3. The Cosmic Microwave Background

EVIDENCE FOR THE MOLECULAR ORIGIN OF SOME HITHERTO UNIDENTIFIED INTERSTELLAR LINES

By Andrew McKellar

In recent years a considerable number of lines of interstellar origin have been discovered by the Mount Wilson observers.[1] Several of these have been identified with known atomic lines arising from spectra of *Na* I, *K* I, *Ca* I, and *Ti* II. However, there have remained unidentified, not only the diffuse lines in the red studied by Merrill and his co-workers[2] and that at λ 4430 examined by Beals and Blanchet,[3] but also five characteristically sharp lines at λλ 4300.3, 4232.6, 3957.7, 3934.3, and 3874.6, the last of which was only recently found.[4] In connection particularly with the diffuse lines, a number of attempts to correlate

It should finally be stressed that, should the $\lambda\,3874.6$ interstellar line actually be the line $R(0)$ of the 0,0 violet CN band, and the lines $R(1)$ and $P(1)$, arising from the next rotational level only $3.39\ \text{cm}^{-1}$ above, do not appear, the "effective" or "rotational" temperature of interstellar space must be extremely low if, indeed, the concept of such a temperature in a region with so low a density of both matter and radiation has any meaning. The intensity of the line $R(1)$ relative to that of $R(0)$ will enable us to compute an upper limit for this "rotational" temperature. To give actual figures, using the well-known expression for the intensity of a band line,

$$I = cie^{-\frac{E_r}{kT}}$$

where c is a constant, i the intensity factor, E_r the rotational energy, k the Boltzmann constant, and T the absolute temperature, it is found that if $R(1)$ is not more than one-third, one-fifth, or one-twentieth as intense as $R(0)$, the maximum "effective" temperature of interstellar space would be $2.7°\ K$, $2.1°\ K$, and $0.8°\ K$, respectively.

DOMINION ASTROPHYSICAL OBSERVATORY
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The Origin of Chemical Elements

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AS pointed out by one of us,[1] various nuclear species must have originated not as the result of an equilibrium corresponding to a certain temperature and density, but rather as a consequence of a continuous building-up process arrested by a rapid expansion and cooling of the primordial matter. According to this picture, we must imagine the early stage of matter as a highly compressed neutron gas (overheated neutral nuclear fluid) which started decaying into protons and electrons when the gas pressure fell down as the result of universal expansion. The radiative capture of the still remaining neutrons by the newly formed protons must have led first to the formation of deuterium nuclei, and the subsequent neutron captures resulted in the building up of heavier and heavier nuclei. It must be remembered that, due to the comparatively short time allowed for this process,[1] the building up of heavier nuclei must have proceeded just above the upper fringe of the stable elements (short-lived Fermi elements), and the present frequency distribution of various atomic species was attained only somewhat later as the result of adjust-

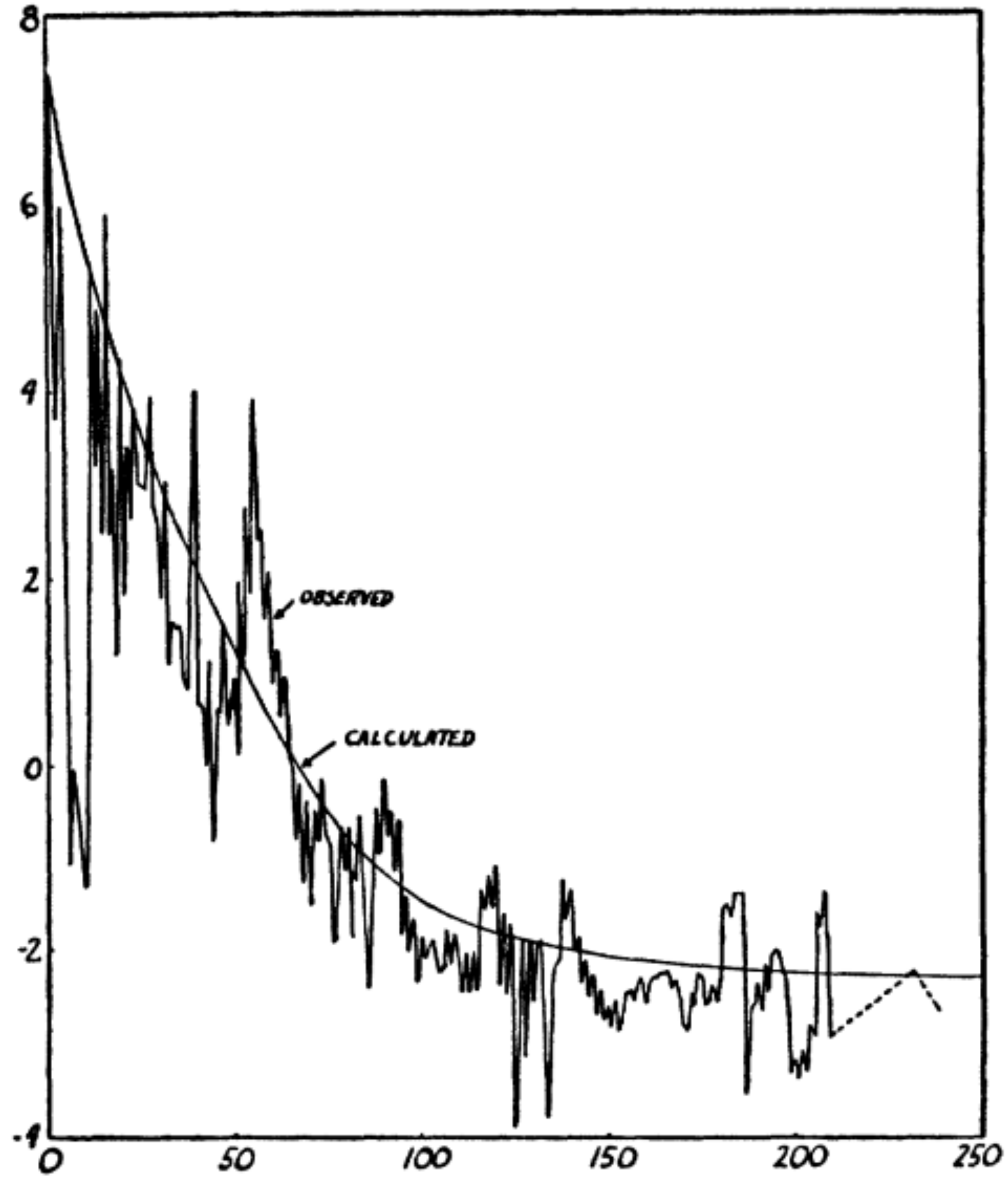
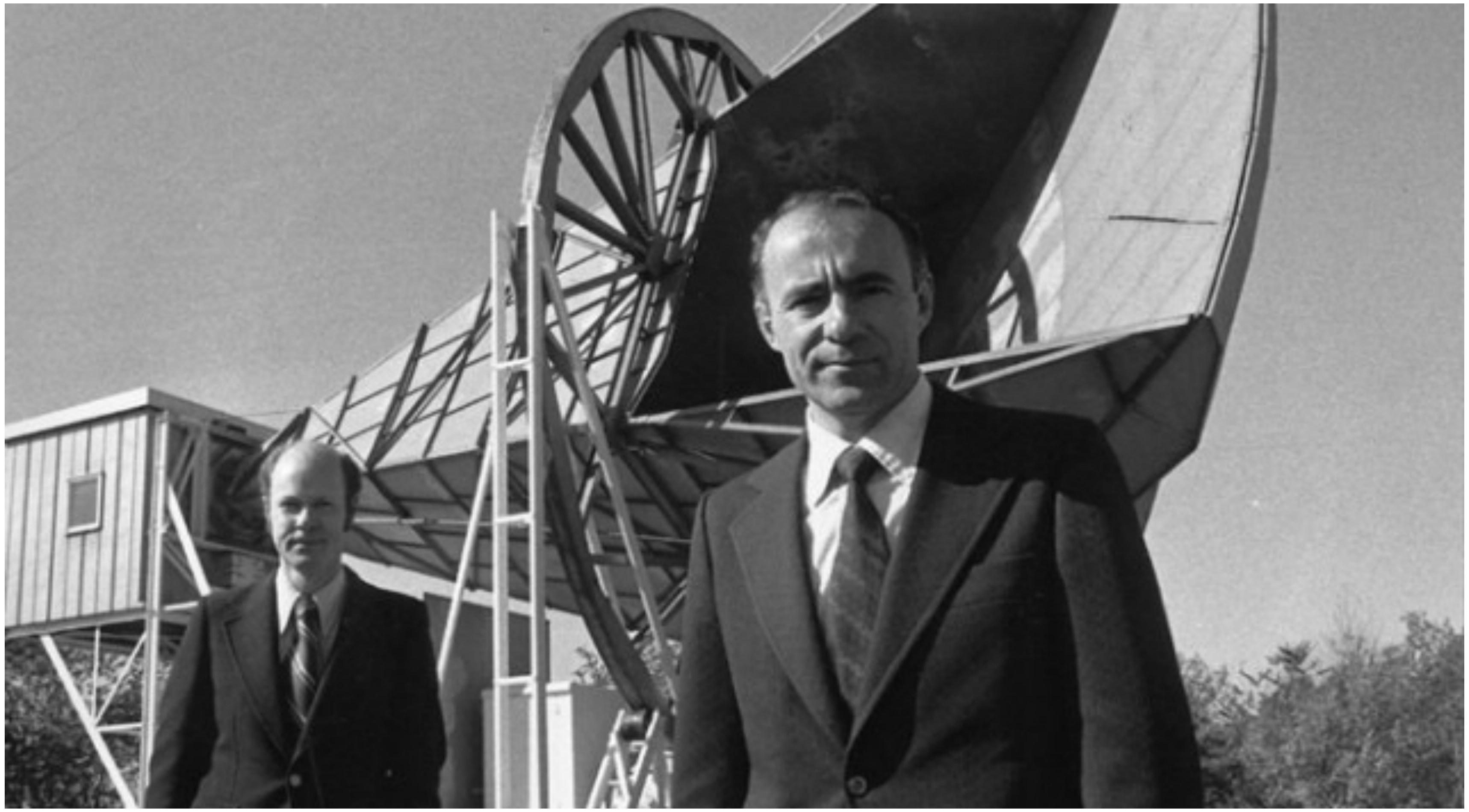


FIG. 1.

