

Title: Are There Echoes From The Pre-Big Bang Universe? A Search for Low Variance Circles in the CMB Sky

Date: Feb 24, 2011 11:00 AM

URL: <http://pirsa.org/11020163>

Abstract: The existence of concentric low variance circles in the CMB sky, generated by black-hole encounters in an aeon preceding our big bang, is a prediction of the Conformal Cyclic Cosmology. Detection of three families of such circles in WMAP data was recently reported by Gurzadyan & Penrose (2010). We reassess the statistical significance of those circles by comparing with Monte Carlo simulations of the CMB sky with realistic modeling of the anisotropic noise in WMAP data. We find that the circles are not anomalous and that all three groups are consistent at 3sigma level with a Gaussian CMB sky as predicted by inflationary cosmology model.

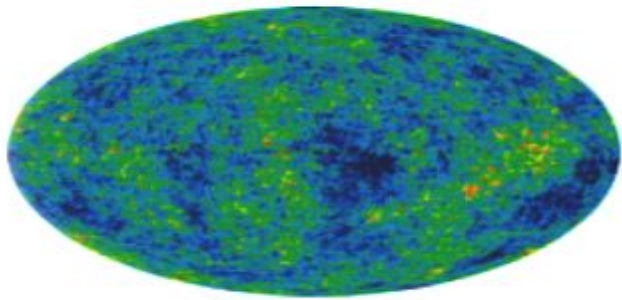
Are There Echoes From the Pre-Big Bang Universe?



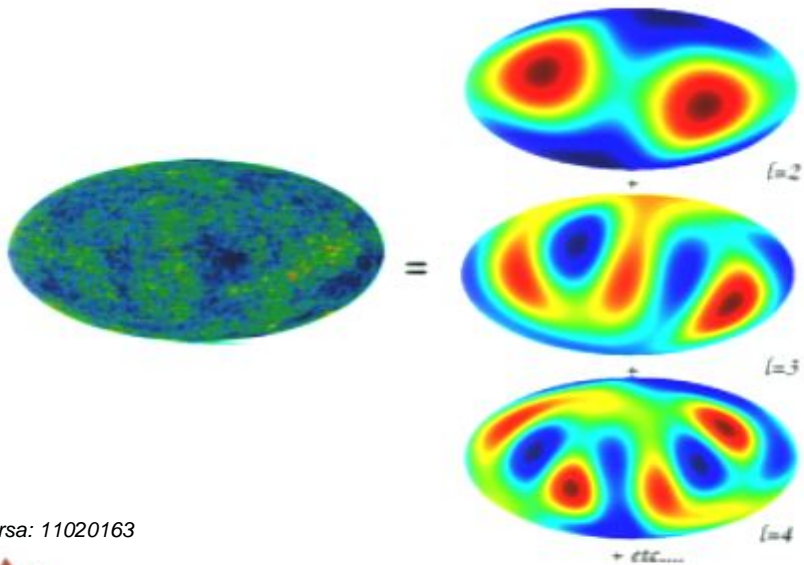
Amir Hajian

Canadian Institute For Theoretical Astrophysics

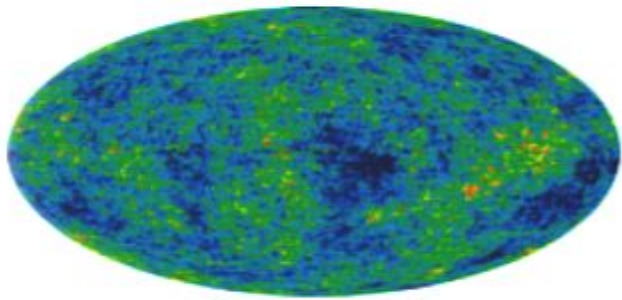
Definitions



$$\Delta T(\theta, \phi) = \sum_{l=2}^{\infty} \sum_{m=-l}^l a_{lm} Y_{lm}(\theta, \phi)$$



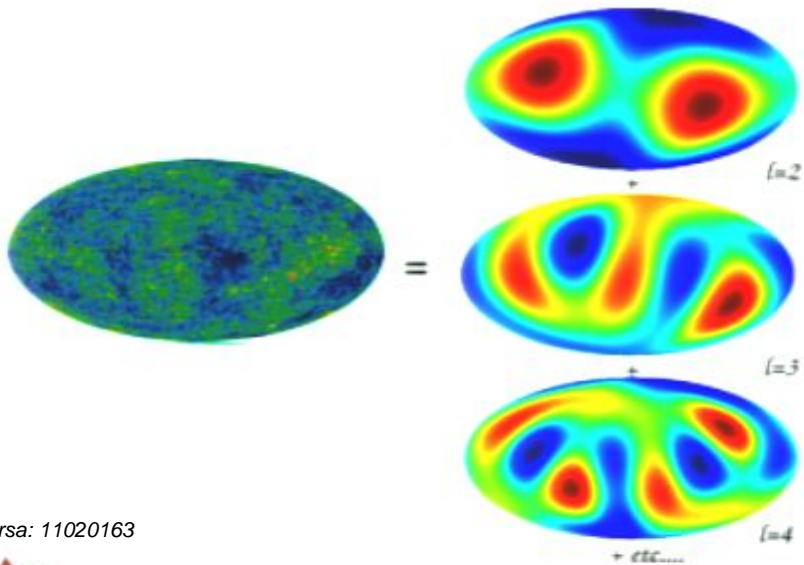
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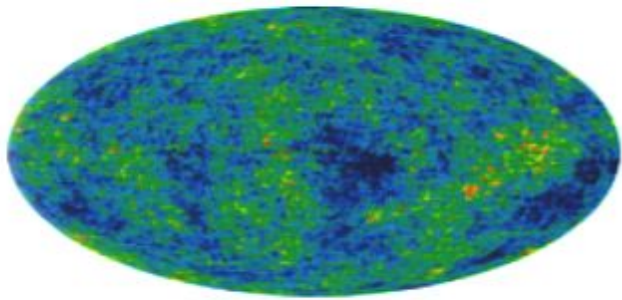
$$\int d\Omega_{\hat{n}} \Delta T(\hat{n}) Y_{lm}^*(\hat{n})$$

a_{lm}

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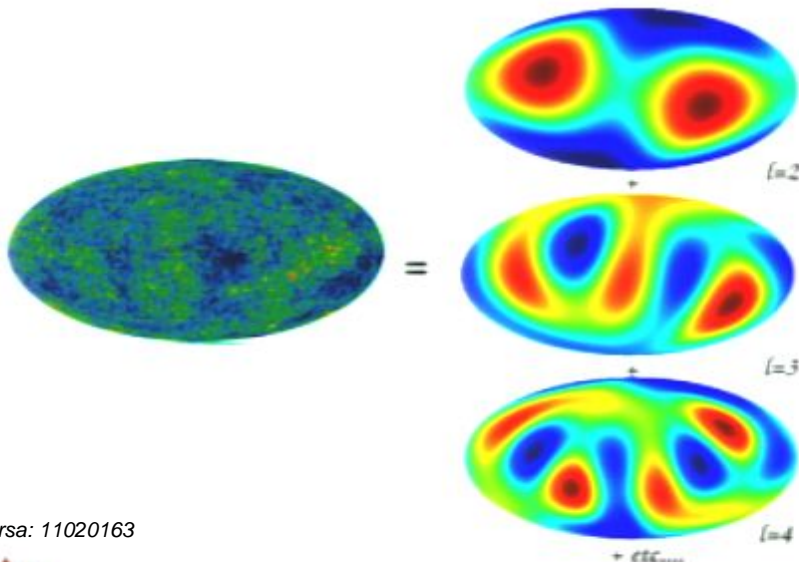


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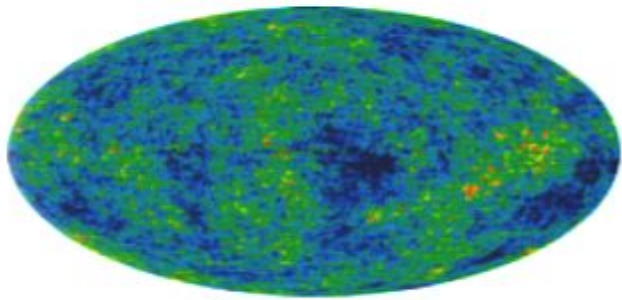
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$$\frac{1}{2l+1} \sum_{m=-l}^l |a_{lm}|^2$$



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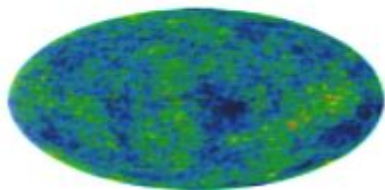


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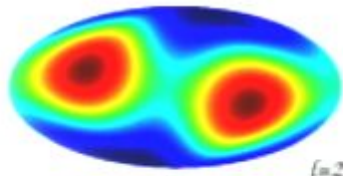
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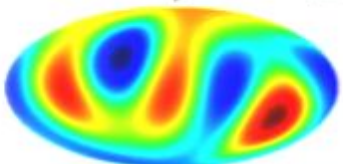
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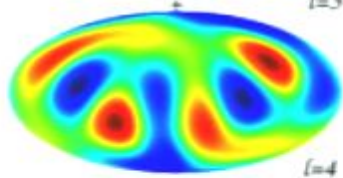
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$l=2$

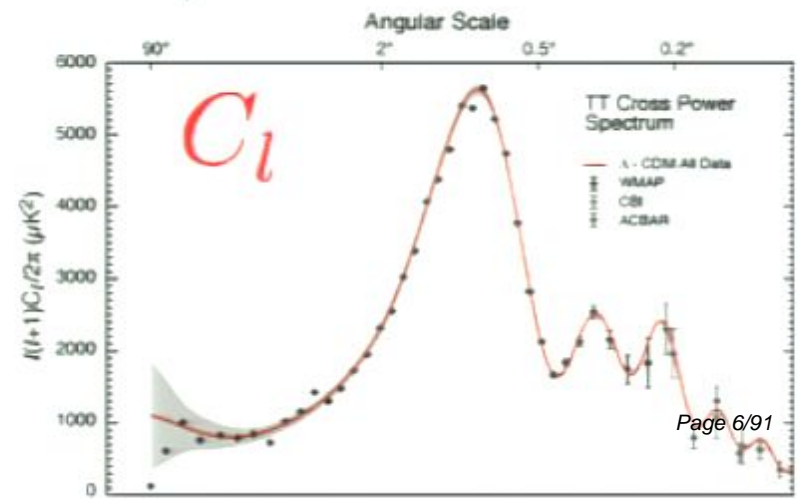


$l=3$



$l=4$

+ etc....



Amazing agreement between the theory and observations!

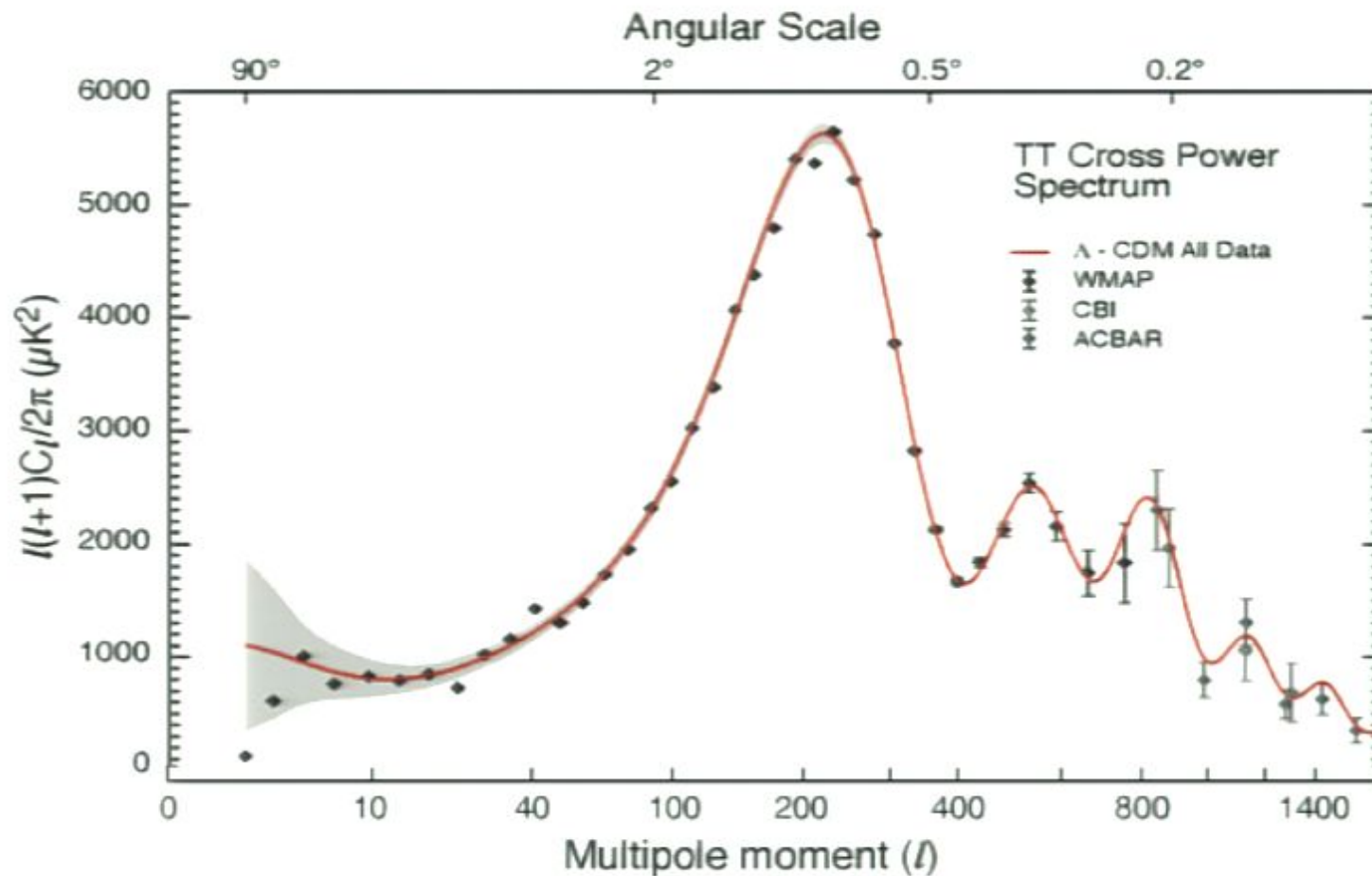
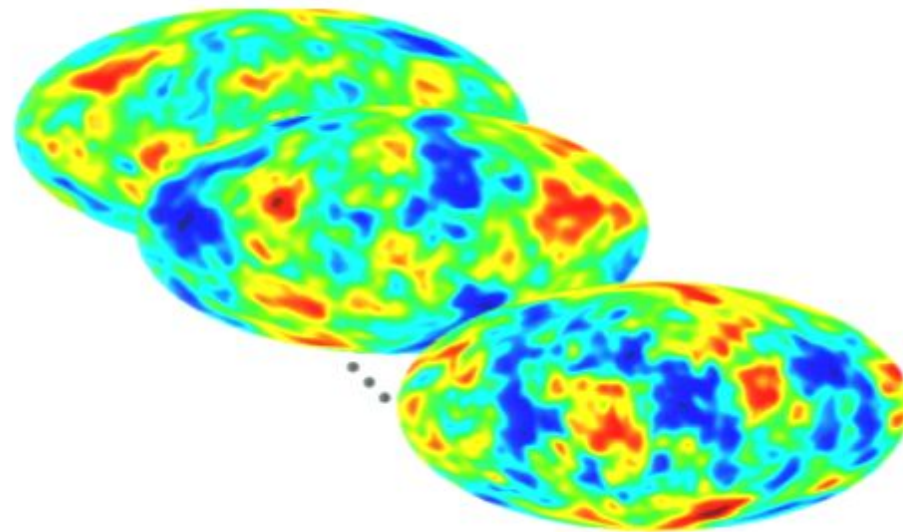


Figure: WMAP

Simulations



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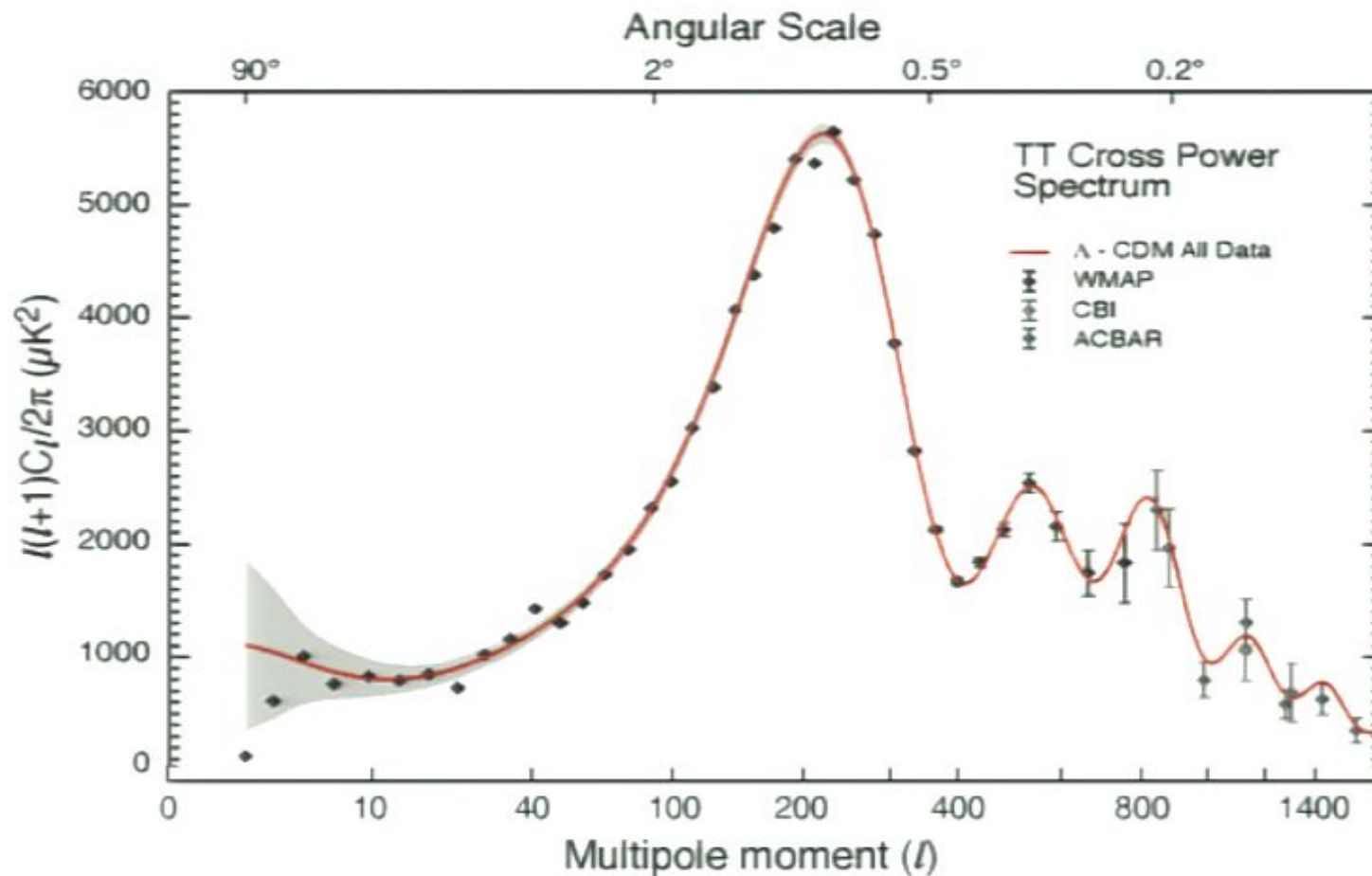
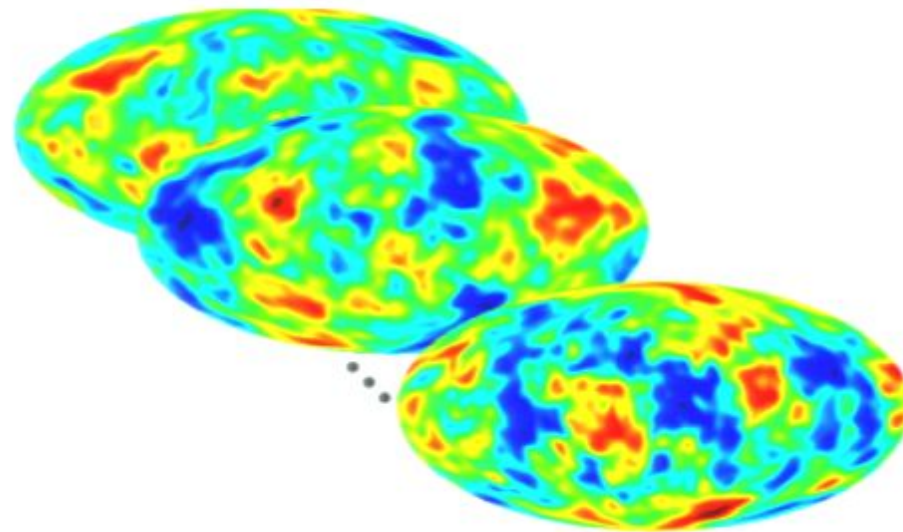
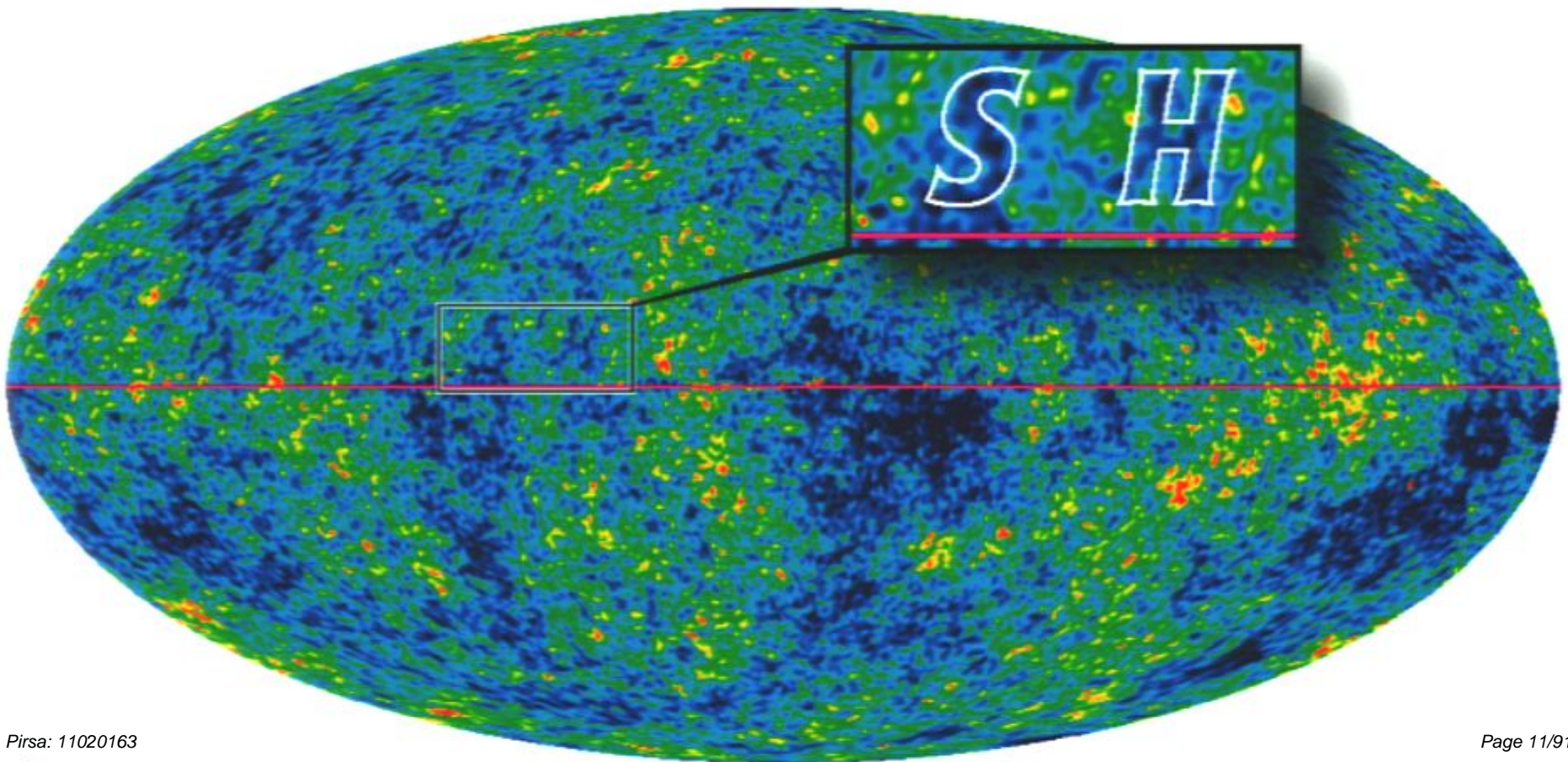


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Beware of a posterior statistics!



