Taurus

A Balloon-borne Polarimeter for Cosmic Reionization and Galactic Dust

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Taurus

- CMB E-Mode polarization
- Mid-latitude balloon (2026)
  - Up to 50 days

- High Frequencies
  - 4 bands: 150 – 350 GHz

- Large Scales
  - 70% of the sky
  - Simple Refractive Optics
  - Degree Resolution

- Recently Funded! (NASA APRA)
Big Bang

??? Inflation ???

Particles Form

Photons + matter coupled

Recombination

Dark Ages

First Stars and Galaxies
Nuclear fusion (again)
Chemistry

Geology
Biology

Anthropology, etc

Today

Reionization, Neutrinos

“Initial” fluctuations:
- $A_s$ amplitude
- $n_s$ scale-dependence

Kinds of stuff:
- $\Omega_b h^2$ baryons
- $\Omega_c h^2$ dark matter
- $\Omega_\Lambda$ dark energy
- $\Sigma m_\nu$ neutrino mass

Reionization:
- $\tau$ optical depth
CMB E-modes and Reionization (Tau’R’Us)
CMB E-modes and Reionization and Neutrinos

With CMB-S4:

![Graph showing CMB E-modes and Neutrino contributions.](image)
Why on a balloon? The atmosphere

![Graph showing optical loading vs frequency for different altitudes and ground conditions.](image-url)
Conventional Balloon vs. Super Pressure

Conventional: zero pressure, constant daylight, diurnal He loss
Super Pressure: pressurized, day/NIGHT cycles, fixed He quantity
# Taurus Bands

![Graph showing optical loading and band normalization against frequency.

<table>
<thead>
<tr>
<th>Band Center (GHz)</th>
<th>Bandwidth (GHz)</th>
<th>Beam FWHM (arcmin)</th>
<th>Number of Detectors</th>
<th>Absorbed Power (pW)</th>
<th>Detector Sensitivity ($\mu K_{\text{CMB}} \sqrt{S}$)</th>
<th>Instrument Sensitivity ($\mu K_{\text{CMB}} \sqrt{S}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>40</td>
<td>60</td>
<td>3024</td>
<td>0.9</td>
<td>76</td>
<td>1.5</td>
</tr>
<tr>
<td>220</td>
<td>55</td>
<td>40</td>
<td>3024</td>
<td>1.1</td>
<td>123</td>
<td>2.4</td>
</tr>
<tr>
<td>280</td>
<td>70</td>
<td>60</td>
<td>2016</td>
<td>1.4</td>
<td>220</td>
<td>5.4</td>
</tr>
<tr>
<td>350</td>
<td>85</td>
<td>50</td>
<td>2016</td>
<td>1.6</td>
<td>550</td>
<td>13.4</td>
</tr>
</tbody>
</table>
Taurus Detectors (NIST)

- ~10k 100 mK TESes. Dichroic 150/220 and 280/350 GHz
- Corrugated feed horns, stacked silicon wafers
- Time-domain multiplexed readout
Taurus Sky Coverage: 70%
High Frequencies: Separating Dust
Projected Limits

Sigma (Tau) vs. Minimum $\ell$

- 7 Days
- 30 Days

30 uK$^{-1}$, 0.55 (0.41) sky
14 uK$^{-1}$, 0.55 (0.41) sky
1 uK$^{-1}$, full sky, 10' beam
Planck 2018 error
Thank you! (and Taurus people)

Steven Benton (PI)  Princeton
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Jake Connors
and more

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Jon Gudmundsson  Stockholm

Barth Netterfield  Toronto
StarSpec Tech.

Sasha Rahlin  FNAL
Extra Slides (hindsight)
Scan-Synchronous Noise Mitigation

... also more sky rotation and better scan strategy
Stratospheric Balloons

- Balloon at Launch
  - 25.2m (83 ft)
- Balloon Characteristics:
  - 1.12 \times 10^4 \text{ meters}^2
  - 89.50 \times 10^6 \text{ meters}^2
  - 20.32 \text{ microns}
  - 32.20 \text{ kilometers}
  - 40.20 \text{ kilometers}
  - 3,175 \text{ kilograms}
- Washington Monument
  - 197m (646 ft)
  - 169.3m tall (555.4 ft)
- Furling Parachute
  - 261m (856 ft)
- Ladder
  - 61m (200 ft)
  - Payload
  - 3m (10 ft)
- Max. Payload Weight
  - 8,000 pounds

- Balloon Volume
  - 39.57 \times 10^6 \text{ feet}^3
- Balloon Surface Area
  - 22.19 \text{ acres}
- Skin Thickness
  - 0.8 \text{ mil}
- Length of Seams
  - 21.6 miles
- Nominal Altitude
  - 132,000 feet
- Max. Payload Weight
  - 8,000 pounds