Log of relative abundance

Atomic weight



A MEASUREMENT OF EXCESS ANTENNA TEMPERATURE AT 4080 Mc/s

Measurements of the effective zenith noise temperature of the 20-foot horn-reflector antenna (Crawford, Hogg, and Hunt 1961) at the Crawford Hill Laboratory, Holmdel, New Jersey, at 4080 Mc/s have yielded a value about 3.5° K higher than expected. This excess temperature is, within the limits of our observations, isotropic, unpolarized, and

COSMIC BLACK-BODY RADIATION*

One of the basic problems of cosmology is the singularity characteristic of the familiar cosmological solutions of Einstein's field equations. Also puzzling is the presence of matter in excess over antimatter in the universe, for baryons and leptons are thought to be conserved. Thus, in the framework of conventional theory we cannot understand the origin of matter or of the universe. We can distinguish three main attempts to deal with these problems.

1. The assumption of continuous creation (Bondi and Gold 1948; Hoyle 1948), which avoids the singularity by postulating a universe expanding for all time and a continuous but slow creation of new matter in the universe.
2. The assumption (Wheeler 1964) that the creation of new matter is intimately related to the existence of the singularity, and that the resolution of both paradoxes may be found in a proper quantum mechanical treatment of Einstein's field equations.
3. The assumption that the singularity results from a mathematical over-idealization,

