A Hint of Poincaré Dodecahedral Topology in the WMAP First Year Sky Map

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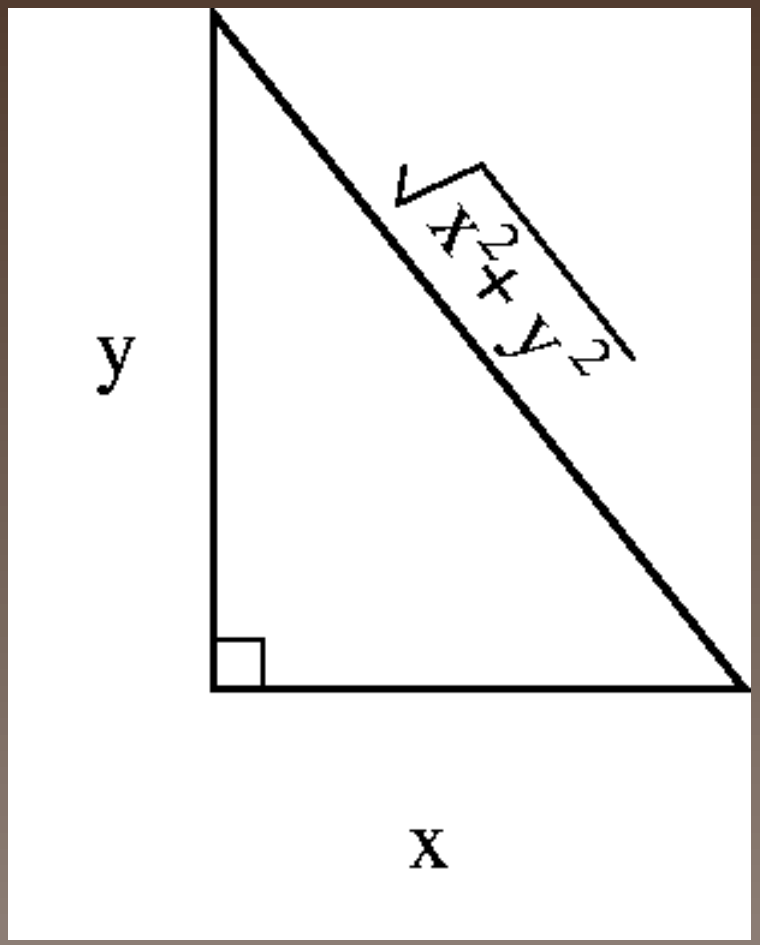
Geometry: Curvature + Topology



0 + - multi-connected

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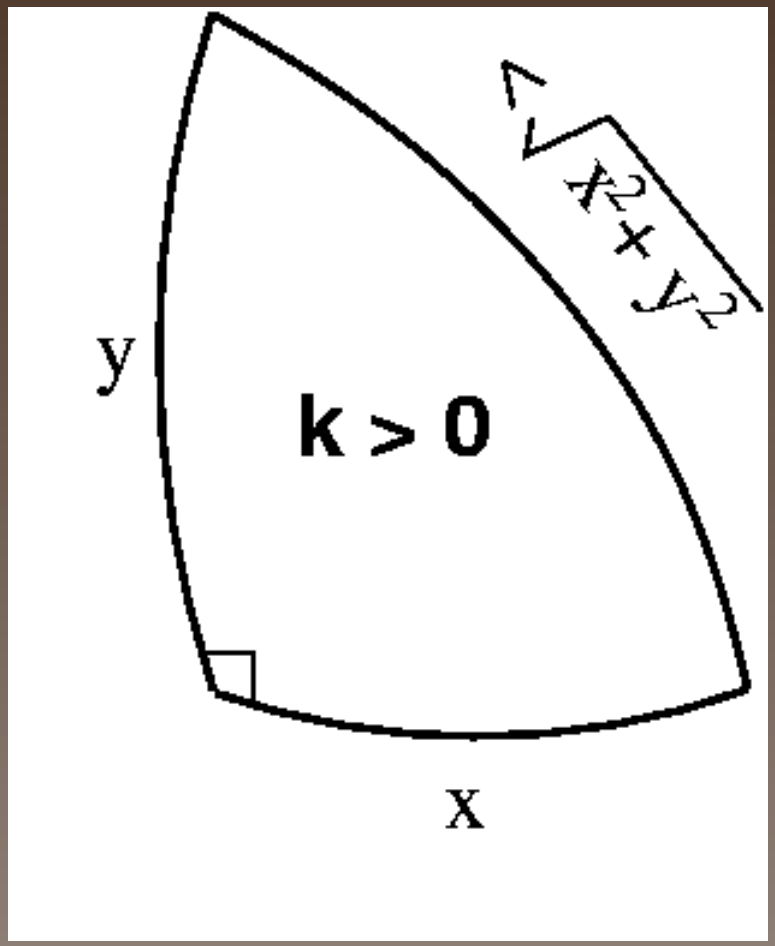

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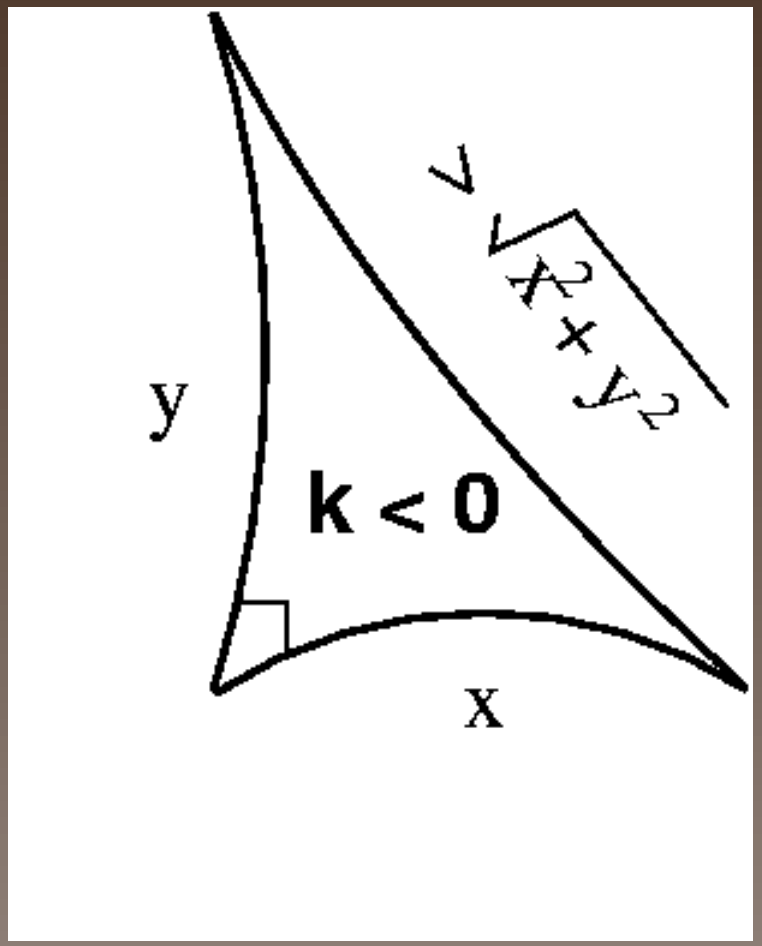

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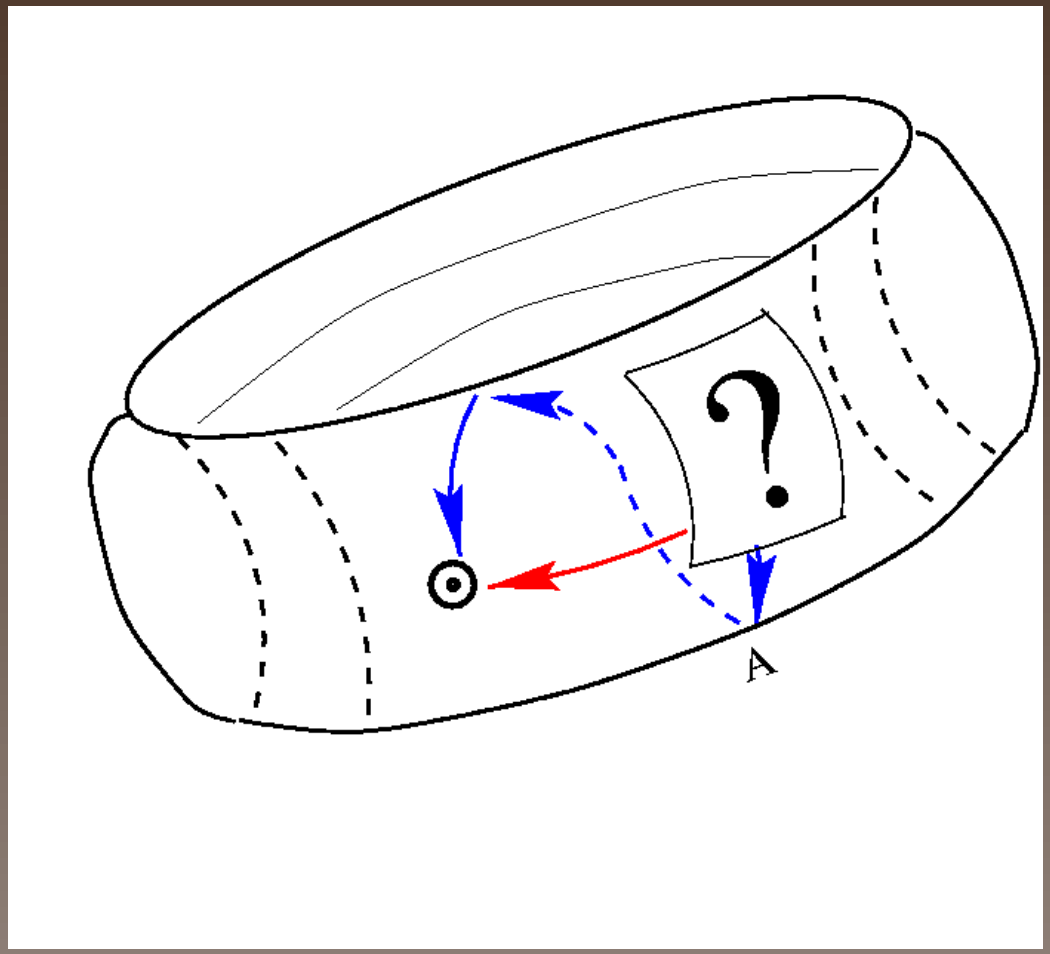

