

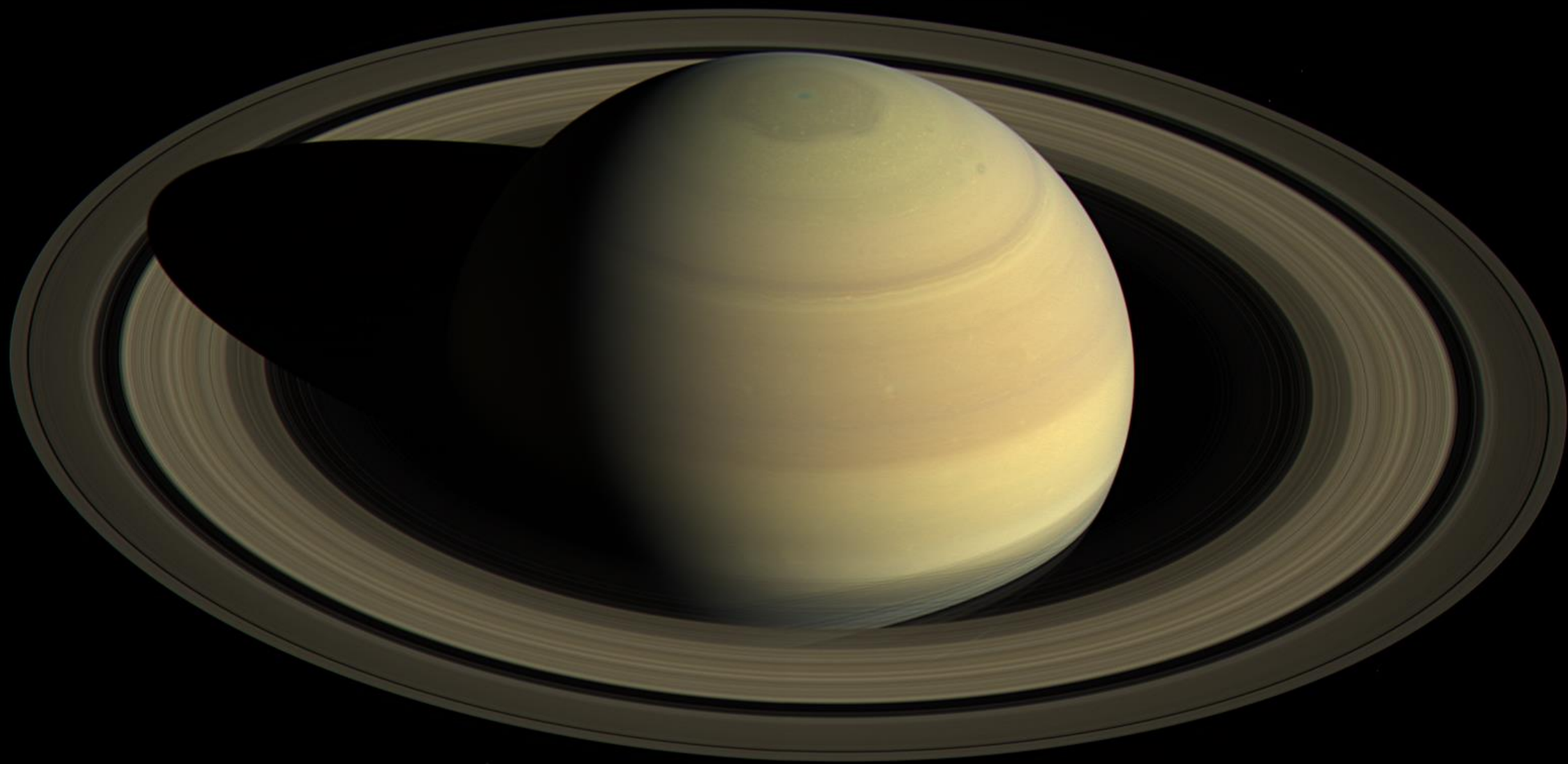
Radio cosmology and the cosmic
microwave background
(or, Why you should believe in the Big
Bang theory)

Mike Jones

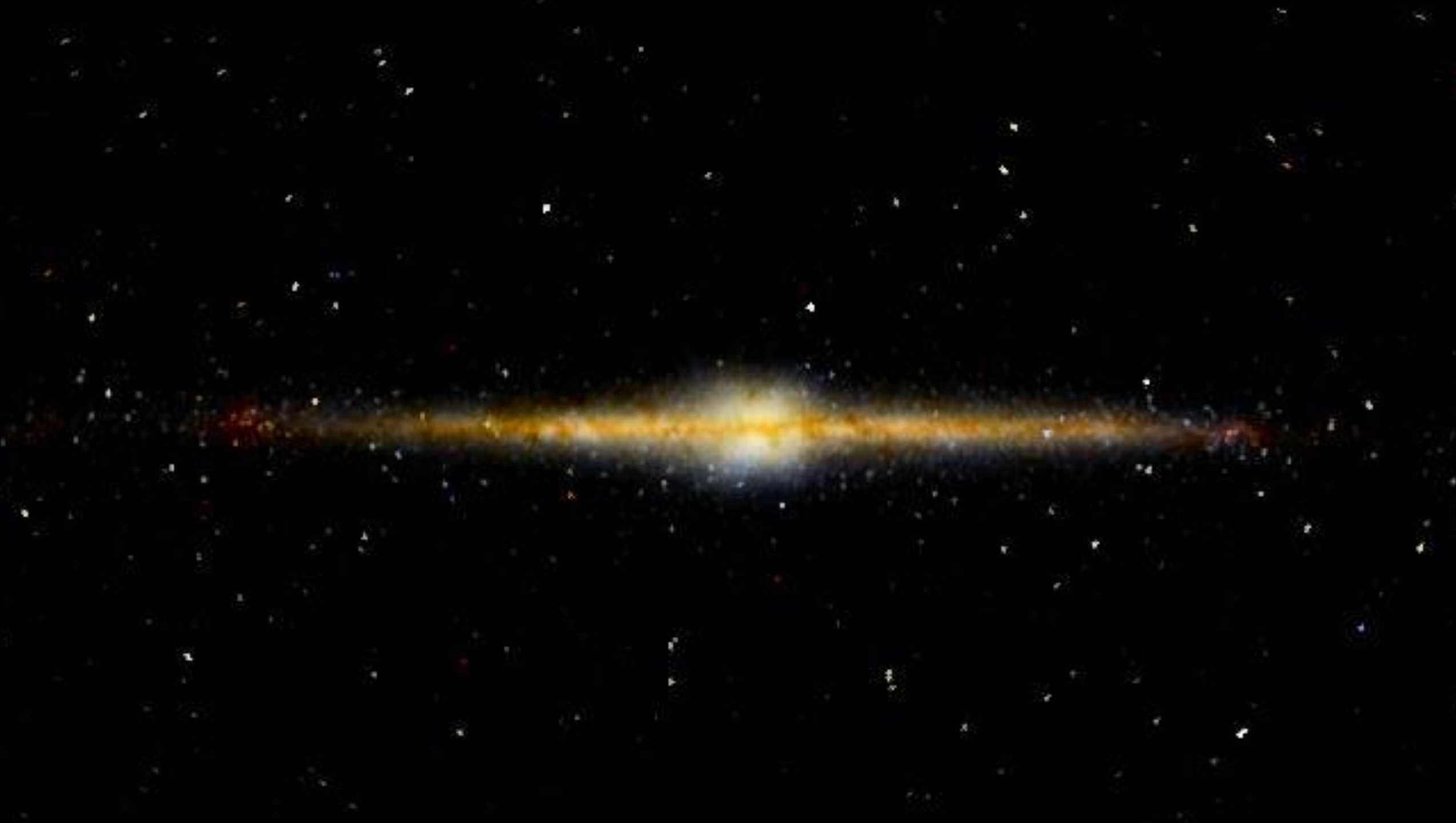
University of Oxford

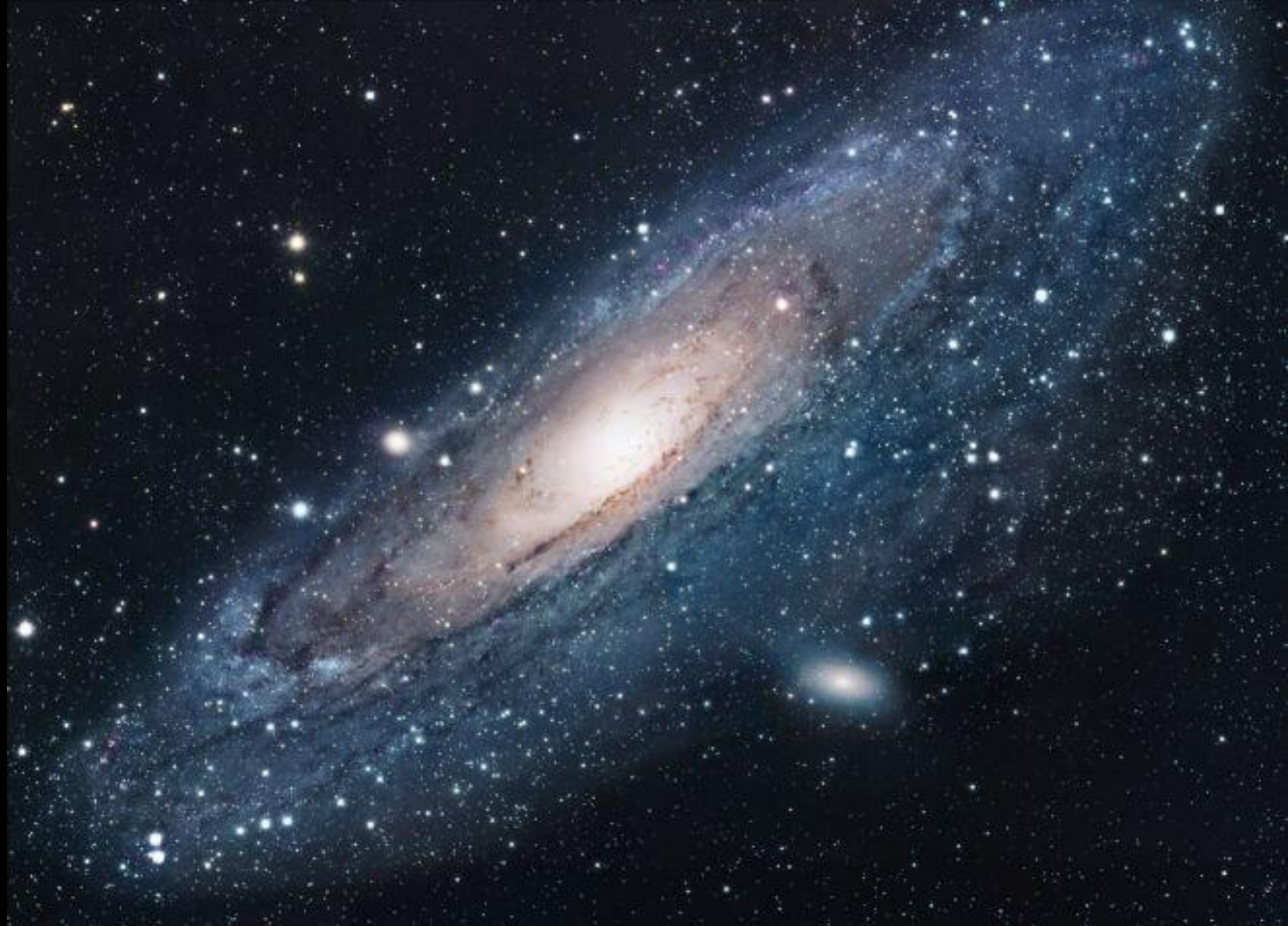
The scale of cosmology





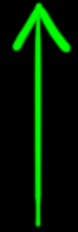






Andromeda's Distance From Us (to Scale)

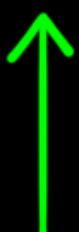
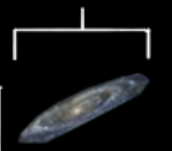
100,000
light years