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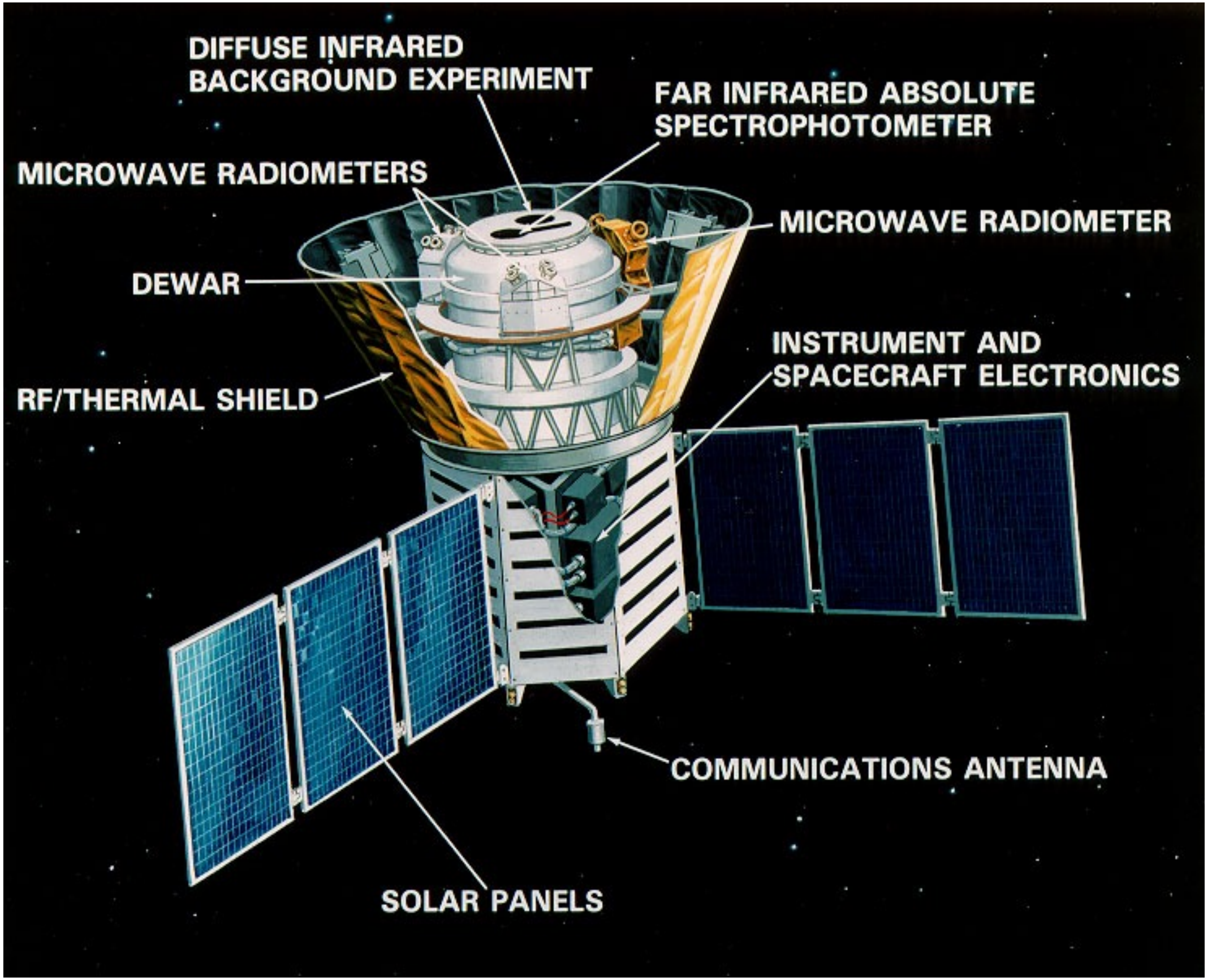
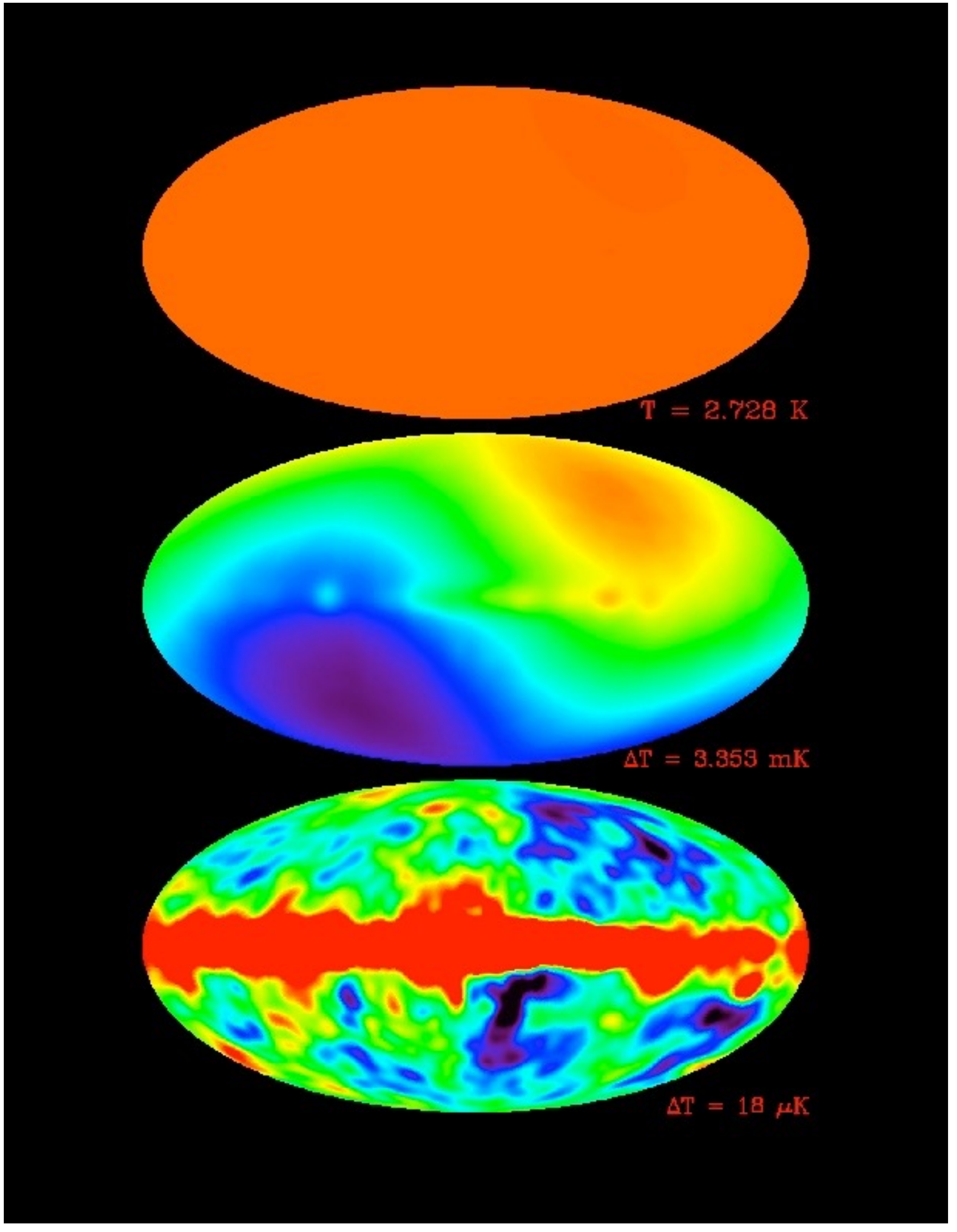
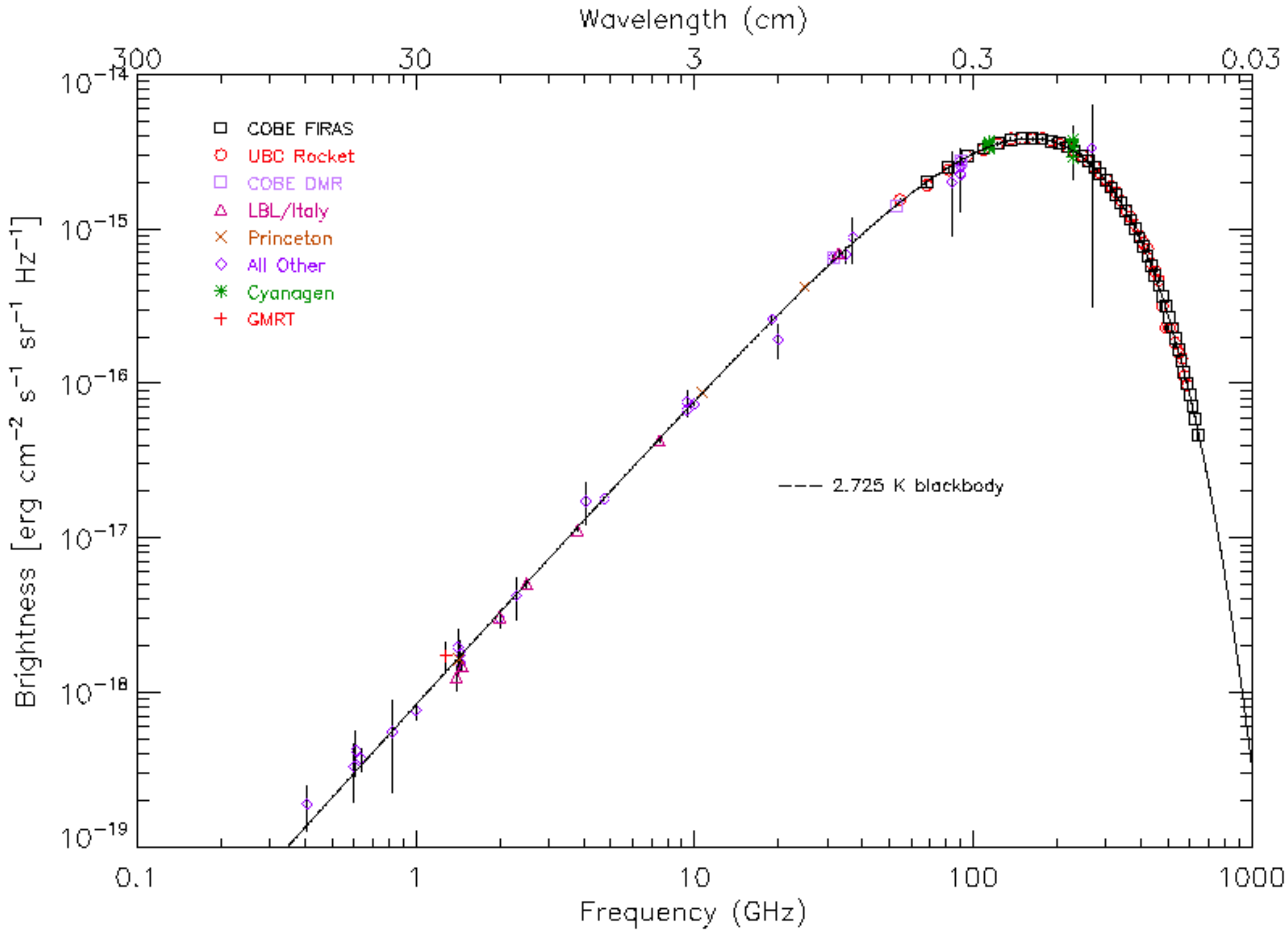
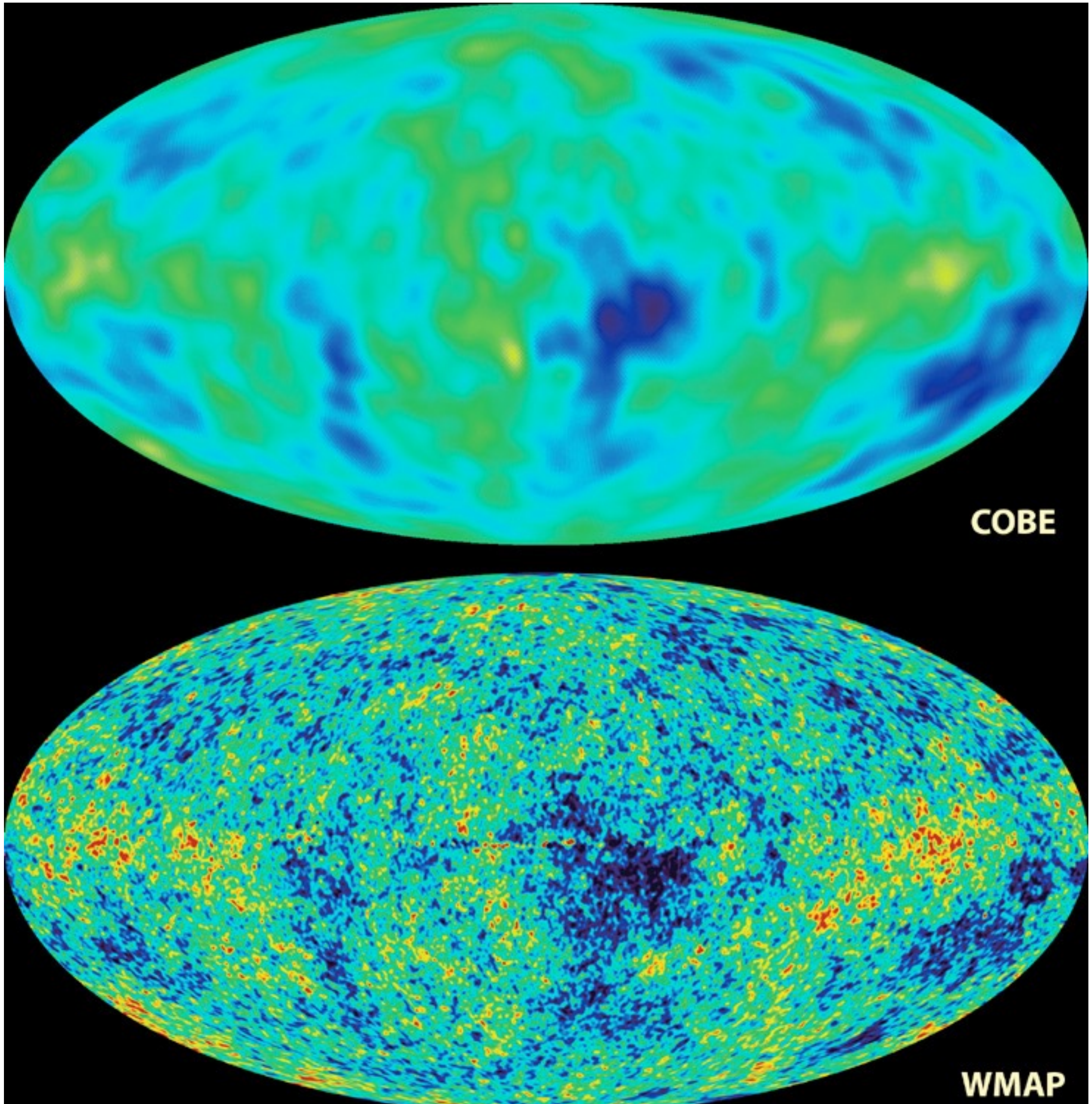
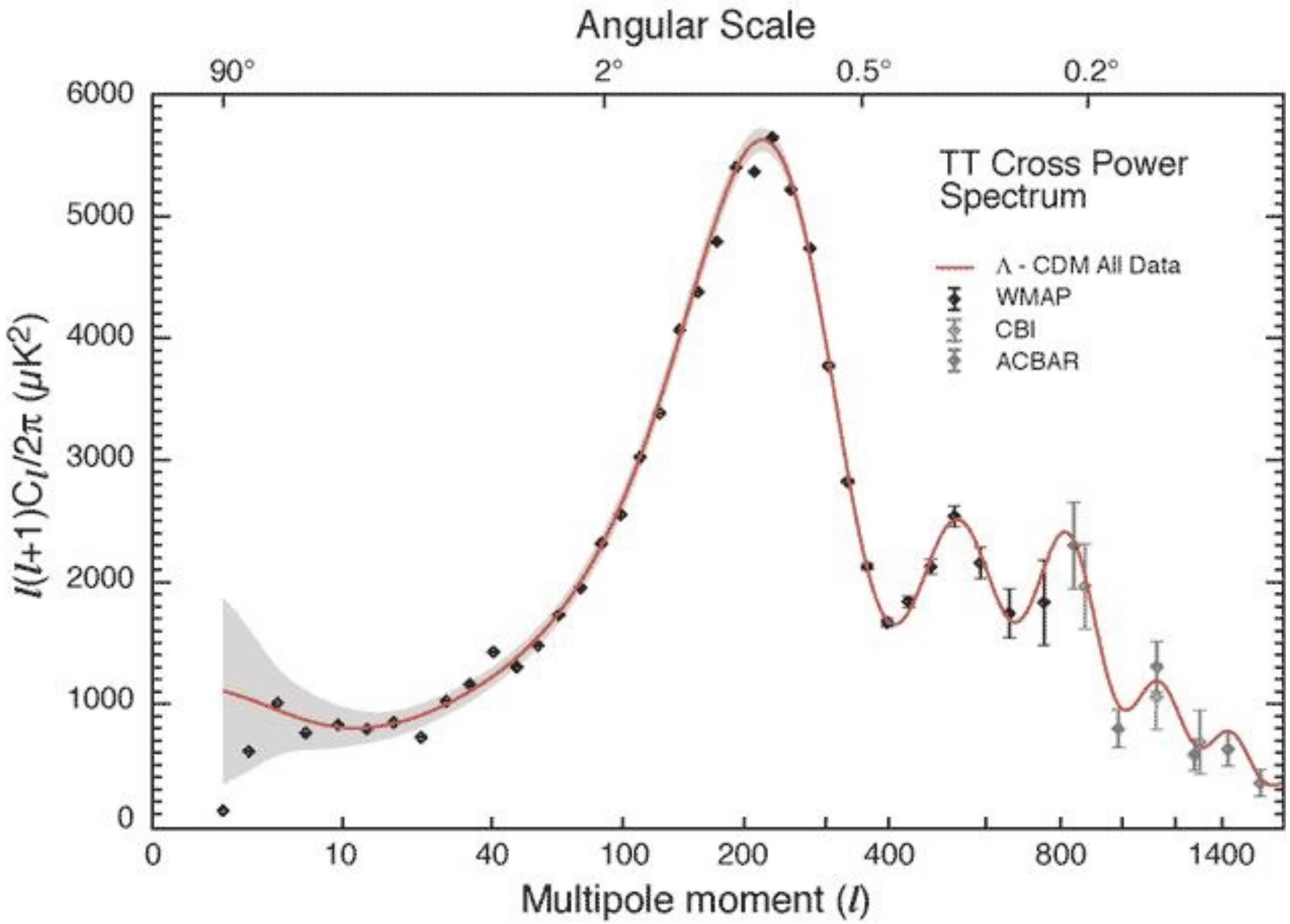

