

Planck: Understanding the Big Bang

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Planck Units

“These necessarily retain their meaning for all times and for all civilations, even extraterrestrials and non-human ones and can therefore be designated as natural units”

$$\hbar, \quad c, \quad G$$

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$\hbar, \quad c, \quad G$

$$\text{Planck length : } \left(\frac{\hbar G}{c^3} \right)^{1/2} = 1.6 \times 10^{-35} \text{ metres}$$

$$\text{Planck mass : } \left(\frac{\hbar c}{G} \right)^{1/2} = 2.1 \times 10^{-8} \text{ kgrams}$$

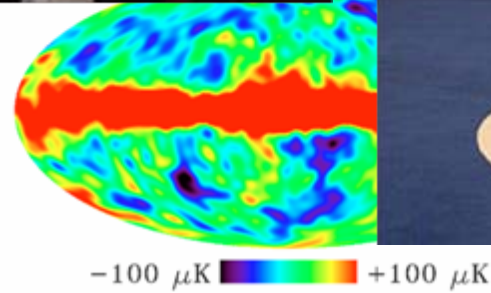
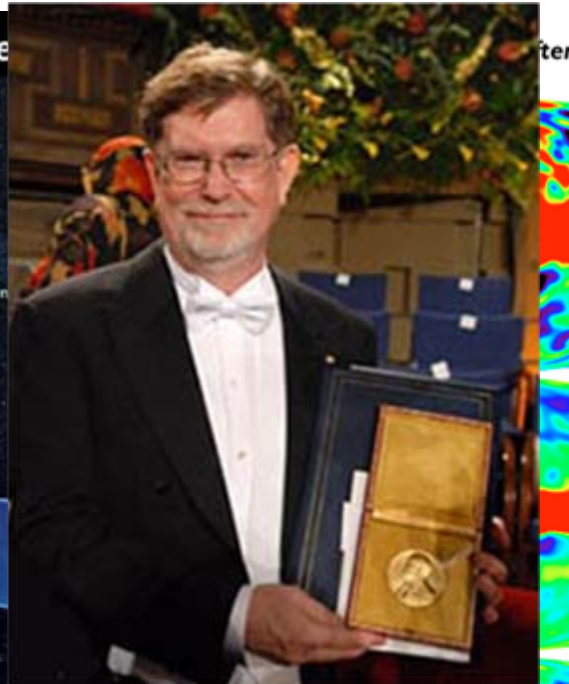
$$\text{Planck time : } \left(\frac{\hbar G}{c^5} \right)^{1/2} = 5.4 \times 10^{-44} \text{ seconds}$$

$$\text{Planck energy : } \left(\frac{\hbar c^5}{G} \right)^{1/2} = 1.2 \times 10^{19} \text{ GeV}$$

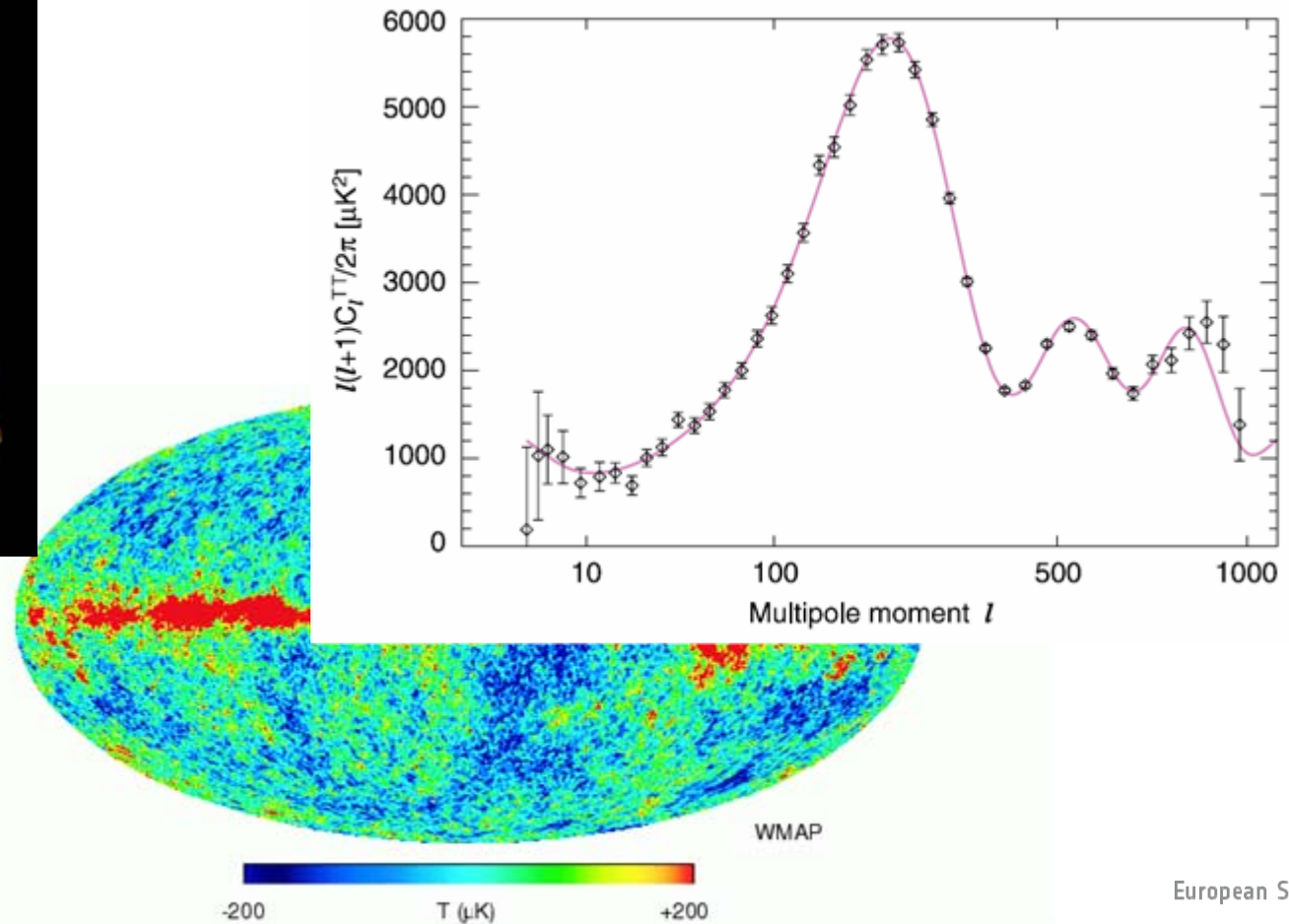
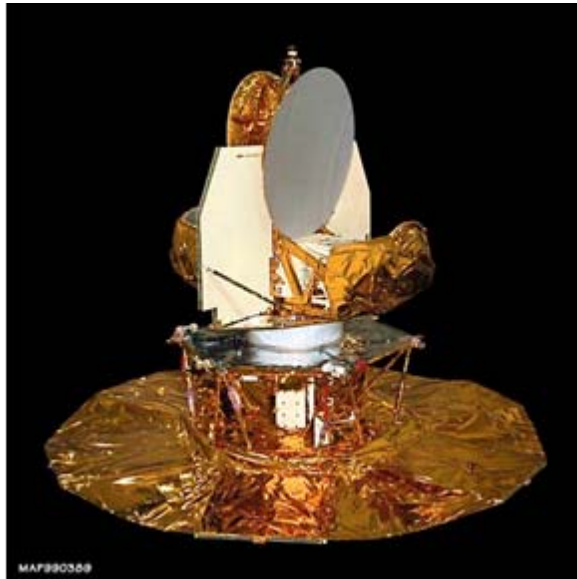
SOME 'BIG' COSMOLOGICAL QUESTIONS :

1. Why is the Universe so big?
2. Why is the Universe so old?
3. Why is the entropy so big?
4. Why is the entropy so small?
5. Why is the Universe so uniform and isotropic?
6. Where did the structure – stars, galaxies, clusters of galaxies...come from?
7. What happened at the Big Bang?
8. Can we probe physics before the Big Bang?
9. What is the fate of the Universe?
10.

