Dipole leakage and low CMB multi-poles

by

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(Indo-UK meeting)

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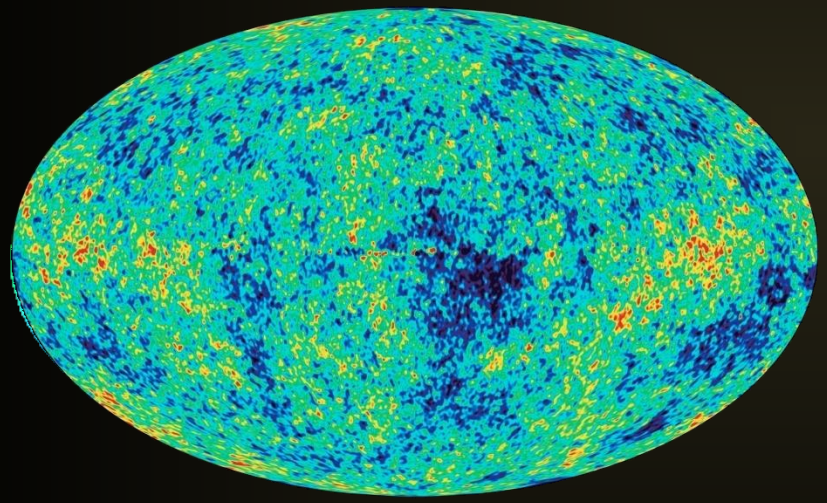
Problem formulation

CMB monopole → (Remove monopole) → CMB dipole → (Remove dipole) → CMB fluctuation



monopole : 2.726 K

dipole : 3.358 mK

fluctuation : ~ μK

Experiments are designed to measure the things up to and extremely high accuracy. Several theories are formulated based on these analysis.

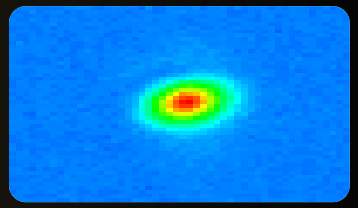
So even a small mistake in the data analysis technique is not acceptable .

Problem formulation

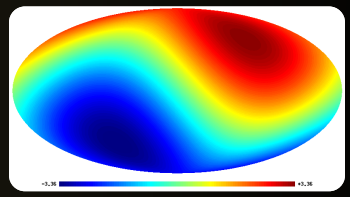
It is seen that the power at the low multi-poles of the CMBR power spectrum is lesser than the theoretically expected power

There may be some physics behind this lesser power at low multi-poles. However it may also happen that this is only a measurement effect.

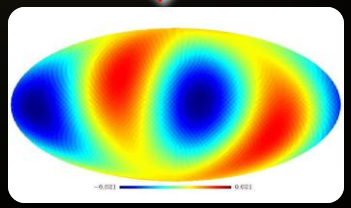
WMAP beam is noncircular.
(noncircular beam → power transfer from pole to pole)



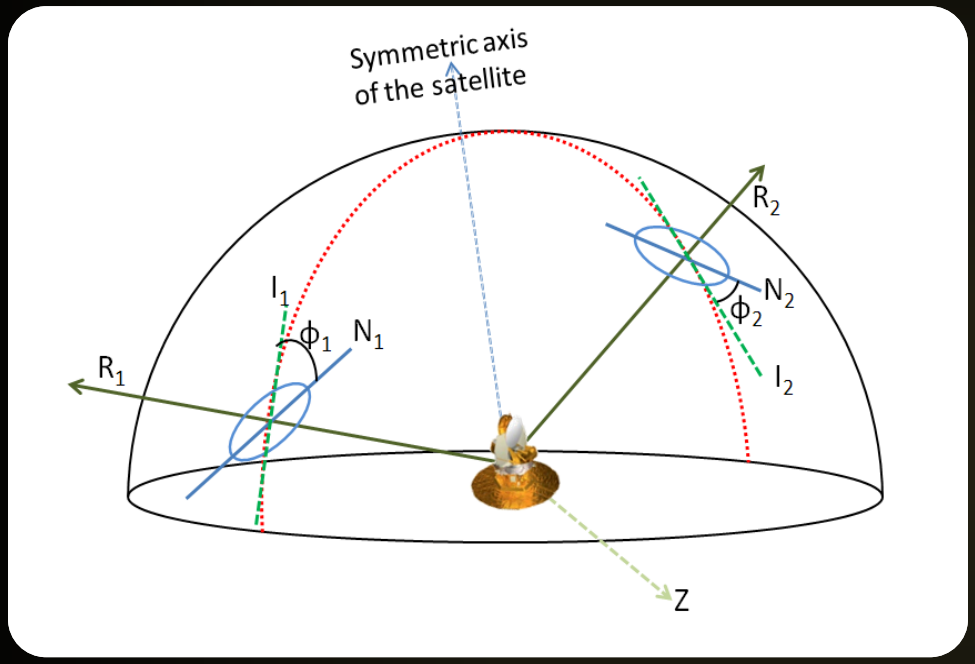
But for data analysis people consider the beam to be circular.