DIFFUSE INFRARED
BACKGROUND EXPERIMENT
FAR INFRARED ABSOLUTE
SPECTROPHOTOMETER
MICROWAVE RADIOMETERS
MICROWAVE RADIOMETER
DEWAR
INSTRUMENT AND
SPACECRAFT ELECTRONICS
RF/THERMAL SHIELD
COMMUNICATIONS ANTENNA
SOLAR PANELS


T = 2.728 K
ΔT = 3.353 mK
ΔT = 18 μK

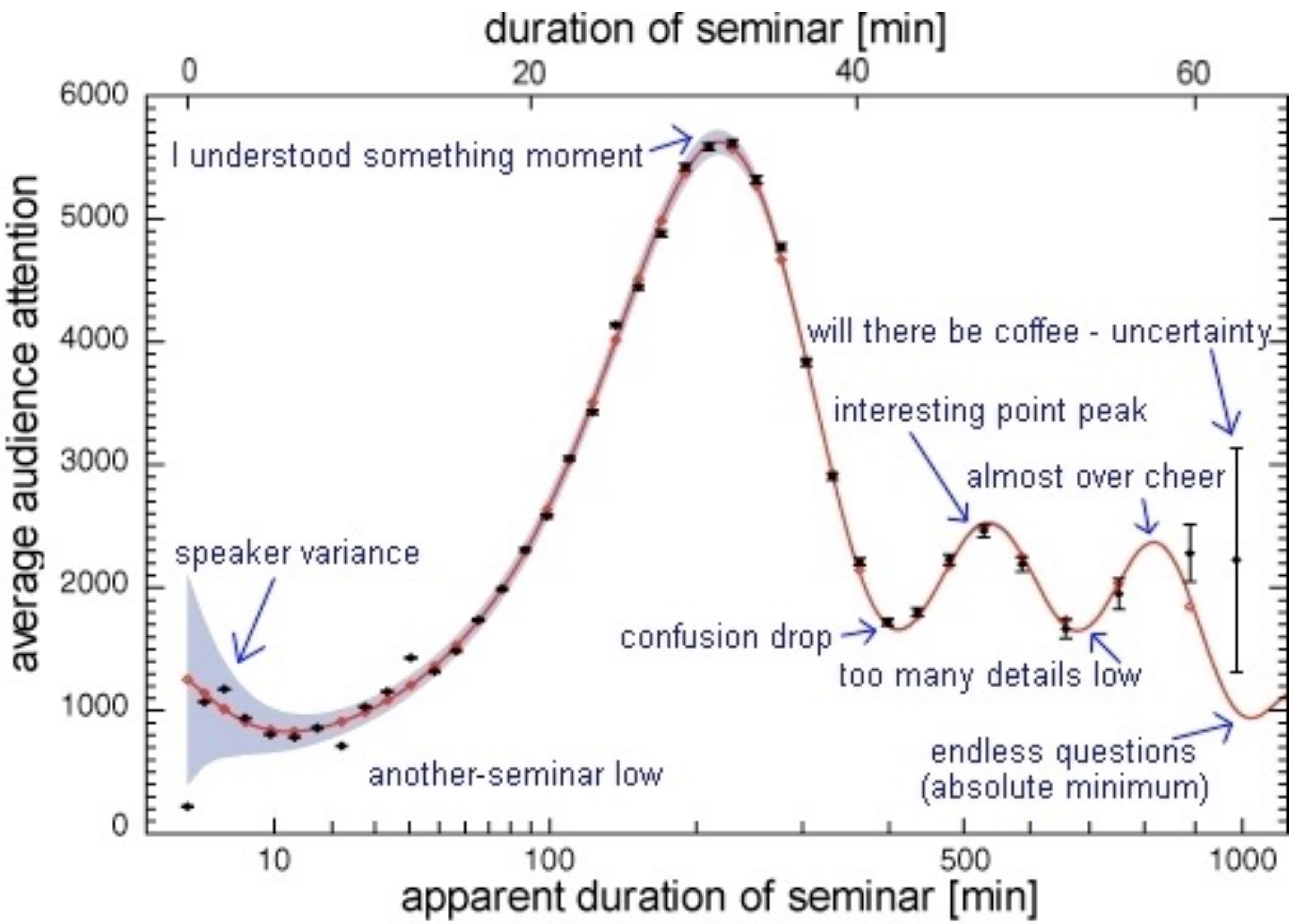


Wavelength (cm)
300
30
3
0.3
0.03
10^{-14}
10^{-15}
10^{-16}
10^{-17}
10^{-18}
10^{-19}
Brightness [erg cm^{-2} s^{-1} sr^{-1} Hz^{-1}]
COBE FIRAS
UBC Rocket
COBE DMR
LBL/Italy
Princeton
All Other
Cyanagen
GMRT
2.725 K blackbody
0.1
1
10
100
1000
Frequency (GHz)

