The Near IR EBL

...the dominant source of error in directly measuring the CIRB, the model-based subtraction of the zodiacal light, will not be significantly reduced with currently available data.

A directly measured map of the zodiacal light, which would have to be observed from outside the bulk of the IPD cloud, beyond about 3AU...

...could be a camera on a probe to one of the outer planets...

...observing the same fields at widely different solar elongations during a long-lived mission as the craft orbits the Sun, or by observing during the cruise from 1 to 3 AU as the dust density decreases ...a space mission of this type will ultimately be required.

- Levenson, Wright & Johnson (2007)
<table>
<thead>
<tr>
<th>DIRBE Minus 2MASS Foreground Subtraction</th>
<th>Spitzer/IRAC Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>•10.1 ± 7.4 kJy/sr at 1.25 μm</td>
<td></td>
</tr>
<tr>
<td>•17.6 ± 4.4 kJy/sr at 2.2 μm</td>
<td></td>
</tr>
<tr>
<td>•16.1 ± 4 kJy/sr at 3.5 μm.</td>
<td>6.5 kJy/sr at 3.6 μm</td>
</tr>
</tbody>
</table>
Foreground Subtraction from DIRBE Maps

\[ I_{\text{DIRBE}} = I_{\text{ZODI}} + I_{\text{STAR}} + I_M + I_{\text{CIRB}} \]

Zodi Subtraction

Kelsall et al. (1998)
Wright (1998)

DIRBE Minus 2MASS

Wright (2001)
Wright & Johnson (2001)
Levenson, Wright & Johnson (2007)
DIRBE Minus 2MASS
40 New Regions at 2.2 Microns

Levenson, Wright & Johnson (2007)
DIRBE Minus 2MASS
40 New Regions at 1.25 Microns

Levenson, Wright & Johnson (2007)
DIRBE Minus 2MASS
40 New Regions at 3.5 Microns

Levenson, Wright & Johnson (2007)
CIRB vs Ecliptic Latitude

**K-Band**

**J-Band**

**L-Band**

Table 5. Error Budget for the CIRB [kJy/sr]

<table>
<thead>
<tr>
<th>Component</th>
<th>1.25 μm</th>
<th>2.2 μm</th>
<th>3.5 μm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scatter</td>
<td>0.51</td>
<td>0.14</td>
<td>0.20</td>
</tr>
<tr>
<td>Faint Source</td>
<td>1.17</td>
<td>0.85</td>
<td>0.42</td>
</tr>
<tr>
<td>Galaxies</td>
<td>0.05</td>
<td>0.10</td>
<td>0.05</td>
</tr>
<tr>
<td>Calibration</td>
<td>1.77</td>
<td>2.24</td>
<td>0.60</td>
</tr>
<tr>
<td>Zodiacal</td>
<td>5.87</td>
<td>3.79</td>
<td>3.25</td>
</tr>
<tr>
<td>Quadrature Sum</td>
<td>6.26</td>
<td>4.49</td>
<td>3.34</td>
</tr>
</tbody>
</table>
Spitzer Counts

Avg of uncorrected observed counts in regions 1,2,3

Completeness corrected observed counts

Model counts

N/mag/deg^2 vs. Vega–Rel Magnitude
MCMC Results

Aperture Photometry

$9.2^{+1.2}_{-0.7}$ kJy sr$^{-1}$

Profile–Fit Photometry

$10.8^{+2.1}_{-1.1}$ kJy sr$^{-1}$
Resolving the *galactic contribution*

- JWST NIRCAM should reach $M_{\text{vega}} > 25$ and resolve the galactic contribution to the CIRB in small fields.
- This does *not* necessarily mean JWST will resolve the CIRB!
# Current Status

