METIS and MATISSE

New insights into the formation of planets in the mid-infrared

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Symposium #2
14./15. December 2015
Pre-Main Sequence Phases

- Class I: ~$2 \times 10^5$ a
  - Classical T Tauri Stars (CTTS)
  - Protoplanetary Disk

- Class II: ~$1 \times 10^6$ a
  - Weak-Line T Tauri Stars (WTTS)
  - Planets & „Debris“

- Class III: ~$1 \times 10^7$ a
  - Planets & „Debris“

© Dauphas & Chaussidon, AREPS 39, 2011
A typical circumstellar disk
A typical circumstellar disk

<table>
<thead>
<tr>
<th>Compound/Feature</th>
<th>Wavelength (μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H$_2$O (gas)</td>
<td>2.8–4.0</td>
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<tr>
<td>H$_2$O (ice)</td>
<td>3.14</td>
</tr>
<tr>
<td>Br $\alpha$, Pf $\beta$</td>
<td>4.05, 4.65</td>
</tr>
<tr>
<td>Polycyclic Aromatic Hydrocarbons</td>
<td>3.3, 3.4</td>
</tr>
<tr>
<td>Nano-diamonds</td>
<td>3.52</td>
</tr>
<tr>
<td>CO (fundamental transitions)</td>
<td>4.6–4.78</td>
</tr>
<tr>
<td>CO (ice)</td>
<td>4.6–4.7</td>
</tr>
<tr>
<td>Amorphous silicates</td>
<td>8–13</td>
</tr>
<tr>
<td>Crystalline silicates (olivines and</td>
<td>9.7, 10.6, 11.3,</td>
</tr>
<tr>
<td>pyroxenes)</td>
<td>11.6</td>
</tr>
<tr>
<td>Polycyclic Aromatic Hydrocarbons</td>
<td>8.6, 11.4, 12.2,</td>
</tr>
<tr>
<td>Fine structure lines</td>
<td>12.8</td>
</tr>
<tr>
<td></td>
<td>10.5, 10.9, 12.8</td>
</tr>
</tbody>
</table>

Lopez et al., ESO Messenger 157, 2014
Schegerer et al., A&A 456, 2006
Herbig Be star (B9Vne)
d = 97 ± 6 pc
t ~ 5 Myr

© Sascha Quanz (ETH Zürich)

Lopez et al., ESO Messenger 157, 2014
Very Large Telescope Interferometer
Very Large Telescope Interferometer

\[ v = 0.5 \text{ m/s} \]
\[ \Delta s = 50 \mu\text{m (140 m)} \]
\[ \Delta s = 1 \mu\text{m (3 m)} \]
The transitional disk around HD 100546
HD 100546 – Steepness of the Wall

© Mulders et al., A&A 557, 2013
MATISSE
(Multi-AperTure mid-Infrared SpectroScopic Imager)

2nd Generation VLTI Instrument

Principal Investigator       B. Lopez (OCA, Nice)
Co-PI & Proj. Scient        S. Wolf (CAU, Kiel)
Co-PI                        J. Hron (University of Vienna)

Specifications

- Usage of up to 4 telescopes / 6 baselines
- Simultaneous observations in 3 spectral bands (L, M & N)
- Spectroscopic resolutions: 30 (LMN), 220 (N), 500 (LM), 1000 (LM), 3500-5000 (LM)

What’s new?

- Image reconstruction on size scales of 3 / 6 mas (L-band)
- 10 / 20 mas (N-band) using ATs / UTs
- New mid-IR observing window for interferometry
- Multi-wavelength approach in the mid-infrared
- Improved spectroscopic capabilities
MATISSE – A Mid-IR Imager
MATISSE – A Mid-IR Imager

successor of MIDI

extension of AMBER

complement to ALMA

bridge to the ELT
Specifications

1\textsuperscript{st} Generation ELT Instrument

Principal Investigator    B. Brandl (Leiden Observatory)
Co-PI & Proj. Scient      S. Quanz (ETH Zürich)
Co-PI                     M. Güdel (University of Vienna)

METIS offers

• coverage of the thermal infrared from 3 to 19 µm
• diffraction-limited imaging in the L-, M-, N-, and Q-band
• long-slit spectroscopy with $900 \leq R \leq 5000$ (LMNQ)
• integral-field spectroscopy with $R \sim 100,000$ (LM)
• polarimetry, coronography
Sensitivity

Meteorological Image and Transmission System

Mid-infrared E-ELT Imager and Spectrograph

Brandl et al., ESO Messenger 140, 2010
1 hour, 4.7 μm, stack of 5 simultaneously observable CO lines
The case of HD 100546

HD100546 2–component SED fit

$T_{\text{planet}} = 1735$ K (fitted)
$R_{\text{planet}} = 2.0$ $R_{\text{Jup}}$ (fixed)
$M_{\text{planet}} = 3.0$ $M_{\text{Jup}}$ (fixed)

$T_{\text{disk}} = 180$ K (fitted)
$R_{\text{disk}} = 1.3$ AU (fixed)

HD100546 @ 9mu with METIS

Circumplanetary disk

Circumstellar disk

0.4" 40 au