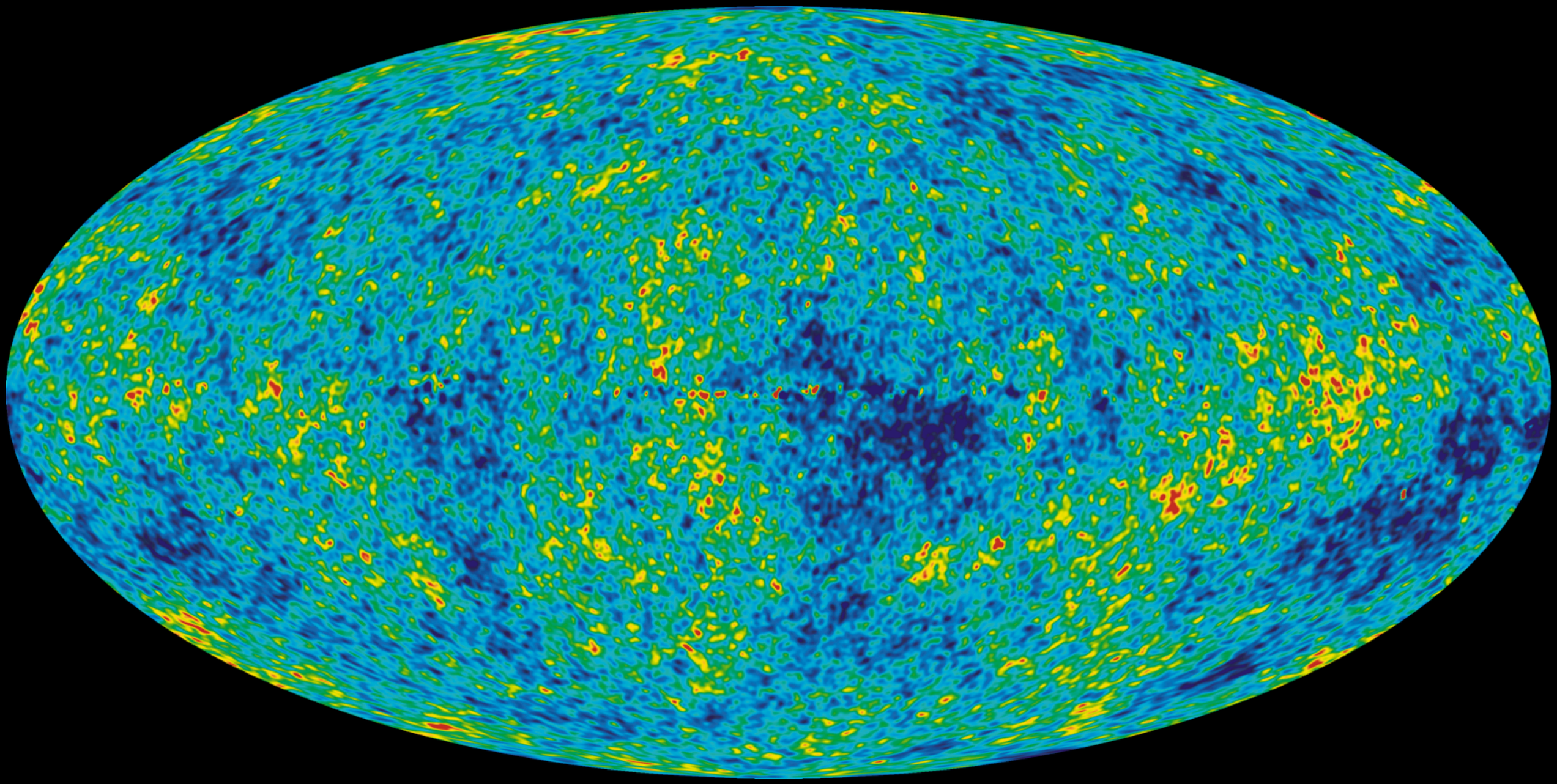
Weak Lensing of the Primary CMB Bispectrum

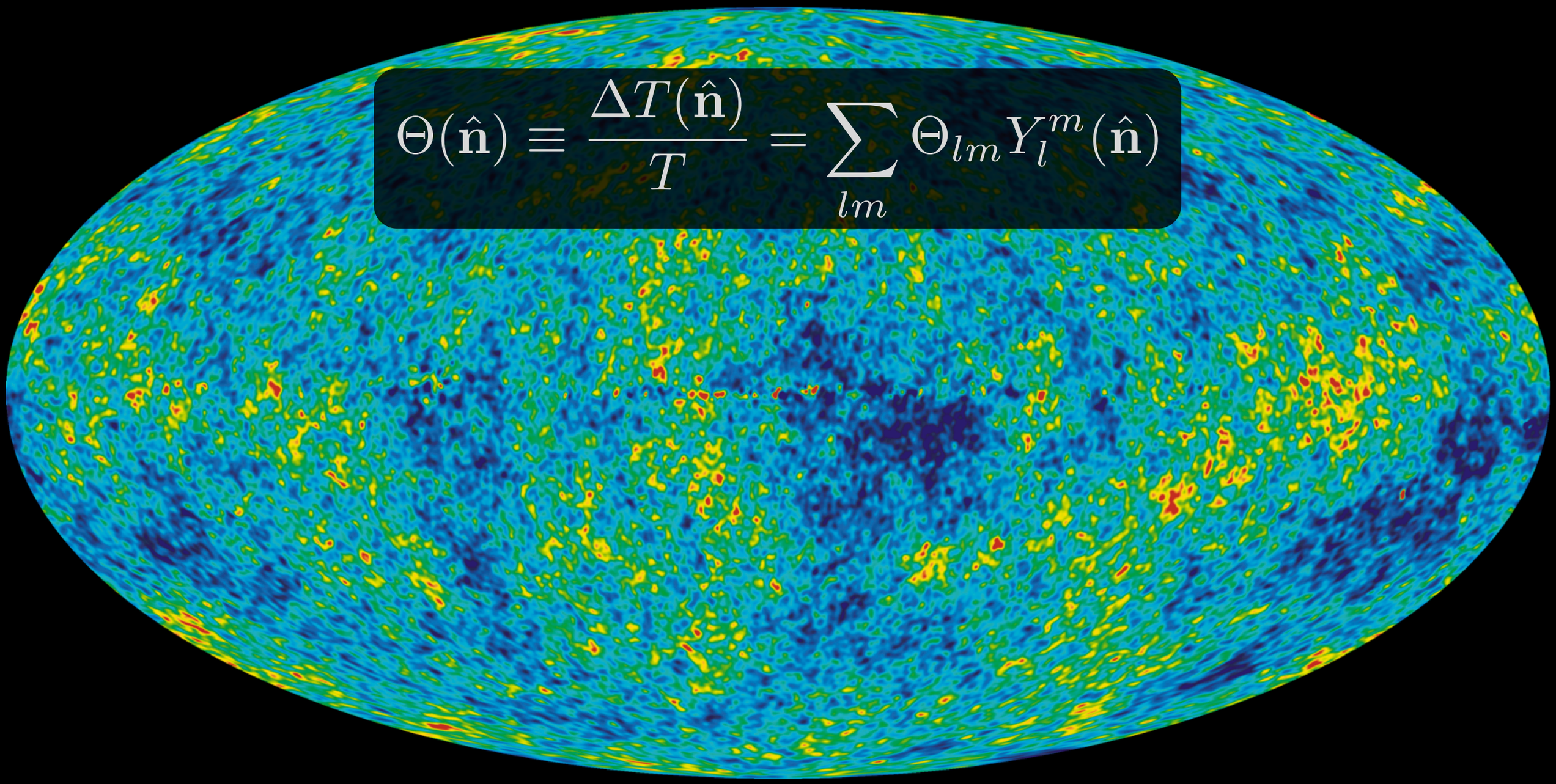
Devdeep Sarkar
Center for Cosmology, UC Irvine

in collaboration with:
Asantha Cooray and Paolo Serra



Credit: NASA/WMAP Science Team

$$\Theta(\hat{\mathbf{n}}) \equiv \frac{\Delta T(\hat{\mathbf{n}})}{T} = \sum_{lm} \Theta_{lm} Y_l^m(\hat{\mathbf{n}})$$



