-resolved debris disk systems studied under this R&TD effort enabled us to:
  1) identify the ~10 & ~20 micron features of Astronomical Silicates revealing the presence of rocky material in their terrestrial planet zones,
  2) advance our understanding of the architecture and evolution of debris system—environments where planets are interacting and forming, and
  3) serve as follow-up targets for *JWST* and *WFIRST*, as we begin to explore the terrestrial-planet zones and the planets that may be carving gaps between dust belts around mature stars.
- The tools developed under this effort, expand JPL capabilities, as it could be readily modified and applied to other systems with *Spitzer*/IRS data for which a large set exists (~600 debris disks). Conceivably, the stacking approach can then be expanded to apply to any type of spectroscopic data and not limited to *Spitzer* spectra only.
- Furthermore, assessing the distribution and impact of exozodiacal dust in the context of exoplanets is an essential element in planning any future exoplanet mission, in particular one that will aim at habitable planets and finding evidence of life.

Acknowledgements:

We thank undergraduate research intern Mr. Justin Beaurone (student at Moorpark College transferring to UCLA) for his helpful python coding contributions.

P.I. Contact Information:

Phone: (818) 354-1940

E-mail: farisa.y.morales@jpl.nasa.gov

National Aeronautics and Space Administration

Jet Propulsion Laboratory

California Institute of Technology

Pasadena, California

www.nasa.gov

Poster No. RPC022