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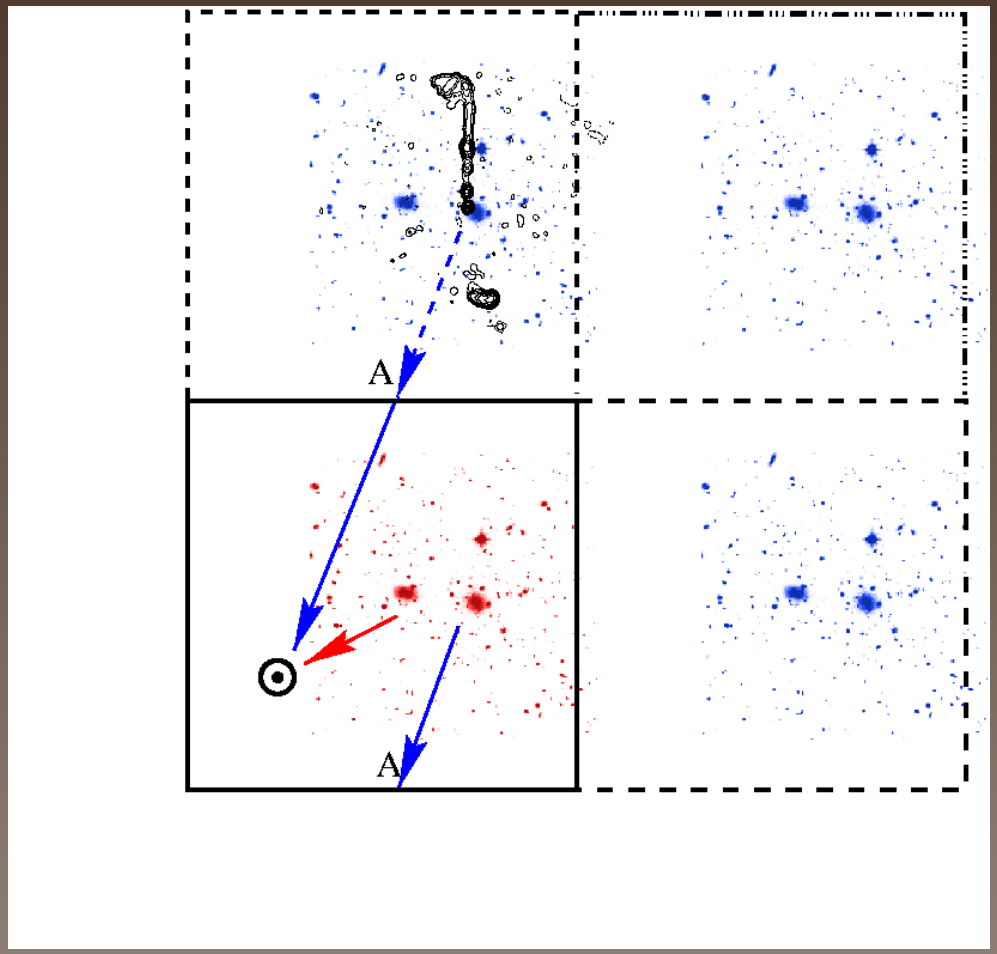

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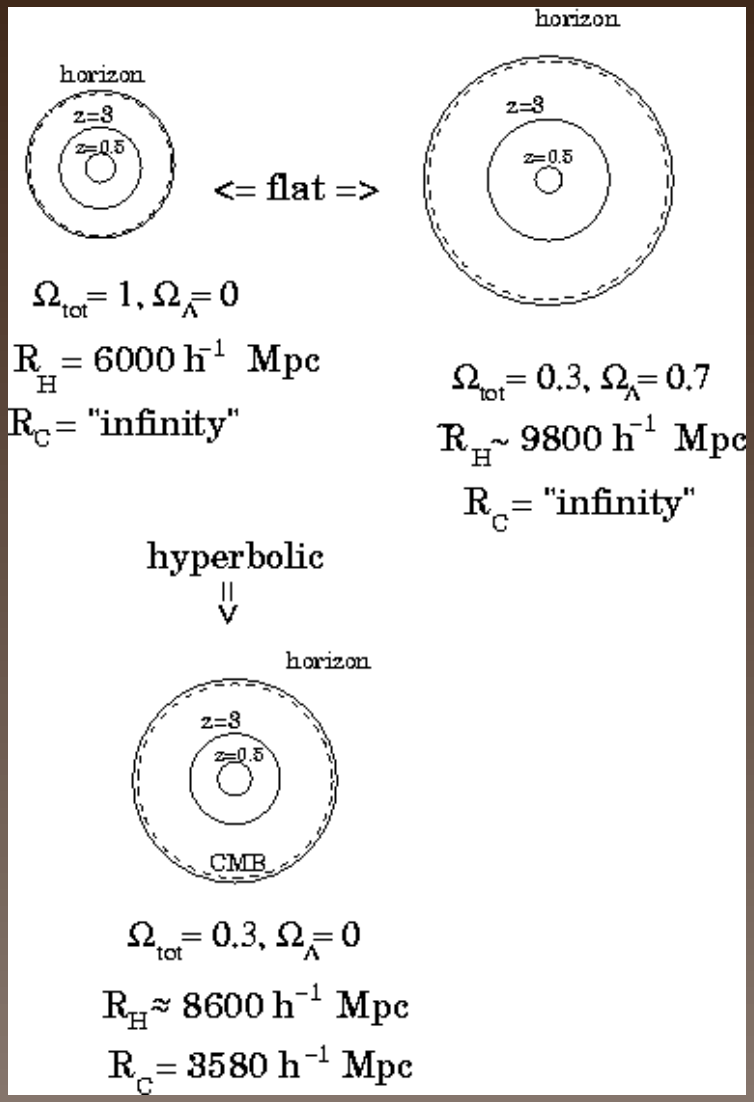

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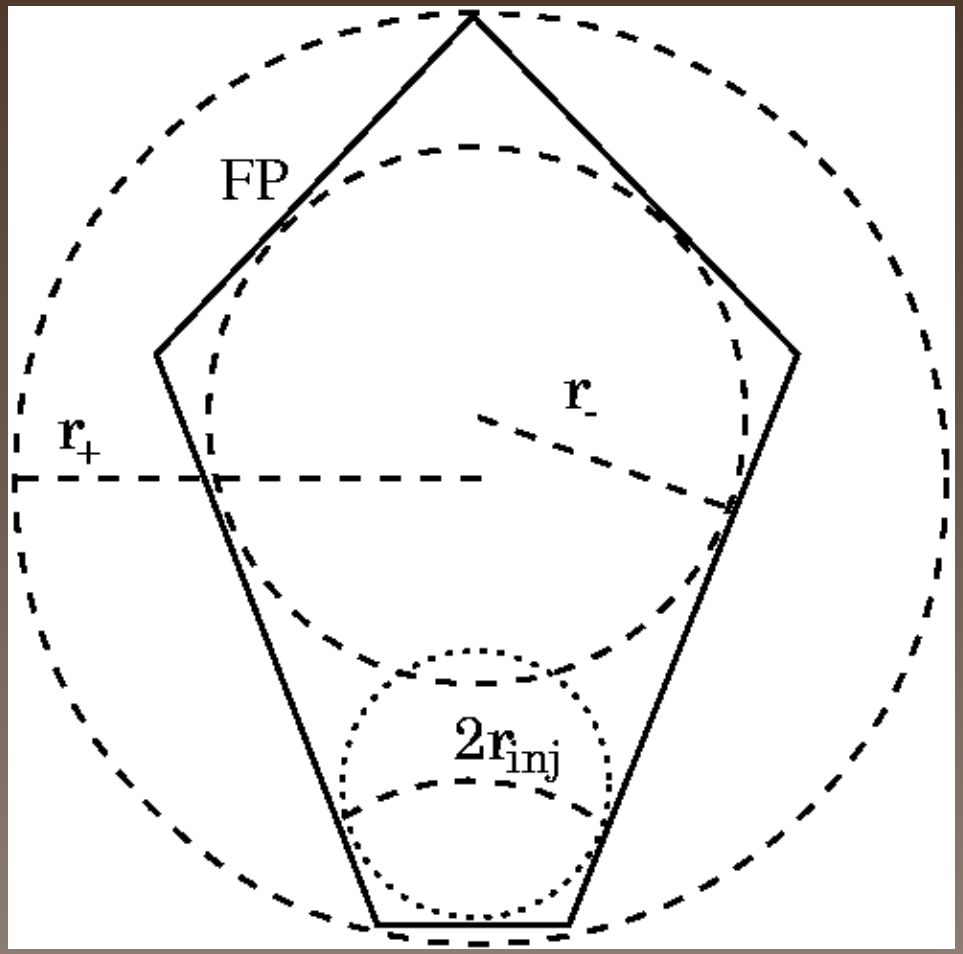