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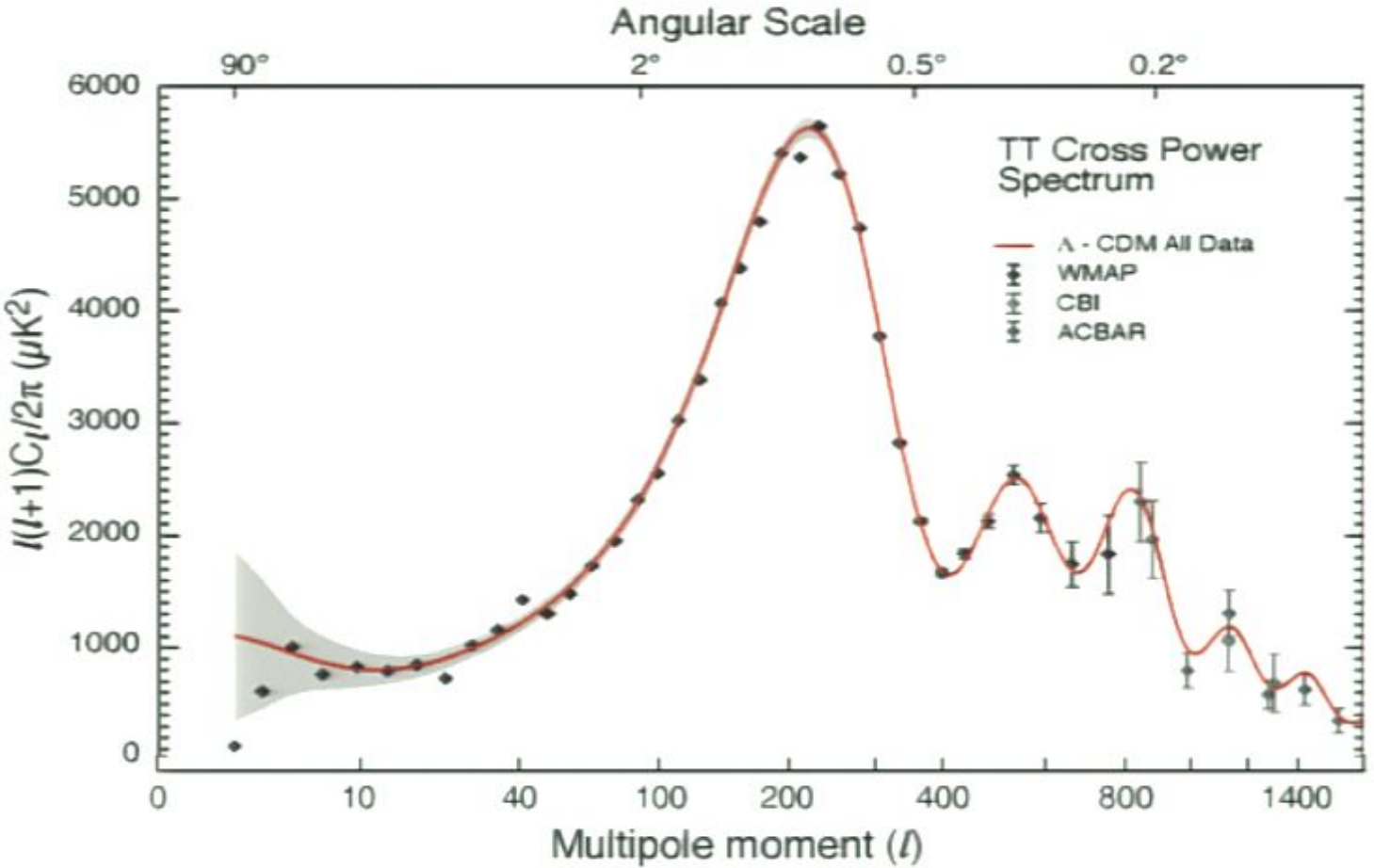
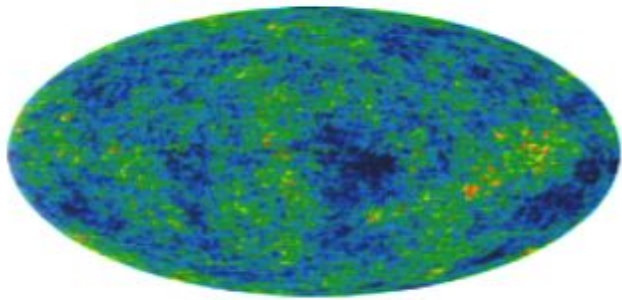
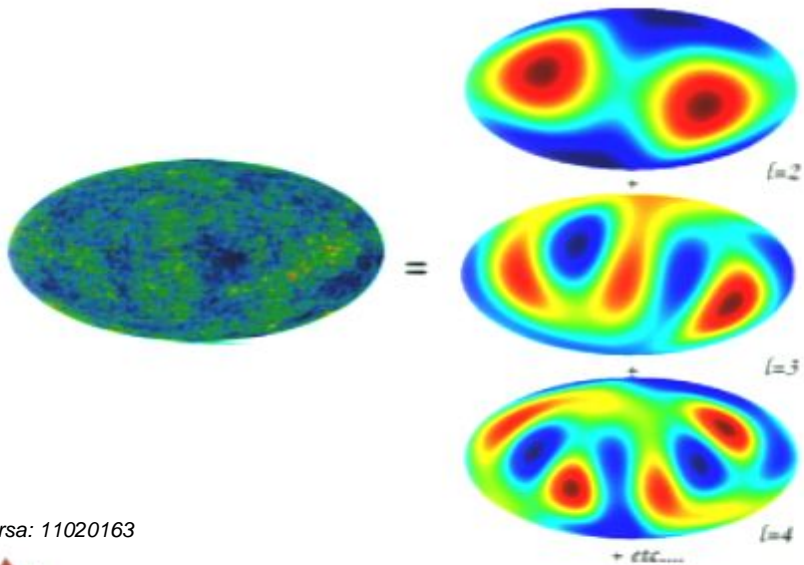


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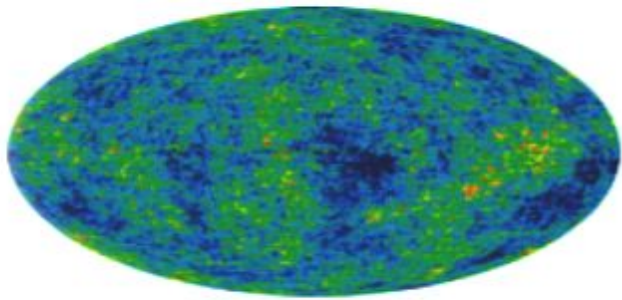
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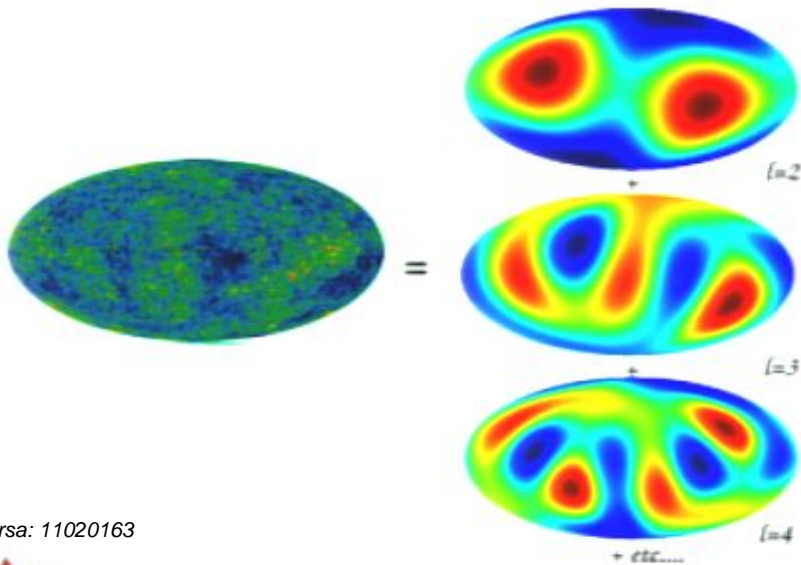
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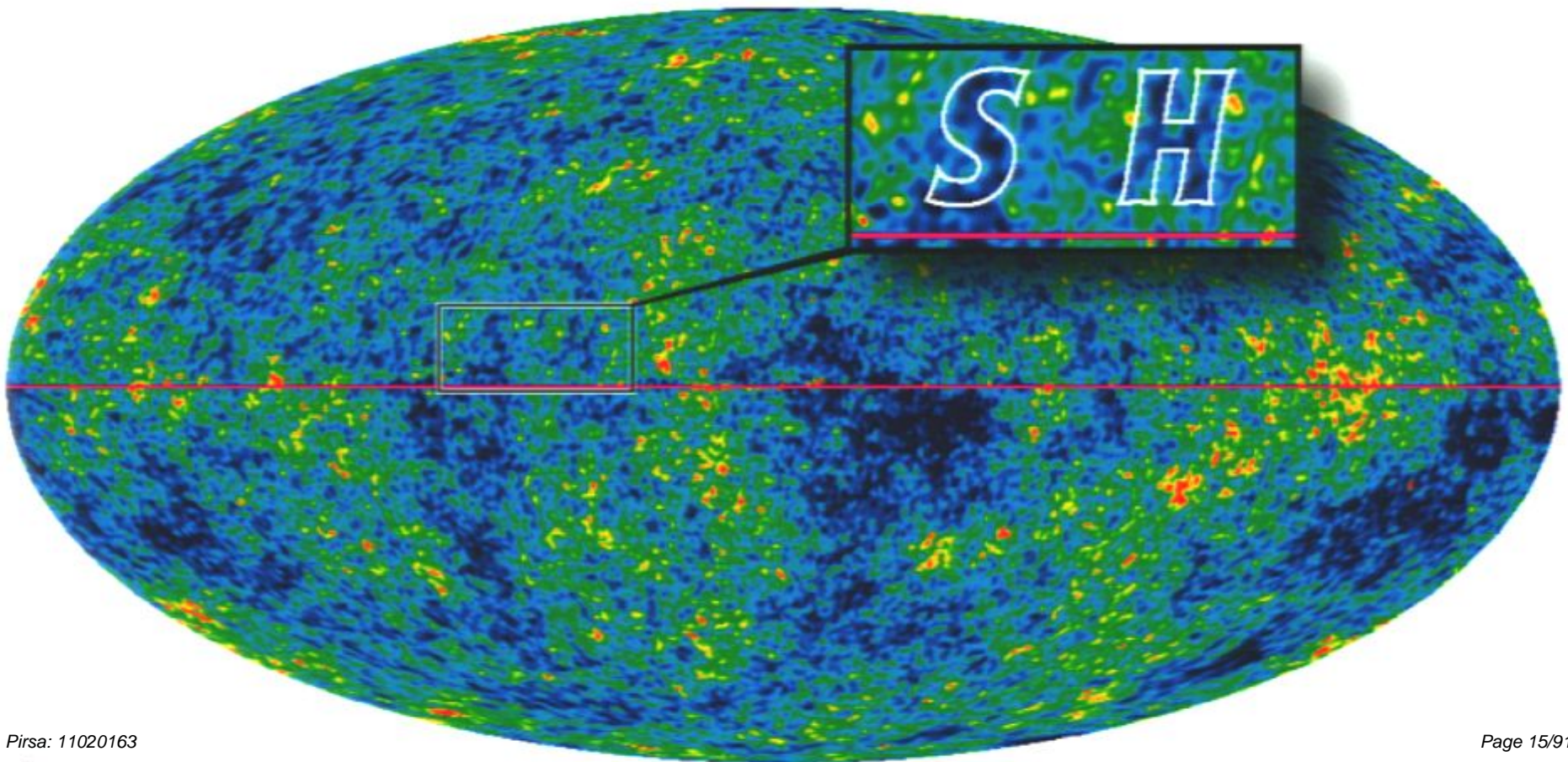
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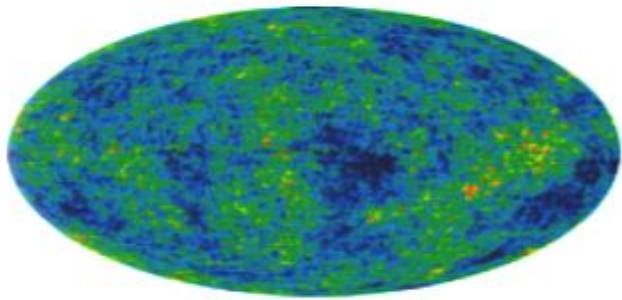
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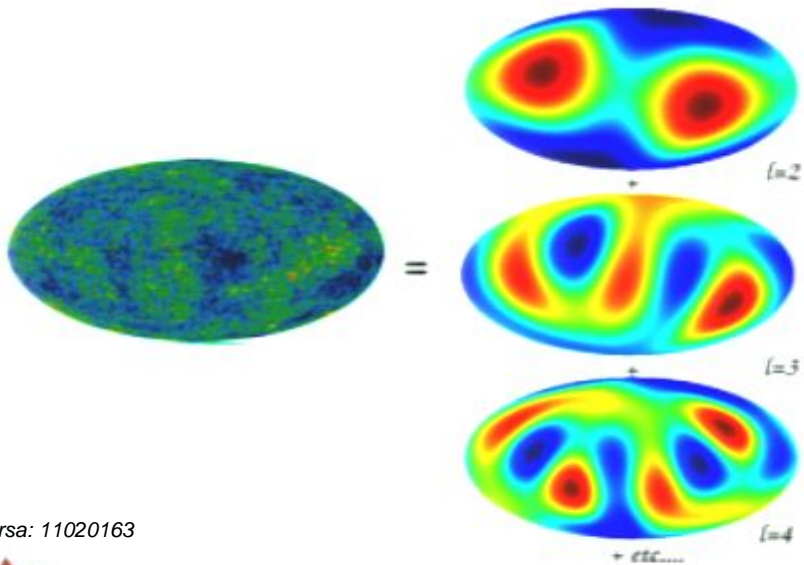
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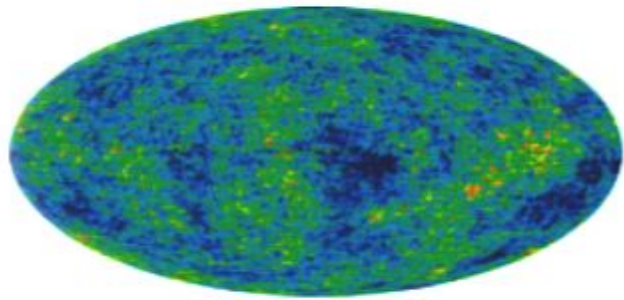
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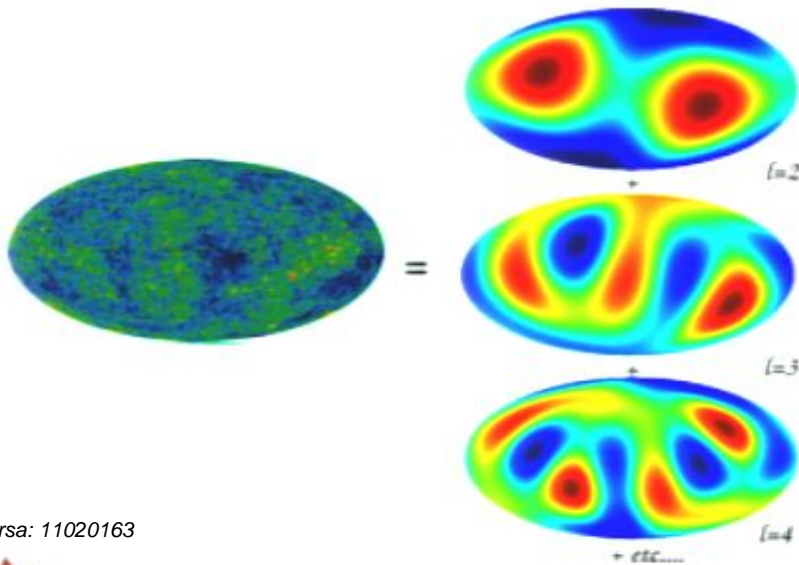


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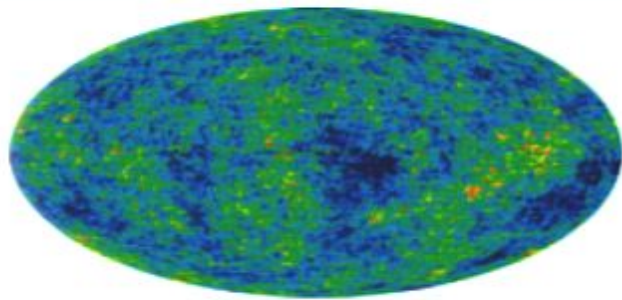
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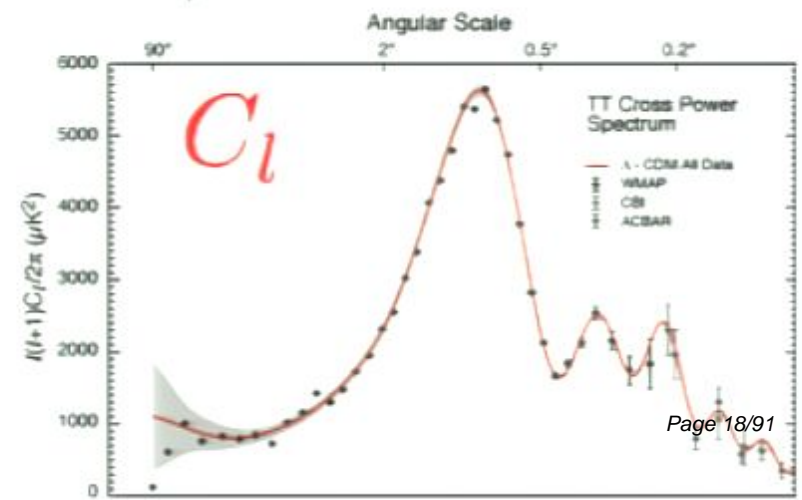
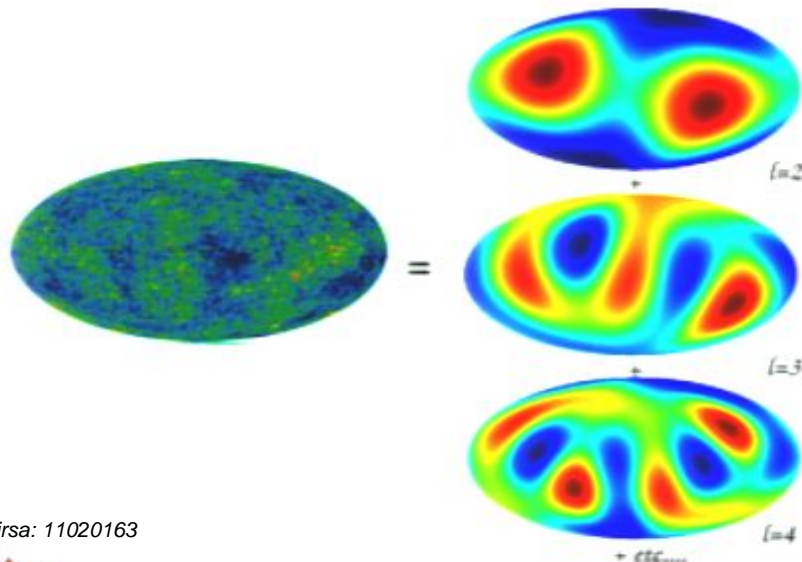


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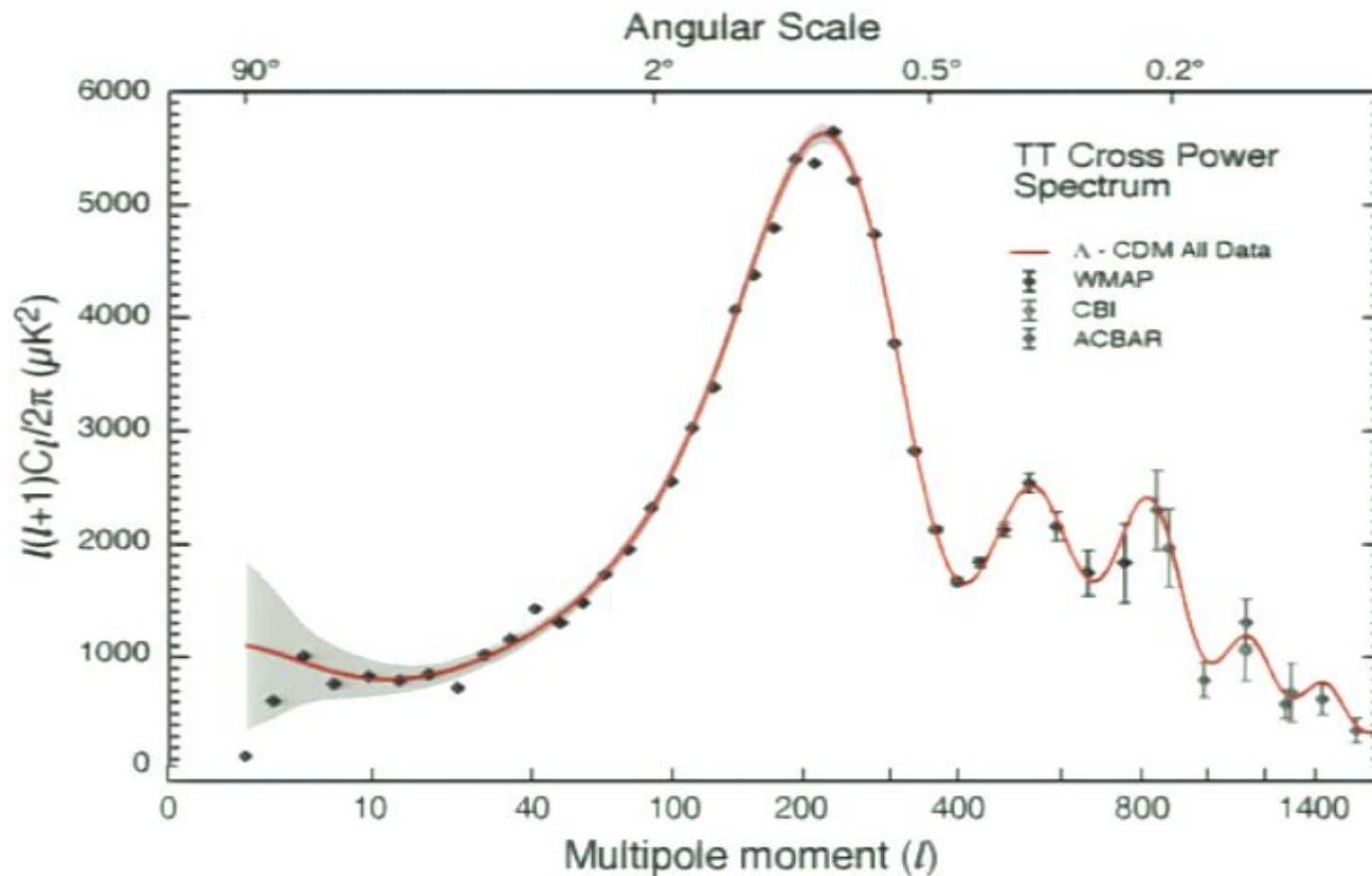
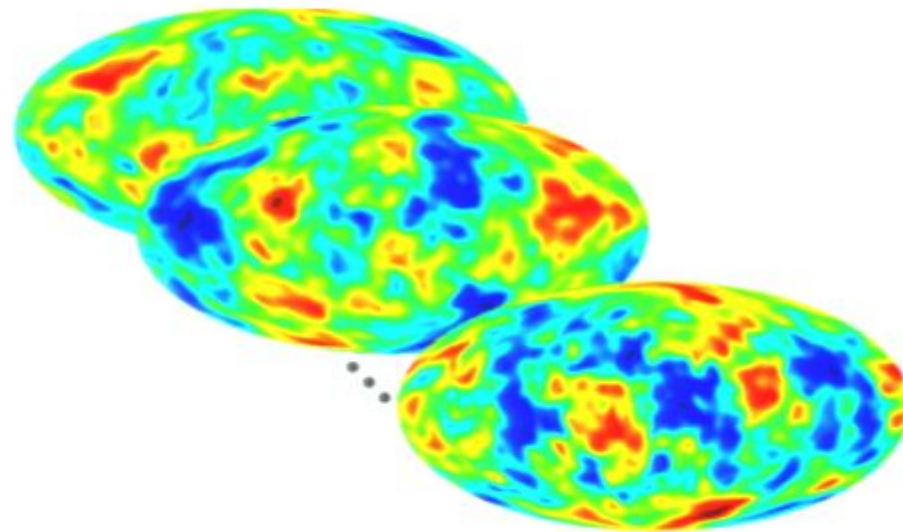
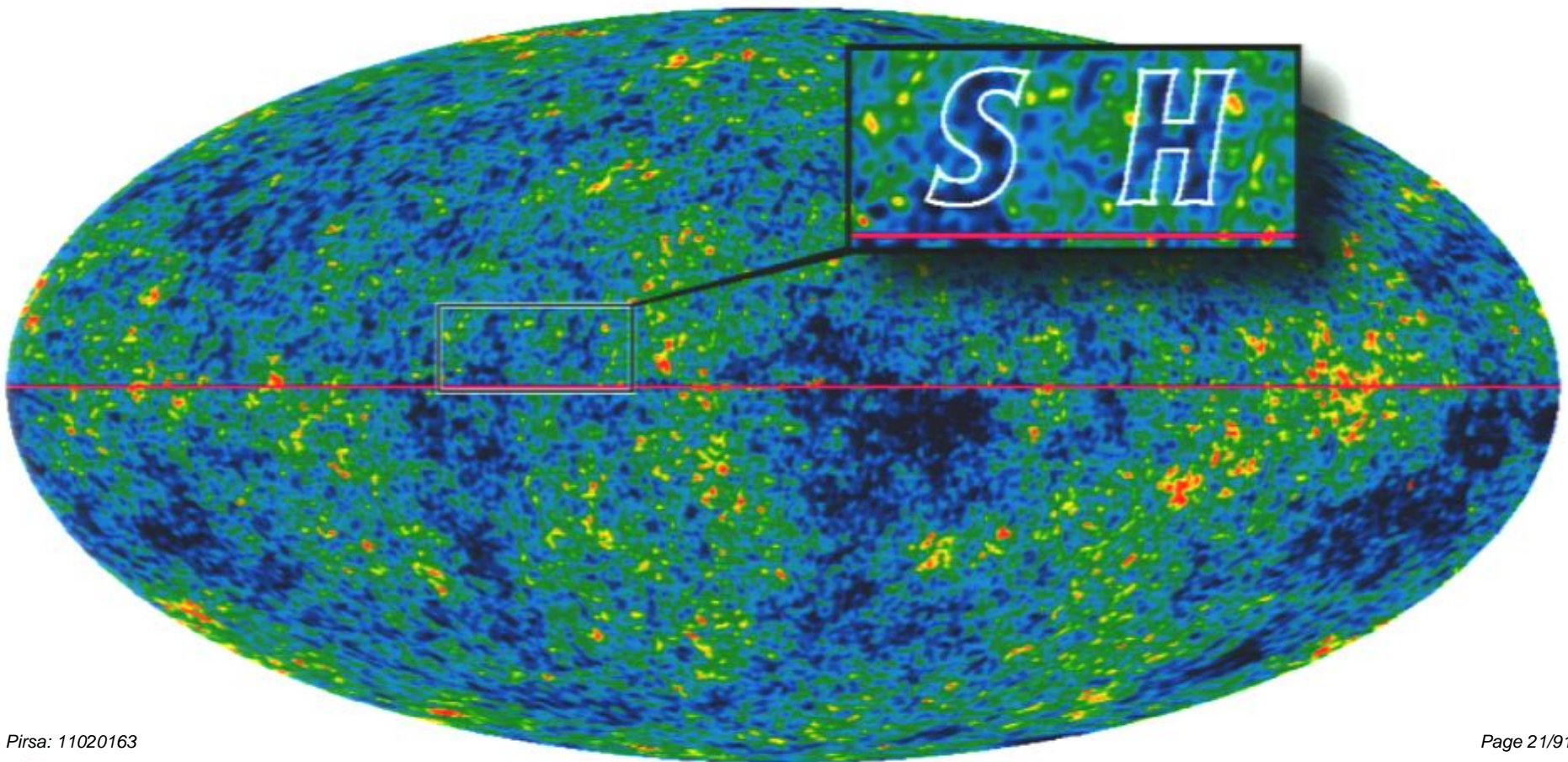