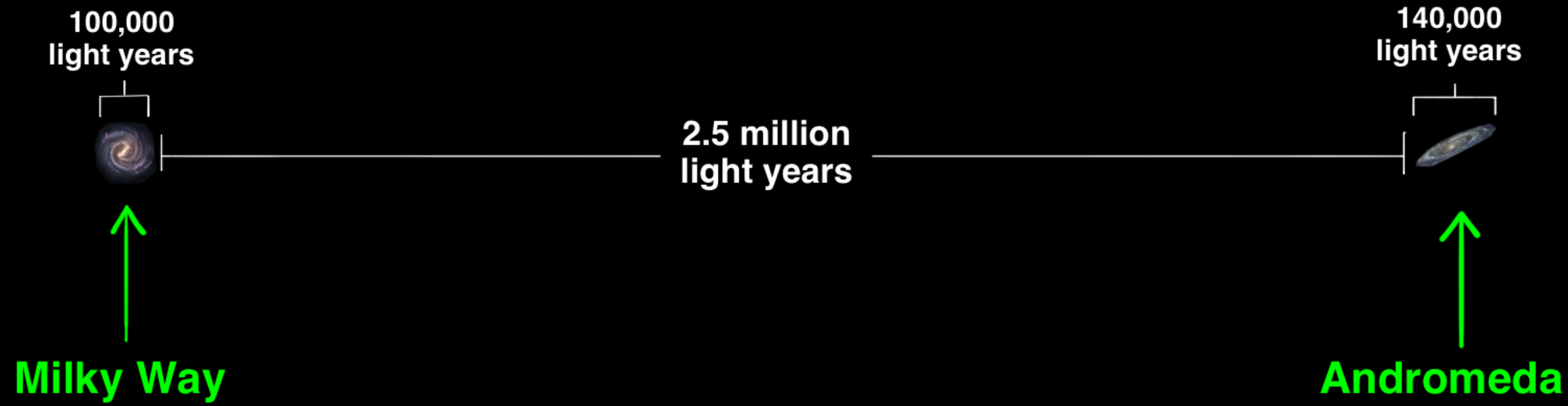
Milky Way

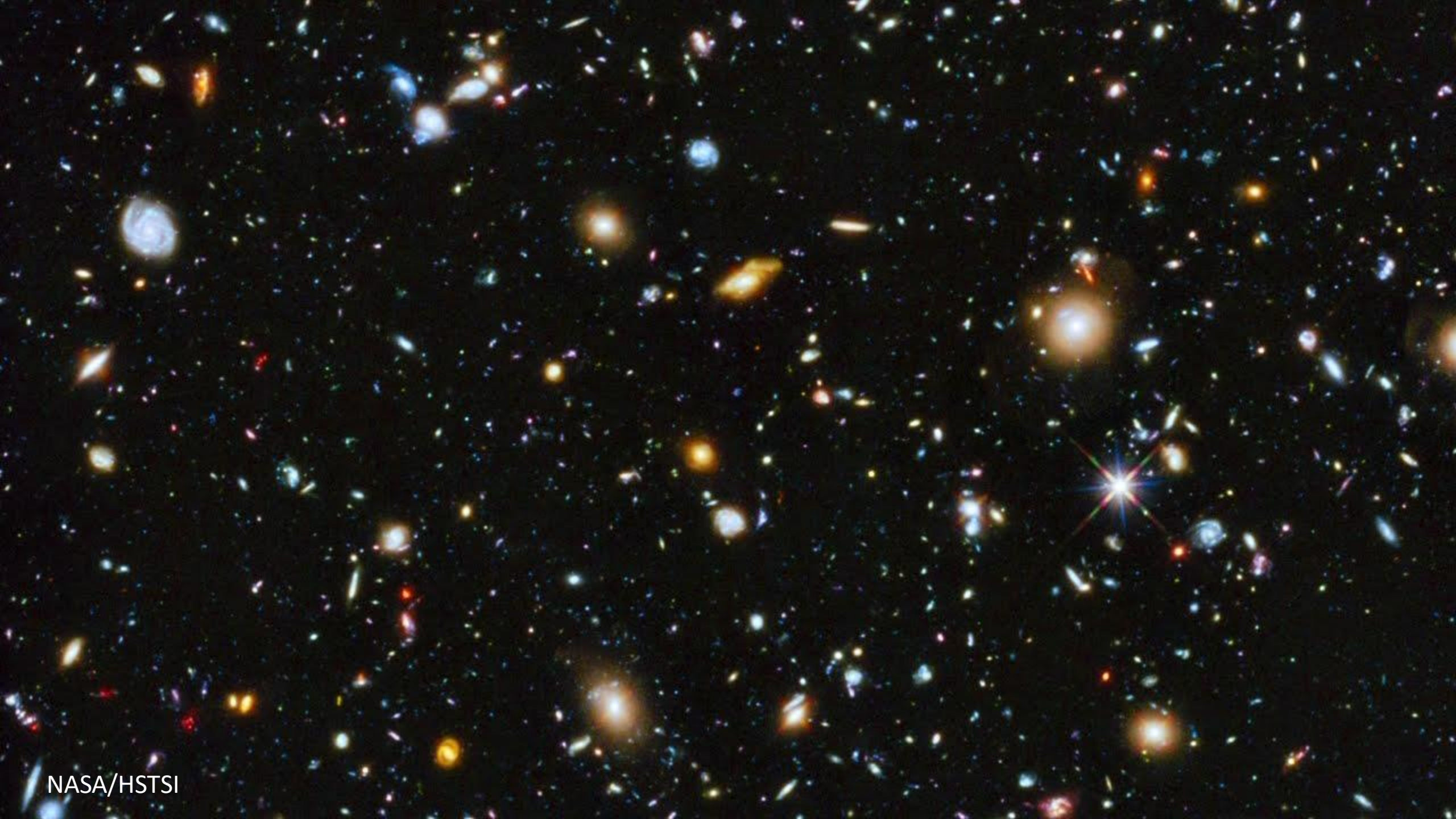
2.5 million
light years

140,000
light years



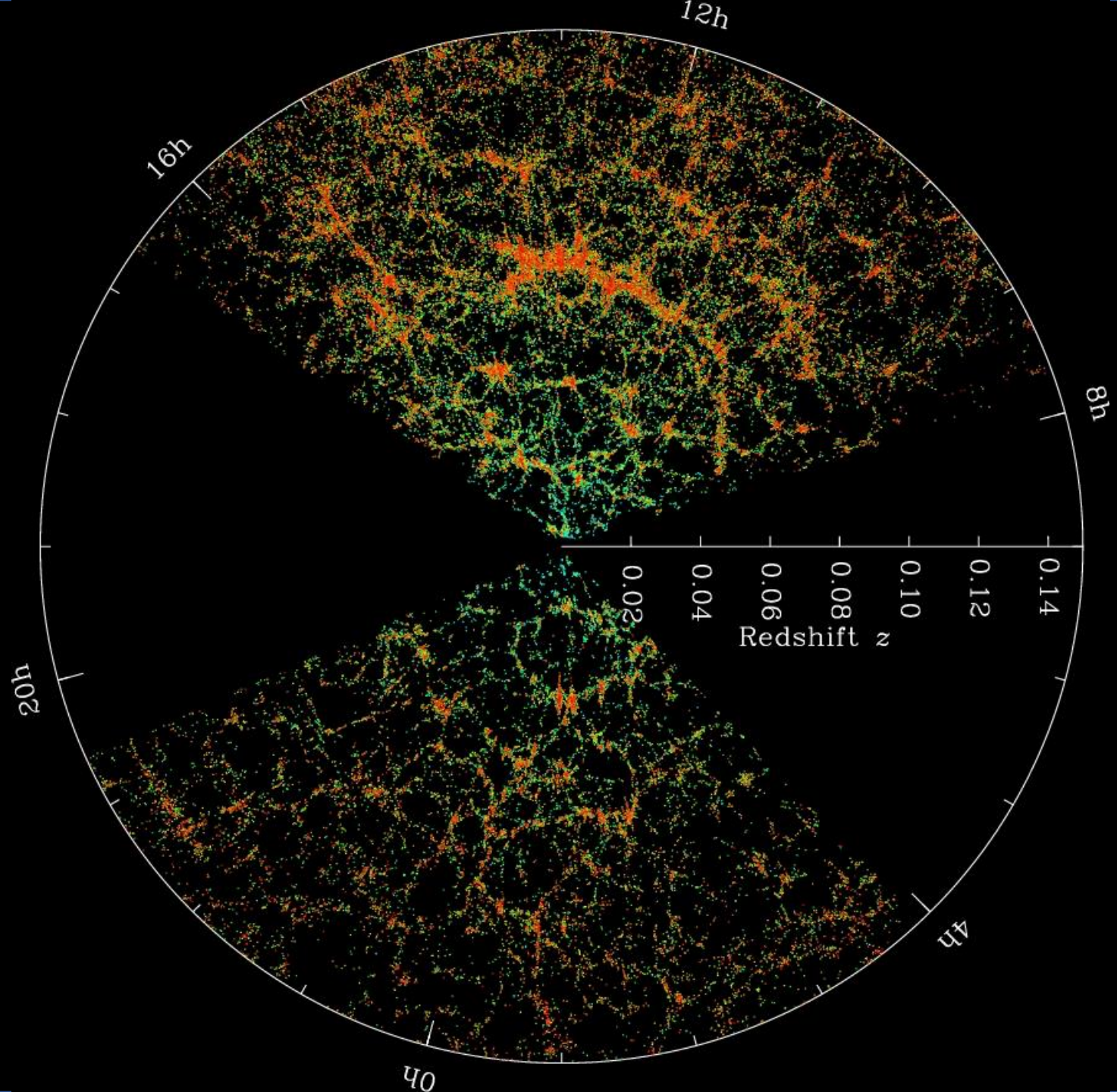
Andromeda

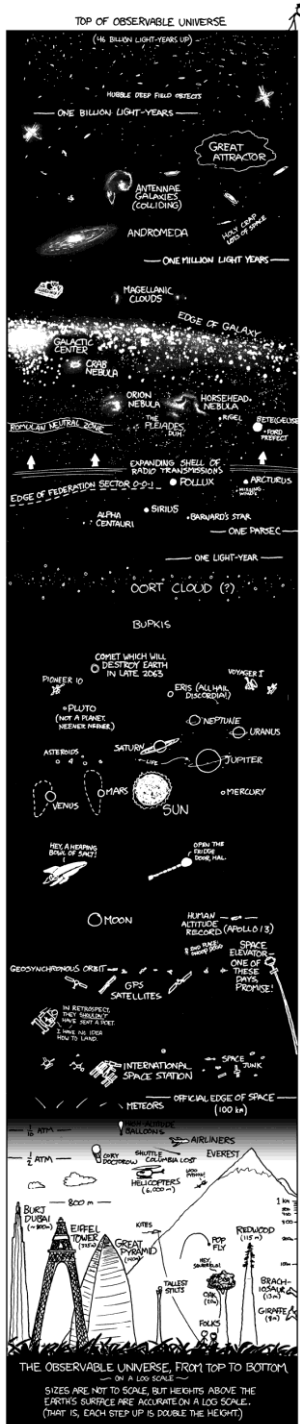


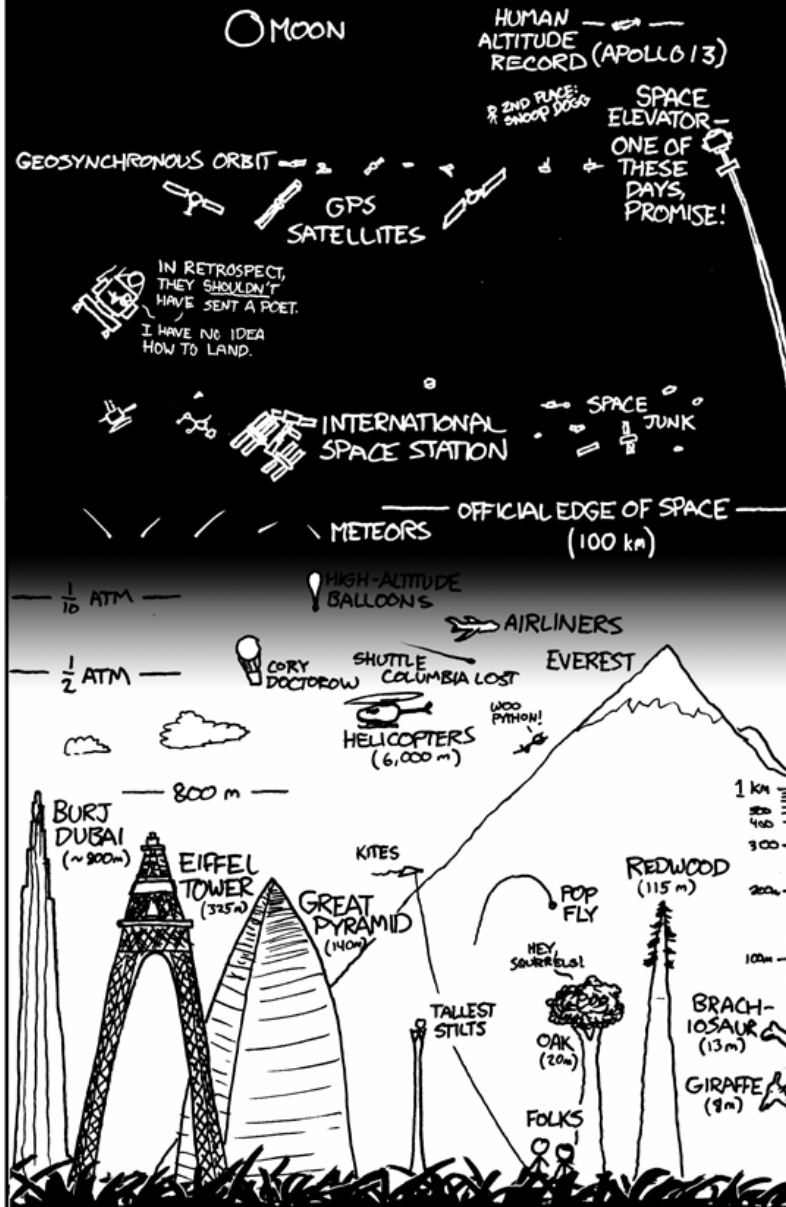


NASA/HSTSI

Sloan Digital Sky Survey

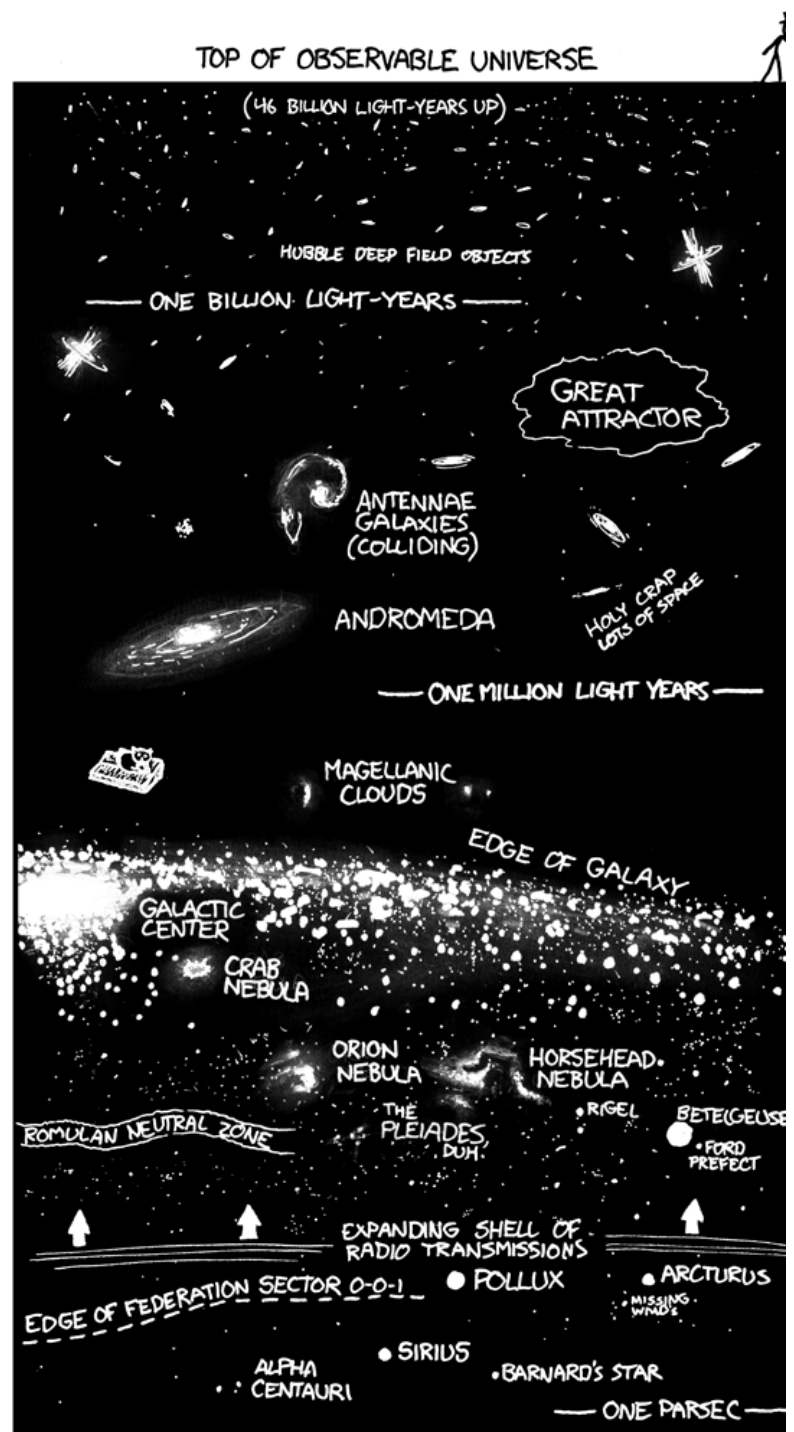
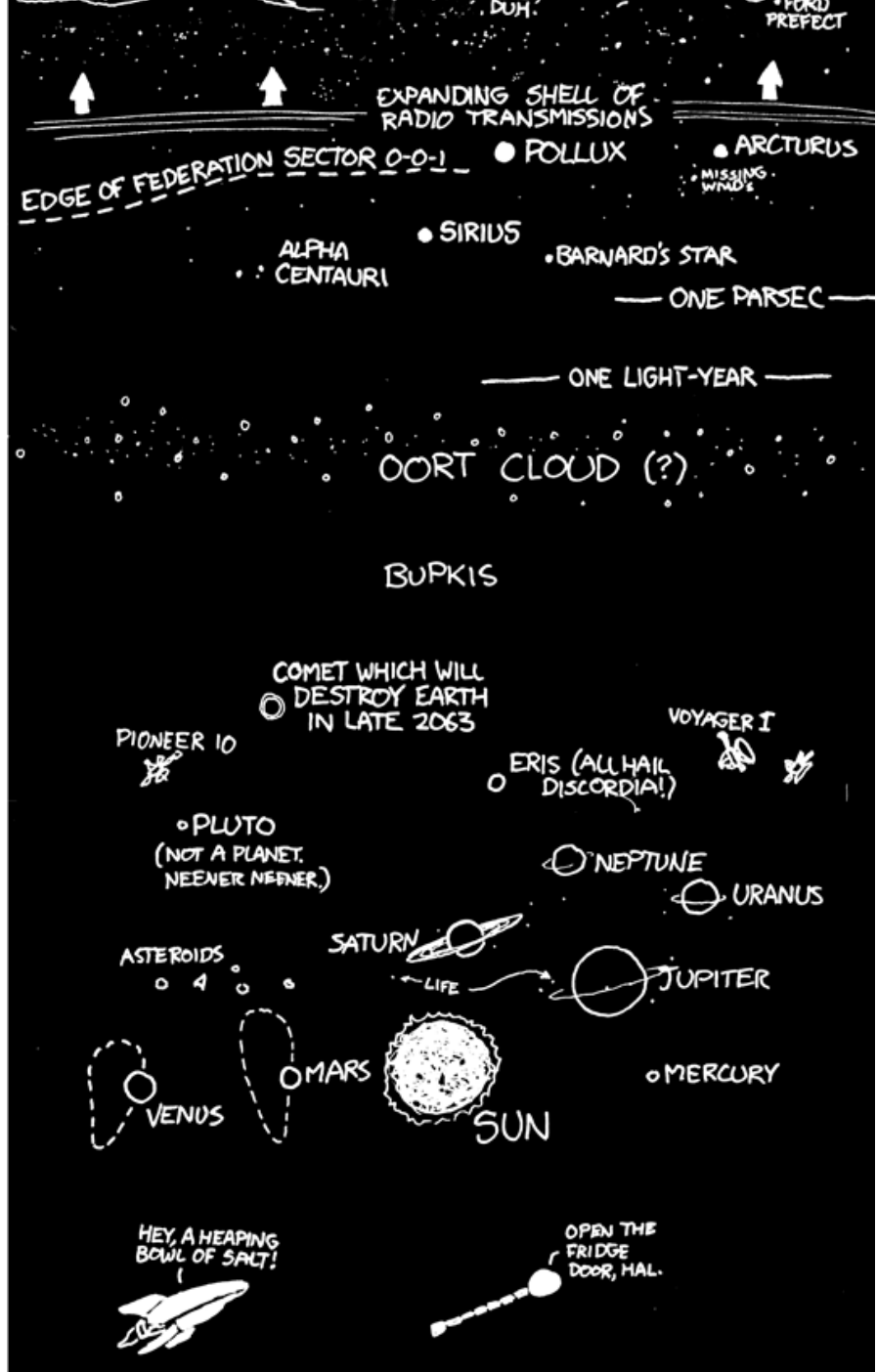






