Story of the Universe

Dr. Jayanti Prasad
Physicist/Data Scientist

https://jayanti-prasad.github.io/

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Govt. PG. College New Tehri (Uttarakhand)

Nobel prize in Physics (cosmology)

1. Arno Allan Penzias & Robert Woodrow Wilson (1978)

“for their discovery of cosmic microwave background radiation”

2. John C. Mather & George F. Smoot (2006)

"for their discovery of the blackbody form and anisotropy of the cosmic microwave background radiation"

3. Brian P. Schmidt & Adam G. Riess (2011)

"for the discovery of the accelerating expansion of the Universe through observations of

4. James Peebles [with Michel Mayor andMichel Mayor] (2019)

"for theoretical discoveries in physical cosmology"

Things everyone should know about the Universe !

1. The universe is very big !

2. The universe is expanding

3. The size and age of the universe is finite

4. The universe was hotter, smaller and denser in the past

5. Most of the universe is made of Dark matter & dark Energy

Size of the Universe

In the beginning of 20th century it was not clear how big the universe was .

In 1920 it was known that apart from stars and planets there are objects in sky Which are fuzzy and were called ‘nebulae’

There were two thoughts of schools about these nebulae.

A debate was held between two leading authorities Shapley & Curtis about the Of nebulae and size of the universe.

Shapley believed that distant nebulae were relatively small and lay within the outskirts of Earth's home galaxy.

Curtis held that they were in fact independent galaxies, implying that they were exceedingly large and distant.

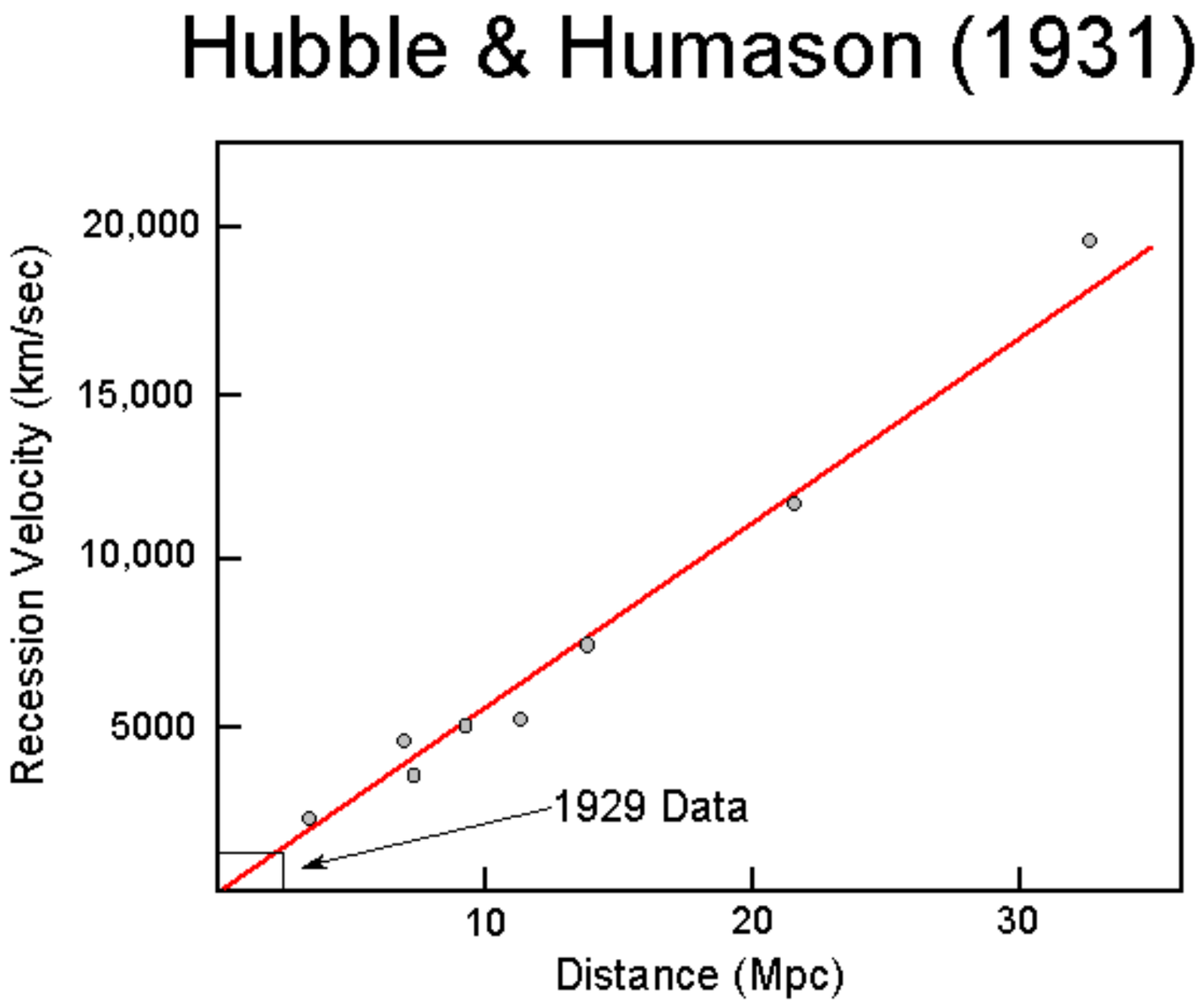
Curtis won the debate !

