CMBFAST

Floor Terra

June 23, 2010

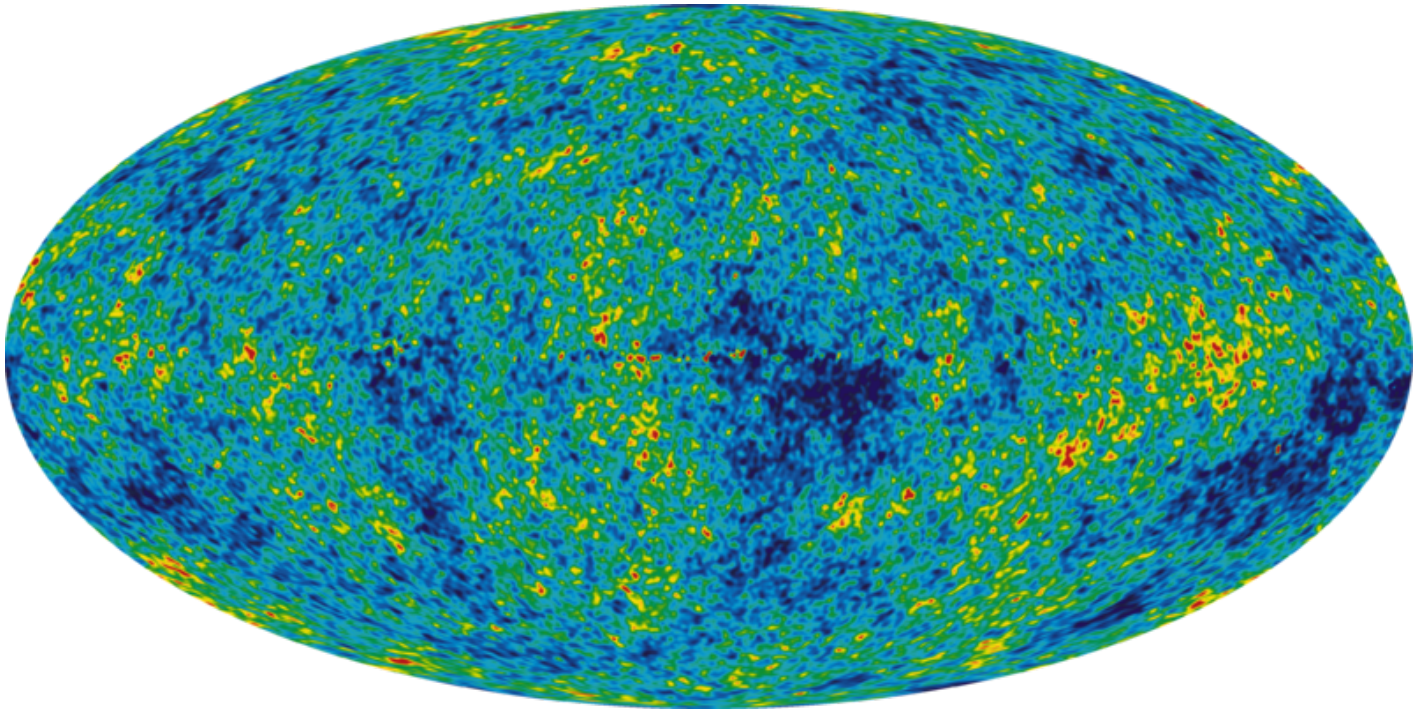
The big bang

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 ($z = 1,\ T = 2.725K$)

WMAP

What do we see today?

