Ground-based imaging of thermal dust emission as a probe of debris disk structure

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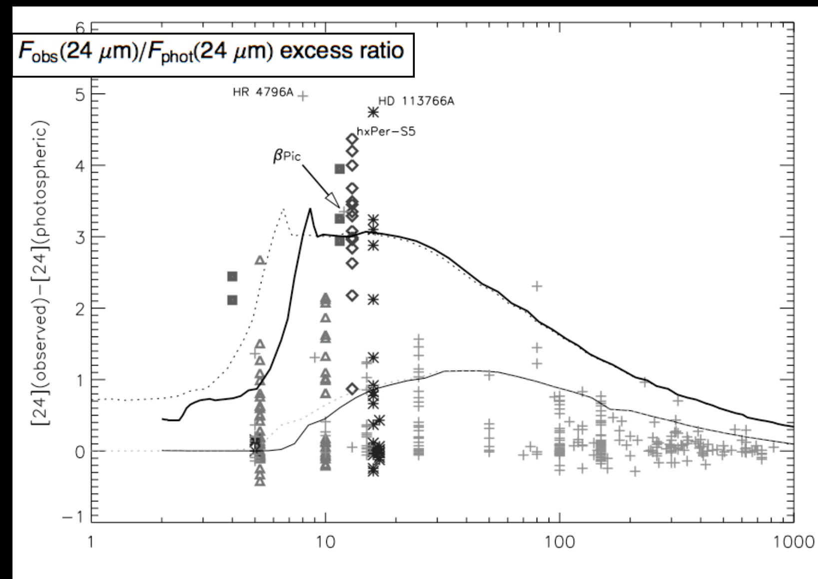
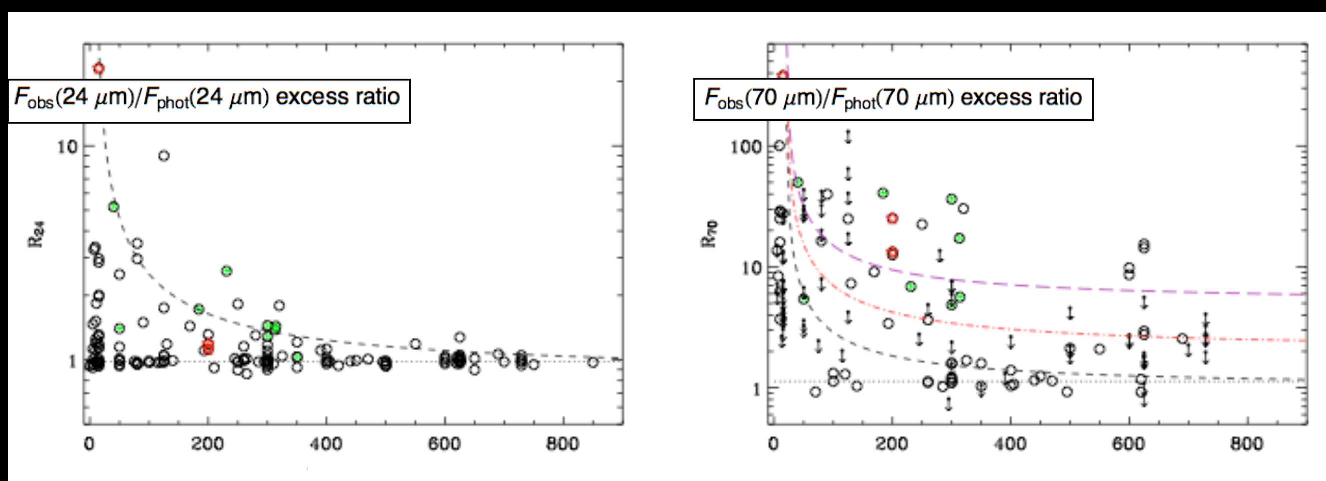
Predictions and observations of disk evolution



Currie et al. 2008
(with models from Kenyon & Bromley 2004)



Su et al. 2006

Debris disks: snapshots of evolution

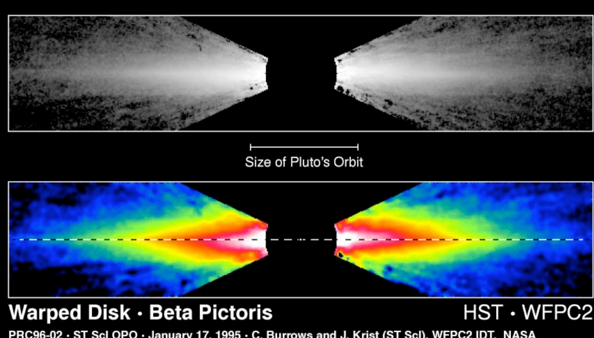
Dust loss timescales << stellar age

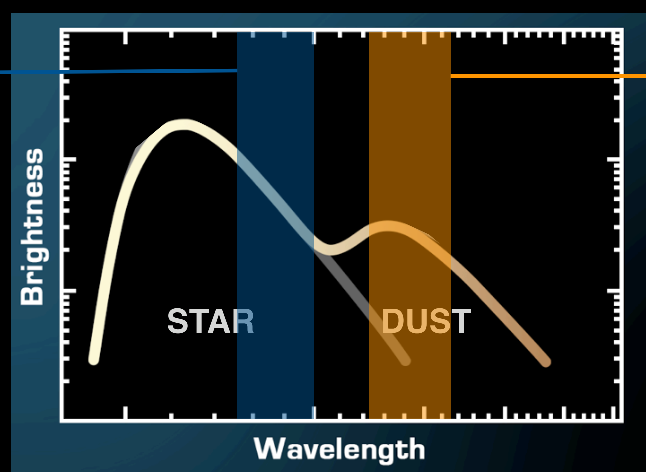
Observed dust must be replenished

Continuous progression from primordial disk

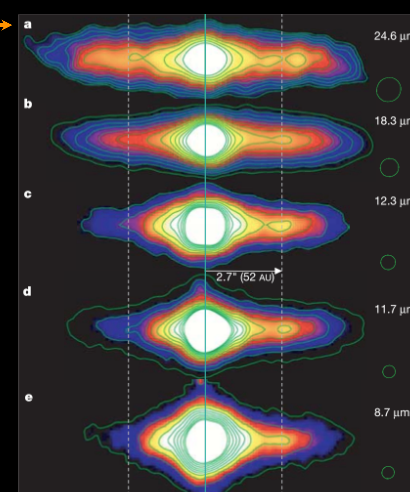
Our debris disk =
zodiacal dust from asteroidal collisions;
dust from cometary ejecta; dust from KBO collisions

