Young Debris Disks with Herschel

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Gas in Protoplanetary Systems (GASPS)

Herschel PACS Open Time Key Programme to study the evolution of gas and dust in protoplanetary and debris disks

PI – Bill Dent

240 targets

Ages: 1 – 30 Myrs

Spectral types B - M

Observations

Photometry: 70 and 160 µm

Spectroscopy: [OI], [CII], ...
Young Debris Disks in GASPS

• Survey of 68 stars, 10-30 Myrs old
  – Debris disk phase, little to no gas

• Goal: to look for trends in disk parameters with stellar properties and/or age

• Result: found a trend between disk temperature and stellar temperature
Gas in Debris Disks

• Gas detected in 3 debris disks
  – HD172555, [OI] (Riviere-Marichalar 2012)
  – 49 Ceti, [CII] (Roberge et al. 2013)
  – HD32297 [CII] (Donaldson et al. 2013)

• Focus on photometry

![Flux versus Wavelength Graph](attachment:image.png)
Photometry Data

- PACS 70, 100, 160 μm
  - All targets

- SPIRE 250, 350, 500 μm
  - Follow up of disks detected by PACS
    - (OT2: PI A. Roberge)
    - Detected ~1/4
Debris Disks from the GASPS Sample
68 Stars, 24 Disks, 10-30 Myrs old

TW Hydrae Association
8 - 10 Myrs
Upper Scorpius
5 - 11 Myrs
β Pictoris Moving Group
12 - 22 Myrs
Tucana-Horologium
30 Myrs
Archive Data & Photosphere Fitting

- Collected Archive Data
  - Hipparcos
  - 2MASS
  - WISE
  - Spitzer

- Stellar Photosphere Fitting
  - Kurucz or NextGen Stellar Atmosphere models
Spectral Energy Distribution Fitting

HD181327
SED Fitting

HD181327

Modified Blackbody
Is the deficit due to detection limit?

Roberge et al. (2012)
We should be able to detect disks in the empty region.
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Morales et al. (2011) – all warm disks have similar temperatures
We split the disks into warm and cold populations.
Power-law temperature trend

$T_d \propto T_\star^\alpha$

$\alpha = 0.95 \pm 0.3$

$\alpha = 0.85 \pm 0.1$
Interpretation of temperature trend

- Constant Temperature: \( T_d = \text{const}, \ \alpha = 0 \)
- Constant Radius: \( T_d \propto T_*^{7/4} \)
- Disk Radius vs Stellar Mass relations: \( R_d \propto M_*^\gamma, \ \gamma \approx 0.9 \)
Interpretation of temperature trend

\[ R_d \propto \sqrt{M_*} \]

The Kuiper Belt

Neptune's orbit

Pluto's orbit
Conclusions

• Surveyed 68 stars in 4 stellar associations
  – Found 24 debris disks

• Fit the disks with modified blackbody models

• Found a trend between disk and stellar temperature
  – Remnant of planet formation?