Expansion of the universe

The man who told the universe is expanding.

Edwin Hubble
(1889 –1953)

Hubble provided evidence that the recessional velocity of a galaxy increases withIts distance from the Earth, a property now known as "Hubble's law".

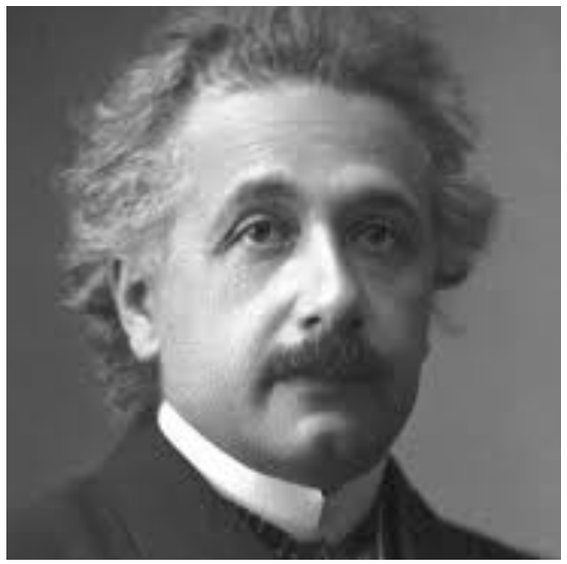


$1Mpc = 3.08 \times 10^{19} Km$

Hubble expansion

Origin of the universe

Einstein's general theory of Relativity which he proposed in 1917 could be used to explain the expansion of the universe.



Albert Einstein
(1879-1955)

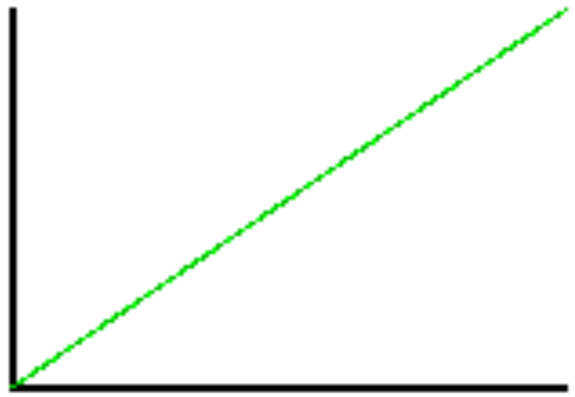
Assuming a universe that was static in time, and possessed of a uniform distribution of matter on the largest scales, Einstein was led to a finite, static universe of spherical spatial curvature.