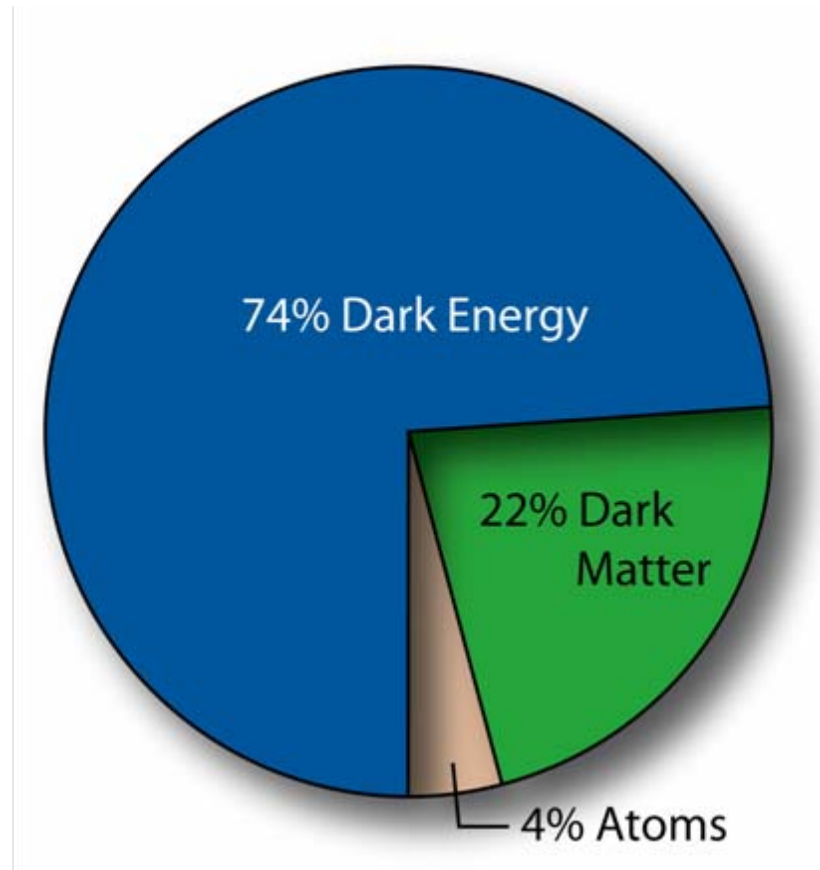
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Wilkinson Microwave Anisotropy Probe (WMAP)



Wilkinson Microwave Anisotropy Probe (WMAP)



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$$p = -\rho$$



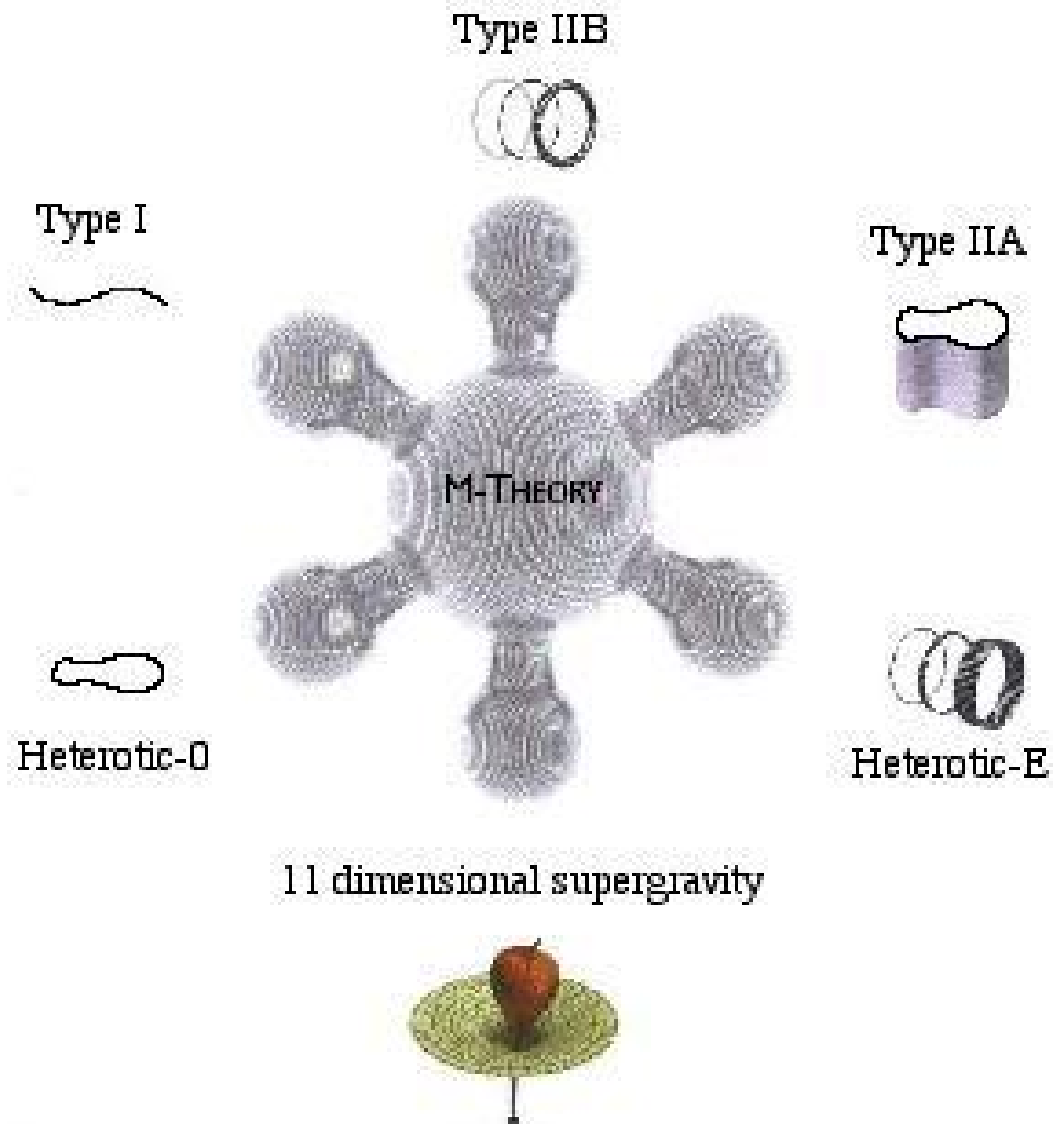
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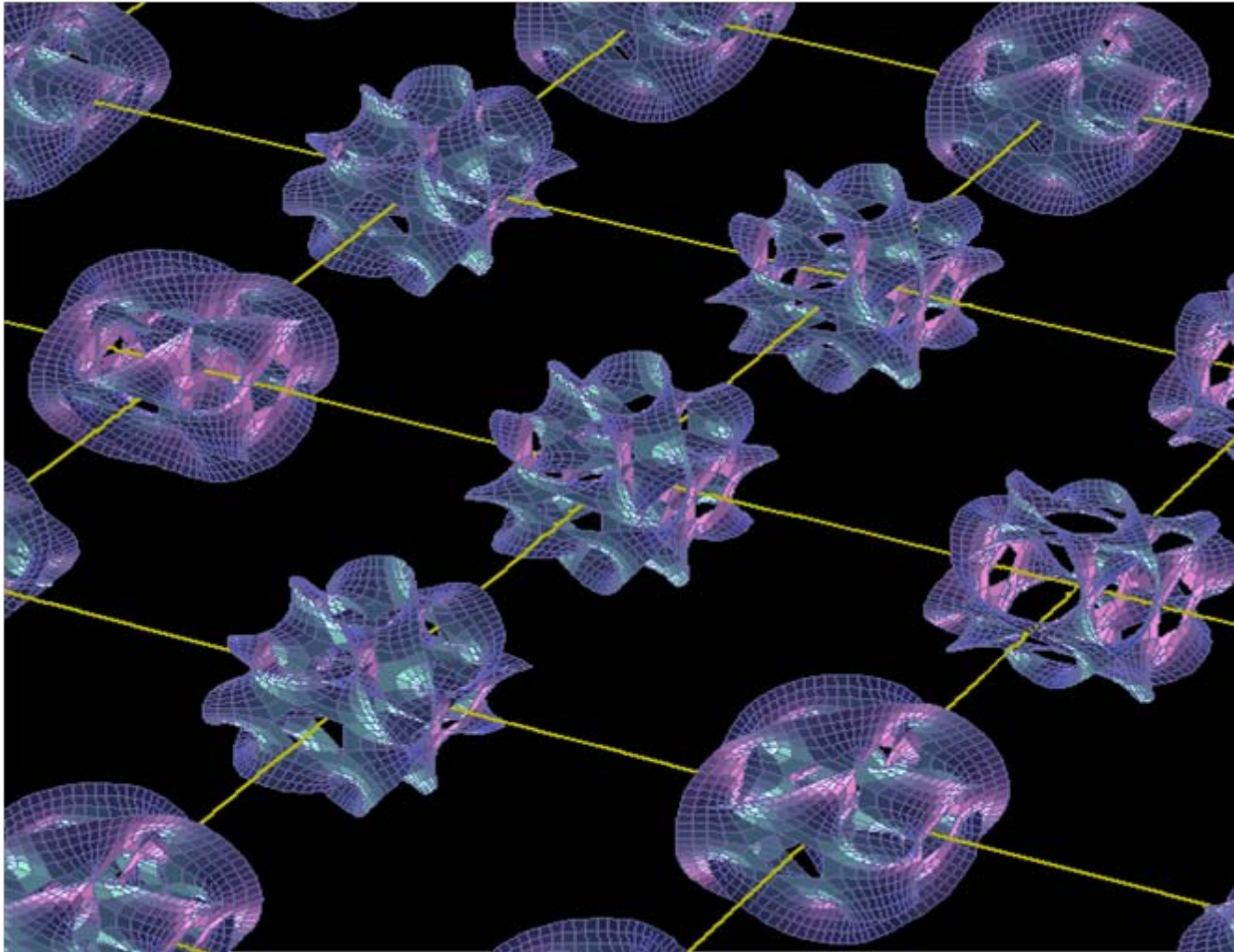
S-dimensional assisted inflation
assisted brane inflation
anomaly-induced inflation
assisted inflation
assisted chaotic inflation
boundary inflation
brane inflation
brane-assisted inflation
brane gas inflation
brane-antibrane inflation
braneworld inflation
Brans-Dicke chaotic inflation
Brans-Dicke inflation
bulky brane inflation
chaotic inflation
chaotic hybrid inflation
chaotic new inflation
D-brane inflation
D-term inflation
dilaton-driven inflation
dilaton-driven brane inflation
double inflation
double D-term inflation

