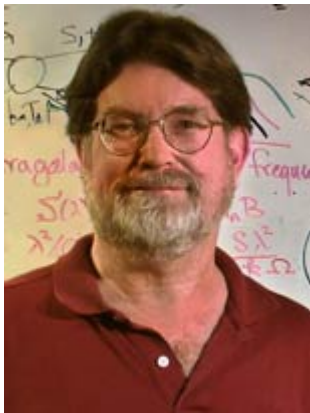


NOBEL PRIZE IN PHYSICS

2006

**DISCOVERY OF THE BLACK-BODY FORM
AND ANISOTROPY OF THE COSMIC
MICROWAVE BACKGROUND RADIATION**



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TALK BY VILLE FÖHR
17.10.2006

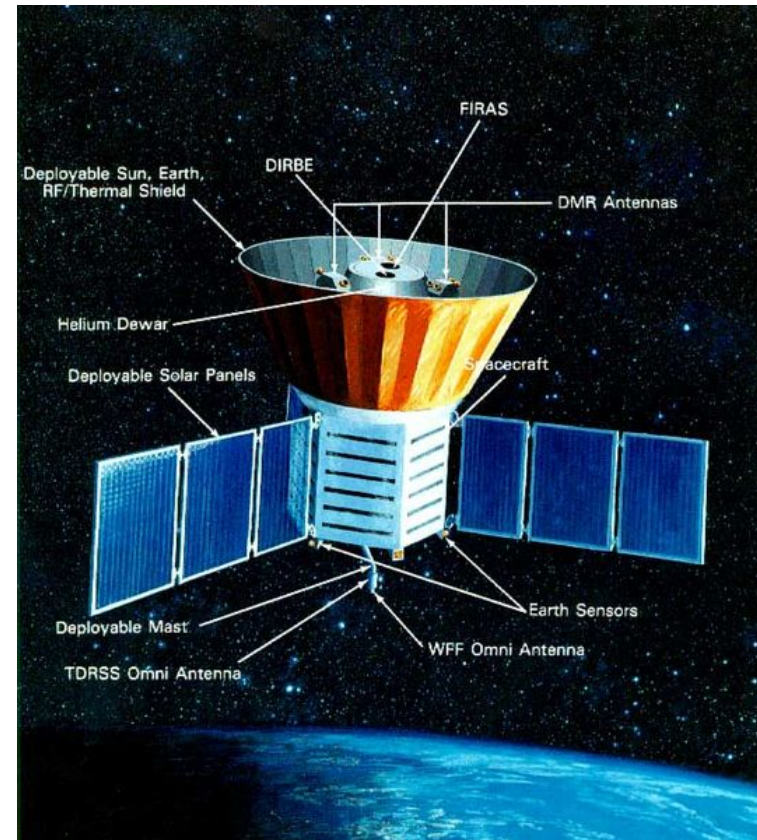
COSMIC BACKGROUND EXPLORER (COBE)

- NASA'S SATELLITE LAUNCHED ON 18.11.1989
- FIRST SATELLITE DEDICATED TO COSMOLOGY
- RECEIVED DATA 4 YEARS
- INSTRUMENTS:

DMR (DIFFERENTIAL MICROWAVE RADIOMETERS)
TO MAP THE COSMIC MICROWAVE
BACKGROUND RADIATION PRECISELY

FIRAS (FAR-INFRARED ABSOLUTE
SPECTROPHOTOMETER) TO COMPARE THE
SPECTRUM OF THE COSMIC MICROWAVE
BACKGROUND RADIATION WITH THAT FROM
A PRECISE BLACK-BODY

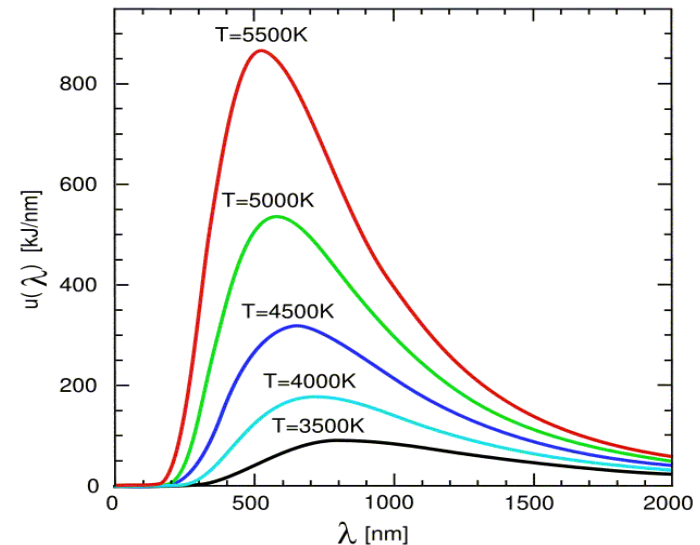
DIRBE (THE DIFFUSE INFRARED EXPERIMENT)
TO SEARCH FOR AND MEASURE THE COSMIC
INFRARED BACKGROUND RADIATION