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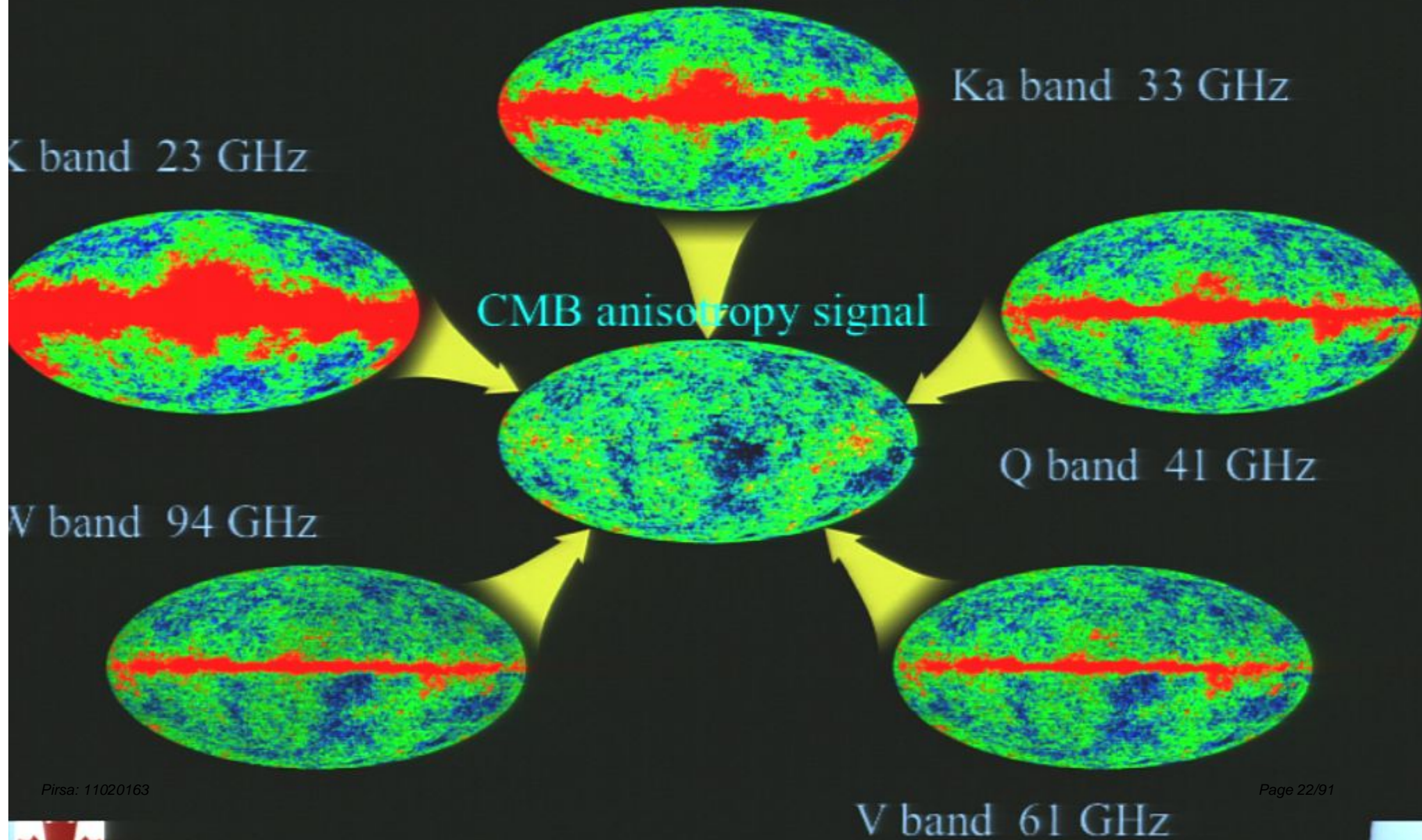
Simulations



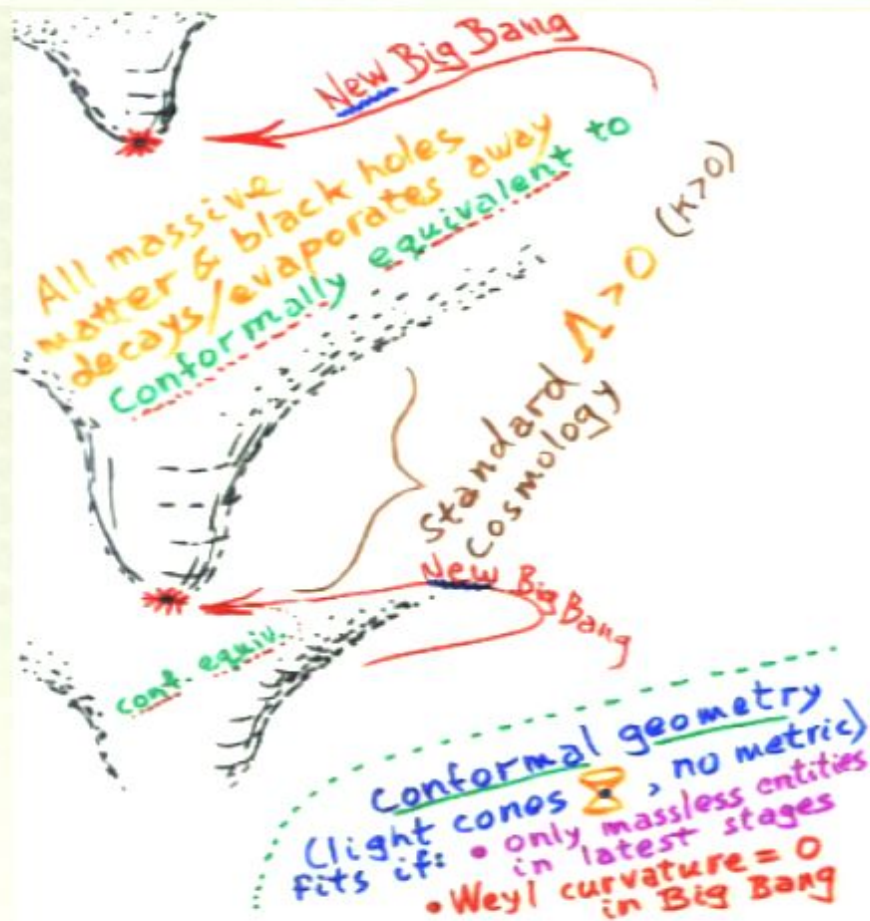
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WMAP multi-frequency maps

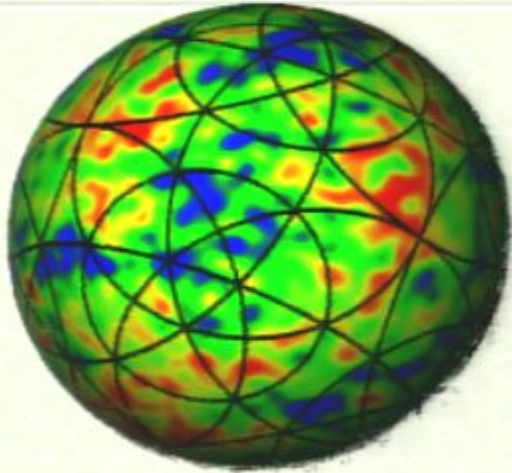


Conformal Cyclic Cosmology



- At high energies (early times), all interactions are conformally invariant.
- Conformal geometry, not metric geometry of spacetime, is relevant.
- Conformal spacetime geometry extends smoothly to before big-bang
- Weyl curvature vanishes at the conformal hypersurface which represents the Big Bang \rightarrow no infinite gravity at Big Bang.
- Fundamental Postulate: what lies beyond the future boundary hypersurface is the big bang of a "new universe", what lay before our BB hypersurface was the future infinity of a "previous universe".
- Physical material of the universe is only sensitive to the conformal structure of the universe and is blind to the component that provides the scale of the metric.
- the information in the gravitational degrees of freedom is transferred into a new scalar field—taken to be the initial form of the dark matter

... like ripples on a pond



• *The effect of such an energy burst would be to provide an outward kick to this initial material of the early universe. The kick will be much more energetic than the normal local variations in temperature in the early Big Bang. Accordingly, the outward (almost impulsive) burst would have, proportionally, a rather closely **uniform intensity** over the whole outward-moving sphere, in this material*

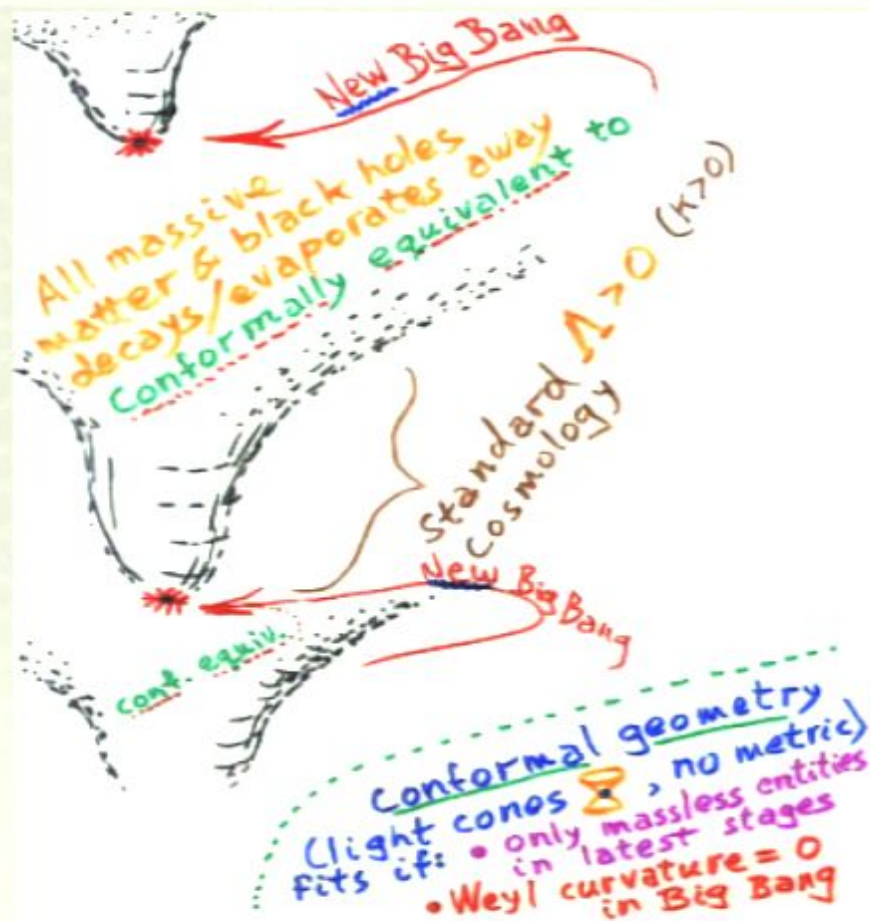
• *Spatial variations in the density after BB caused by gravitational wave bursts from close encounters between black holes*

• *Density fluctuations: scale-invariant (because of the exponential expansion BEFORE the Big Bang)*

• *CMB is a superposition of circular patterns on the surface of last scatter.*

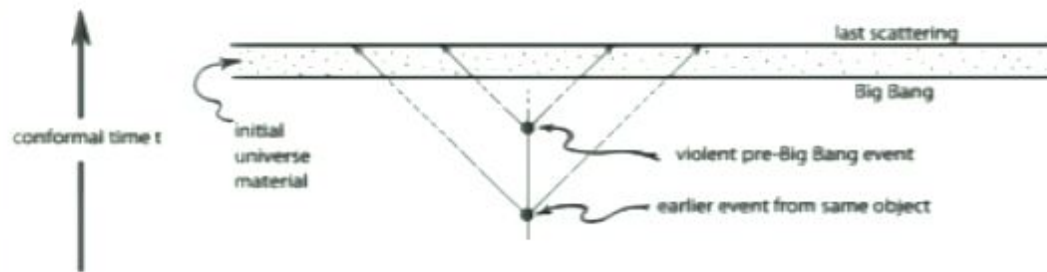


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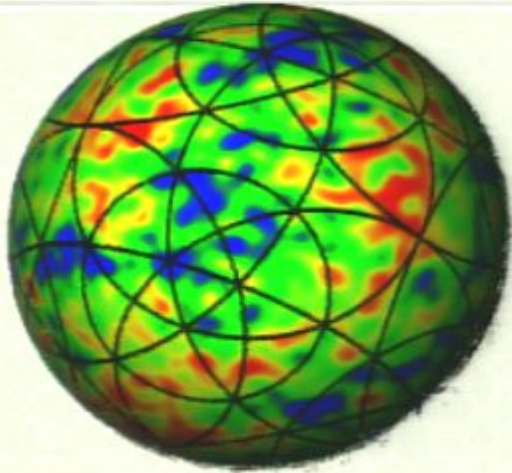
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CCC



- *“The clearest observational signal of CCC results from numerous supermassive black-hole encounters occurring within clusters of galaxies in the aeon previous to ours. These encounters should yield huge energy releases in the form of gravitational radiation bursts. From the perspective of our own aeon, these would appear not in the form of gravitational waves, but as spherical, largely isotropic, impulsive bursts of energy in the initial material in the universe, which we take to be some primordial form of dark matter, the impulse moving outwards with the speed of light up to our last-scattering surface.”*

... like ripples on a pond

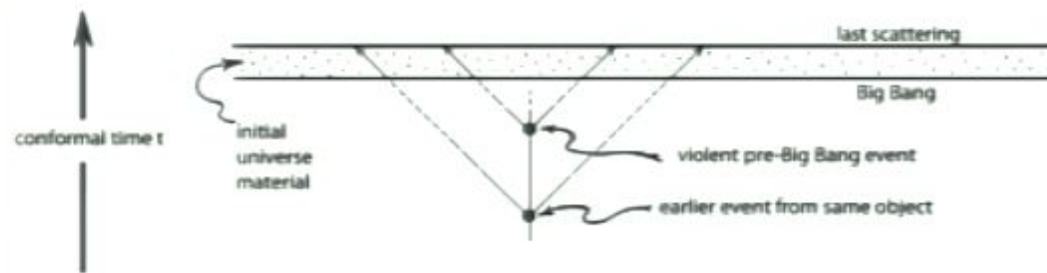


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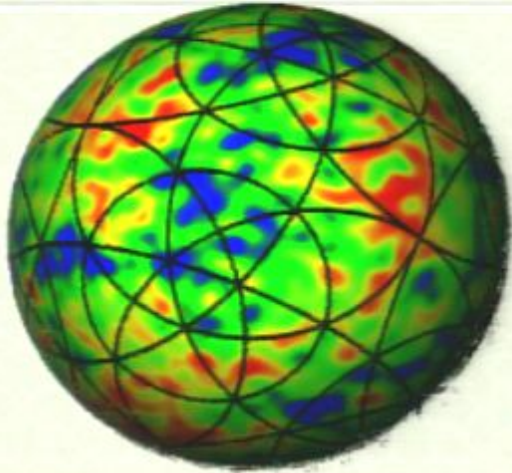
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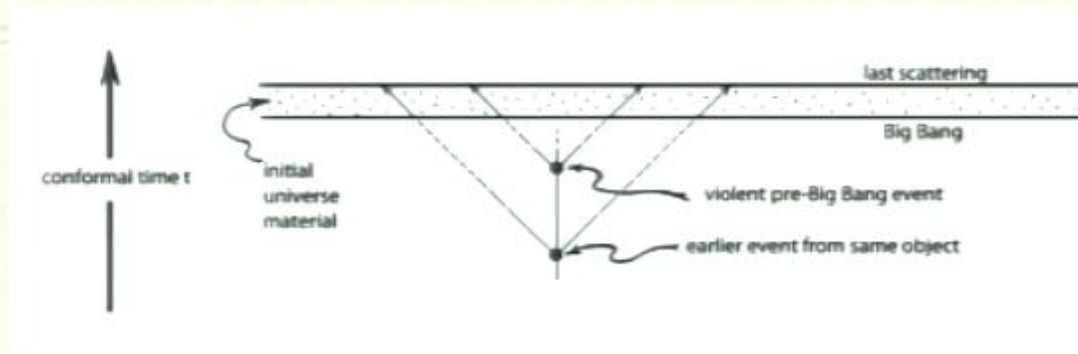


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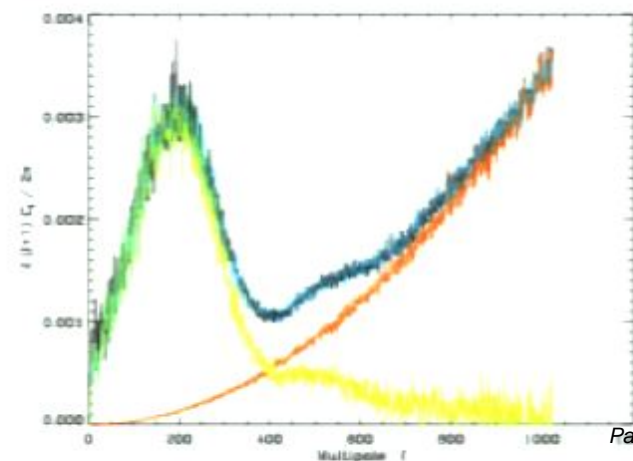
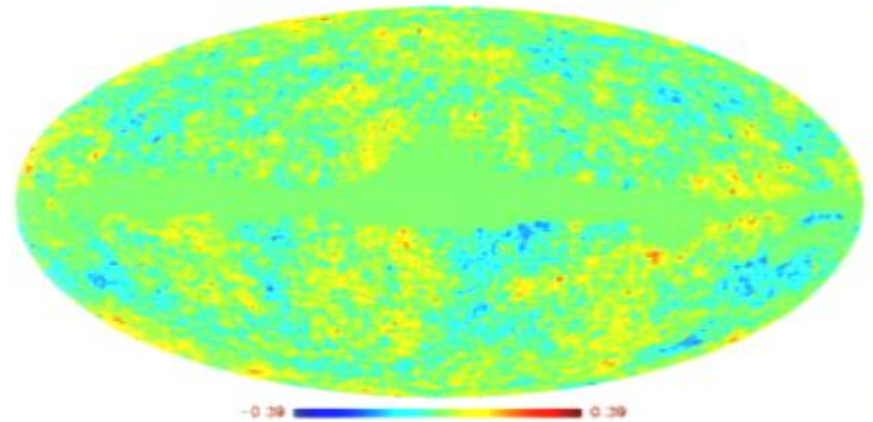
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Looking for circles in CMB sky

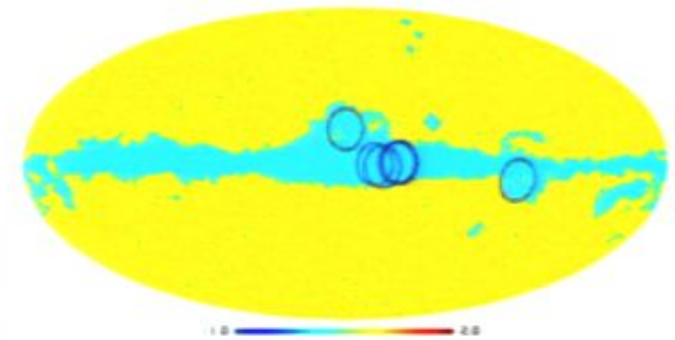
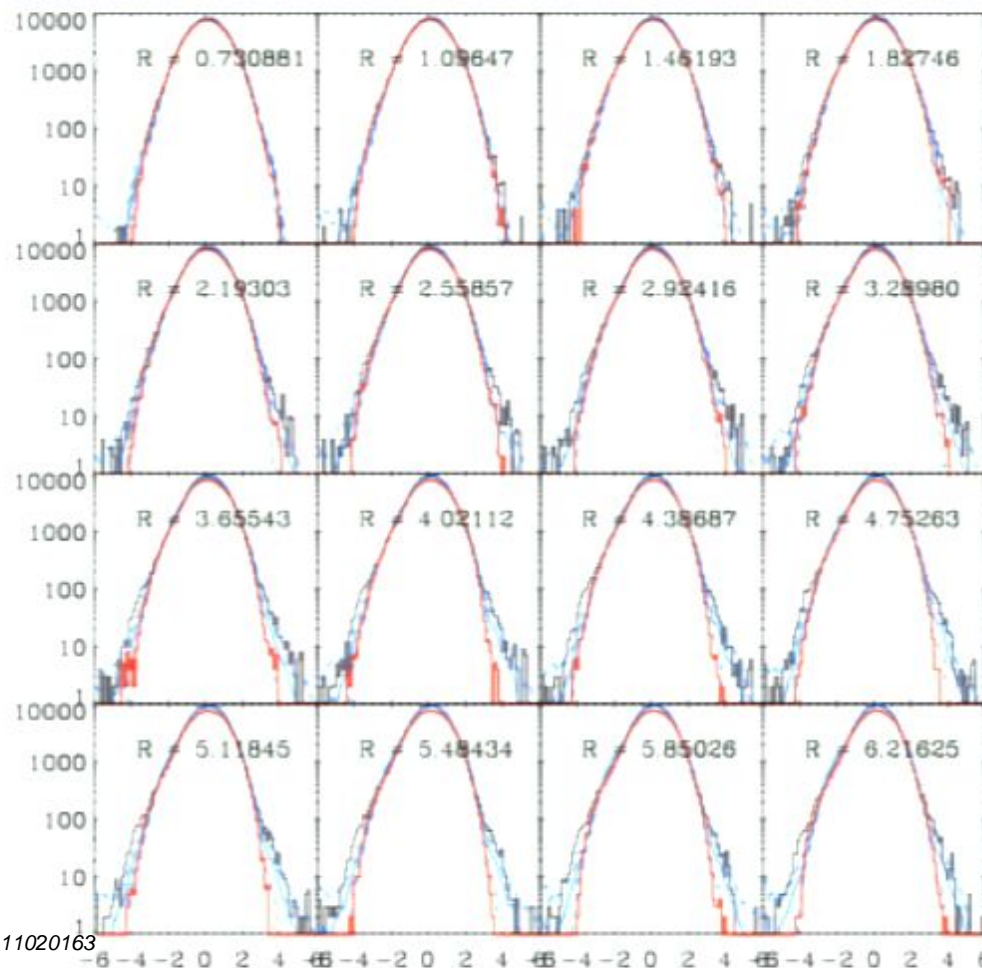
- *Using foreground cleaned W-band map (Galaxy and point sources masked)*
- *Looking for circularly correlated patterns with the statistic*

$$C_{\theta}(\hat{n}_i) = \frac{1}{S_{\theta}} \int \Delta T(\hat{n}_j) \delta(\hat{n}_i \cdot \hat{n}_j - \cos \theta) dS_{\theta}$$

- *Simulations of the LCDM CMB maps with realistic noise are used to assess the statistical significance of the results*



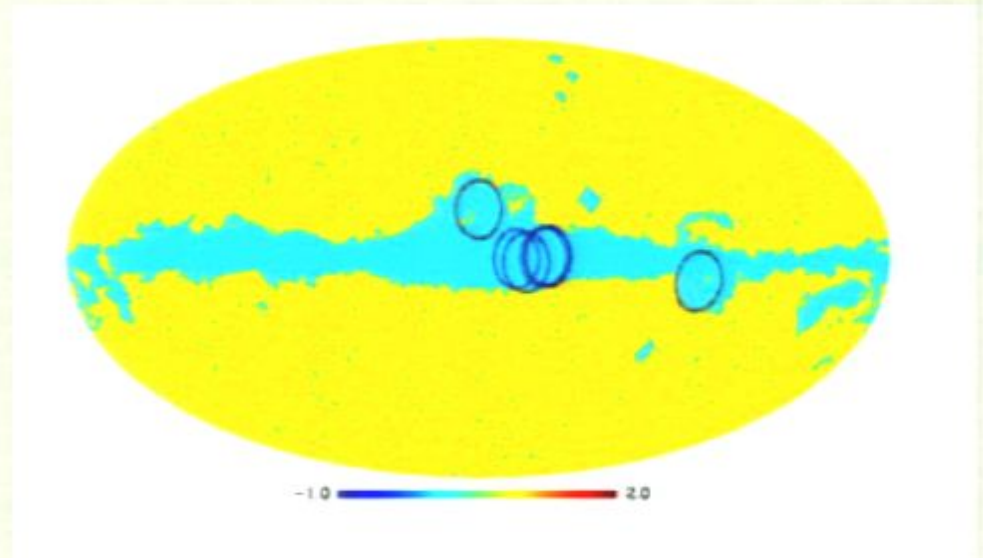
No actual detection of uniform temperature circles



*Detected circles are all at the edges -> suffer from small number statistics
Excluding circles with small number of pixels in them removes large deviations from Gaussian distributions.
No circles in WMAP5 data*

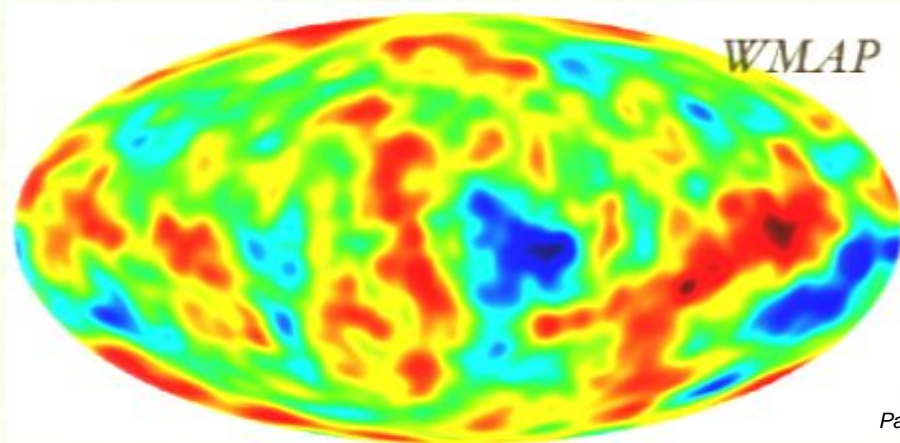
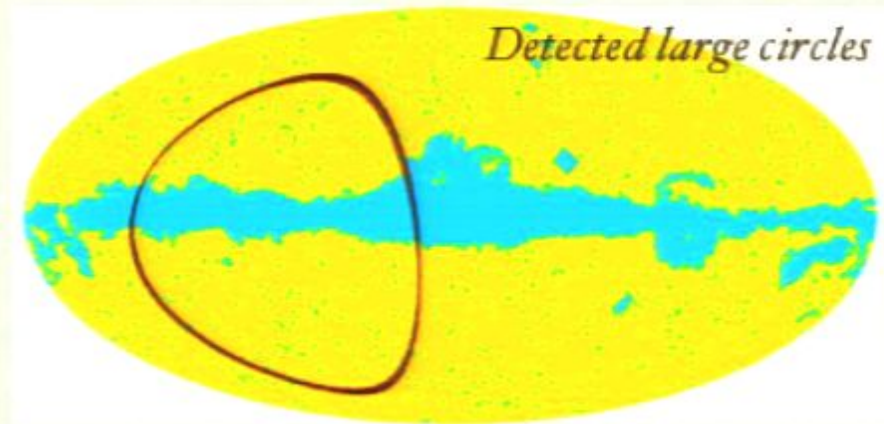
There they are!