scattered light imaging





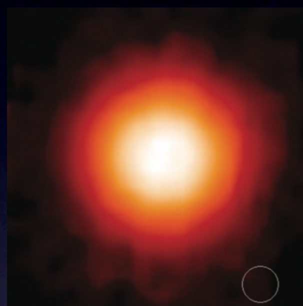
thermal emission imaging



Telesco et al. 2005

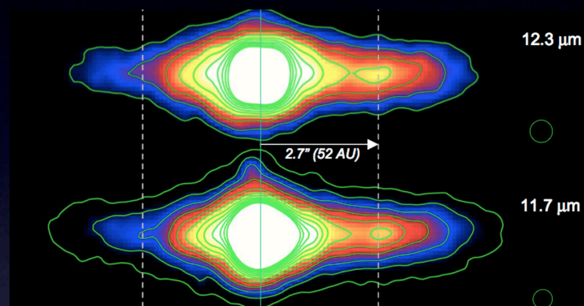
Goals

- **> 100s** of debris disks have been identified with photometric measurements, but **< 20** have been spatially resolved



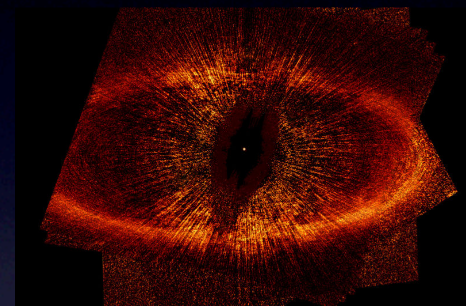
~14" resolution

Vega; Su et al. 2005
MIPS/Spitzer



~0.3" resolution

Beta Pic; Telesco et al. 2005
T-ReCS/Gemini



~0.05" resolution

Fomalhaut; Kalas et al. 2005
ACS/HST

disk truncation by a companion or planet
disk warping by a companion or planet
} particle size & wavelength independent

bright clumps at sites of recent collisions
bright clumps at sites of resonant trapping
} particle size & wavelength dependent

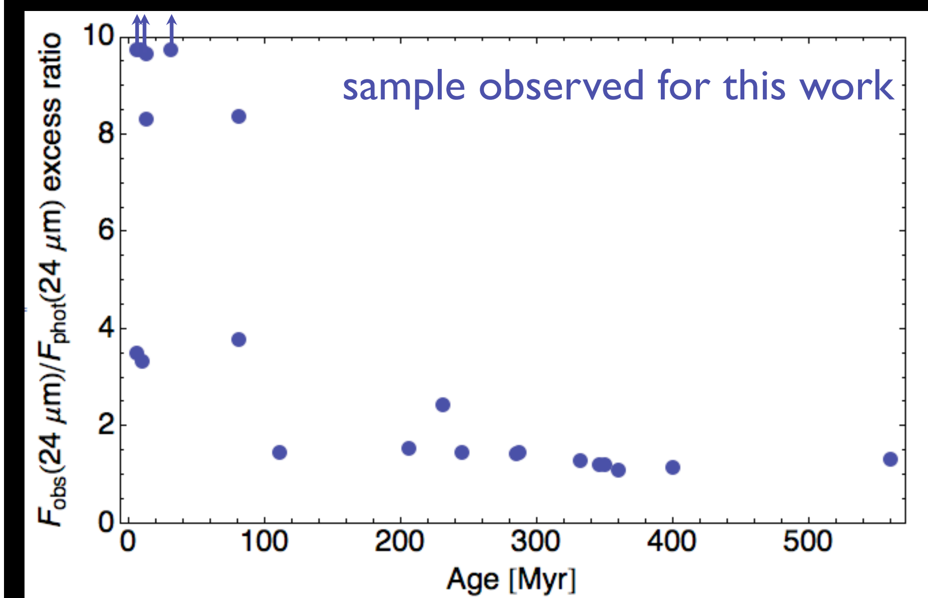
Observational goals:
Investigate physical processes in debris disks by characterizing their structures (whether asymmetric or not)

