

# CMBFAST

Floor Terra

June 24, 2010

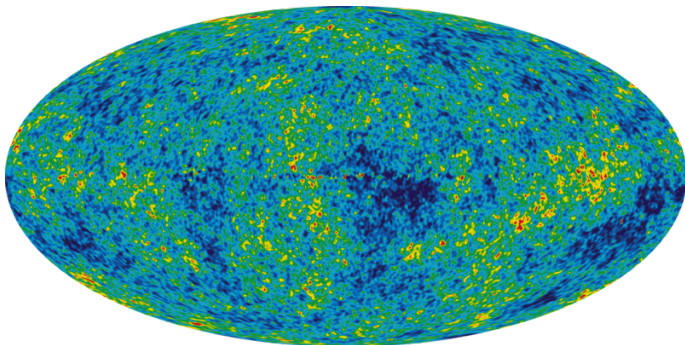
# The big bang

## A simple model

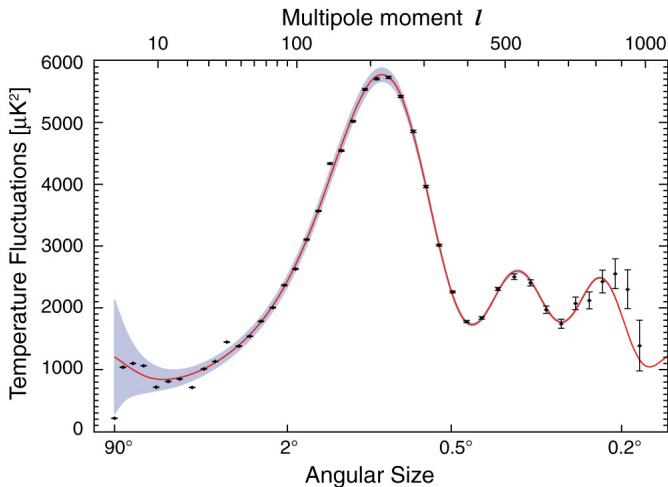
- The universe starts small, hot and dense
- The universe expands and cools
- Recombination ( $z = 1100$ ,  $T = 4000K$ )
- Surface of last scattering
- Universe expands while photons travel freely
- CMB is measured by Arno Penzias and Robert Woodrow Wilson
  - ▶ 1965 ( $z = 1$ )
  - ▶ Nobelprijs in 1978

# WMAP

What do we see today?



*WMAP 7 year data*  
 $T = 2.725K$  fluctuations of order  $10^{-5}$



[http://map.gsfc.nasa.gov/media/080999/080999\\_PowerSpectrumM.jpg](http://map.gsfc.nasa.gov/media/080999/080999_PowerSpectrumM.jpg)

# Perturbations

Where do they come from?

## Theory

- Quantum fluctuations
- Inflation
- Density fluctuations

## CMBFAST

- Plasma physics
- Gravitation and pressure
- Decoupling
- Last scattering surface

## Today

- Gravitation
- Large scale structure

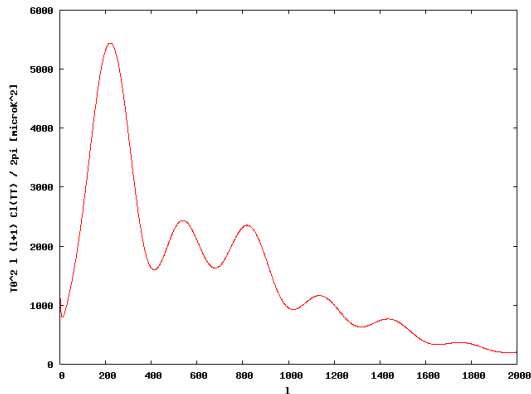
# The calculations

===== CMBFAST Processing =====

## CMB Parameters

```
-----  
ict      =      0  
lmo      =    2000 , akmax0  = 4000.00  
akmaxt   =      5.00, nlnkt  =      5  
ntf      =      1  
z(1)     =      0.00  
ndyn     =      0, wdyn    =     -1.00  
omegab   =      0.05, omegac =      0.22  
omegav   =      0.73, omegan =      0.00  
h0       =     70.00, tcmb   =      2.72  
yhe      =      0.24, annunr =      3.04  
annunr   =      0.00, gsunr  =      0.00  
rcflag   =      0  
riflag   =      1.00, optdlss =      0.09  
zri      =     50.00, rif     =      0.20  
itflag   =      0 , nn      =      1  
itn      =      0 , irt     =      0  
an(1)    =      0.96  
alphans(1) =      0.00  
ant(1)   =      0.00  
alphant(1) =      0.00  
rat(1)   =      0.00  
lensflag =      0 , initfl  =      1
```

Q\_rms-ps = 0.5394E+02 micro K



[http://lambda.gsfc.nasa.gov/toolbox/tb\\_cmbfast\\_form.cfm](http://lambda.gsfc.nasa.gov/toolbox/tb_cmbfast_form.cfm)

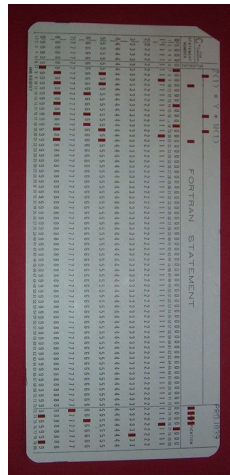
# The CMBFAST code

A line-of-sight integration approach to cosmic microwave background anisotropies

- Written by Uros Seljak and Matias Zaldarriaga.
- Article published in 1996
- The first fast CMB code
- Written in the FORTRAN programming language

# The problems with CMBFAST

- Sparse documentation
- Designed for interactive use
- FORTRAN





# py-cmbfast

A python wrapper around the CMBFAST code

- Suited for both interactive and scripted use
- Easy to use

```
from libcmb import CMB
cmb = CMB()
# Generate a table with Bessel function values
cmb.jlgen(1500, 3000)
```

# Goals

- Finish wrapping all CMBFAST functionality
- Write a CMBFAST manual
- Write a small (improved) interactive interface

# Questions

