Interpretation of the resolved emission from debris discs at far-infrared wavelengths

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Formation and evolution of planetary systems

- Proto-Planetary Discs
- Planet(esimal) formation
- Dynamical scattering/evolution
- Debris Discs
Linking optical and thermal dust properties

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NICMOS, $w = 0.15$

SPHERE, $w = 0.06$

The Solar system

[Minor Planet Center]
Dust as a tracer of architecture

- Hot dust
- Asteroid belt
- Edgeworth-Kuiper belt
- Halo
- Exoplanets (?)

Temperature (T [K]):
- 1500
- 300
- 50

Radius (R [au]):
- 0
- 0.1
- 1 – 3
- 10 - 100

[Su & Rieke 2014]
Evolution of planetary systems

[Andrews et al. 2018] [exoplanets.org]
Herschel disc detections

[Sibthorpe et al. 2018]
Disc–planet correlations

- Planet-bearing stars: 28/99 = 28±5% with disks
- No known planets: 43/203 = 21±3% with disks
- Debris disk luminosity is correlated with the presence of known planets at >99% significance.

Herschel-resolved debris discs

[HD 105211; Hengst et al. 2017]
Herschel-resolved debris discs

[HD 48682; Hengst et al. in prep.]
$R_{\text{disc}} / R_{\text{bb}}$ vs $L_{\text{star}}$

[Pawellek et al. 2014; Pawellek & Krivov 2015]
$R_{\text{disc}}/R_{\text{bb}}$ vs $L_{\text{star}}$

[Pawellek et al. 2014; Pawellek & Krivov 2015; Marshall et al. in prep.]
$R_{\text{disc}}$ vs $t_{\text{Age}}$

[Marshall et al. in prep., models from Mustill & Wyatt 2009]
$R_{\text{disc}}$ vs $L_{\text{star}}$

[Matra et al. 2018]
Far-infrared vs. millimetre

• Comparison of the radii inferred from this analysis with the radial extents observed by Matra et al. (2018)

• Moderate agreement between the two wavelength regimes
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• Imaging
  • High continuum sensitivity will yield serendipitous detections down to EKB levels of dust; begin to characterise true Solar system analogues in conjunction with contemporaneous exoplanet studies
  • Low angular resolution at far-infrared wavelengths means few if any systems will be spatially resolved
  • May identify faint, broad discs absent in prior surveys? (M-dwarf discs, dynamically cold debris discs)
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- **Spectroscopy**
  - Mid-infrared spectra unlikely to yield many detections or dust features, but high sensitivity to faint warm excesses from spectral shape
  - Far-infrared spectral features for dust composition, presence of (water) ice and gas ([OI], [CII])
  - Rapid spectral mapping for surveying clusters (synergy with JWST MIRI photometry for recovery of discs)
Summary

• Debris discs are a by-product of the planet formation process; the dust location and properties reveal the architecture, dynamics, and composition of larger bodies in the system
• Pawellek et al.’s 2015 sample of 39 far-infrared resolved debris discs identified a trend between disc radius and stellar luminosity
• I have re-examined the full sample of 119 resolved (extended) debris discs from Herschel/PACS; the trend remains, and is consistent with previous analysis
• Comparison with mm-resolved sample reveals broad agreement in the measured and inferred disc extents
• Spica will not resolve its discs; a reliable metric for inference of disc extent as a function of dust properties is therefore desirable to interpret the dynamical state of the system