

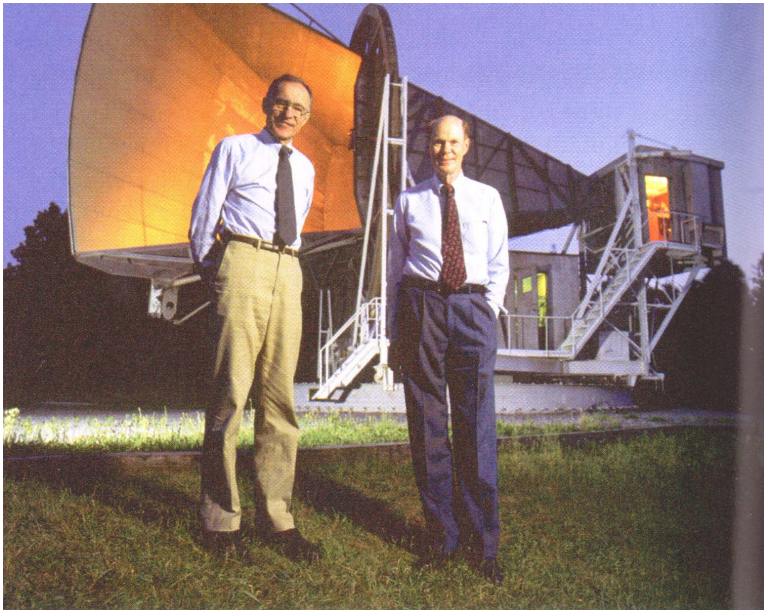
ORIGIN AND DISCOVERY OF THE COSMIC MICROWAVE BACKGROUND

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DISCOVERY OF THE COSMIC MICROWAVE BACKGROUND

ARNO PENZIAS AND ROBERT WILSON
Bell Laboratories, Crawford Hill, NJ



- In 1964 Penzias and Wilson were investigating sources of noise that might interfere with satellite telephone transmissions at microwave frequencies.
- They used a 20ft horn antenna at 4.08 GHz.
- They discovered a noise signal which was the same in all directions.
- It was equivalent to a signal from a 2.7 K blackbody
- Prof Robert Dicke at Princeton explained this result as the remnant of the Big Bang.

RELEVANT TEMPERATURE SCALE

KELVIN		FAHRENHEIT	CELCIUS
ABSOLUTE ZERO	-460	-273	0
COSMIC BACKGROUND	-455	-270	2.73
LQUID HELIUM BOILS	-452.1	-268.9	4.2
LIQUID NITROGEN BOILS	-321	-196	77
WATER FREEZES	32	0	273
WATER BOILS	212	100	373
SUN'S SURFACE	10340	5720	6000

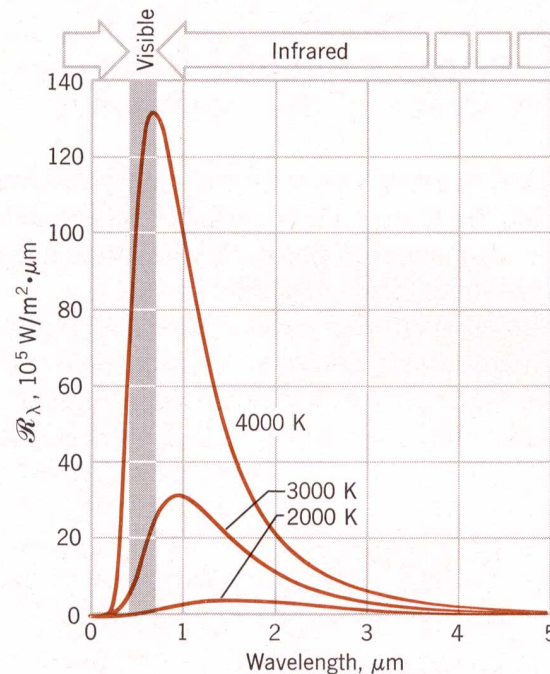
This is the temperature range we use to discuss the CMB. Note especially the ambient temperature above the freezing point of water, liquid Nitrogen, liquid Helium and the CMB black body radiation.