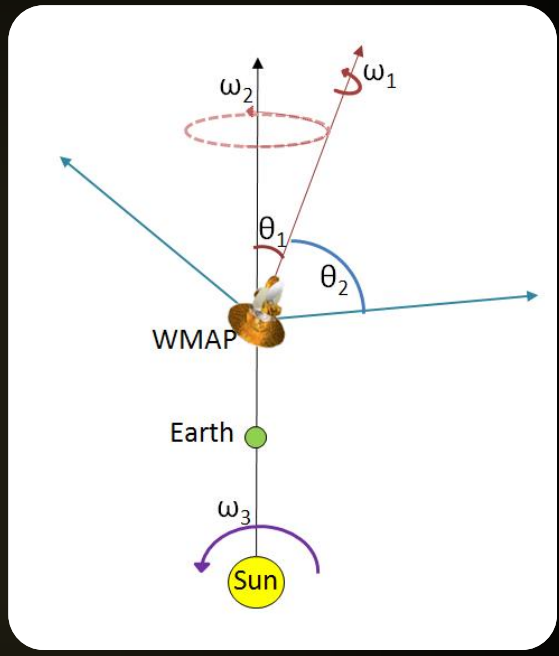


Due to noncircular beam some power can gets transferred from dipole to higher multipoles.