r_- : biggest sphere *inside* FD

r_+ : smallest sphere *containing* FD

$2r_{\mathrm{inj}}$: smallest closed spatial geodesic

0 + - multi-connected

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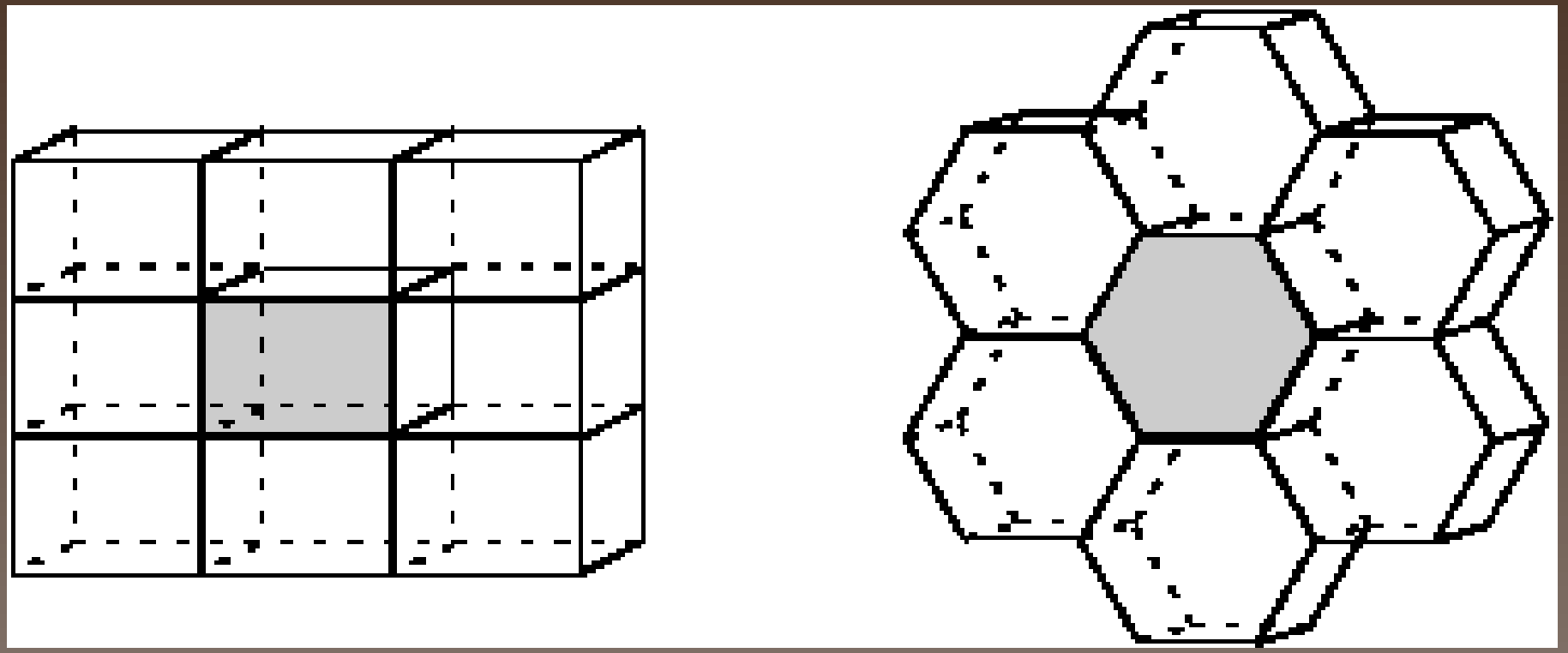
Geometry: Curvature + Topology



0

\+ - multi-connected (Luminet & Roukema 1999: http://arXiv.org/abs/astro-ph/9901364)

Strategies - 3D

http://arXiv.org/abs/astro-ph/0010189

A. multiple topological images:

A.i 3D (grav collapsed objects):

A.i.1 local isometries - many "type I pairs" or "local pairs"

A.i.2 cosmic crystallography - many "type II pairs" or "generator pairs",

A.i.3 characteristics of individual objects

Strategies - 2D and non-multiple-imaging

A.ii 2D (microwave background, CMB):
- A.ii.1 identified circles principle:
- A.ii.2 patterns of spots
- A.ii.3 perturbation statistics assumptions

B. other:
- B.i cosmic strings
- B.ii nested crystallography

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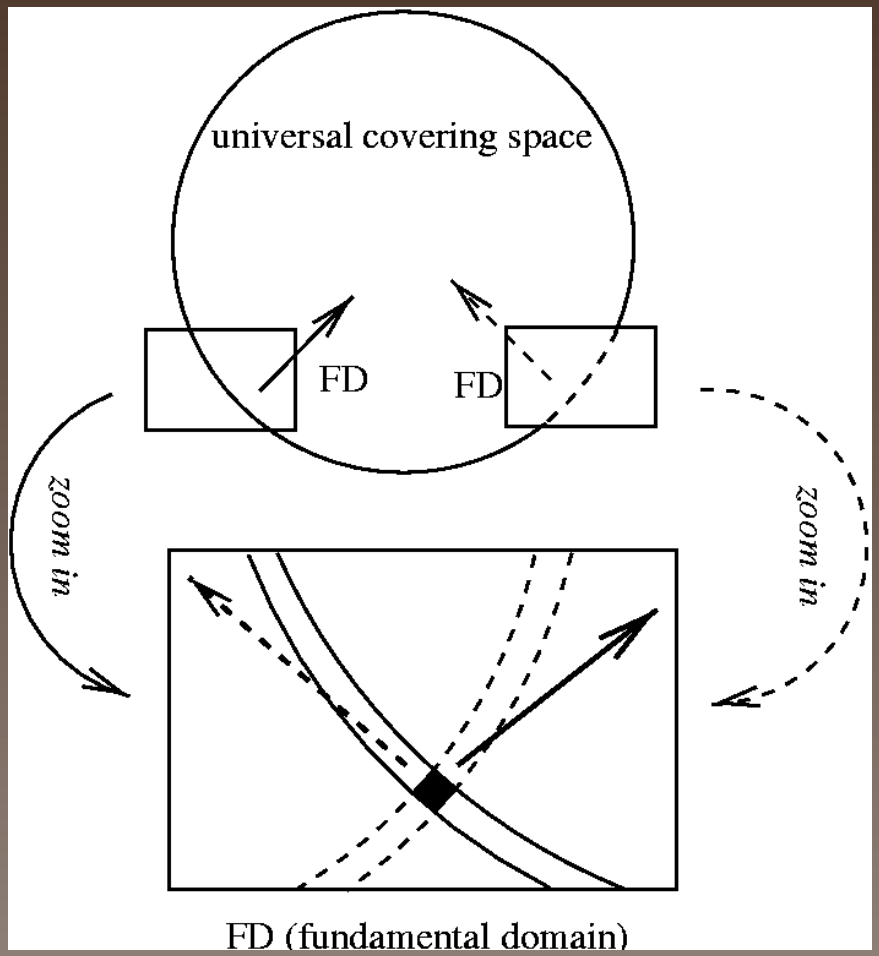
The Identified Circles Principle

Discovery of principle: Cornish, Spergel & Starkman (1996)

http://arXiv.org/abs/gr-qc/9602039

CQG, 15, 2657 (1998)

The Identified Circles Principle



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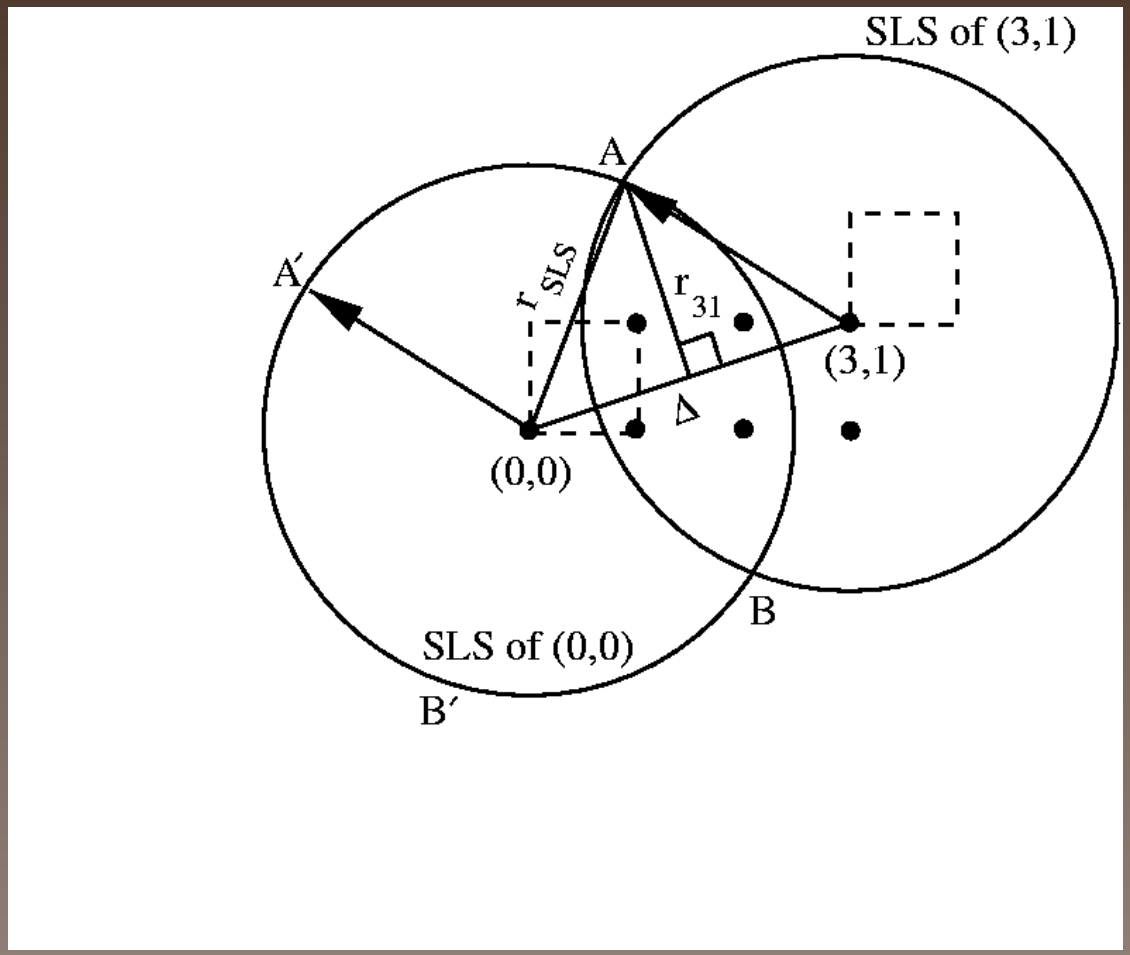

