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in collaboration with

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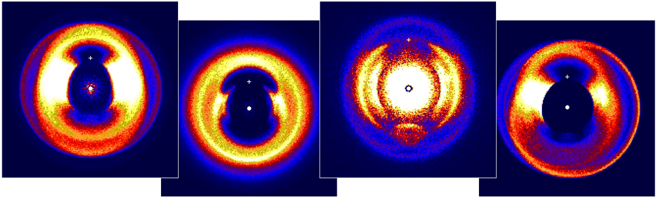
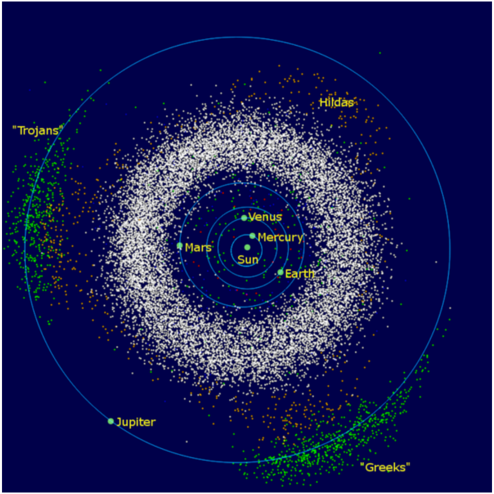
Modeling Planet-Disk Interaction in Debris Disks



What are Debris Disks?

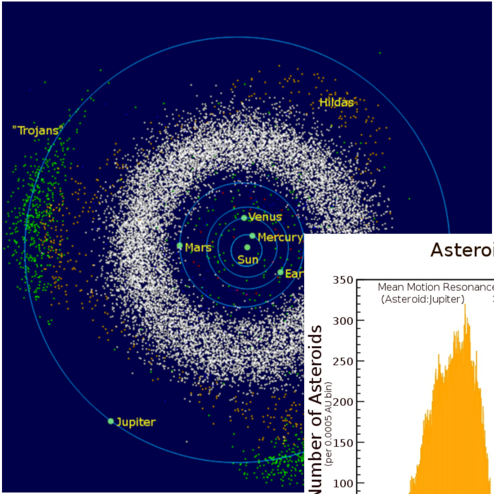
- **Optically thin** disks of dust around older (main sequence) stars
- Radii of few AU to several 100 AU, **broad disks, large inner holes, narrow rings**
- Dust is removed on short timescales, **continuously replenished**
- Dust distribution influenced by **potential planets** and the **position of parent bodies** in addition to stellar radiation and gravity

