Holey debris disks, Batman! Where are the planets?

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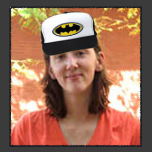


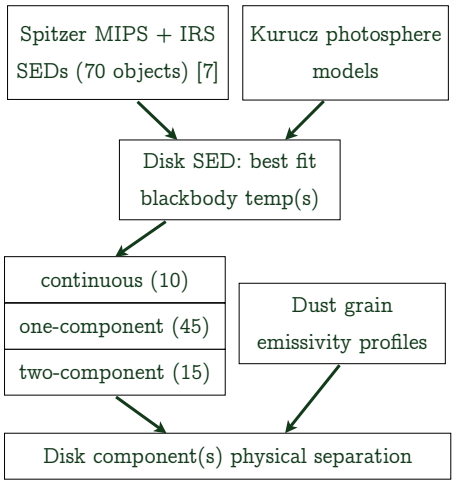
Background

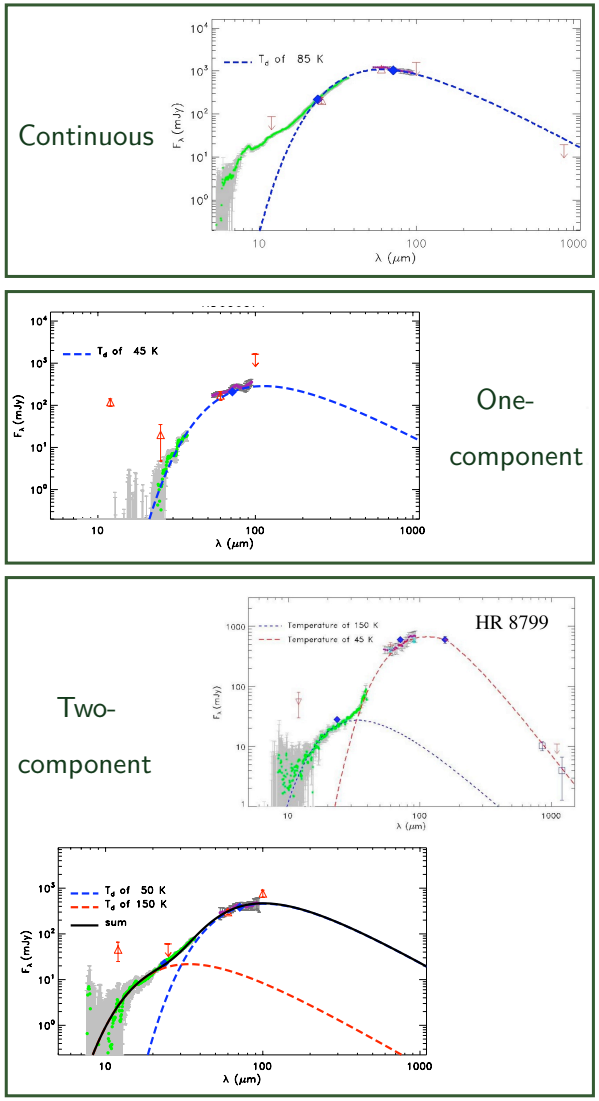
The location of the gas giants at large radii is a key feature of our Solar System, in contrast to the many other discovered systems where giant planets have migrated into tight orbits [1]. Previous surveys have shown that gas giants in wide configurations are rare [2,3,4]. The targets in these surveys were selected by age, proximity or broadband color-indicated disks.

Interestingly HR8799, Fomalhaut, and other directly imaged systems have disks with gaps, based on spectral energy distributions (SEDs) and direct imaging [5,6]. The crucial piece of evidence in support of sculpting by planets is that the disk components have sharply defined edges.

We propose to test to what extent detailed disk morphology based on SEDs may inform future direct imaging target selection.

Disk SED modeling





Example SEDs (after stellar photospheric subtraction) for continuous, one- and two-component disks. Dashed lines show the best fit blackbody component(s). Two-component disk systems, like HR8799, are marked by a sharp rise between 10-35μm and 55-95μm, suggesting an absence of material between two belts. Planets have been found in this gap in HR8799, Fomalhaut, and other systems. Blue diamonds: MIPS 24μm & 70μm photometry; green dots: IRS spectra; purple dots: MIPS-SED data; red triangles: IRAS photometry (less accurate due to larger beam size).

MMT/Clio + Gemini/NICI (Proposed) Sample

- Clio imager at L' with optional phase plate
- NICI imager at H with coronagraphic mask
- Target selection:
  - D < 100pc & age < 1Gyr
  - All observable two-component systems
  - One-component with interesting truncation
    - Cold component only (> few 10s AU)
    - Warm component only (<10AU) = outer truncation
- NICI: 5 are proposed
- Clio: 8 are proposed or have archival data
  - 3 systems just observed are undergoing analysis

Future Work

- Combine with archival NICMOS & NICI protected data
  - >25 one-component & >12 two-component disks
  - Null detection on the full sample will place an upper bound of <10% on the fraction of sculpted debris disks with planets of mass greater than 5-10MJ.
- Reverse search
  - Analyze disk morphology of systems with directly imaged planets using existing spectra and photometry
- Model disk/planet interactions
  - Constrain the minimum mass necessary to cause the observed clearing.
  - Provide an estimate of the likelihood that a planet, rather than some other mechanism such as sublimation, is responsible for observed clearing.

References
[1] Udry & Santos 2007 AARA 45, 397
[2] Nielsen and Close 2010 ApJ 717, 878
[3] Kasper et al. 2007 A&A 472, 321
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[5] Quillen 2006 MNRAS 372, L14
[6] Su et al. 2009 ApJ 705, 314
[7] Su et al. 2010 BAAS 42, 348

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