BLACK BODY RADIATION

IT IS THE DISTRIBUTION OF WAVELENGTHS OF ENERGY
RADIATED FROM A HEATED OBJECT

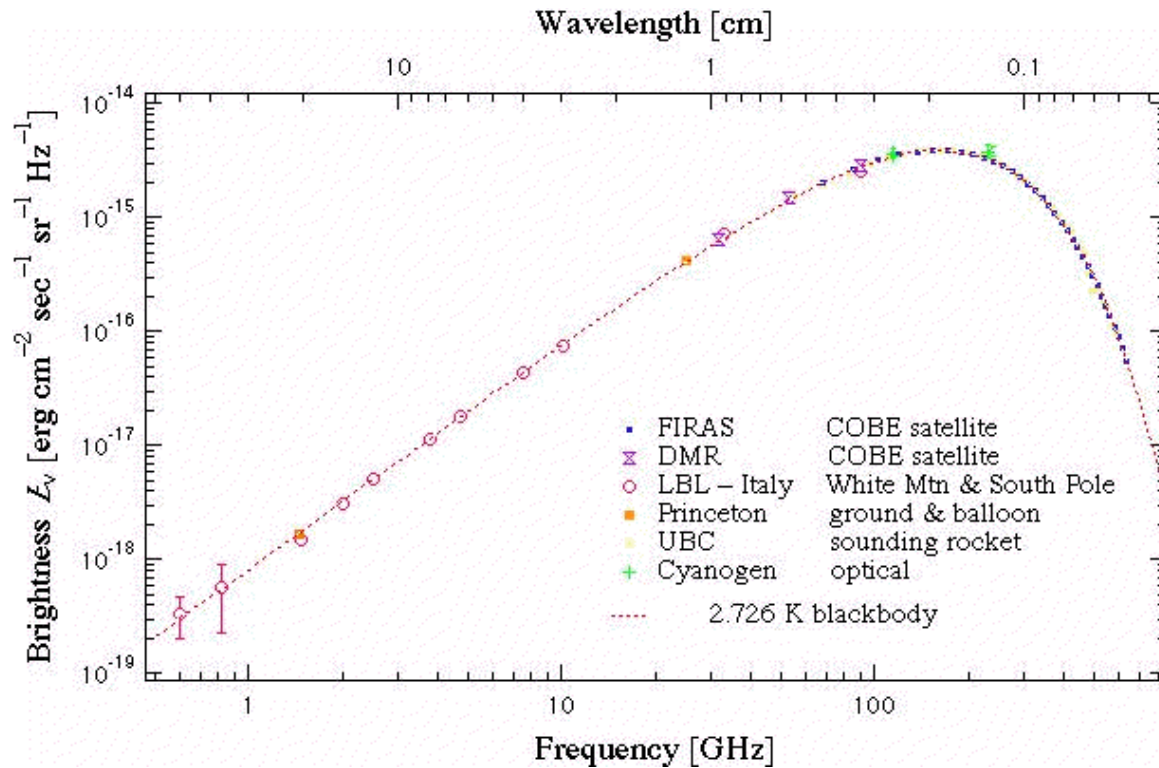
IN THE IDEAL CASE A PERFECT ABSORBER,
A BLACK BODY, RADIATES IN A WAY WE
CAN DERIVE FROM THE LAWS OF PHYSICS

THE RADIATION FROM A GLOWING OBJECT HAS A CHARACTERISTIC OUTPUT



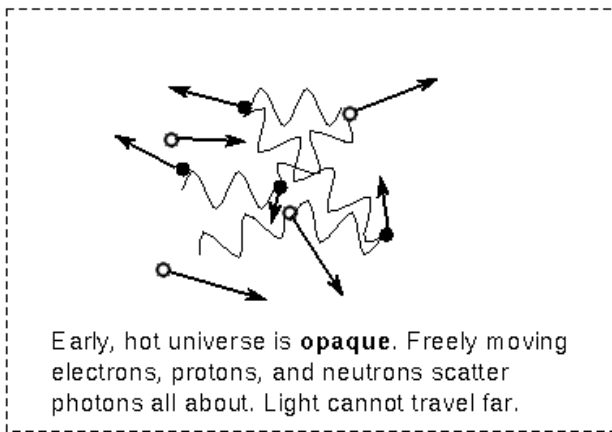
The Sun glows mostly at visible wavelengths. Room temperature objects glow mostly at infrared wavelengths (IR glasses) and cold objects glow at microwave wavelengths.