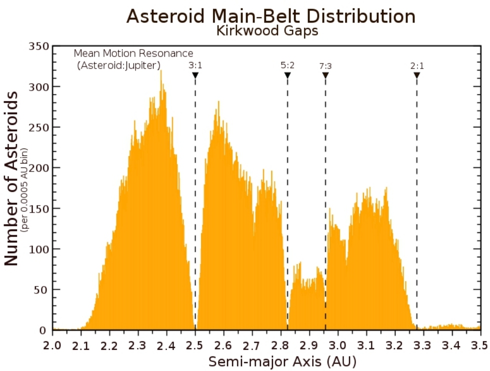
Motivation: The Solar System



Wikipedia

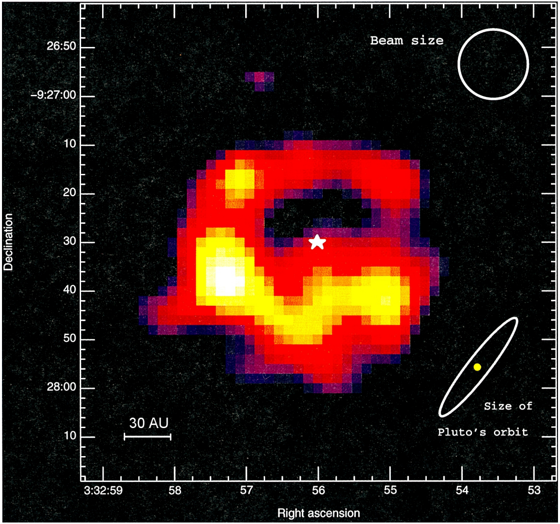
Motivation: The Solar System



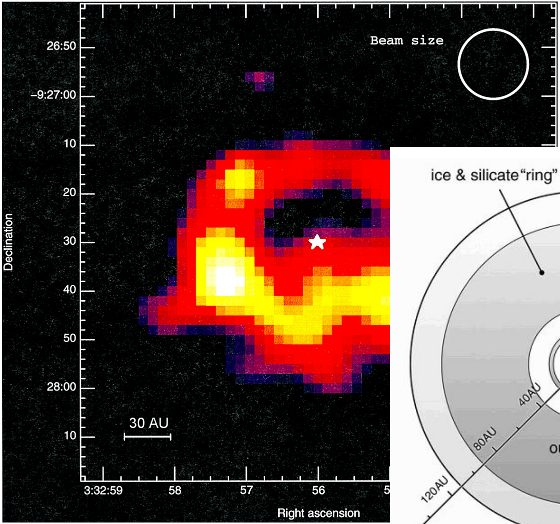


Wikipedia

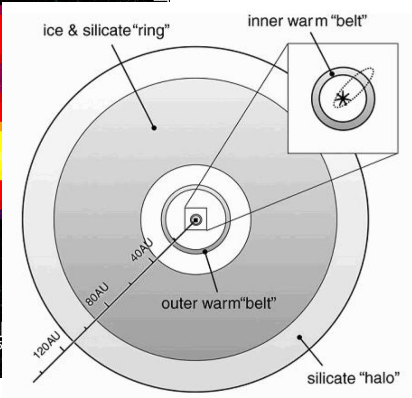
Extrasolar Systems: ϵ Eridani



Greaves et al. 1998, SCUBA 850 μm

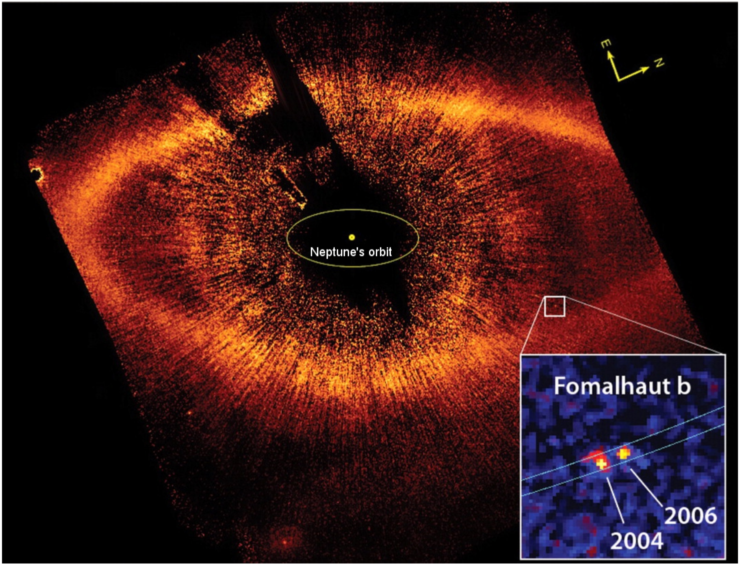


Greaves et al. 1998,
SCUBA 850 μm



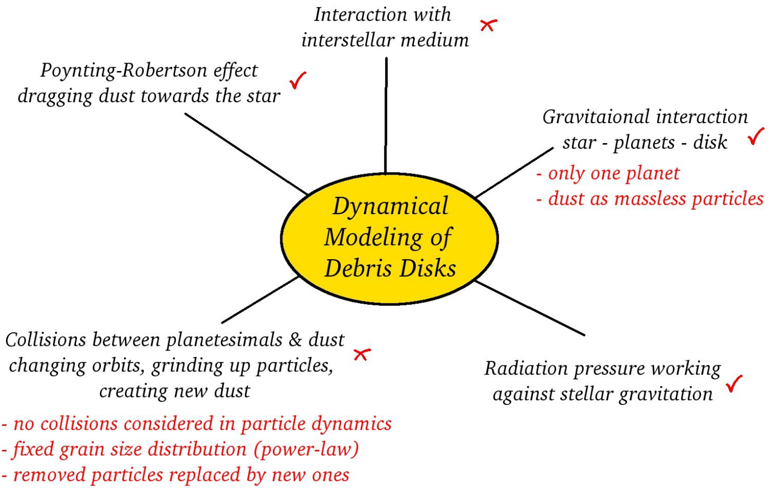
Backman et al. 2009, basically based on Spitzer data