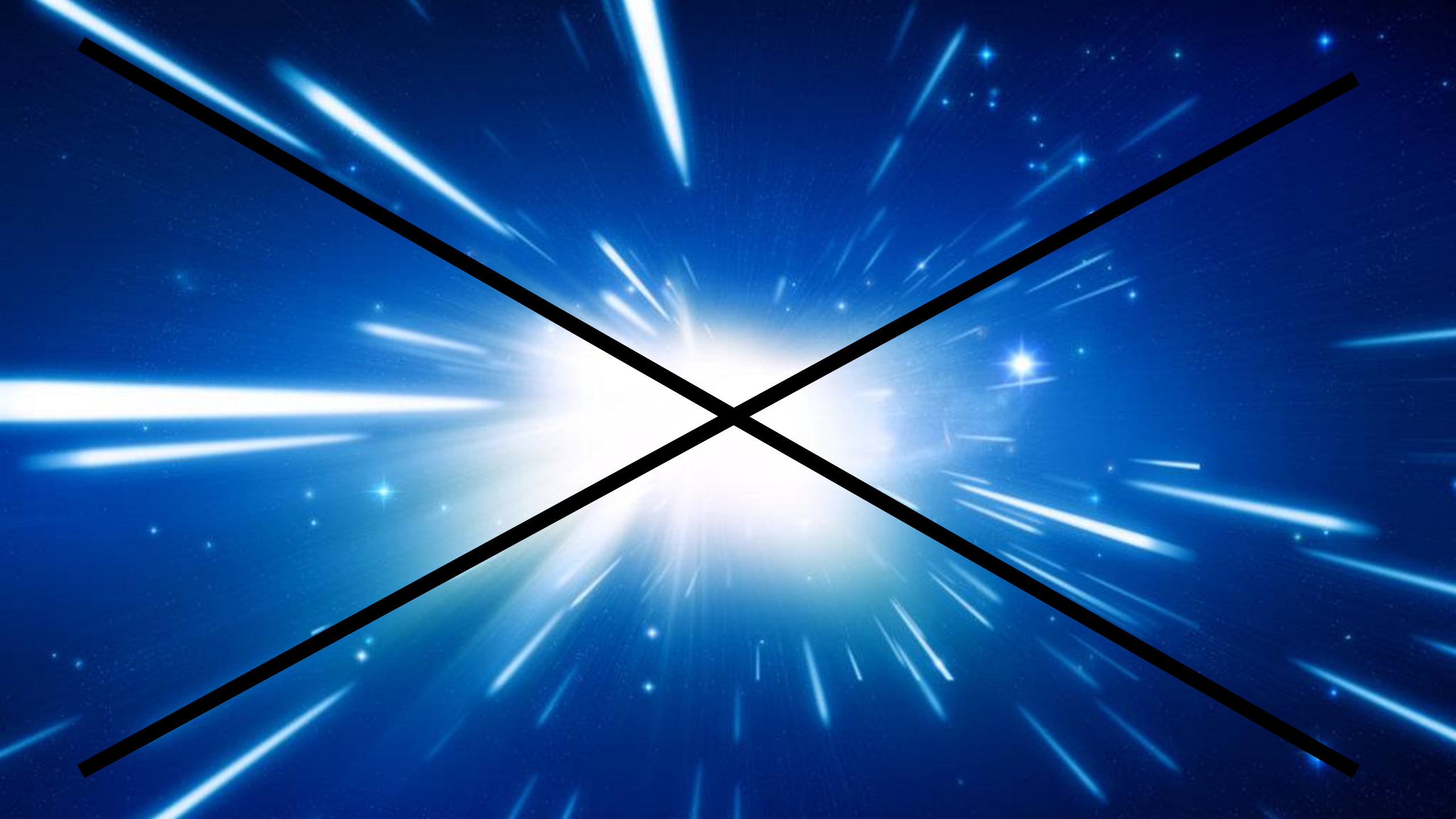
THE OBSERVABLE UNIVERSE, FROM TOP TO BOTTOM
ON A LOG SCALE

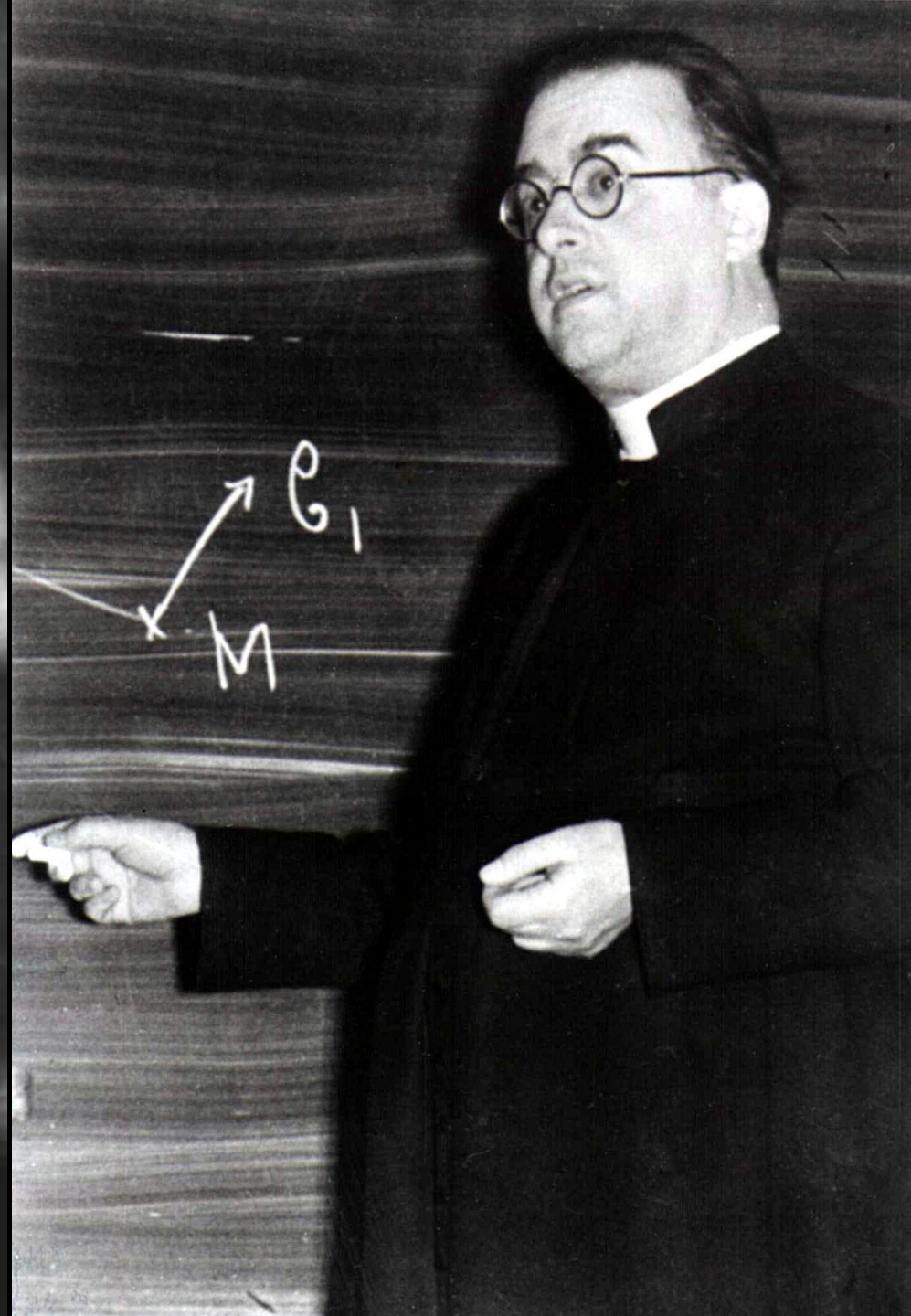
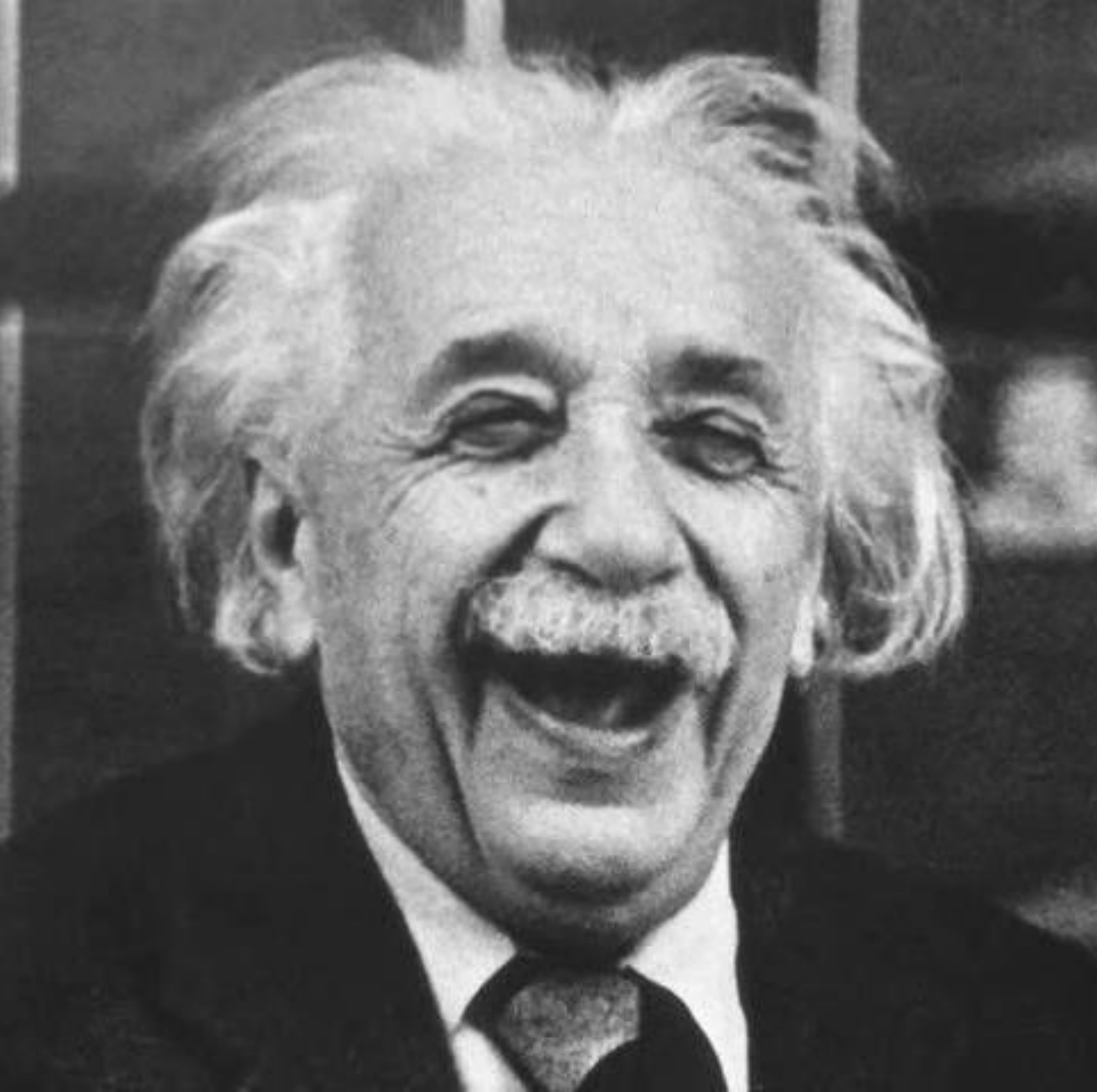
SIZES ARE NOT TO SCALE, BUT HEIGHTS ABOVE THE EARTH'S SURFACE ARE ACCURATE ON A LOG SCALE. (THAT IS, EACH STEP UP IS DOUBLE THE HEIGHT.)



The Expanding Universe

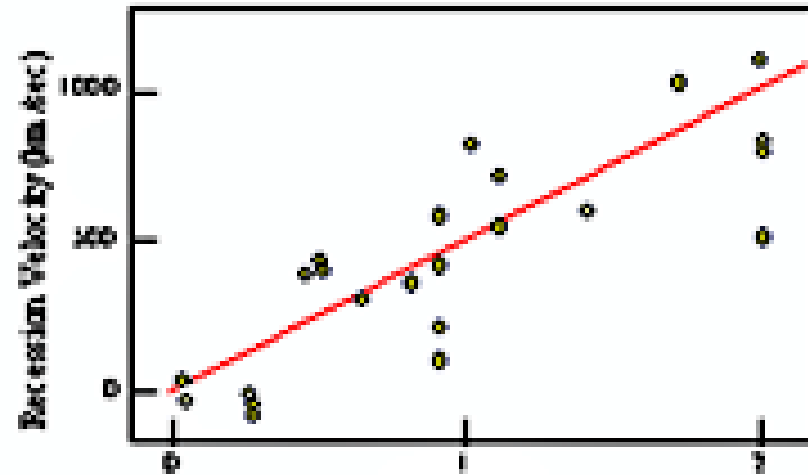




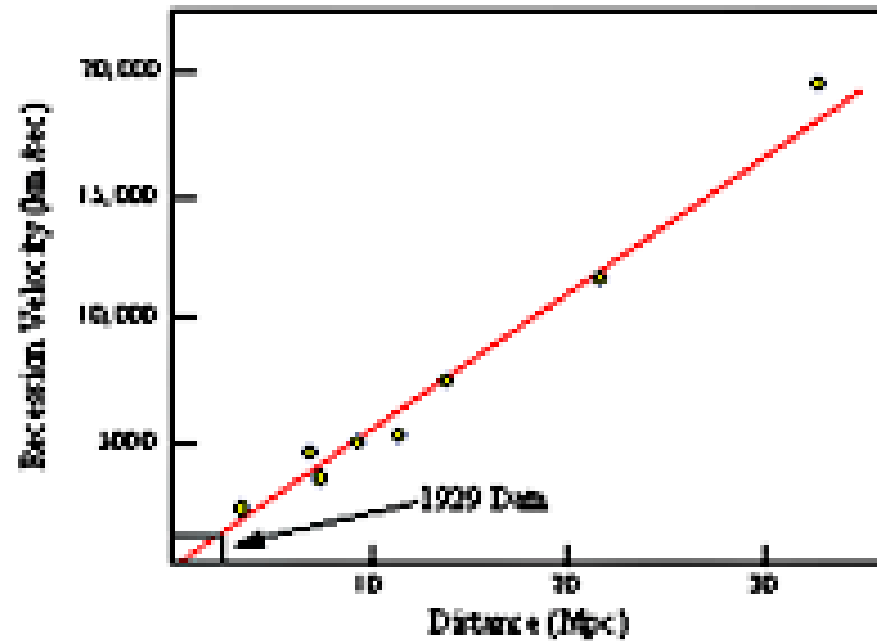


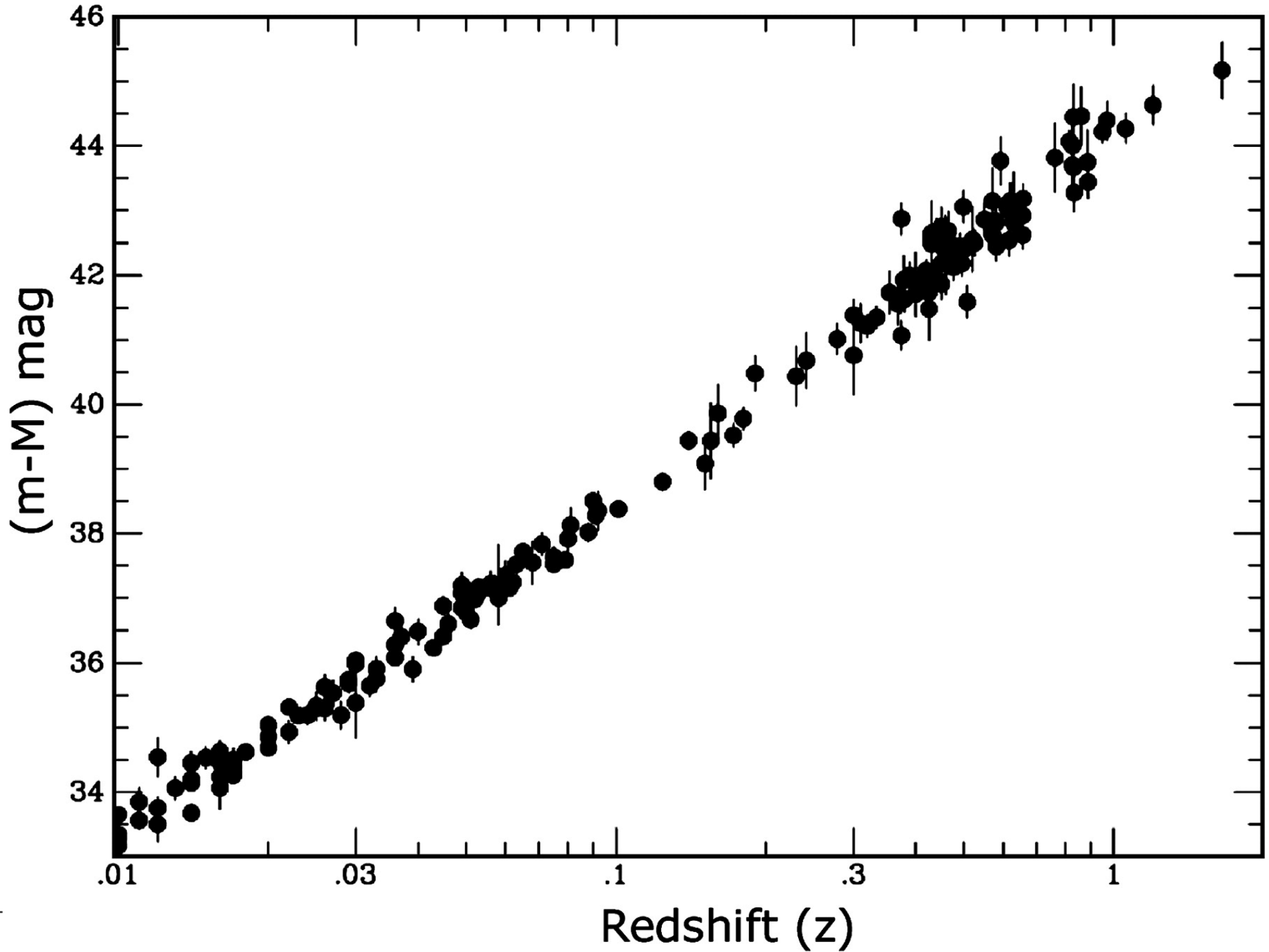


Hubble's Data (1929)



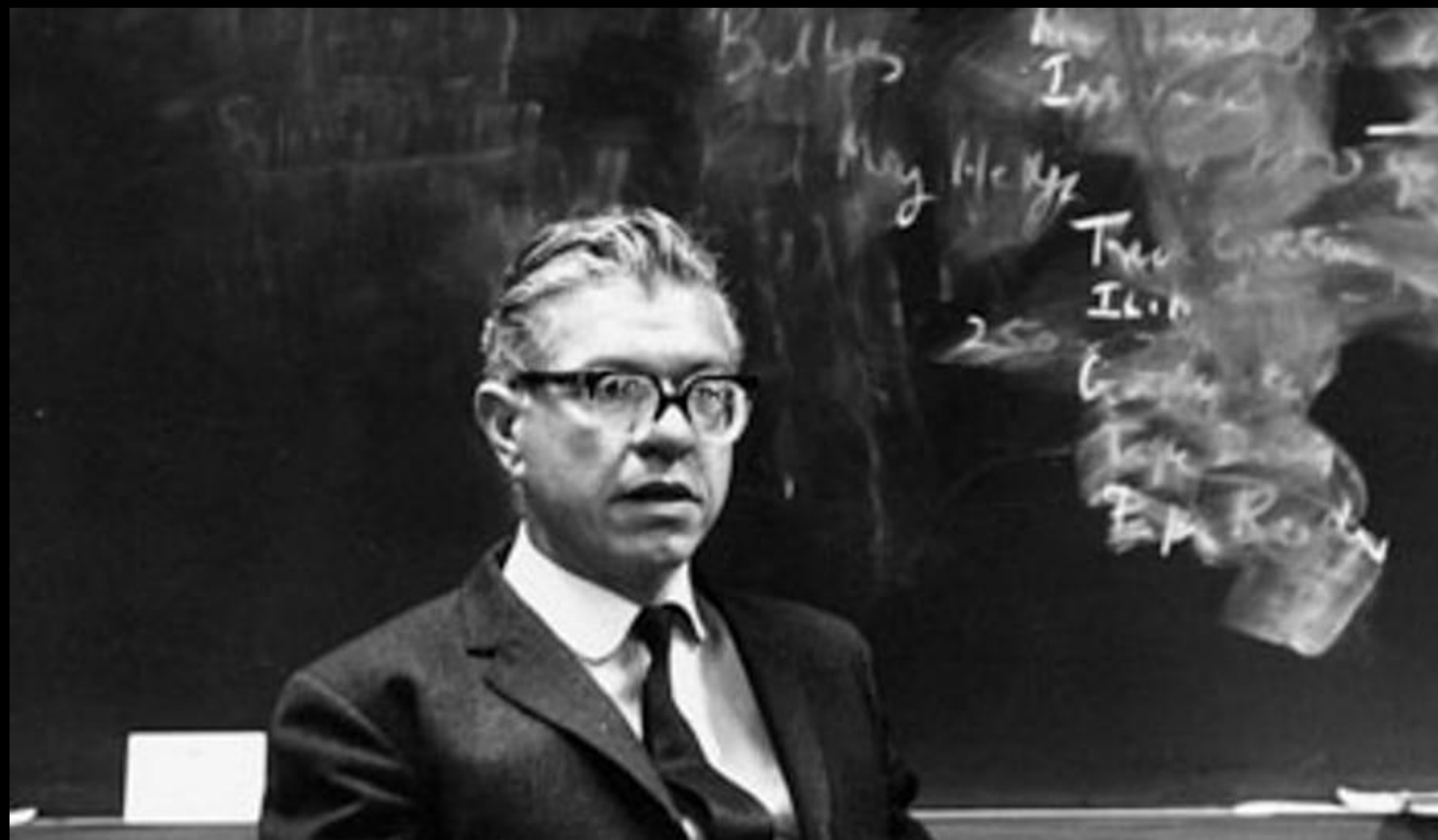
Hubble & Humason (1931)