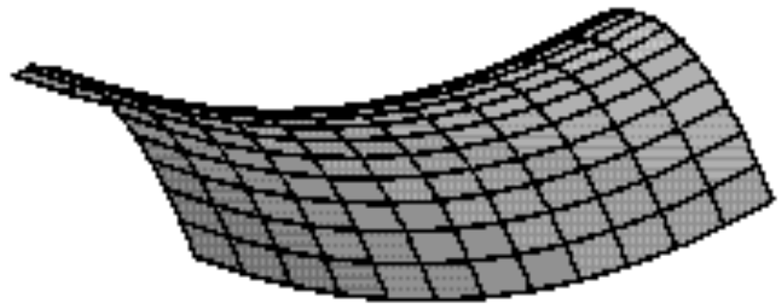
Georges Lemaître first noted in 1927 that an expanding universe could be traced back in time to an originating single point, scientists have built on his idea of cosmic expansion.

Einstein de-Sitter Model

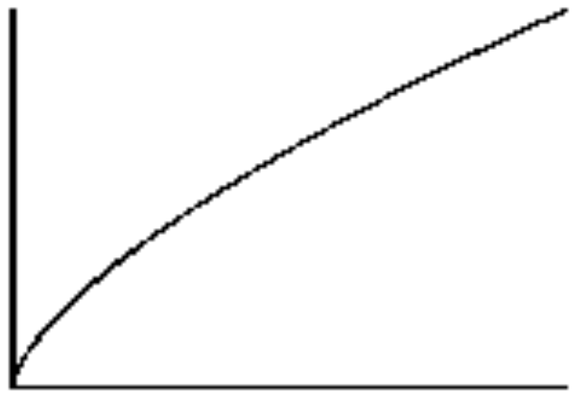
An expanding universe can have one of the following three “spatial geometries” on the basis of the energy density it has :

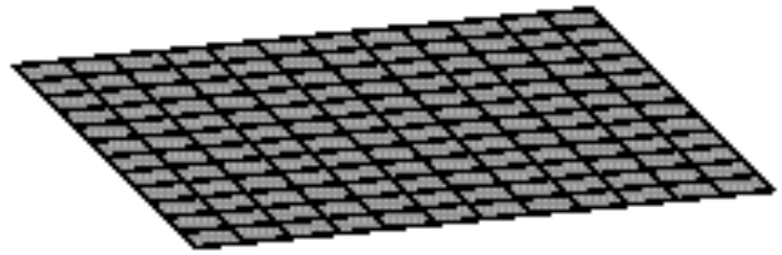
Flat	density = critical density
Open	density < critical density
Close	density > critical density