- *Found two families of such circles: with small and large radii*
- *small circles are right at the edges of the masked regions in the map. They have a small number of pixels and therefore large errors. Excluding circles with small number of pixels, eliminated them.*

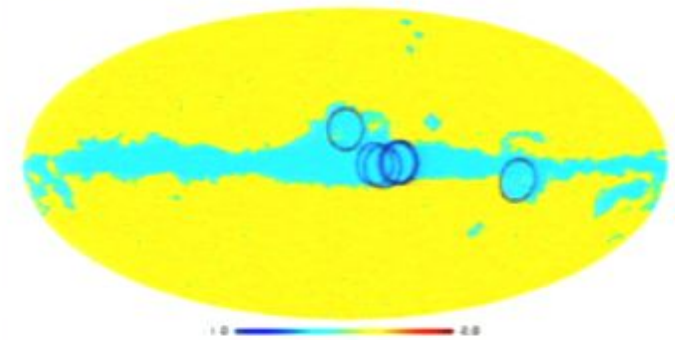
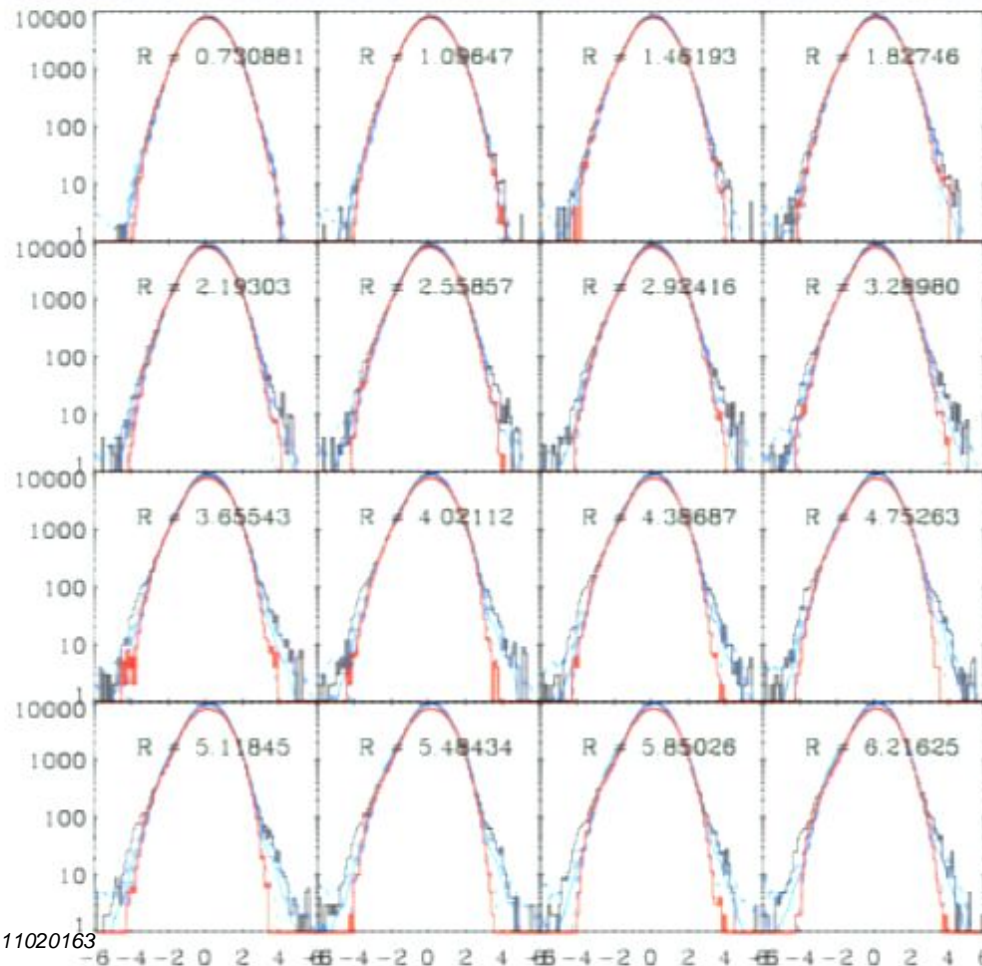


There they are!

- *Found two families of such circles: with small and large radii*
- *Large circles are due to correlated modes on large angular scales.*
- *Smoothing WMAP data shows what is causing these circles.*

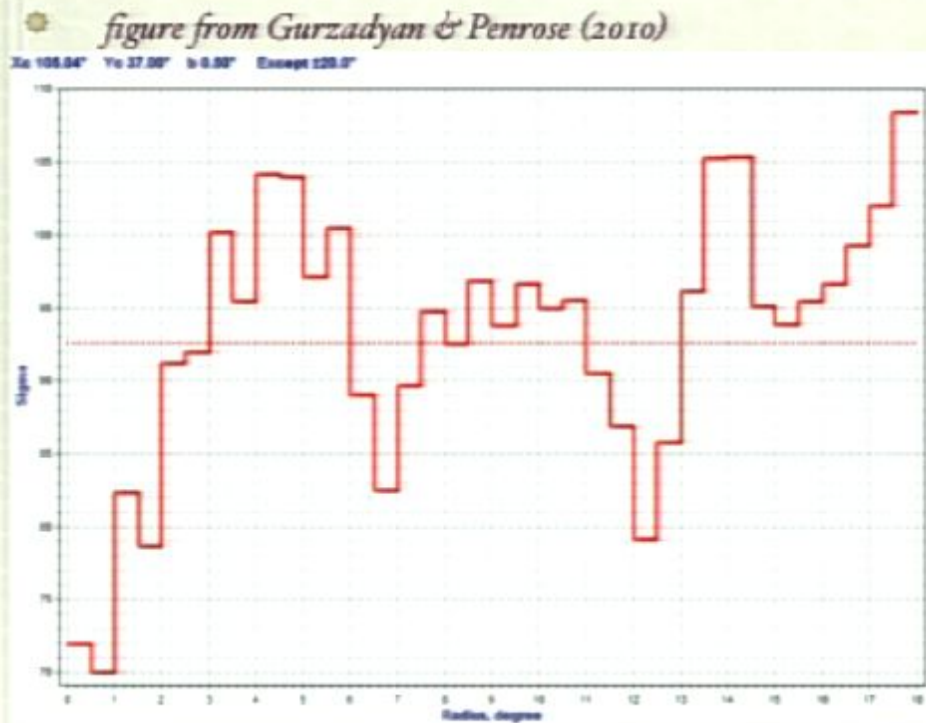


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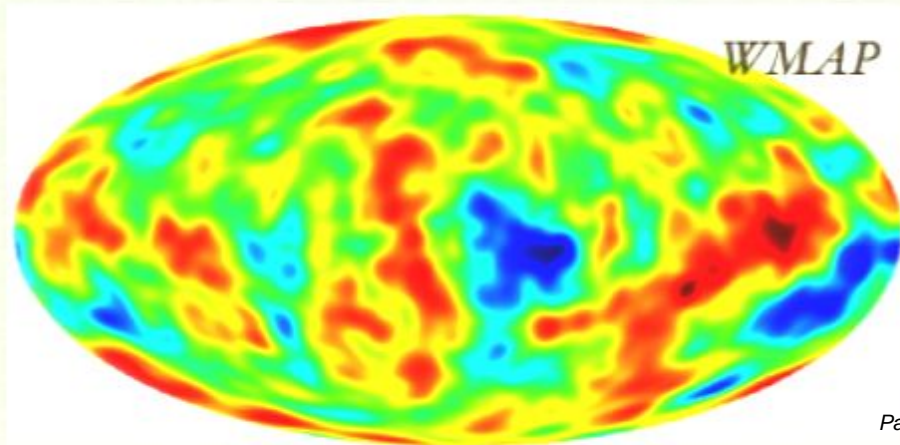
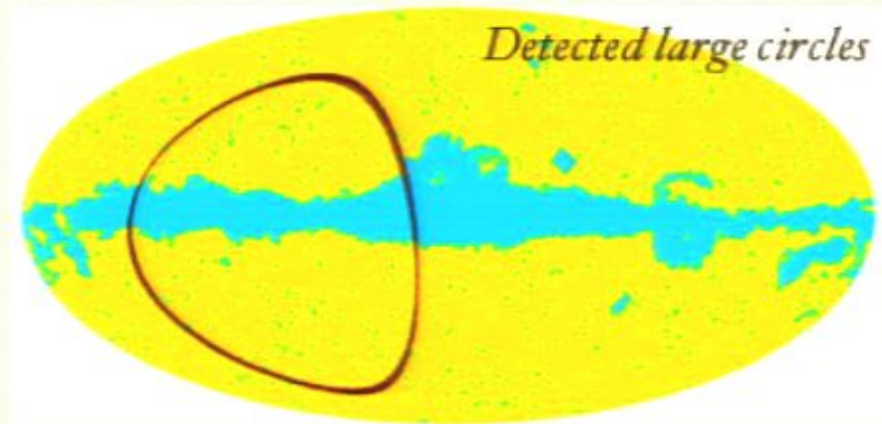
Concentric circles in WMAP7 data?



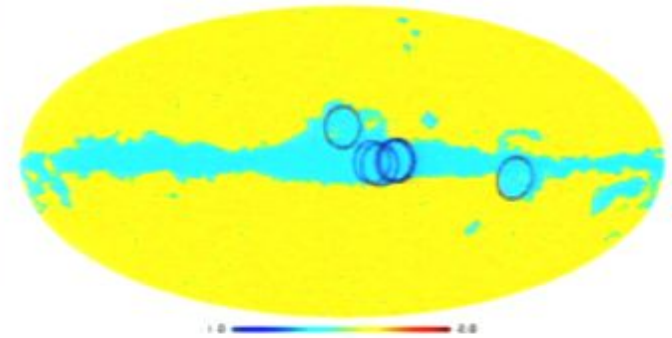
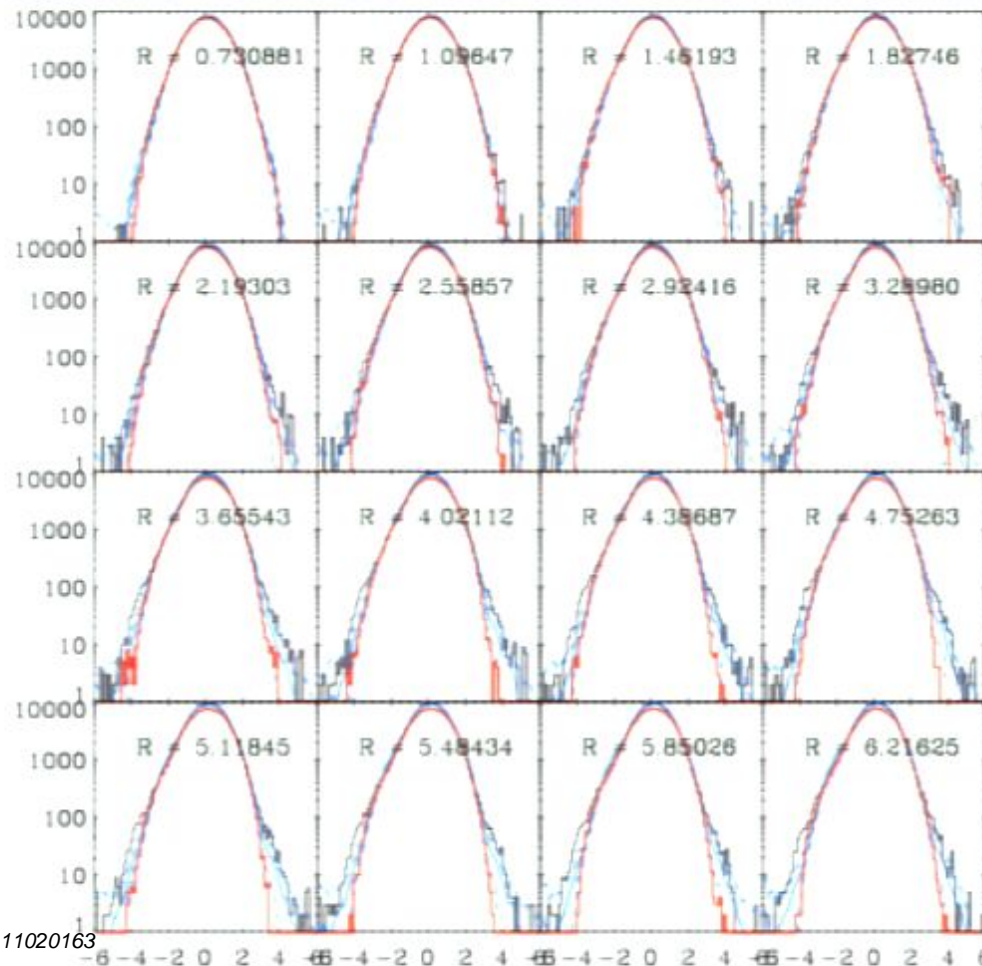
- Gurzadyan & Penrose (2010) claim to have detected three families of “anomalous low-variance concentric circles” in WMAP7 data
- 3 critical papers show the patterns are not anomalous:
 - Webus, Eriksen (arXiv:1012.1268)
 - Moss, Scott, Zibin (arXiv:1012.1305)
 - A.H. (arXiv:1012.1656), *ApJ* accepted

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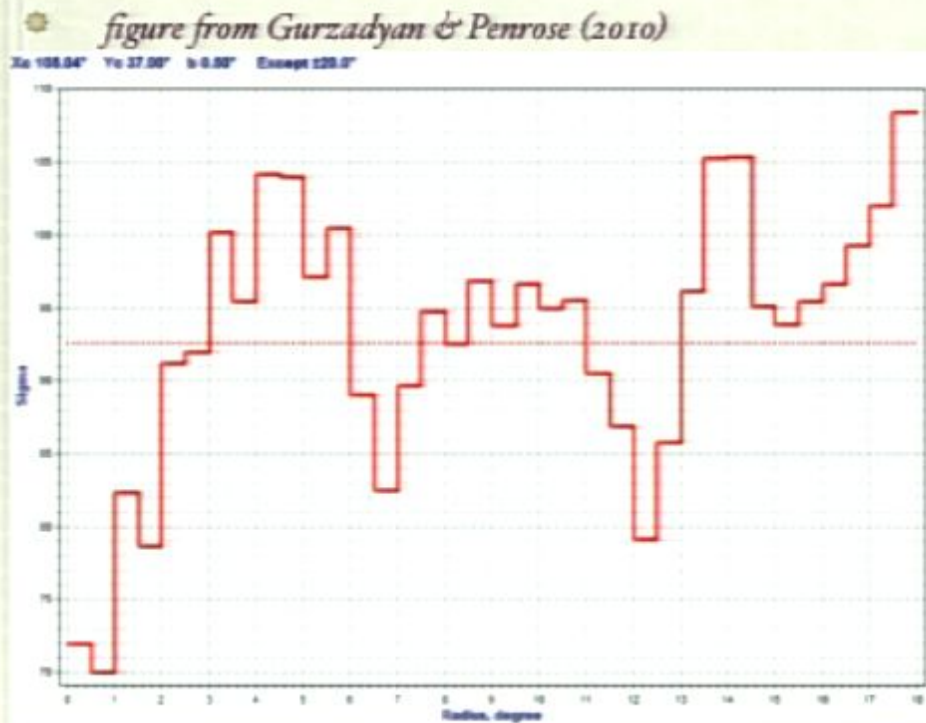


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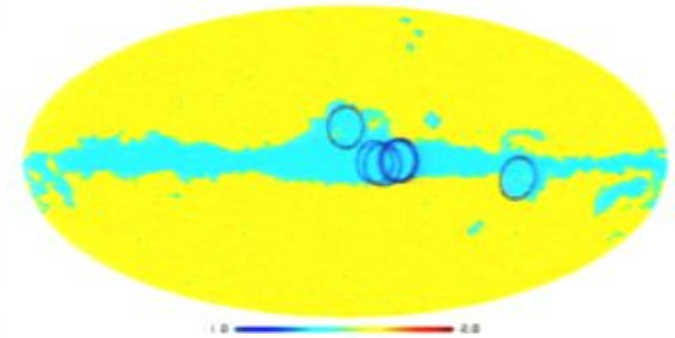
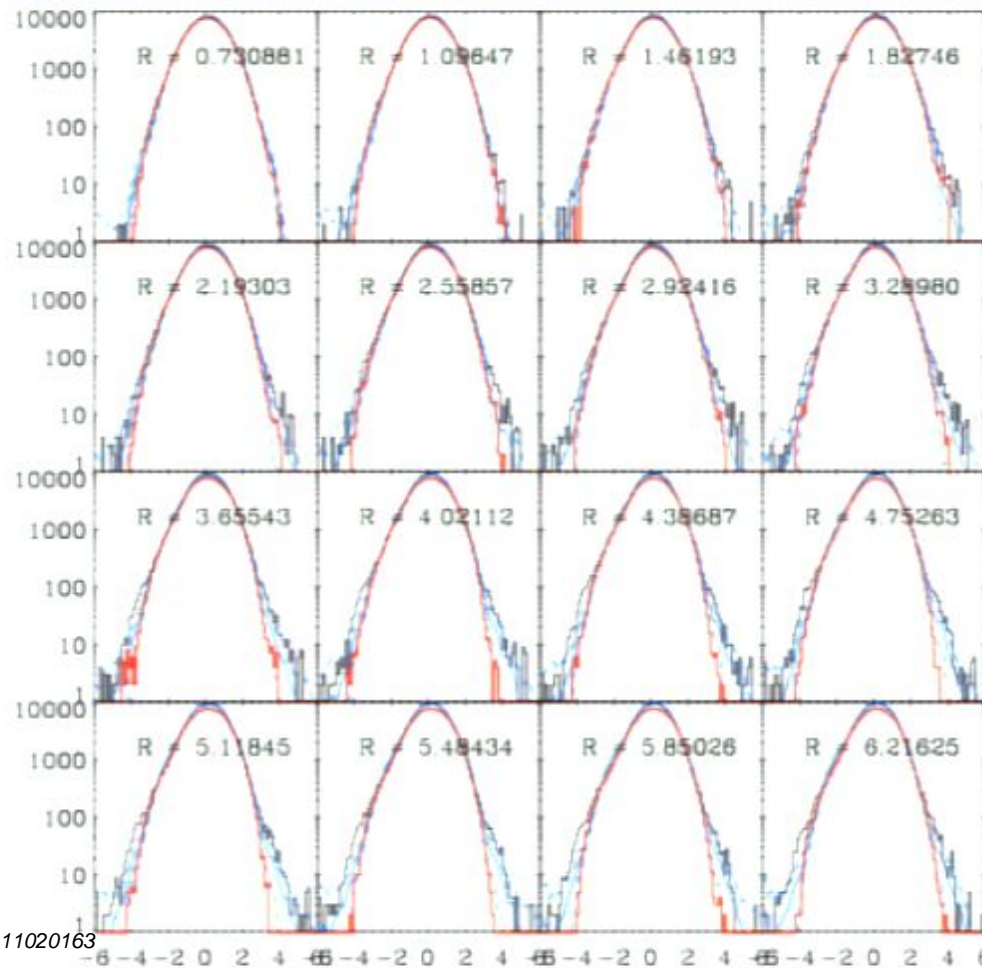
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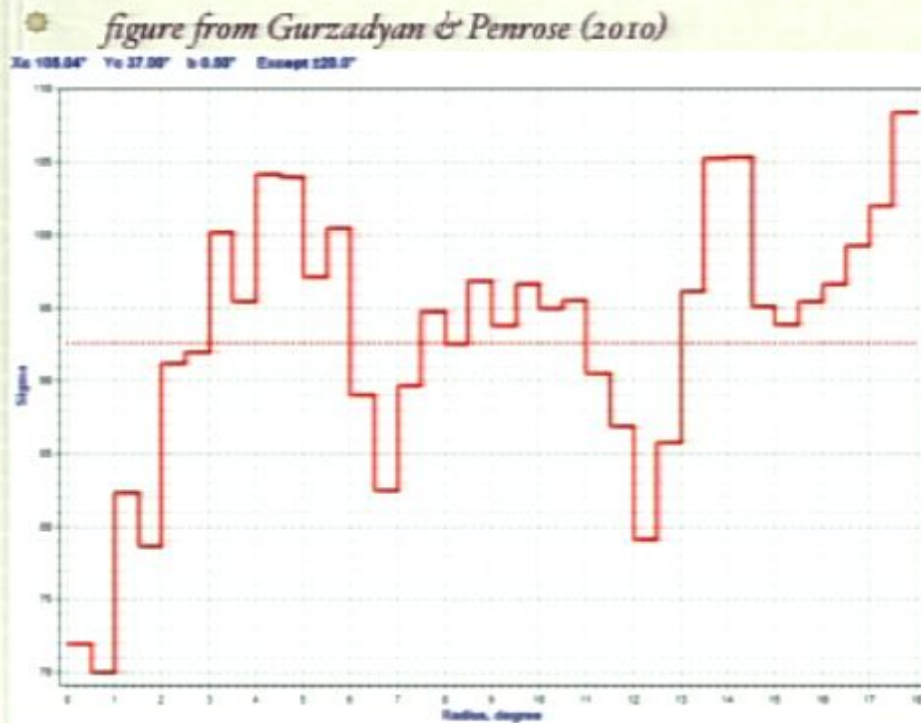
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Circles in Conformal Cyclic Cosmology

The
Economist

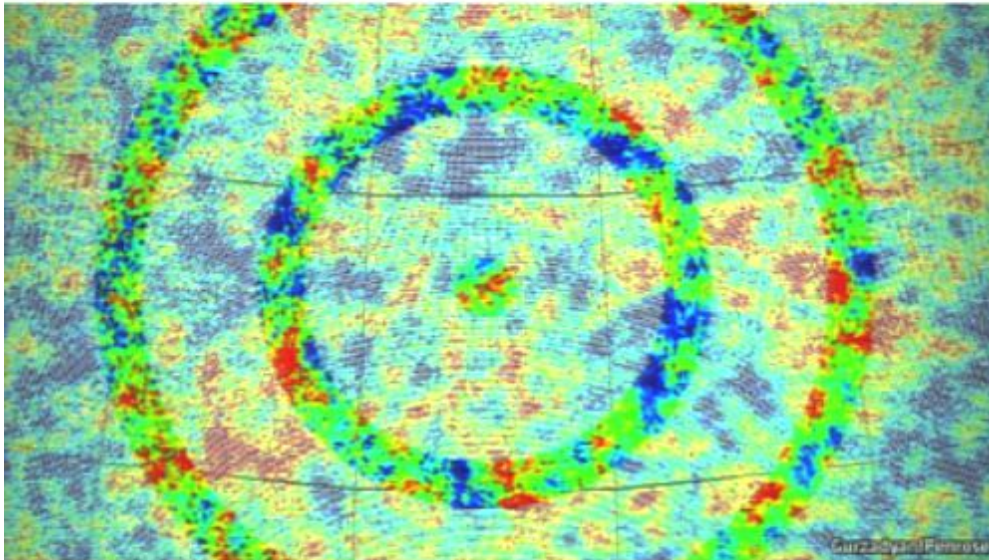
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Going round in circles

In contradiction to most cosmologists' opinions, two scientists have found evidence that the universe may have existed for ever

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Published online 10 December 2010 | Nature | doi:10.1038/news.2010.665

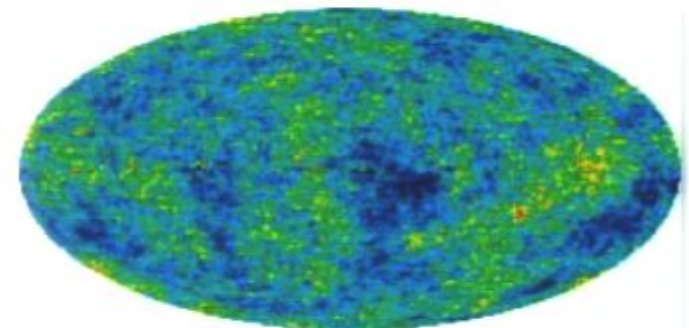
News

No evidence of time before Big Bang

Latest research deflates the idea that the Universe cycles for eternity.