dual inflation
dynamical inflation
dynamical SUSY inflation
eternal inflation
extended inflation
extended open inflation
extended warm inflation
extra dimensional inflation
F-term inflation
F-term hybrid inflation
false-vacuum inflation
false-vacuum chaotic inflation
fast-roll inflation
first-order inflation
gauged inflation
Hagedorn inflation
higher-curvature inflation
hybrid inflation
hyperextended inflation
induced gravity inflation
intermediate inflation
inverted hybrid inflation
isocurvature inflation.....

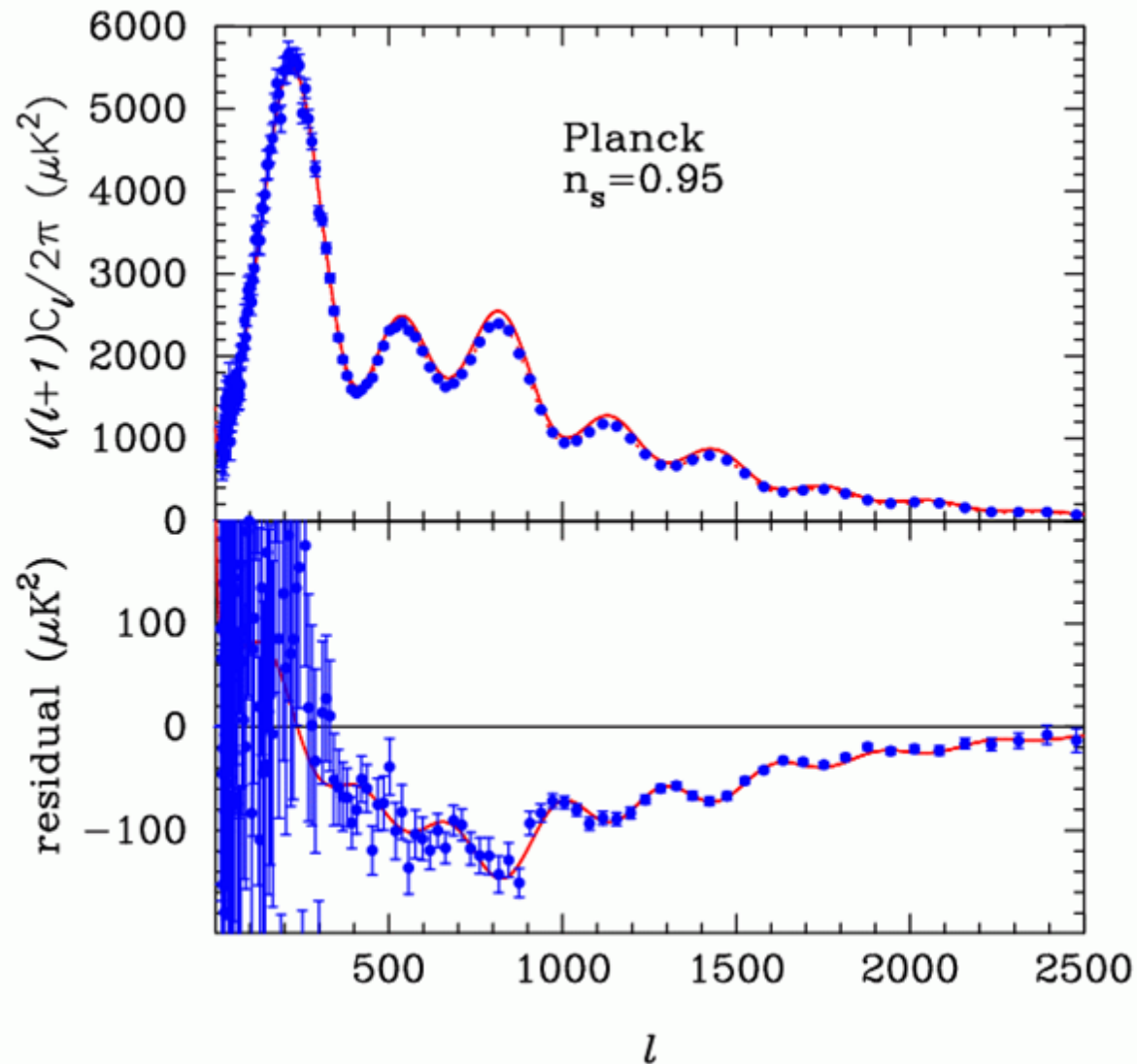
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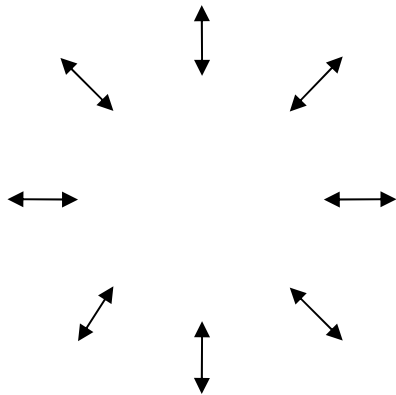


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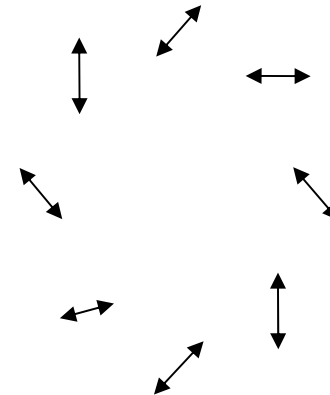