Big-bang Nucleosynthesis



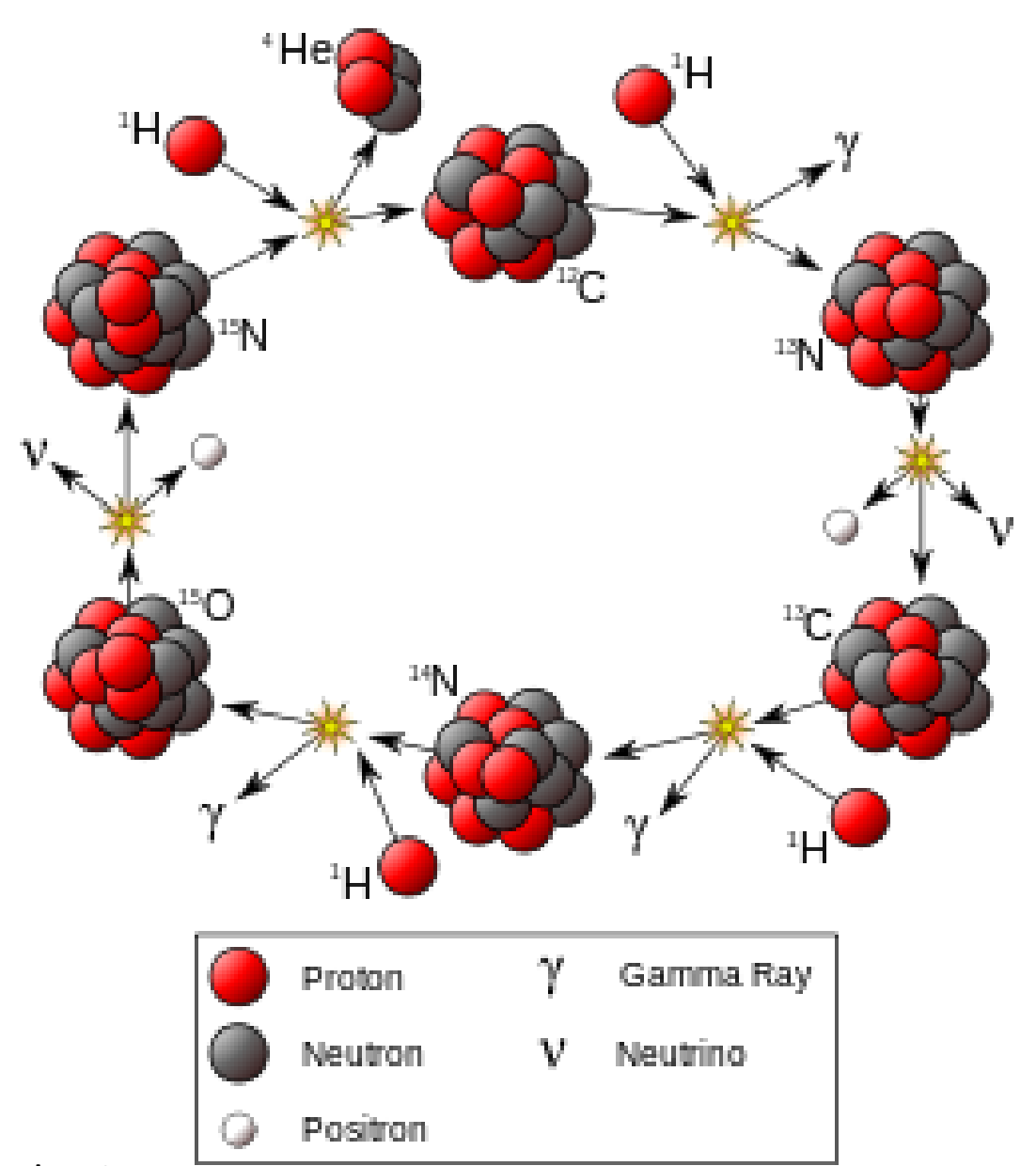
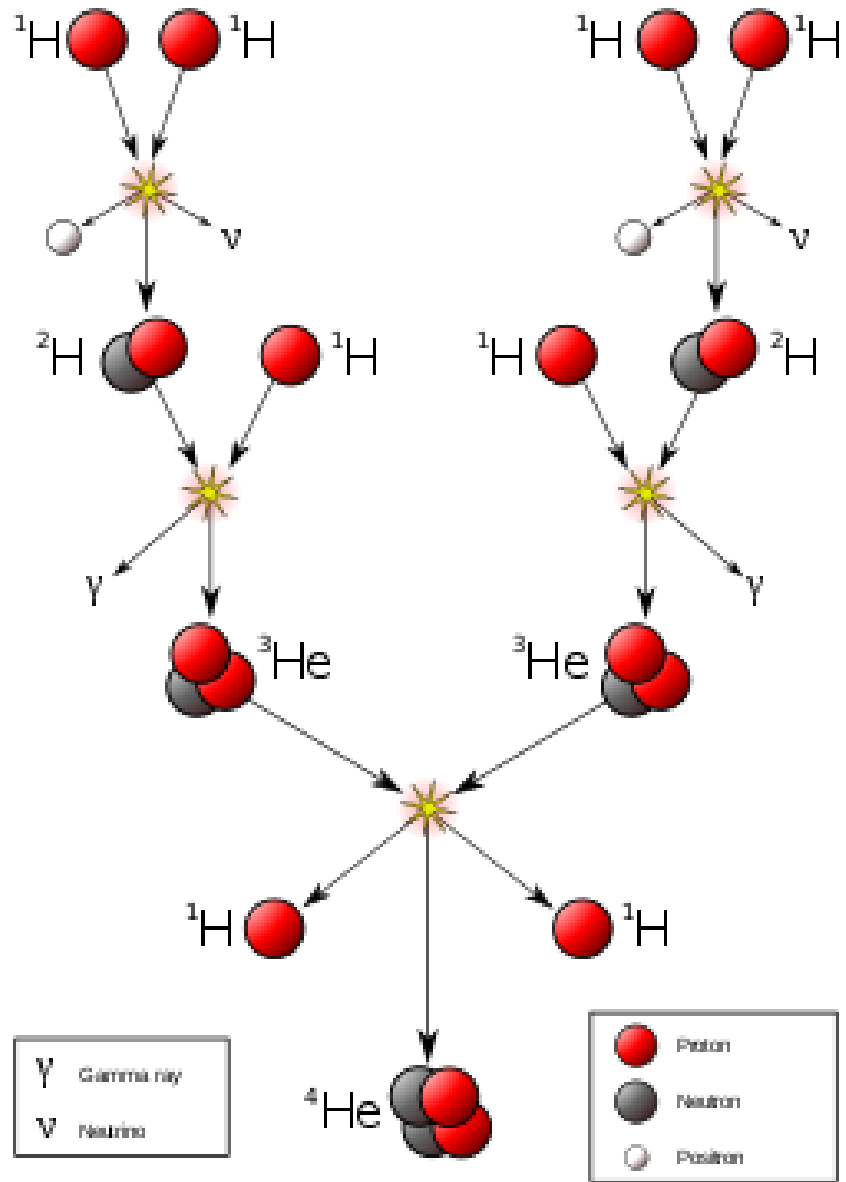