Edwin Cartlidge

Our view of the early Universe may be full of mysterious circles — and even triangles — but that doesn't mean we're seeing evidence of events that took place before the Big Bang. So says a trio of papers taking aim at a



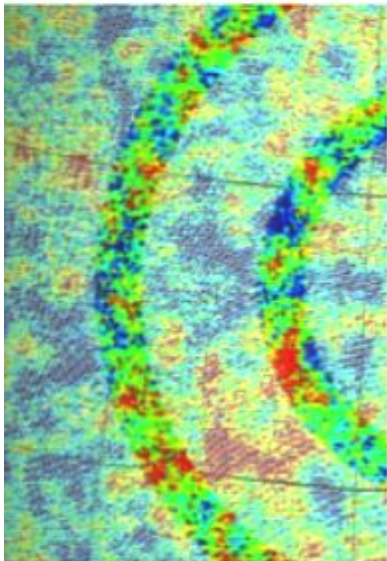
Circular ripples in the cosmic microwave background have been making waves

Stories by subject

- [Space and astronomy](#)
- [Physics](#)

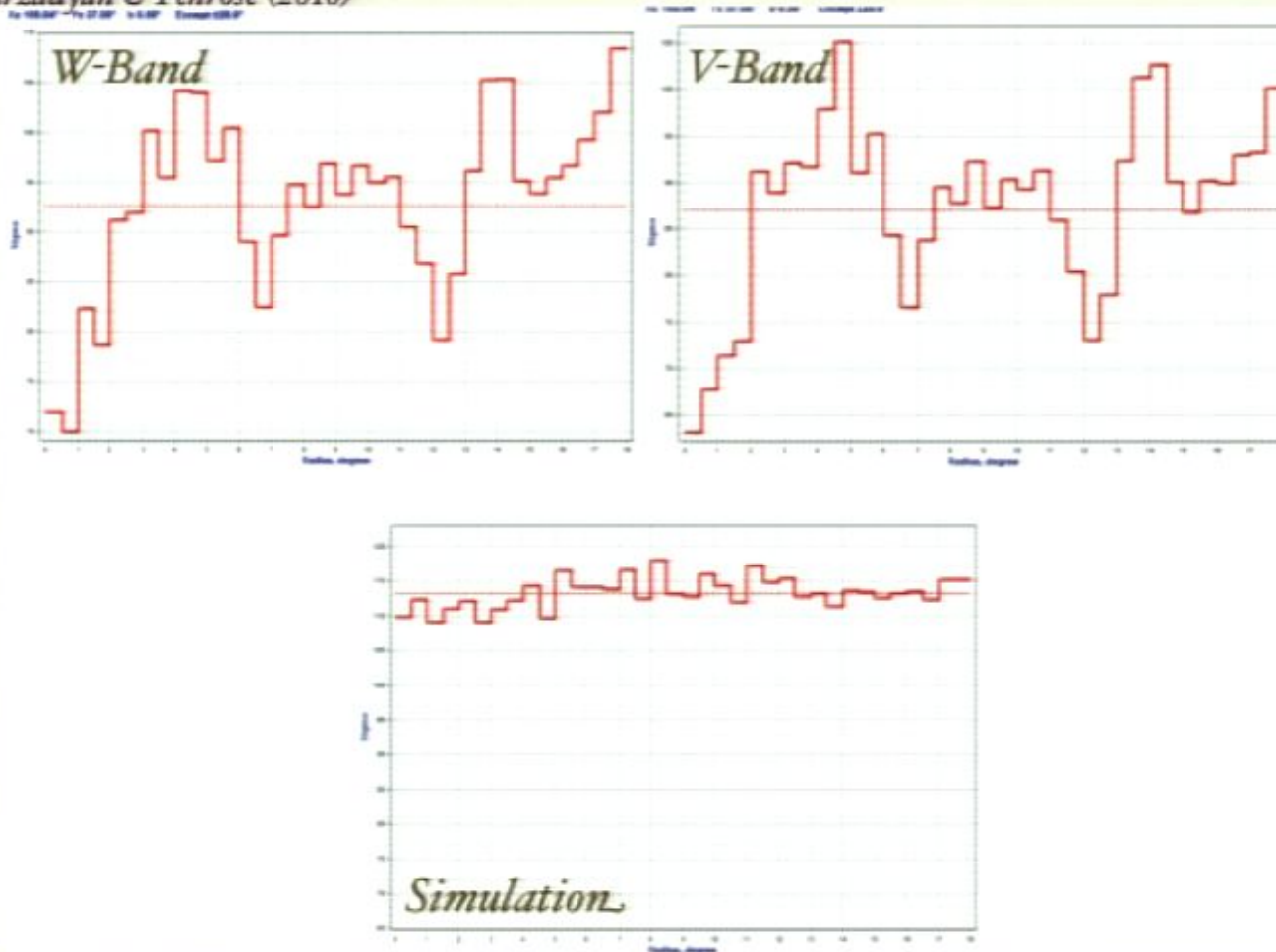
Stories by keywords

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- [WMAP](#)
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- [Universe](#)
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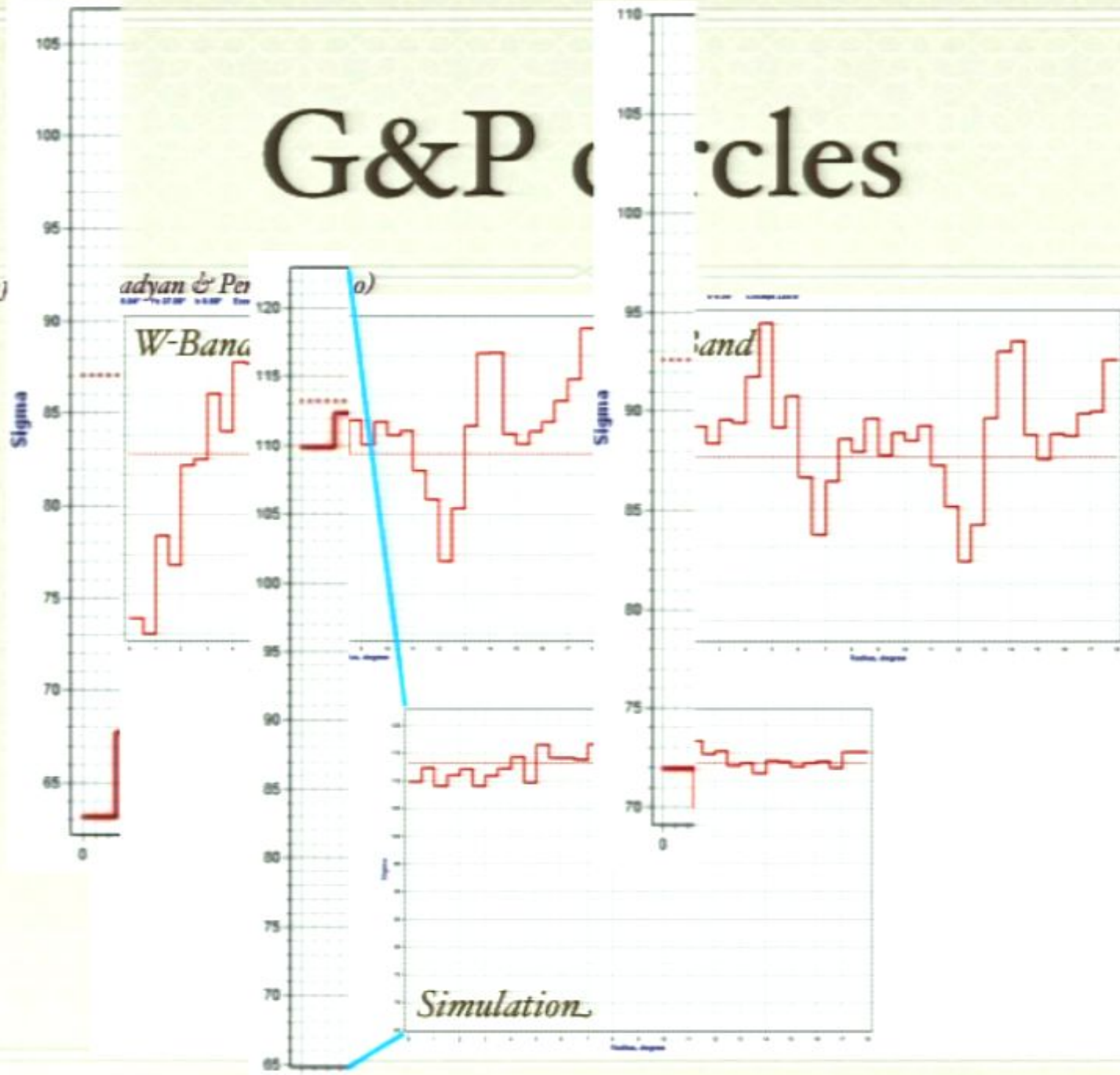
G&P circles

figure from Gurzadyan & Penrose (2010)



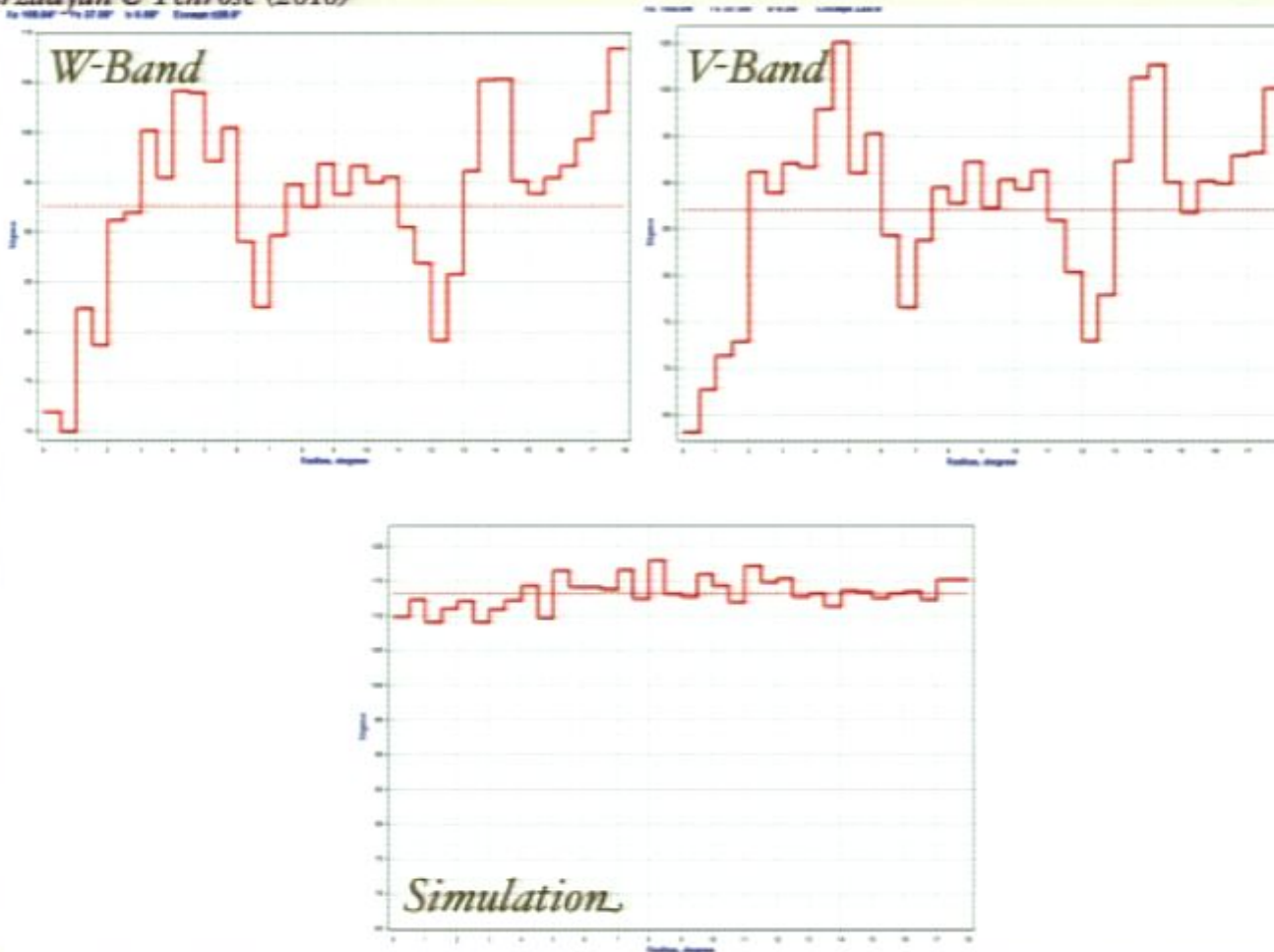
G&P circles

figure j



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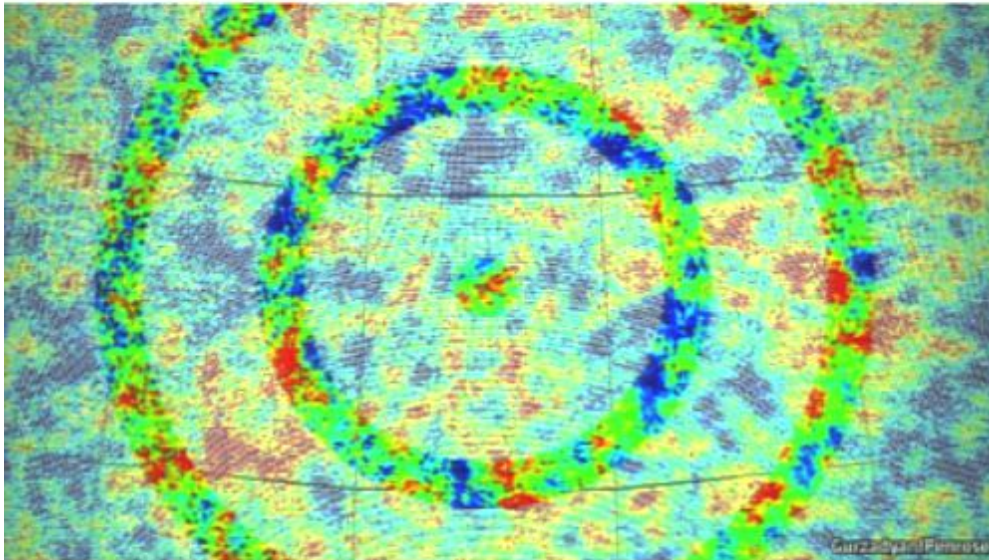
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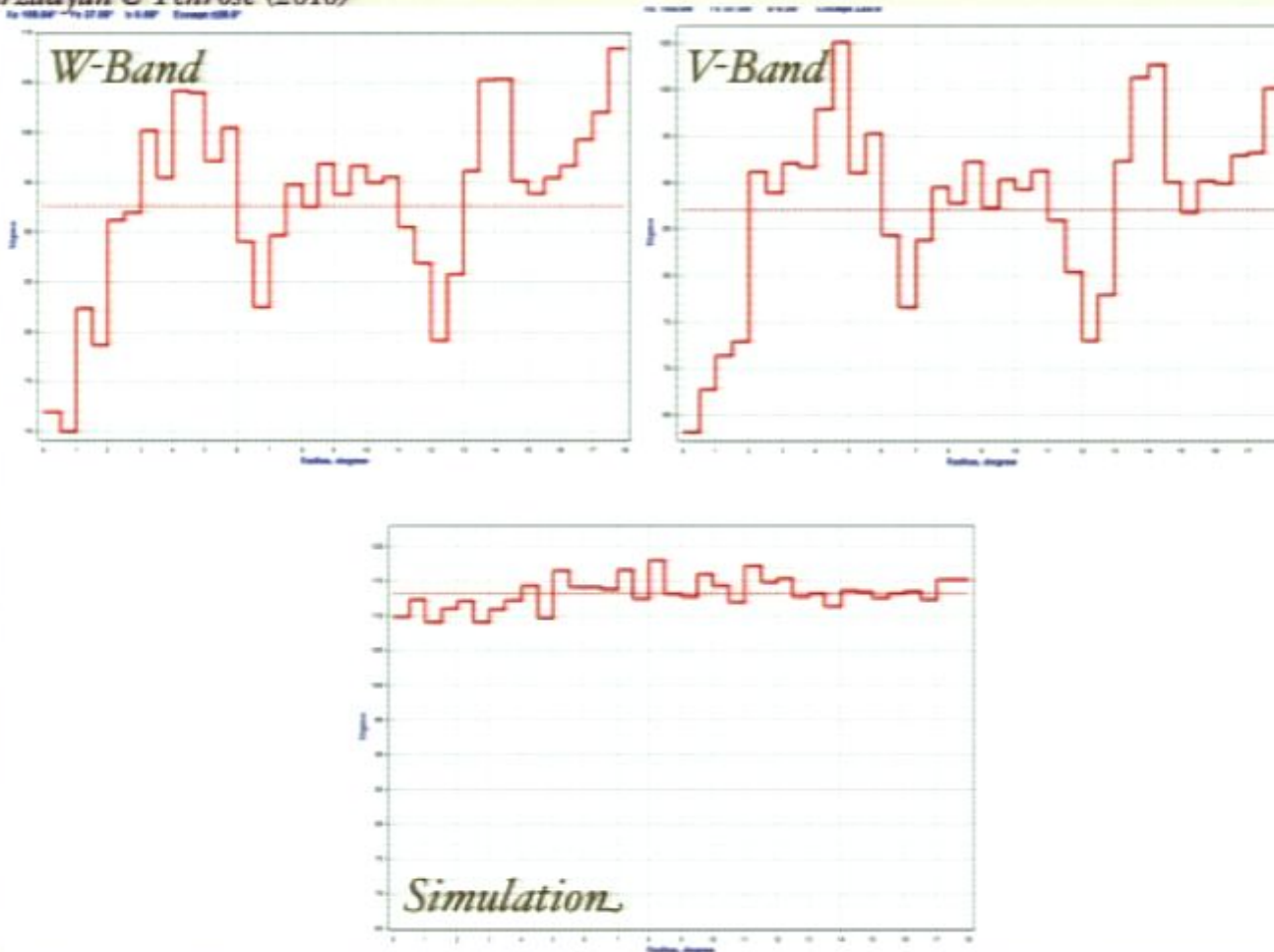
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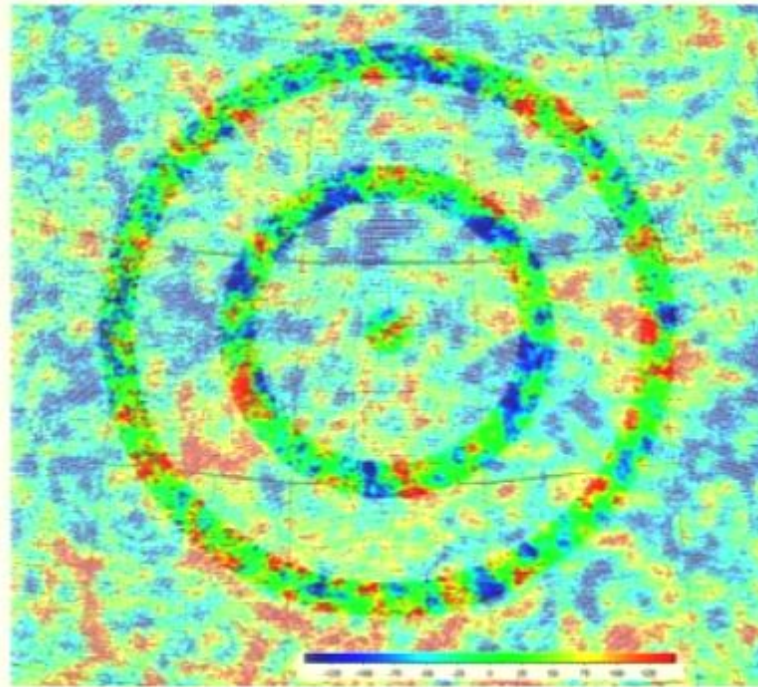
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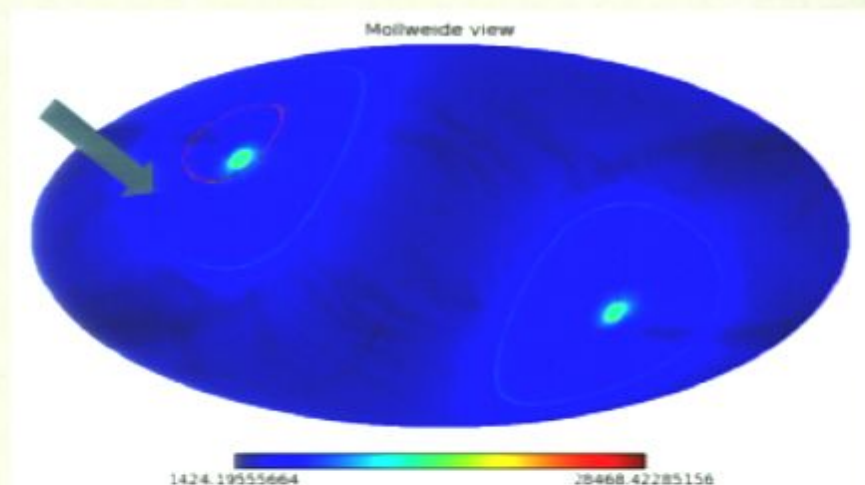
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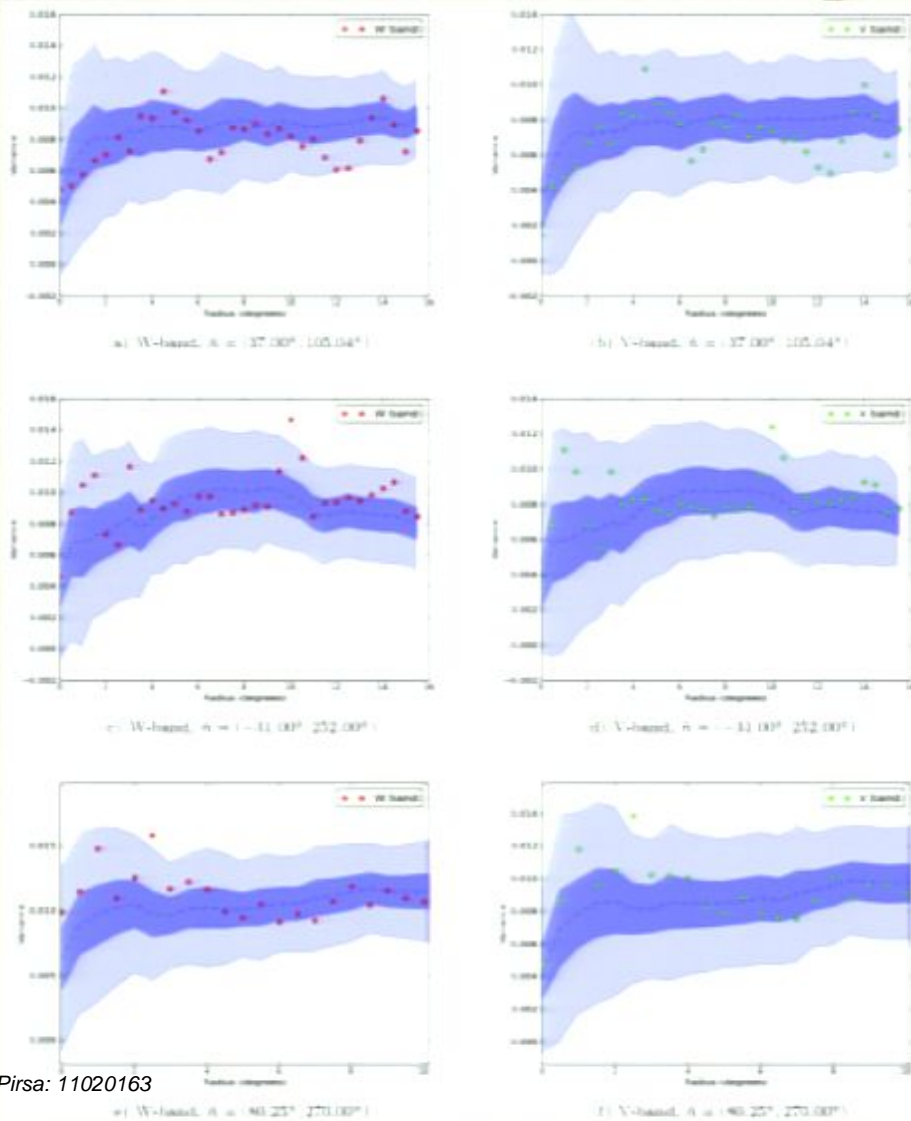


Reassessing statistical significance of the G&P patterns

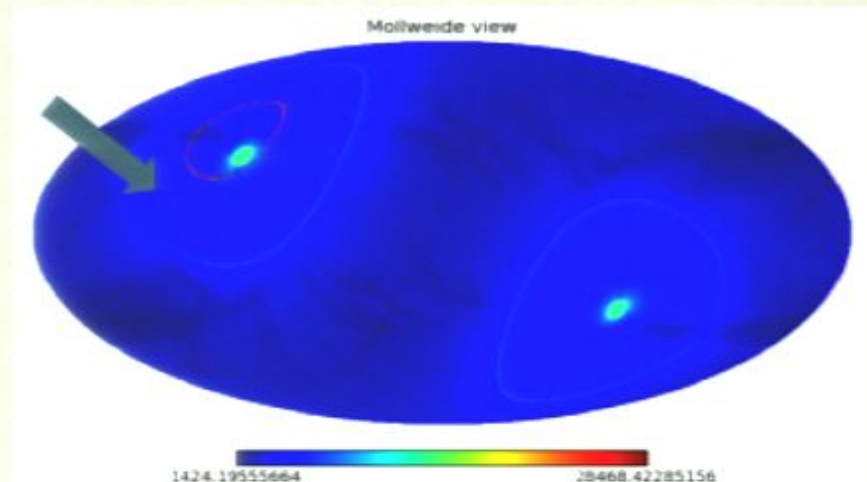
- *Repeating G&P analysis at three centers we get similar patterns as G&P*
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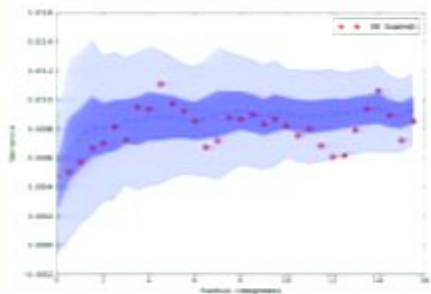
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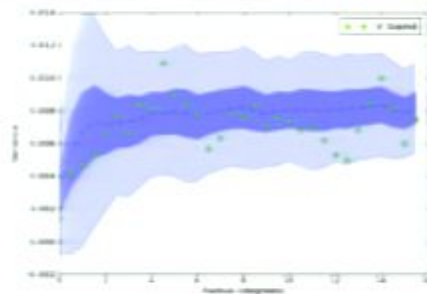
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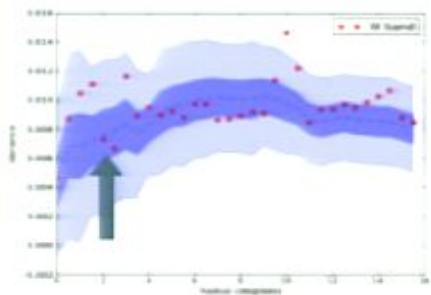
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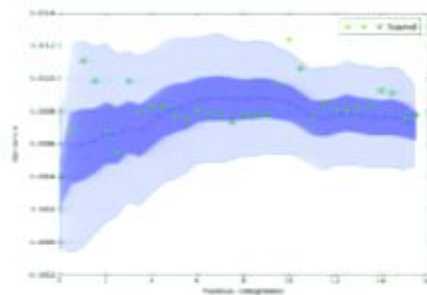
(a) W-band, $\alpha = -17.00^\circ$ (103.04 $^\circ$)



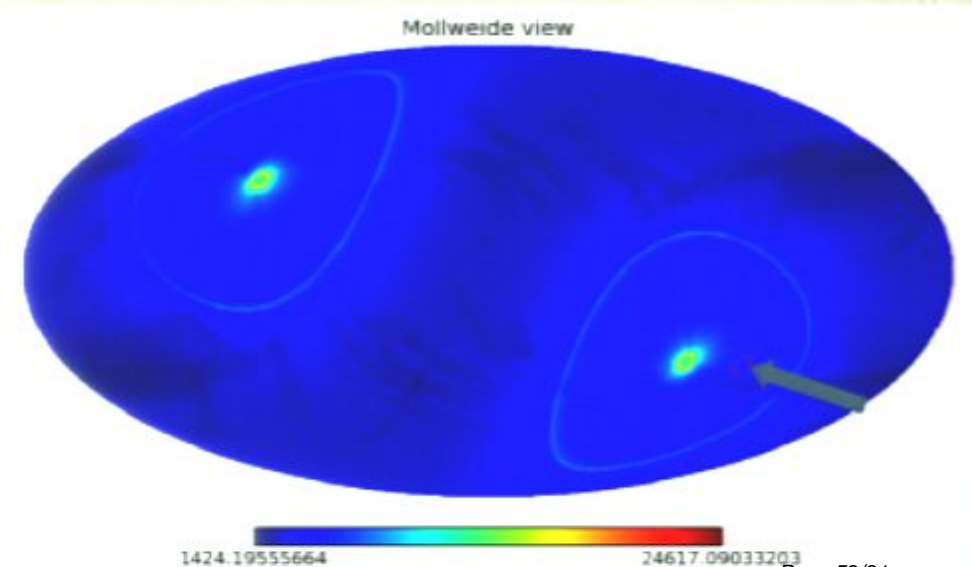
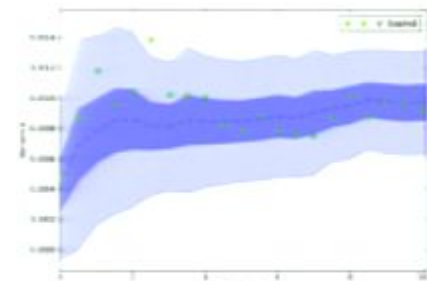
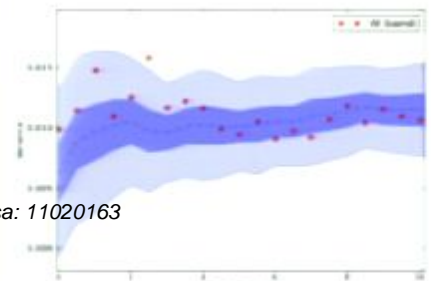
(b) V-band, $\alpha = -17.00^\circ$ (103.04 $^\circ$)