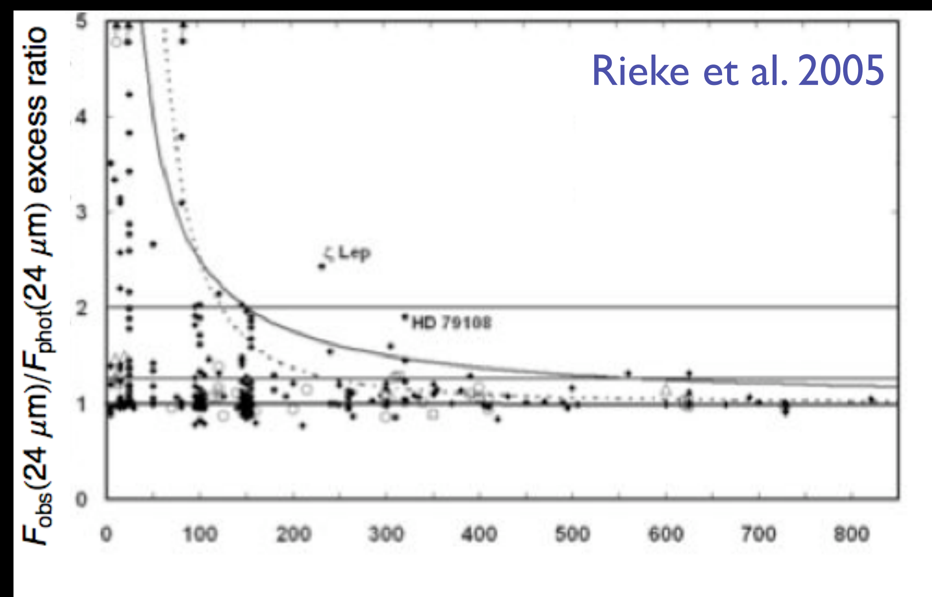
Disk "mini-survey" source selection

The sample: 18 disk candidates,
primarily from a *Spitzer* survey of 266 A stars at 24 microns

Selection criteria: *proximity*

high estimated flux density of excess at 10 & 18 microns



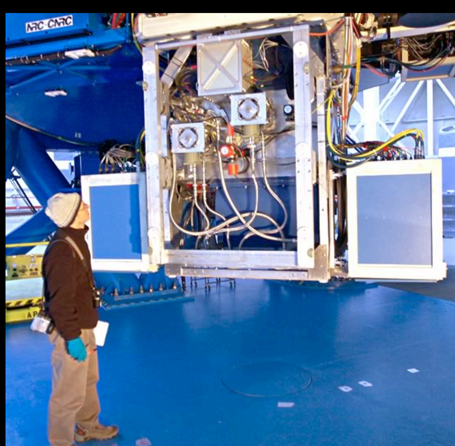


Observations

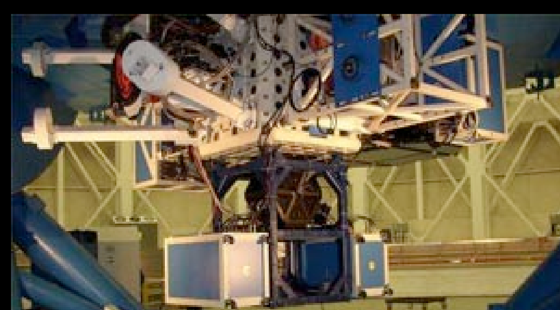
Imaging bands:	N	North: N’ (11.2 microns) South: broadband N (10.4 microns), Si-5 (11.7 microns)
	Q	North: Qa (18.1 microns) South: Qb (18.3 microns)

Diffraction-limited resolution:

~ λ/D	*at 50 pc*
= 0.27” at 10.4 microns	*~13 AU*
= 0.47” at 18.3 microns	*~24 AU*



Michelle (Gemini North)

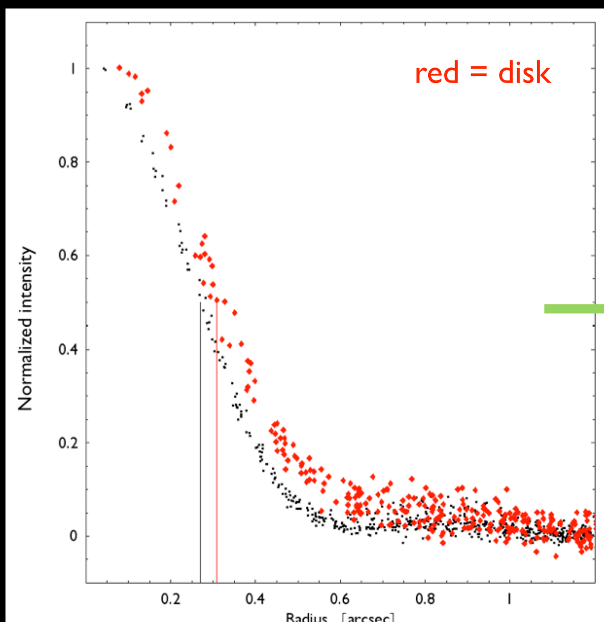


T-ReCS (Gemini South)

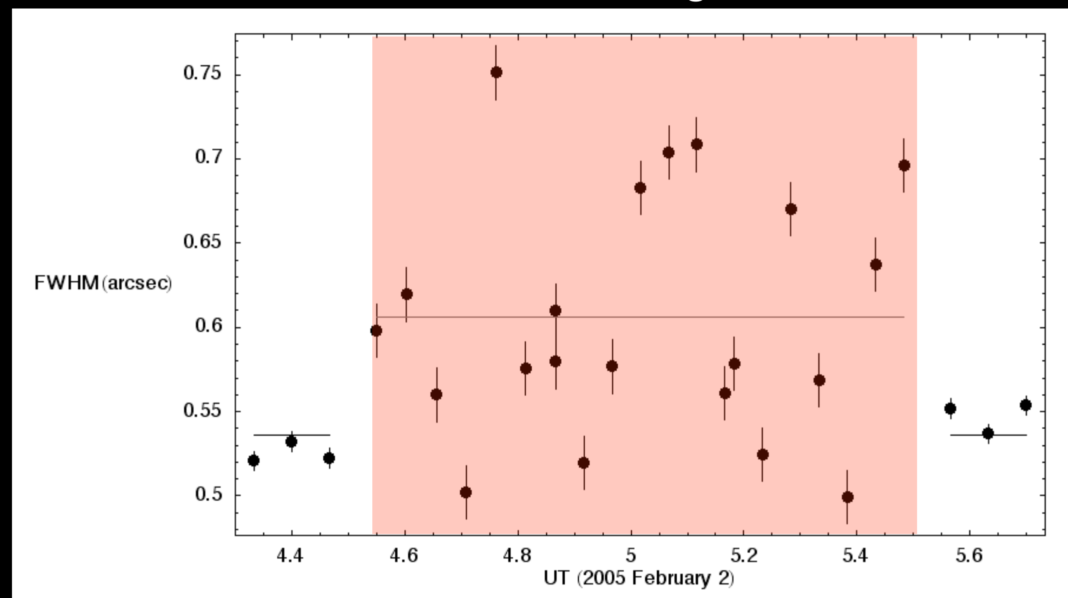
Testing for spatial resolution

All target observations sandwiched by observations of a known point source (PSF)