Cosmic Microwave Background

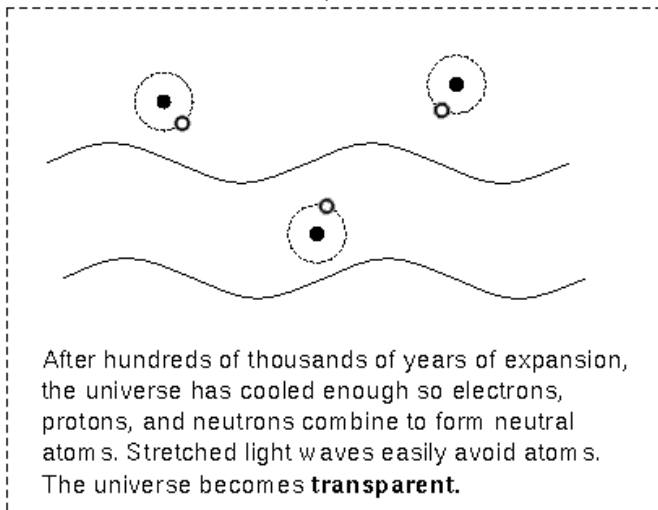


This plot shows the frequency range of the CMB microwave emission. The peak brightness is at a frequency of 160 GHz. Amateur measurements are limited to the 1 – 10 GHz region because of galactic noise and atmospheric emission from oxygen and water vapor.