Polarization E and B modes $P = \begin{pmatrix} Q & U \\ U & -Q \end{pmatrix}$

Gradient: E polarization



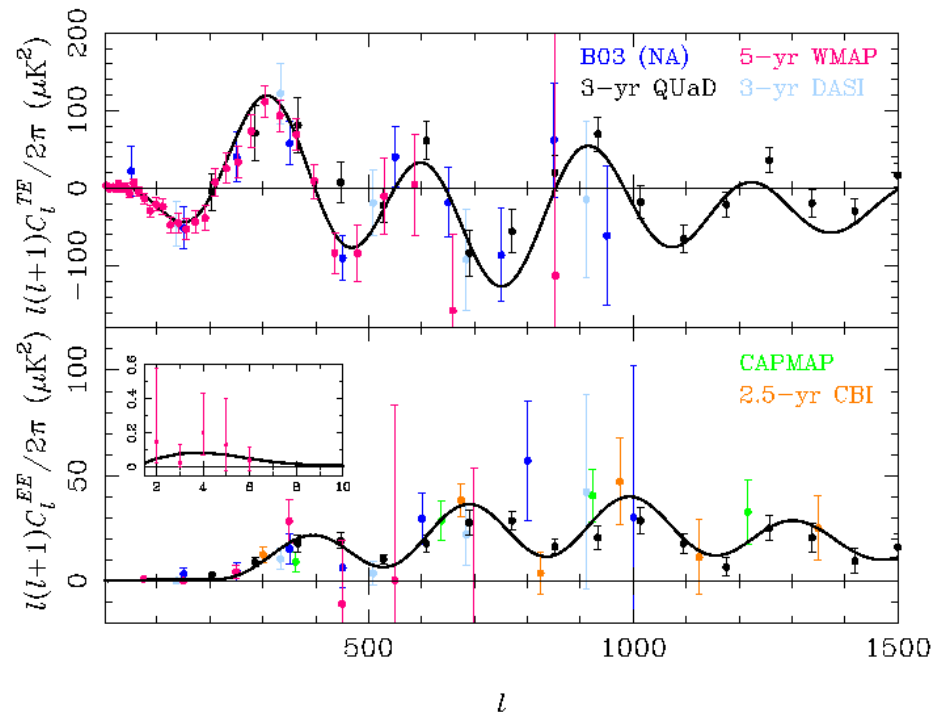
Curl: B polarization



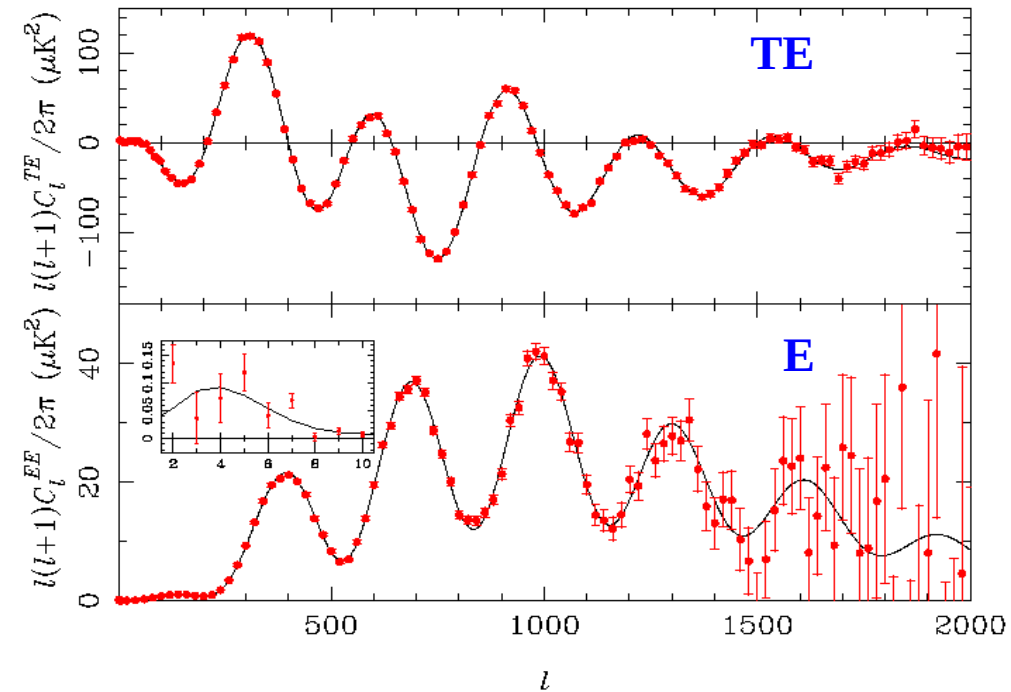
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CURRENT OBSERVATIONS



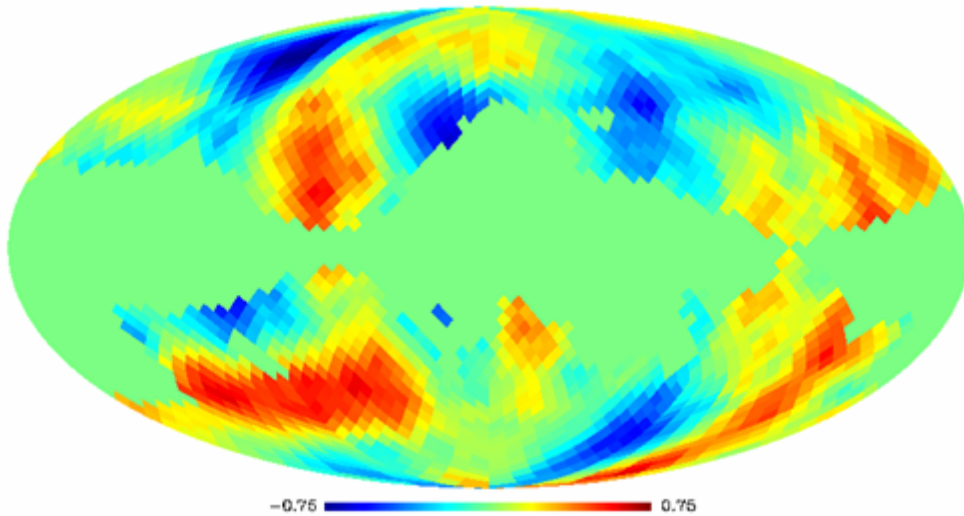
PLANCK FORECAST



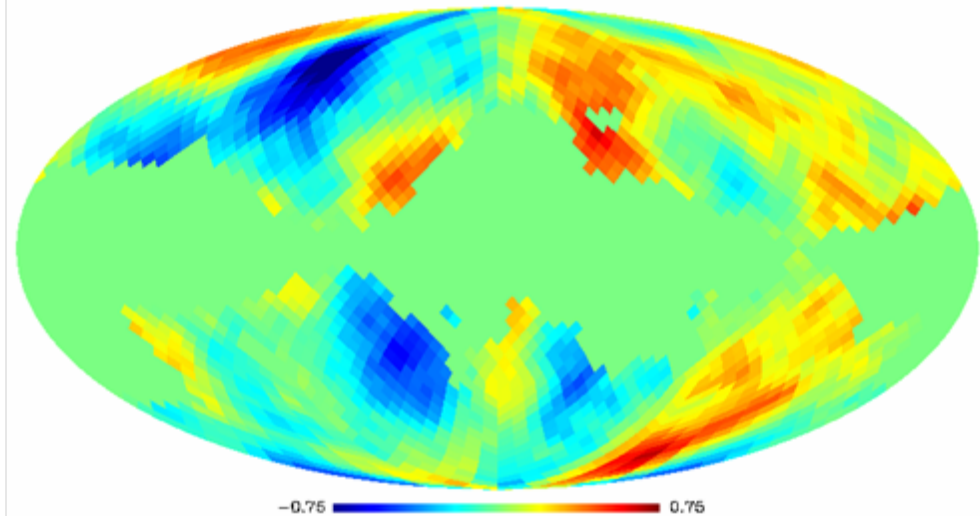
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CMB Q