Why is this necessary?
longer integration ⟶ worse image quality



PSF disk target PSF



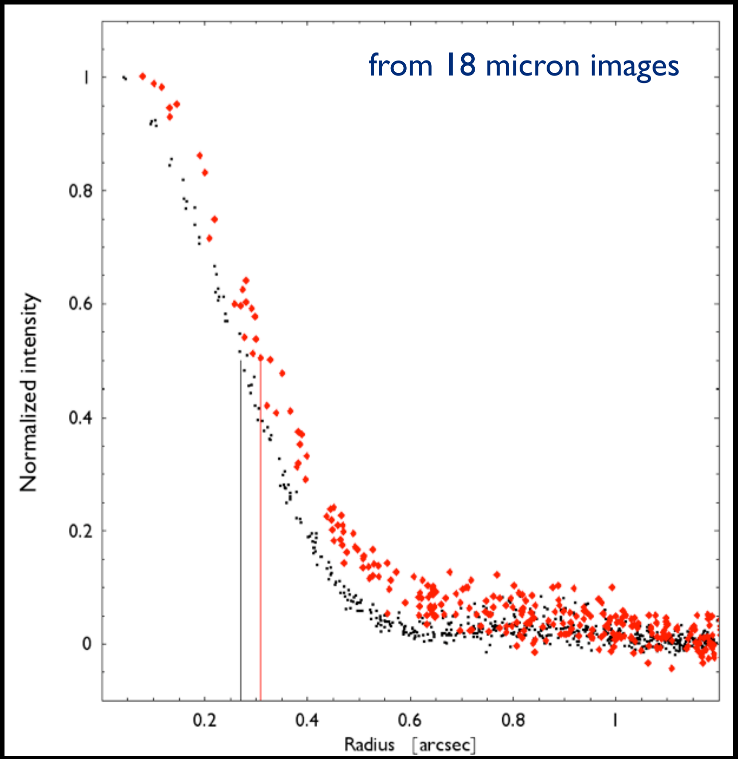
Moerchen et al. 2007a

see also Mariñas et al. 2006
& Radomski et al. 2008
for use of this technique

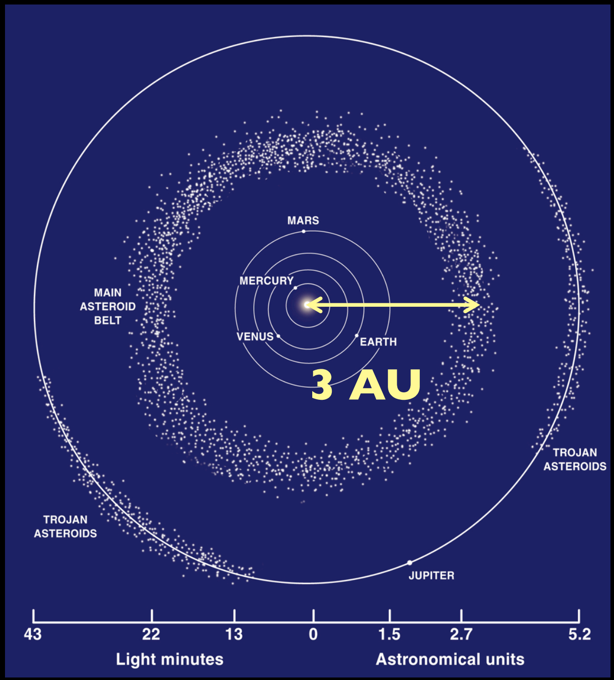
A new resolved archetype: asteroid belt-type disks