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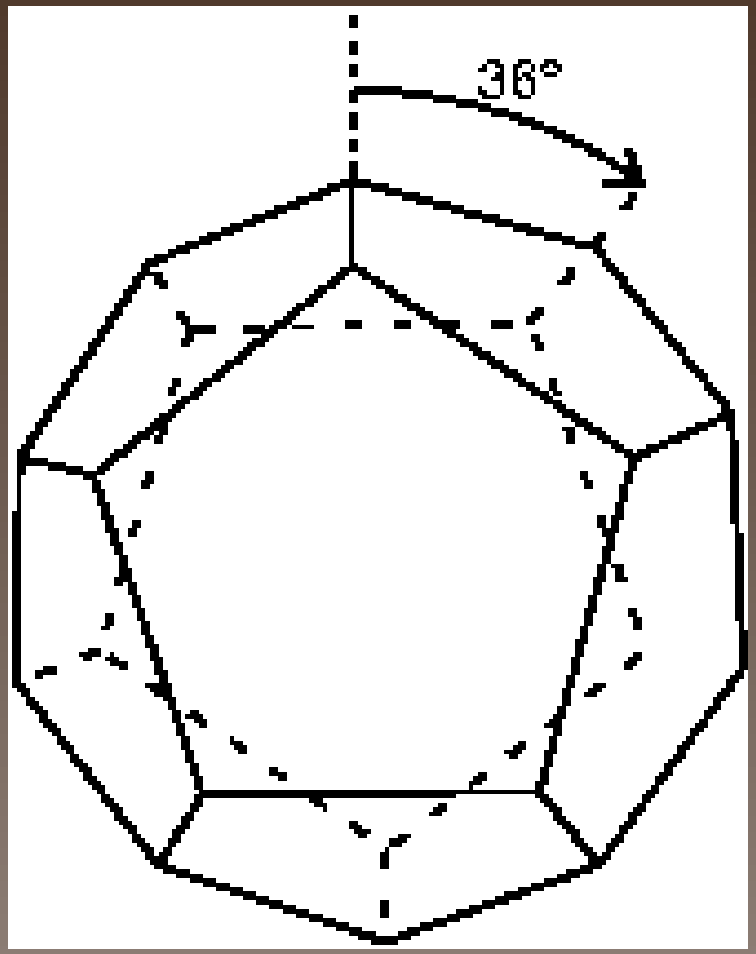
The Poincaré Dodecahedral 3-Manifold



- FD = positively curved dodecahedron
- covering space is S^3 (hypersphere)
- 120 copies of FD tile S^3
- Luminet et al. (2003) find this favoured by WMAP statistics

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The Poincaré Dodecahedral 3-Manifold

Correlation statistic to detect best circle matches:

$$S \equiv \frac{\left\langle 2 \left(\frac{\delta T}{T}\right)_i \left(\frac{\delta T}{T}\right)_j \right\rangle}{\left\langle \left(\frac{\delta T}{T}\right)_i^2 + \left(\frac{\delta T}{T}\right)_j^2 \right\rangle} \qquad (1)$$

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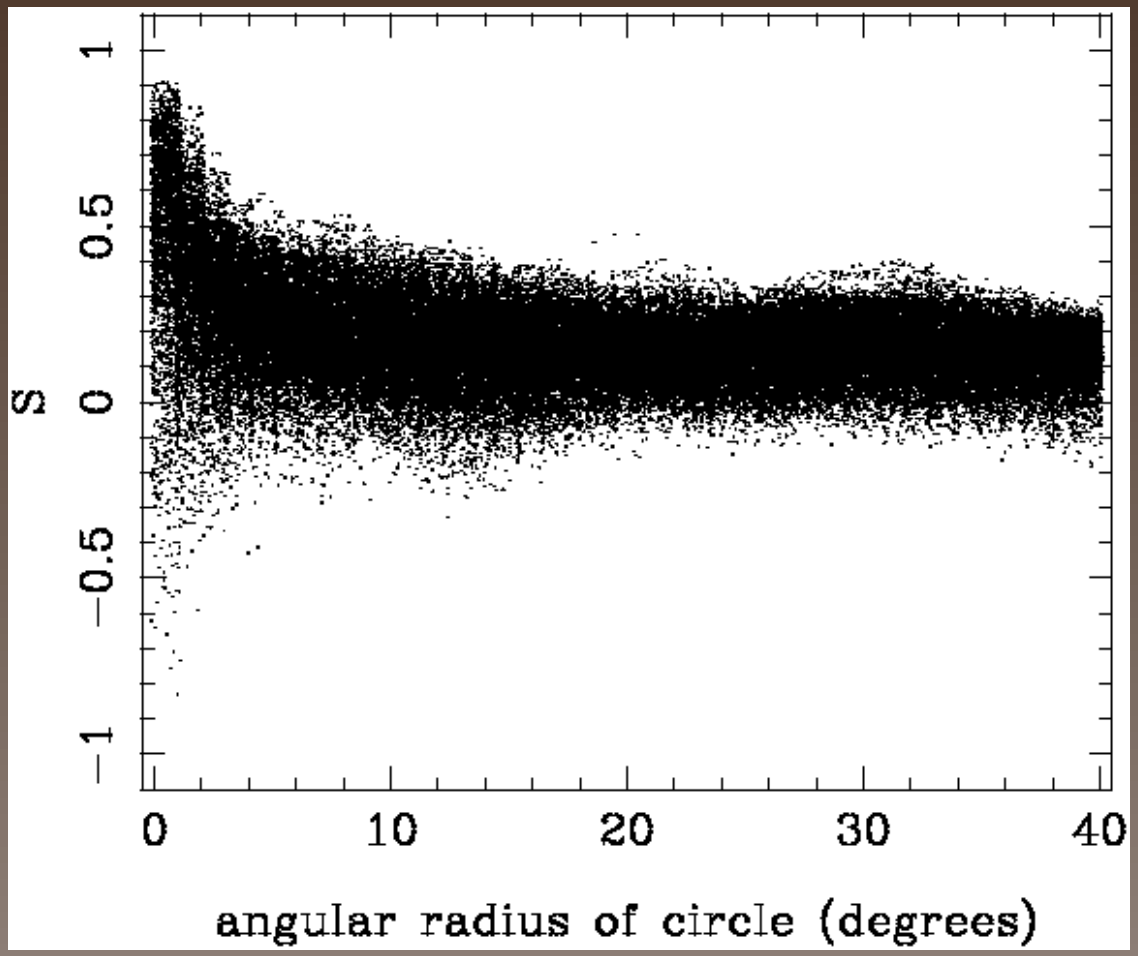

zero rotation

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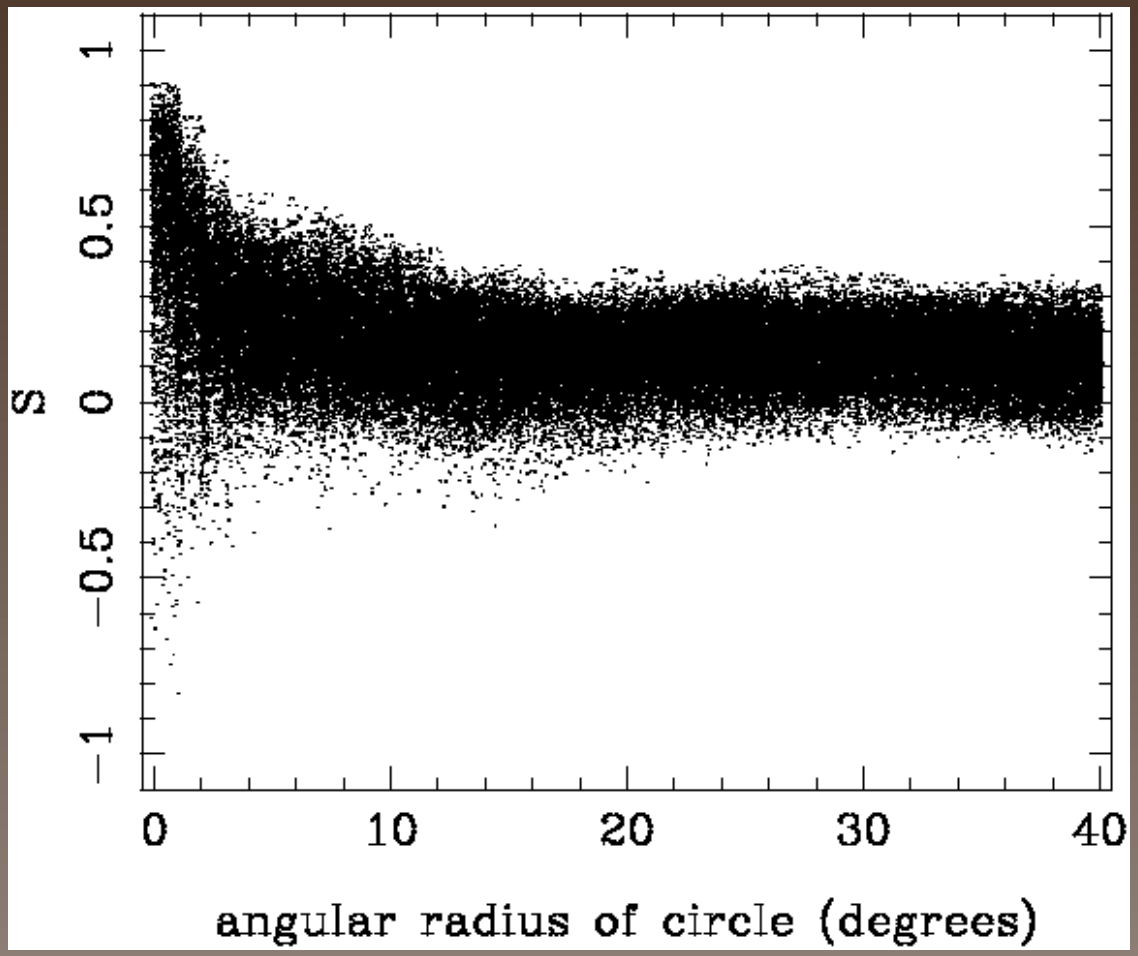