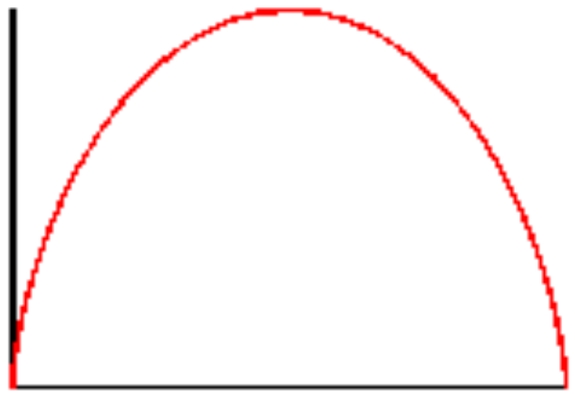


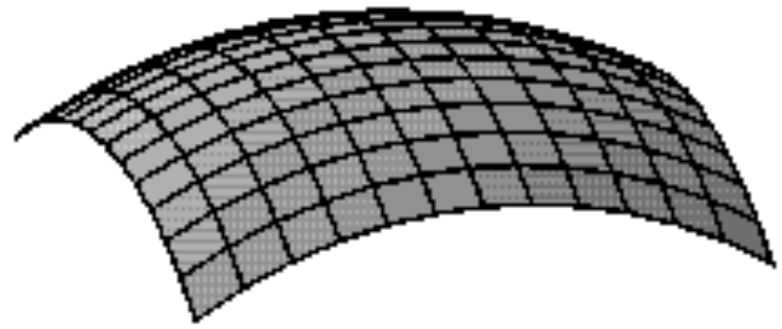
Open





Flat

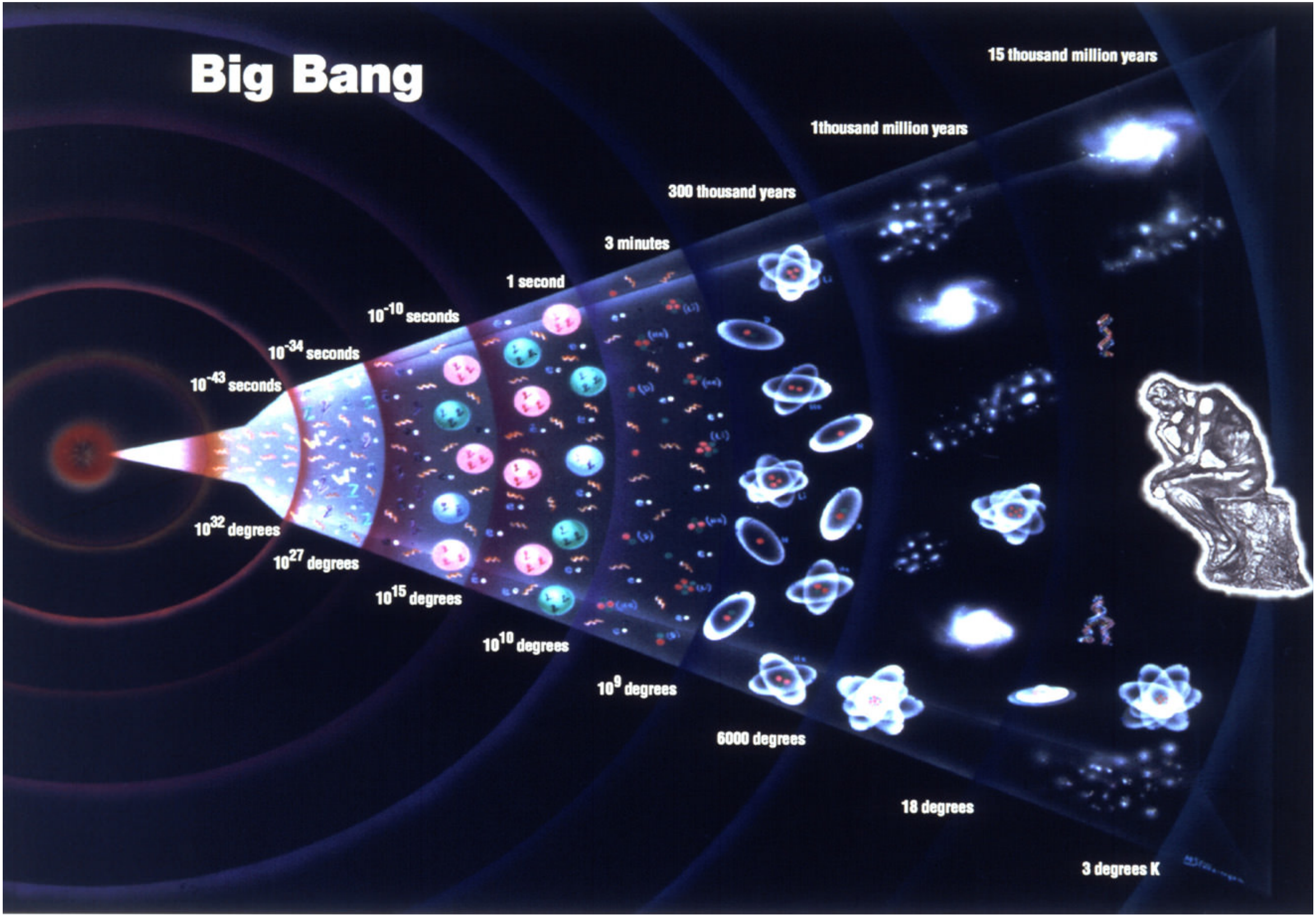


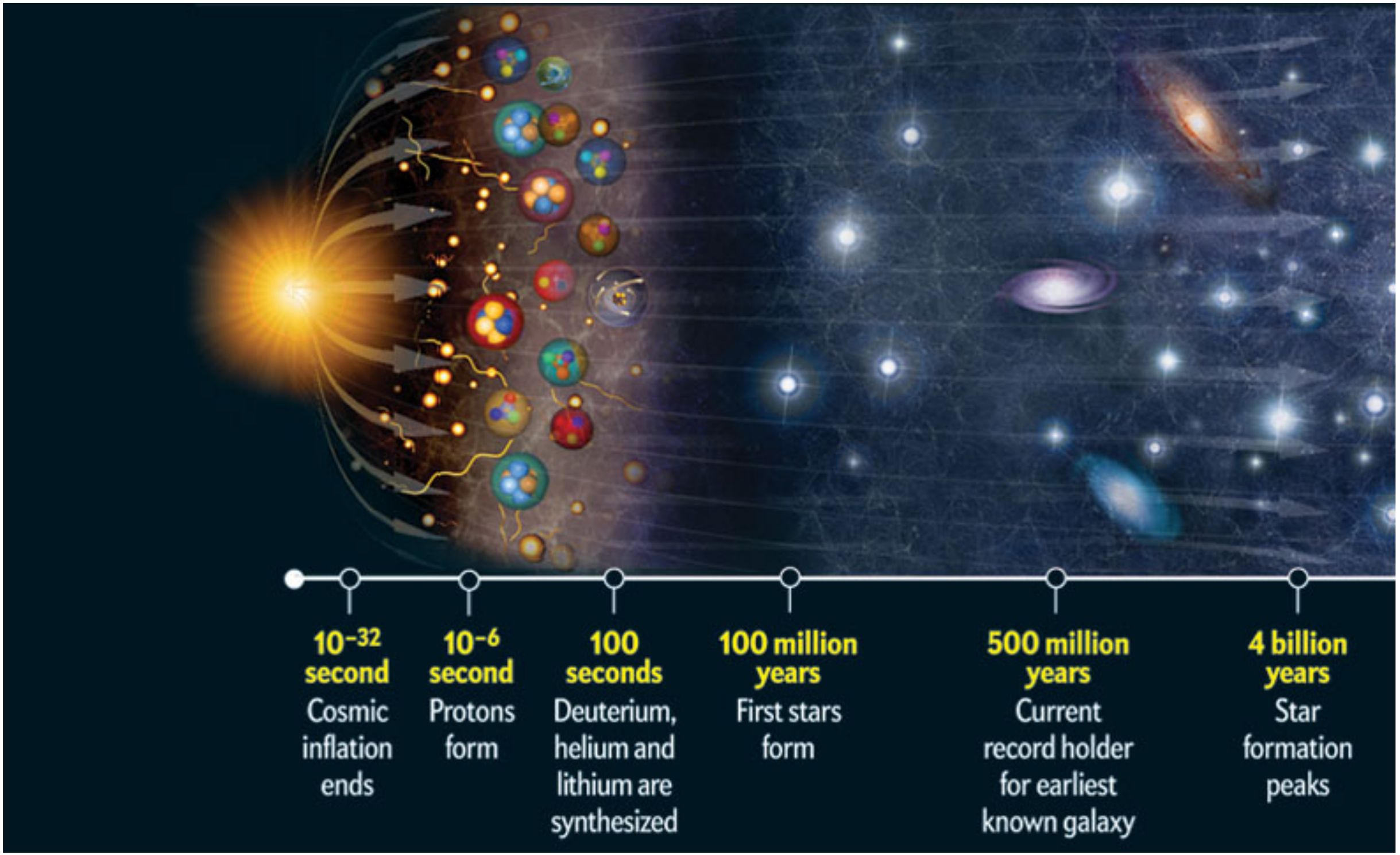


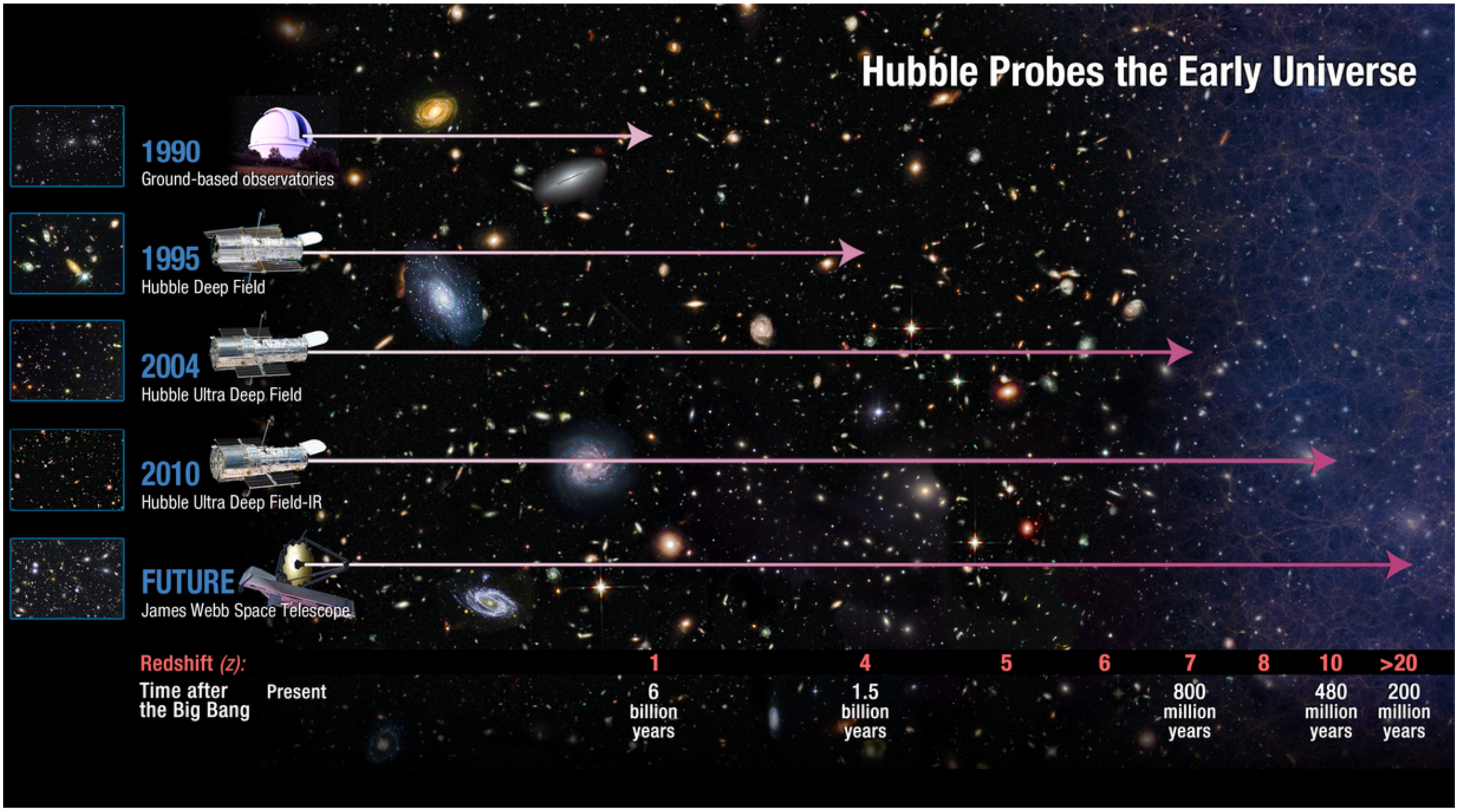
Close

Geometry of the universe

The Early Universe




10⁻³² second
Cosmic inflation ends
10⁻⁶ second
Protons form
100 seconds
Deuterium, helium and lithium are synthesized
100 million years
First stars form
500 million years
Current record holder for earliest known galaxy
4 billion years
Star formation peaks


Hubble Probes the Early Universe
1990
Ground-based observatories
1995
Hubble Deep Field
2004
Hubble Ultra Deep Field
2010
Hubble Ultra Deep Field-IR
FUTURE
James Webb Space Telescope
Redshift (z):
1
4
5
6
7
8
10
>20
Time after the Big Bang
Present
6 billion years
1.5 billion years
800 million years
480 million years
200 million years