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$$\langle \Theta_{lm} \Theta_{l'm'} \rangle = \delta_{l,l'} \delta_{m,m'} C_l^{\Theta\Theta}$$

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$$\langle \Theta_{l_1 m_1} \Theta_{l_2 m_2} \Theta_{l_3 m_3} \rangle = \begin{pmatrix} l_1 & l_2 & l_3 \\ m_1 & m_2 & m_3 \end{pmatrix} B^{\Theta}_{l_1 l_2 l_3}$$

$$\langle \Theta_{lm} \Theta_{l'm'} \rangle = \delta_{l,l'} \delta_{m,m'} C_l^{\Theta\Theta}$$

Credit: NASA/WMAP Science Team

Primordial non-Gaussianity

↳ Primary CMB Bispectrum

Primordial non-Gaussianity

↳ Primary CMB Bispectrum

Gaussian Quantum Fluctuation

⇩ ⇩

Non-Gaussian Inflation Fluctuation

⇩ ⇩

Non-Gaussian Curvature Perturbation

⇩ ⇩

Non-Gaussian CMB Anisotropy

Primordial non-Gaussianity

Primary CMB Bispectrum

$$\frac{\Delta T(\mathbf{x})}{T} \sim \Phi(\mathbf{x})$$

$$\Phi(\mathbf{x}) = \Phi_L(\mathbf{x}) + f_{NL}\left[\Phi_L^2(\mathbf{x}) - \langle \Phi_L^2(\mathbf{x}) \rangle\right]$$

Non-Linear Coupling Parameter

Measurement of non-Gaussian CMB anisotropies can potentially constrain non-linearity, "slow-rollness", and "adiabaticity" in inflation.

Primordial non-Gaussianity

↳ Primary CMB Bispectrum

Non-Gaussianity from the simplest inflation model is very small:

$$f_{NL} \sim 0.01 - 1$$

Much higher level of primordial non-Gaussianity is predicted by:

- Models with Multiple Scalar Fields
- Non-Adiabatic Fluctuations
- Features in the Inflation Potential
- Non-Canonical Kinetic Terms
- ...

Review: N. Bartolo, E. Komatsu, S. Matarrese, and A. Riotto, Phys. Rep. 402, 103 (2004)

Evidence of Primordial Non-Gaussianity (f_{NL}) in the Wilkinson Microwave Anisotropy Probe 3-Year Data at 2.8σ

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[2]*Department of Physics, University of Illinois at Urbana-Champaign, 1110 W. Green Street, Urbana, Illinois 61801, USA*

(Received 7 December 2007; revised manuscript received 6 March 2008; published 7 May 2008)

We present evidence for primordial non-Gaussianity of the local type (f_{NL}) in the temperature anisotropy of the cosmic microwave background. Analyzing the bispectrum of the Wilkinson Microwave Anisotropy Probe 3-year data up to $\ell_{\mathrm{max}} = 750$ we find $27 < f_{\mathrm{NL}} < 147$ (95% C.L.). This amounts to a rejection of $f_{\mathrm{NL}} = 0$ at 2.8σ, disfavoring canonical single-field slow-roll inflation. The signal is robust to variations in l_{max}, frequency and masks. No known foreground, instrument systematic, or secondary anisotropy explains it. We explore the impact of several analysis choices on the quoted significance and find 2.5σ to be conservative.

FIVE-YEAR WILKINSON MICROWAVE ANISOTROPY PROBE (WMAP[1]) OBSERVATIONS: COSMOLOGICAL INTERPRETATION

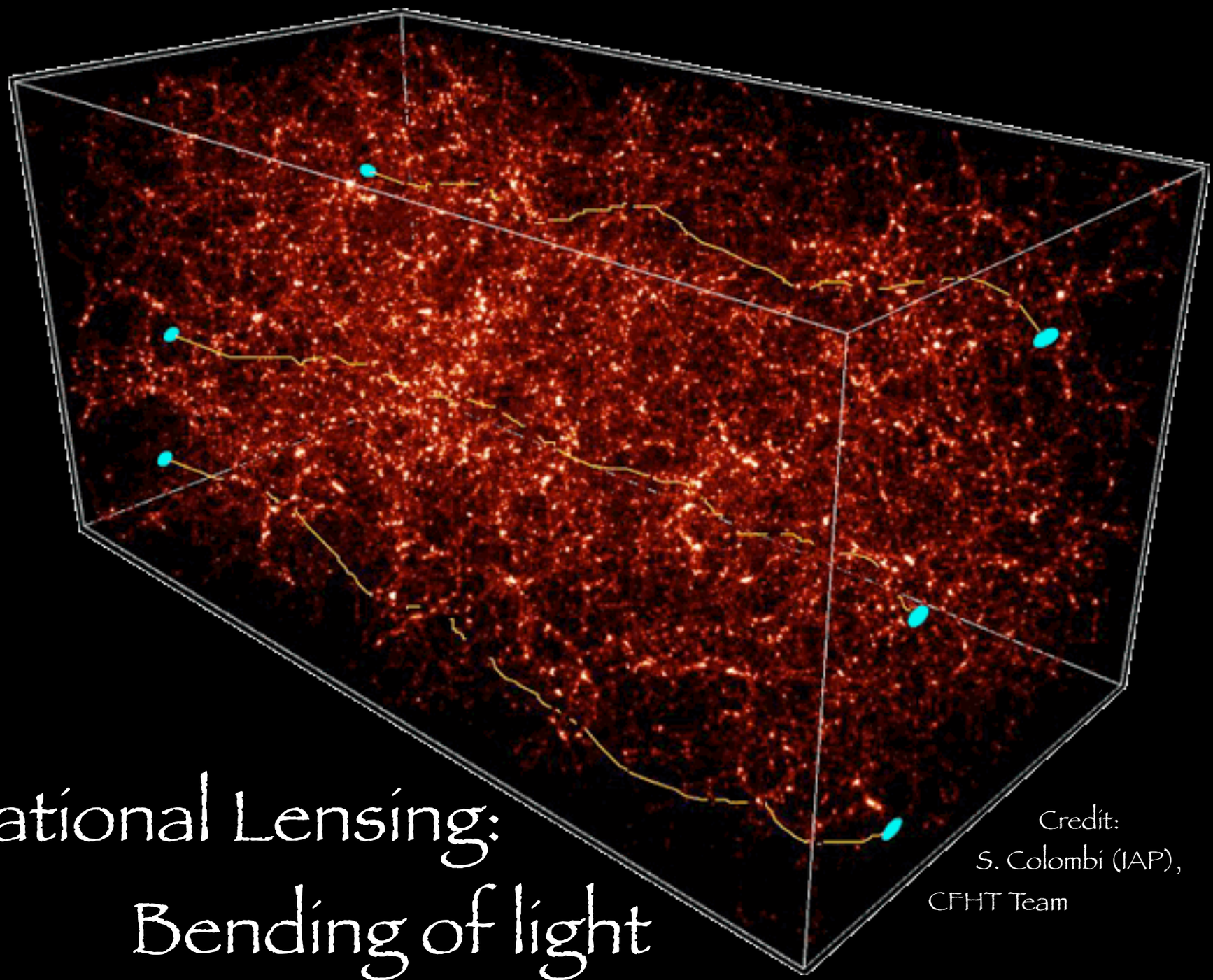
E. Komatsu [1], J. Dunkley [2,3,4], M. R. Nolta [5], C. L. Bennett [6], B. Gold [6], G. Hinshaw [7], N. Jarosik [2], D. Larson [6], M. Limon [8] L. Page [2], D. N. Spergel [3,9], M. Halpern [10], R. S. Hill [11], A. Kogut [7], S. S. Meyer [12], G. S. Tucker [13], J. L. Weiland [10], E. Wollack [7], and E. L. Wright [14]

