# Primordial non-Gaussianity and the Bispectrum of the Cosmic Microwave Background


Filippo Oppizzi

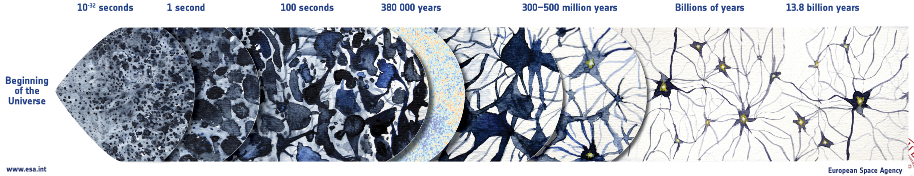
Università degli studi di Padova

Dipartimento di Fisica e Astronomia "Galileo Galilei"

# Inflation

- it is an extension of the Standard Cosmological Model introduced to overcome some of its limits
- it is the process that generates the primordial density fluctuations and sets the initial conditions

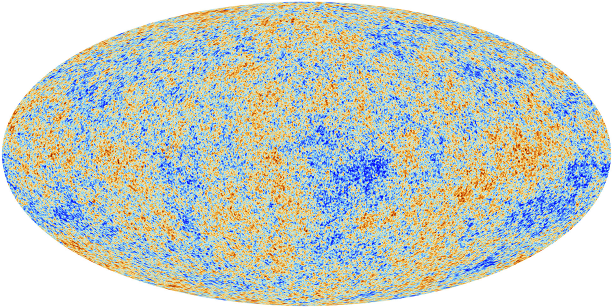
*The early Universe underwent a phase of accelerated expansion in which quantum fluctuations were stretched at cosmological scales*



## Observable

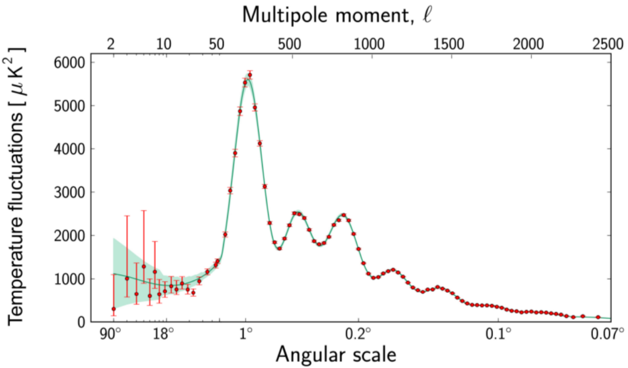
- CMB temperature is linearly linked to the primordial field
- the CMB temperature field can be expressed as a multipole expansion

$$\{\Theta(\hat{n})\} \equiv \{a_{\ell m}\} \qquad a_{\ell m} = \int \mathrm{d}\Omega \overline{Y}_{\ell}^{m}(\hat{n})\Theta(\hat{n})$$



## Random fields

- Inflation predict that the CMB field is a nearly Gaussian random field
- a Gaussiam random field is totally described by its 2-point correlator, or Power Spectrum: $\langle a_{\ell m}\overline{a_{\ell m}}\rangle = C_\ell$



# non-Gaussianity

- All Inflationary models predict the right Power Spectrum
- the key to discriminate among different scenarios lies in the non-Gaussian component of the field

## The Bispectrum

- the statistic most sensitive to the non-Gaussian component is the 3-point correlator, the Bispectrum:

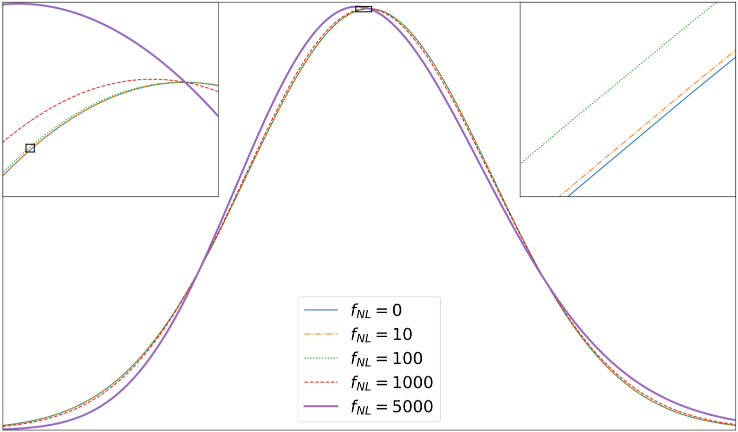
$$\langle a_{\ell_1 m_1} a_{\ell_2 m_2} a_{\ell_3 m_3} \rangle \sim f_{NL} b_{\ell_1 \ell_2 \ell_3}$$