Beam of WMAP satellite



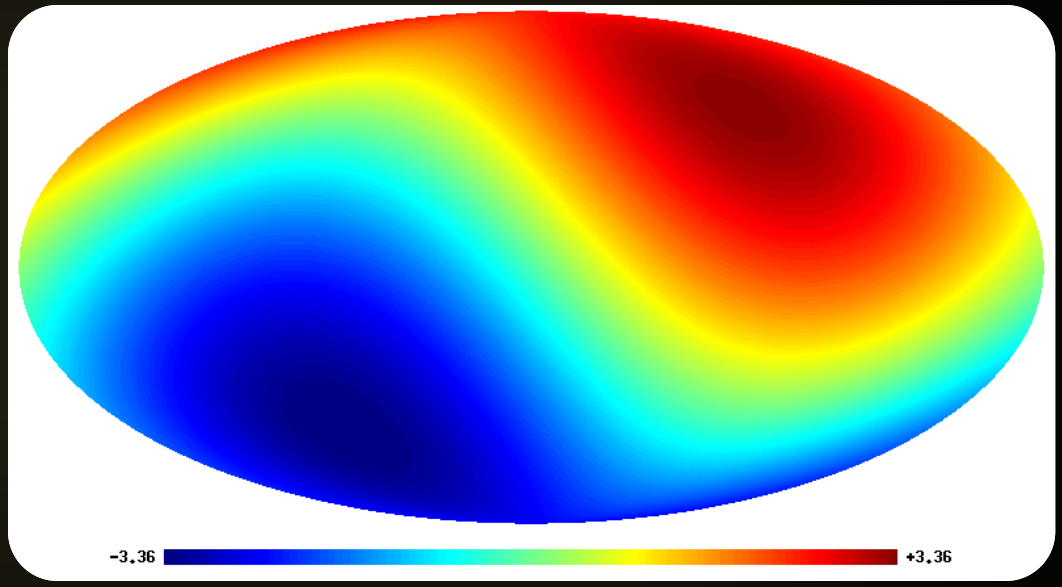


Direction of the two beams

Orientation of the beam

Analysis

Take Dipole Map



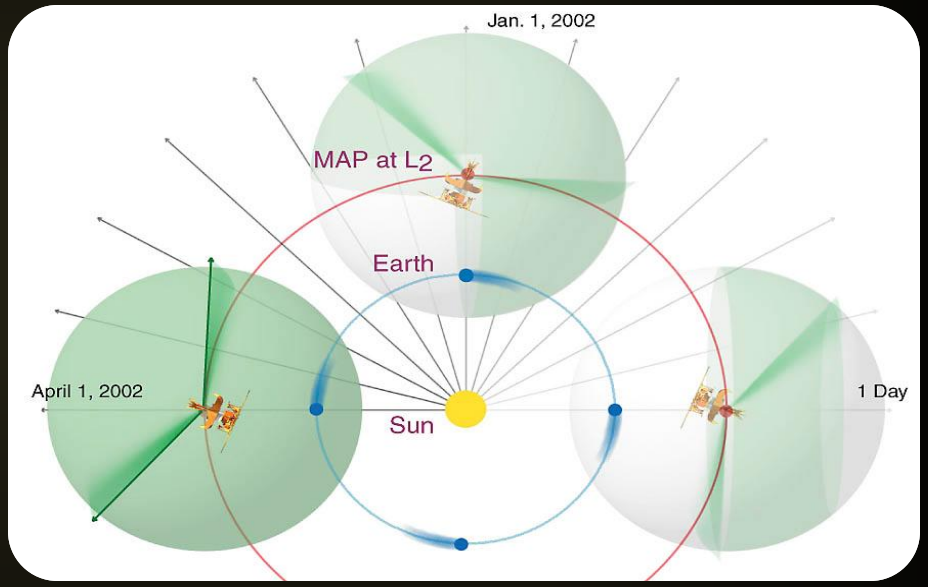
Dipole map in the galactic coordinate
Temperature : T = 3.358 mK
Direction : (l,b) = (264.31°,48.05 °)

Analysis

Take Dipole Map

Scan it

WMAP scan pattern
elliptical beam



Scan the dipole map for 6 month & get the TOD
(WMAP scans the entire sky once in 6 months)