Zeta Lep

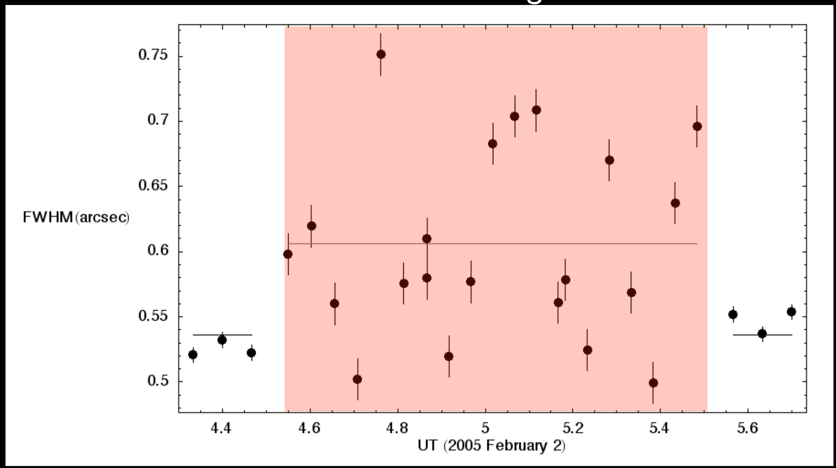
d=21 pc



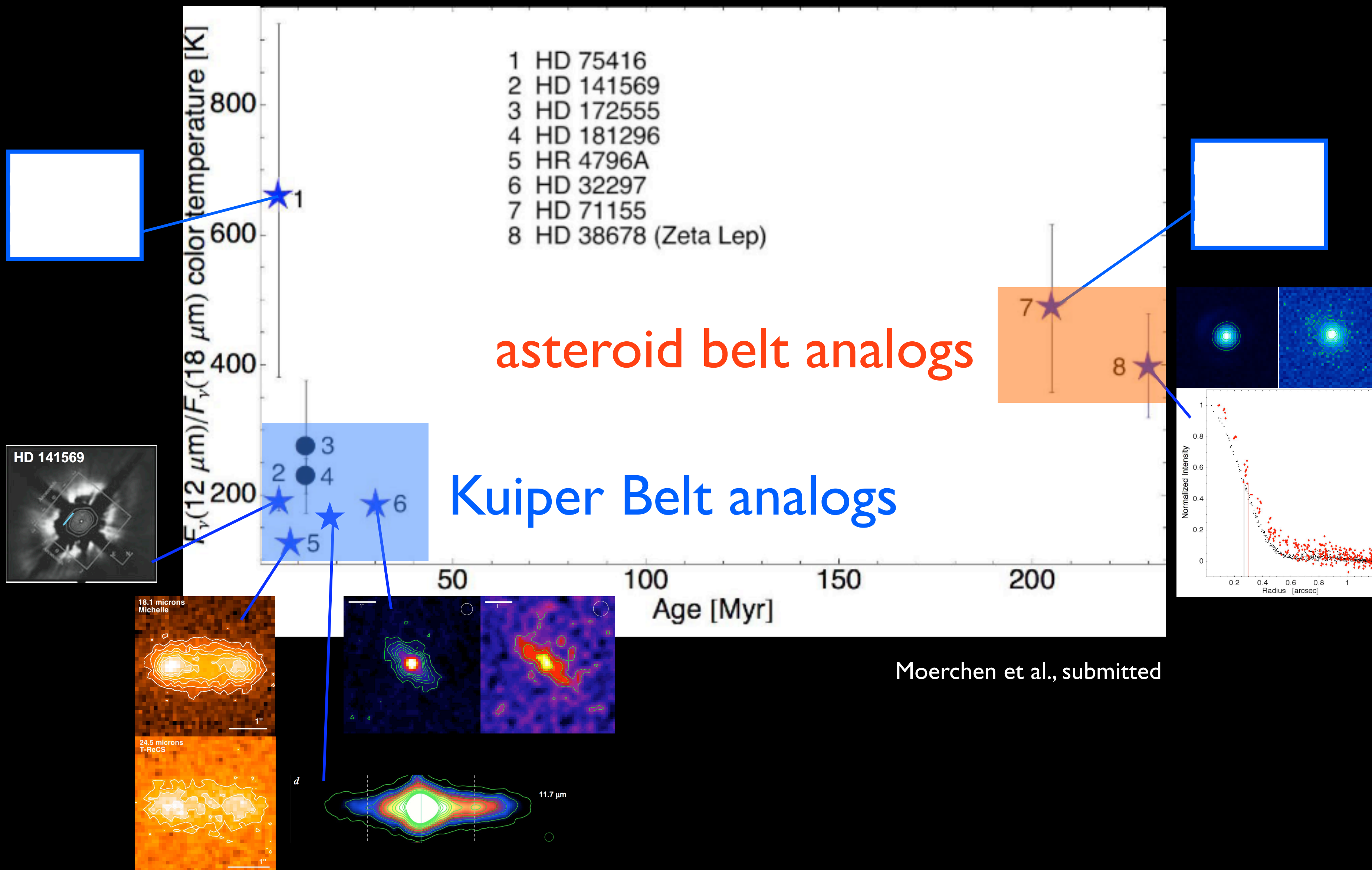
Moerchen et al. 2007a



PSF disk target PSF

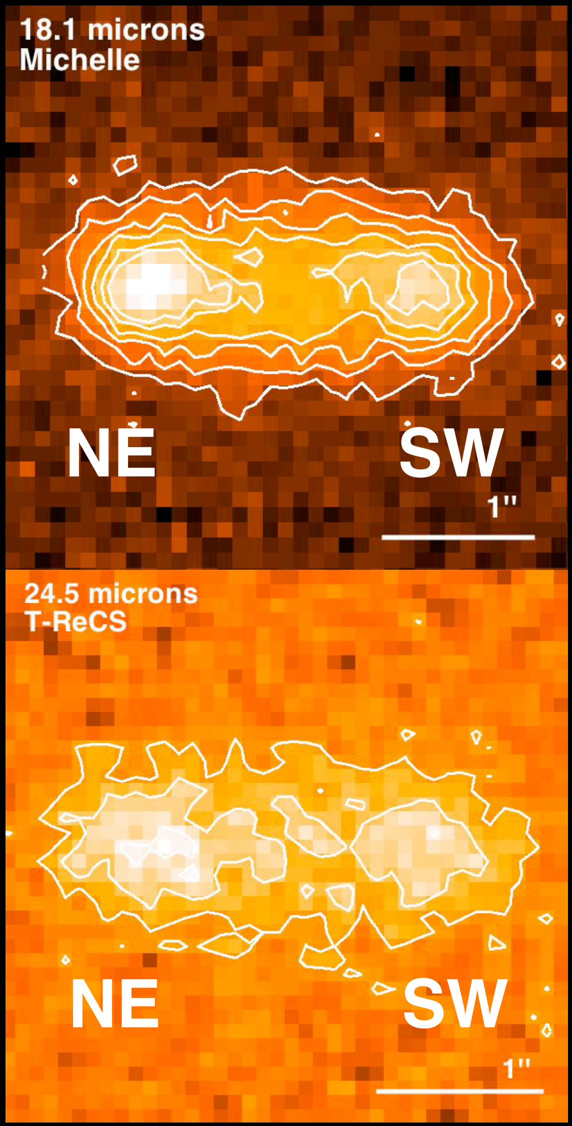


Overview of the disk sample



Moerchen et al., submitted

Re-examining HR 4796A



Moerchen et al., in prep.