Submitted to the Astrophysical Journal Supplement Series

ABSTRACT

$$-9 < f_{NL}^{local} < 111 \text{ and } -151 < f_{NL}^{equil} < 253 (95\% \, CL)$$

Journey Through the "Clumpy" Universe



Weak
Gravitational Lensing:
Bending of light

Credit:
S. Colombi (IAP),
CFHT Team

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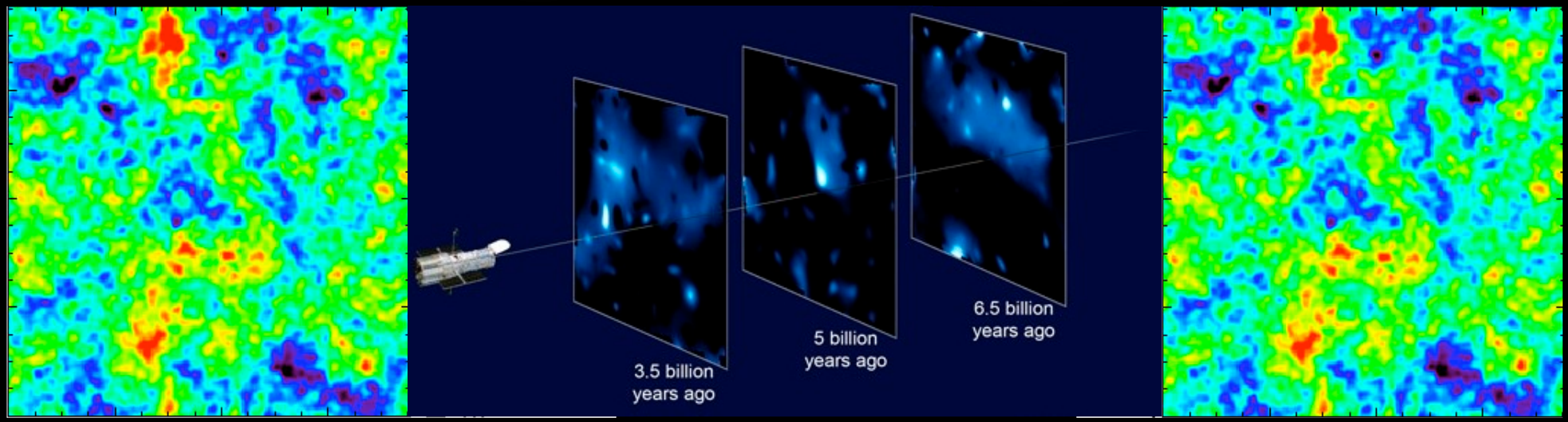

Credit: Vale, Amblard, White (2004)

NASA, ESA, and R. Massey (CalTech)

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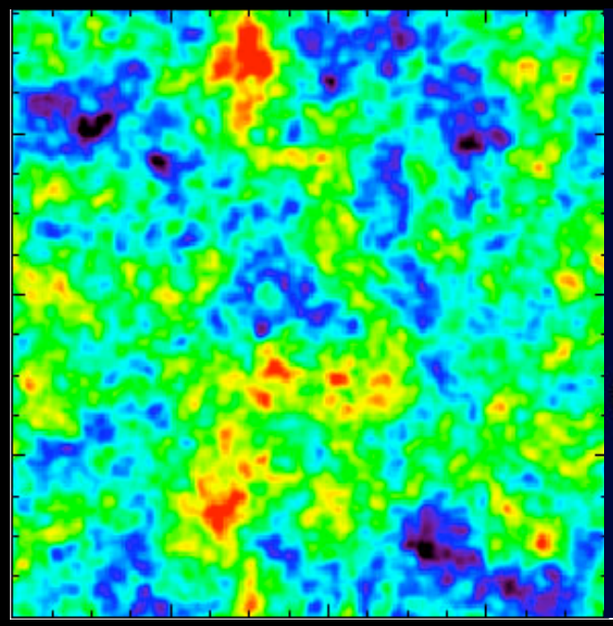

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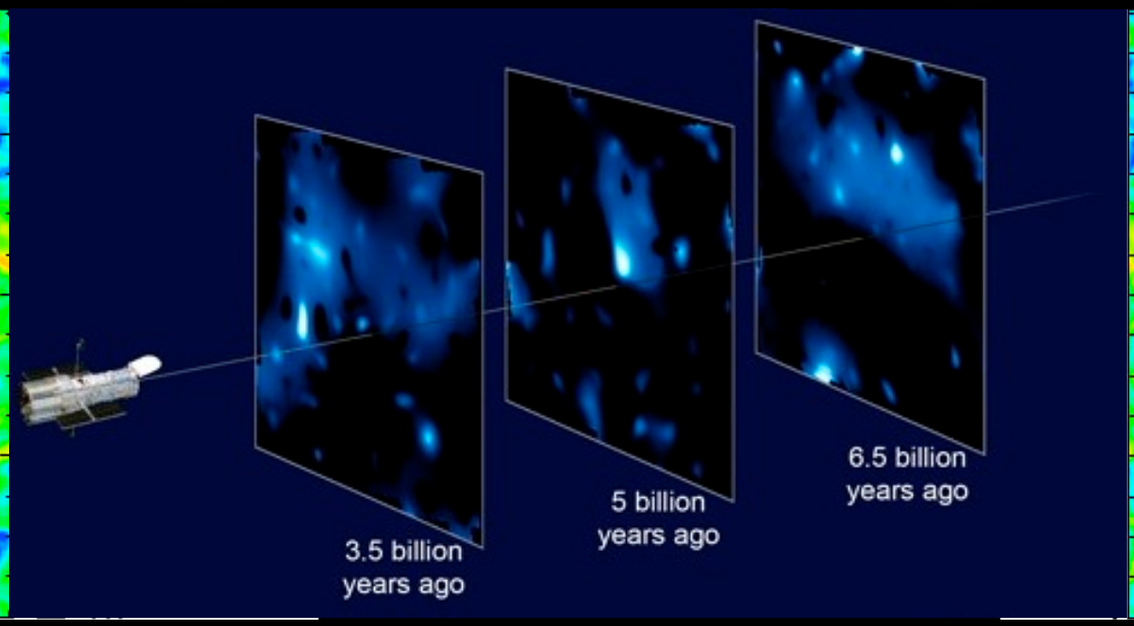

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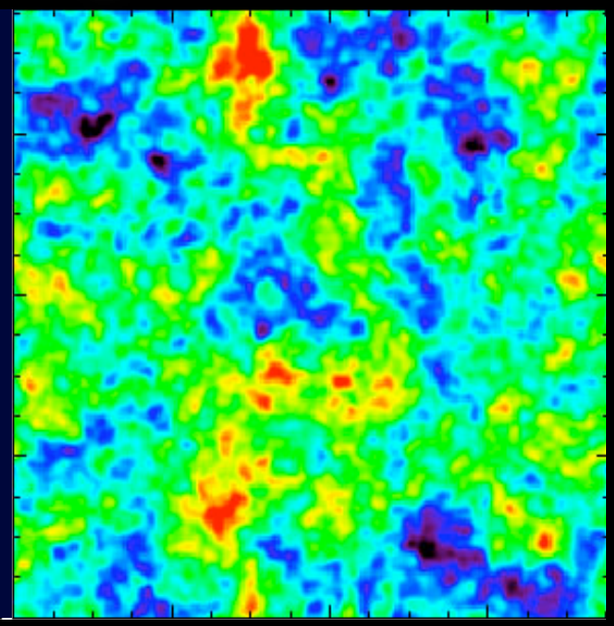