$+36^\circ$ rotation

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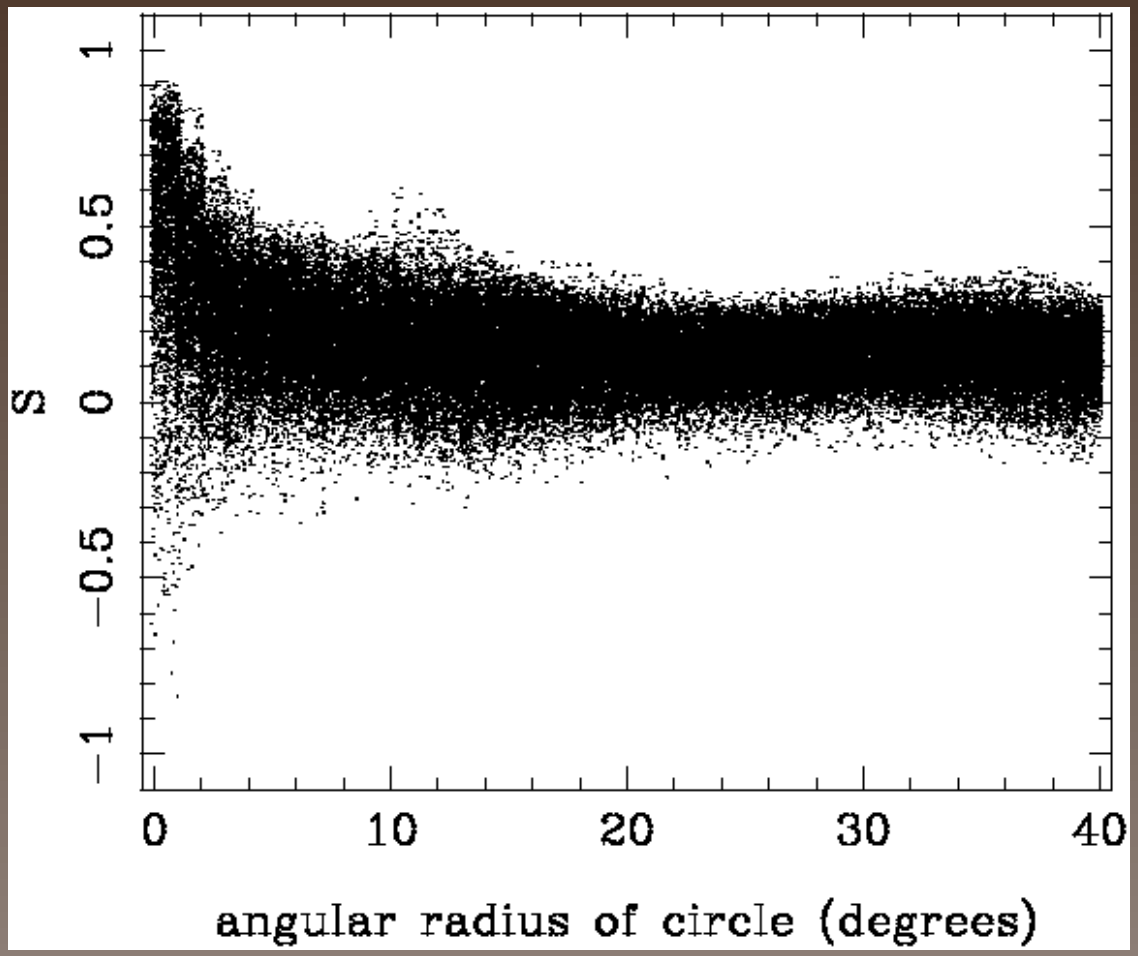

-36° rotation

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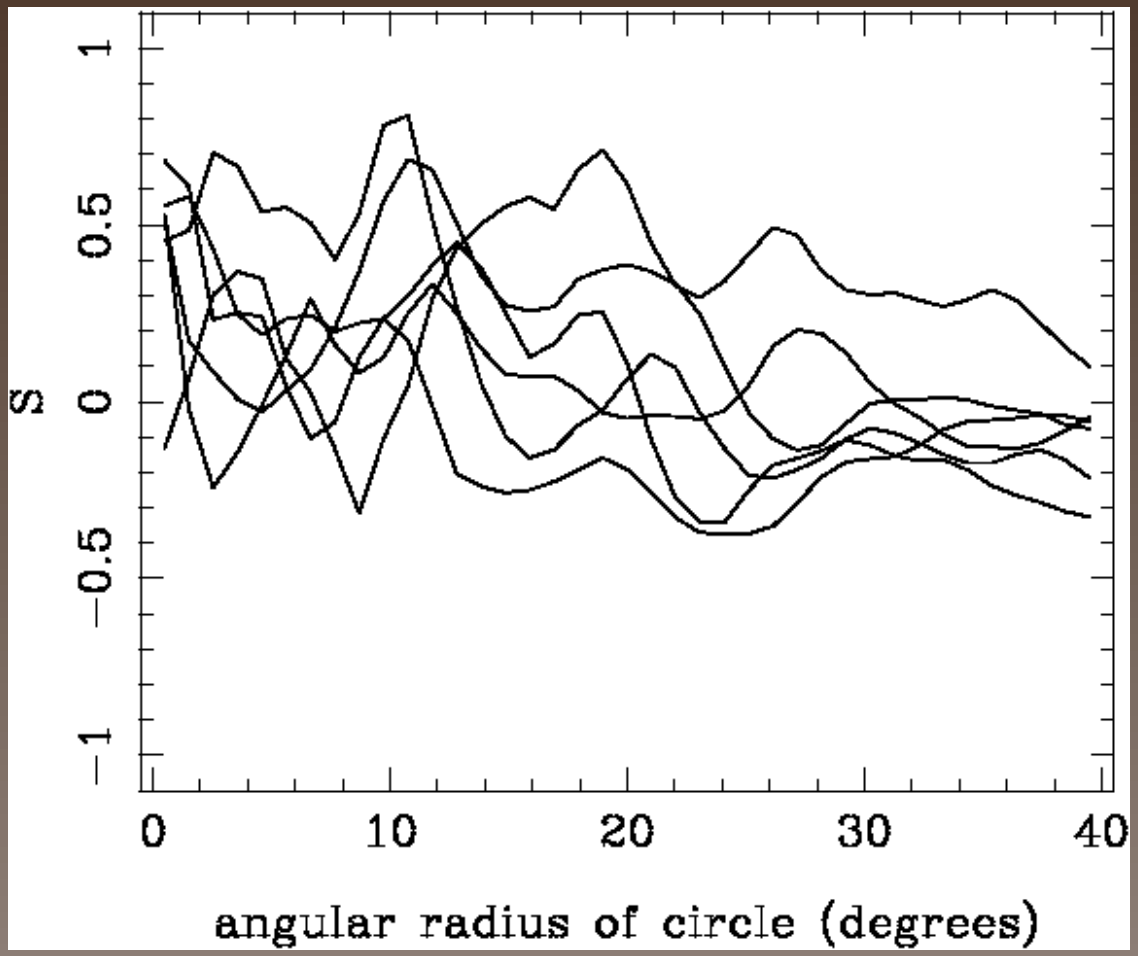