<table>
<thead>
<tr>
<th>DIRBE Minus 2MASS in 53 Regions:</th>
<th>MCMC simulation of Profile Fit Galaxy Counts:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- K: 14.7 ± 4.5 kJy/sr</td>
<td>- L: $10.8^{+2.1}_{-1.1}$/sr</td>
</tr>
<tr>
<td>- L: 15.6 ± 3.3 kJy/sr</td>
<td>- Weakly constrains CIRB on bright end</td>
</tr>
<tr>
<td>- J: 8.9 ± 6.3 kJy/sr</td>
<td></td>
</tr>
</tbody>
</table>

**Cosmic Infrared Background ExpeRiment (CIBER, Jamie Bock PI)**
- Engineering Flight Completed (Feb 2009)
- 2nd Flight Scheduled (June 2010)
- Narrow Band Fraunhofer Line Spectrometer (CaII)
- Low Resolution Spectrometer
- I & H Band Wide Field Images for Fluctuations
- Will nail down absolute zodi intensity in a few regions of sky from 1AU
- See Zemcov poster in this workshop.
The View from 5AU

2 orders of magnitude improvement on main systematic!
Conclusions

• Zodi-prevents precision measurement of the total CIRB.

• Galaxy counting is only ever a lower limit on the CIRB.

• CIBER will not map the shape of the IPD cloud.

• Transition from foregrounds that are 1,000% to foregrounds that are < 10-25% of the signal we are looking for!
Residuals

J–Band Residuals

Median: 0.005
Interquartile Range: 3.57

K–Band Residuals

Median: 0.233
Interquartile Range: 2.85

L–Band Residuals

Median: 0.070
Interquartile Range: 2.11
# CIRB Corrections

Table 4. CIRB Corrections [kJy sr\(^{-1}\)]

<table>
<thead>
<tr>
<th>Photometry</th>
<th>(\sum n(m) f(m))</th>
<th>(\sum (n(m)/\text{comp}(m)) f(m))</th>
<th>(\sum n_{\text{model}}(m) f(m))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profile Fit</td>
<td>9.3</td>
<td>12.9</td>
<td>(10.8^{+2.1}_{-1.1})</td>
</tr>
<tr>
<td>Aperture</td>
<td>5.3</td>
<td>7.1</td>
<td>(9.2^{+1.2}_{-0.7})</td>
</tr>
</tbody>
</table>

Note. — The non-Gaussian nature of the flux errors, seen in Figures 8 and 15, makes a determination of the errors in the first two numerical columns difficult, necessitating the modeling procedure that gives the above 1\(\sigma\) confidence limits on the modeled CIRB.
Zodiacal Light Model

\[ I_{\text{obs}}(\lambda, l, b, t) = Z(\lambda, l, b, t; P) + I_c(\lambda, l, b) \]

\[ Z(\lambda, l, b, t; P) = \sigma_\lambda \int \left( \rho_c[r(s)] + \rho_r[r(s)] + (p_{12S}) \rho_b[r(s)] \right) \Phi(\mu) D_\lambda(T_\odot) R^{-2} ds \]
\[ + \kappa_\lambda \int \left( \rho_c[r(s)] + \rho_r[r(s)] + (p_{12T}) \rho_b[r(s)] \right) D_\lambda(T(R)) ds. \]

Kelsall et al. (1998), Wright (1998)
Foreground Subtraction from DIRBE Maps

\[ I_{\text{obs}}(\lambda, l, b, t) = Z(\lambda, l, b, t; P) + I_c(\lambda, l, b) \]

Kelsall et al. (1998), Wright (1998)

\[ I_c(\lambda, l, b) = B(\lambda, l, b) + F(\lambda, l, b) + CIRB(\lambda) \]
Galaxy Counts: Flux Uncertainty

- Poisson Error
- Cosmic Variance
- Completeness
- Flux Uncertainty
We find a consistent residual intensity in the 40 regions of:

- J: $8.9 \pm 6.3$ kJy/sr
- K: $14.7 \pm 4.5$ kJy/sr
- L: $15.6 \pm 3.3$ kJy/sr

These values are consistent with previous determinations of the NIR CIRB via direct detection.