Bulbas

May Helly

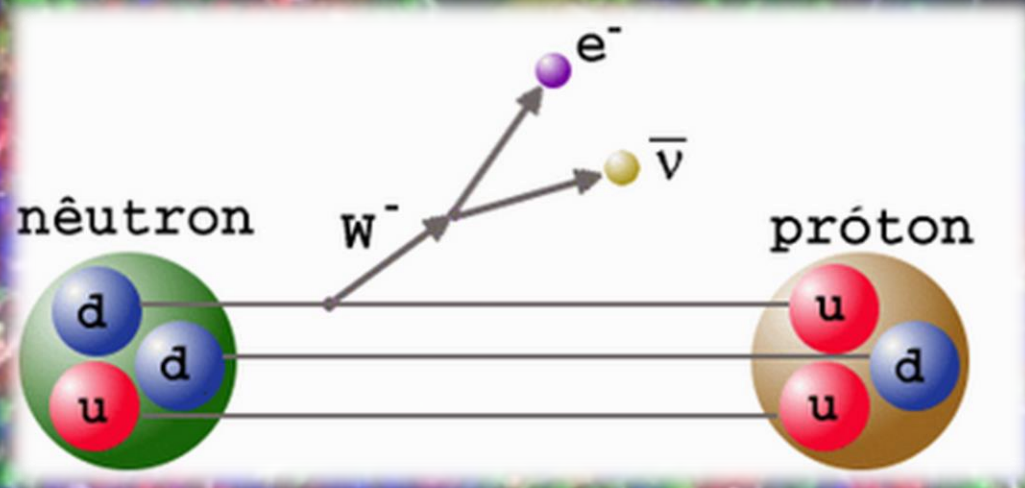
250

Tree
I.L.H.
EPA Rodin

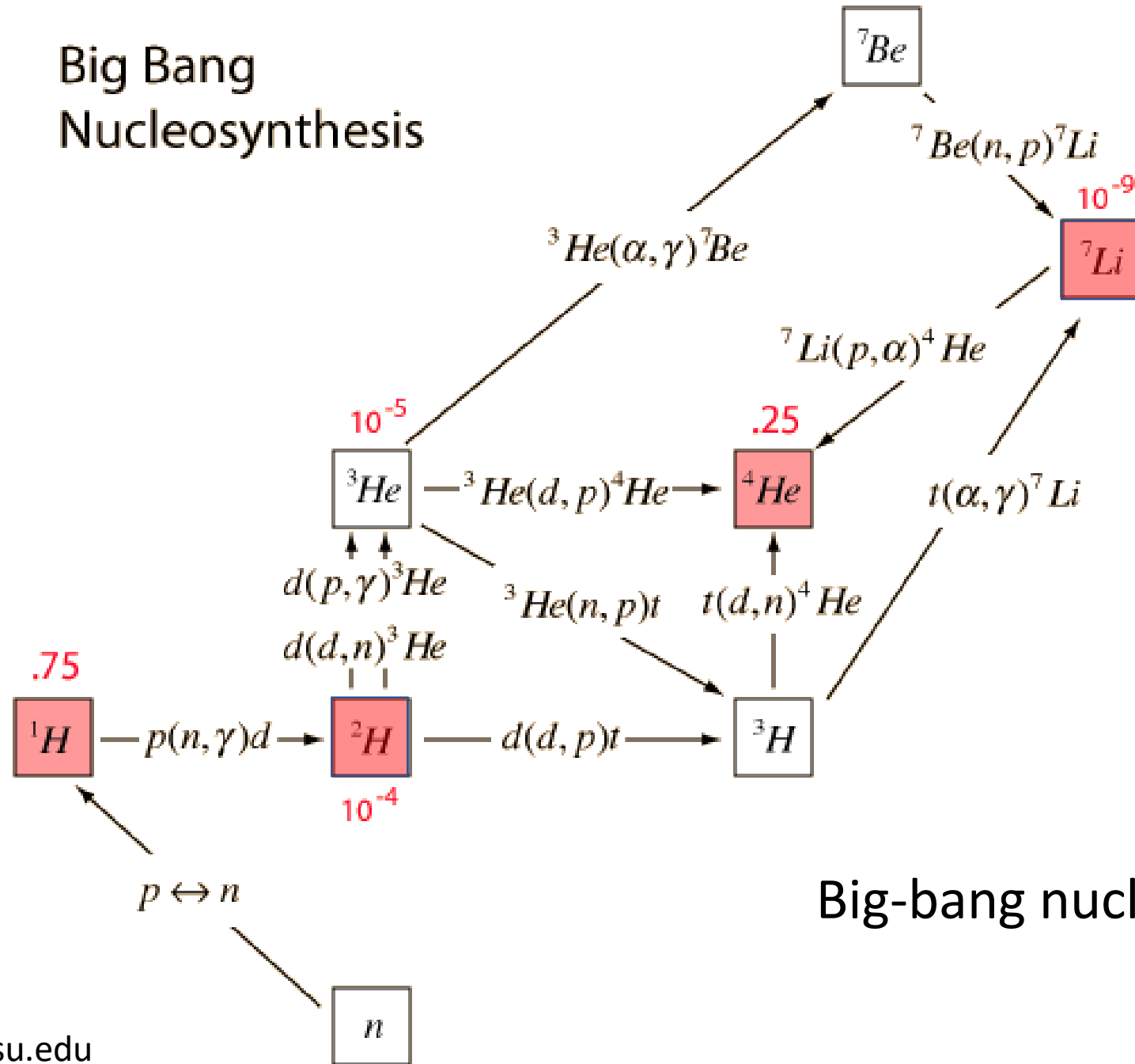


Wikipedia

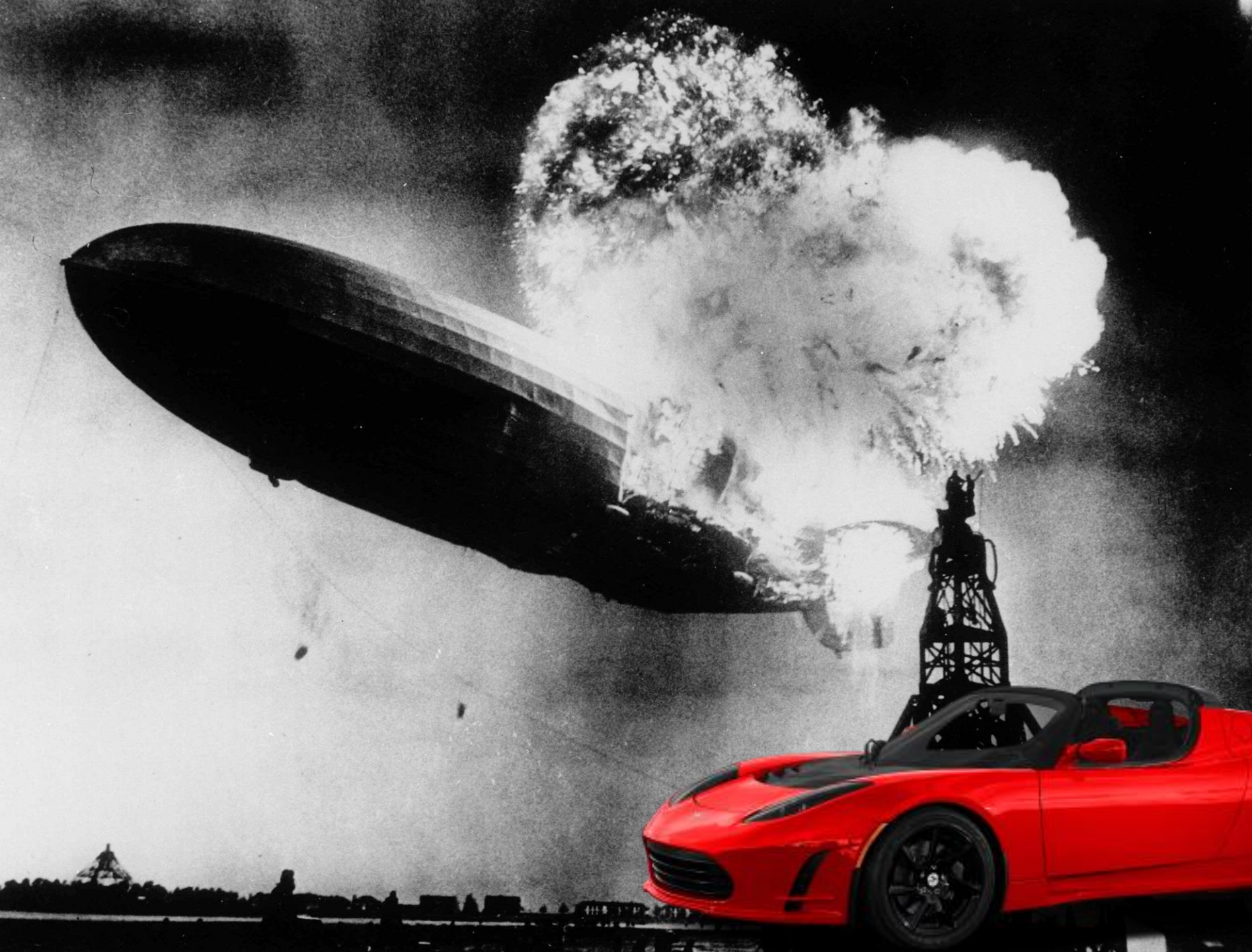
Stellar nucleosynthesis

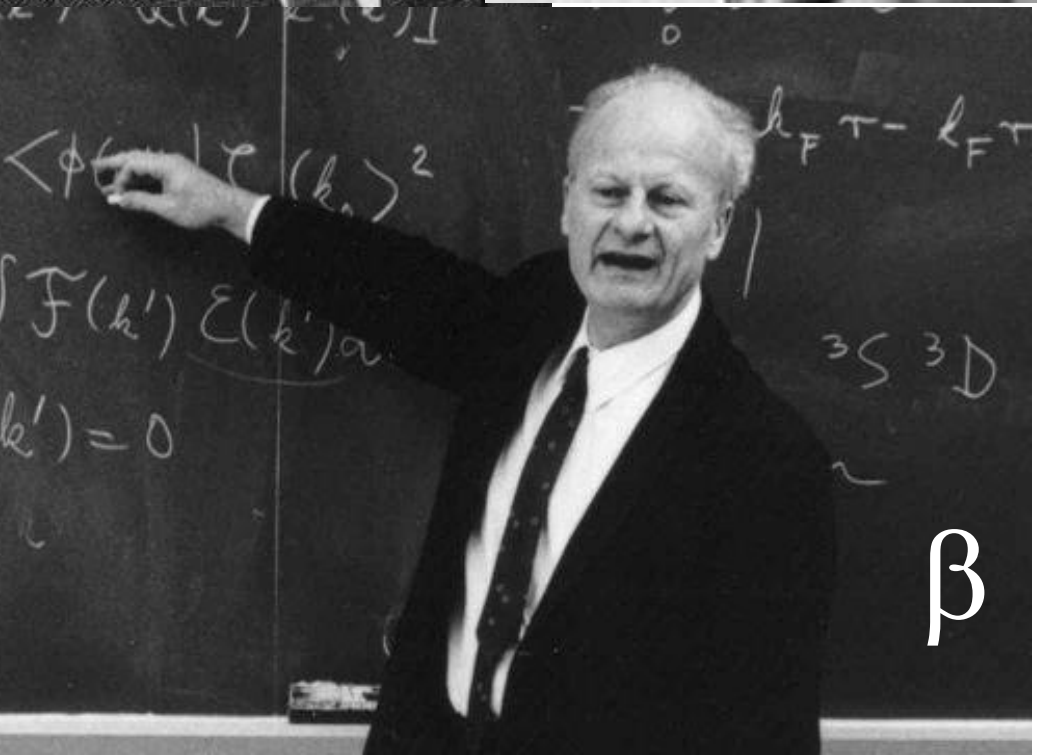
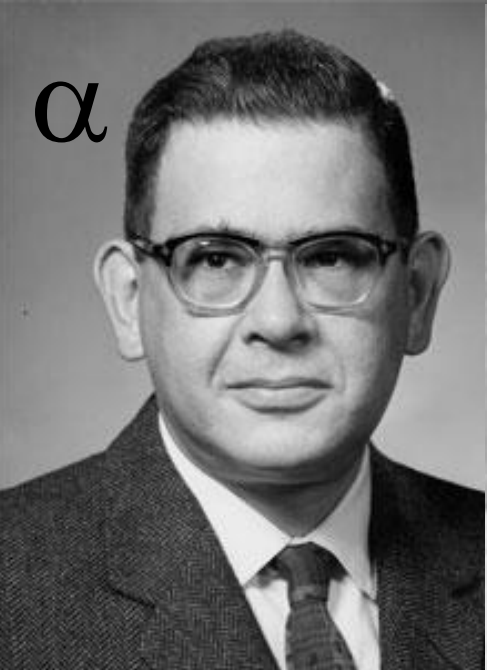
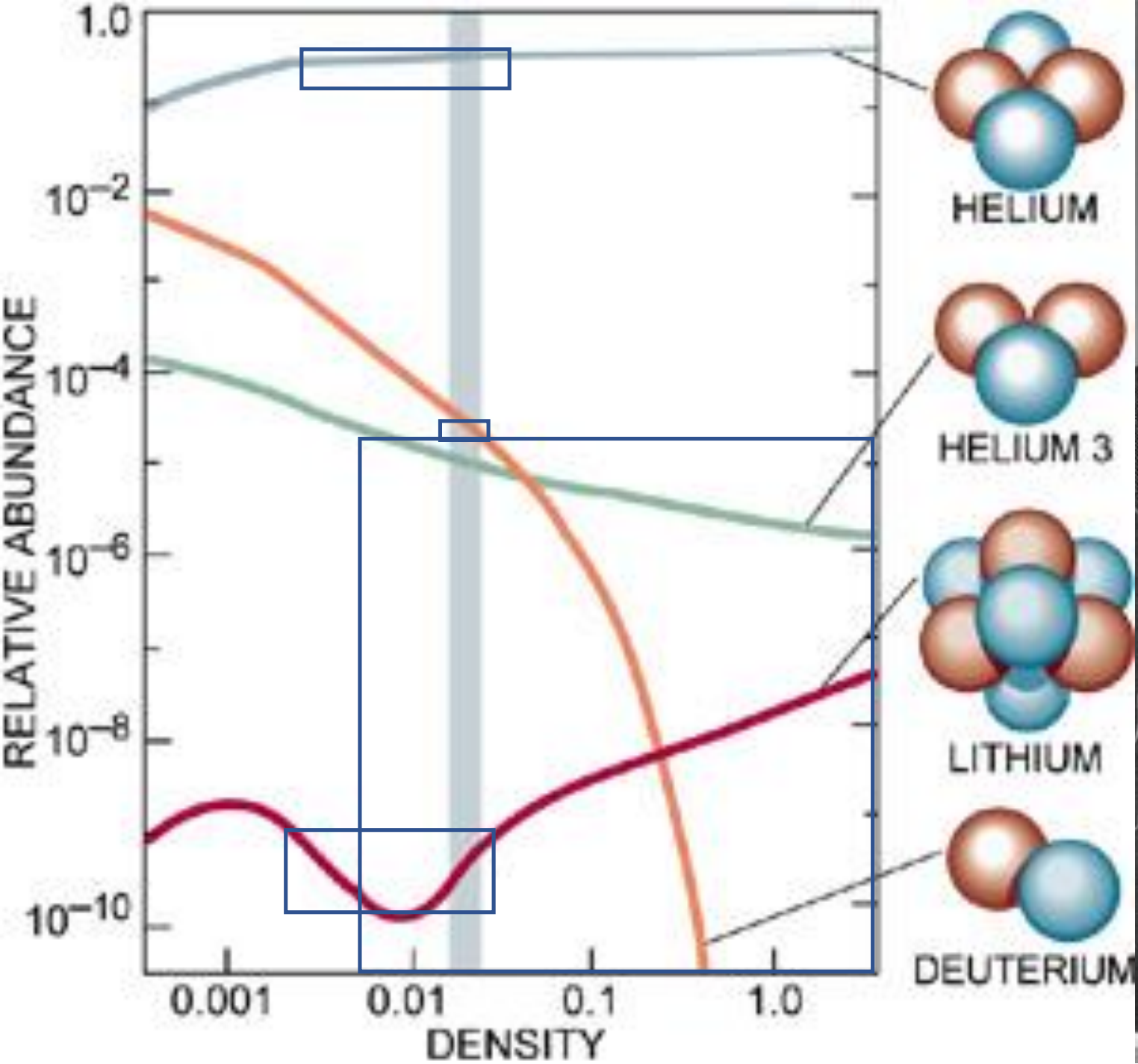


Big Bang Nucleosynthesis



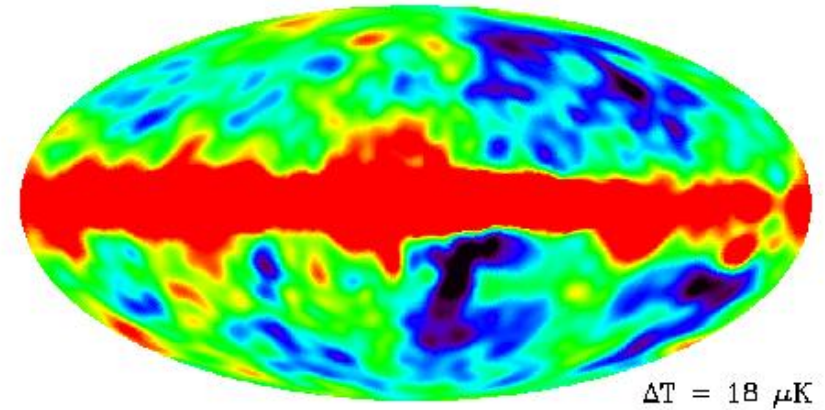
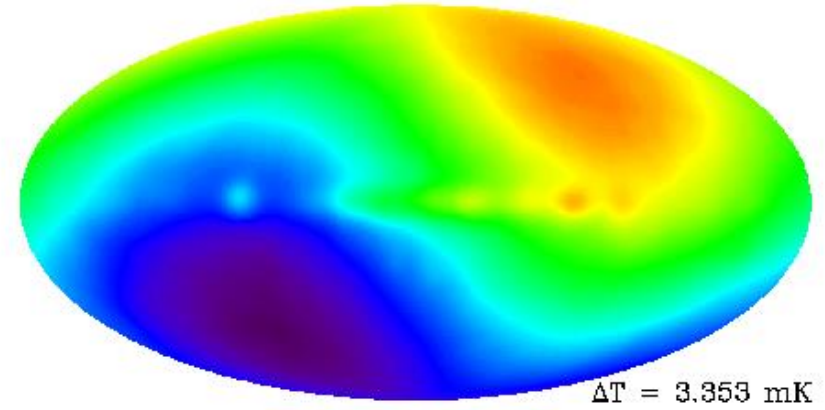
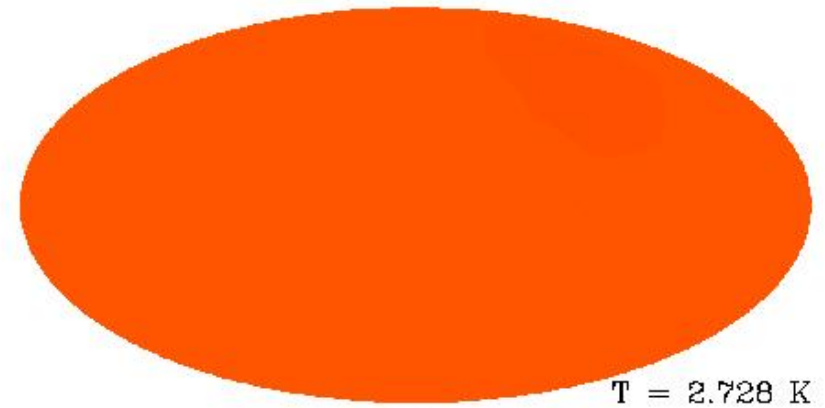
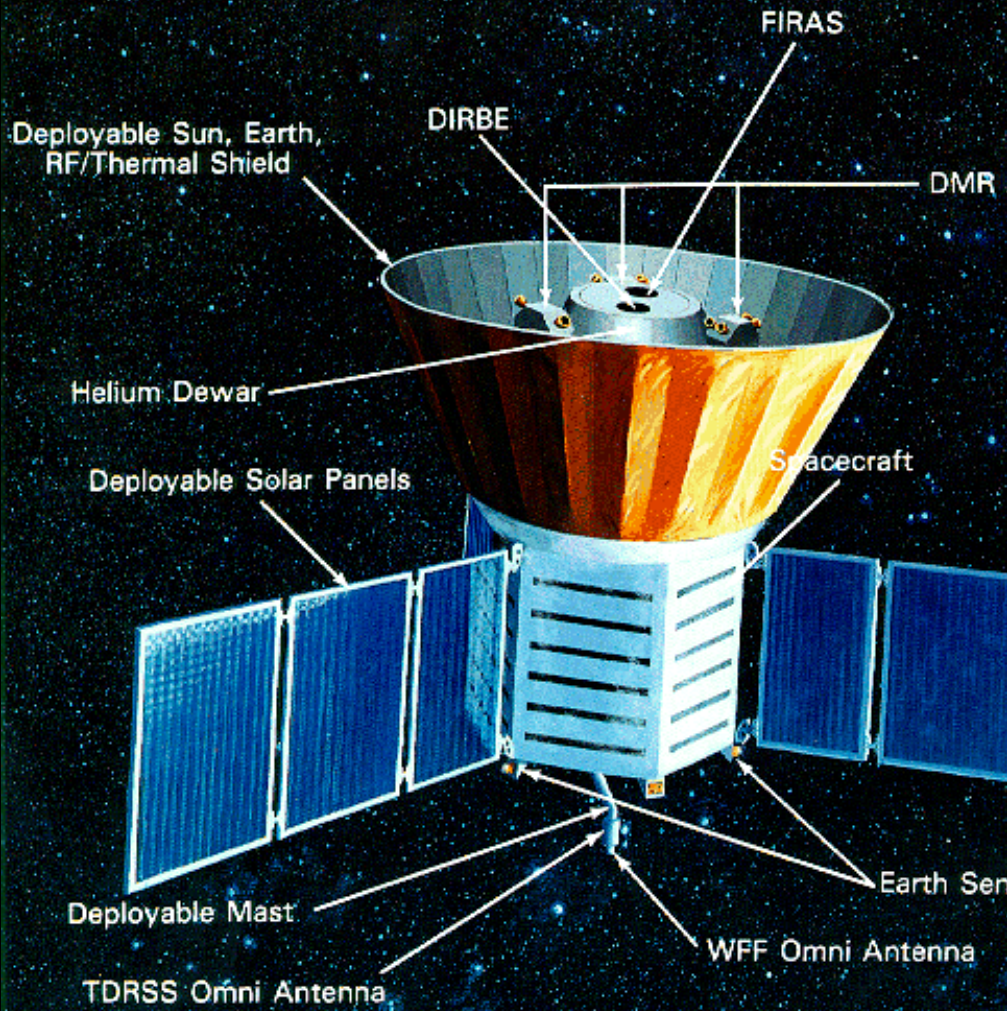
Big-bang nucleosynthesis

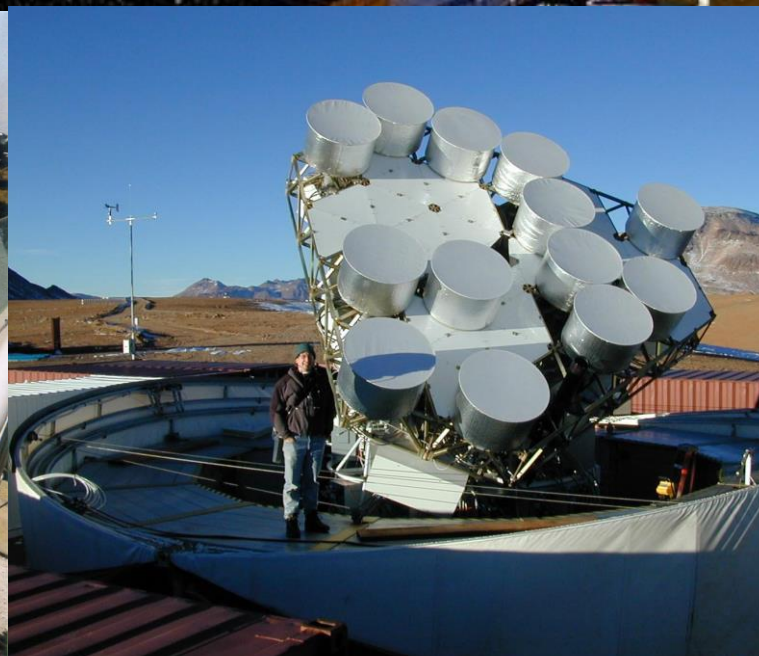
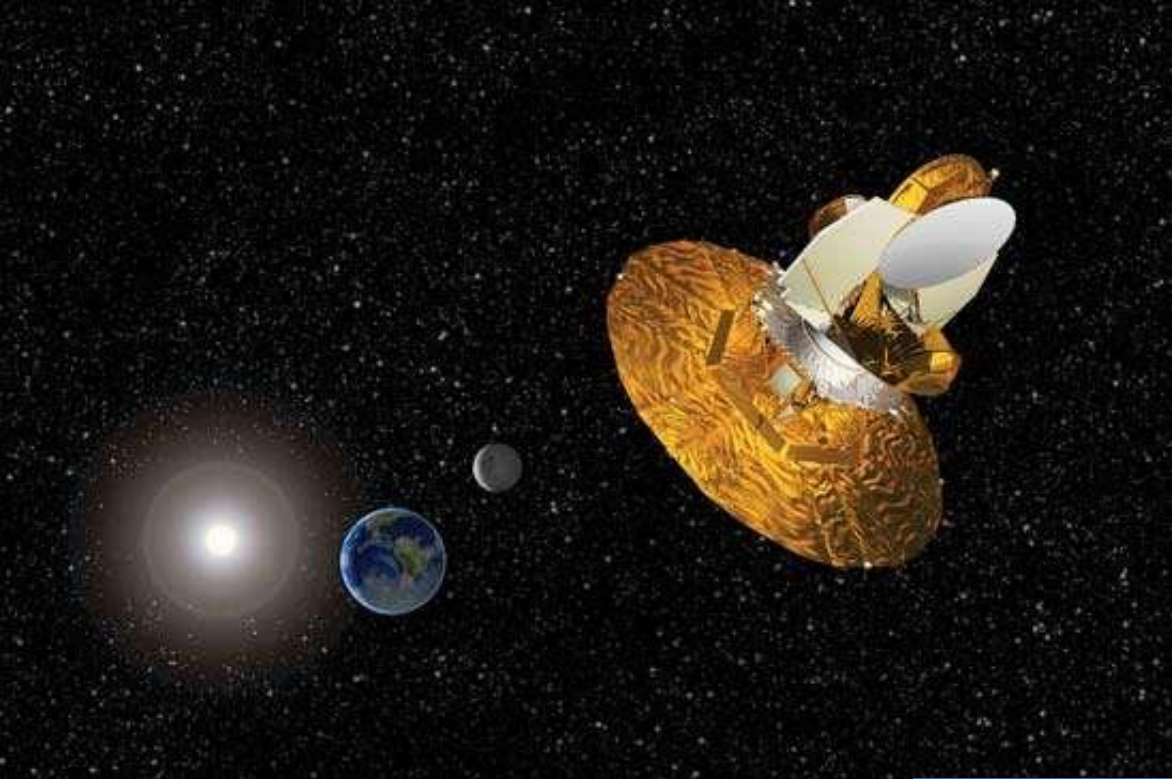