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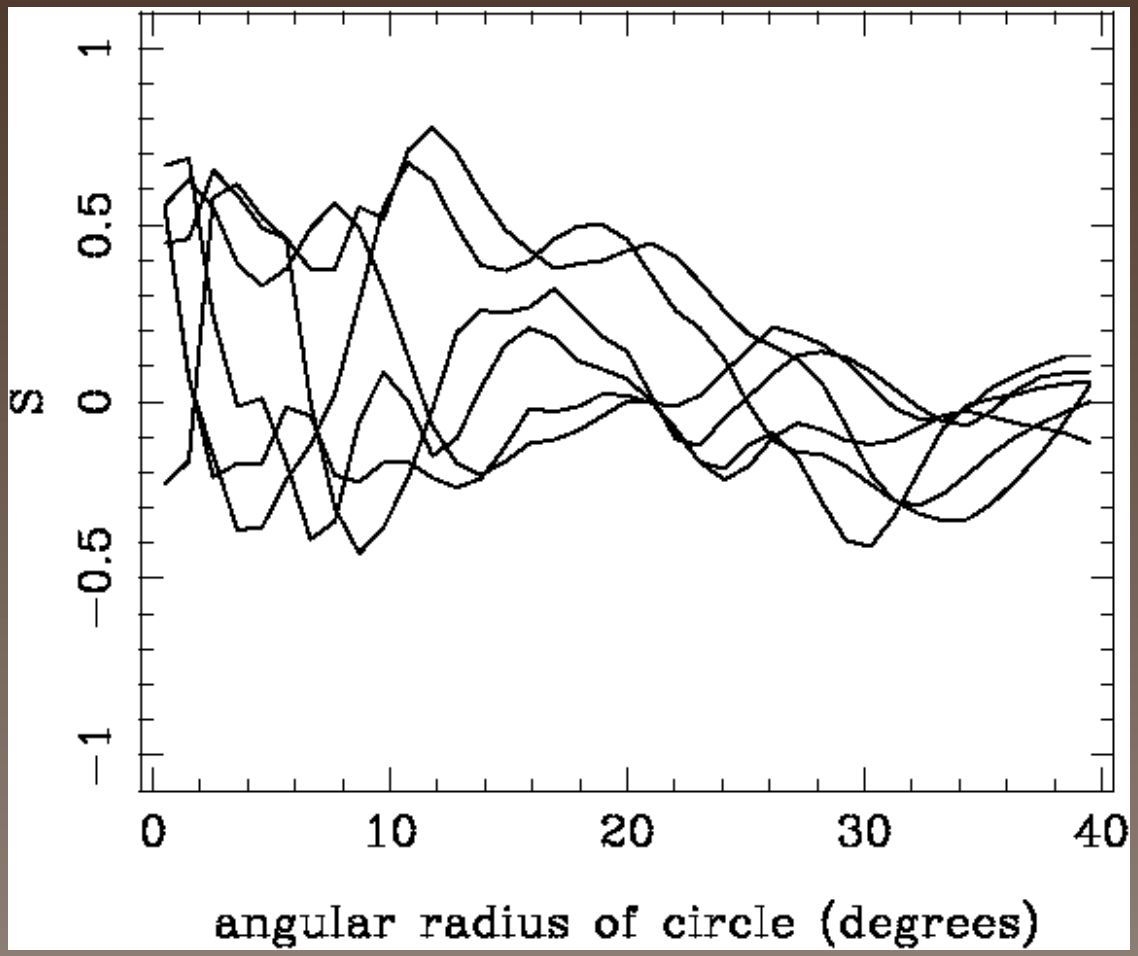

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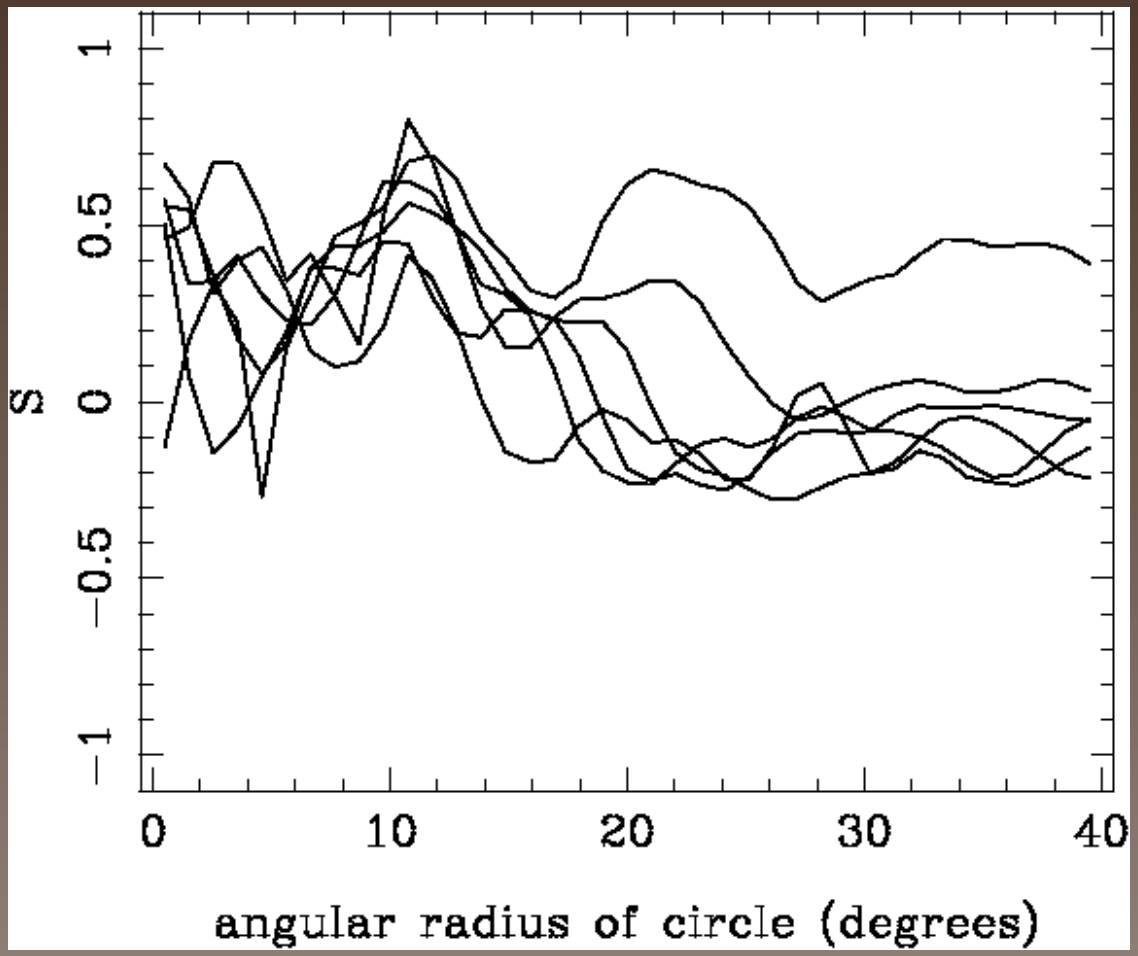

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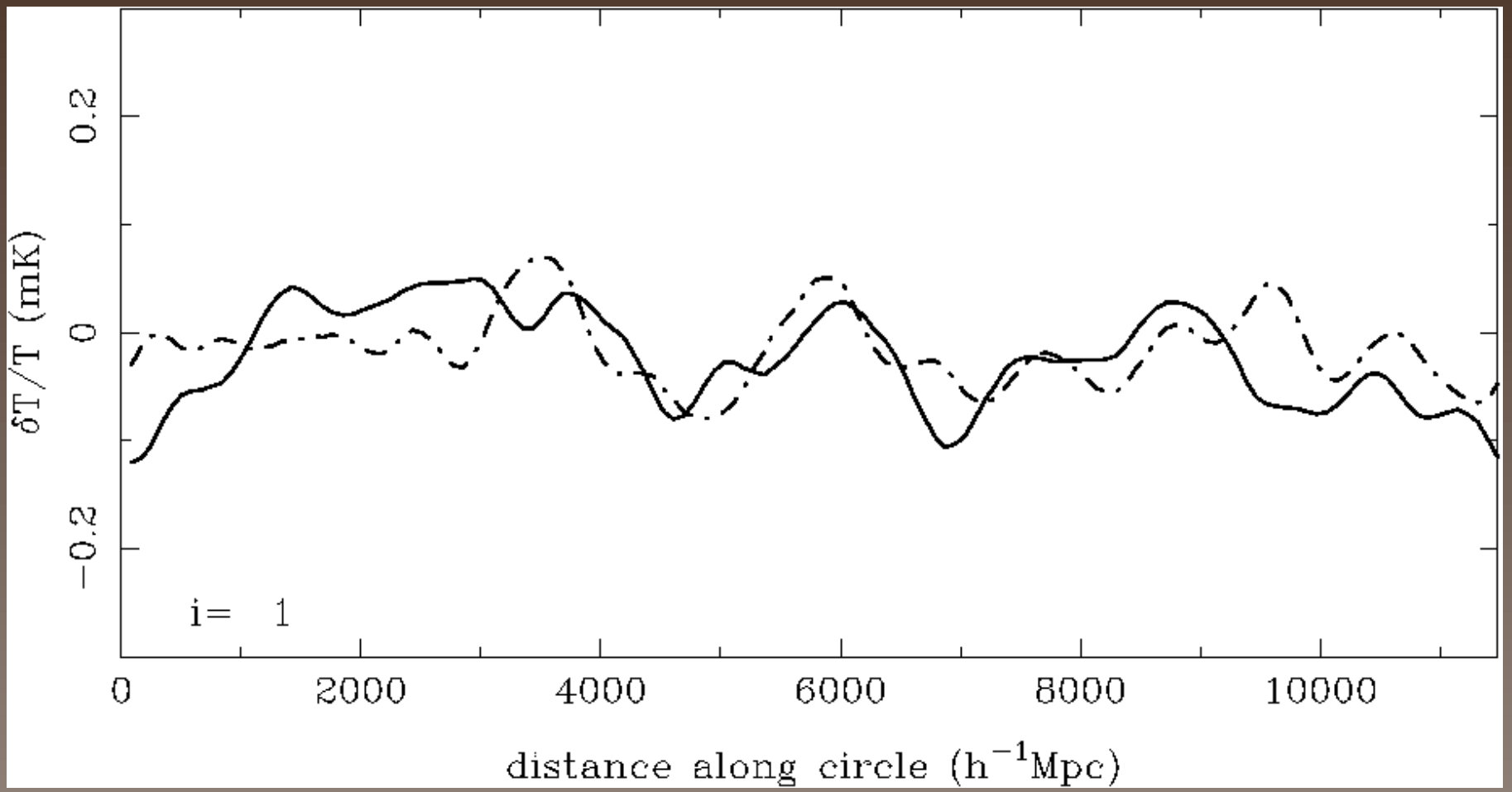