THE VISIBLE SURFACE OF THE BIG BANG FIREBALL IS CAUSED BY RECOMBINATION OF PROTONS AND ELECTRONS TO FORM HYDROGEN ATOMS



time



BIG BANG

COOLING

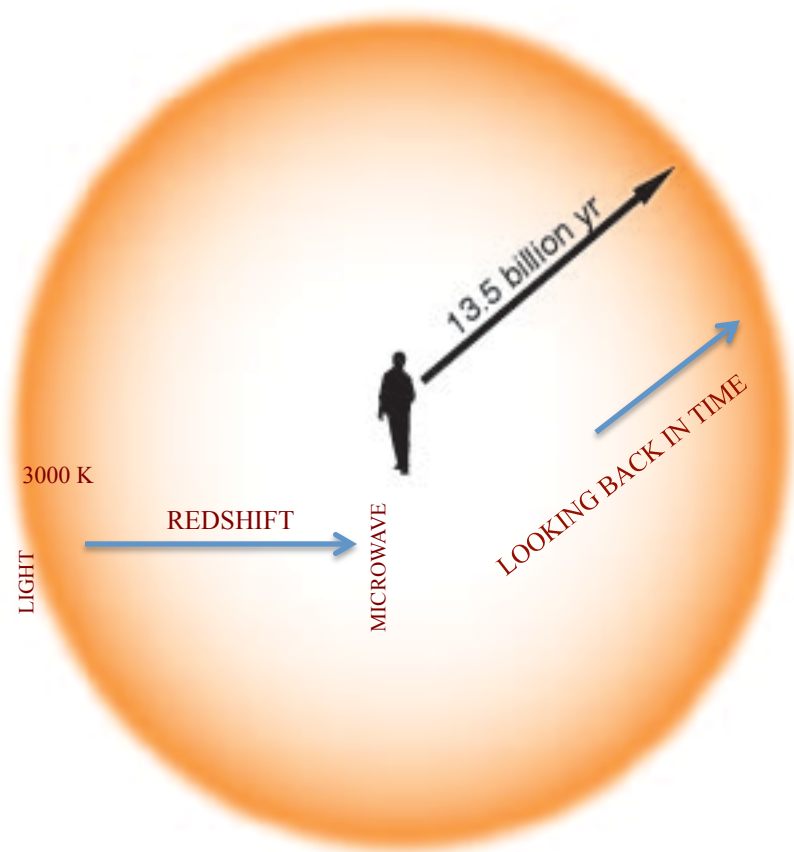
380,000 Yrs



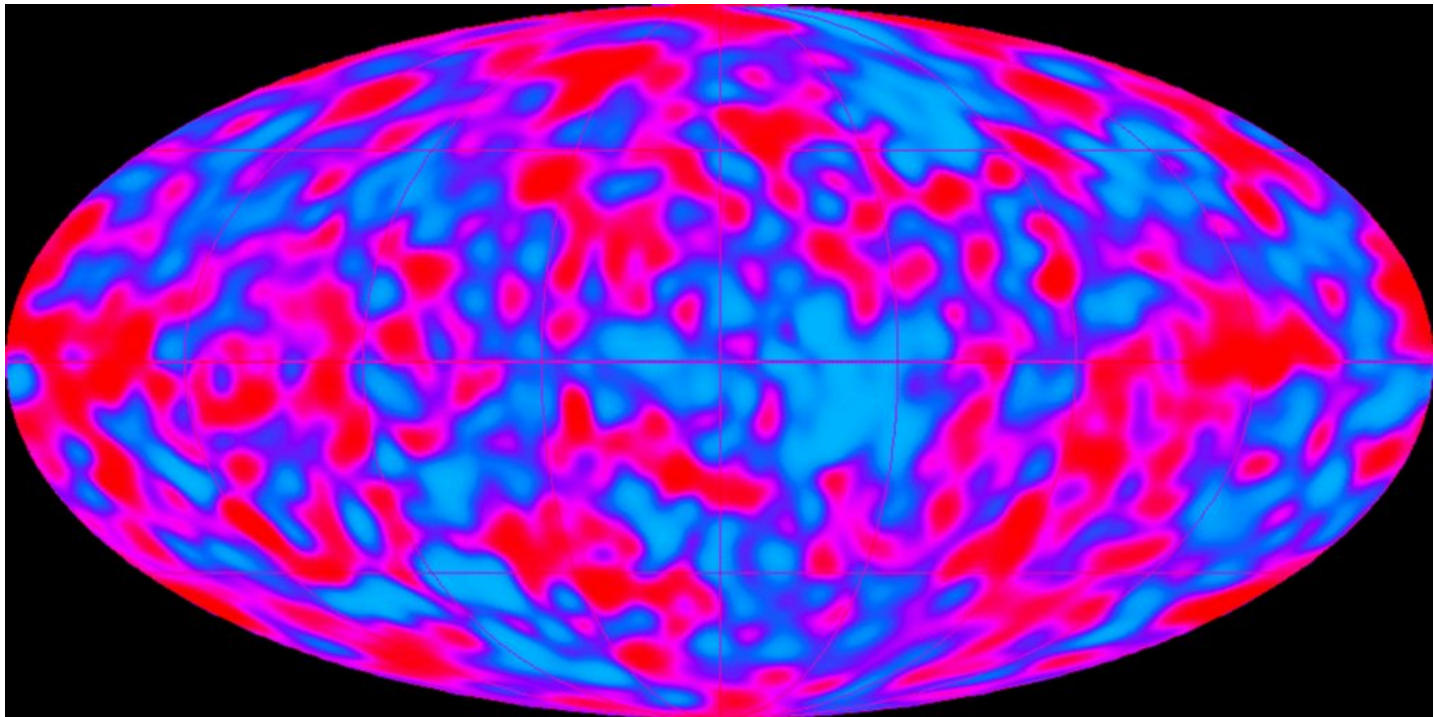
3000 K

RECOMBINATION

CMB IS REDSHIFTED FROM VISIBLE RADIATION TO MICROWAVE



As we look out into the universe we see back into time through a transparent interstellar medium to where the opaque 3000K plasma recombined. This would glow yellow if there were no cosmic redshift. Instead it glows in the microwave peaking at 160 GHz.



COBE data found that the microwave background had very small fluctuations in temperature. From red to blue = $1/10,000$ K

Amateurs cannot expect this level of temperature resolution