Degree Scale Anomalies in the CMB: Localizing the First Peak Dip to a Small Patch of the North Ecliptic Sky

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arxiv.org:1005.5389
• Temperature maps are decomposed into spherical harmonics and their coefficients

\[ \Delta T(n) = \sum_{l>0} \sum_{m=-l}^{l} a_{lm} Y_{lm}(n) \]

• The coefficients can be written in terms of the temperature fluctuations

\[ a_{lm} = \int d\Omega_n \Delta T(n) Y_{lm}^*(n) \]

• If the coefficients are gaussian, we can exploit their properties to find the power spectrum

\[ \langle a_{lm} \rangle = 0 \]

\[ \langle a_{lm} a_{l'm'}^* \rangle = \delta_{ll'} \delta_{mm'} C_l \]

• We can rewrite the \( C_l \)'s in terms of the coefficients and use them to plot the power spectrum

\[ C_{l}^{\text{sky}} = \frac{1}{2l+1} \sum_{m=-l}^{l} |a_{lm}|^2 \]
The Angular Power Spectrum

Hinshaw 2003
Gray – Data from the poles
Black – Data from the plane

Hinshaw 2003
Changes to 1\textsuperscript{st} year analysis

- Beam transfer function changed
- Additional point sources masked out
- Map weighting scheme changed

1\textsuperscript{st} year power spectrum

For $200 < l < 450$

$$W(p) = \frac{M(p)}{1/\langle N_{\text{obs}} \rangle + 1/N_{\text{obs}}(p)}$$

3\textsuperscript{rd} year power spectrum and beyond

$$l = 500$$

$$W(p) = M(p)$$

Hinshaw et al. 2003

Nolta et al. 2008
The Game Plan

• Mask different regions of the WMAP skies (specifically the north and south ecliptic poles)

• Calculate the corresponding power spectra

• Generate 10,000 realistic random LCDM skies

• Use random maps to determine statistical significance
Shown are the full sky (blue), full sky without the north (red) and south (black) ecliptic caps, the ecliptic plane only (green), and the ecliptic poles only (yellow). The galaxy is always masked out.
Shown are the full sky (blue), full sky without the north (red) and south (black) ecliptic caps, the ecliptic plane only (green), and the ecliptic poles only (yellow). The galaxy is always masked out.
Fifth year data

Shown are the full sky (blue), full sky without the north (red) and south (black) ecliptic caps, the ecliptic plane only (green), and the ecliptic poles only (yellow). The galaxy is always masked out.
Simulated Sky Maps

- Generate a random set of $a_{\ell m}$ from input LCDM power spectrum
- Make map from $a_{\ell m}$
- Make map more “realistic” by adding
  - Pixel noise
  - Beam transfer function
- Use realistic sky maps to calculate peak statistic
\[ S_{\text{peak}} \equiv 2 \frac{\sum_{\ell = \ell_{\text{min}}}^{\ell_{\text{max}}} \left( C_{\ell}^{KQ85 + \text{add'l mask}} - C_{\ell}^{KQ85} \right)}{\sum_{\ell = \ell_{\text{min}}}^{\ell_{\text{max}}} \left( C_{\ell}^{KQ85 + \text{add'l mask}} + C_{\ell}^{KQ85} \right)} \]
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First year weighting

Third year weighting

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<th>1st year weighting</th>
<th>3rd year weighting</th>
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<td>95.78%</td>
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<td>96.23%</td>
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First year weighting

Third year weighting

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Conclusions

• WMAP claims that decrease in power went away after first year, despite changes in weighting scheme
• We find that using the data from the north ecliptic pole decreases the power of the CMB across all data releases
• This increase is significant to above 96% in the 5th year release

Future Work

• Use 7 year data for analysis
• Look at modulation of other anomalous points
• Planck
• Check modulation around the sky