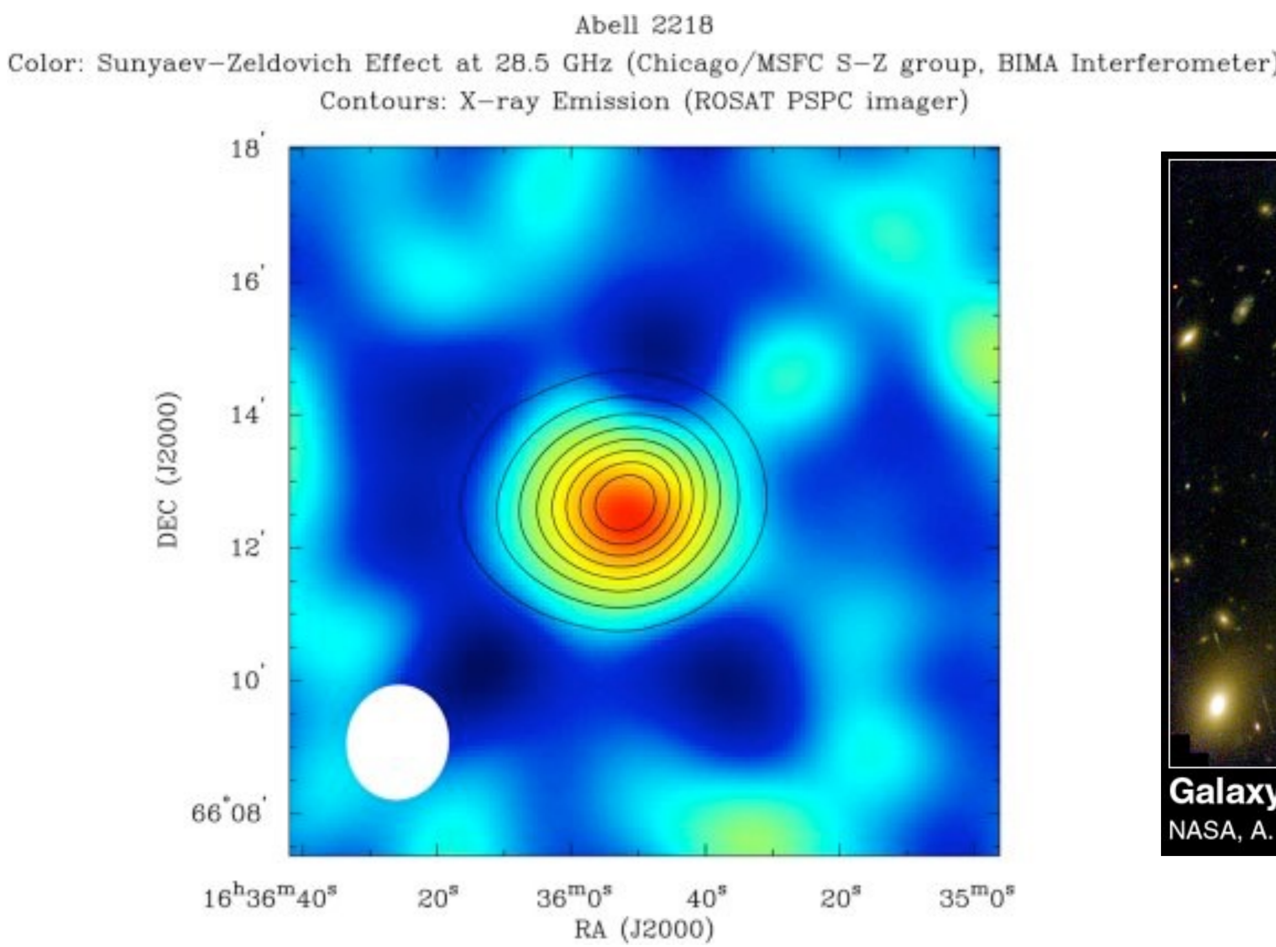

COBE
WMAP

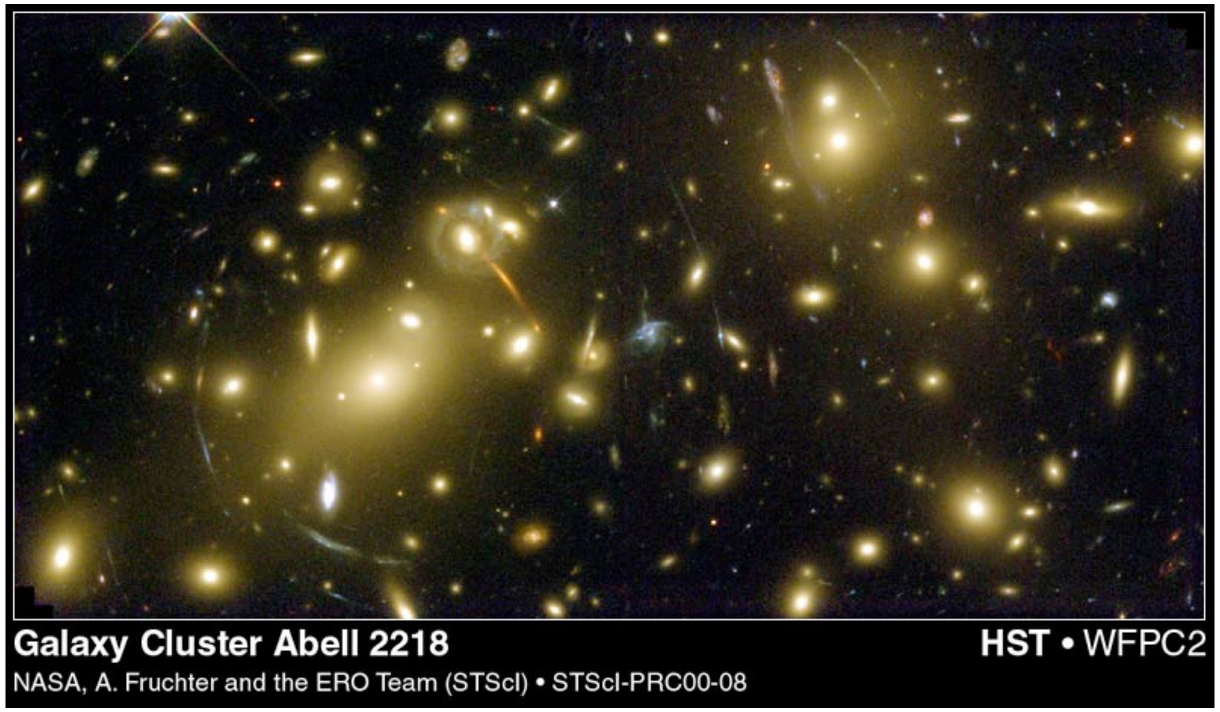


Angular Scale
90°
2°
0.5°
0.2°
6000
5000
4000
3000
2000
1000
0
$l(l+1)C_l/2\pi$ (μK^2)
TT Cross Power Spectrum
Λ - CDM All Data
WMAP
CBI
ACBAR
0
10
40
100
200
400
800
1400
Multipole moment (l)

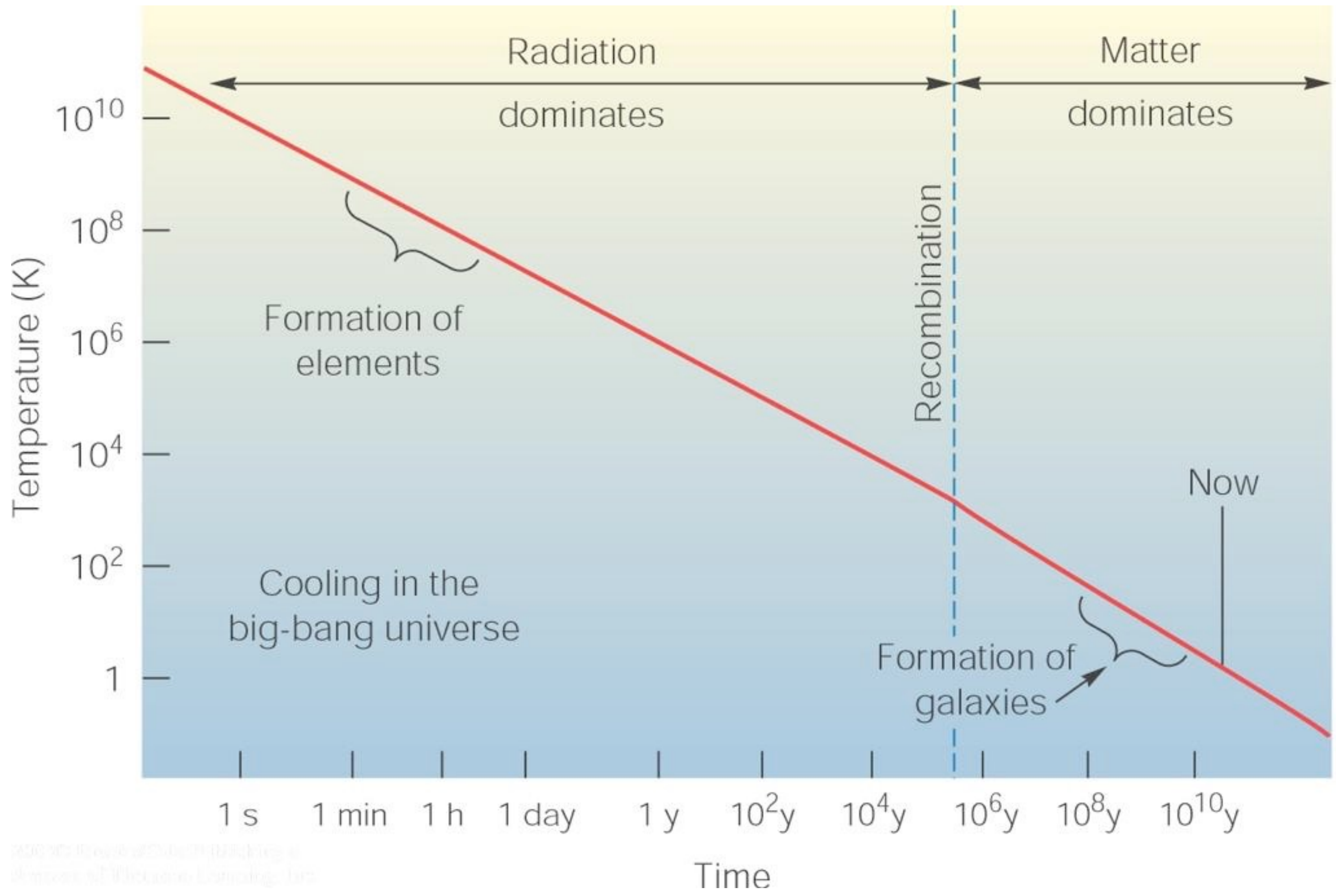

duration of seminar [min]
0
20
40
60
6000
5000
4000
3000
2000
1000
0
average audience attention
I understood something moment
will there be coffee - uncertainty
interesting point peak
almost over cheer
speaker variance
confusion drop
too many details low
another-seminar low
endless questions
(absolute minimum)
10
100
500
1000
apparent duration of seminar [min]