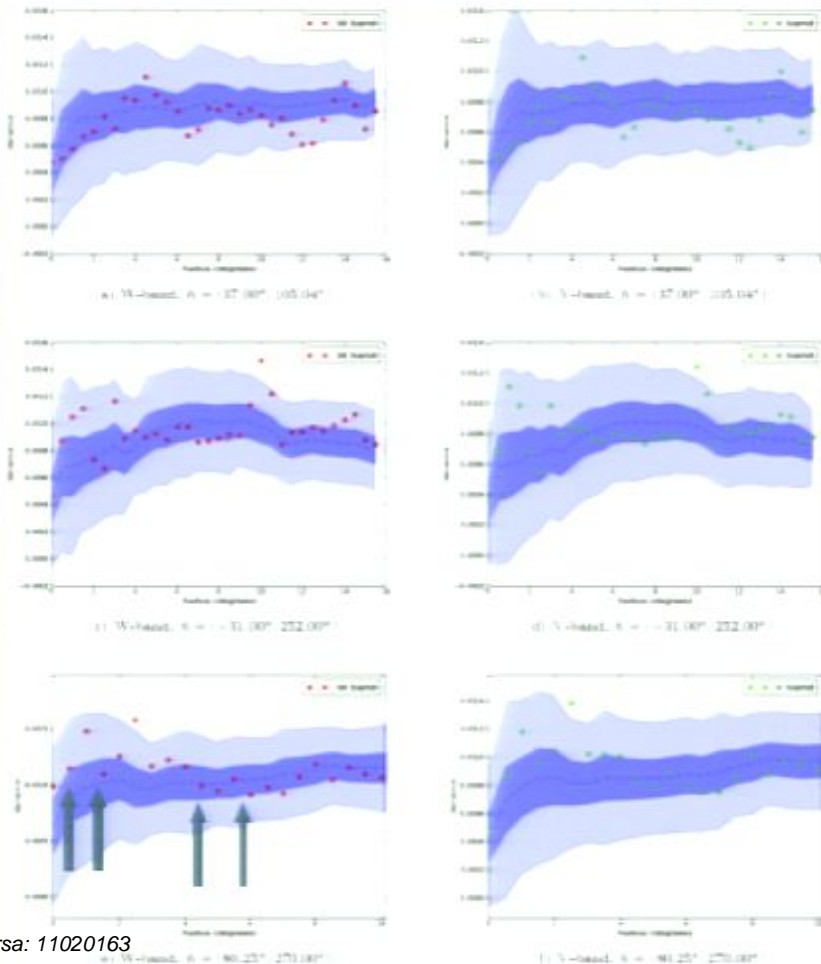
(c) W-band, $\alpha = -31.00^\circ$ (252.00 $^\circ$)



(d) V-band, $\alpha = -31.00^\circ$ (252.00 $^\circ$)



Reassessing statistical significance of the G&P patterns

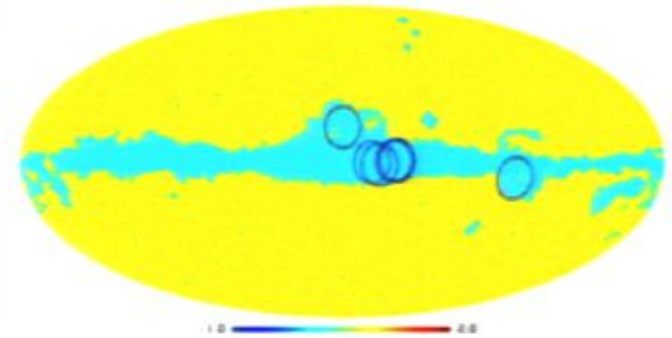
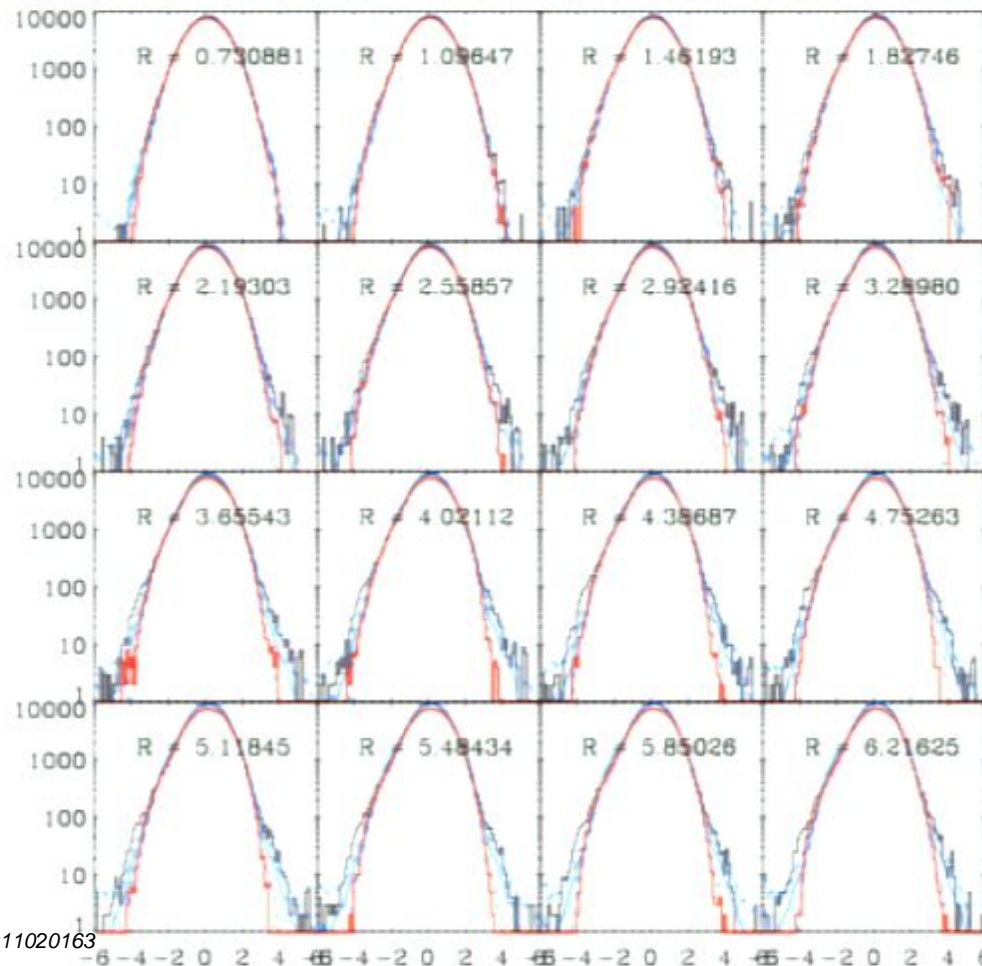


*5M pixels in the maps
-2.5M left after masking
165,000 independent data points
after 0.5deg smoothing
we expect to find
 $0.003 * 165,000 - 500$ incidents
below 3sigma deviations*

More details:

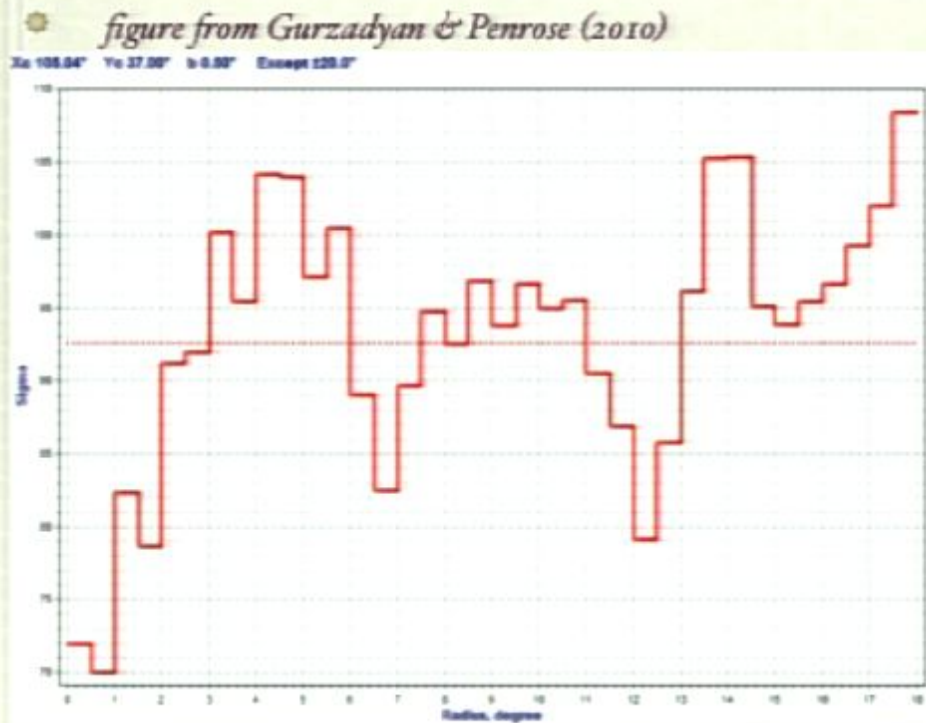
<http://www.cita.utoronto.ca/~abajian/pBB.html>

No actual detection of uniform temperature circles



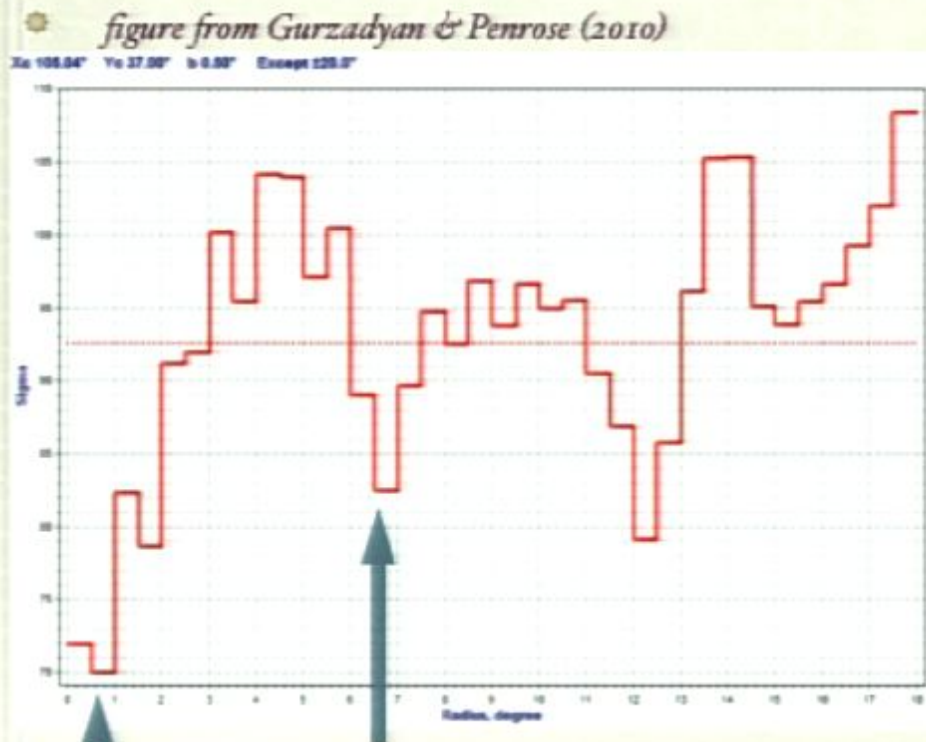
*Detected circles are all at the edges -> suffer from small number statistics
Excluding circles with small number of pixels in them removes large deviations from Gaussian distributions.
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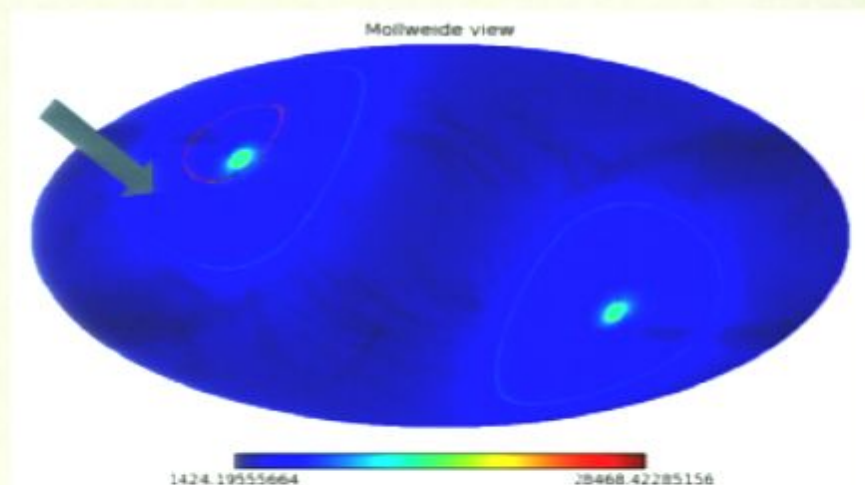
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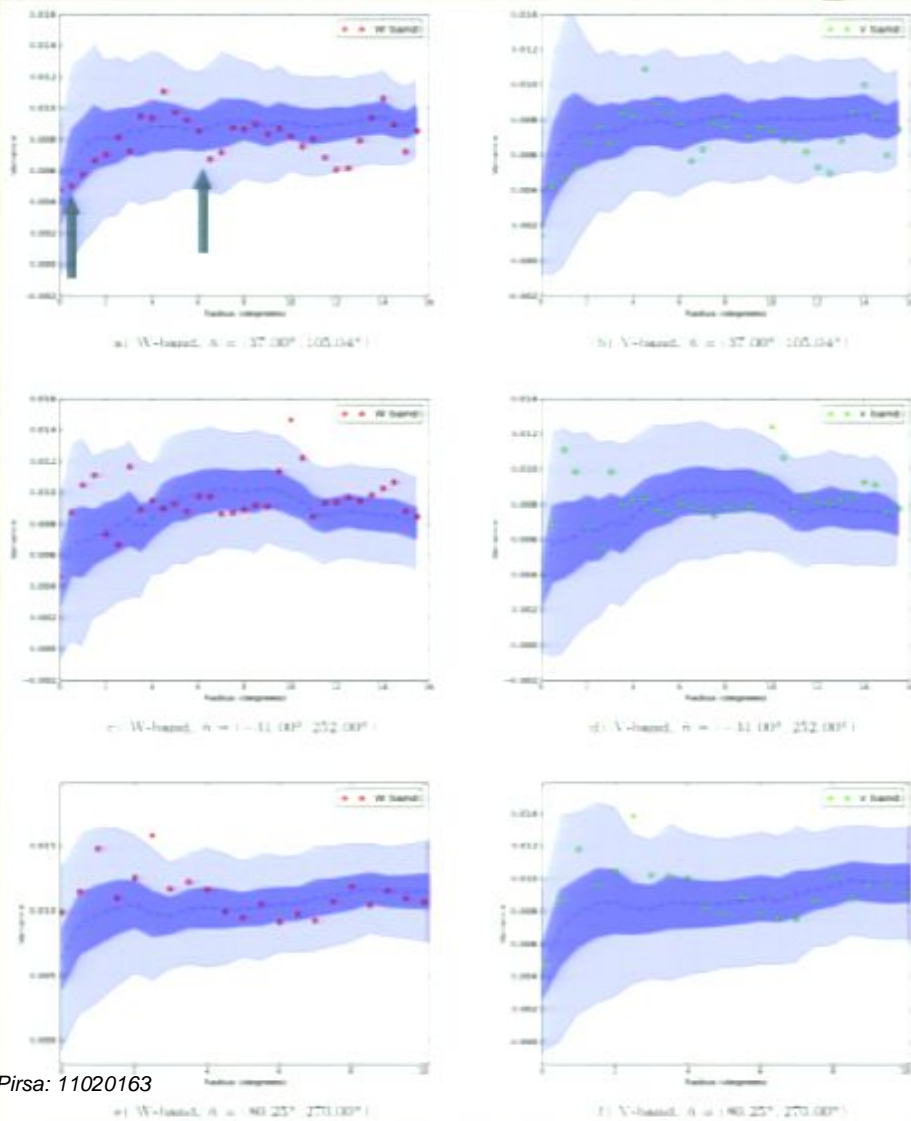
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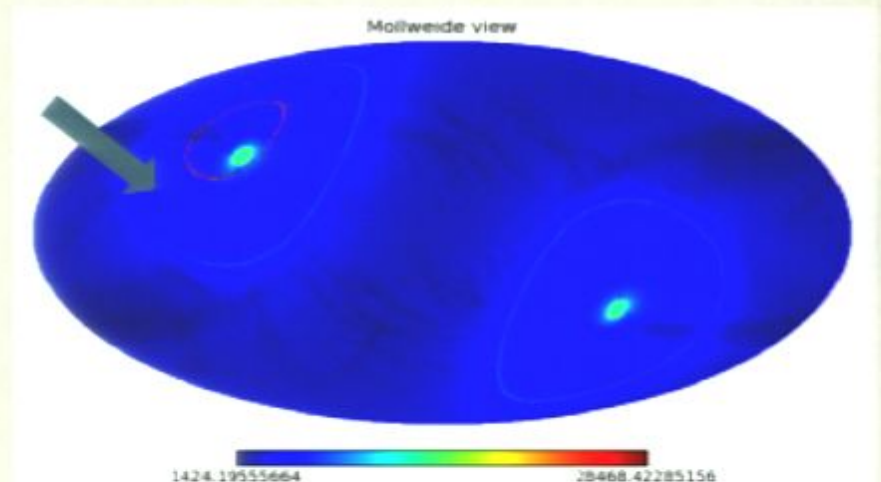
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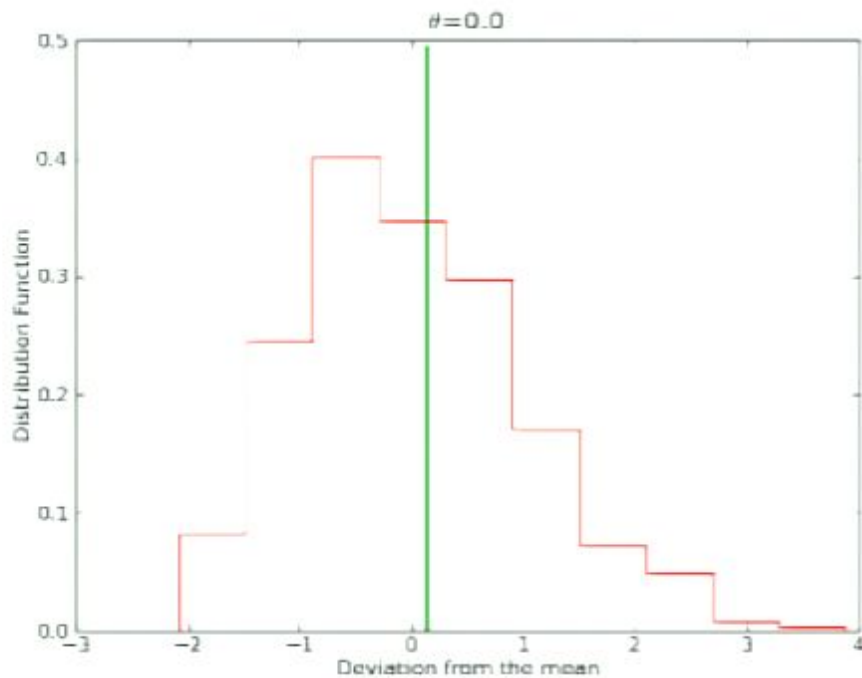
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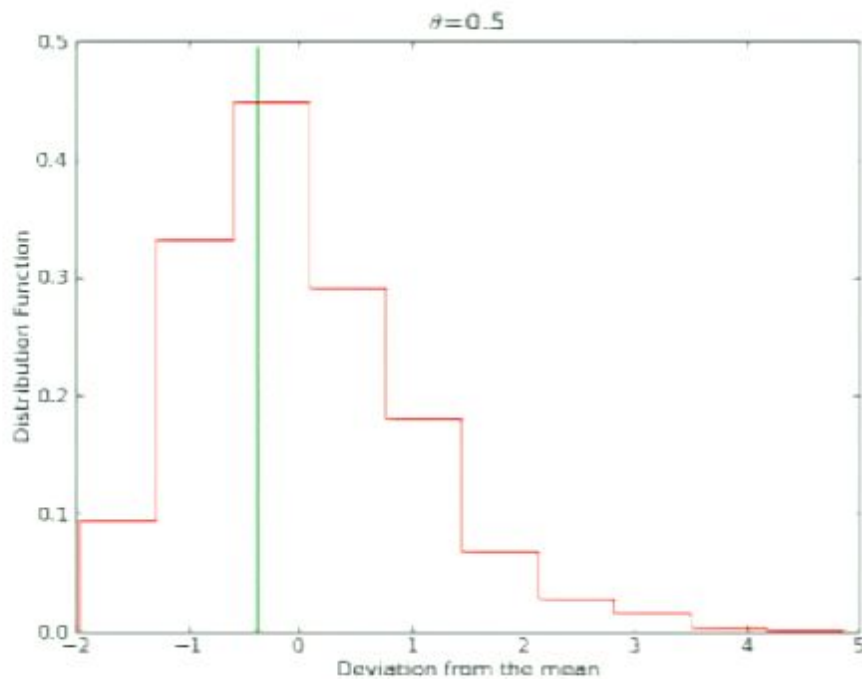


Measured variances along the G&P circles in WMAP data compared with the PDF of the variances of the same circles in 1000 simulations.

More details:

<http://www.cita.utoronto.ca/~ahajian/pBB.html>

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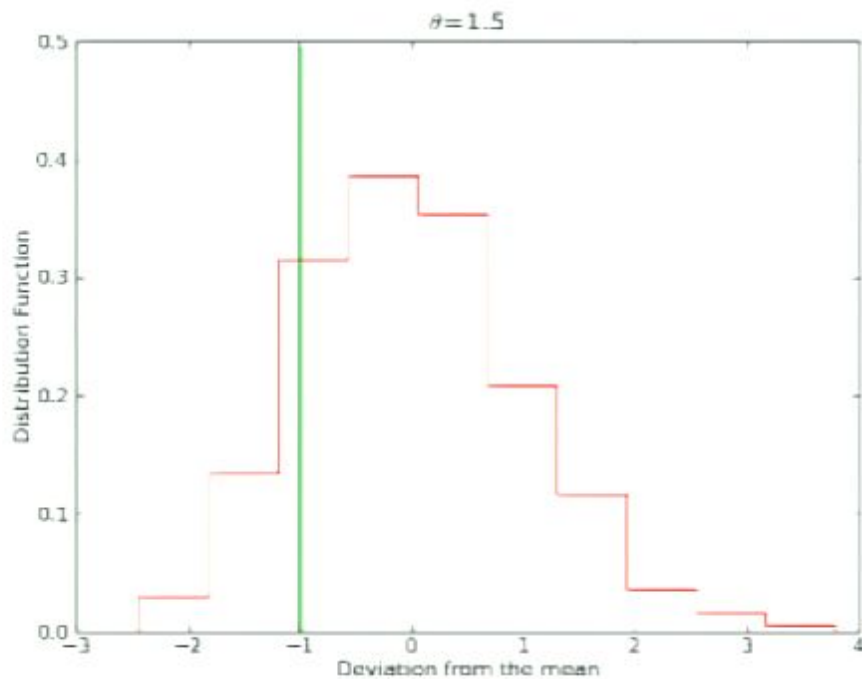


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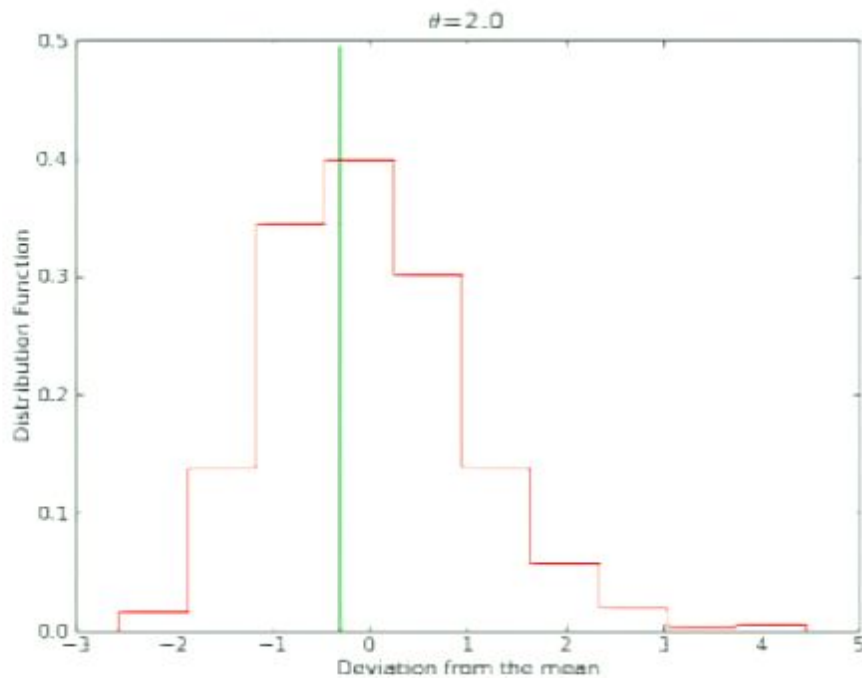