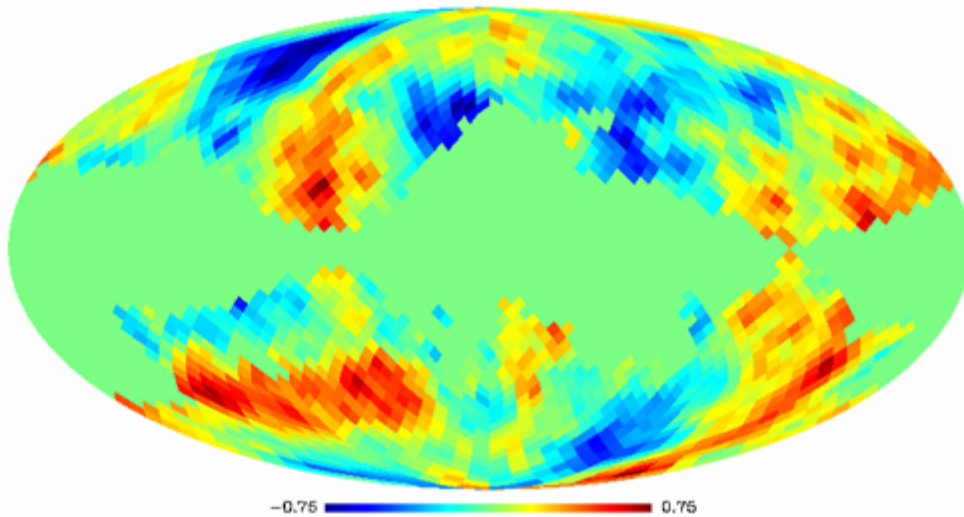
CMB U



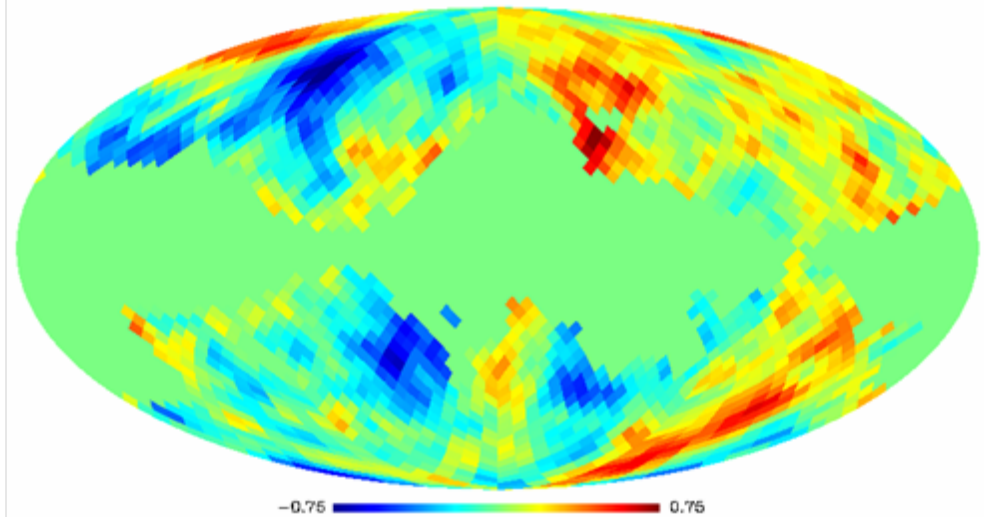
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CMB $r=0.1$ Q foreground subtracted

