Observations with JouFLU
Update and First Results

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Differences

• Remote operations
• Software & hardware integrated with CHARA environment
• Pupil imaging
• Improved fiber injection
• Improved alignment procedure
• Spectral dispersion mode
• FTS
Current status report

• First science data taken
• Preliminary data reductions done
  – Initial science data reduced
  – More testing of reduction code planned
• New alignment procedures being documented
• Remote ops tested and working
  – Barring network issues
• Polarization issues investigated
• OAP improvement planned

Better throughput
Fiber injection raster scan

Configuration and log data saved with each alignment

2013-7-16 13:57:34 beam A     NOSTAR
size of raster=               9.00000
zaber step size=              40.0000
Mean =                       240.138214
Stddev =                     524.807007
baseline=                    119.698
peak=                        3948.22
peak half-width (x)=         0.496464
peak half-width (y)=         0.789272
Avg FWHM (steps)=            1.28574
peak centroid (x)=           3.78804
peak centroid (y)=           4.79696
rotation angle (radians)=    0.000000
size of raster=              9.00000
micro step size (radians)=   5.95372e-005
physical step size (um)=     6.04898
number of steps across fiber diameter (um)=         1.07456
Avg FWHM (microns)=          7.77739
Number of zaber steps across FWHM=          1.28574
Comparison to known diameter

- Tabby 0.981 ± 0.015
- One bracket, more obs planned
Total CHARA nights

- FLUOR nights awarded 13%
- other programs 87%

FLUOR nights

- no data collected 29%
- FLUOR data collected 71%

number of files per night

- all nights
- good night
Noted in log

seeing/piston: 56%
clouds: 22%
instrument problem: 7%
microscopy problem: 7%
user error: 3%
network problem: 5%

seeing for number of files
Number of brackets (1o2o3o1)

- 0.5 Per hour
- 4.6 Per night

mK magnitude limit

- 4.86 HD 27789
- 5.17 FU Ori
Polarization

Why can we only get a maximum $V$ of $\sim 0.3+$?
Polarizer at each beam entrance, One rotated.
Polarization rotation

<table>
<thead>
<tr>
<th></th>
<th>Sig1</th>
<th>Sig2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test1-0</td>
<td>30</td>
<td>80</td>
</tr>
<tr>
<td>Test1-90</td>
<td>40</td>
<td>110</td>
</tr>
</tbody>
</table>

differential polarization rotation = 50°
70°
\[ I = 2 \times (1 + \cos(\phi) \times (\cos(\theta))^2 + \cos(\phi + d\phi) \times (\sin(\theta))^2) \]

differential delay \( d\phi \) wrt to polarization

JouFLU V_SCANS 4

one polarizer at WL source, no polarizer also shown

differential phase delay \( d\phi \) btw orthogonal polarizations

\( d\phi = 109 \) degree \( \pm \) max

Classic V_SCANS 4

V_SCANS Detector1 Mean
V_SCANS Detector2 Mean
V_SCANS Combined Mean
no plz det1
no plz det2
no plz combined

Classic test 4

I1 detector1 mean
I1 detector2 mean
I2 detector1 mean
I2 detector2 mean

one polarizer at WL source

JouFLU 4

V

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180

one polarizer at WL source

V

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180

one polarizer at WL source
Polarization Summary

- Found differential polarization rotation and differential phase delay
- Modelling differential phase delay gives $d\phi = 109^\circ$ and $90^\circ$ periodicity
- Max $V \sim 0.73$
  - bandwidth smearing / dispersion
  - beam intensity imbalance
  - fringe sampling & finite integration effects
  - AND differential polarization rotation.

Differential rotation:
- $V$ loss is analogous to beam intensity mismatch

\[
V_{\text{obs}} = V \frac{2 \cos(\alpha)}{1 + \cos^2(\alpha)}
\]

- $50^\circ \quad \Rightarrow \quad 90\% V$
- $70^\circ \quad \Rightarrow \quad 60\% V$

Additionally,
- WL is probably not circularly polarized.
- We observe average $V\sim0.42$ instead of expected $0.59$.
- WL is elliptically polarized (close to $50$ or $150^\circ$).

Beam Balance

- Factor of 2-3 diff between FLUOR beams
  - Beam A weak
- 15% difference between CLASSIC beams
- Reduces maximum visibility
- Replace OAPs
Spectral dispersion

- K band
- Up to 10 spectral channels
- 500 Hz fastest rate possible with 5 spectral channels
- Remove chromatic biases / bandwidth smearing
- Expect factor of 100 improvement when science star and calibrator are of different types
Spectrally dispersed lab fringes
Scan vel for calc, fitted fringe to each scan for wavelength

\[ y = -0.0285x + 2.2012 \quad \text{R}^2 = 0.3171 \]

\[ y = -0.0611x + 2.2826 \quad \text{R}^2 = 0.8866 \]

<table>
<thead>
<tr>
<th></th>
<th>S1</th>
<th>S2</th>
<th>avg</th>
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<tbody>
<tr>
<td>total</td>
<td>0.17</td>
<td>0.27</td>
<td>0.22</td>
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<tr>
<td>bandwidth</td>
<td>12.94</td>
<td>7.90</td>
<td>9.81</td>
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</table>
Dust production mechanism poorly understood

Close-in dust extremely short lived

≈ few yrs

≈ $10^{-8} \ M_\oplus/yr$ to replenish

(10 Hale-Bopps per day)