Analysis

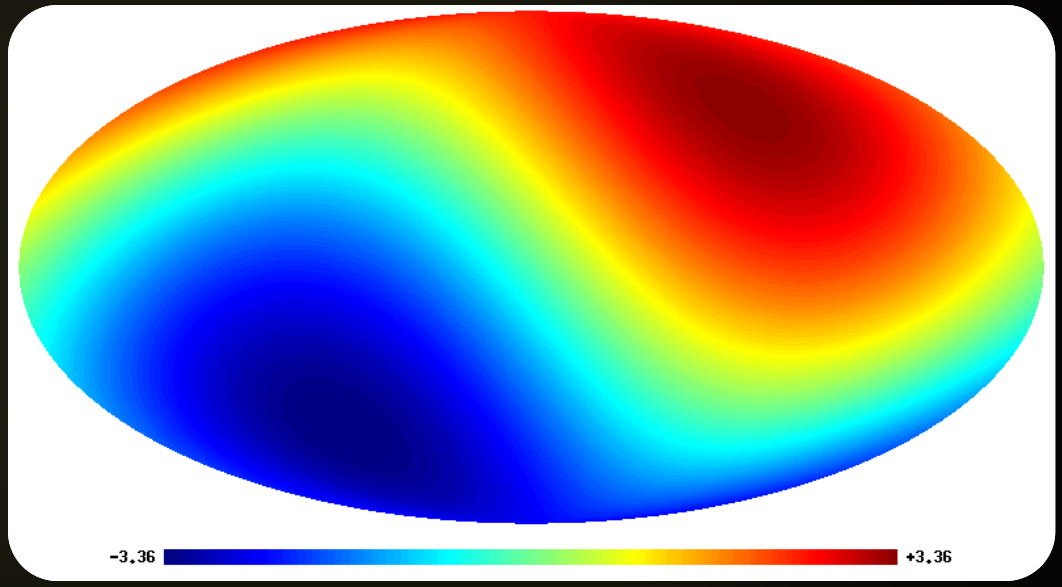
Take Dipole Map

Scan it

WMAP scan pattern
elliptical beam

Reconstruct map

Mapmaking algorithm



From the TOD reconstruct the map

Analysis

Take Dipole Map

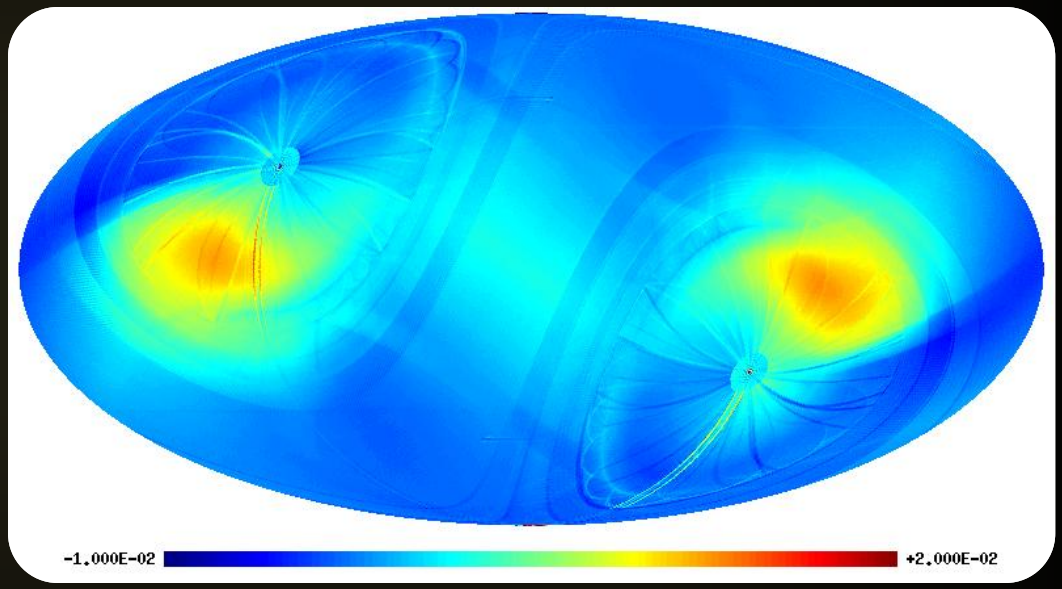
Scan it

WMAP scan pattern
elliptical beam

Reconstruct map

Mapmaking algorithm

Remove dipole



After removing the dipole from the scanned map
we can get this type of map.

Analysis

Take Dipole Map

Scan it

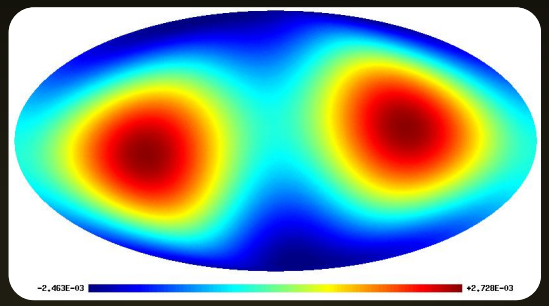
WMAP scan pattern
elliptical beam

Reconstruct map

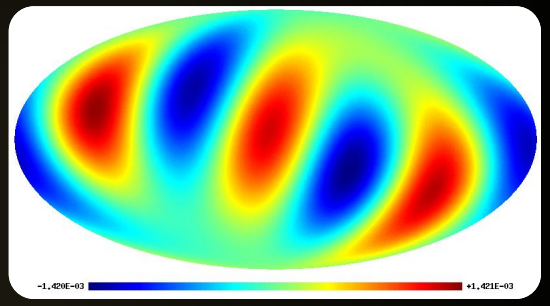
Mapmaking algorithm

Remove dipole

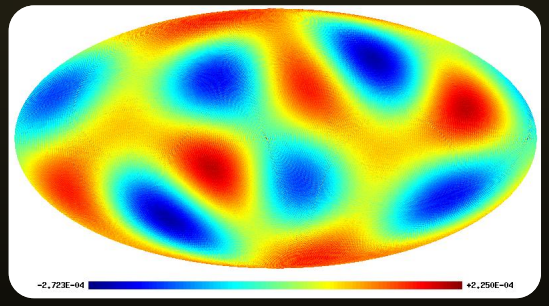
Extract quadrupole
& higher multipoles



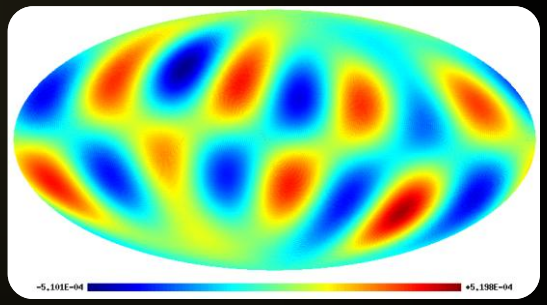
l =2 (quadrupole)



l =3 (octapole)