BLACK-BODY RADIATION

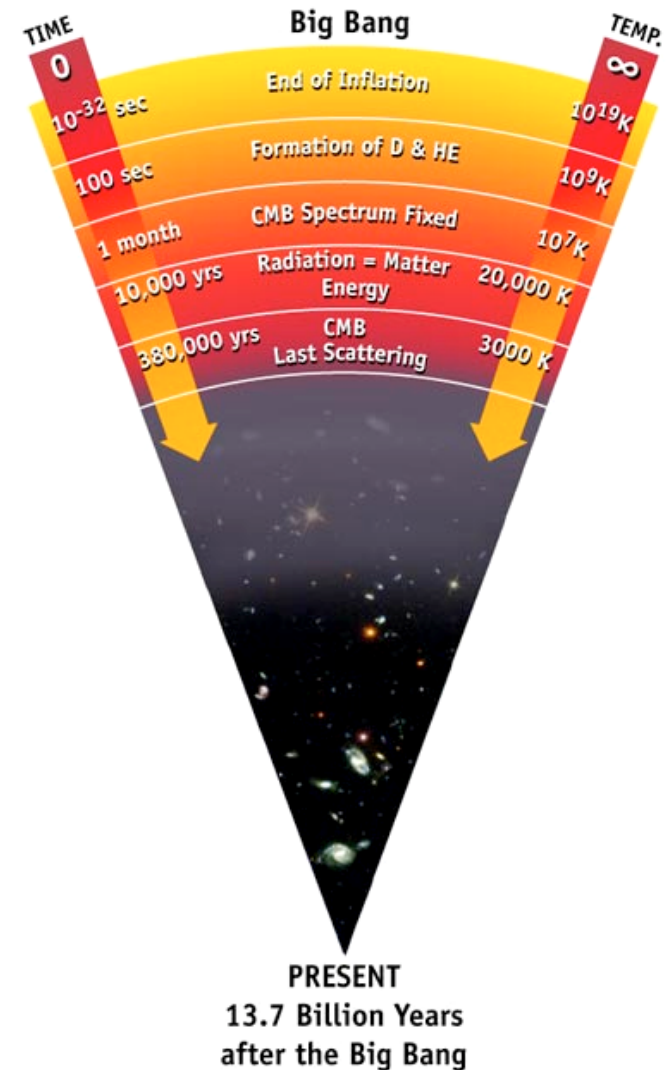
- **ABSORBS ALL ELECTROMAGNETIC RADIATION THAT FALLS ONTO IT**
- **NO RADIATION PASSES THROUGH IT AND NONE IS REFLECTED**
- **NOT REALLY BLACK: RADIATES EVERY POSSIBLE WAVELENGTH OF ENERGY**
- **THE AMOUNT AND TYPE OF ELECTROMAGNETIC RADIATION THEY EMIT IS DIRECTLY RELATED TO THEIR TEMPERATURE.**
- **FORMULATED BY MAX PLANCK IN 1901**

