Recent Progress and Results from LBTI

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Talk Outline

• Motivation
• Measurement Technique
• Survey Status
• Preliminary Results
Motivation
Zodiacal Dust in the Solar System

Solar System w/out Sun
\(\lambda = 0.6 \, \mu m\)

Image credit: M. Rizzo / A. Roberge
• Scattered light in ecliptic plane.
• Infrared emission first seen by IRAS.

from Nesvorny et al. 2010
Origin of Zodiacal Dust

- Asteroid belt thought to provide much of the dust seen at Earth (Dermott et al. 2002).

- Recent Dynamical models (cf. Nesvorny et al. 2010) suggest Jupiter-family comets provide the majority of the dust for the zodiacal cloud.

from Nesvorny et al. 2010
Exozodi Affects Exoplanet Yield

- Telescope aperture and exozodi level affect exoplanet yield.
- Exozodi is particularly important for small telescopes, especially when confusion taken into account.

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<th>Exoplanet Yield</th>
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<td>30 Earths</td>
<td>9 m</td>
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Stark et al 2015
Exozodi Clumps Can Create False Positives

If exozodi >20x Solar System level, resonant dust ring structures could be confused for an exo-Earth at 1 AU (Defrere et al. 2012)
LBTI Must Determine Exozodi Luminosity Function

• To demonstrate that EZ is manageable part of noise budget, LBTI must observe enough stars to determine exozodi luminosity function to ~10 Zodi level

• A NASA review concluded that a 35 star survey is the minimum needed to provide the necessary data
State of the Art – Keck Nuller

- Surveyed 20 stars and demonstrated 24 zodi, 1 \( \sigma \) uncertainty on median exo-zodi level

Performance is currently improved 12X over KIN.
Measurement Technique
LBTI and the HOSTS Survey

- LBTO is located on Mt. Graham in Arizona
- LBTI is a mid-infrared nulling interferometer
- Designed to carry out the Hunt for Observable Signatures of Terrestrial planetary Systems (HOSTS)
- Managed by Exoplanet Exploration Office at JPL
- Operated by University of Arizona
- Data archiving at NExScI
How Nulling Interferometry Works

- First proposed by Bracewell (1978) to directly detect “non-Solar” planets;
- Subtracts starlight by destructive interference;
Nulling Implementation

see Defrere et al. 2016
Survey Status
How routine are the observations?

• A queue observing strategy was implemented starting in fall 2016.
  – Improved ability to obtain useful conditions.

• Observing now routinely can obtain 3 stars per night.

• We can obtain good data on stars as faint as 1 Jy
  – This was the original survey brightness limit.

• Observations of stars at southerly declinations is a problem.
HOSTS Tally

• 13 stars observed in 2017 A
• 11 stars observed in 2016 B
• 2.3 stars previously observed

• Total HOSTS survey = 26.3 stars (75% complete)

A star is considered observed after three calibrated data sets on it.
HOSTS Progress

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- 29 total stars observed with some data
- 14 early type stars (<F5)
- 15 solar type stars (F6 – K8)
Preliminary Results
Caveats:
(Why I shouldn’t be showing you these results)

• Only about ¾ of total data has been analyzed to-date.
  – Some requires additional pre-conditioning
  – Our last observing block ended May 22 – this set is not included.

• Conservatively large aperture was used to measure the null:
  – Increases noise but ensures all flux is measured.
  – More recent pipeline comparisons suggest a significant improvement can be achieved via smaller apertures without losing flux.
Example Results (1)

- Beta UMa warm dust detected.
  - Preliminary indication that more excess is detected along major axis of cold disk seen by Herschel.

From Booth et al. (2014).
Incl=84 deg, PA=114

Figures courtesy of D. Defrere
Example Results (2)

• Most measurements are consistent with a non-detection of dust.
Distribution of Measurements

- Excess Flux Signal/Uncertainty level for
  - subset of 22 stars.
  - Preliminary analysis.

Sigma of the distribution: 1.02

Figure courtesy of S. Ertel
Constraint on Exozodi Luminosity Function

- Median dust level does not appear to be a show stopper for imaging missions.
- Is the median zodi level non-zero?

Assumed Distribution: Log-Normal

Stars without known nIR/fIR excess (16)

- Median: 11 ± 7 zodis
- 3σ upper limit: 26 zodis

Figure courtesy of S. Ertel
Summary

  - 26 stars have now been observed.
- The initial look at the data suggest an exozodi luminosity distribution that is not an obvious hindrance to future exo-imaging missions.
- Additional observations and improved data analysis can provide input to mission planning for future exo-Earth imaging missions.
Backup Slides
Modeling other Dust Disks

- Collisional model by A. Gaspar can predict evolution of dust from comets (3-D model in the works).
- Collisional in-situ model from Kennedy and Wyatt provides comparison.

Gaspar et al. (2012)  
Kennedy and Wyatt (2013)