- **the Bispectrum vanish for a Gaussian random field**

# non-Gaussianity

## "local" non-Gaussianity

$$\Phi(x) = \Phi_G(x) + f_{NL}\Phi_G^2(x)$$



# Estimation of non-Gaussianity

## Issues

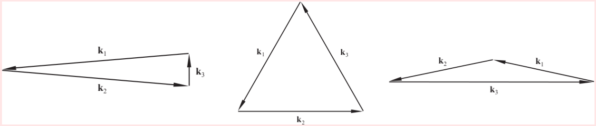
- the single configuration is too small to be detected
- the bispectrum computational cost is very high $\mathcal{O}(\ell^5)$

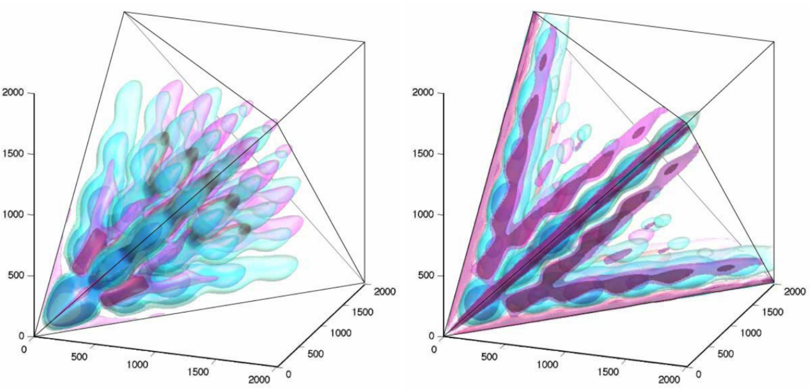
## Solutions

- to maximize the sensitivity the NG sygnal is parametrized by the overal amplitude $f_{NL}$
- the primordial bispectrum is expressed in "factorizable form" on the three wavenuber

$$b_{\ell_1\ell_2\ell_3} \to X_{\ell_1} Y_{\ell_2} Z_{\ell_3} + permutations$$

## Triangle configurations



# Scale-Dependent non-Gaussianity

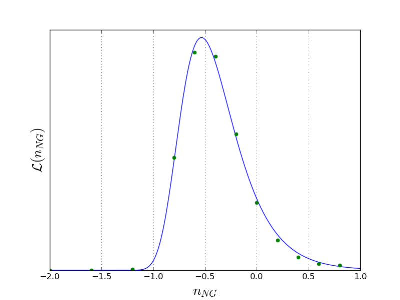
- A scale dependent $f_{NL}$ is a natural prediction of Inflation
- we consider generalization of the classical shapes with: $f_{NL} \to f_{NL} k^{n_{NG}}$

## Iterative approach

1. we obtain estimates of $\hat{f}_{NL}$ for a set of fixed values of $n_{NG}$
2. we use these values to interpolate $\mathcal{L}(n_{NG})$
3. we reconstruct the full likelihood to have the best fit values for both parameters

## Test on simulation

- $\ell_{MAX} = 500,\ f_{NL} = 50,\ n_{NG} = -0.6$

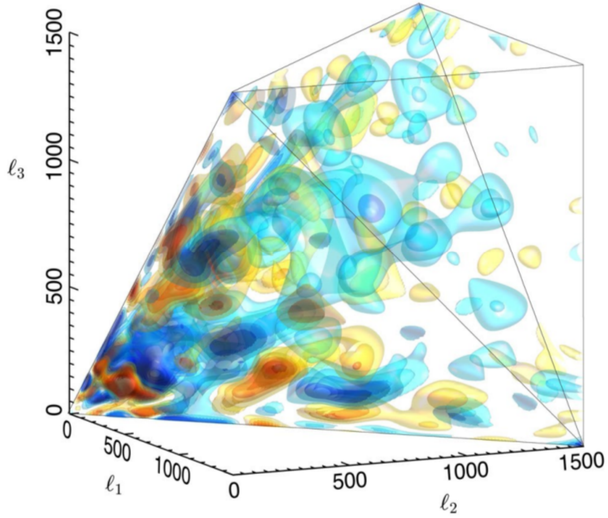



- best fit: $n_{NG} = -0.54^{+0.45}_{-0.16}$

# Conclusion

- characterizing Inflation is one of the main goal of modern Cosmology
- the measurement of primordial non-Gaussianity is a powerful tool to discriminate between different scenarios
- modern CMB data set are a splendid window into primordial Universe
- the statistic most sensitive to NG dignal is the Bispectrum
- to extend the analysis to new template could provide new information

Thank you for your attention!




CMB bispectrum measured by Planck