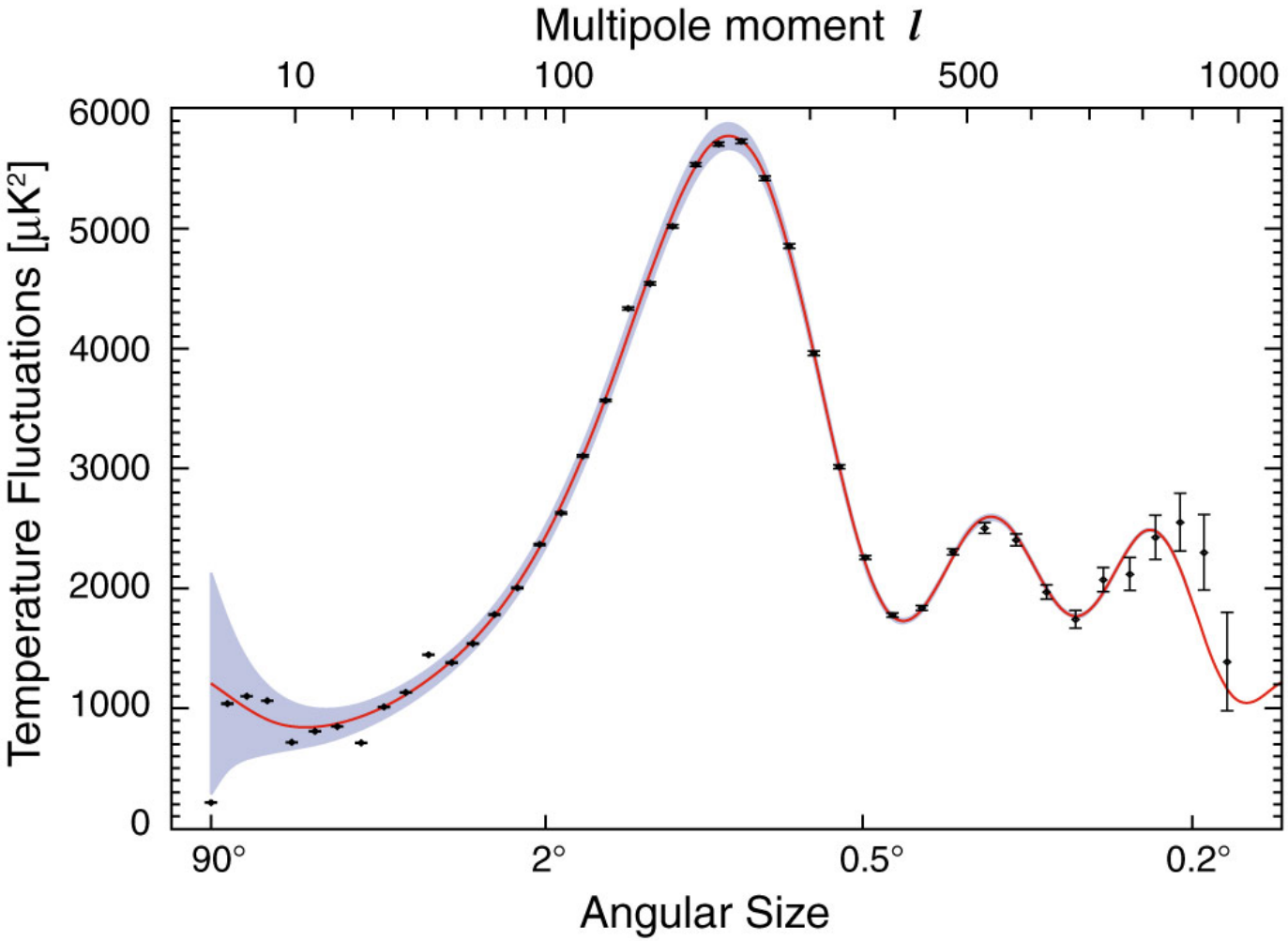


WMAP 7 year data

$T = 2.725K$ fluctuations of order 10^{-5}

WMAP

The data



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

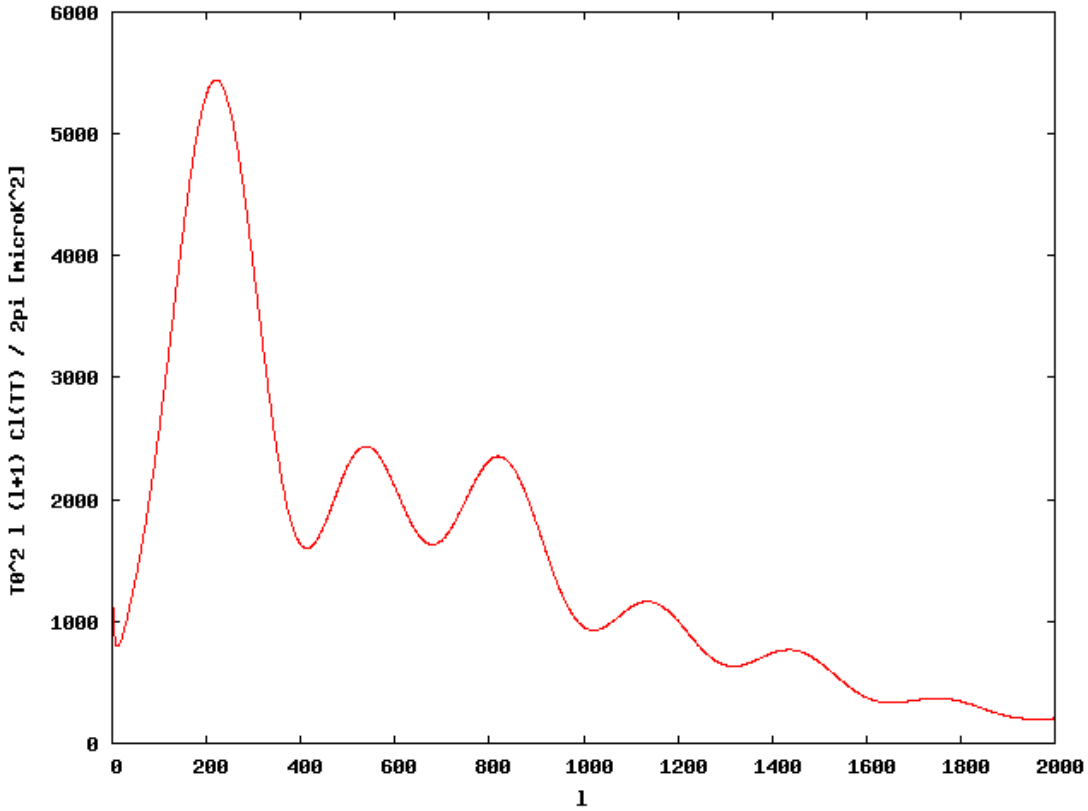
- Gravitation
- Large scale structure