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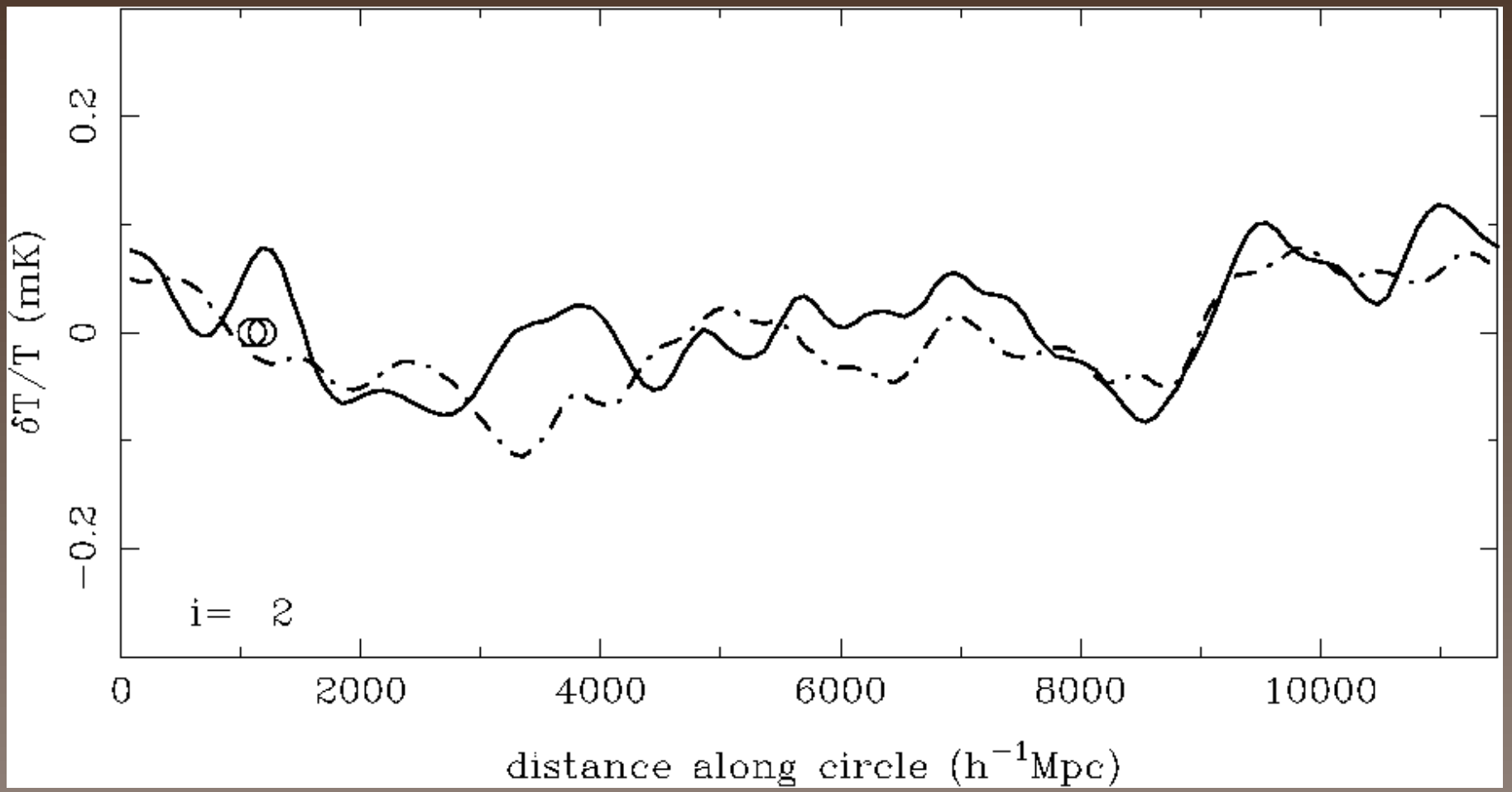

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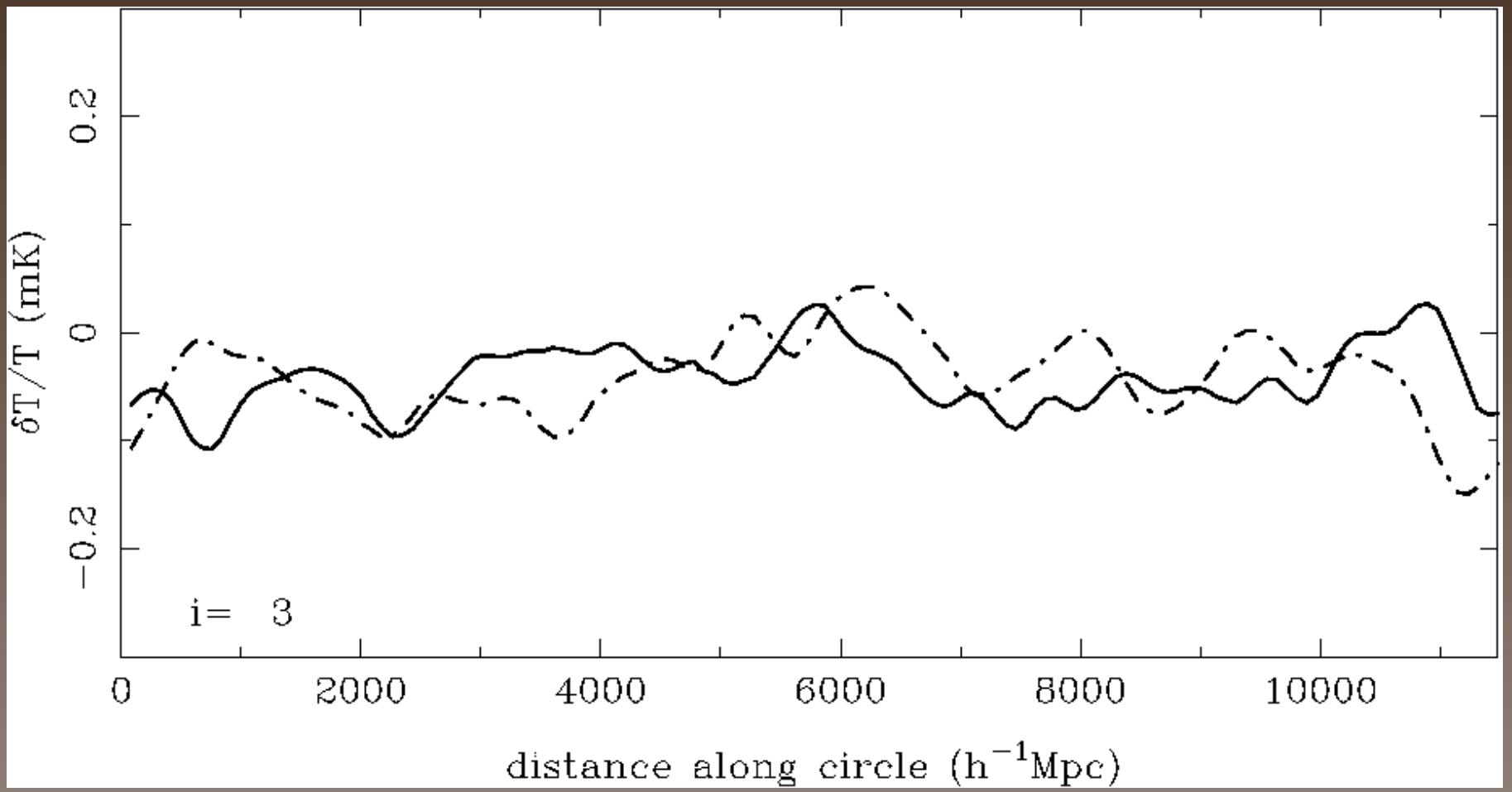

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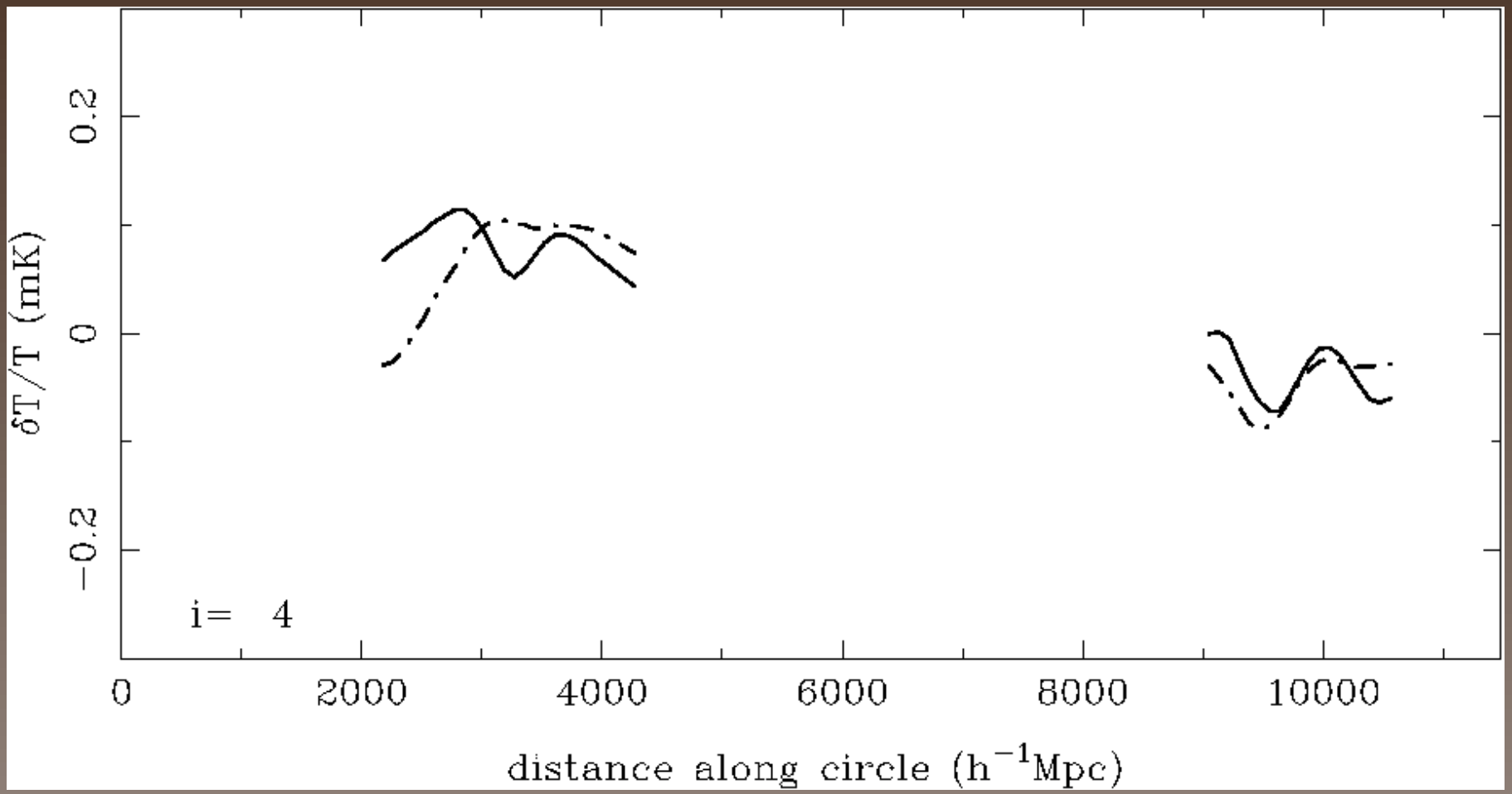