$$I(\nu, T) = \frac{2h\nu^3}{c^2} \frac{1}{e^{\frac{h\nu}{kT}} - 1}$$



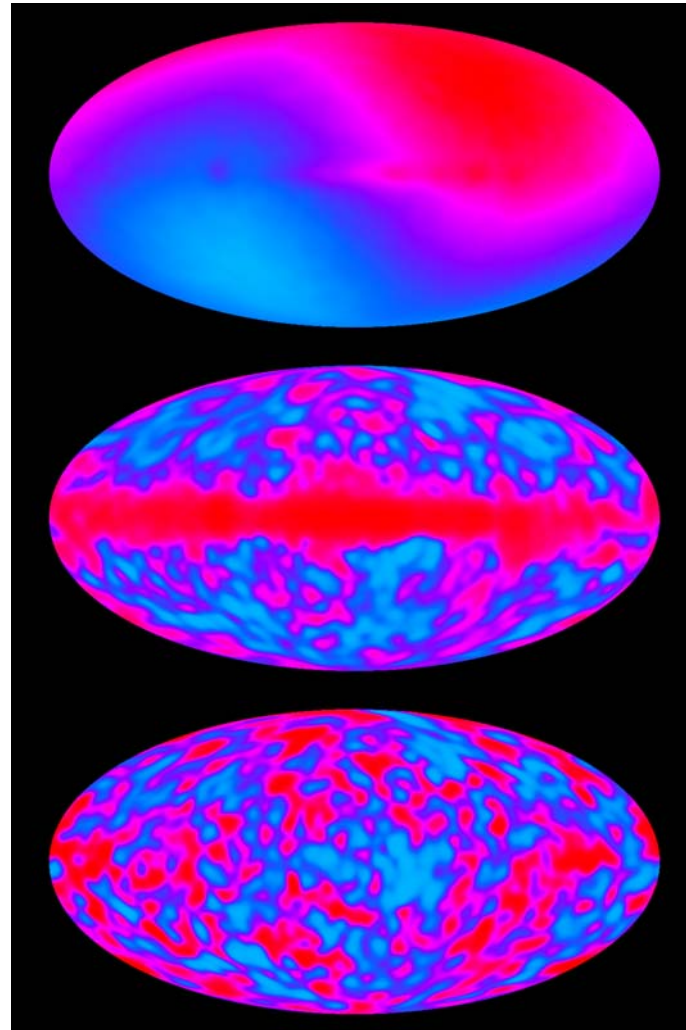
COSMIC MICROWAVE BACKGROUND (CMB)

- FIRST DISCOVERED IN 1965 BY PENZIAS AND WILSON
- REMNANT OF BIG BANG
- CMB OBSERVED NOW WAS PHOTONS FROM THE TIME OF RECOMBINATION
- EXPANSION OF THE SPACE CAUSED PHOTONS TO RED SHIFT



RESULTS OF COBE

- PICTURE FROM THE TIME OF RECOMBINATION ($T \approx 10^4 \text{ K} \approx 0.86 \text{ eV}$, $T \approx 300000 \text{ YR AFTER BIG BANG}$)
- ANISOTROPY CAN BE SEEN
- VARIATION OF $\sim 30 \text{ MICROK}$ FROM AVERAGE OF $2,7 \text{ K}$