Extrasolar Systems: Fomalhaut



Kalas et al. 2008, HST/ACS 0.6 μm

MODUST (Rodmann 2006)

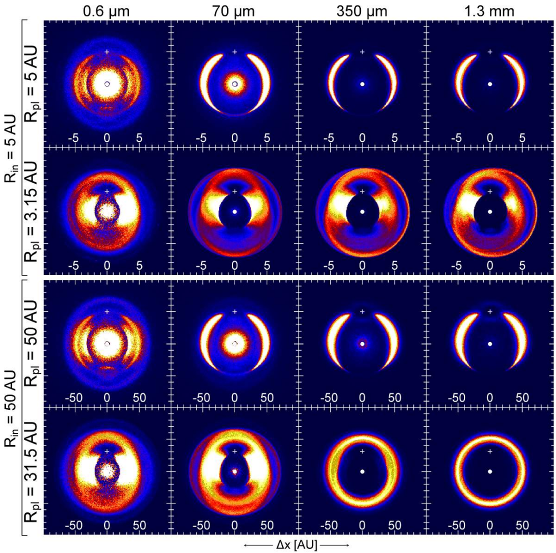


Poynting-Robertson Time Scale

$$\tau_{\rm PR}\ [\rm yr] \approx \frac{400}{\beta}\left(\frac{M_{\rm star}}{\rm M_\odot}\right)^{-1}\left(\frac{r_0}{\rm AU}\right)^2 \ ; \quad \beta \propto \frac{1}{a}$$

(Gustafson 1994)

	$\beta = 0.5$ ($a \approx 0.5\,\mu$m)	$\beta \approx 1.5 \times 10^{-4}$ ($a \approx 1\,mm$)
$r_0 = 1$ AU	800 yr	2.9 Myr
$r_0 = 50$ AU	2 Myr	7.1 Gyr
$r_0 = 200$ AU	32 Myr	114.3 Gyr



Initial dust distribution:

- R_{in}: see graphic
- $R_{\mathrm{out}} = 1.1\,R_{\mathrm{in}}$
- $n(R) \propto R^{-1.0}$

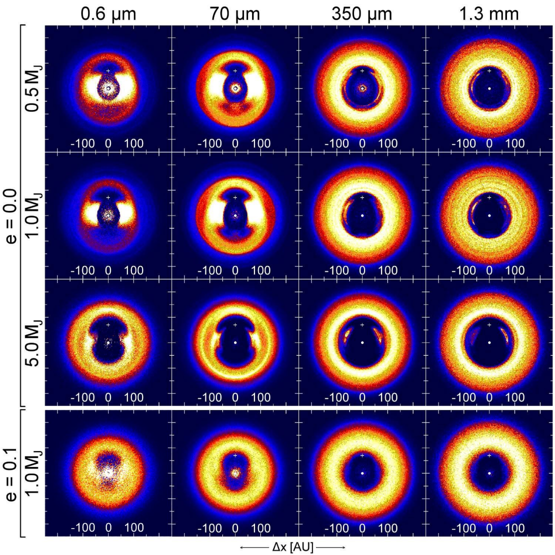
Grain size distribution:

- $a_{\mathrm{min}} = 0.5\,\mu\mathrm{m}$
- $a_{\mathrm{max}} = 2\,mm$
- $n(a) \propto a^{-3.5}$

Planet's parameters:

- $M_{\mathrm{pl}} = 1.0\,\mathrm{M_J}$
- $e = 0.0$
- R_{pl}: see graphic

Results - Some Models



Initial dust distribution:

- $R_{\rm in} = 70$ AU
- $R_{\rm out} = 250$ AU
- $n(R) \propto R^{-1.5}$

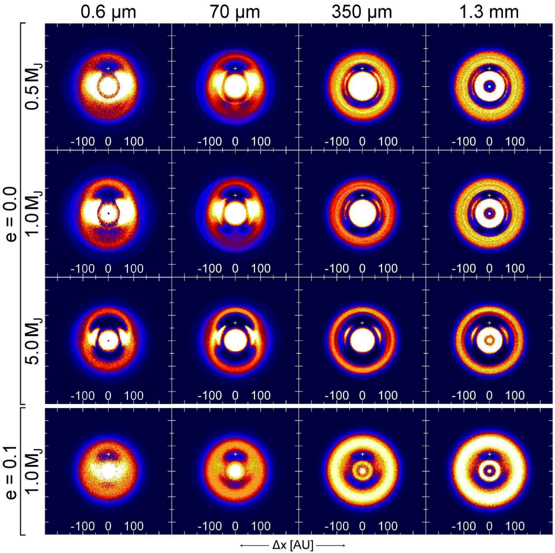
Grain size distribution:

- $a_{\rm min} = 0.5\,\mu$m
- $a_{\rm max} = 2\,mm$
- $n(a) \propto a^{-3.5}$

Planet's parameters:

- $M_{\rm pl}$: see graphic
- e: see graphic
- $R_{\rm pl} = 70$ AU

Results - Some Models



Initial dust distribution:

- $R_{\rm in} = 35$ AU
- $R_{\rm out} = 210$ AU
- $n(R) \propto R^{-1.5}$

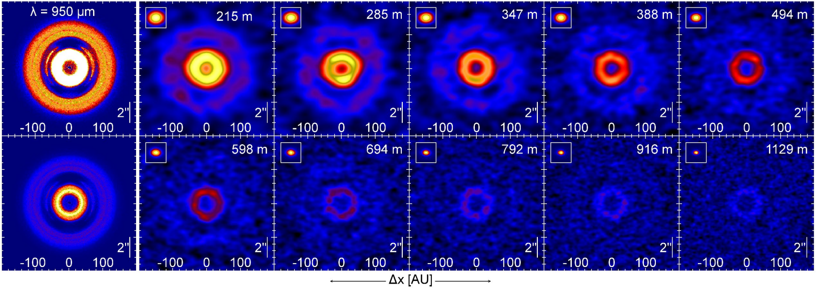
Grain size distribution:

- $a_{\rm min} = 0.5\,\mu$m
- $a_{\rm max} = 2$ *mm*
- $n(a) \propto a^{-3.5}$

Planet's parameters:

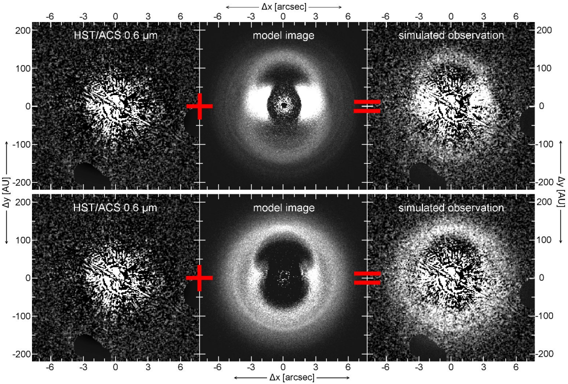
- $M_{\rm pl}$: see graphic
- e: see graphic
- $R_{\rm pl} = 70$ AU

Results - ALMA Observational Perspectives



- High spatial resolution $\Longleftrightarrow$ high sensitivity to surface brightness
  - $\Rightarrow$ ALMA observations on debris disks limited by sensitivity, not resolution possible
  - $\Rightarrow$ Only prominent features can be detected even in very bright disks
- Probability of prominent structures in (long wavelength) thermal reemission rather low

Results - Scattered Light Observational Perspectives



- High spatial resolution, but stellar PSF residuals, how about JWST?
- Sensitivity of HST sufficient for bright disks, JWST even better
- Probability of prominent structures in scattered light high
- Careful with faint disks: Sometimes hard to disentangle structures, scattering asymmetries, projection effects (inclination)

Thank you very much!