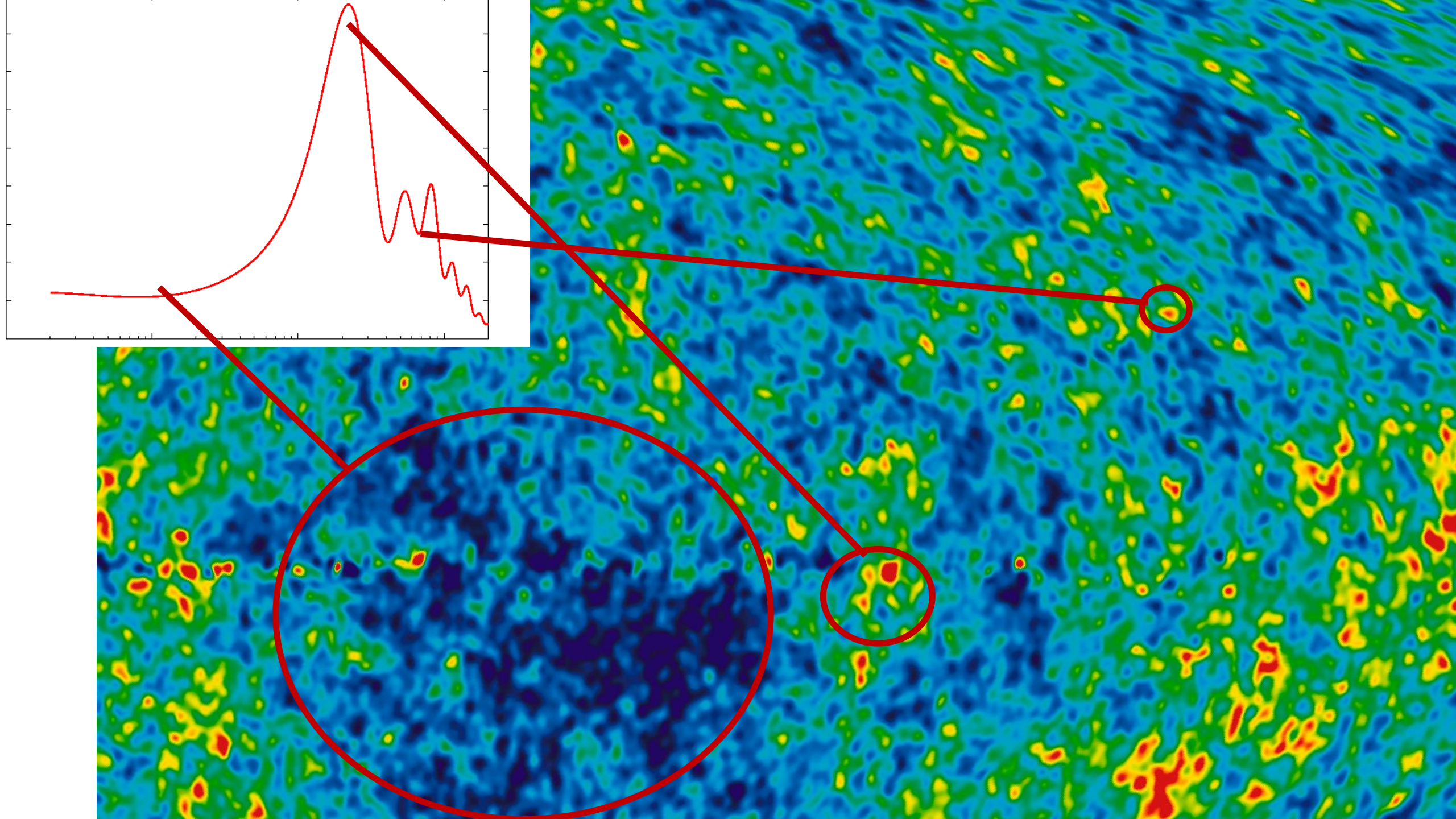


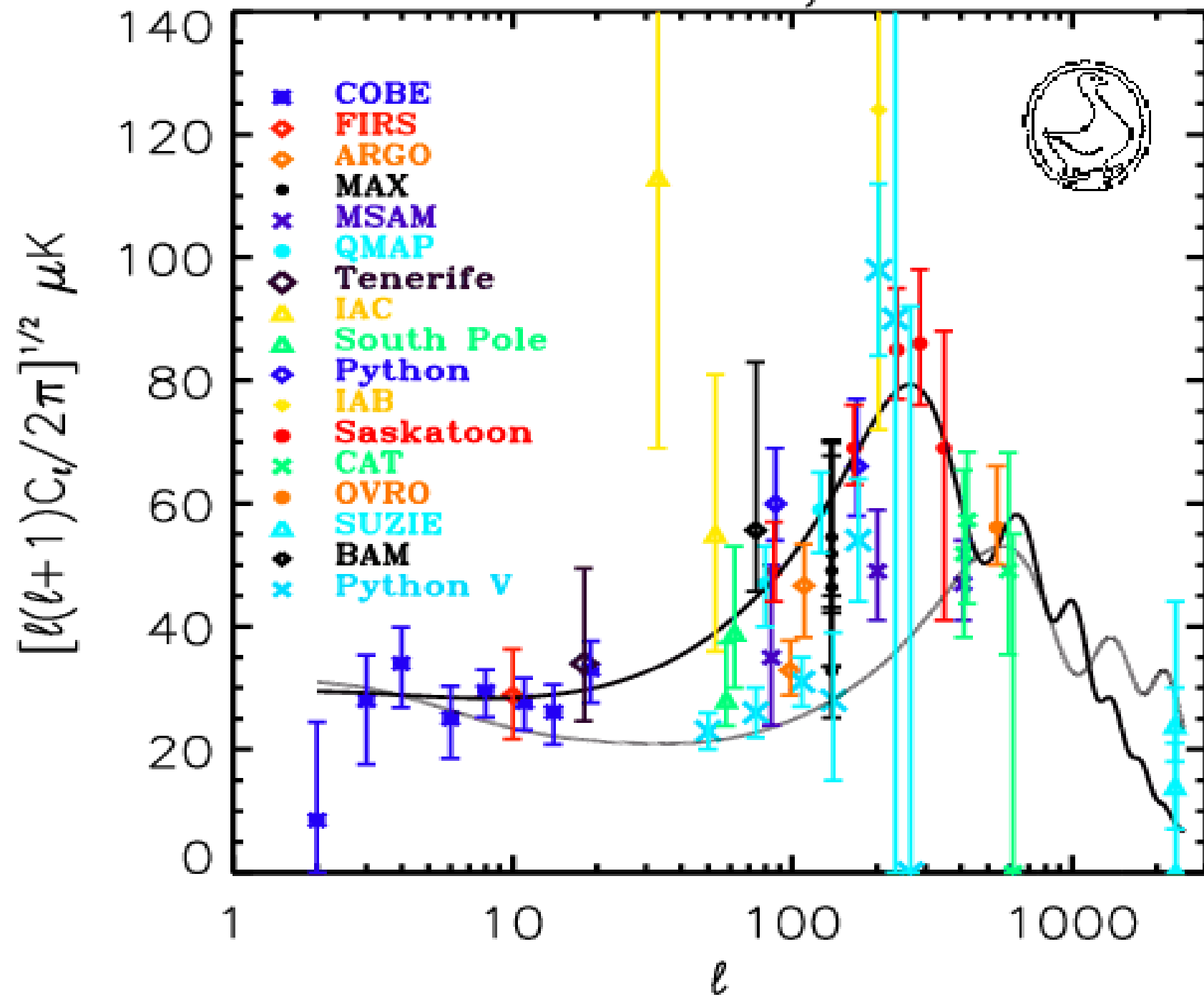
The Cosmic Microwave Background

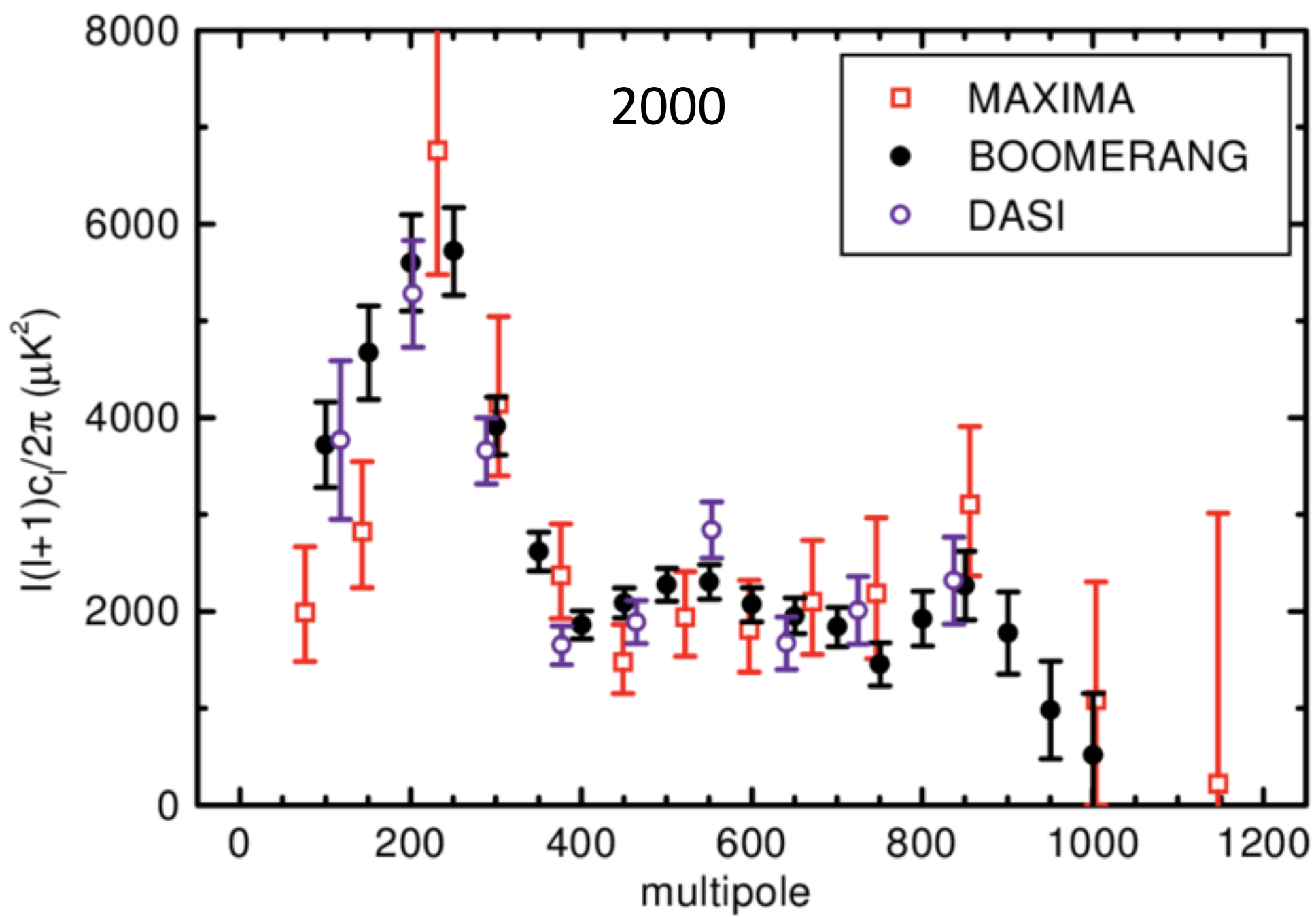




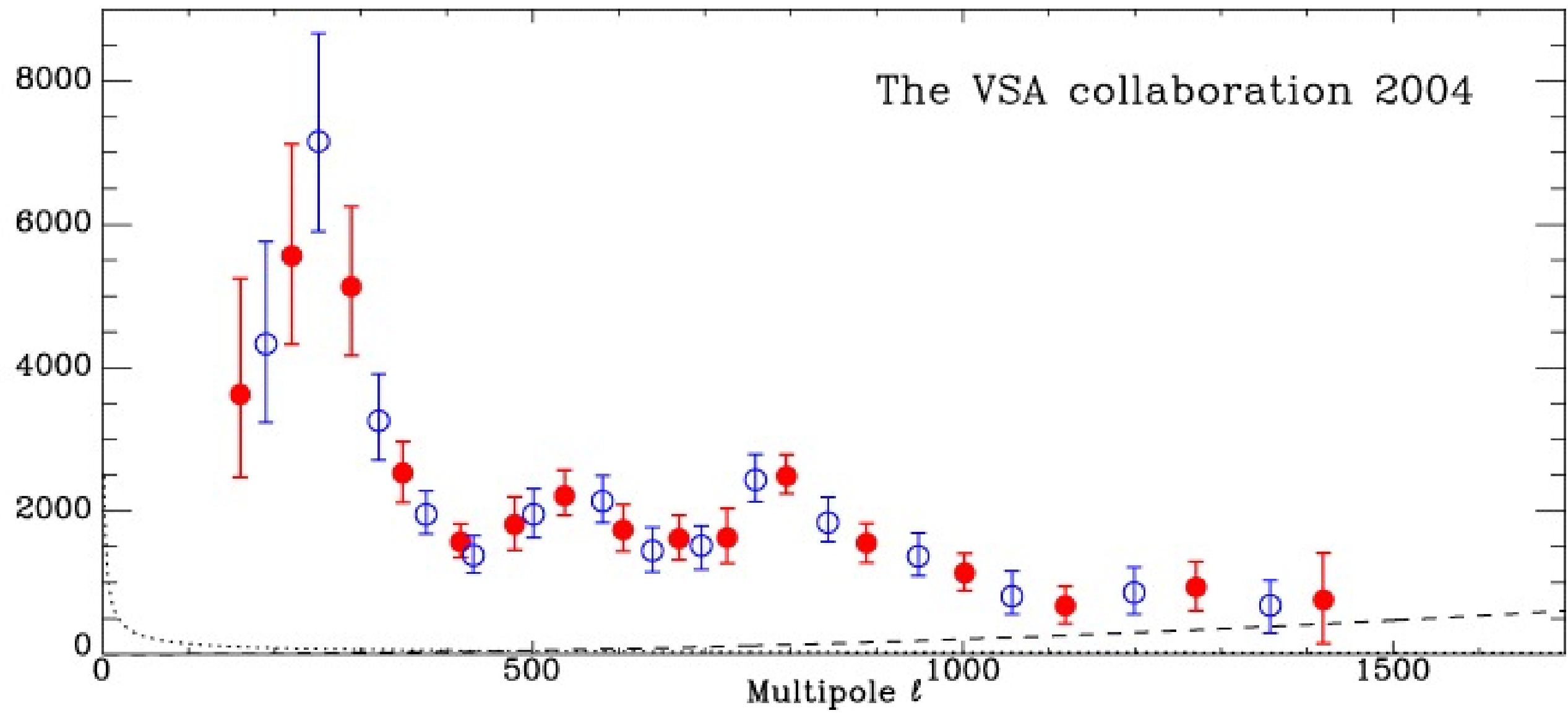


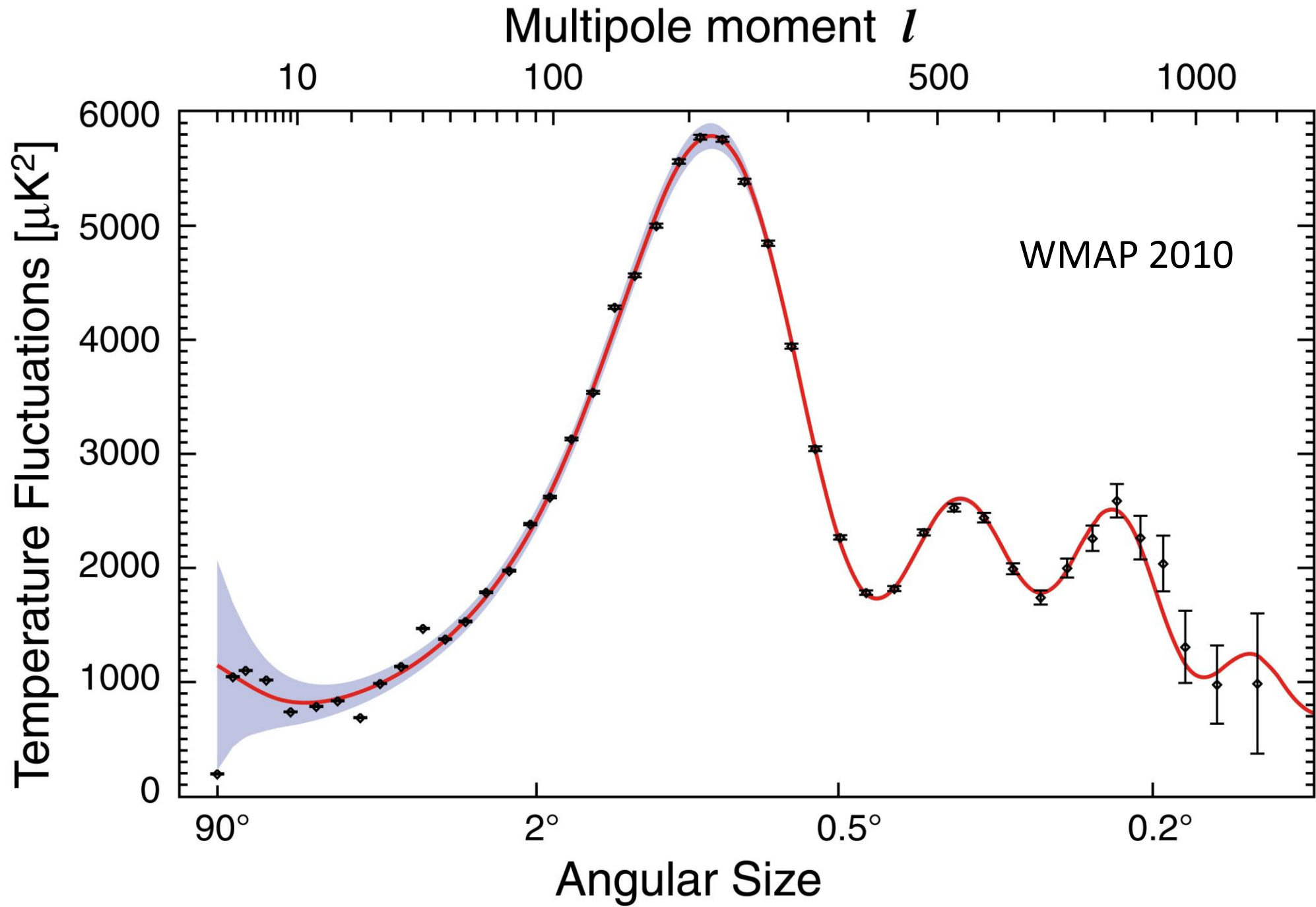


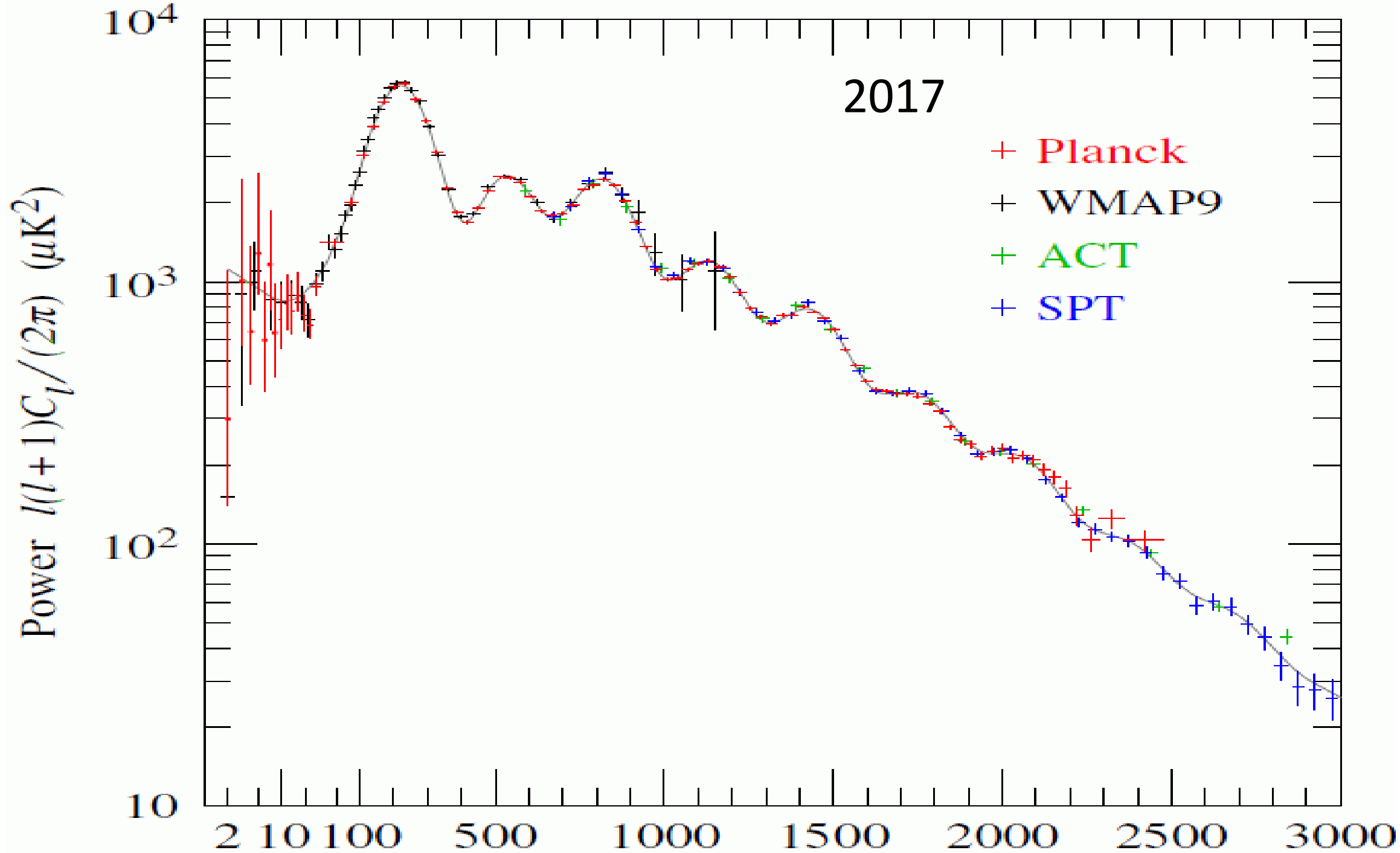




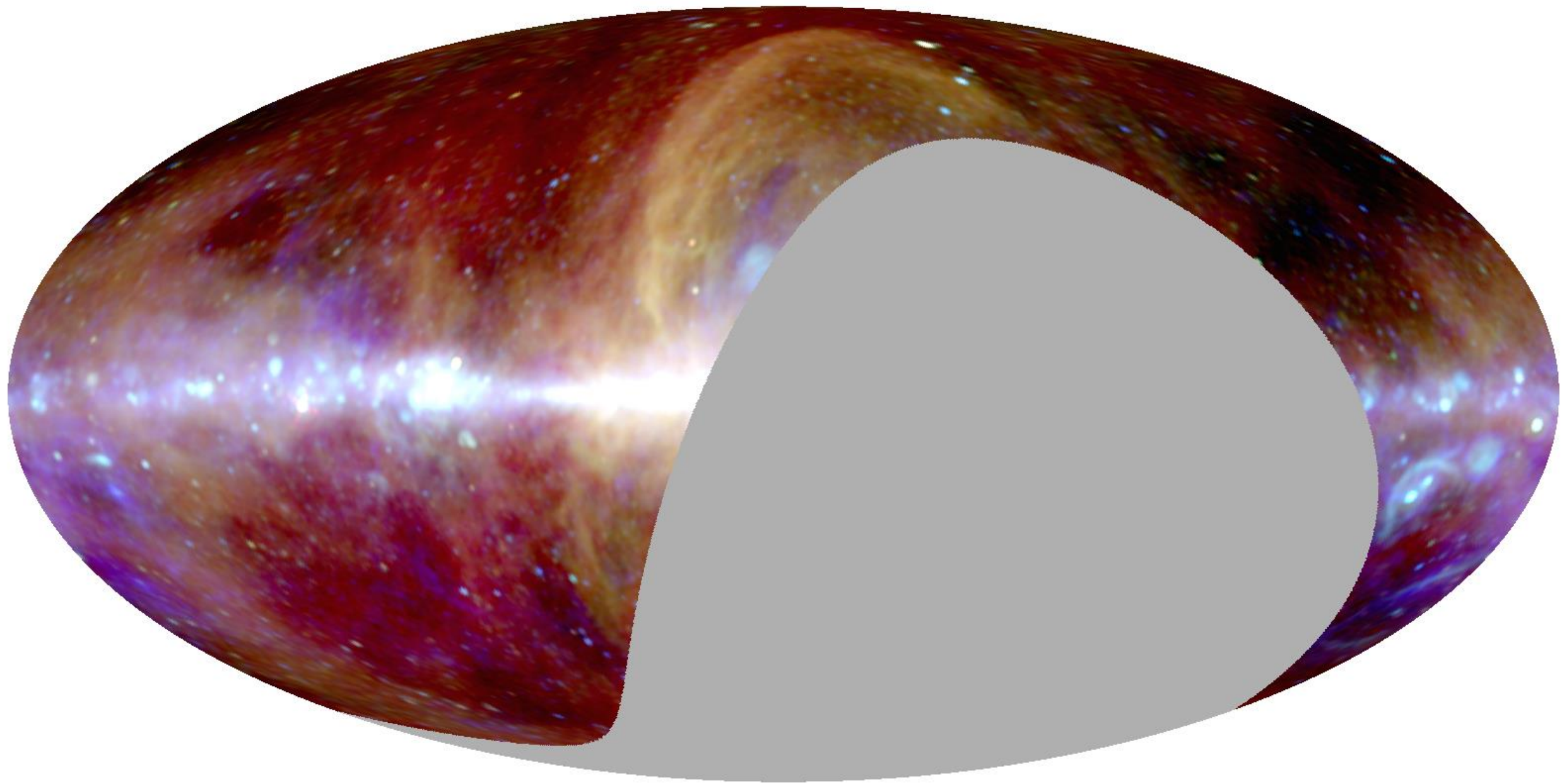
The VSA collaboration 2004



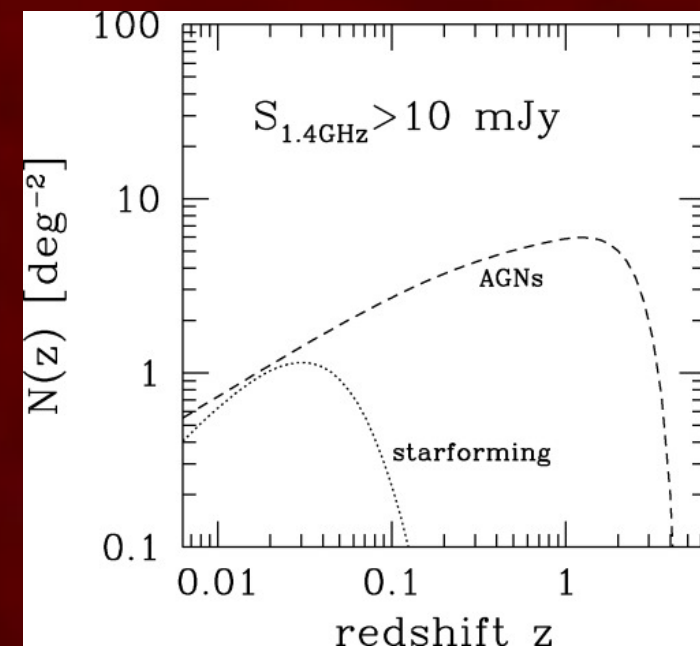




Radio Source Counts