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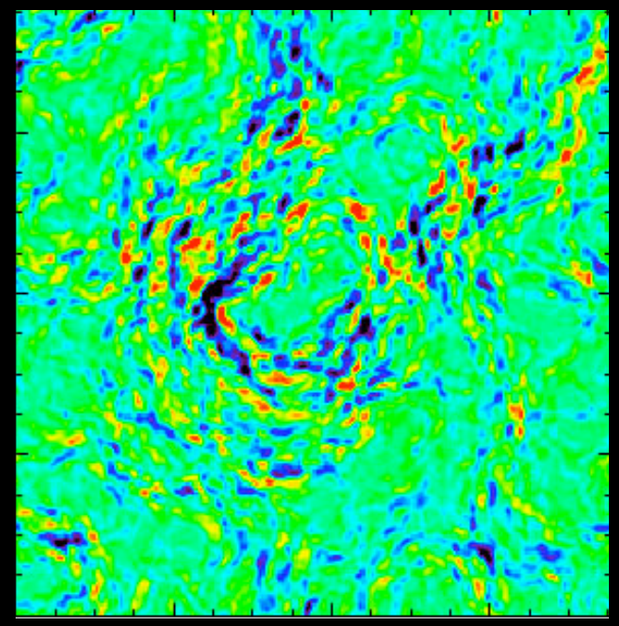

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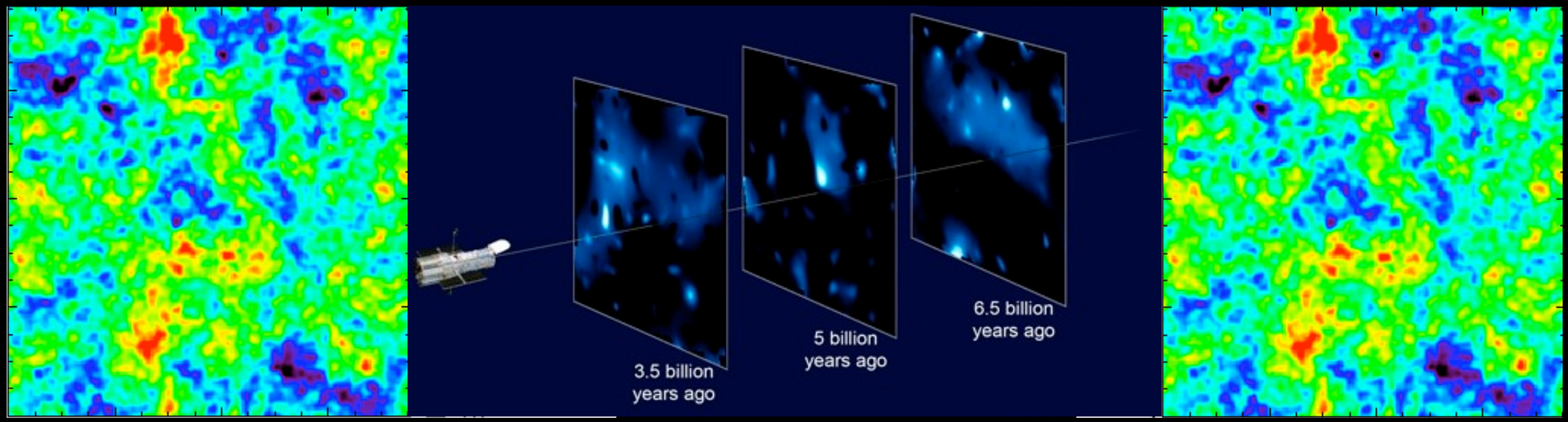

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\begin{aligned}
\tilde{\Theta}(\hat{\mathbf{n}}) &= \Theta[\hat{\mathbf{n}} + \hat{\alpha}] \\
&= \Theta[\hat{\mathbf{n}} + \nabla\phi(\hat{\mathbf{n}})] \\
&\approx \Theta(\hat{\mathbf{n}}) + \nabla_i\phi(\hat{\mathbf{n}})\nabla^i\Theta(\hat{\mathbf{n}}) \\
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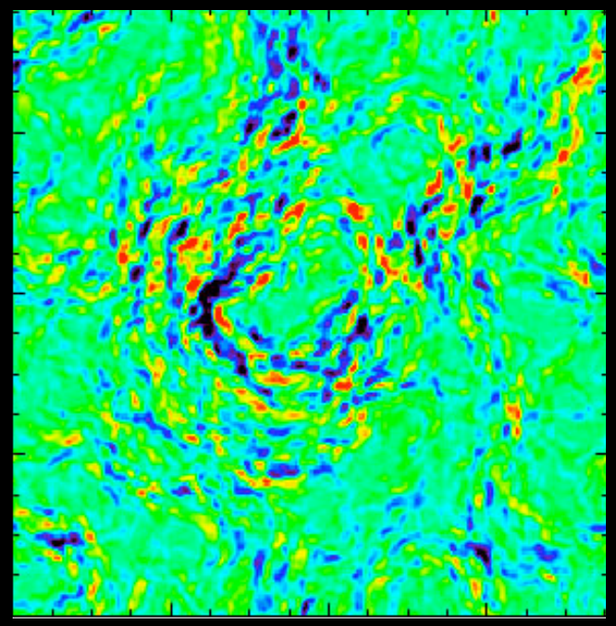

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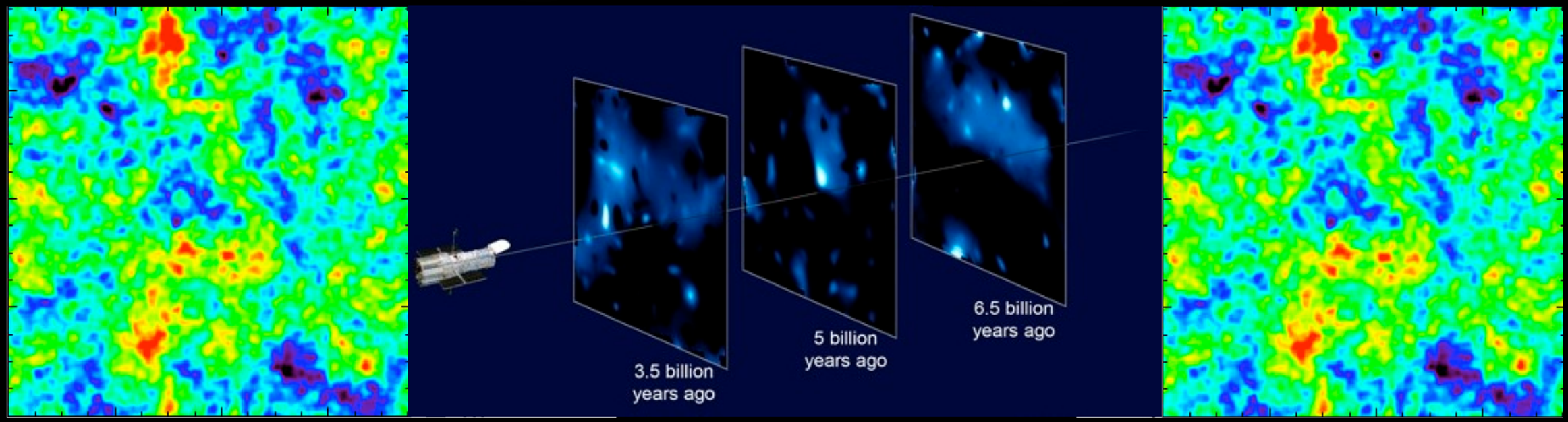