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, gsnunr    =     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

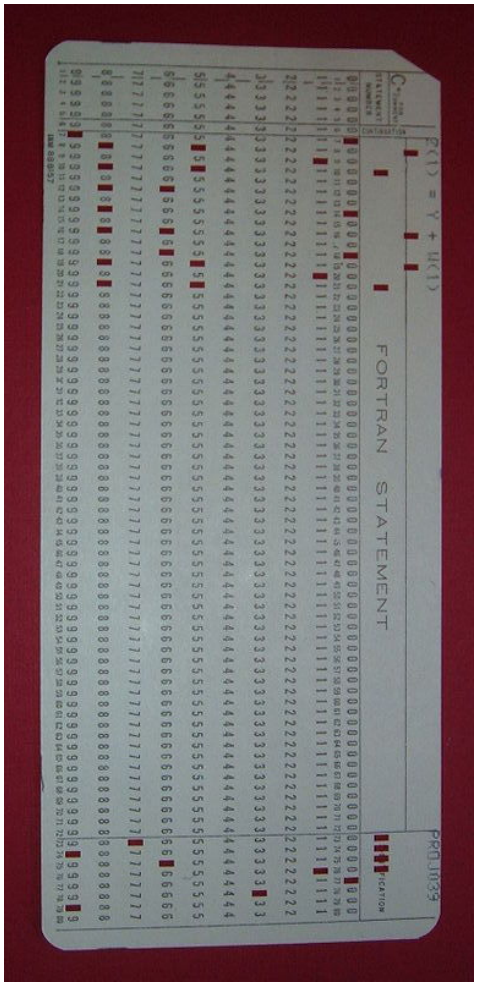
The CMBFAST code

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