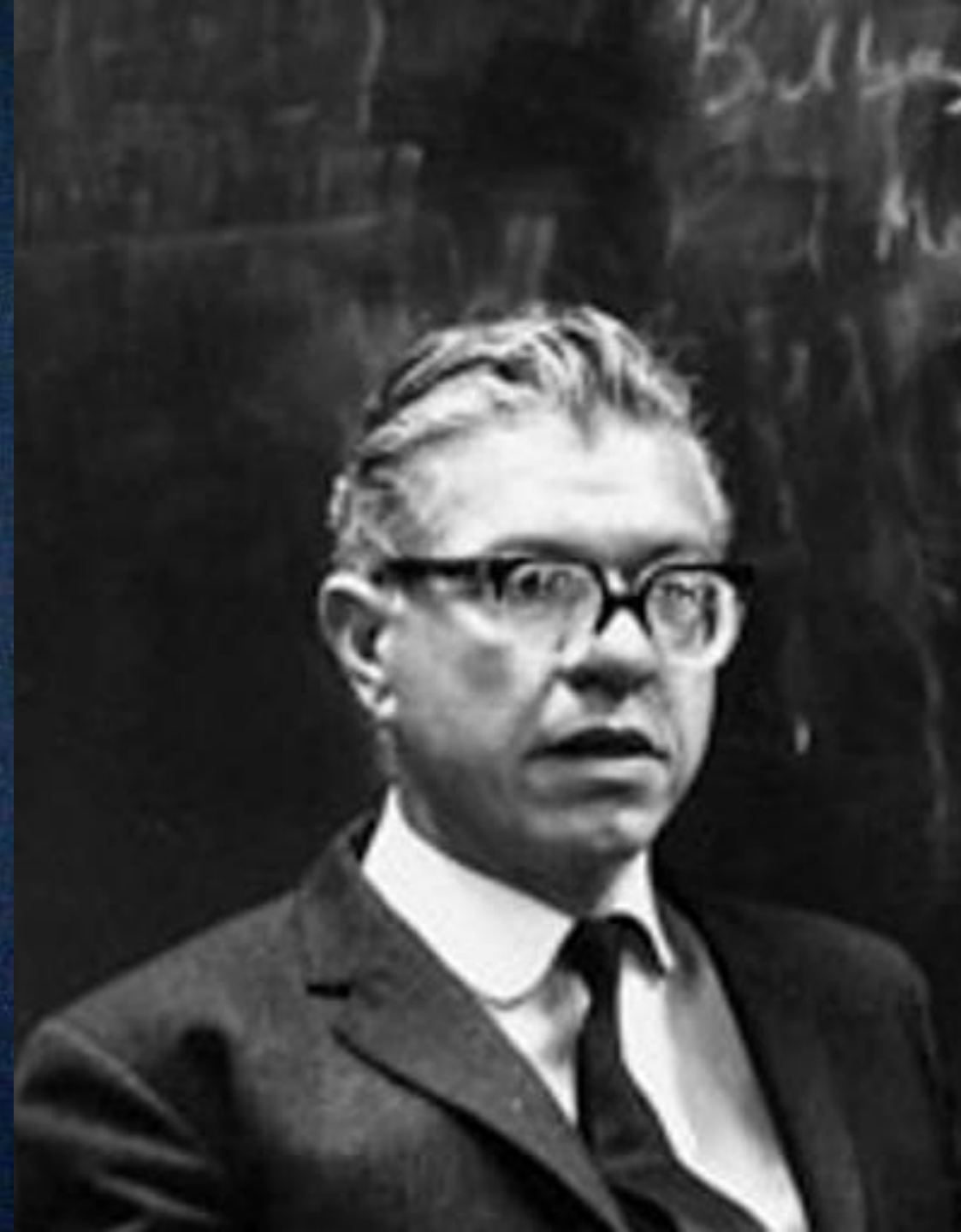
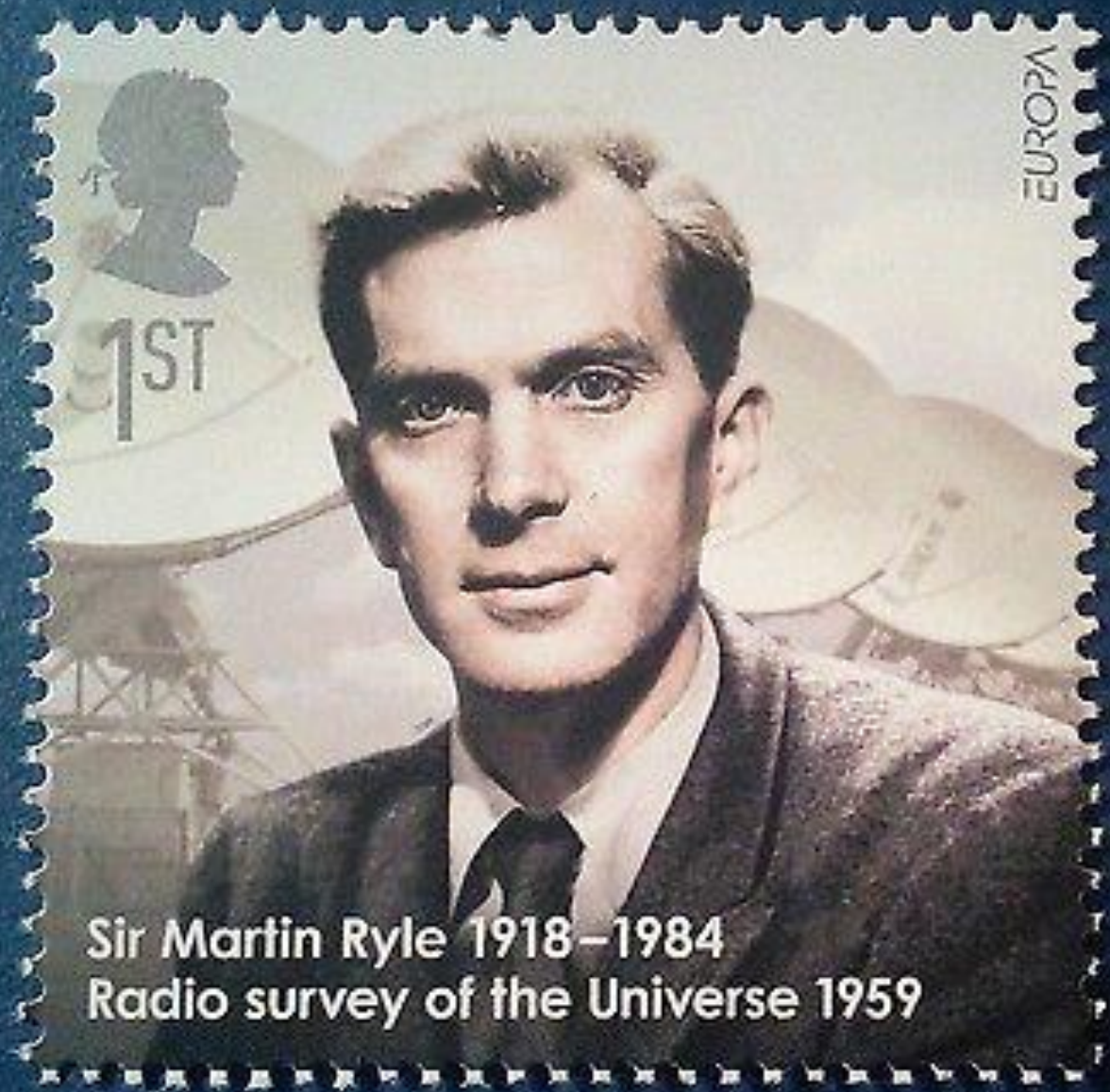
Euclidean Source Counts

- Consider a non-expanding universe with Euclidean geometry (ie angles of a triangle add up to 180 degrees)
- If the distribution of intrinsic power of radio sources $F(P) dP$ is constant with time, ie the Universe is not evolving...
- The observed flux density of sources will be

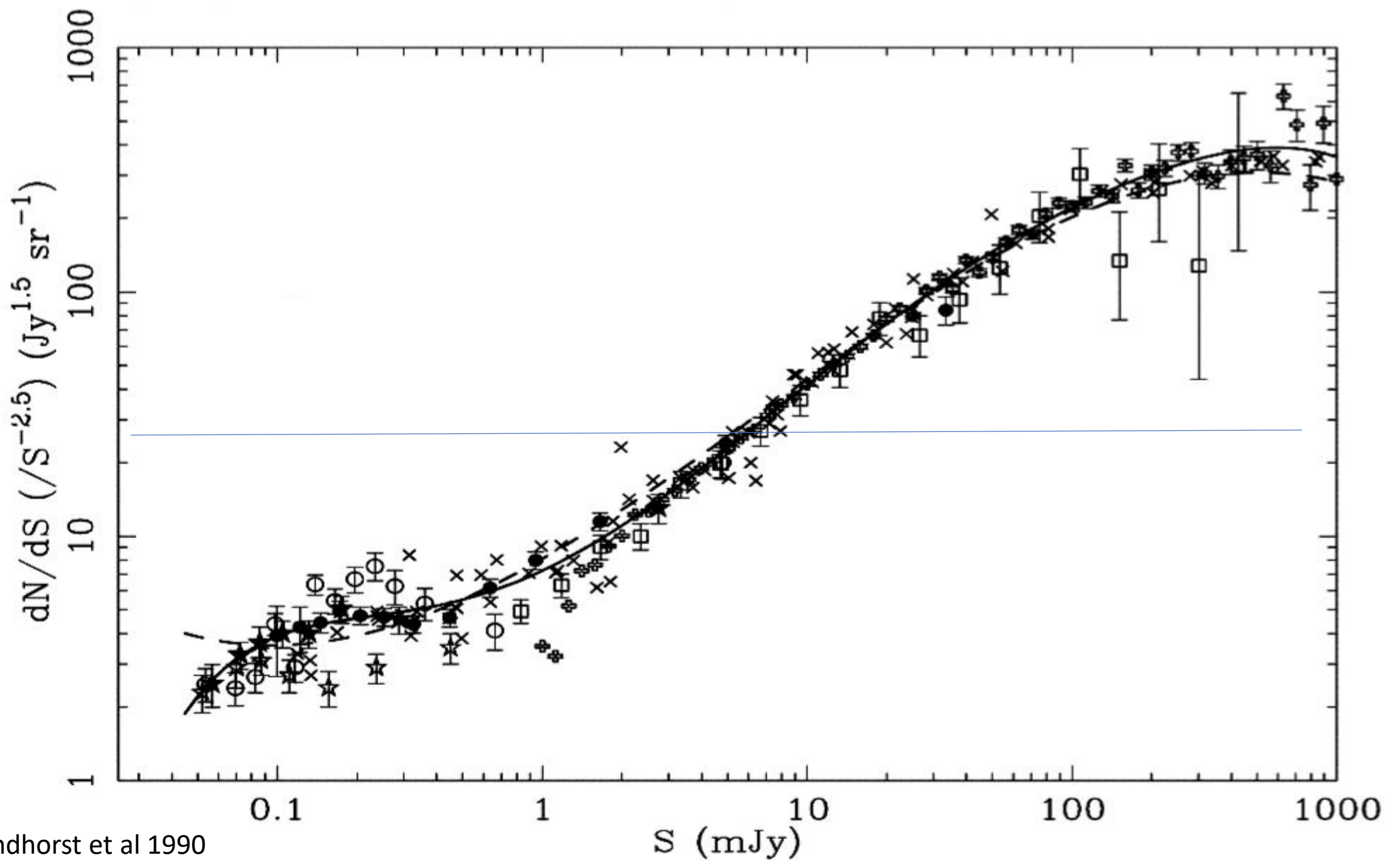
$$N(S) dS = K S^{-5/2}$$

whatever $F(P)$ is.