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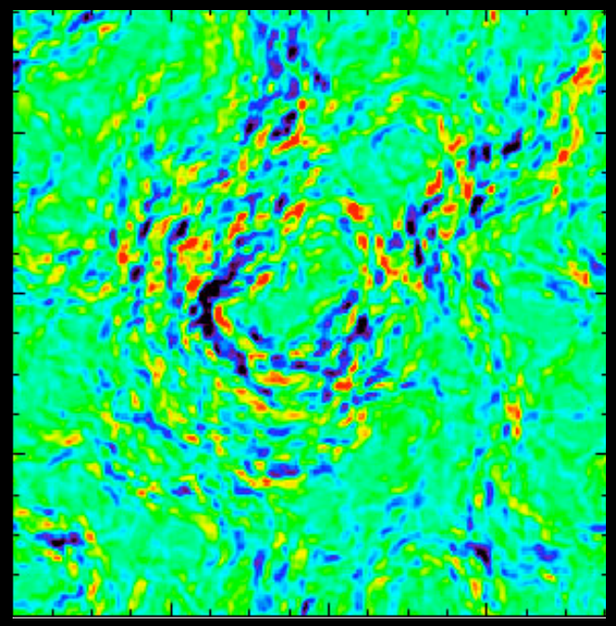

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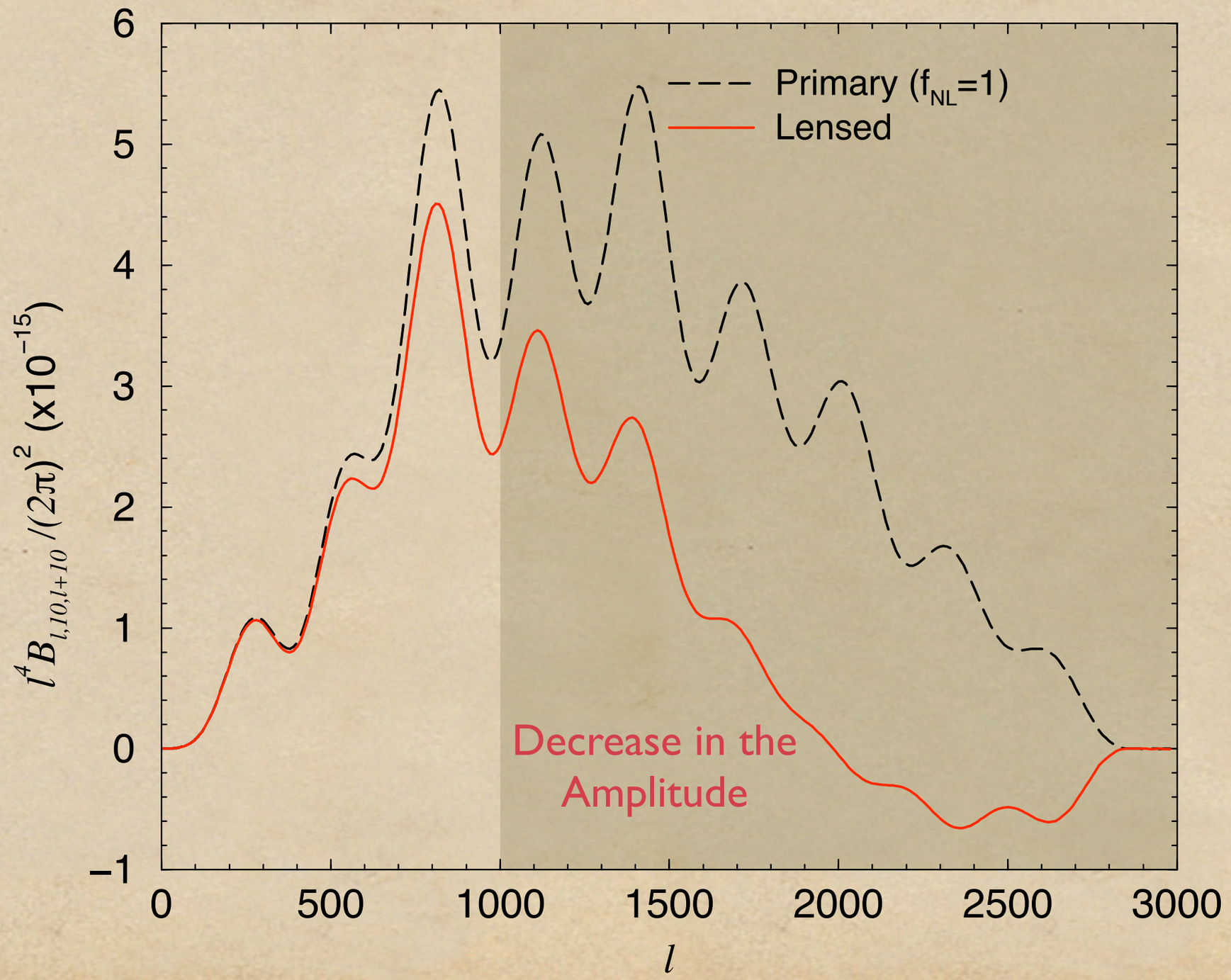
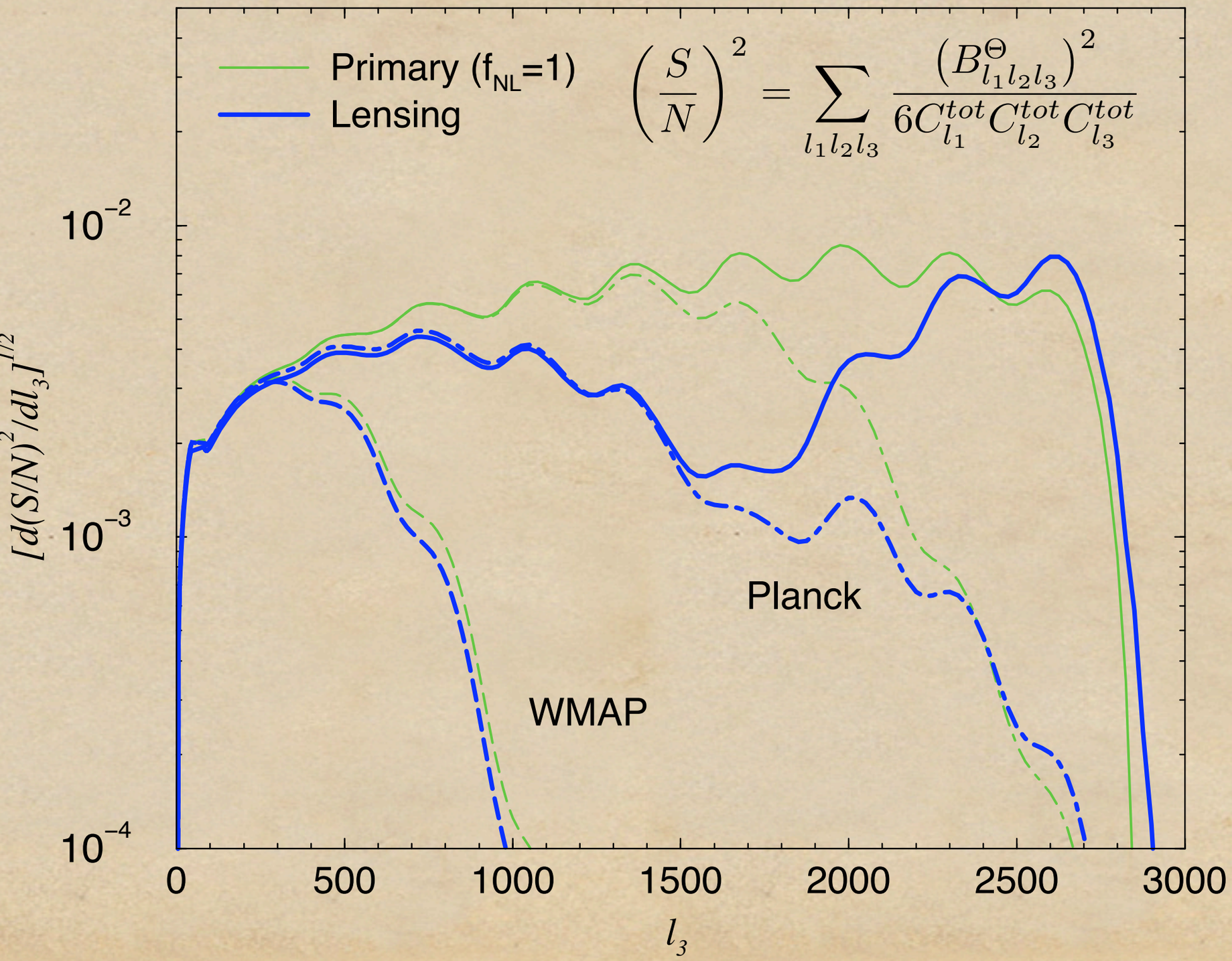
$$