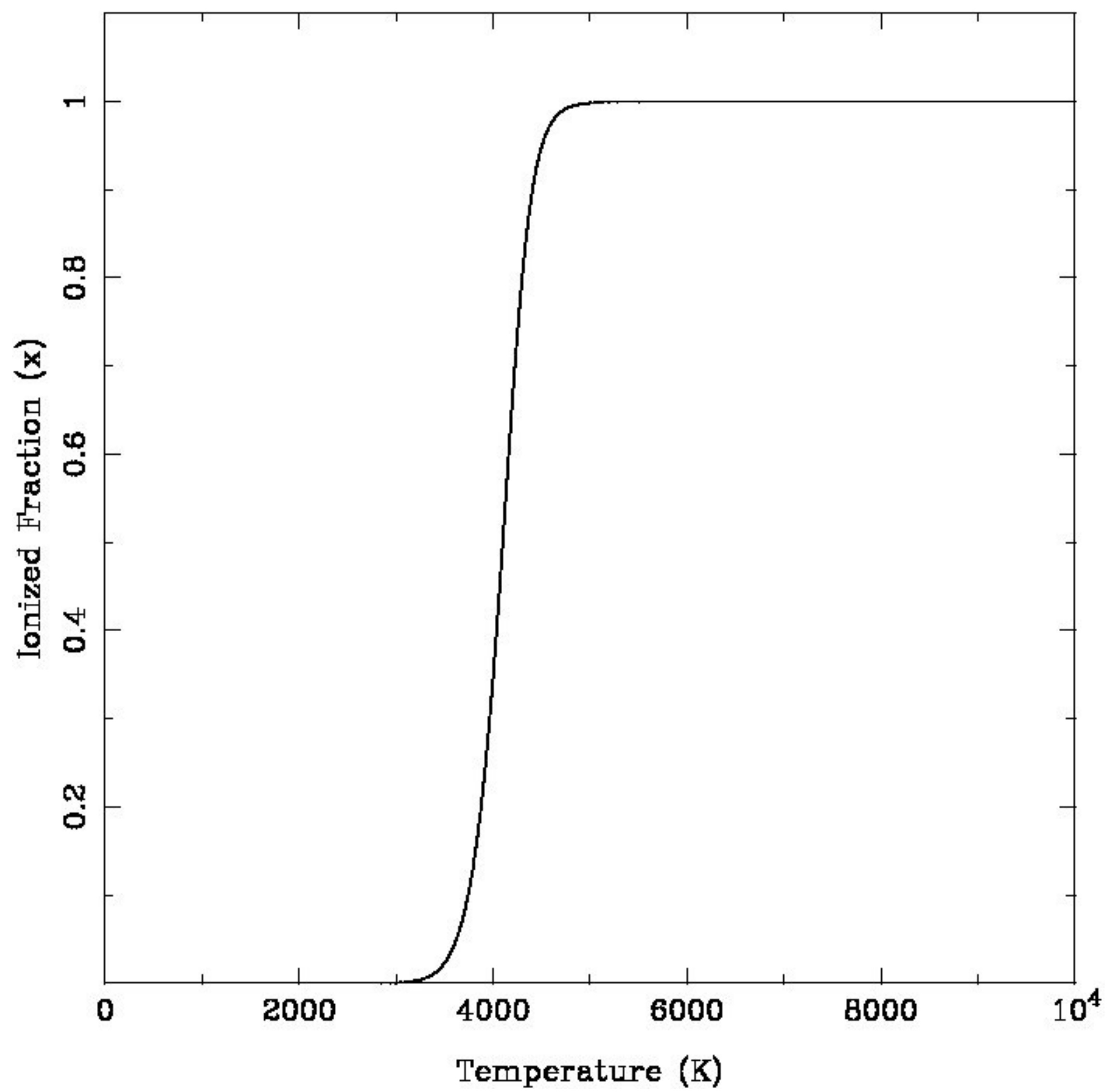
The Sunyaev-Zel'dovich effect:



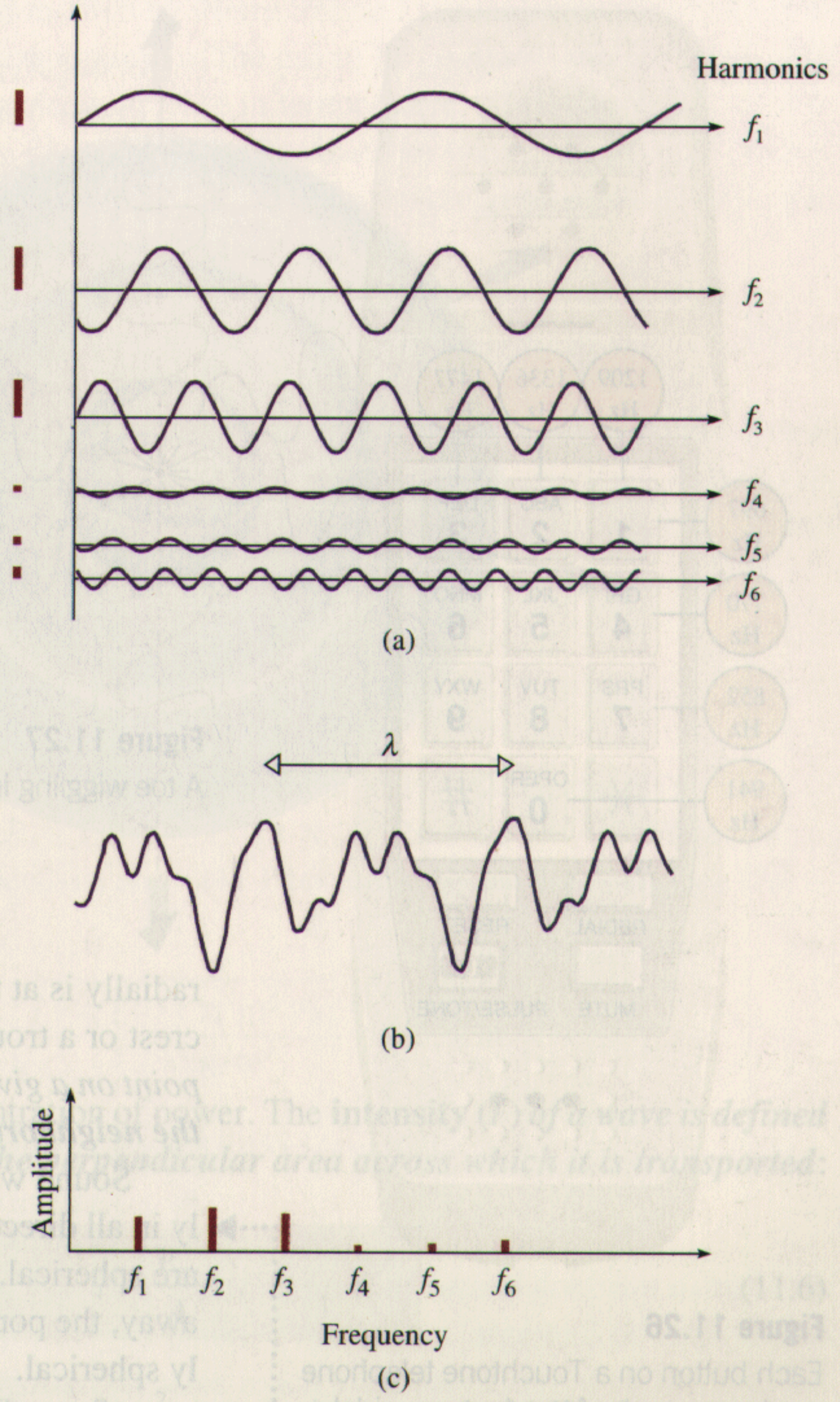


Thermal history of the universe

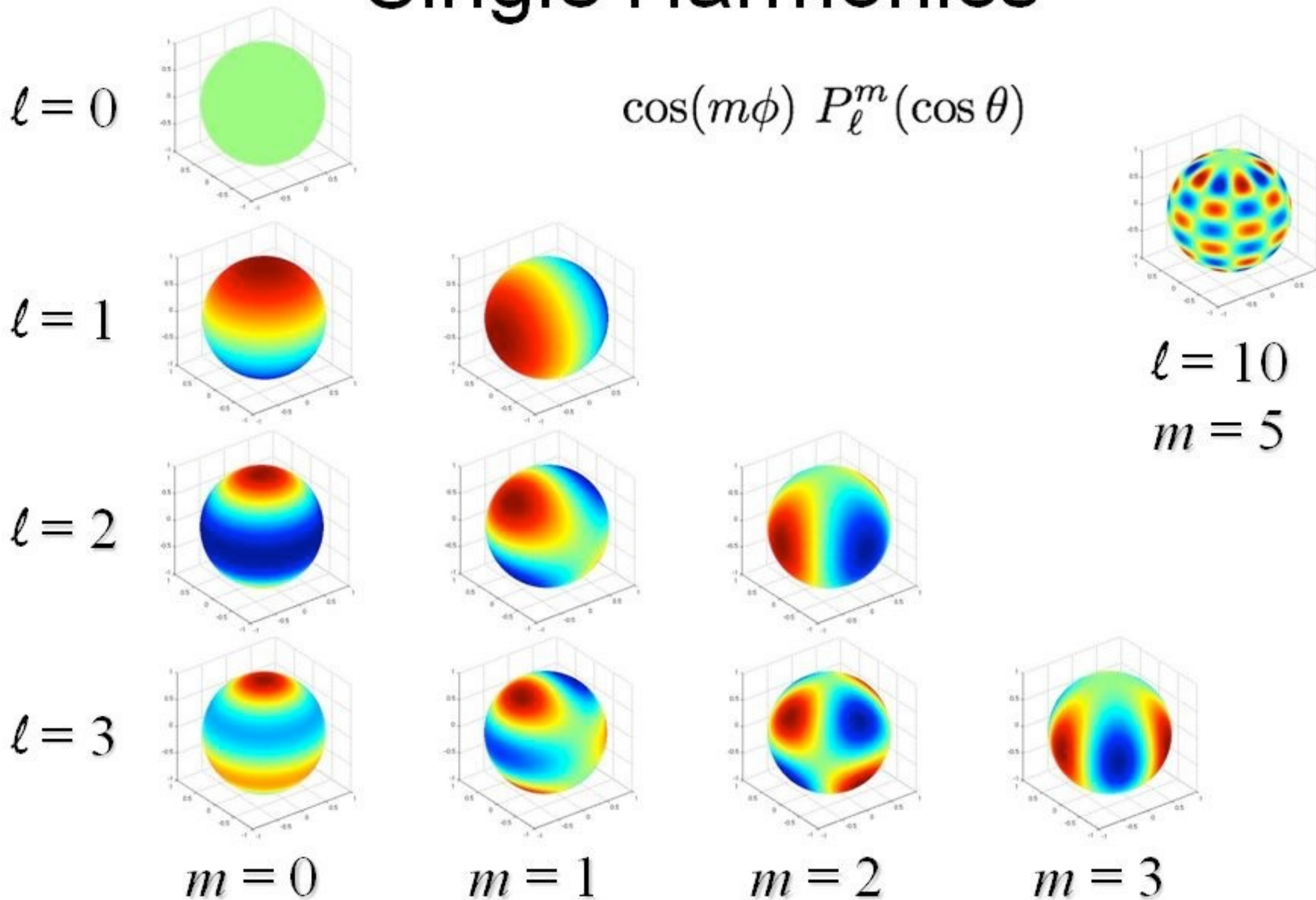


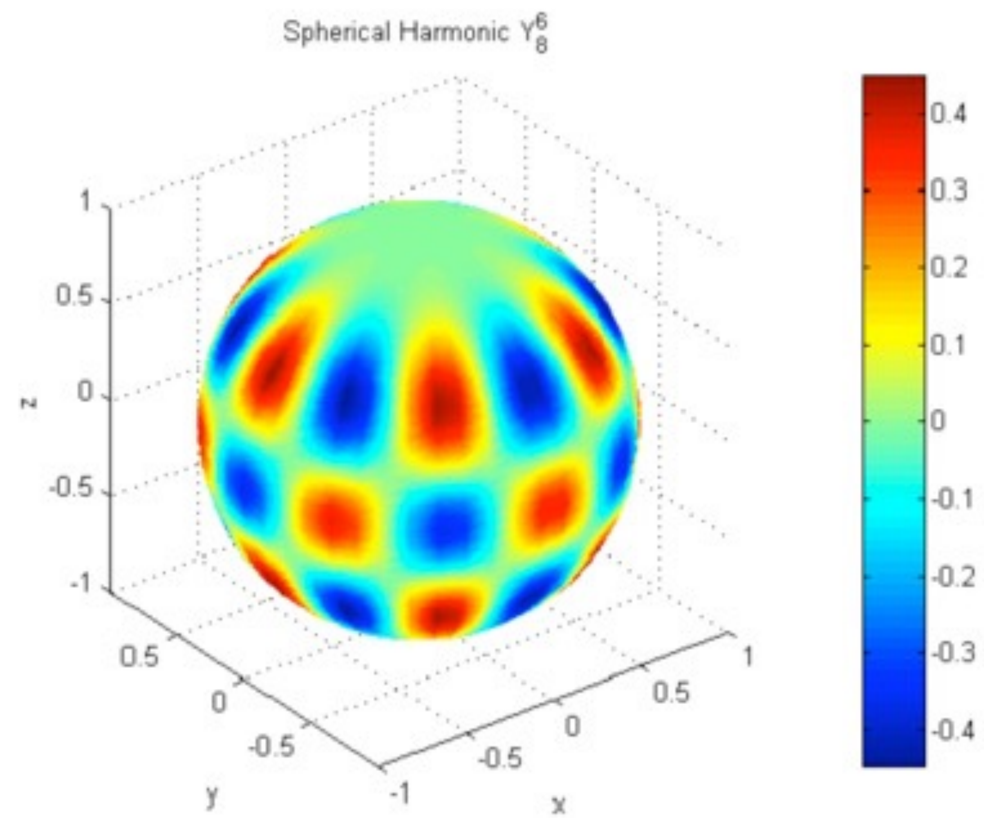


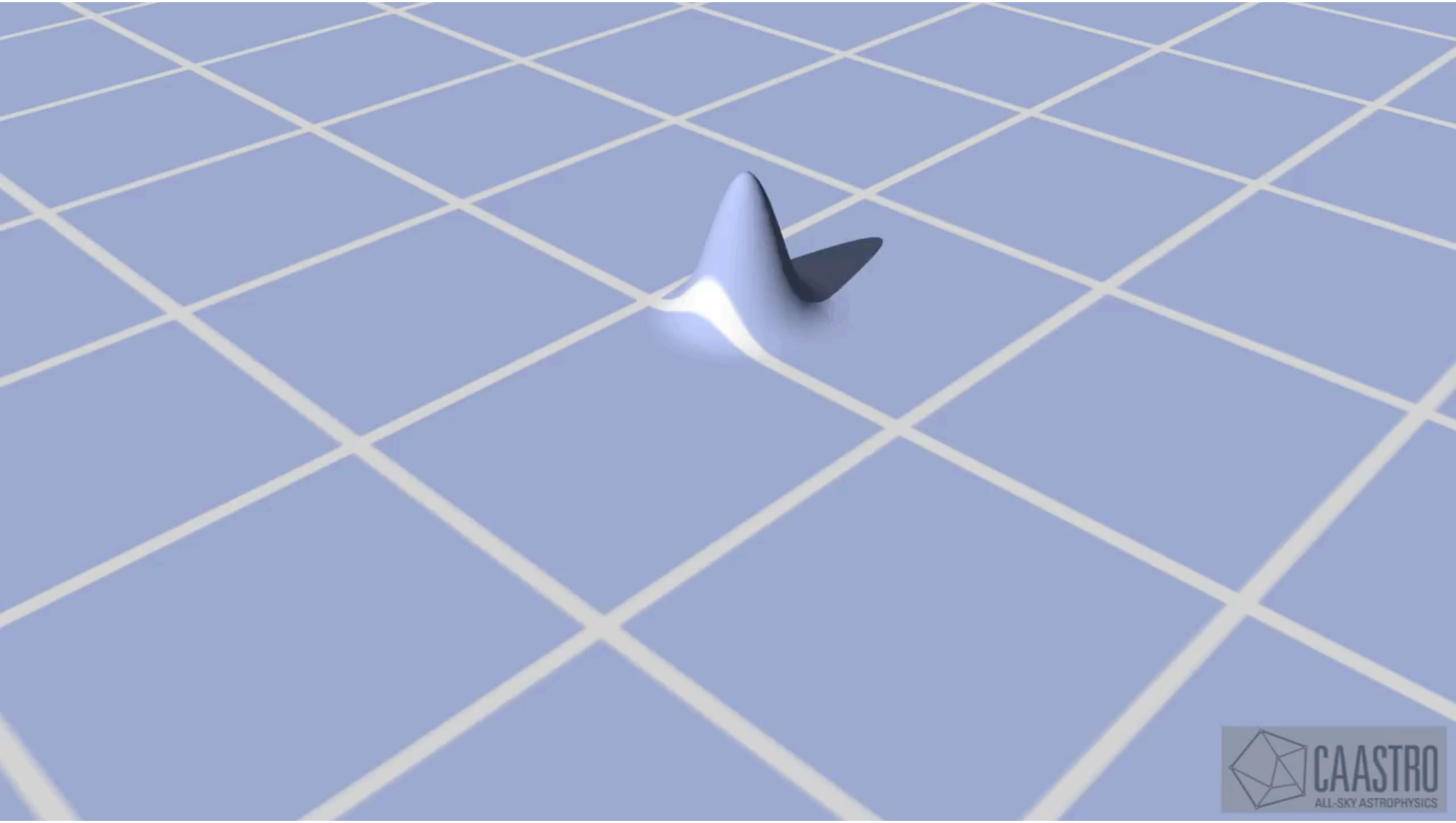
Ionized Fraction (x)
0.2
0.4
0.6
0.8
1
0
2000
4000
6000
8000
10^4
Temperature (K)