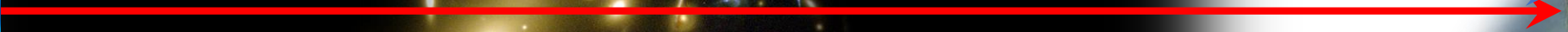
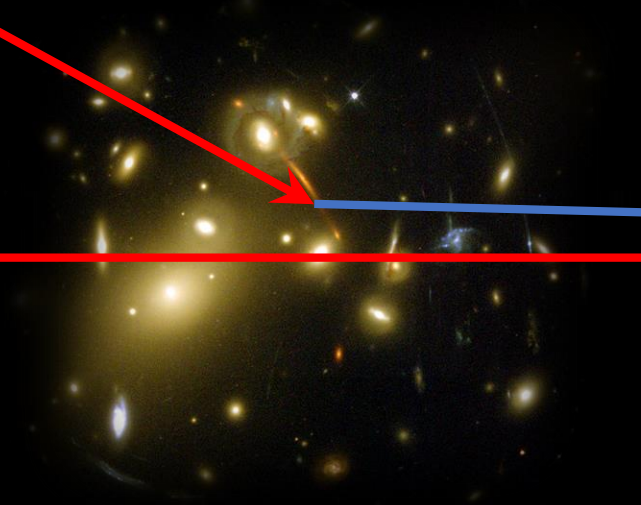
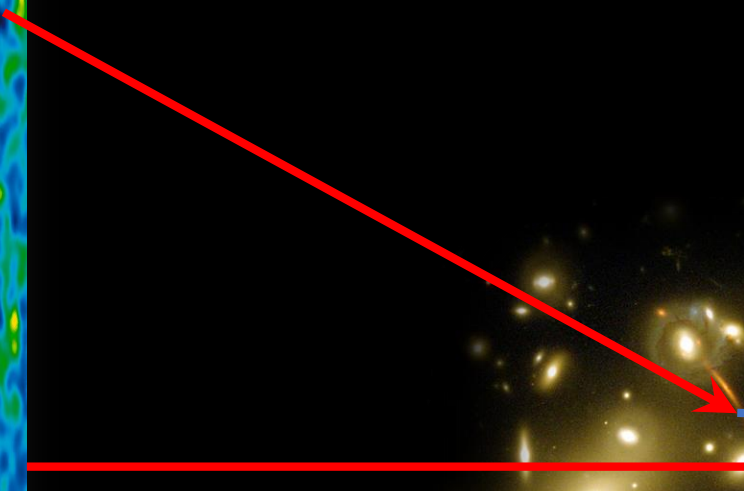
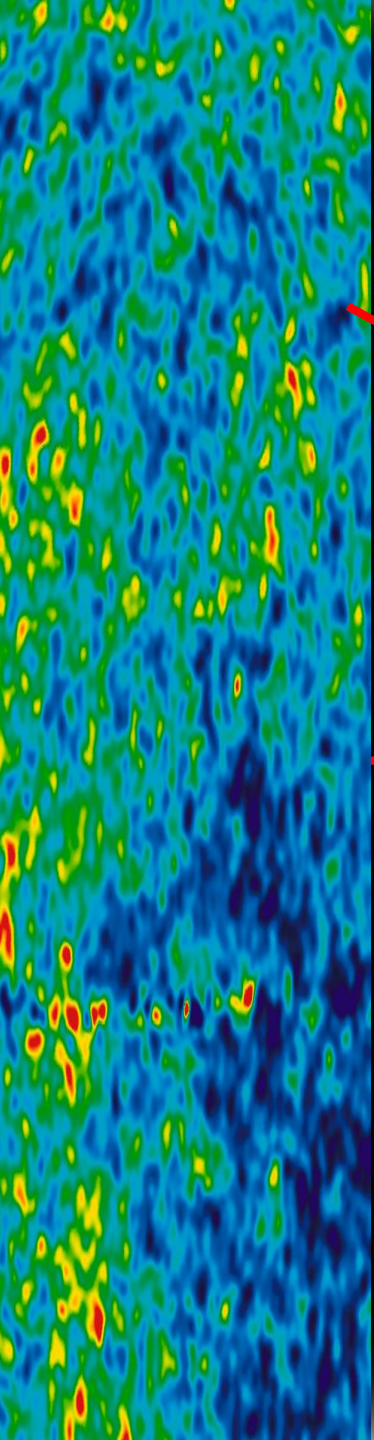
- This is a test of the eternal, non-evolving Universe theory, eg the Steady-State theory

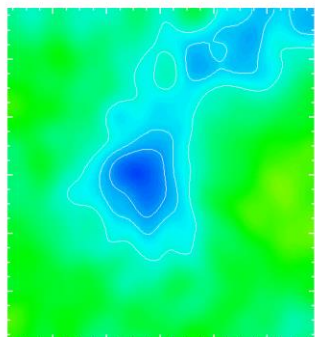
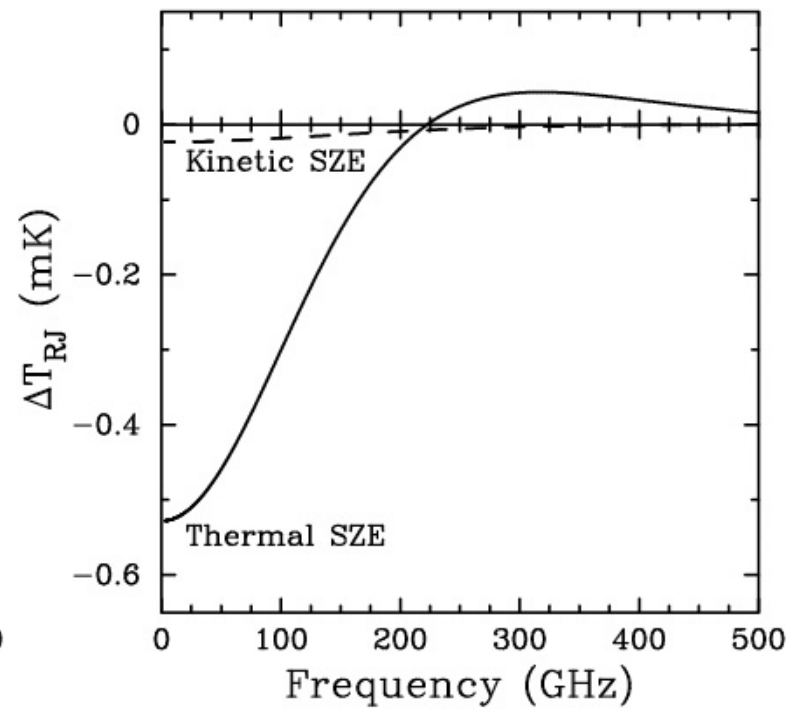
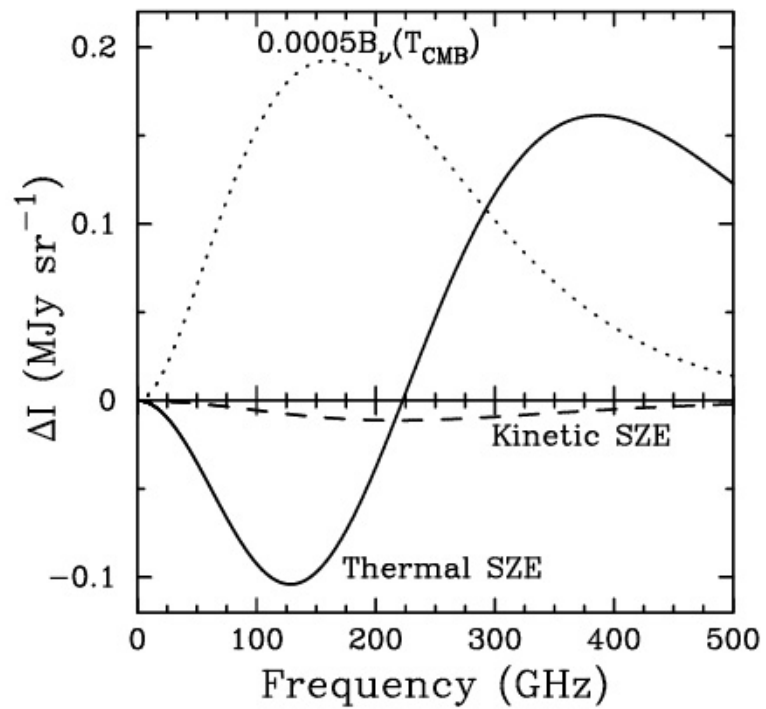




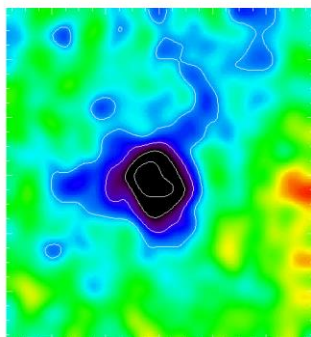


The Sunyaev – Zel'dovich effect

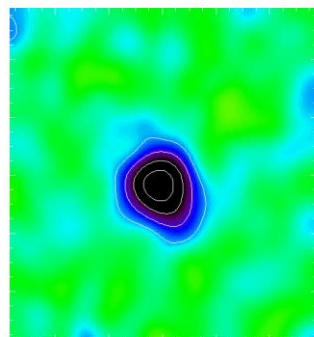




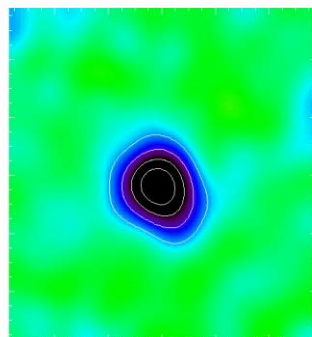
44 GHz



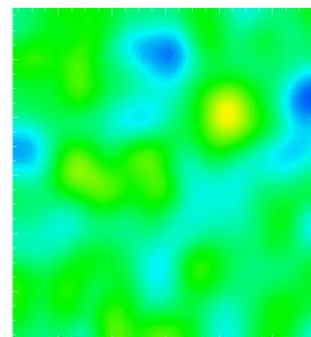
70 GHz



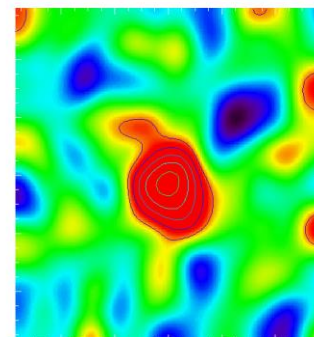
100 GHz



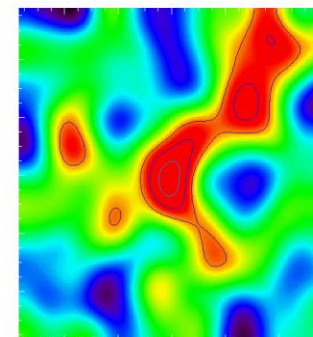
143 GHz



217 GHz



353 GHz

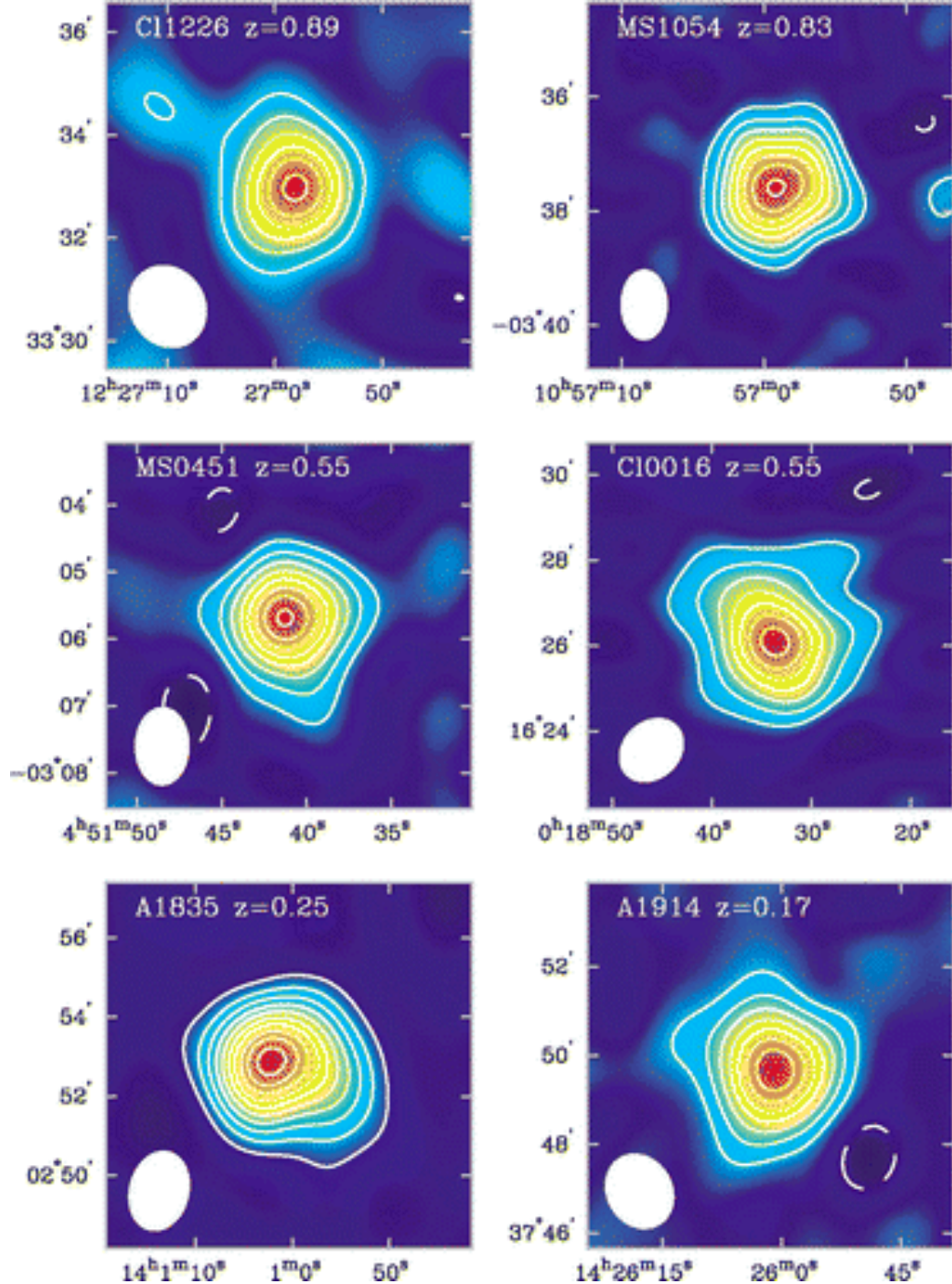


545 GHz

- Surface brightness of S-Z effect depends on energy density of radiation field $U = \sigma T^4$
- Energy density of CMB goes as $(1 + z)^4$:
- $(1 + z)^3$ from space density of photons
- $(1 + z)$ from redshift decrease in photon energy
- Surface brightness of all objects in expanding universe goes as $(1 + z)^{-4}$ (constant in non-expanding universe)

Prediction: redshift dependence of SZ effect is $(1+z)^4 (1+z)^{-4} = \text{constant!}$

- Six clusters at redshifts 0.17 to 0.89
- Similar physical properties
- Look exactly the same!
- Ordinary luminous objects would vary in brightness by a factor of 7 over this redshift range.
- Thousands of clusters now detected in SZ effect.



So if anyone says to you they don't believe in the Big Bang, ask them:

“How do *you* explain

- The redshift – distance relationship for galaxies?
- The cosmic microwave background?
- The cosmic abundance of deuterium, helium and lithium-7?
- The slope of the radio source counts?
- The redshift independence of the Sunyaev – Zel'dovich effect?”