The Effect of Lensing on the Bispectrum



A. Cooray, D. Sarkar, and P. Serra; Phys. Rev. D, 77, 123006 (2008)

Reduction in the S/N due to Lensing



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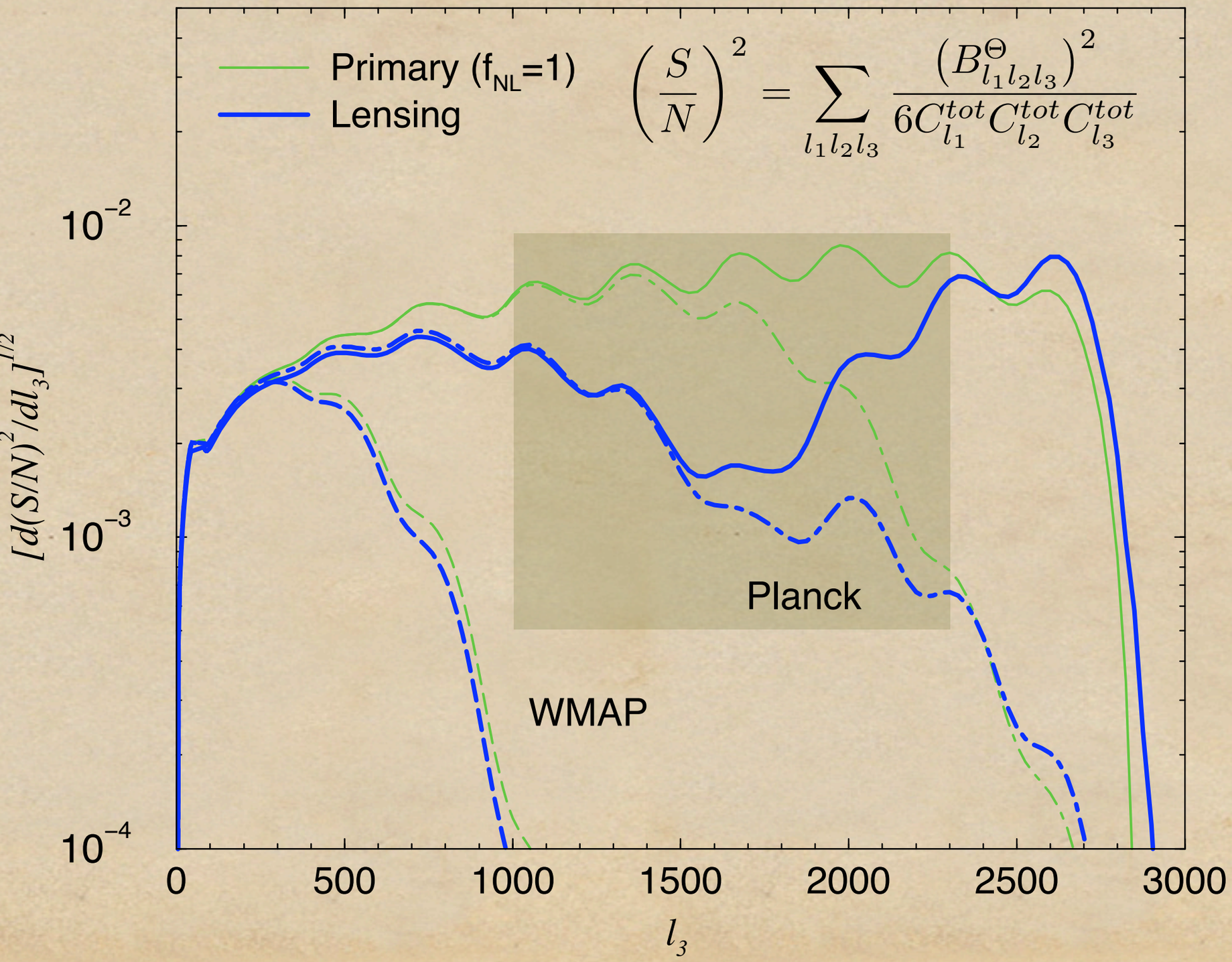

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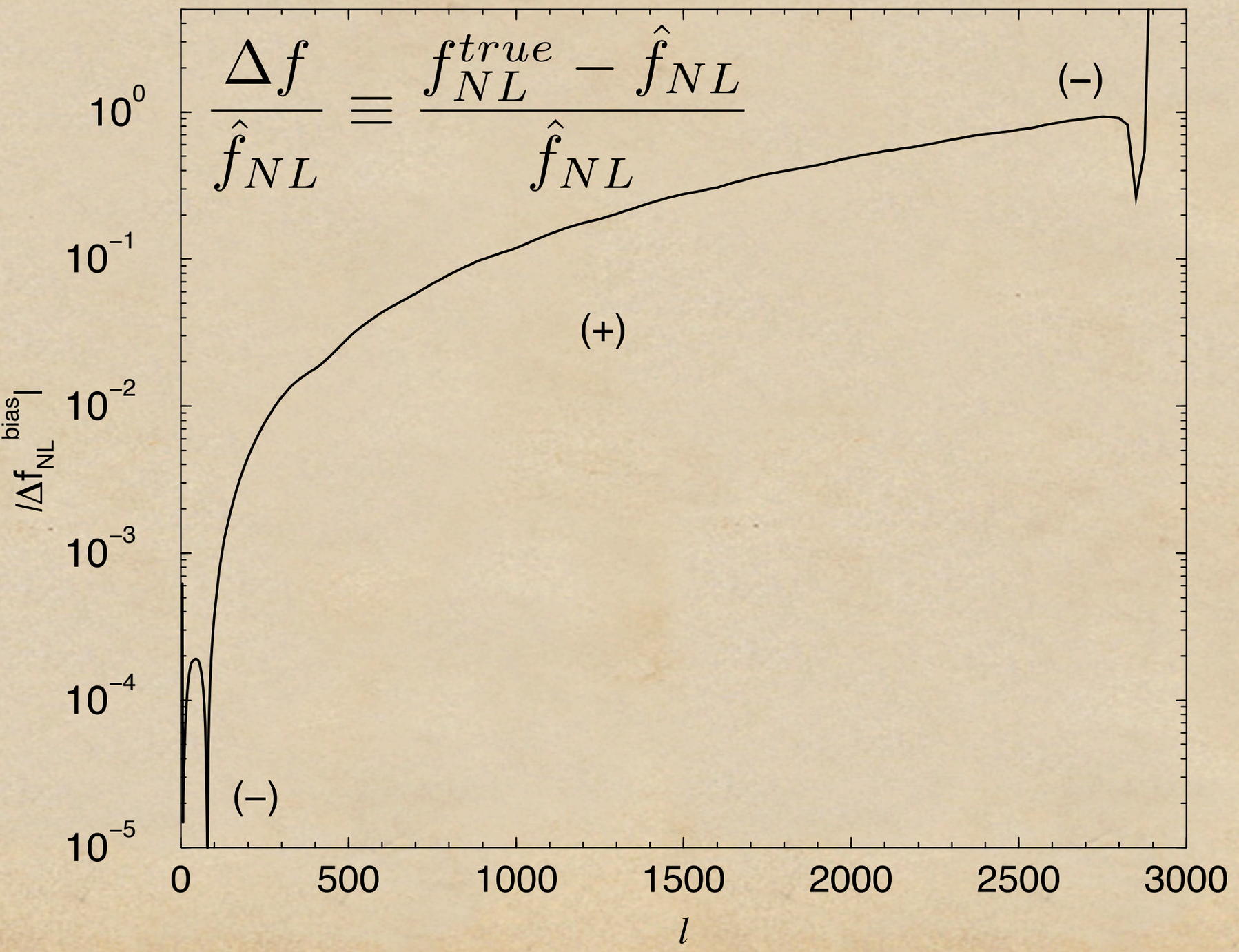
Bias in the non-Gaussian Parameter



