Modeling the η Corvi debris disk from the sub-AU scale to its outermost regions

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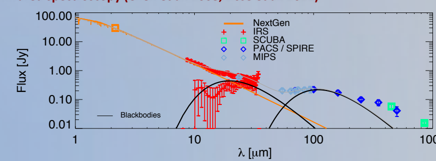
Context

- **The inner Solar System is filled with zodiacal dust grains originating from the Main Asteroid Belt and the disruption of comets**
- **Exo-zodiacal dust disks are detected around a large fraction of nearby Main Sequence stars using near- and mid-infrared interferometry**
  - Hot dust: VLTI/PIONIER H-band = 13^{+5}_{-3}% (Ertel et al. 2014) ; CHARA/Fluor K-band = 28^{+8}_{-6}% (Absil et al. 2013)
  - Warm dust: KIN N-band ~12% (Millan-Gabet et al. 2011) ; Spitzer = ~1% (Lawler et al. 2009)
- **Detailed exozodiacal disk models**
  - **Vega** Fluor, IONIC: ~8x10−8 M_{Earth} of hot dust in a 0.1-0.3 AU ring (Defrère et al. 2011)
  - **β Pictoris** PIONIER dispersed over H-band: scattering from the cold disk + hot excess (Defrère et al. 2012)
  - **Fomalhaut** KIN + VINCI: A hot dust ring at 0.1 – 0.3 AU + A warm dust belt at 2 AU (Lebreton et al 2013)

The case of η Corvi

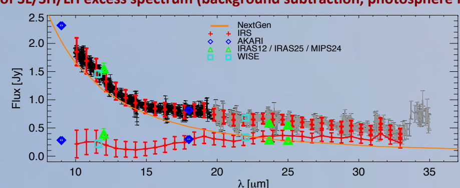
- **A ~1.4 Gyr nearby (18.2 parsec) F2V star**
- **130 AU-wide cold debris belt**
  Scuba / Wyatt et al. 2005, Herschel / Matthews et al. 2010
- **A warm dust belt within 10 AU**
  - Mid-infrared interferometry (Millan-Gabet et al. 2011, Smith et al. 2009)
  - Imaging/photometry (Beichman et al. 2006, Smith et al. 2008, Duchene et al. 2014)
  - Mid-infrared spectroscopy (Chen et al. 2008, Lisse et al. 2011)



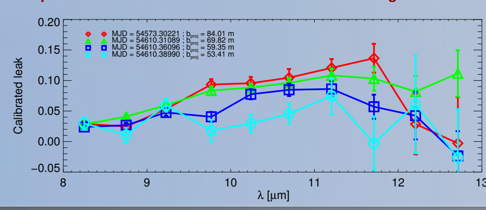
Observations

- **Mid-infrared photometry + Spitzer/IRS spectroscopy**
  Careful recalibration of SL/SH/LH excess spectrum (background subtraction, photosphere fitting)

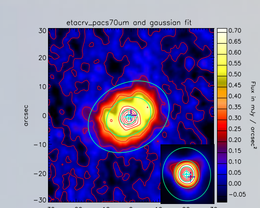
→ *strong spectral features (Lisse et al. 2011)*

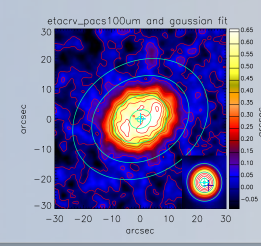


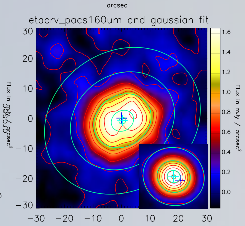
- **Keck Interferometer Nullery**
  4 nulls measurements dispersed across the N-band for 4 different baseline lengths and orientations



- **Herschel far-infrared and sub-millimeter observations**
  - **Resolved imaging with PACS:**
    70 µm (FWHM: 14.3" x 10.7" – PSF: 4.6")
    100 µm (FWHM: 16.7" x 13.0" – PSF: 5.8")
    160 µm (FWHM: 17.6" x 14.6" – PSF: 9.5")
  - **PACS and SPIRE photometry**
    70, 100, 160, 250, 350 and 500 µm



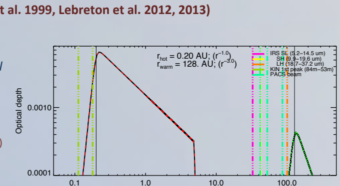




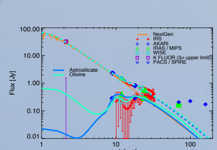
Models

Modeling strategy

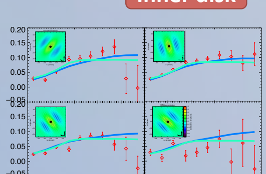
- **Detailed modelling with the GRaTer radiative transfer code** (Augereau et al. 1999, Lebreton et al. 2012, 2013)
  1) **Inner disk / exozodi:** Mid-IR SED (IRS) + KIN nulls ← *Separable from the outer disk (total 80 data points)*
  2) **Outer disk / cold belt:** 6 Herschel radial profiles + SED ← *Includes the unresolved exozodi model (total 116 data points)*
- **6 free parameters for each component**
  (1) Grain composition (Astrosil., Olivine, amorph. carbon, ice, porosity)
  (2) Grain size distribution ($dn/da \propto a^{\kappa}$, a_{min}, κ)
  (3) Density profile (2-power law: r_o, α_{in}, α_{out}=10)
  (4) Total dust mass



Inner disk



SED and IRS spectrum

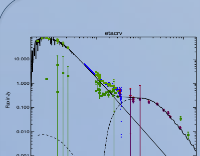


KIN nulls

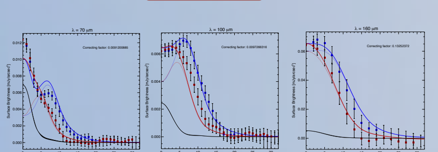
Material		Astrosilicates	Olivine
Grain Size	a_{min}	0.8 µm	0.8 µm
	κ	-3.5	-4.0
Density profile	r_0	0.93	0.2 AU
	α_{out}	-2	-1
Mass		$2.7 \times 10^{-5} M_{Earth}$	$5.9 \times 10^{-5} M_{Earth}$
L_{disk}		$3.0 \times 10^{-4} L_{star}$	$2.5 \times 10^{-3} L_{star}$

Best models (χ^2 = 2.52 – 1.89)

Outer disk



SED



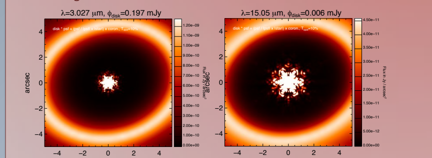
Herschel radial profiles

Material		Astrosilicates
Grain Size	a_{min}	4.1 µm
	κ	-3.5
Density profile	r_0	119
	α_{out}	-3.0
Mass		$3.4 \times 10^{-2} M_{Earth}$
L_{disk}		$1.9 \times 10^{-4} L_{star}$

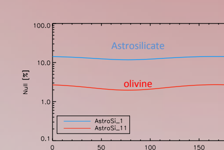
Best model (χ^2 = 1.34)

Conclusions

- The cold belt is a « classical », likely **ice-free** debris disk in **collisional equilibrium** with a **mass comparable to much younger disks**.
- The hot belt has an **extreme mass** and it is dominated by **small olivine grains**.
  ⇒ Delayed stirring and LHB-like event?
- **An interesting target for JWST**
  Cold belt in scattered light with NIRCam — Thermal light imaging with MIRI — *(ongoing work)*



- **Large Binocular Telescope Interferometer**



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