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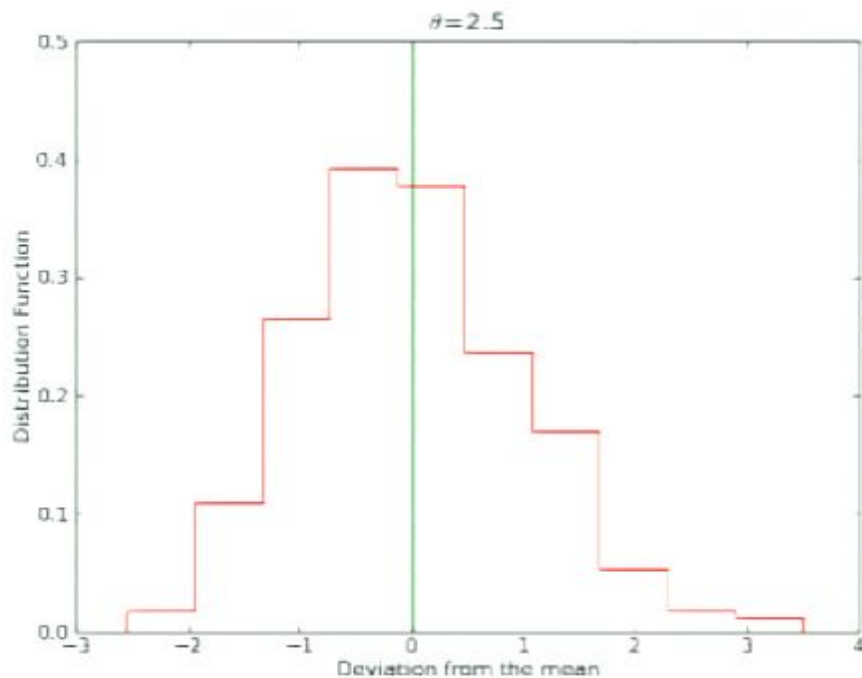


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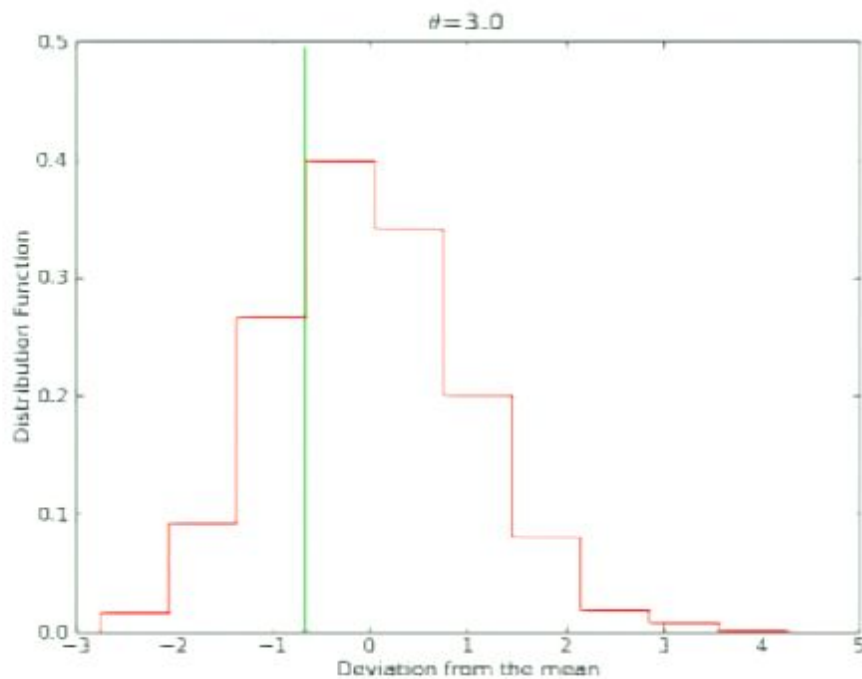


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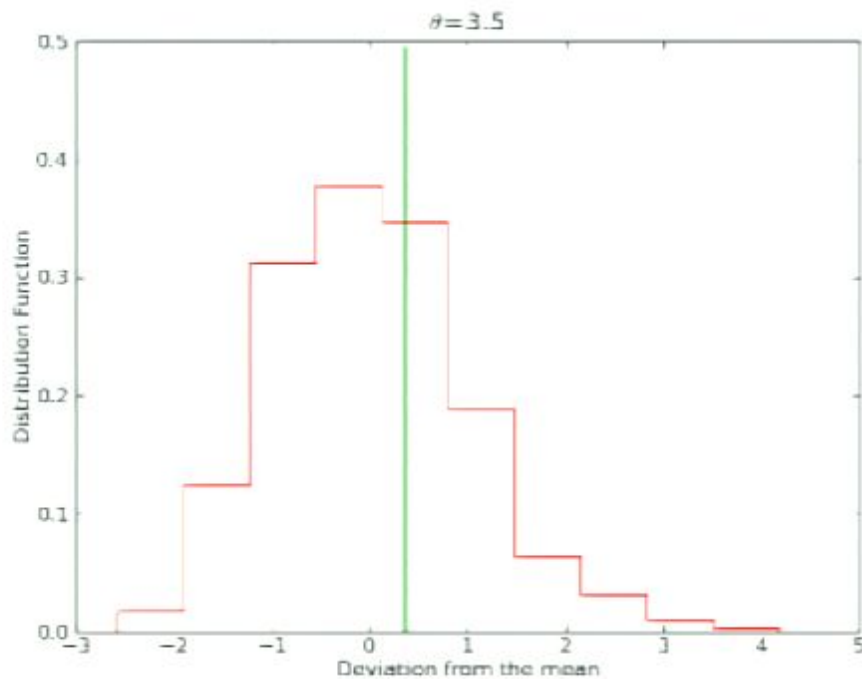


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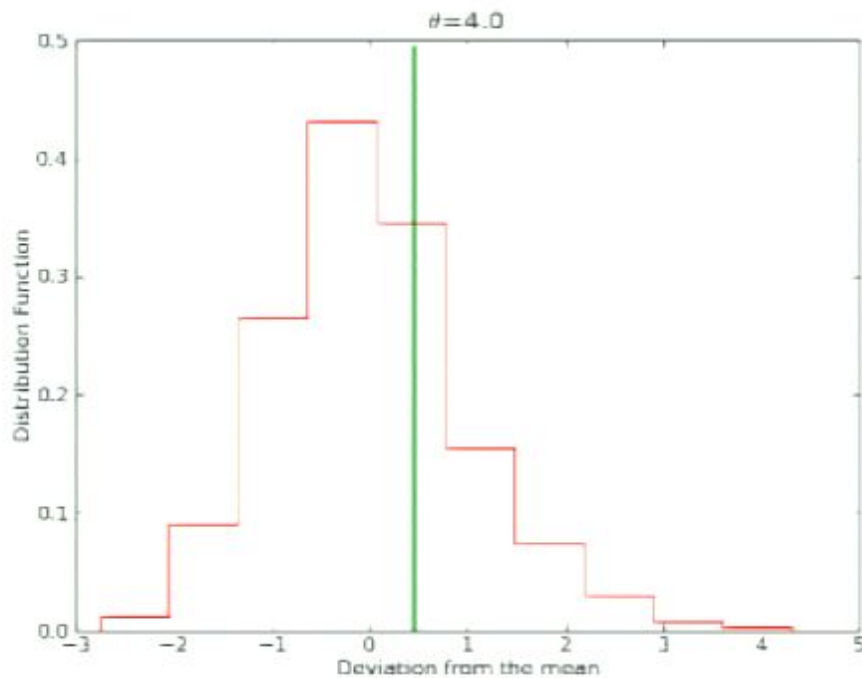


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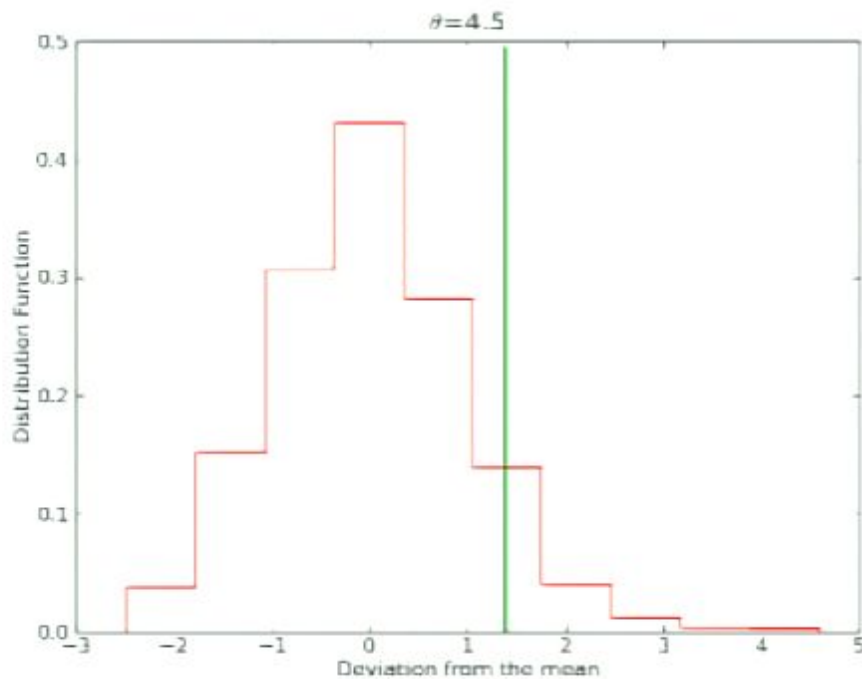


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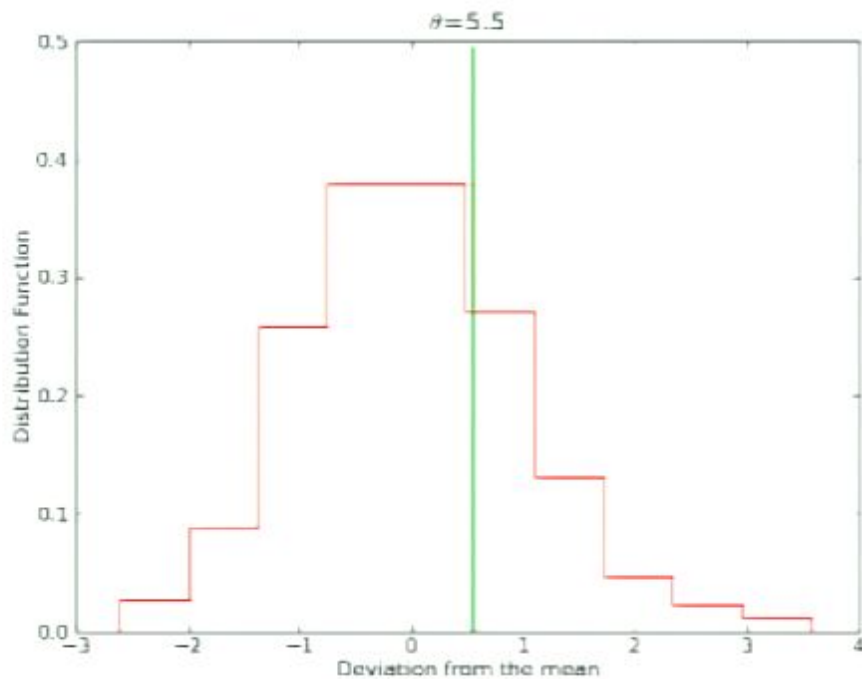


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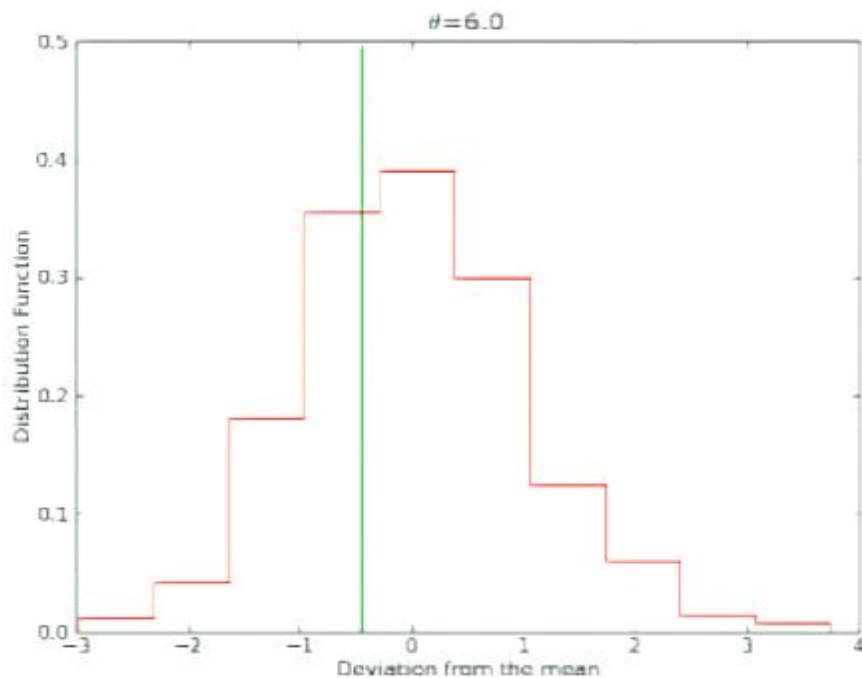


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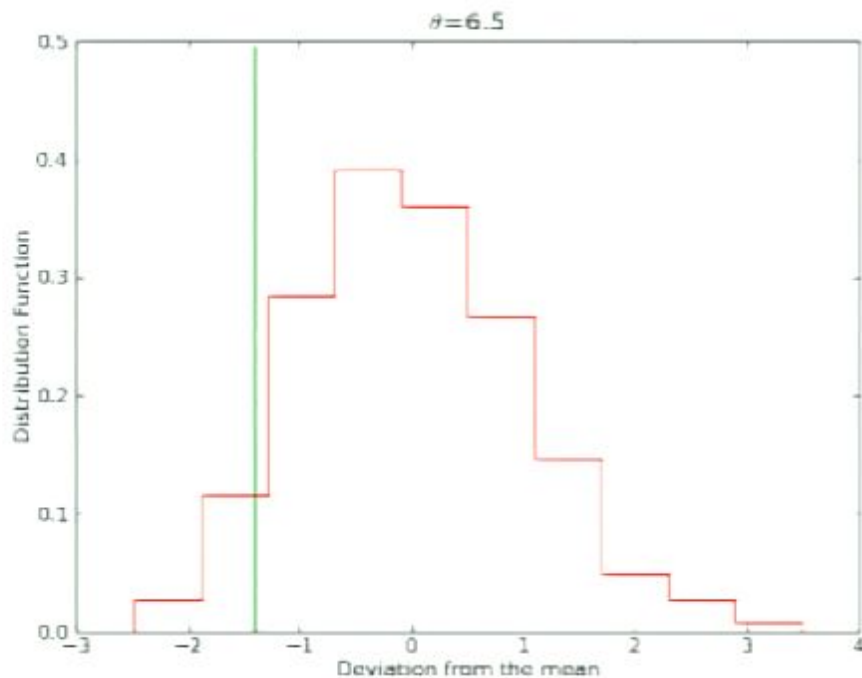


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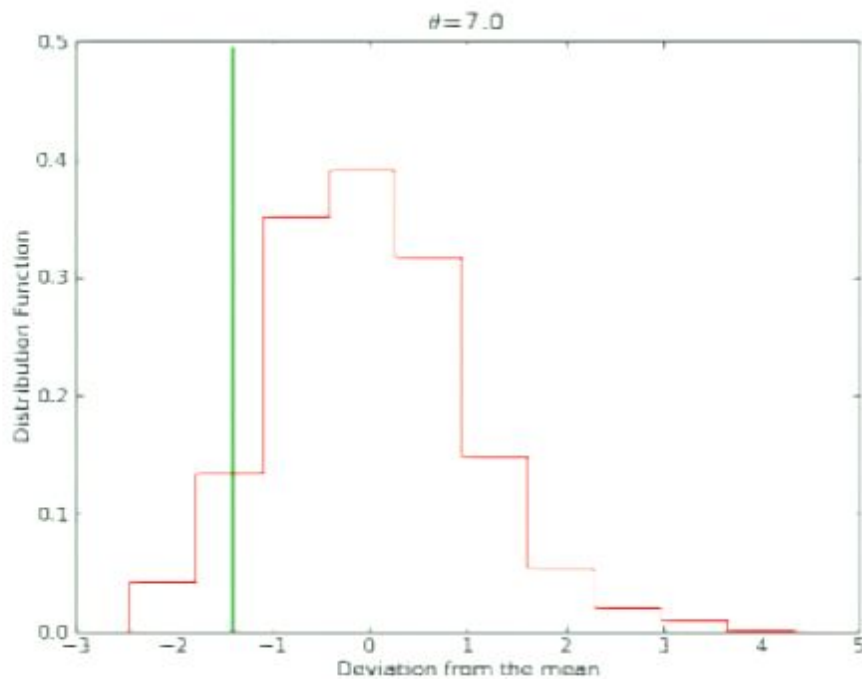


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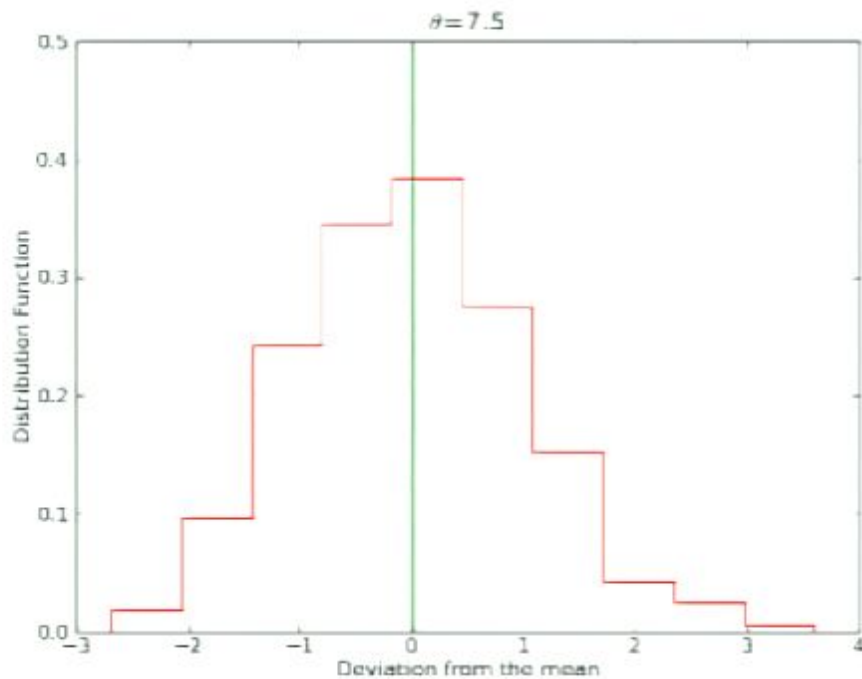


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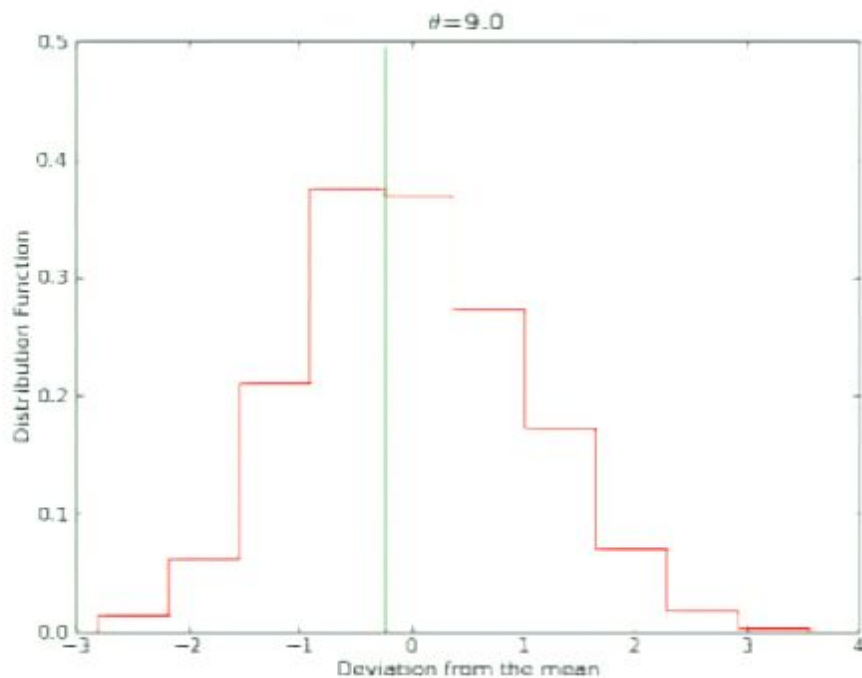


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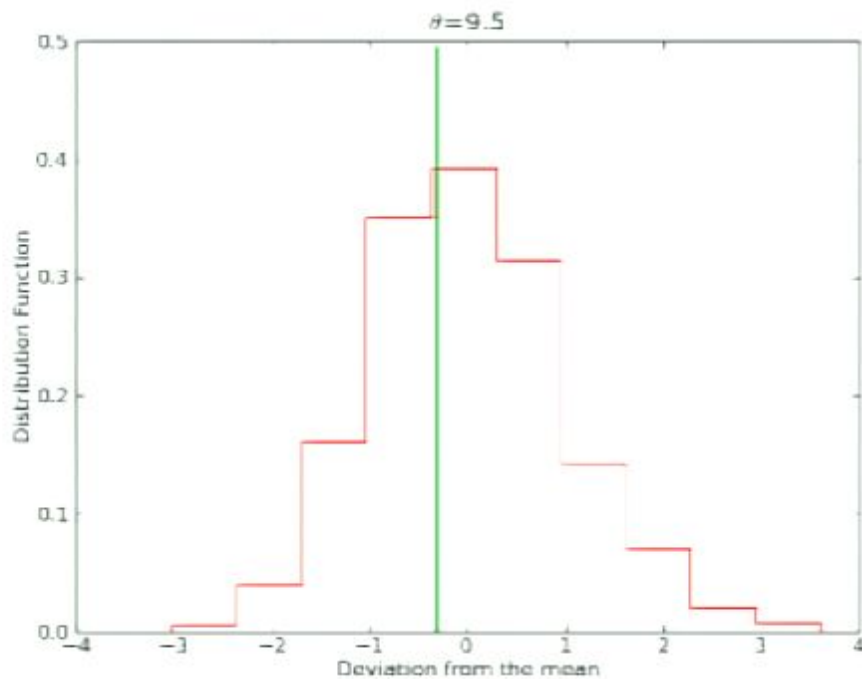


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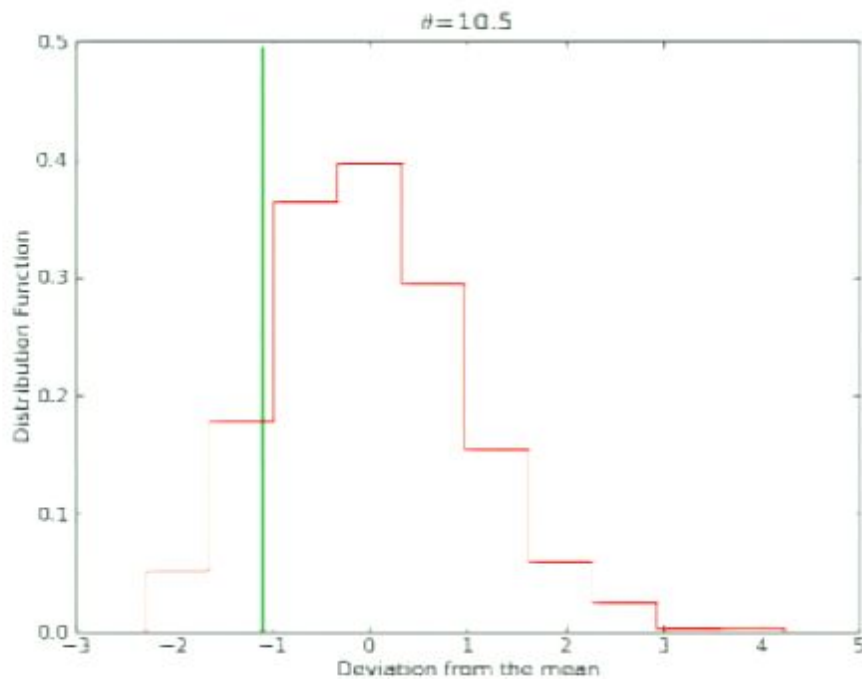


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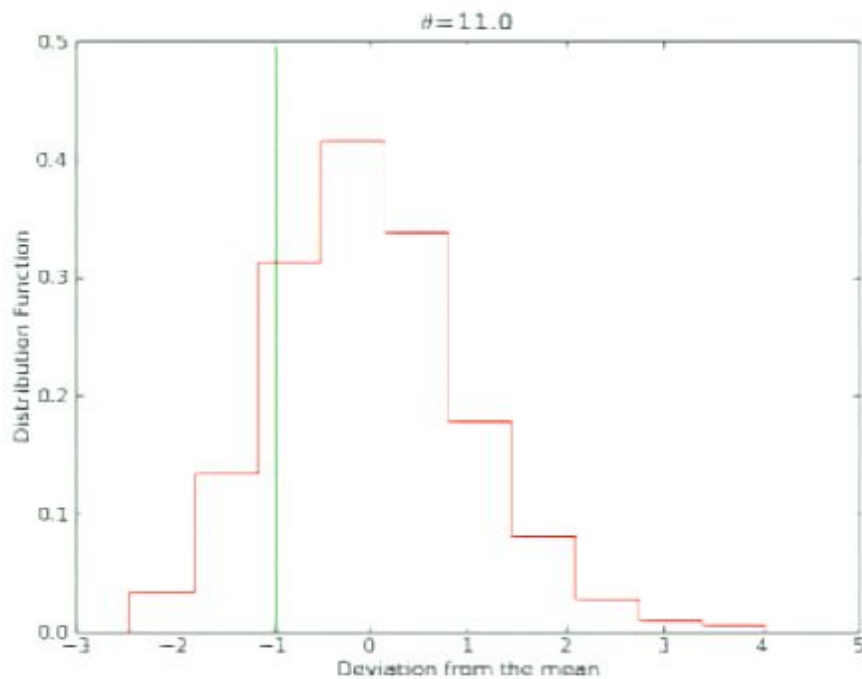