l =4



l =5

Results

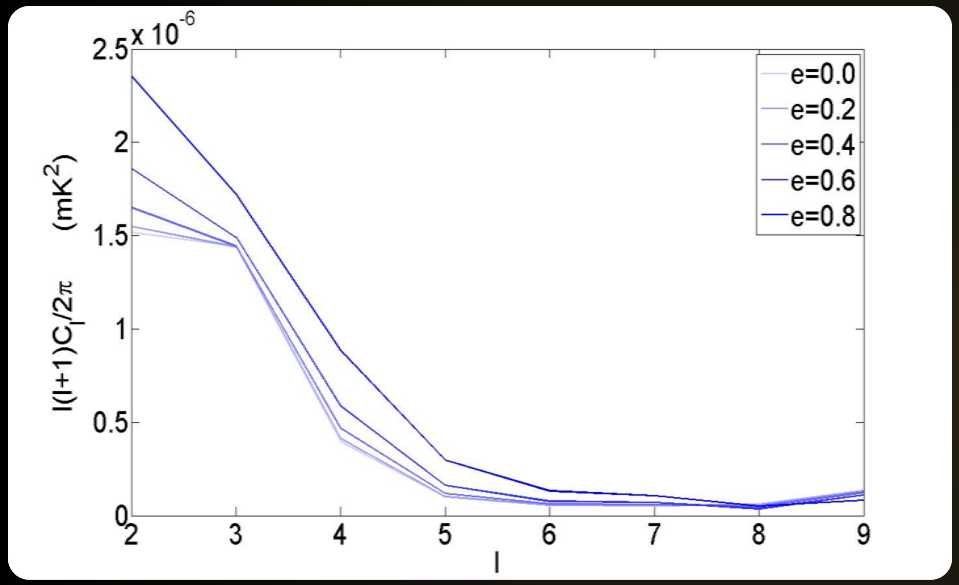


Figure is showing the power leakage for different eccentricity

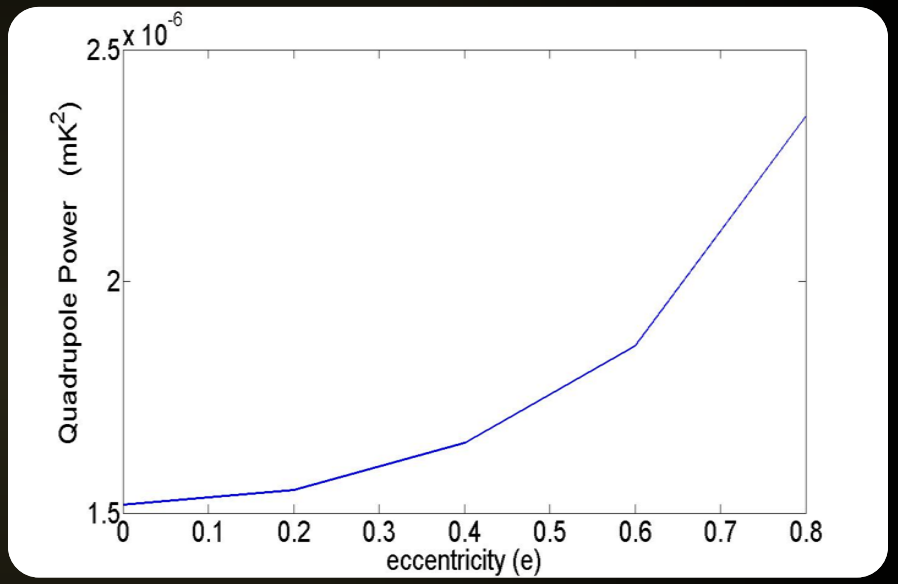
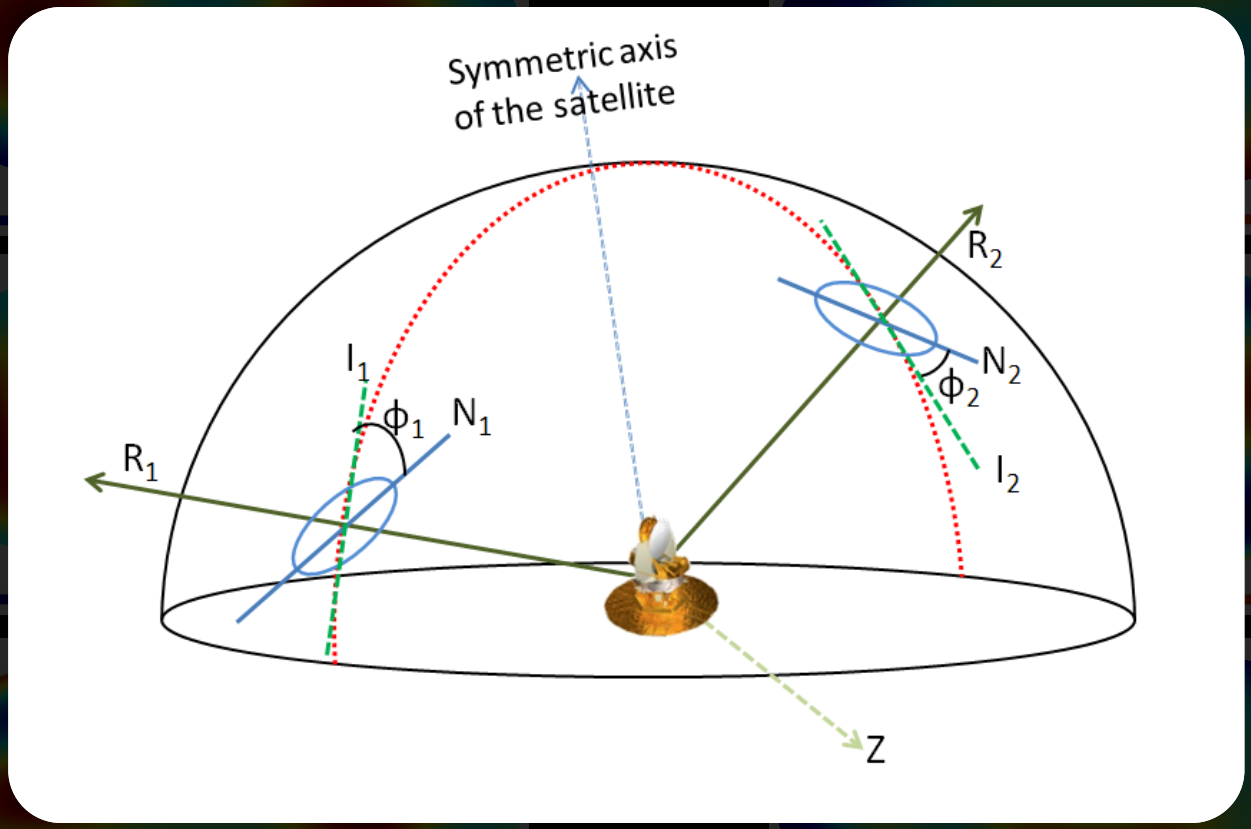