"RAW" DATA

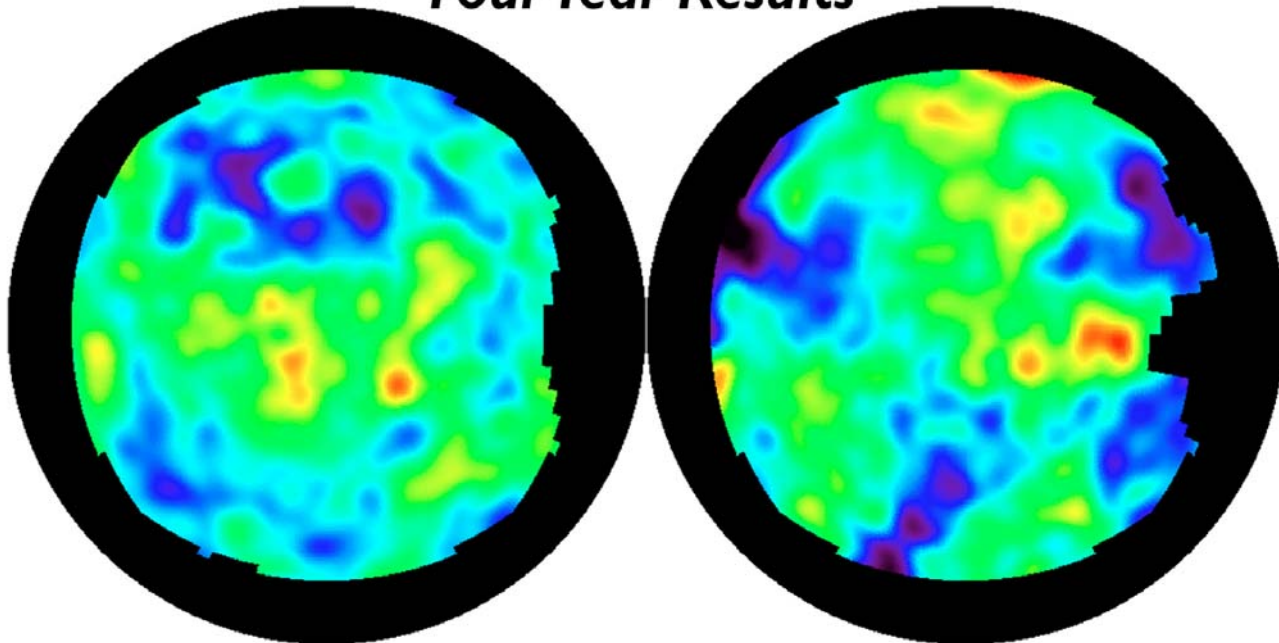
DIPOLE
REMOVED

DIPOLE AND
MILKY WAY
REMOVED

FACE OF THE GOD

FOUR YEAR DATA

COBE - DMR Map of CMB Anisotropy Four Year Results



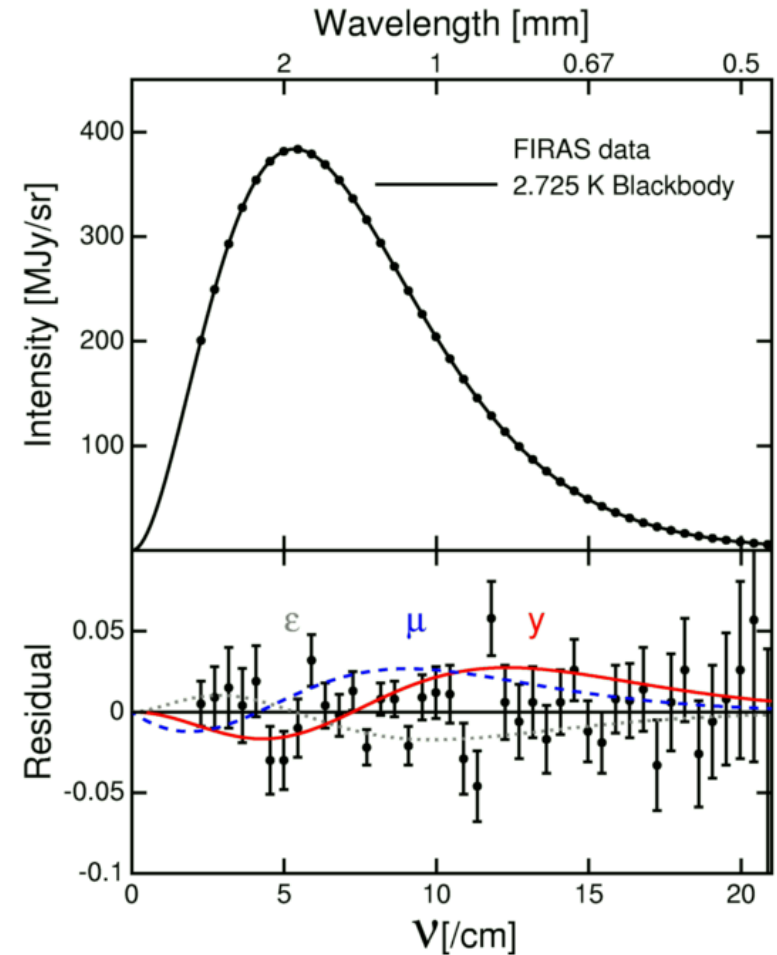
North Galactic Hemisphere

South Galactic Hemisphere

$-100 \mu\text{K}$  $+100 \mu\text{K}$

BLACK-BODY FORM OF CMB SPECTRUM

- FIRST EVIDENCE OF SPECTRUM BEING BLACK-BODY FORM
- THEORETICAL CURVE AND MEASURED DATA WITH IN PERFECT MATCH
- CORRESPONDS TO BLACKBODY RADIATION IN TEMPERATURE OF 2.725 ± 0.002 K



WHAT WE GAINED

- GRAVITATIONAL FORCES DUE TO ANISOTROPY ARE LARGE ENOUGH TO PRODUCE THE OBSERVED CLUSTERING
- DATA AGREES WITH THEORIES OF THE EXISTENCE OF DARK MATTER/ENERGY
- BEST EVIDENCE FOR THE HOT BIG BANG MODEL OF THE UNIVERSE SO FAR

REMARKS

- WMAP MEASURED CMB WITH HIGHER ACCURACY IN 2003
- FUTURE MEASUREMENTS:
 - EARLY NEUTRINOS?
 - GRAVITATIONAL WAVES?
- QUESTIONS? COMMENTS?

KEEP WATCHING THE SKIES