•Highest fractional luminosity among debris disks

$L_{IR}/L_{*} = 5 \times 10^{-3}$

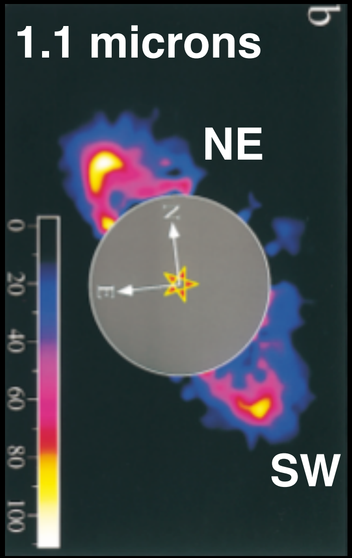
•First resolved by ground-based MIR images
(OSCIR at CTIO, Jayawardhana et al. 1998)
(MIRLIN at Keck, Koerner et al. 1998)

•Resolved also in space-based NIR images
(HST NICMOS, Schneider et al. 1999)

Distance = 73 pc

Dust annulus radius = 76 AU

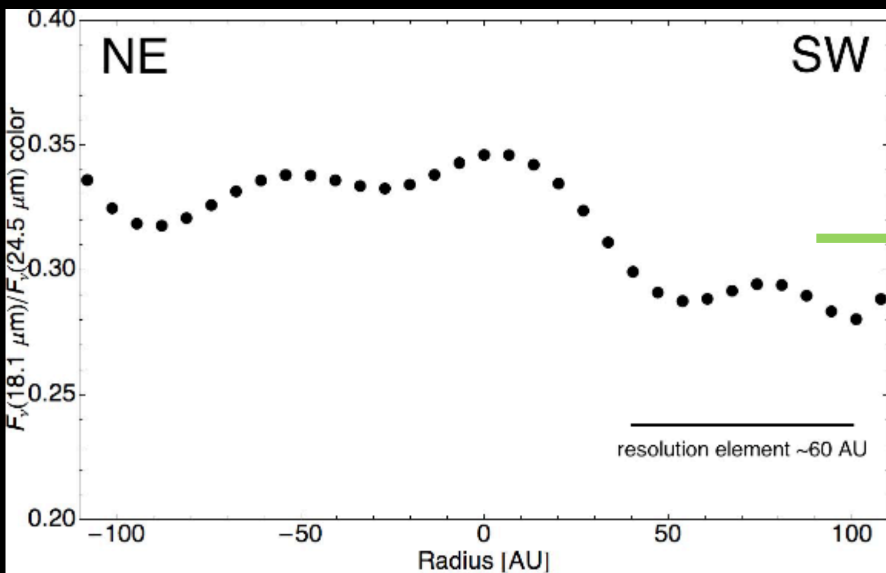
Dust annulus width = 19 AU

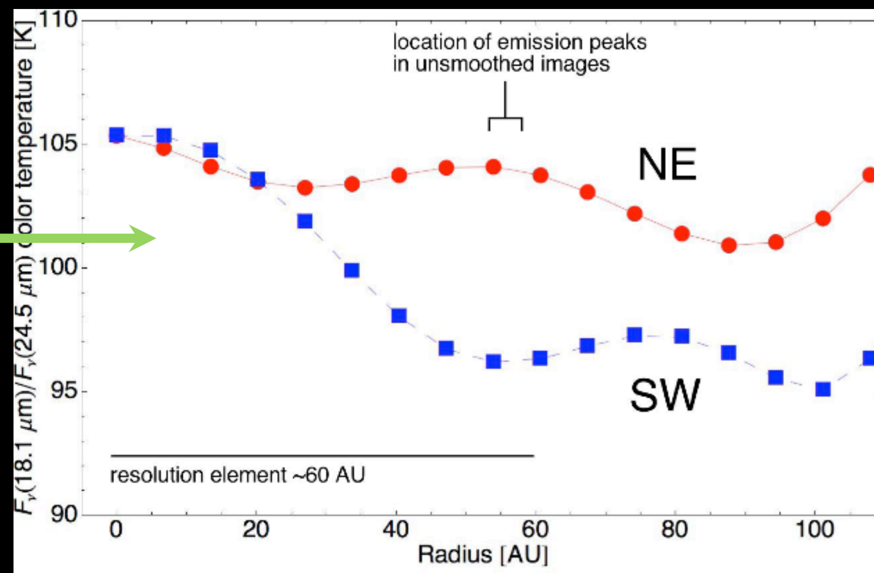


Schneider et al. 1999

Temperature asymmetry in HR 4796A

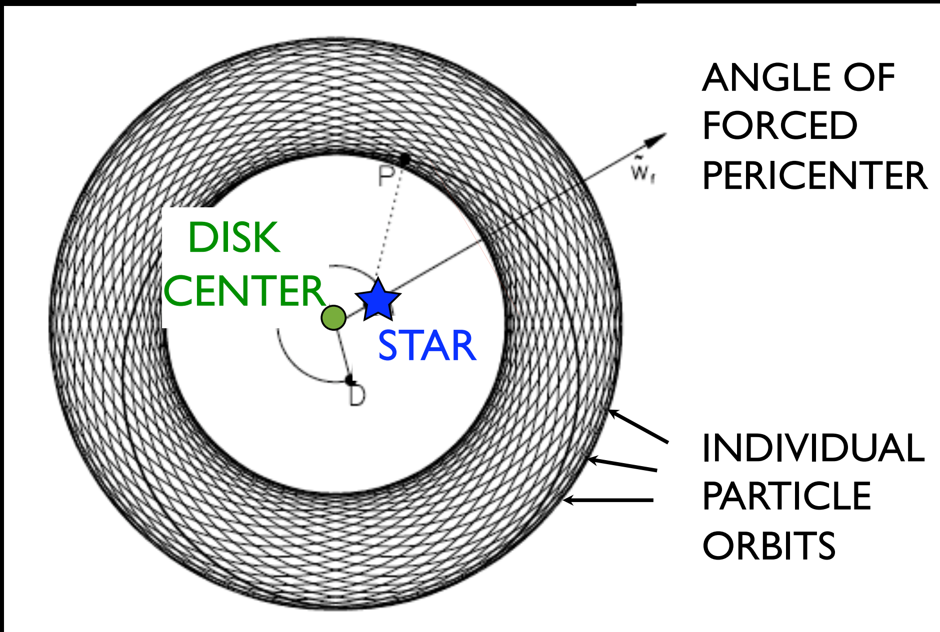
Constructing a MIR color temperature profile