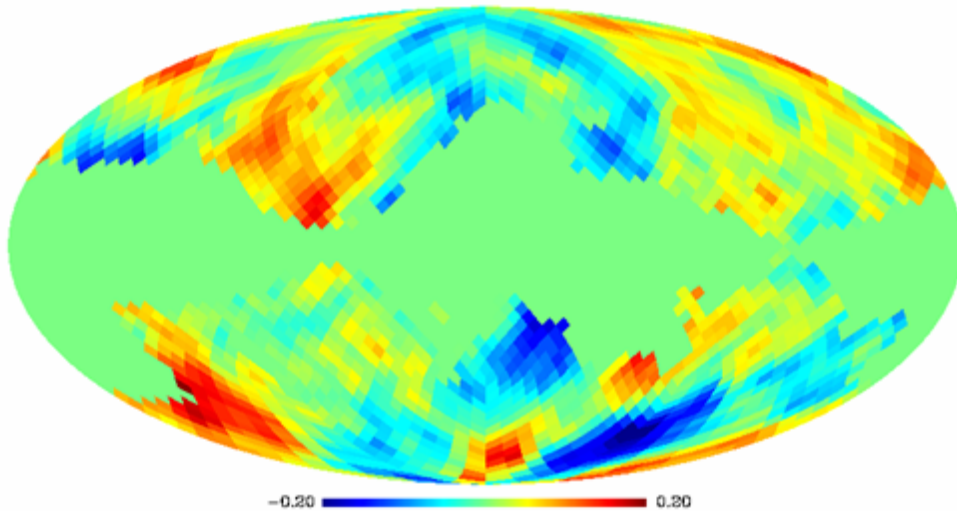


CMB $r=0.1$ U foreground subtracted

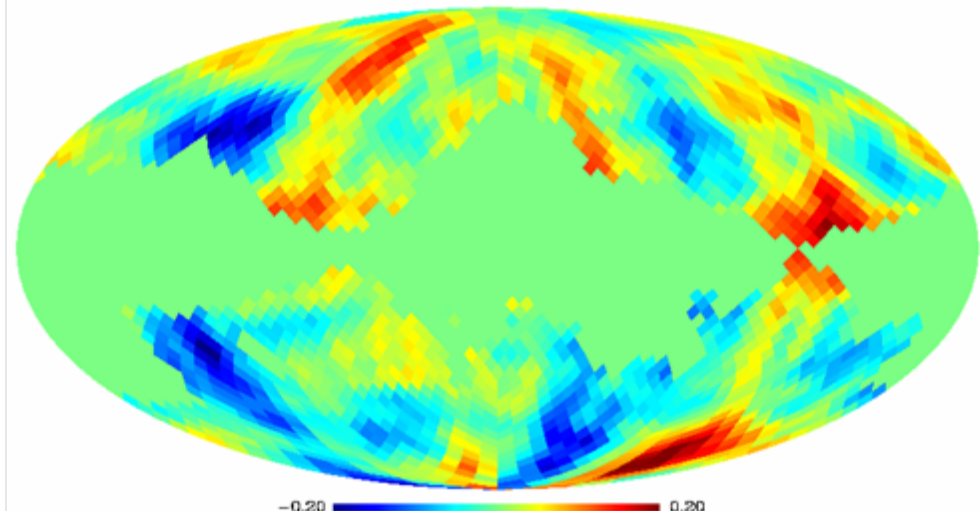


GRAVITATIONAL WAVES THEORETICAL MODEL

B mode Q

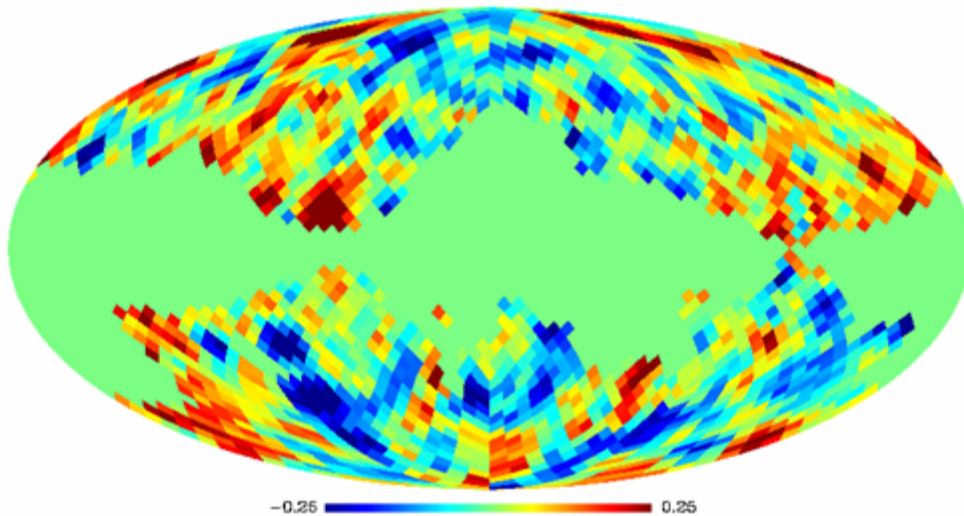


B mode U

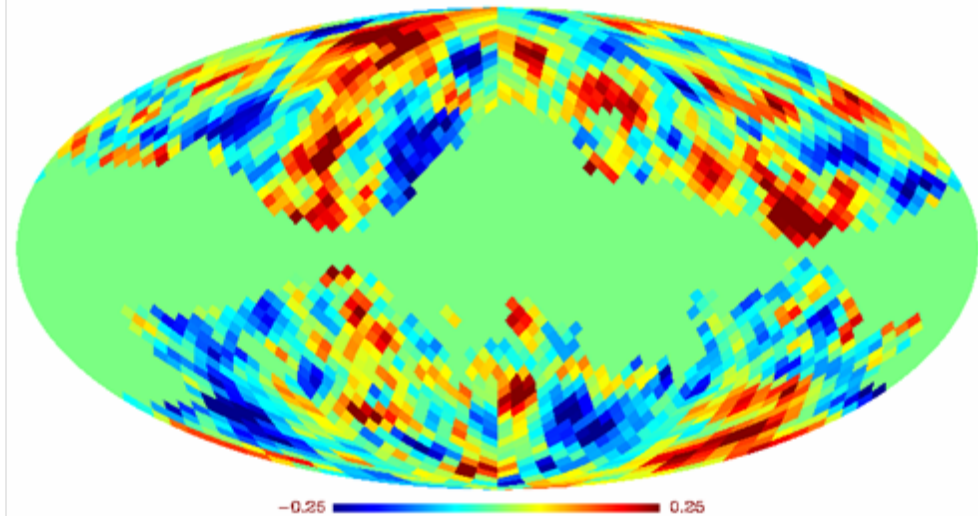


GRAVITATIONAL WAVES NOMINAL MISSION: 2 SKY SURVEYS

B-mode $r=0.1$ Q foreground subtracted

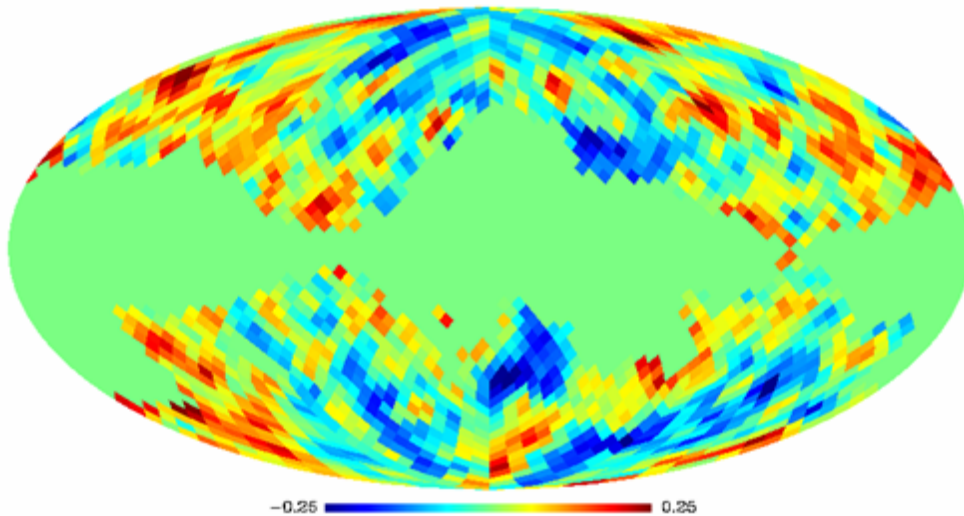


B-mode $r=0.1$ U foreground subtracted

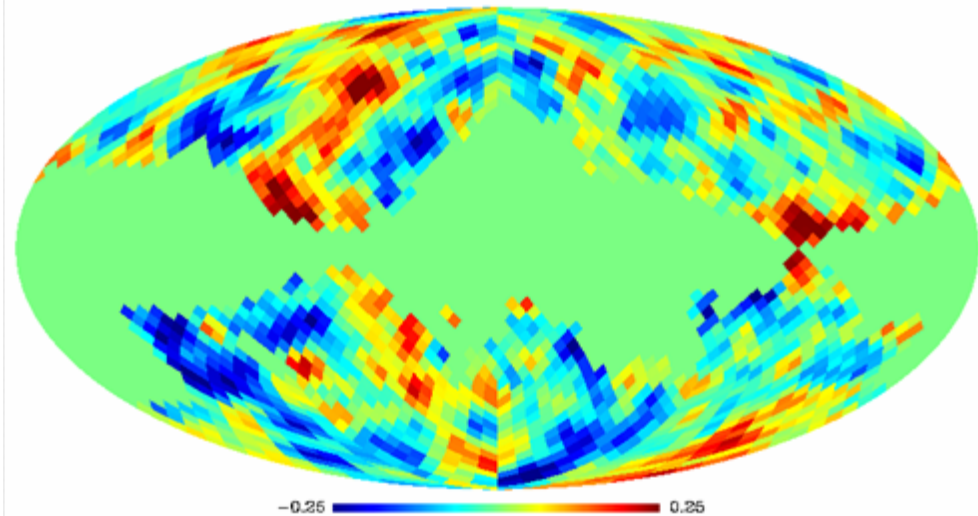


