Open Problems.

WMAP data anomalies.

♡ Low Quadrupole. WMAP showed that is not due to galactic contamination.

♡ Quadrupole-Octopole Alignment.

♡ North-South hemispherical assymetry.

♡ Cold-Spot.

Multipole Alignment.

• Let us define a coordinate system where the Z-axis is in a given direction $\hat{n}$. Let us compute the quantity:

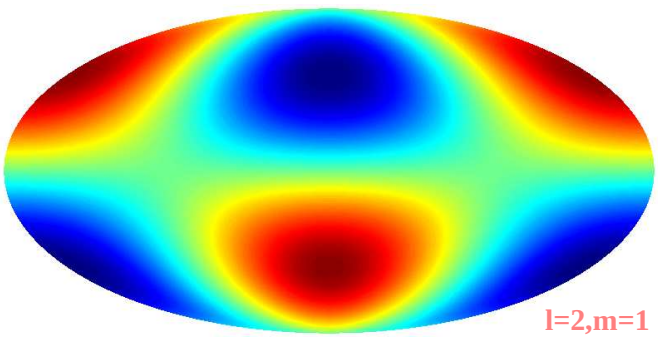
$$\langle \frac{\delta T}{T_o}(\hat{n}) | (\hat{n}\vec{L})^2 | \frac{\delta T}{T_o}(\hat{n}) \rangle = \Sigma_m m^2 |a_{lm}(\hat{n})|^2$$

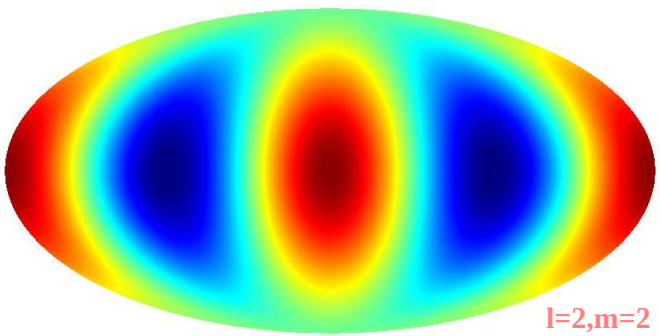
and maximize it for all possible directions $\hat{n}$. The preferred directions for $l = 2, 3$ are:

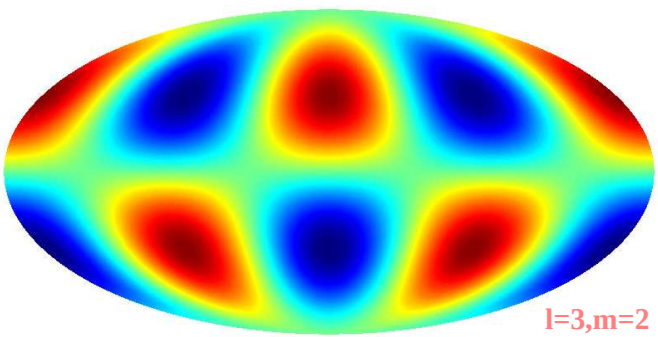
$$\begin{aligned} \hat{n}_2 &= (-0.1145, -0.5265, 0.8424), \\ \hat{n}_3 &= (-0.2578, -0.4207, 0.8698). \end{aligned}$$

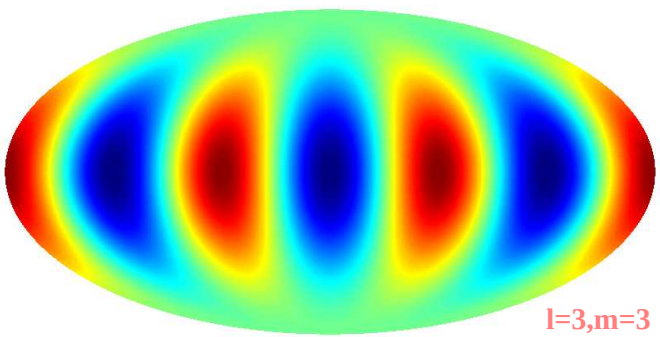
• The probability that 2 random vectors $\hat{n}_2$ and $\hat{n}_3$ are within 10^o of each other is $1/62$, the fraction of are ocupied by a patch of 10^o radius over half the sky.