Destruction factors:

- Sublimation
- Radiation Pressure
- Poynting-Robertson (P-R) drag

Models:

- Steady state/continuous replenishment
- Steady state/trapped nano-grains [Su et al. (2013), Lebreton et al. (2013)]
- LHB & outgassing
Statistics, origin, and evolution
Absil et al. Disk Survey

42 stars A-K (mag limited)
Spectral type, age, metallicity, presence of cold dust

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>F</th>
<th>G-K</th>
<th>Total</th>
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<tbody>
<tr>
<td>Cold disk</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>No outer disk</td>
<td>4</td>
<td>7</td>
<td>9</td>
<td>19</td>
</tr>
<tr>
<td>Unknown</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>15</td>
<td>15</td>
<td>42</td>
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• Most common around A stars

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<table>
<thead>
<tr>
<th></th>
<th># MS (K &lt; 4)</th>
<th># MS w. debris (K &lt; 4)</th>
<th># MS (K &lt; 5)</th>
<th># MS w. debris (K &lt; 5)</th>
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<tbody>
<tr>
<td>All</td>
<td>303</td>
<td>45</td>
<td>1158</td>
<td>103</td>
</tr>
<tr>
<td>North</td>
<td>156</td>
<td>16</td>
<td>536</td>
<td>42</td>
</tr>
<tr>
<td>South</td>
<td>147</td>
<td>29</td>
<td>622</td>
<td>61</td>
</tr>
<tr>
<td>-10° &lt; dec &lt; +20°</td>
<td>73</td>
<td>8</td>
<td>256</td>
<td>21</td>
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</tbody>
</table>
**Age or amount of available material?**

- A stars: not clear if correlation with metallicity
- FGK stars lack warm dust due to ages > 1 Gyr

Absil et al. 2013 (submitted)
NASA Origins Program with Betrand Mennesson

• 3 year program: exozodi disk survey
  ≈ 100 nearby MS stars
  20% long/short, rest only short baselines
  – hot dust (1000-1500K), expected in 25-30% of MS systems

• Goal: excesses at 0.5% level (5σ) for $m_K=5$
  – Determine grain properties, disk morphology, correlations b/t stellar properties

• Visibility precision to <0.1%
IRTF

• SpeX
  – 2-5 µm spectra
  – Followup to survey
  – Photosphere-subtracted SED slope
  – Cross-correlate with Interferometric data
  – Add constraints to dust disk models
    • temperature, size of the dust grains, age estimate, composition, mass, albedo
  – Look for spectroscopic debris disk markers
Future plans

• CHARA AO
  – Increased sensitivity
  – Fainter magnitude limit
  – More targets
  – On axis, small field of view AO systems for each telescope.

• CHAMP
  – Full fringe tracking and locking capability on all baselines.

for FLUOR

• Spectral dispersion mode observations
• Integration with CHAMP
• Further camera and software improvements
Complementary studies

- Follow-up of gravitational microlensing survey
  - Faint, 7th mag
  - Targets of opportunity
  - Alert network? (Cassan 2012)

- CHEOPS (CHaracterizing ExOPlanet Satellite)
  - Photometry of known exoplanet host stars
    - Bright, low activity stars
  - Determine radii, dynamics, and atmospheric properties

- Investigate potential targets of EChO transit space mission
  - 2022 launch
  - Feasibility study, full program requires CHARA AO
  \[ \approx 100 \text{ planetary spectra} \]
References

• http://www.cfa.harvard.edu/COMPLETE/learn/debris_disks/debris.html
CHARA systems interface

server

Hardware

vpn

Gtk client

Array systems

CHARA messages
11.8963 % S2 obstruction
8.83448 % W1 obstruction
0.862847 % W2 obstruction
6.49262 % E1 obstruction
1.40250 % E2 obstruction

(solid angle above 20.0000 degrees)
<table>
<thead>
<tr>
<th>Date</th>
<th>Description</th>
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<tr>
<td>7/1/2011</td>
<td>Switch from LabView to C</td>
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<tr>
<td>9/29/2011</td>
<td>Remote obs setup</td>
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<td>10/4/2011</td>
<td>1st remote run</td>
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<tr>
<td>2/1/2012</td>
<td>JouFLU hardware install</td>
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<tr>
<td>5/1/2012</td>
<td>First fringes</td>
</tr>
<tr>
<td>11/7/2012</td>
<td>CALI Meudon tests</td>
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<td>12/19/2012</td>
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<tr>
<td>4/1/2013</td>
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<tr>
<td>4/28/2013</td>
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<tr>
<td>5/5/2013</td>
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<tr>
<td>5/7/2013</td>
<td>Optimized MONA plz</td>
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<tr>
<td>5/14/2013</td>
<td>First on-sky fringes w NICMOS</td>
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<tr>
<td>5/29/2013</td>
<td>Moved MONA, NICMOS, &amp; output</td>
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<td>5/30/2013</td>
<td>Realigned OAPs</td>
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<td>6/3/2013</td>
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<td>7/17/2013</td>
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<tr>
<td>10/10/2013</td>
<td>FLUOR run-IV</td>
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<tr>
<td>2/17/2014</td>
<td>Switched to ethernet readout</td>
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<tr>
<td>2/18/2014</td>
<td>Spectral dispersion mode added</td>
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