GRAVITATIONAL WAVES NOMINAL MISSION: 4 SKY SURVEYS

B-mode $r=0.1$ Q foreground subtracted extended mission

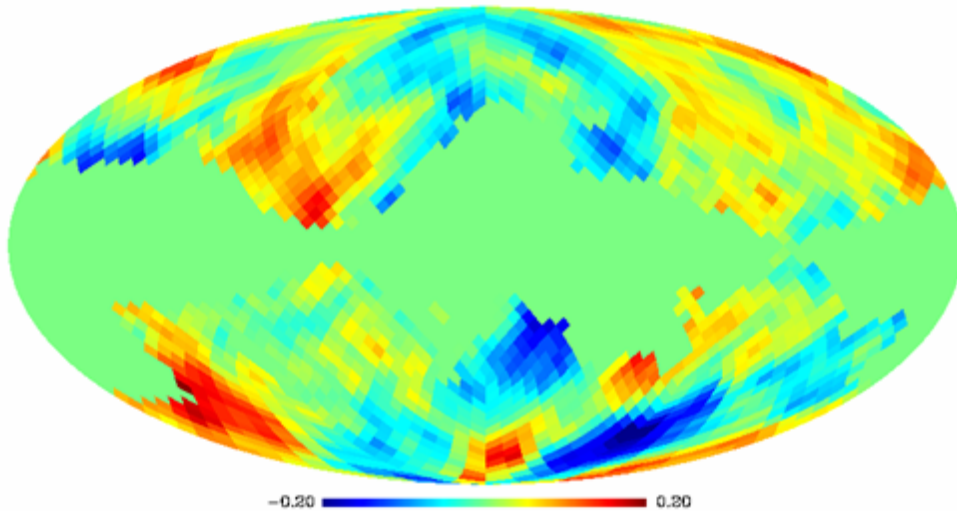


B-mode $r=0.1$ U foreground subtracted extended mission

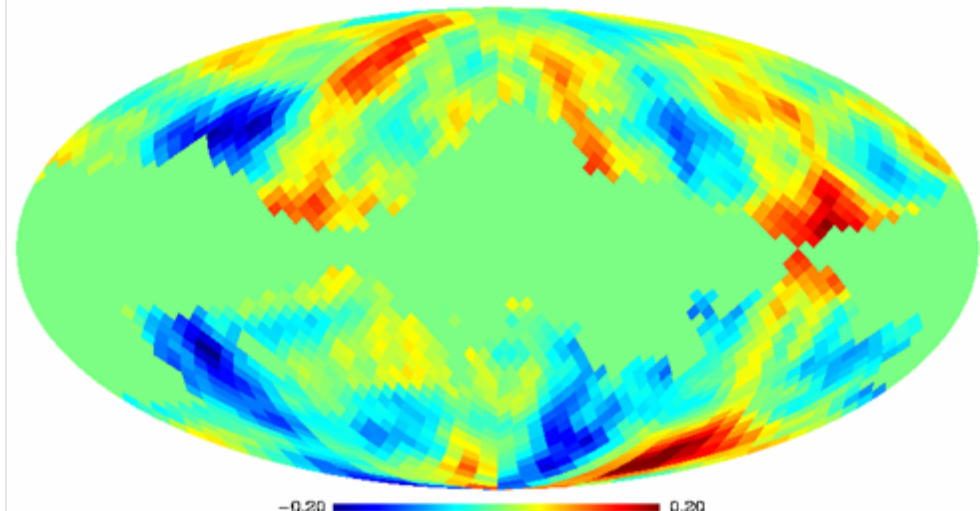


GRAVITATIONAL WAVES THEORETICAL MODEL

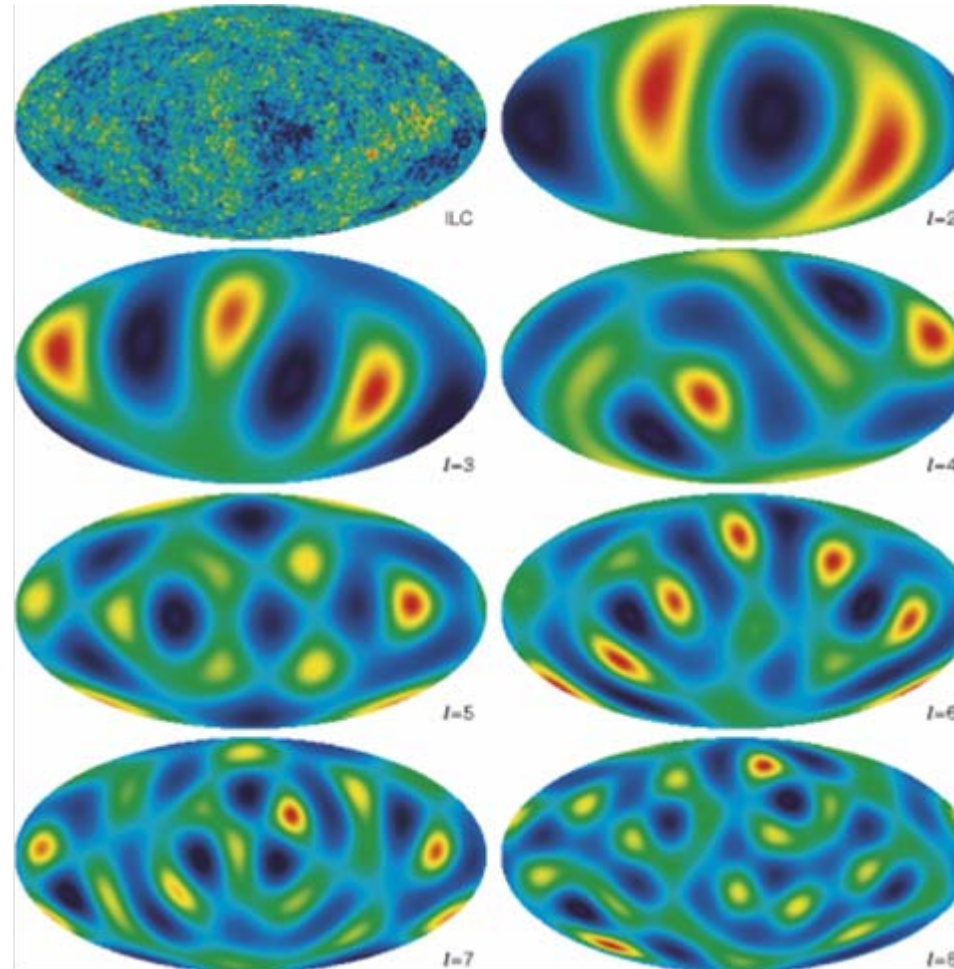
B mode Q



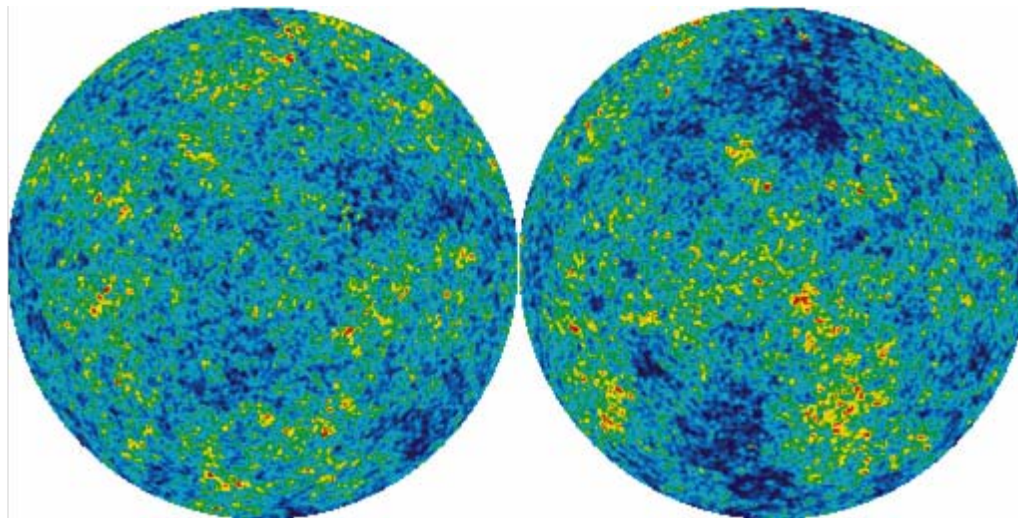
B mode U



ALIGNMENTS?



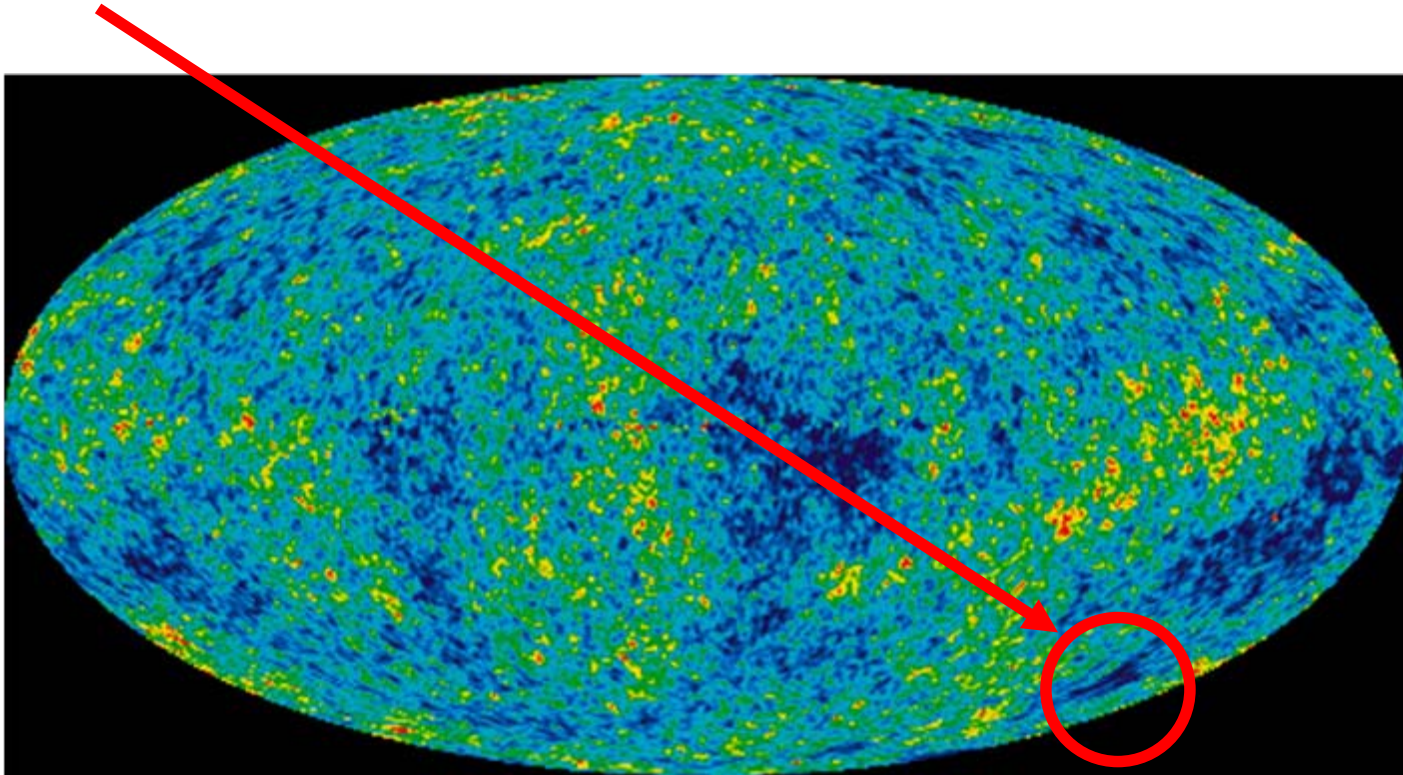
ASYMMETRY?