Figure is showing **the quadrupole power for different eccentricity**

Simulation with beam FWHM ~ 20 arcmin

Simulation with ϕ_1 =30, ϕ_2=45

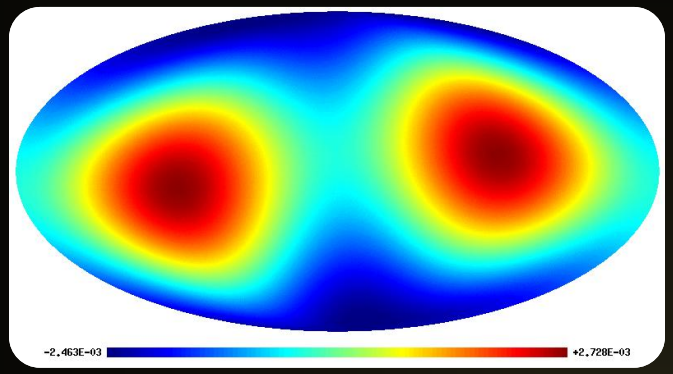
Galactic coordinate

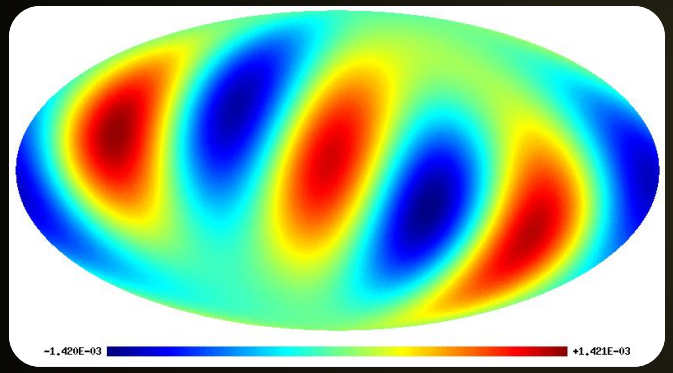


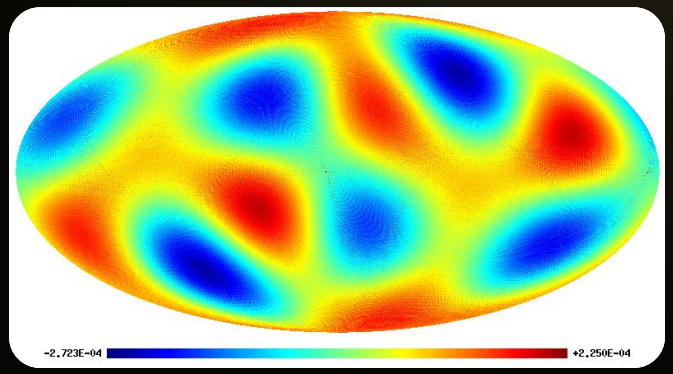
Beam FWHM ~ 40 arcmin and eccentricity = 0.8