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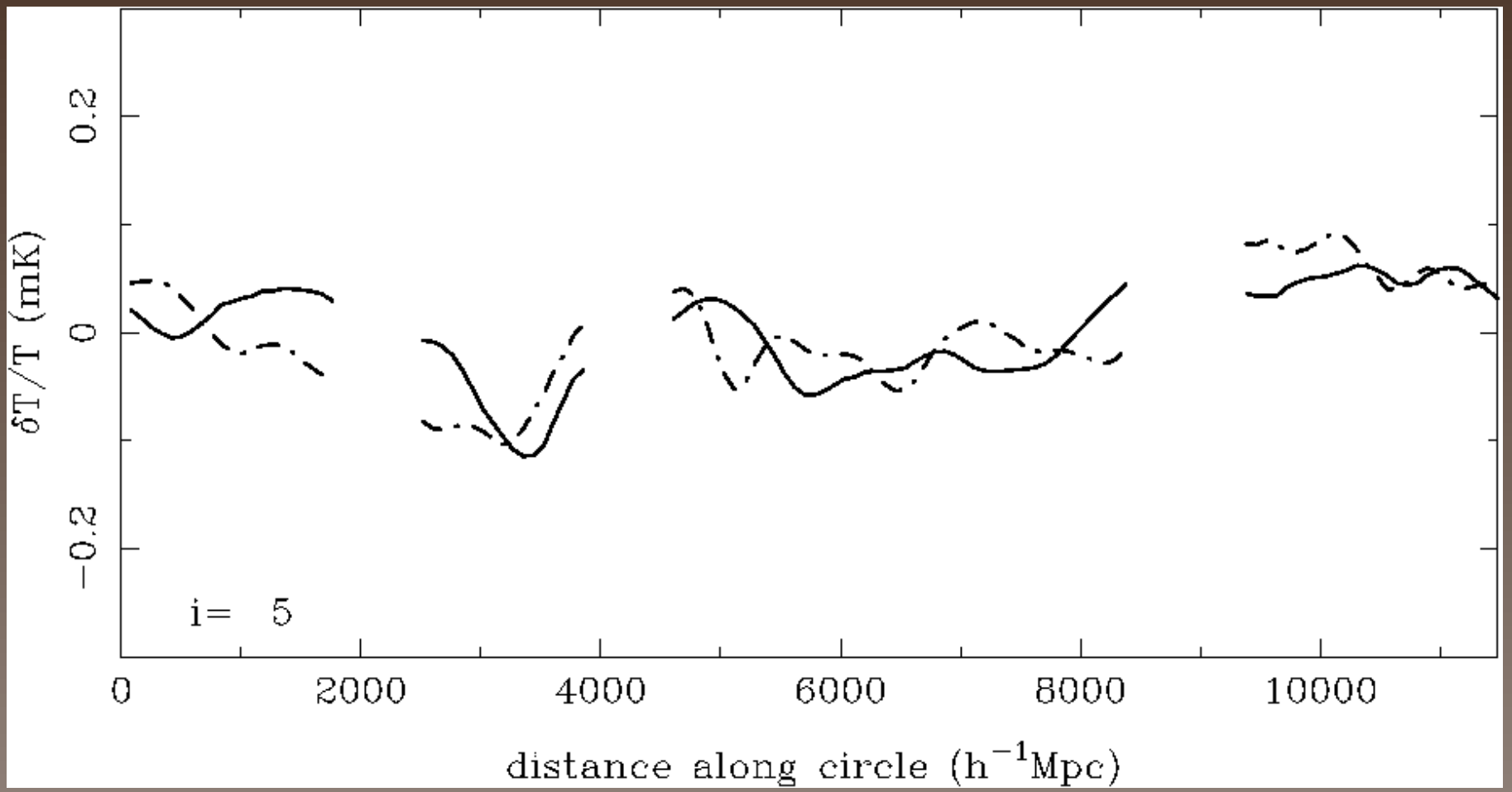

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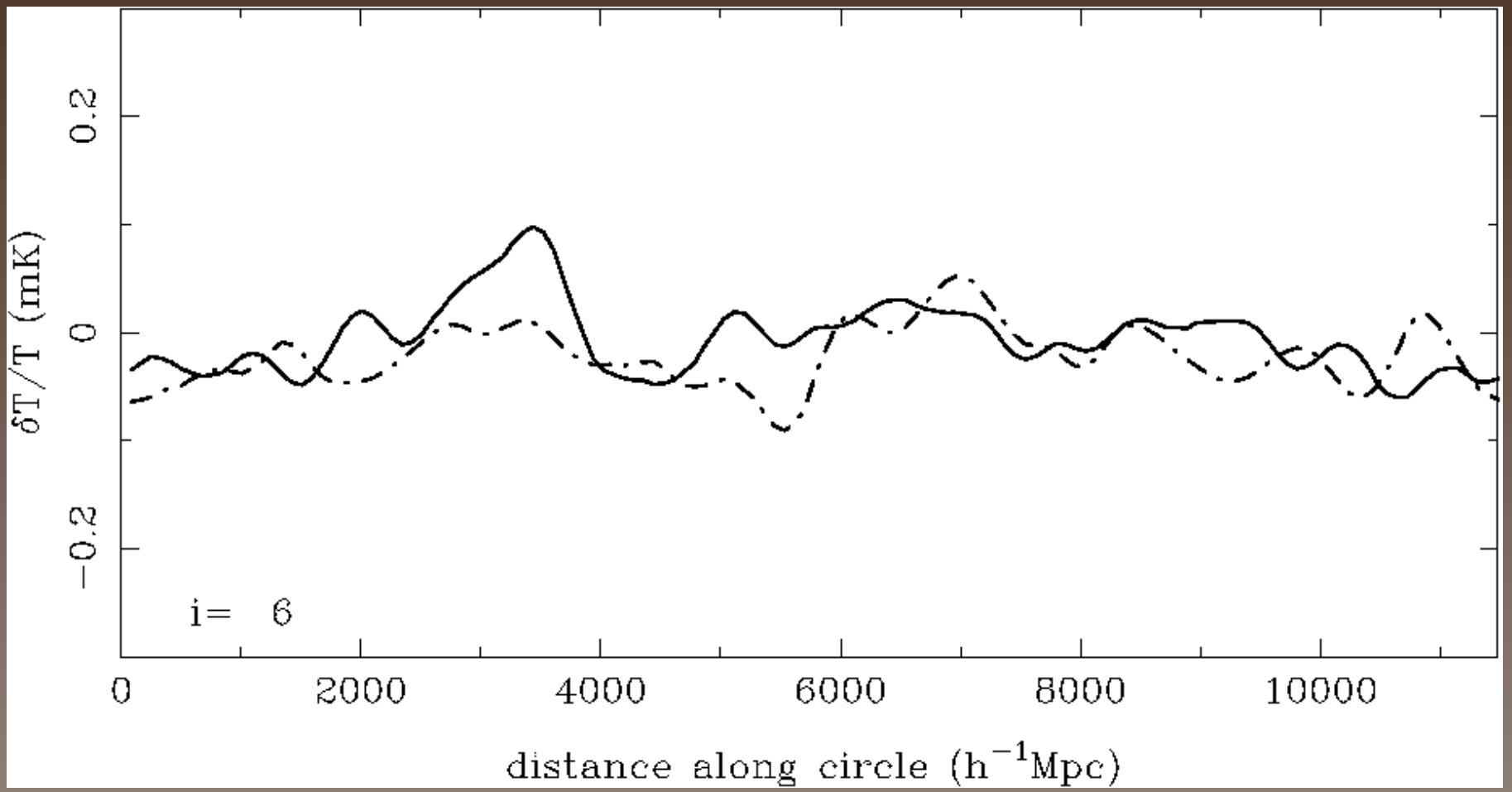

Dodecahedral Hypothesis: Conclusions

- best Poincaré dodecahedral solution has matched circles of radius $11 \pm 1^\circ$
- the six circle pairs independently have high correlations

Dodecahedral Hypothesis: Conclusions

i	l^{II} in $^\circ$	b^{II} in $^\circ$	α in $^\circ$
1	252.4	64.7	9.8
2	50.6	50.8	10.7
3	143.8	37.8	10.7
4	207.5	9.5	10.7
5	271.0	2.7	11.8
6	332.8	25.0	10.7

Roukema, Lew, Cechowska, Marecki, Bajtlik, A&A in press (2004)

http://arXiv.org/abs/astro-ph/0402608

Future tests

Tests without assumptions on hypothetical statistical ensembles of universes include:

- separate naïve-SW, ISW and doppler components
- foreground "predictions"
- polarisation data

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