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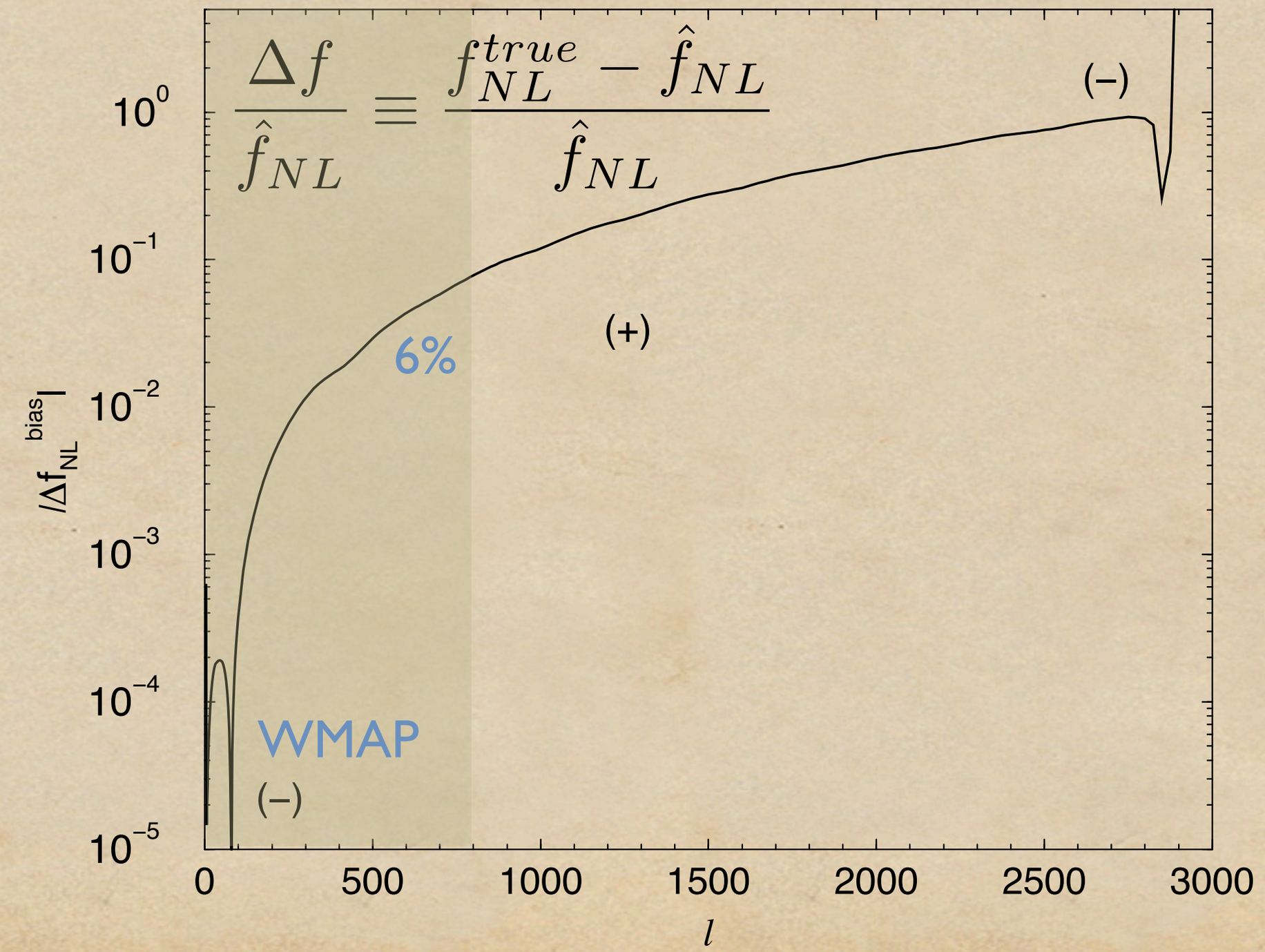

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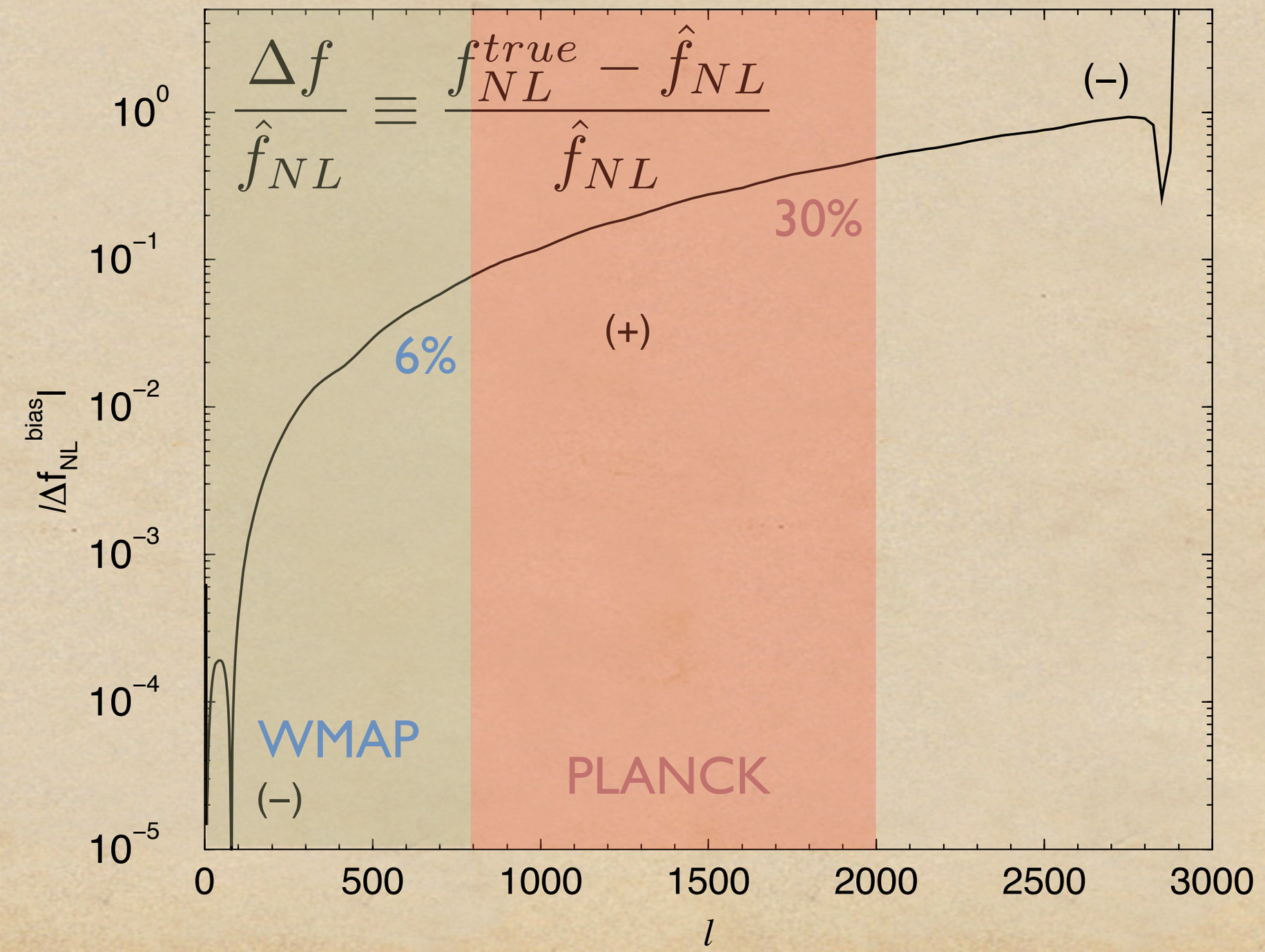

