A Precise Measurement of the Infrared Background: Instrumental Requirements

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The EBL ≠ IGL Mystery

Extragalactic Background Light =
Total Line of Sight Brightness – Stars – Zodiacal Light – Interstellar Medium

Integrated Galaxy Light =
Sum over light from all individually detected galaxies

IGL =< EBL

Isotropy is a requirement!
The tentative but persistent disconnect between EBL and IGL measurements

Cambresy, WTR et al. 2001
2.2 microns

Are we missing sources and/or flux?
Or are we incorrectly subtracting zodiacal light?
Or is everything hunky dory within uncertainties

GOODS 3.6 microns
Two Critical Science Questions

• What is the reionization history of the Universe?
  – Sets metallicity floor for normal stars/galaxies to form
  – 1-3% of current metals formed in first generation of stars
  – Addresses top down vs bottom up galaxy formation
  – Addresses why not all DM halos might form dwarf galaxies

• What is the fractional contribution of comets and KBOs to the dust in the outer solar system?
Unfortunately Sky Background at Infrared Wavelengths is Dominated By Zodiacal Light at 1 AU

**2.2 micron contributions**

- **Zodiacal Light**: 74%
- **Stars**: 0%
- **CIRB**: 14%
- **ISM**: 12%

CIRB (nW m\(^{-2}\) sr\(^{-1}\))

<table>
<thead>
<tr>
<th>λ</th>
<th>νI(_ν)</th>
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<tbody>
<tr>
<td>2.2</td>
<td>22.4±6.0 (reionization &gt;0.2)</td>
</tr>
<tr>
<td>3.5</td>
<td>11.0±3.3 (reionization &gt;0.1)</td>
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<tr>
<td>140</td>
<td>25±7</td>
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<tr>
<td>240</td>
<td>14±3</td>
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This is a needle in a haystack problem. To get a 5σ measurement of the most pessimistic reionization epoch signal needs a precision of ~0.2% on the EBL. This is a factor of 150 (!) better than current measurements.
A Clue?
There is an “Isotropic” Excess even at 60 and 100 µm

Contribution from galaxies

Finkbeiner et al. 2000
Chary & Pope 2010
High Albedo Cometary Dust at Kuiper Belt Distances?

Hahn et al. 2002
A. Stern 1996
This is NOT a needle in a haystack problem. To get a 5σ measurement of the likely cometary dust signal needs a precision of ~10% on the EBL @ 2.2micron. This is a factor of 3 better than current measurements.

NIR Spectrum is different compared to reionization signal

Chary & Pope, 2010
How can we measure this signal?

A Unique Opportunity to Measure the EBL at 5 AU

Getting out to 5AU is a minimum requirement. 10 AU might be preferred.

Chary: View from 5AU
Instrument Specs at 5-10 AU

Pipe Dream
2.5m telescope, 0.06” pix
absolute dark/bias calibration
degree FOV
R~500 spectrometer

Reality
10-30cm telescope, 0.6-2” pix
absolute dark/bias calibration
degree FOV
R~500 spectrometer
Requires ancillary deep imaging

4%, 10%, 34% unmasked pix
With 10, 15, 30 cm and 0.6”
An Imager and/or a Spectrometer?

- We need to have a spectrometer to measure Fraunhofer lines and calibrate out residual foreground signal even at 5-10 AU.
  - Spectral resolution of ~300
  - Get critical lines e.g. Ca
- Goal for absolute flux calibration of 0.1% @ 2 microns.
- 5sigma requirement @ 2 microns = 0.2 nW/m²/sr
- Minimum wavelength range of 0.5-3 microns with multiple filters
  - To distinguish solar spectrum from reionization spectrum
- Telescope aperture and pixel scale trade off
  - Small pixel scale to avoid confusion of pixel flux from nearby sources
  - Large pixel scale to cover wide area
  - Large aperture so PSF does not result in spill over of flux from brighter sources
  - Small aperture to piggyback on to an existing spacecraft
Its hard but that’s the challenge

ZEBRA: Zodiacal dust, Extragalactic Background, & Reionization Apparatus
Reionization
-The conversion of neutral hydrogen to ionized Hydrogen
-Thought to be due to the photons from star-forming galaxies
-QSOs/AGN are thought to be a negligible contributor
-Other exotic candidates have been proposed e.g. decaying dark matter, cosmic strings

The Problem:
The total ionizing photon budget from detected star-forming galaxies falls x10 short of addressing reionization.
Bouwens et al. 2009; Chary & Cooray 2010