Pericenter glow as the origin of asymmetry in HR 4796A

- Dust particle orbits experience secular perturbations by a planet on an eccentric orbit
- Center of disk is offset opposite direction of forced pericenter
- Dust nearest star is heated more



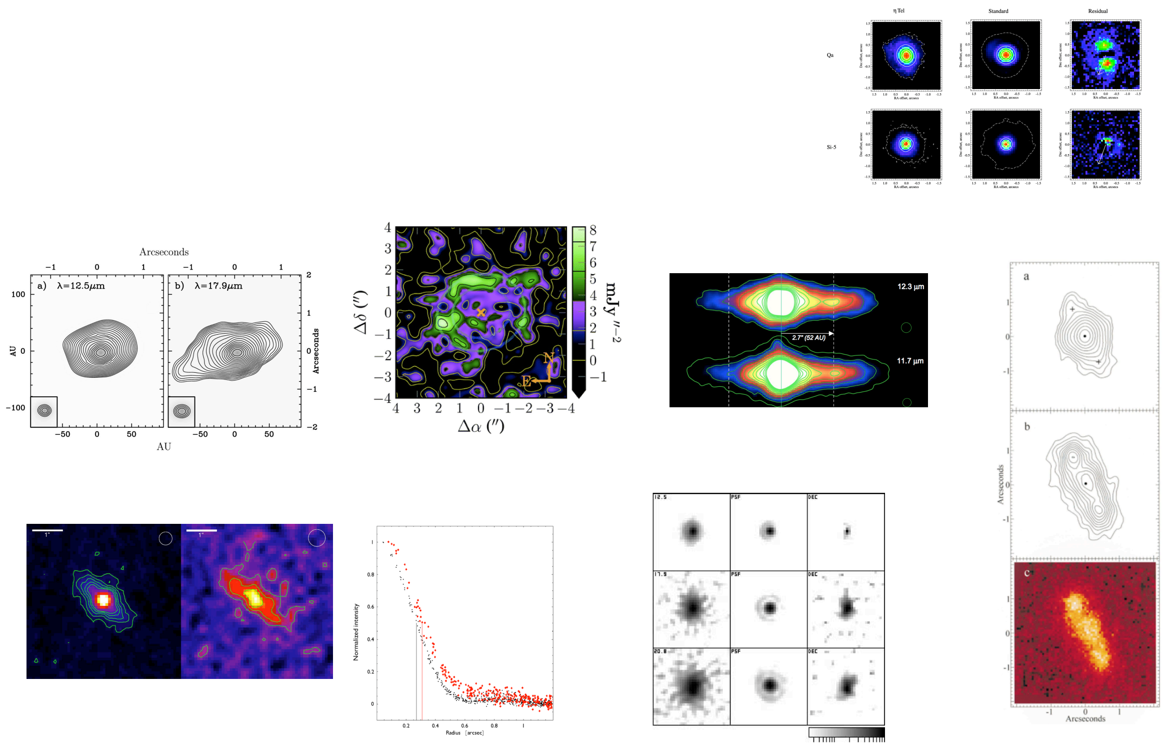
Wyatt et al. 1999

Temperature & brightness asymmetry (MIR) can be replicated in disk models with a 0.06 forced eccentricity

possibly due to the influence of a giant planet

Moerchen, Churcher, Telesco, Wyatt, Fisher & Packham, in prep.