Simulation with ϕ_1 =20, ϕ_2=45

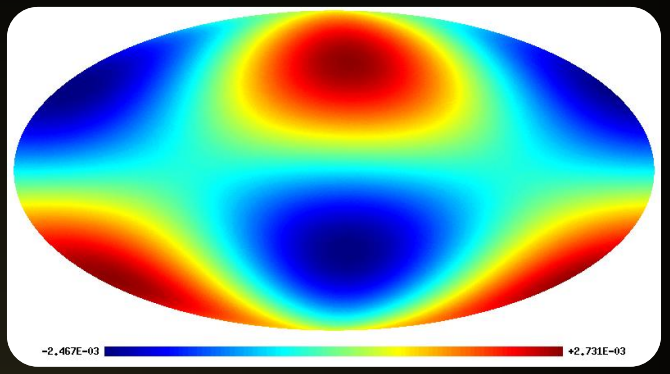
Galactic coordinate

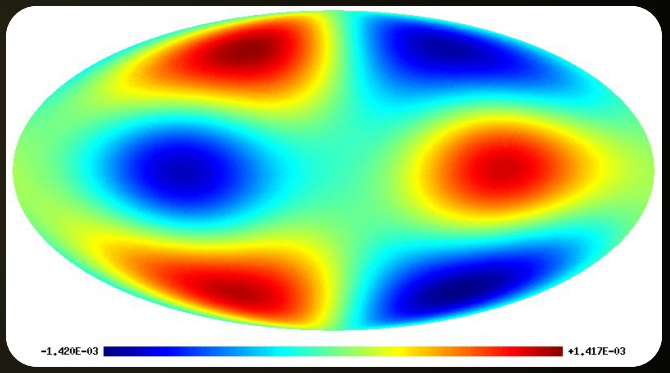


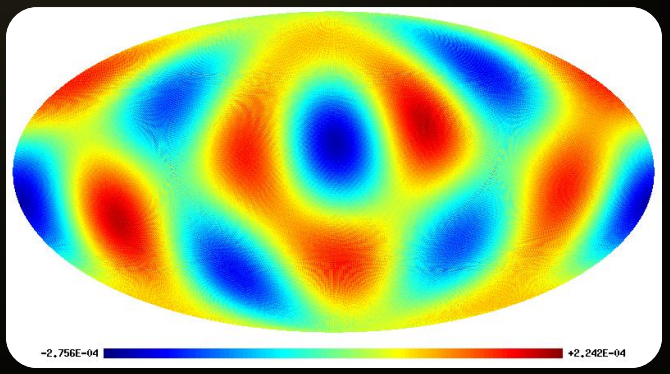




Ecliptic coordinate



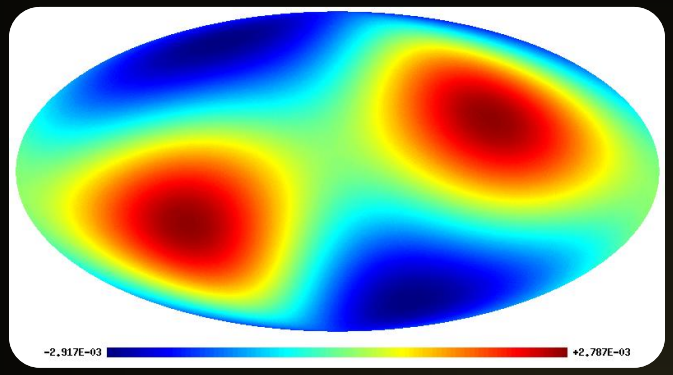


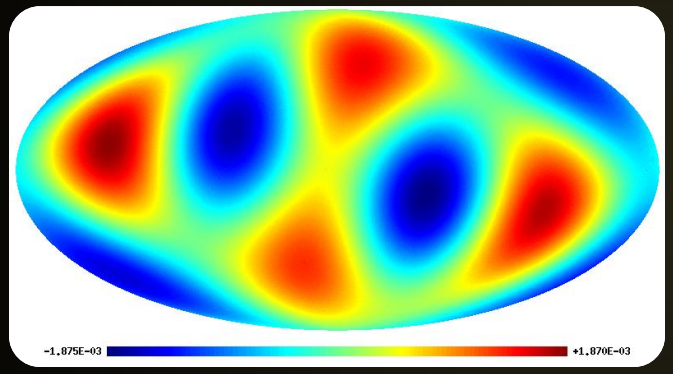


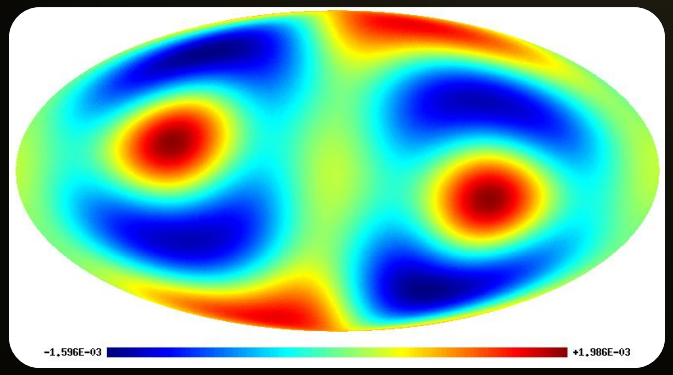
Beam FWHM ~ 40 arcmin and eccentricity = 0.8

Simulation with ϕ_1 =10, ϕ_2=45

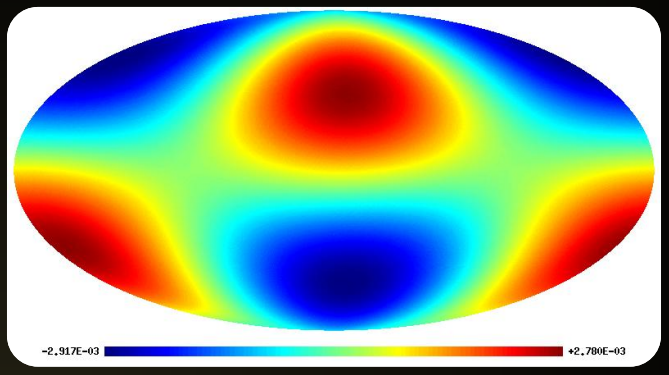
Galactic coordinate

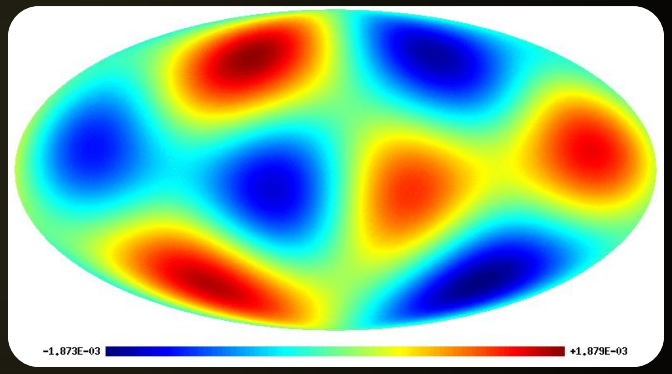


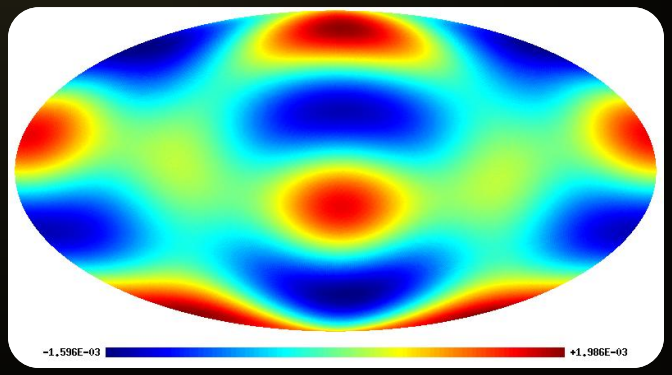




Ecliptic coordinate







Beam FWHM ~ 40 arcmin and eccentricity = 0.8

Conclusion

1. Power can gets transferred from the dipole to quadrupole and higher multi-poles due to the noncircular beam.

2. The amount of power transfer depends on the eccentricity
   high eccentricity → more power leakage

Two cases	Dipole to quadrupole ratio
Eccentricity = 0.8	~1000 - ~1200
Actual sky	~550

3. The shape of the quadrupole and higher multipoles due to power leakage depends on the orientation of the two beams of the WMAP satellite.

4. The amount of power transfer depends on the orientation of the dipole.

Future Plan

We are planning to simulate this effect for the PLANCK satellite scan pattern and check what are all the effects we get for PLANCK maps.

We are planning to simulate this effect for the actual beam shape of WMAP satellite instead of taking the elliptical beam.

Thank You