Debris disks with SPICA/SAFARI

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Why SAFARI?

Debris disk detection
- Unique far-IR capability
- Ability to survey many stars - statistics

Debris disk characterisation
- What is it made of? - spectra (de Vries, Bouwman)
- What does it look like? - resolved images
Outline

- Large N calibration limited survey
  - Limited by photosphere/instrument cal
  - Statistics - e.g. Planet - disk connection
- Faint disk imaging survey
  - Search for Kuiper belt analogues
  - Solar System context - are we typical?
PACS disk - planet correlation

Bryden et al in prep

\[ \frac{F_{\text{dust}}}{F_*} \text{ at } 100\mu m \]

some systems just better at forming large bodies?
Low-mass planet correlation?

(low-mass planets only scatter, and don’t eject planetesimals?)

need many more planet + disk systems...

Bryden et al in prep
Current state of the art

DEBRIS FGK-type stars

All disks detectable

No disks detectable

Solar System
Are we unusually undustly?

Fraction > x

- Kuiper belt
- Calibration limit

Gaspar et al (2013)
Calibration-limited SAFARI survey

- Strategy: observe all stars where calibration limit can be reached (few minutes per star)
  - e.g. ~2% of stellar flux > confusion limit

- Survey sensitivity only surpassed with better calibration of instrument and photospheres

- Follow-up required for structure (e.g. ALMA)
Calibration-limited SAFARI survey

Solar System

Blackbody Temperature (K)

Fractional luminosity
Calibration-limited SAFARI survey

Distance (pc) vs. Stellar luminosity ($L_{\text{sun}}$)

- SW-cal
- MW-cal

Confusion limited

- G-type
- Total

$\sim 1000$ G-type

$\sim 100$ total
SAFARI survey return

- As many targets as you dare apply for...
  - e.g. ~1000 G-type stars within 100pc
- Huge statistical power (big N sub-samples)
  - e.g. planets, metallicity, sp. type, age
- Uniform disk sensitivity (per spec.type)
- Disk luminosity function
- 3-colour resolved disks at high S/N
- Flux calibration + beam characterisation
Planet-disk connection

Number of planets vs. Distance to a host star, pc

- DEBRIS
- DUNES
- SPICA SW
- Cal limited

exoplanet.eu, 2014-5-13
By ~2025 all Sun-like stars within 100pc will have been looked at in search of planets (+rotation periods, space motions, asteroseismology...)

MEARTH
HARPS(N)
CARMENES
GAIA
NGTS
TESS
ESPERRESSO
PLATO
etc.
Are we unusually undusty?

![Graph showing the fraction of objects with a certain property against a parameter. The graph includes a red shaded region labeled "SAFARI survey". There are dotted lines and a dashed line indicating the Kuiper belt and calibration limit. The x-axis represents $F_{70}/F_{\text{star}}$, ranging from 0.001 to 100,000, and the y-axis represents the fraction greater than x, ranging from 0.001 to 1.00. The graph references Gaspar et al. (2013).]
How to detect a Kuiper belt

- e.g. go ~25x deeper than confusion limit (1h)
- Star at 5pc moves by half beam FWHM over ~4yr, difference shows disk detection
- Detect faint azimuthal structure in large disks
Solar System context

- Distance (pc)

Proper motion (arcsec/yr)

- $N_{\text{sun-like (SW)}}: 43$
- $N_{\text{sun-like (MW)}}: 19$

- too slow
- unresolved
Are we unusually undusty?

Fraction > x

Kuiper belt
Calibration limit

photometry

imaging
Summary

- SPICA can do a large N nearby star survey with uniform sensitivity to debris
  - Powerful statistical tool after ~20 years of low-mass planet discoveries
- SPICA can find Kuiper-belt analogues around ~50 Sun-like stars
- Is Solar System typical? □ No □ Unsure
Could you live here?