A new disk-exploring tool: CanariCam



Increase sample of MIR resolved disk structures

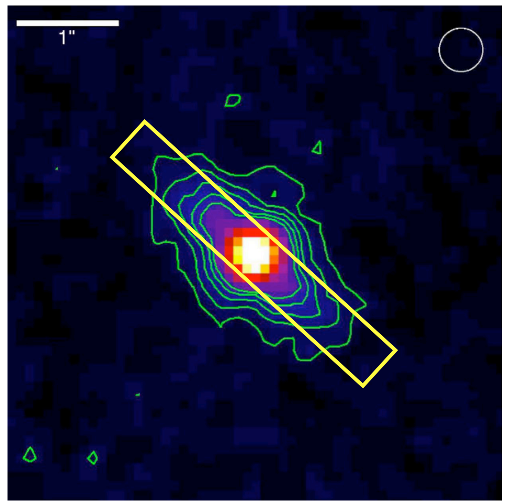
Spectroscopy

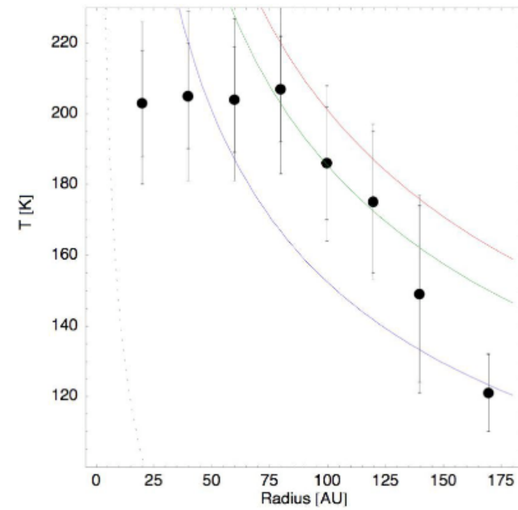
Polarimetry

Coronagraphy

A new disk-exploring tool: CanariCam

Imaging





Obtain spatially resolved spectra to study disk properties

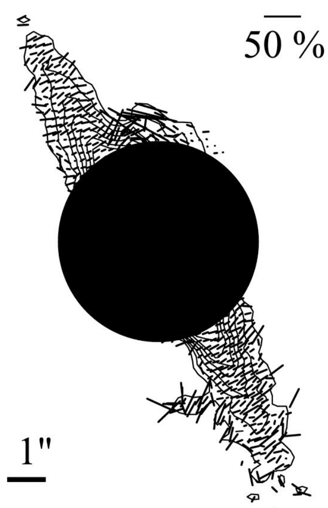
Polarimetry

Coronagraphy

A new disk-exploring tool: CanariCam

Imaging

Spectroscopy

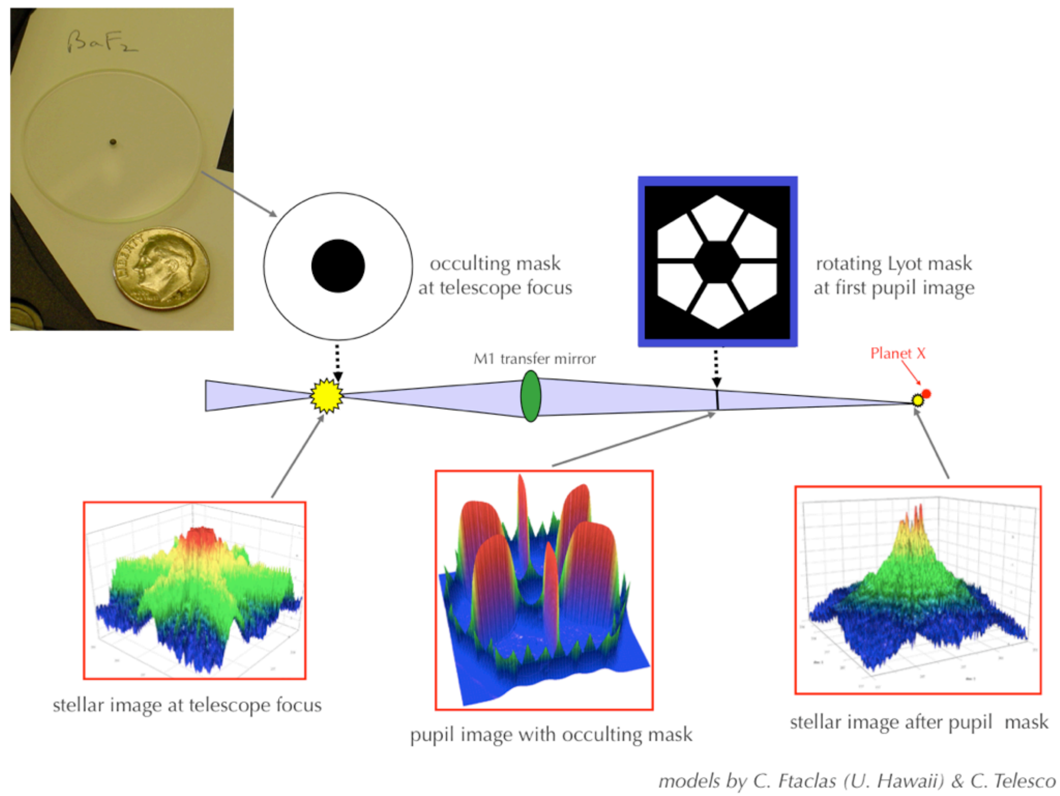


Coronagraphy

A new disk-exploring tool: CanariCam

Imaging

Spectroscopy



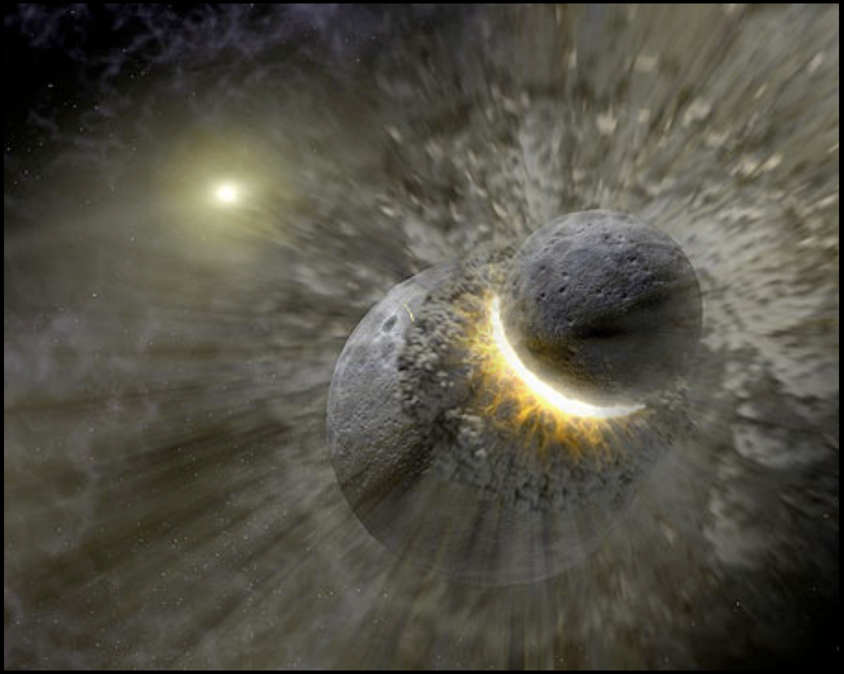
Polarimetry

Next debris disk studies

Continue search for resolved disks & investigation of disk structures

Resolved spectroscopy of disks to examine changes of dust properties with radius

Explore capabilities of MIR polarimetry & coronagraphy



NASA/JPL-Caltech