Multipole Alignment.

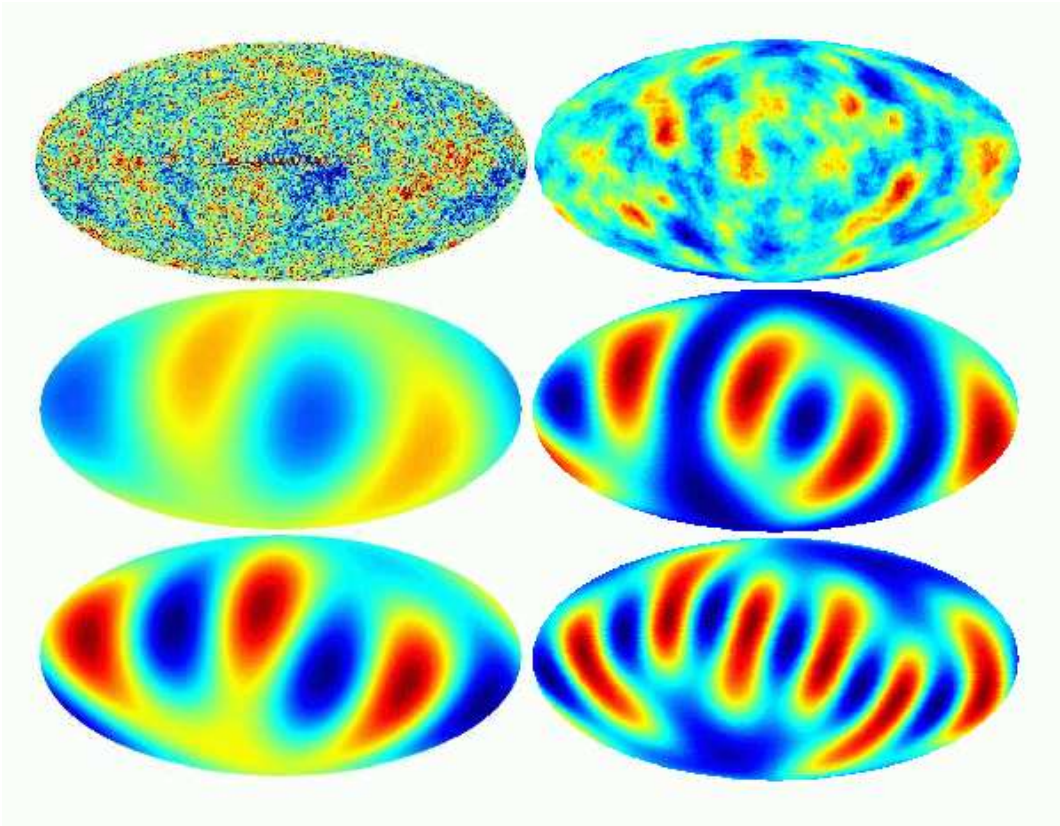




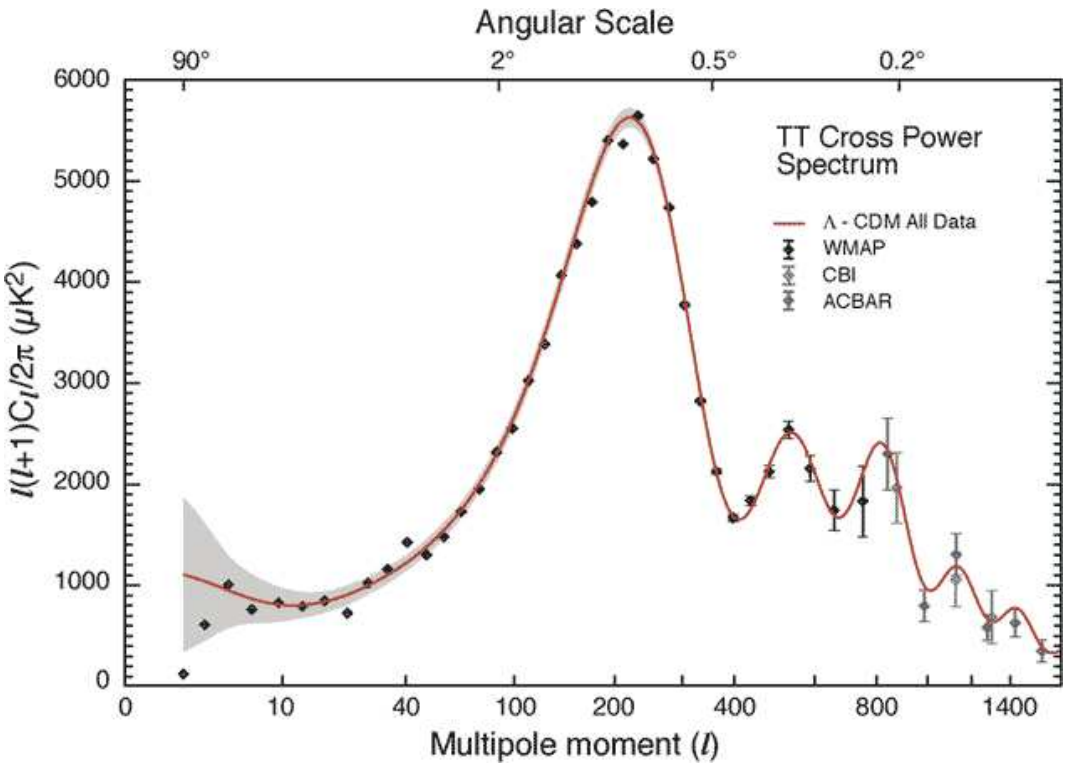




Quadrupole-Octopole Alignment: Data.



The low amplitude of the Quadrupole.



Radiation Power Spectrum from WMAP 1st year data.

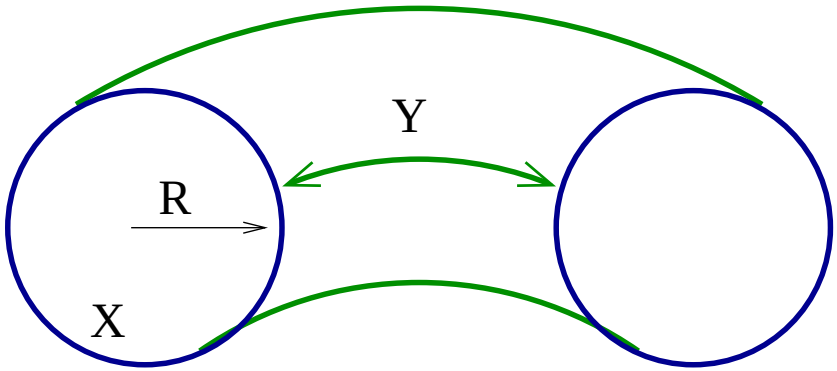
A Topological Compact Universe?.

• The radiation Power Spectrum at low multipoles is dominated by the Sachs-Wolfe effect (with a small contribution comming from the ISW effect):

$$C_l = \frac{H_o^4}{2\pi} \int_o^\infty k^2 dk \frac{P(k)}{k^4} j_l^2(kR_H)$$

• The amplitude of C_2 can be reduced introducing a cut-off scale in the power spectrum:

$$P(k) = \begin{cases} Ak^n & if \quad k > k_{cut-off} \\ 0 & if \quad k < k_{cut-off} \end{cases}$$



• A more elegant solution is to assume one -or more- dimensions are compact. If R is the size of the compact region, then:

$$P(k) = \begin{cases} A(k_x^2 + k_y^2 + k_z^2)^{n/2} & if \quad k_x > 2\pi/R \\ A(k_y^2 + k_z^2)^{n/2} & if \quad k_x < 2\pi/R \end{cases}$$