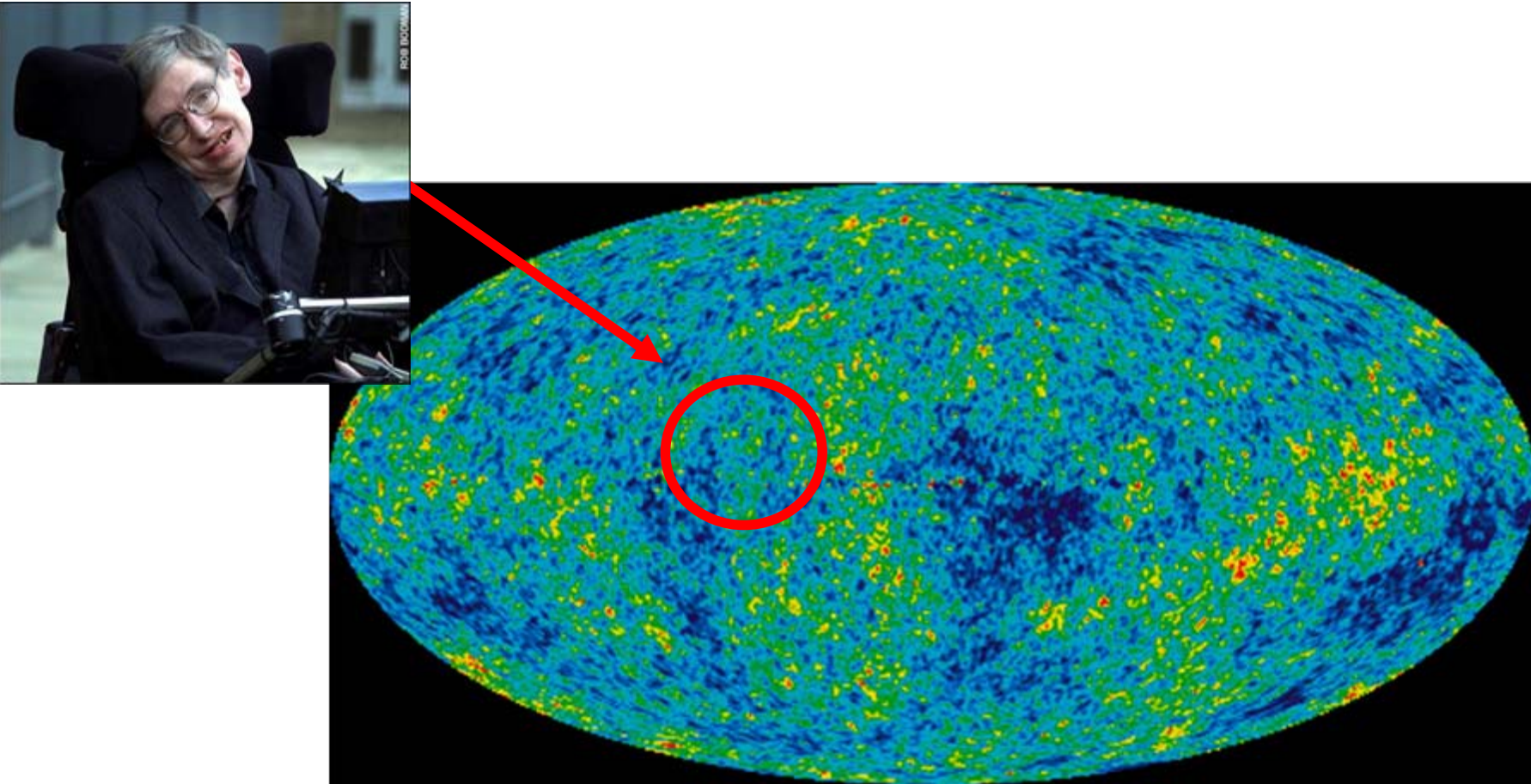
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COLD SPOT?

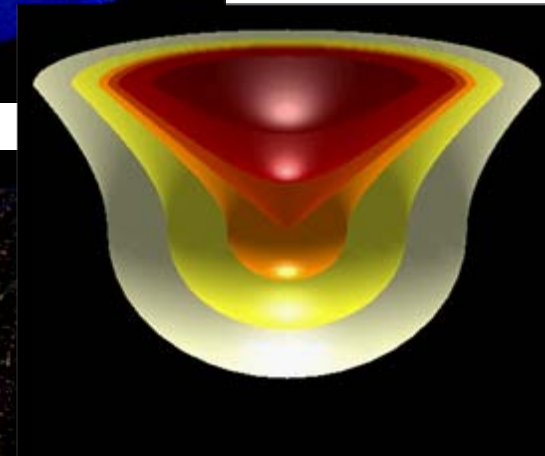
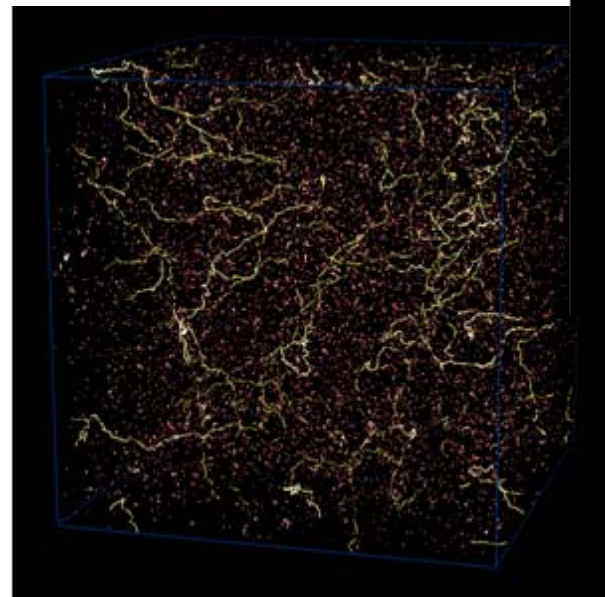
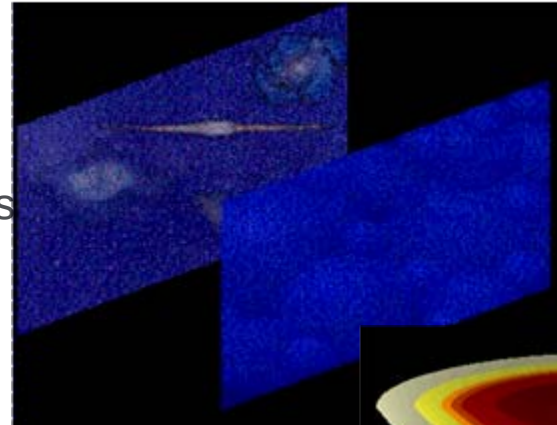


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BEYOND THE 'STANDARD' BIG BANG::

1. Brane-worlds – signatures of higher dimensions
2. Pre-big bang signatures
3. Cosmic defects, cosmic superstrings
4. Non-Gaussianity
5. Evidence for warped geometry
6. Isocurvature perturbations
7. Deviations from Einstein gravity
8. Neutrino masses
9. Interacting dark matter
- 10.....



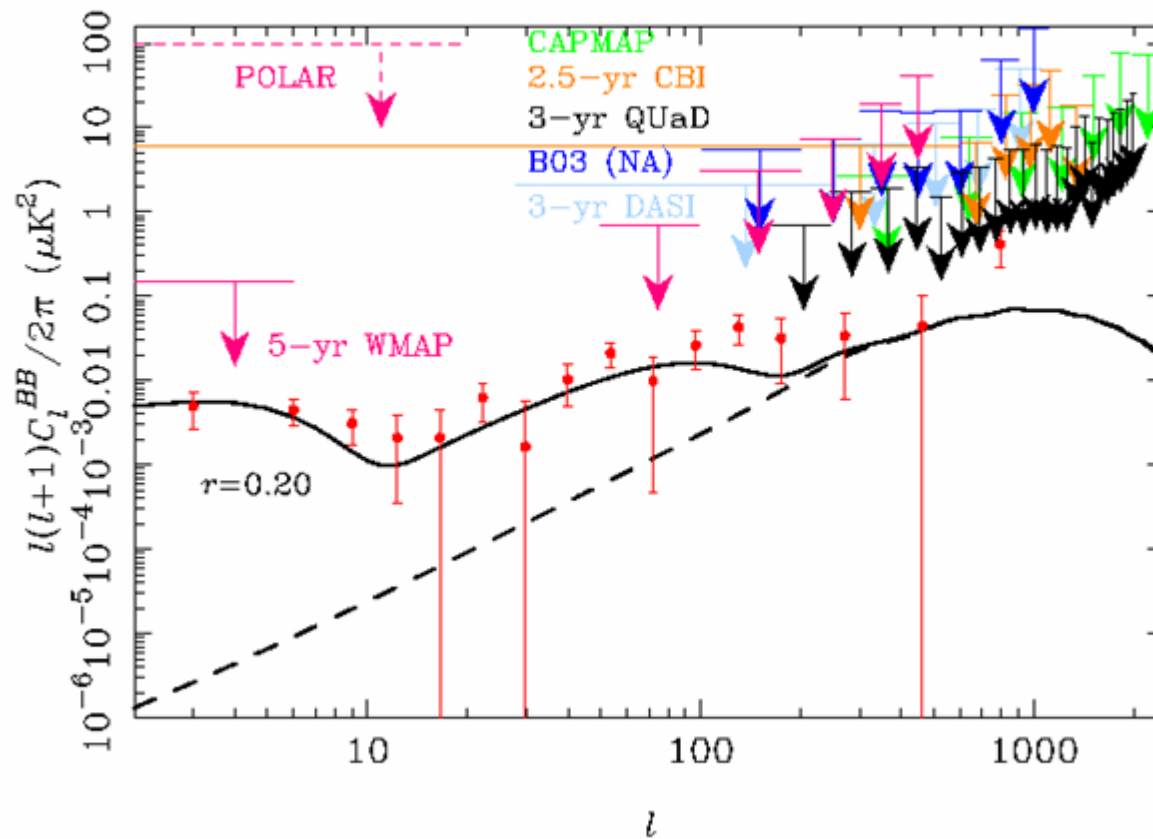
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THANK YOU

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