The JWST Debris Disk Spatially Resolved Imaging
GTO Programs

András Gáspár, M. Rieke, G. Rieke, J. Leisenring, M. Ygouf, C. Beichman +
the JWST MIRI and NIRCam GTO teams

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Debris Disk architecture

- Terrestrial planets
- Asteroid-belt analogs
- Gas giants
- Ice giants
- Scattered - NIRCam
- Hot dust
- Sublimation point
- H$_2$O iceline
- CH$_4$ iceline
- Thermal - MIRI
- Kuiper-belt analogs
The JWST GTO Debris Disk Programs

Five Debris Disk Coronagraphic Imaging GTO programs will be executed in Cycle 1:

- The MIRI Archetypical Debris Disks program (three sources)
- The NIRCam Scattered Light Disks program (five sources)
- The Space Telescope Team In-Depth program on Beta Pictoris
- MIRI EC imaging of TW Hya and HD135344B (transitional disks)
- NIRCam M-stars program: Fomalhaut C and AU Mic

There will also be Debris Disks spectral IFU imaging GTO programs executed in Cycle 1:

- MIRI MRS program (PI: Kate Su) will observe five extreme variable debris disks in Cycle 1
- A NIRSpec/MIRI program (PI: Christine Chen) will observe HD32297 and Beta Pic
- MIRI EC MRS imaging of TW Hya, AU Mic, HD 181327

Plus, additional programs to image the HR8799 system, which also has a disk!
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Goal: Spatially resolve one of the brightest debris disks from 1.8 – 23 um

• Span the transition from scattered light to thermal emission to inform dust size-distribution and composition
• Search for spatial variations
• Search for wide-separation planets (Beta Pic b not expected to be observed)

Adapted from Ballering et al. (2016)
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The MIRI GTO Archetypical Disks Program

Program Goals

Goals of the program are to (1) resolve the asteroid belts of the nearest systems and (2) understand the physical processes that form the structures and their evolution history.

These include:
- Are there shepherding planets?
- Particle size constraints
- Particle spatial locations

The strength of the effects vary by radial distance:
- Collisions are more destructive closer to the star
- Radiative effects are stronger closer in (PR-drag is $\propto r^2$)

Therefore: high spatial-resolution panchromatic imaging of disks from the iceline to their halos is necessary.
The MIRI GTO Archetypical Disks Program
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The MIRI GTO Archetypical Disks Program

Notable mentions:
- γ Dor
- ζ Eri
- η Crv
- 61 Vir
- HD139664
- ρ Vir
- HD 195627
- HD 172555
Coronagraphic:
@ 15.5 μm (4QPM) and 23 μm (Lyot), using alternating T.A. quadrants. PSFs are dithered (9 point)

non-Coronagraphic Imaging:
@ 25.5 μm using the BRIGHTSKY subarray and 4-point set dithering.)
The MIRI GTO Archetypical Disks Program

Vega

- A0V
- ~ 400 Myr
- 7.7 pc
- Extensive multi-wavelength dataset
- Spatially resolved with Spitzer
- Large solar system analog belts
- No resolved scattered light data
The MIRI GTO Archetypical Disks Program

15.5 μm

23.0 μm

25.5 μm
Fomalhaut

- A3V
- ~ 440 Myr
- 7.7 pc
- Outer Kuiper belt resolved at multiple wavelengths
- Inner asteroid belt inferred from thermal flux
- Recently approved HST program to spatially resolve its Asteroid belt analog (PI Gáspár)
- Possible planet detection (Kalas 2008)
The MIRI GTO Archetypical Disks Program

15.5 µm

23.0 µm

25.5 µm

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epsilon Eridani

- K2V
- 400-800 Myr
- 3.2 pc
- True solar system analog with likely three belts
- Recently resolved with SOPHIA
- We have a recently approved HST program to resolve its belts in scattered light (PI Gáspár)
The MIRI GTO Archetypical Disks Program

15.5 μm  

23.0 μm  

25.5 μm
Program Goals

Goals of the program are to resolve the full belt systems of the brightest scattered light disks in the IR and answer questions:

- Disk compositions represent those of parent planetesimals - are they universal? what are they? do they resemble KBOs?

- Grain sizes reveal intensity of collisional activity, locations probe non-gravitational forces. How do they relate to stellar type and other disk characteristics?

- What are the scattering phase functions (SPF) of the grains in the systems?

- Are there indications of planetary interactions with the disks in these systems?

- Can we possibly image any planets in these systems?
- We expect to recover the composition in our target systems using the following filters: F182M, F210M, F250M, F300M, F360M, and F444W.
The NIRCam GTO Scattered Light Disks Program
HD 181327

- Disk is nearly face-on, allowing dynamics to be studied.
- Well resolved with HST/STIS
- Stark et al. (2014) studied the SPF in the system. Highly forward scattering!
- Dust-size segregation studies
- Ideal system for composition studies.

Schneider et al. (2014)
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The NIRCam GTO Scattered Light Disks Program

HD 181327

2.10 μm  3.00 μm  3.35 μm  4.44 μm

(assuming an astronomical silicate mixture)
- There are a number of Cycle GTO programs for JWST that will observe a large number of debris disks!
  - NIRCam: 8 disks imaged across all programs; 5 within ours.
  - MIRI: 6 disks imaged across all programs; 3 within ours.
  - MIRI/NIRSpec: 10 systems studied spectroscopically.

- MIRI will enable us to study the asteroid belts of the nearest systems! The data provided by MIRI will not be superseded by any observations in the foreseeable few decades! Our 25 h program will observe Fomalhaut, Vega, and eps Eri.

- NIRCam’s sensitivity and stability will enable the study of dust composition and the locations of volatiles in the systems. Our 50 h program will observe HD 61005, HD 107146, HD 32297, HD 181327, and HD 10647.