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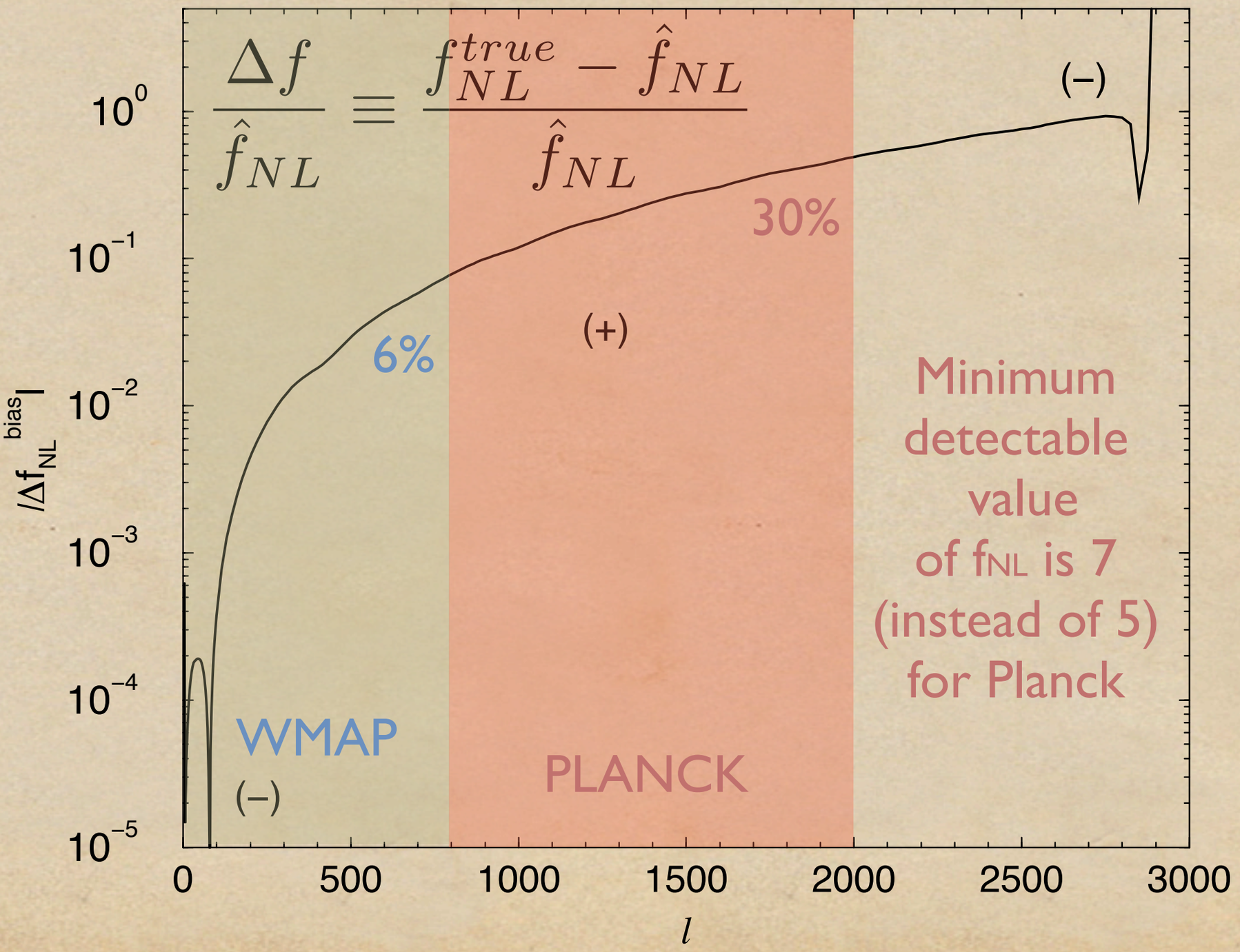

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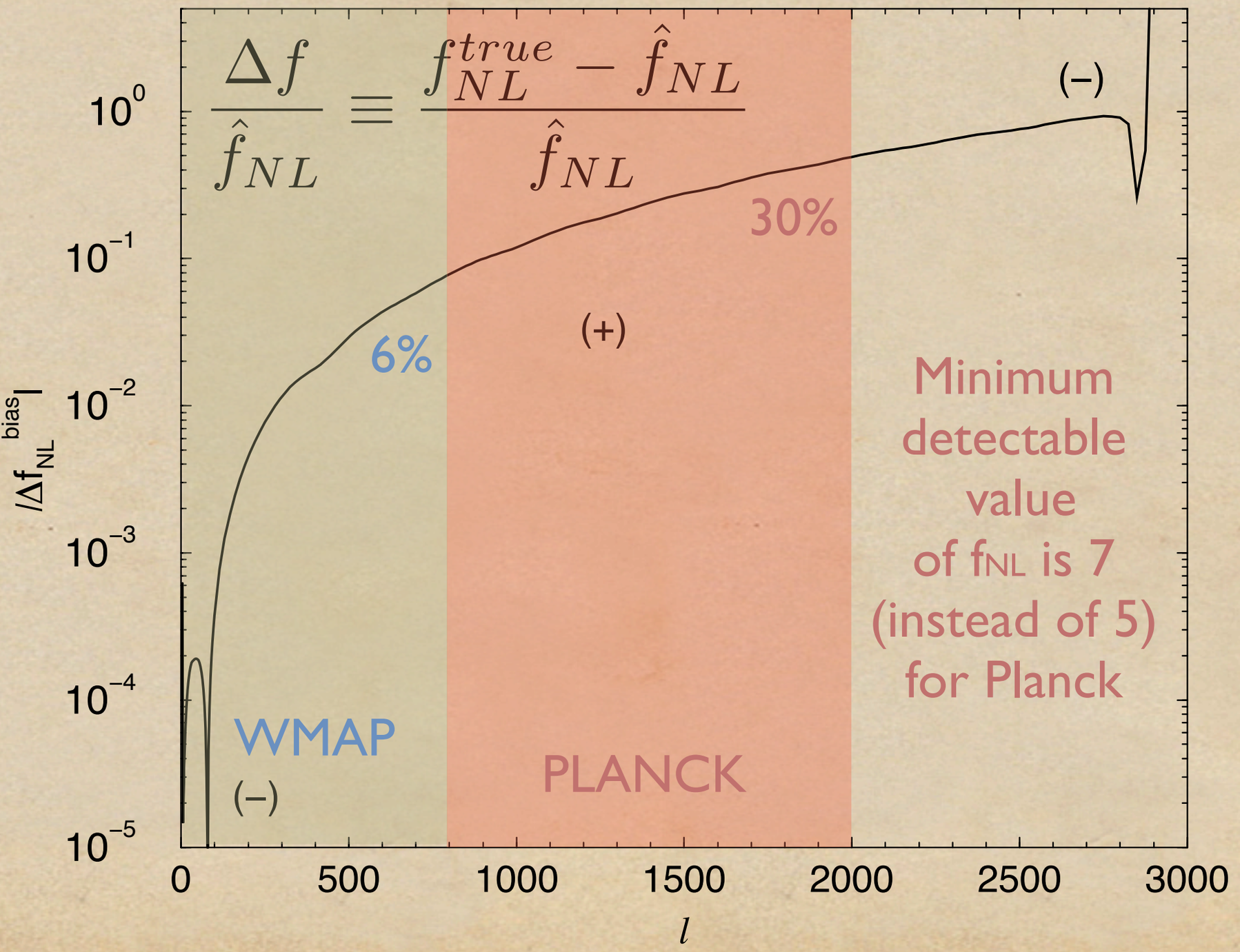

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