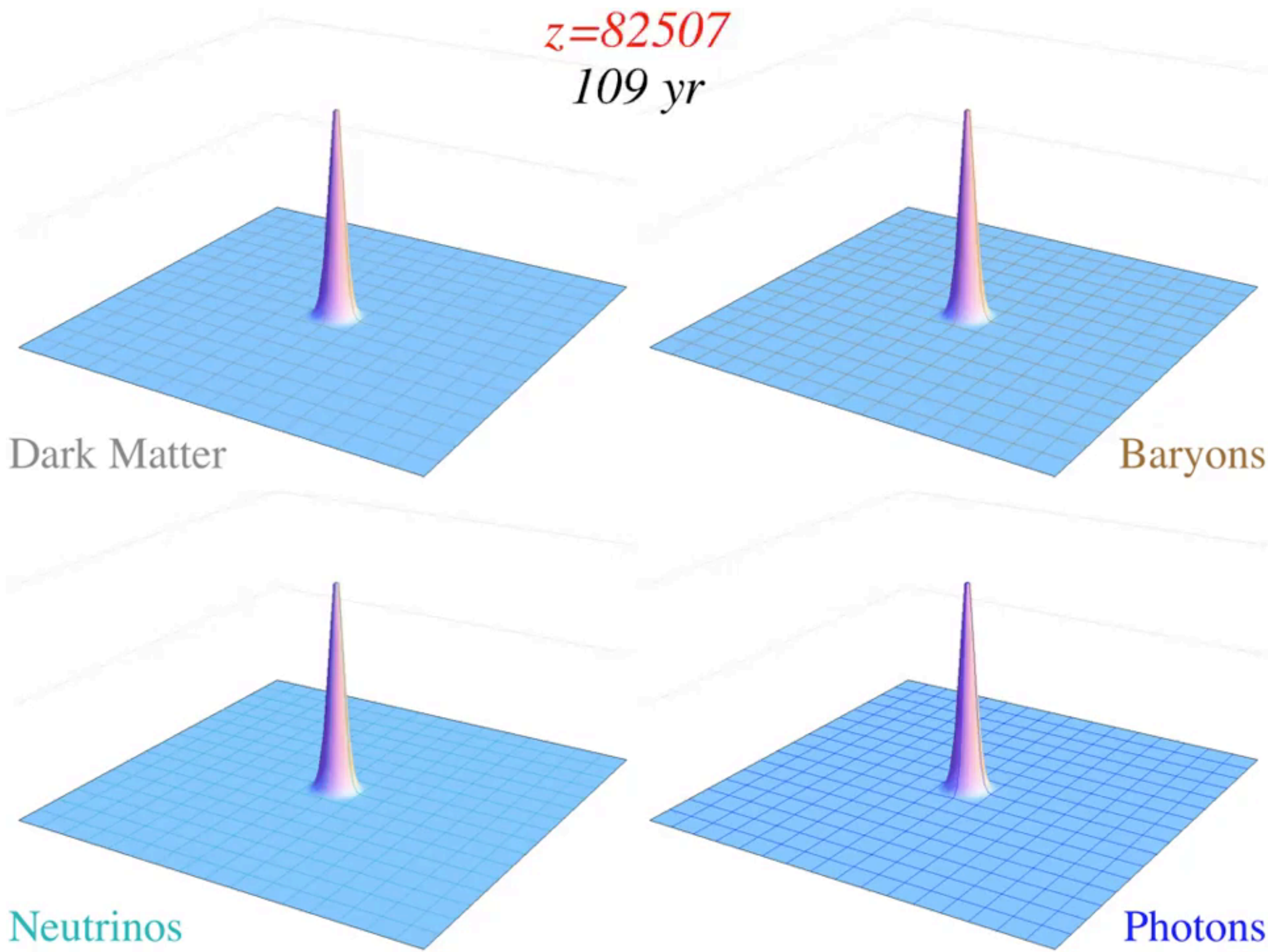

Harmonics
f_1
f_2
f_3
f_4
f_5
f_6
(a)
λ
(b)
Amplitude
f_1 f_2 f_3 f_4 f_5 f_6
Frequency
(c)

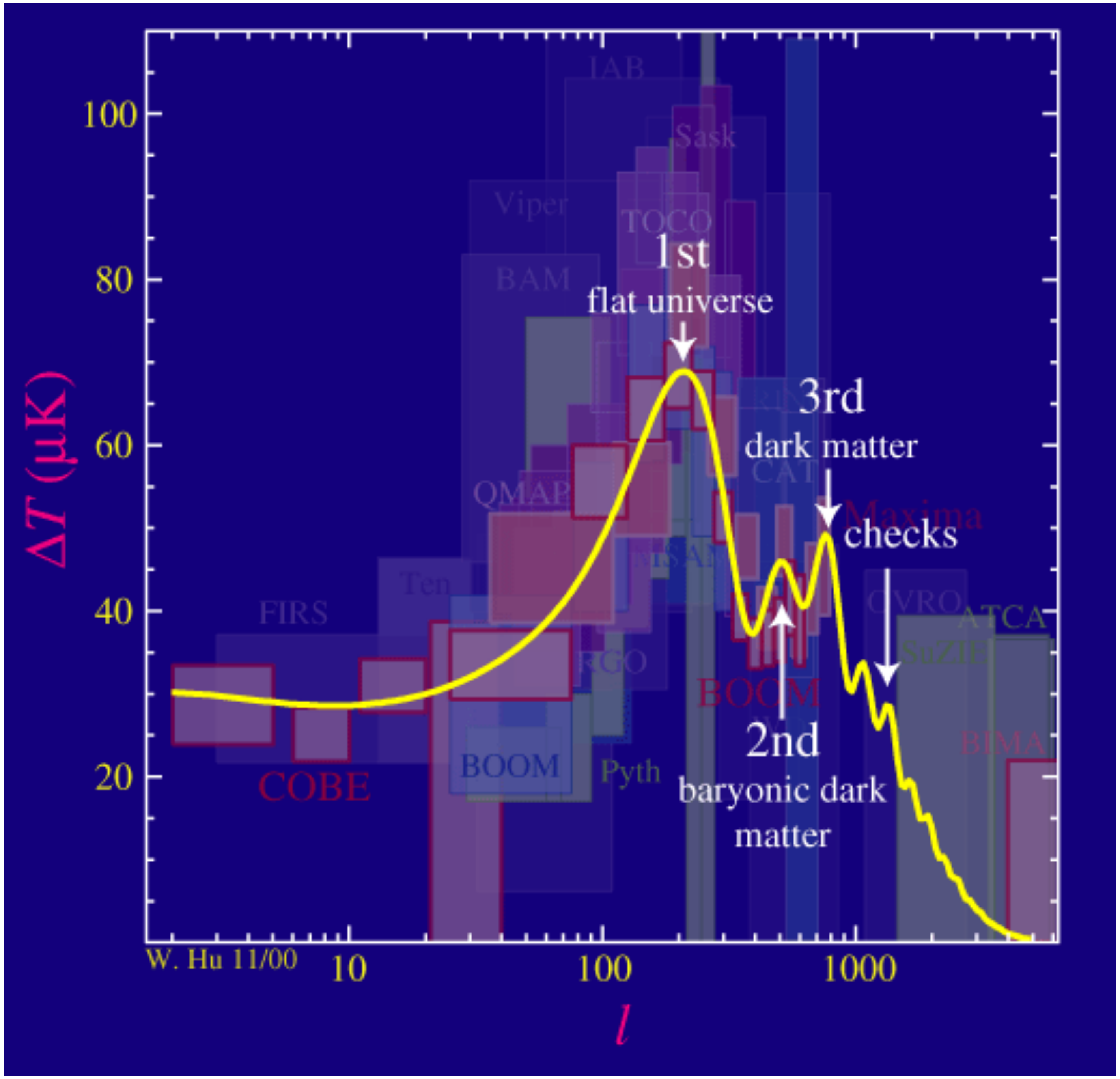
Single Harmonics




Spherical Harmonic Y_8^6
z
1
0.5
0
-0.5
-1
y
0.5
0
-0.5
x
-1
-0.5
0
0.5
1
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4


CAASTRO
ALL-SKY ASTROPHYSICS


z=82507
109 yr
Dark Matter
Baryons
Neutrinos
Photons



1st
flat universe
3rd
dark matter
checks
2nd
baryonic dark
matter
COBE
BOOM
Maxima
FIRS
Ten
QMAP
BAM
Viper
TOCO
Sask
IAB
CAT
RGO
Pyth
CVRO
ATCA
SuZIE
BIMA
ΔT (μK)
l
W. Hu 11/00
100
80
60
40
20
10
100
1000