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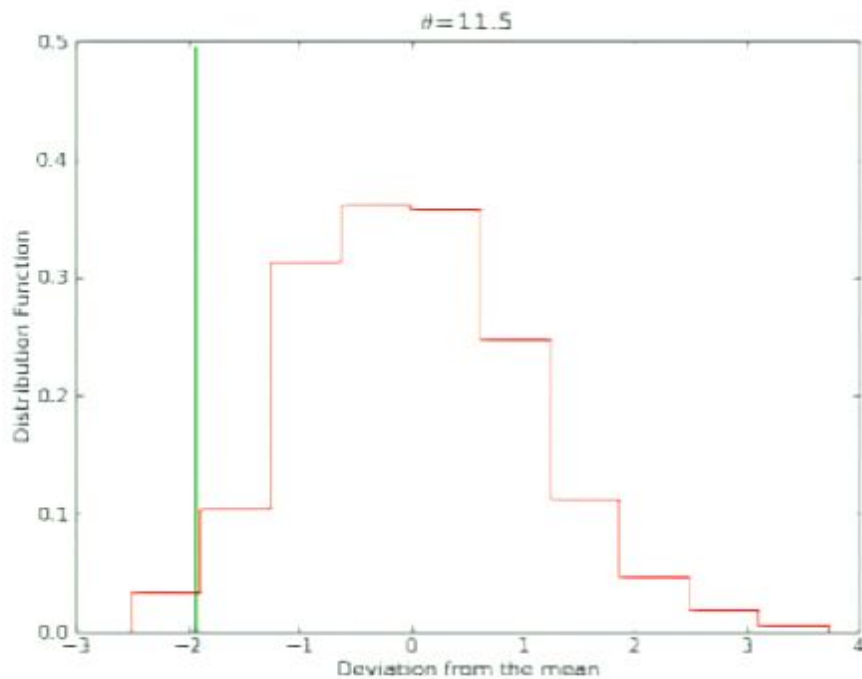


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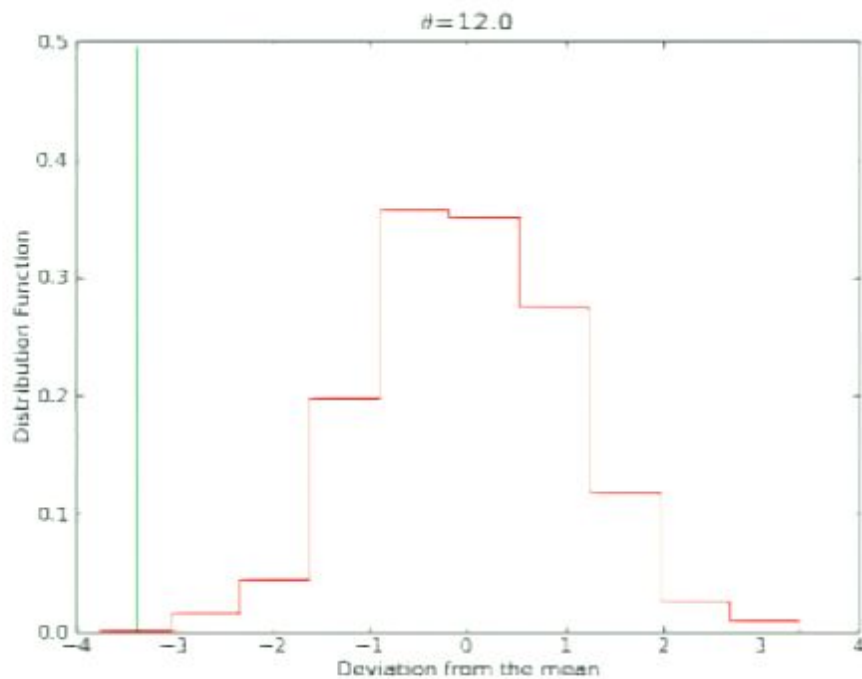


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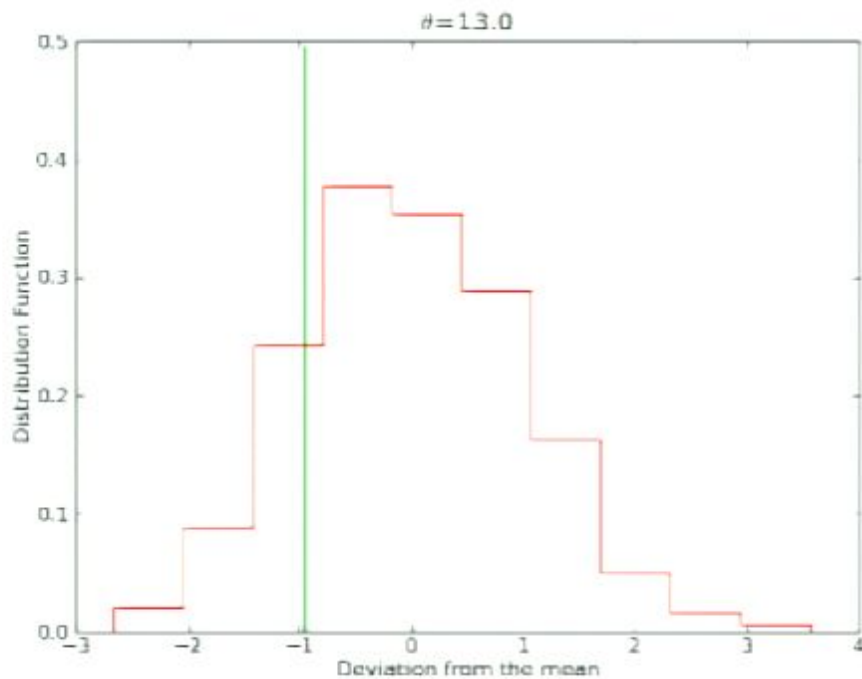


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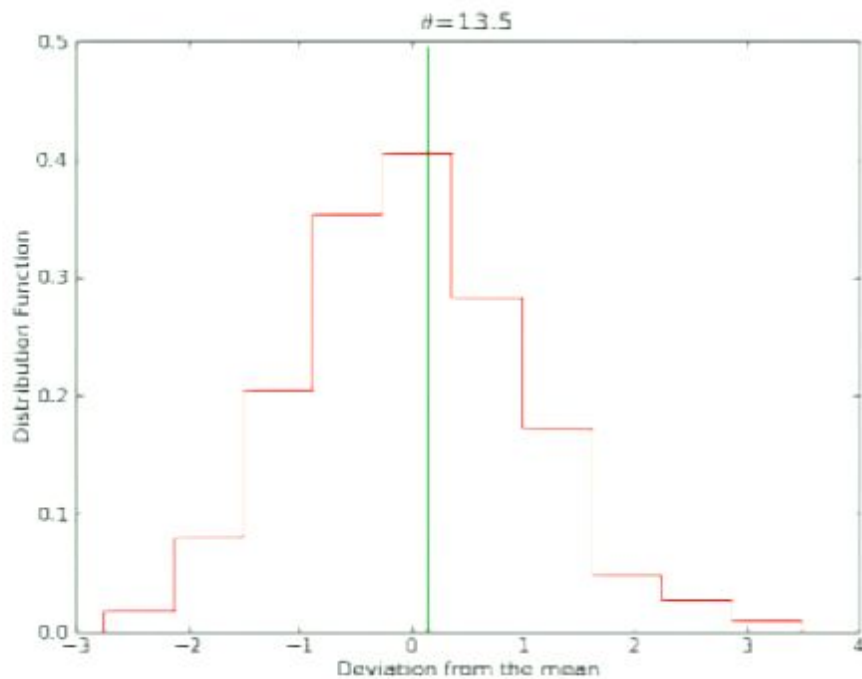


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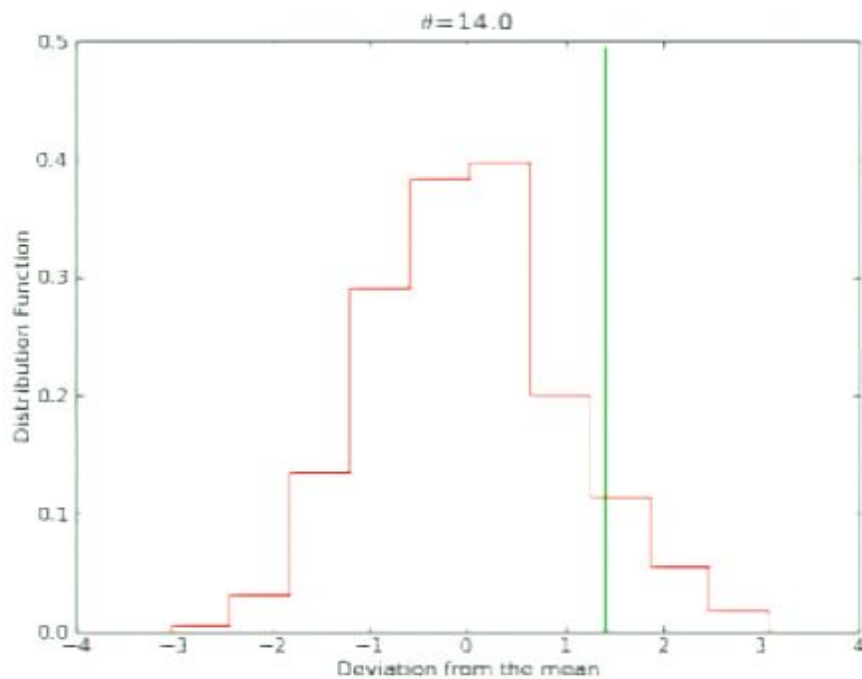


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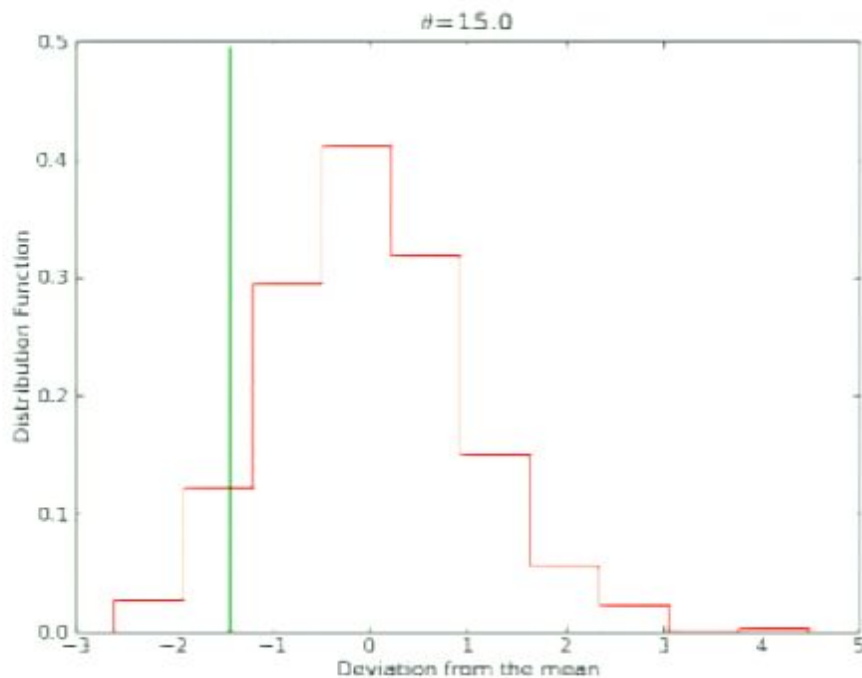


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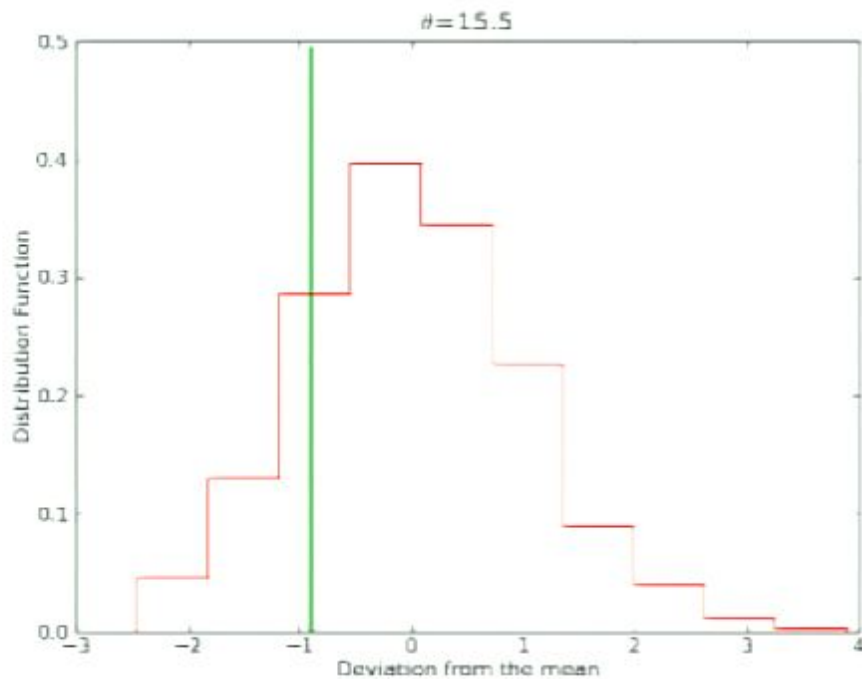


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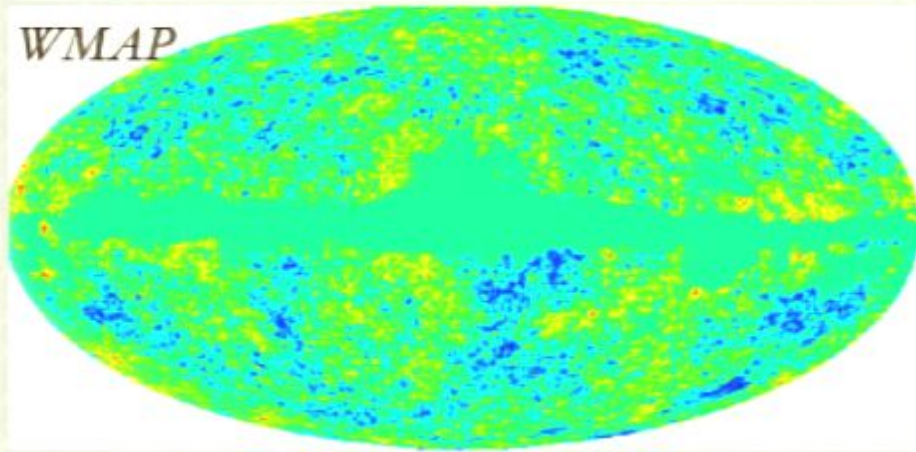
Why are the results
different?

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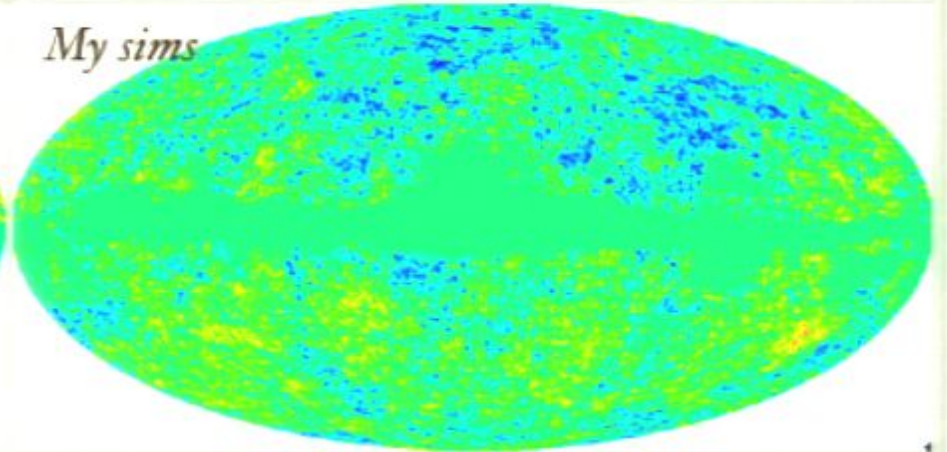
- *The signal is the same, the main difference is in the statistical significance of the signal*
- *Statistical significance is obtained by comparing with the sims*
- *Our simulations are done with: correct power spectrum (vs. flat spectrum), realistic noise realizations (vs. ?), proper treatment of WMAP beams (vs. ?)*

Simulated Maps vs. Real CMB Sky

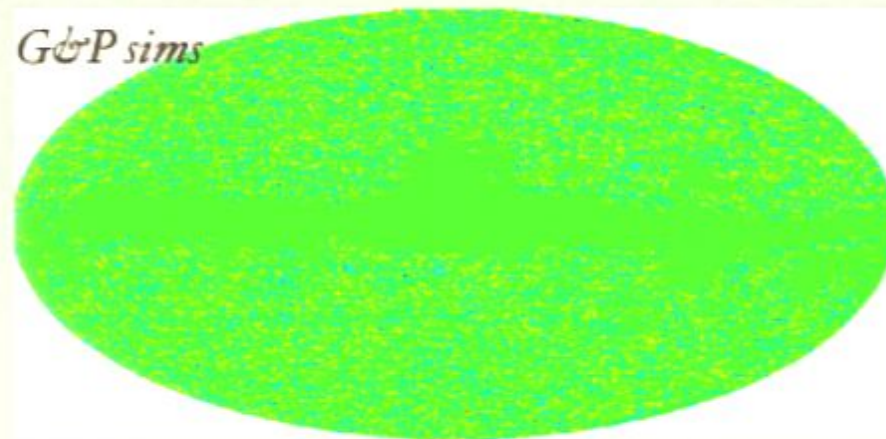
WMAP



My sims



G&P sims

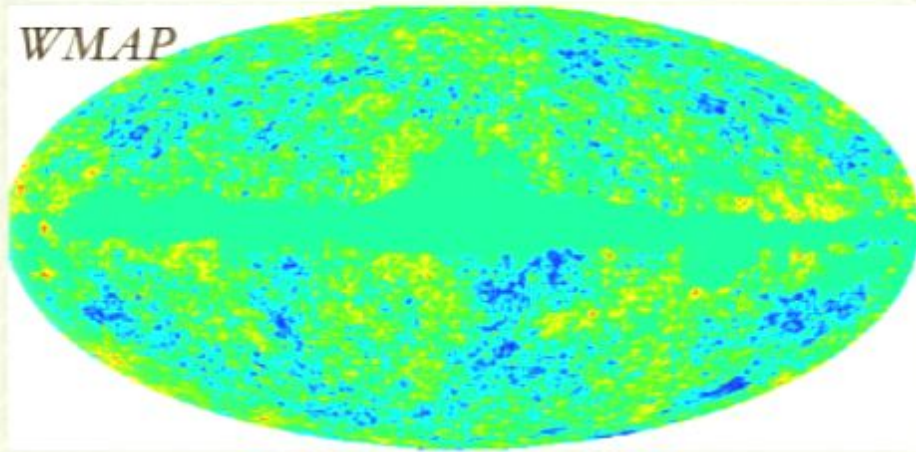


Why are the results different?

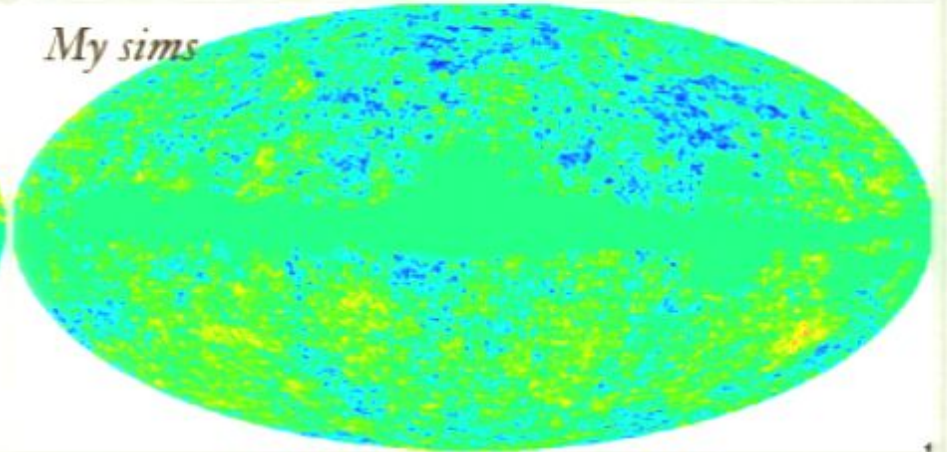
- *The signal is the same, the main difference is in the statistical significance of the signal*
- *Statistical significance is obtained by comparing with the sims*
- *Our simulations are done with: correct power spectrum (vs. flat spectrum), realistic noise realizations (vs. ?), proper treatment of WMAP beams (vs. ?)*

Simulated Maps vs. Real CMB Sky

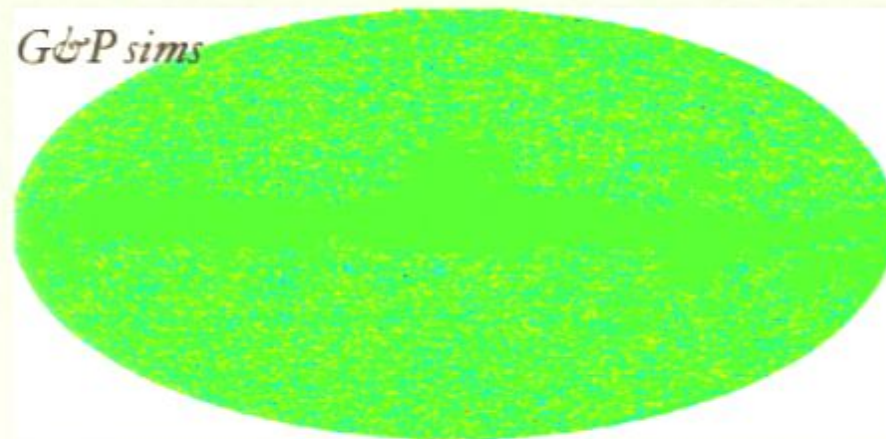
WMAP

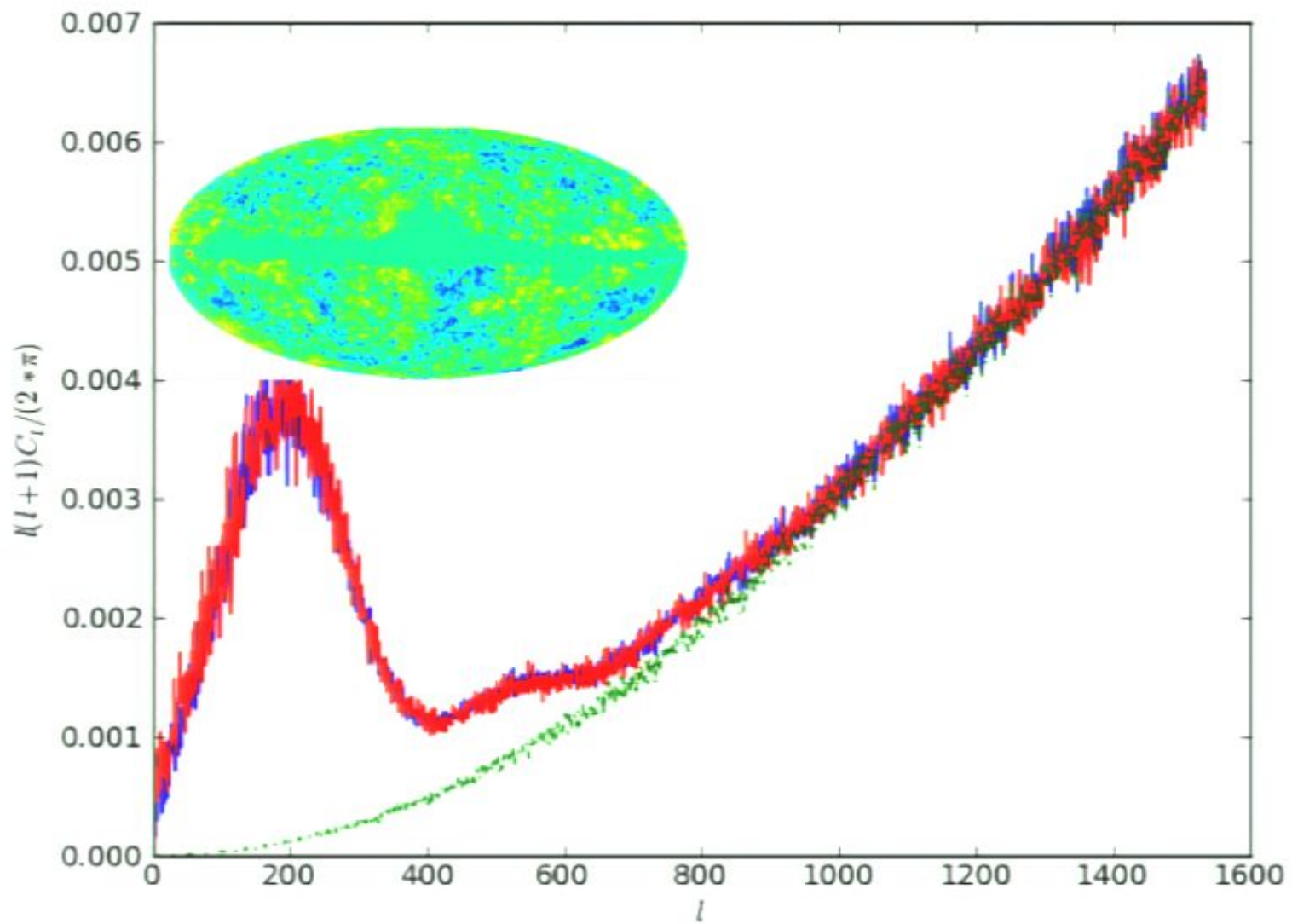


My sims



G&P sims





Conclusion

- *The low variance circles of G&P are not anomalous and can very well exist in a LCDM cosmology consistent with the Big Bang*
- *These results do not rule out the CCC model, but prove that the three regions in WMAP data have normal variances and they can't be used as an evidence in favour of the CCC model.*

Eugene's Profile · Eugene's Wall

**Eugene Lim**

Can we say that a posterior statistics strikes again?

[1011.3706] Concentric circles in WMAP data may provide evidence of violent pre-Big-Bang activity
arxiv.org

November 29, 2010 at 4:31pm · Like · Comment · Share

Francesco Mercurio likes this.



Joshua Schroeder I believe Roger predicted this effect before making the graduate student do the analysis. He talked about it two years ago when he visited Columbia.

November 29, 2010 at 4:37pm · Like



Eugene Lim Sure. But their analysis is based on a posterior stats. I would be more convinced if they simulated 10000 gaussian maps, and then look for these features in each, and find none at all. That would then be a 3 sigma detection.

November 29, 2010 at 4:46pm · Like



Joshua Schroeder Roger has always been a more "proof of concept" kind of guy, I agree!

November 29, 2010 at 5:00pm · Like



David Johnston Making a convincing statistical argument was apparently beyond the scope of the paper.

November 29, 2010 at 5:01pm · Like



Amir Hajian I did a detailed statistical analysis of this model more than two years ago on WMAPS. I used a different statistic that was unbiased and compared it with sims including realistic noise simulations for WMAP. There were no circles beyond 3sigma detection level (i.e. no believable circles).

November 29, 2010 at 8:36pm · Like · 4 people



Tom Crawford Penrose gave a really nice colloquium at Chicago a few weeks ago and absolutely ruined it by bringing this up at the end. I particularly enjoyed his statement to the effect of "I asked Hajian to look at it, he didn't find what I wanted, so I asked this other guy."