Big Bang Nucleosynthesis

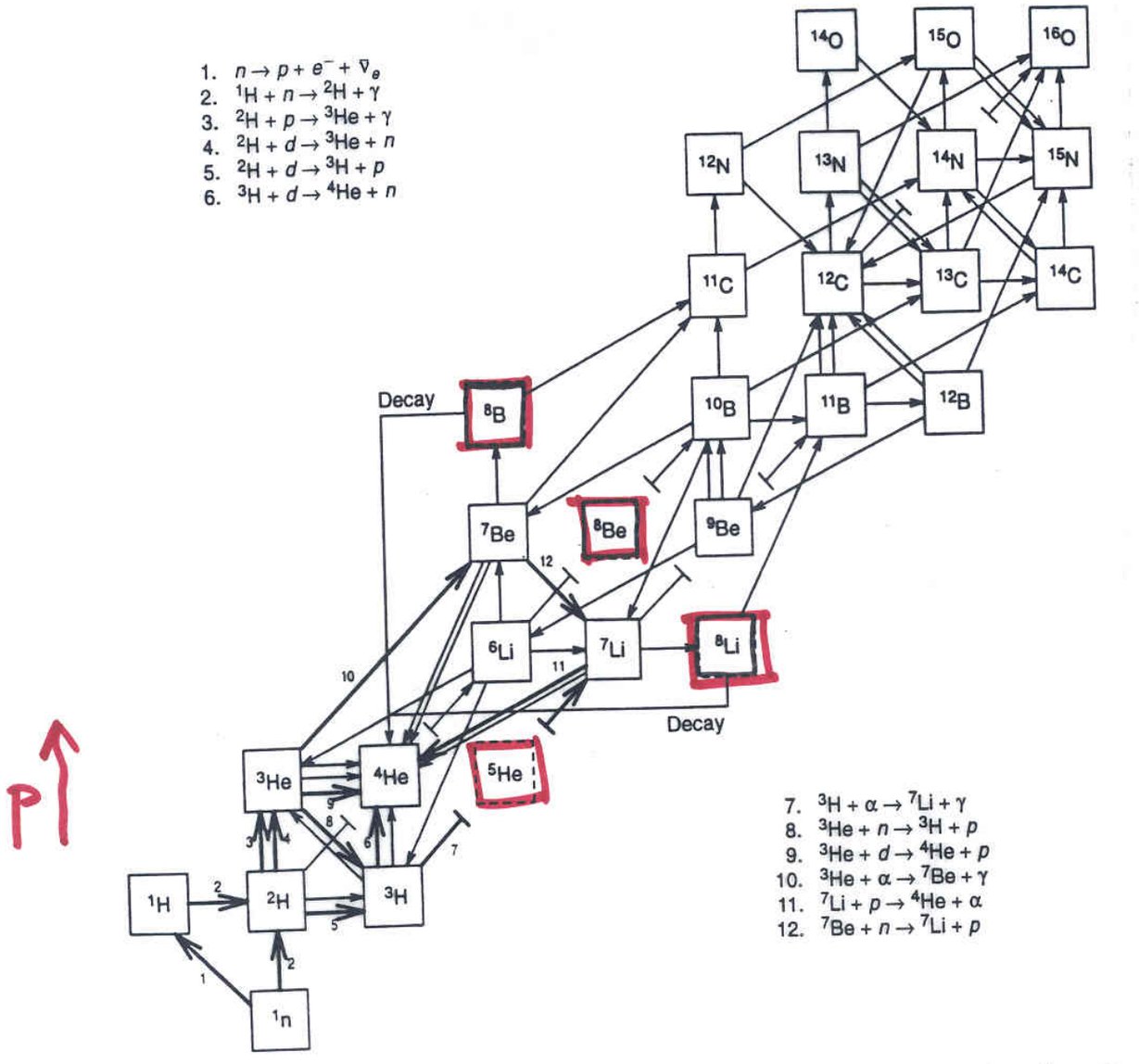
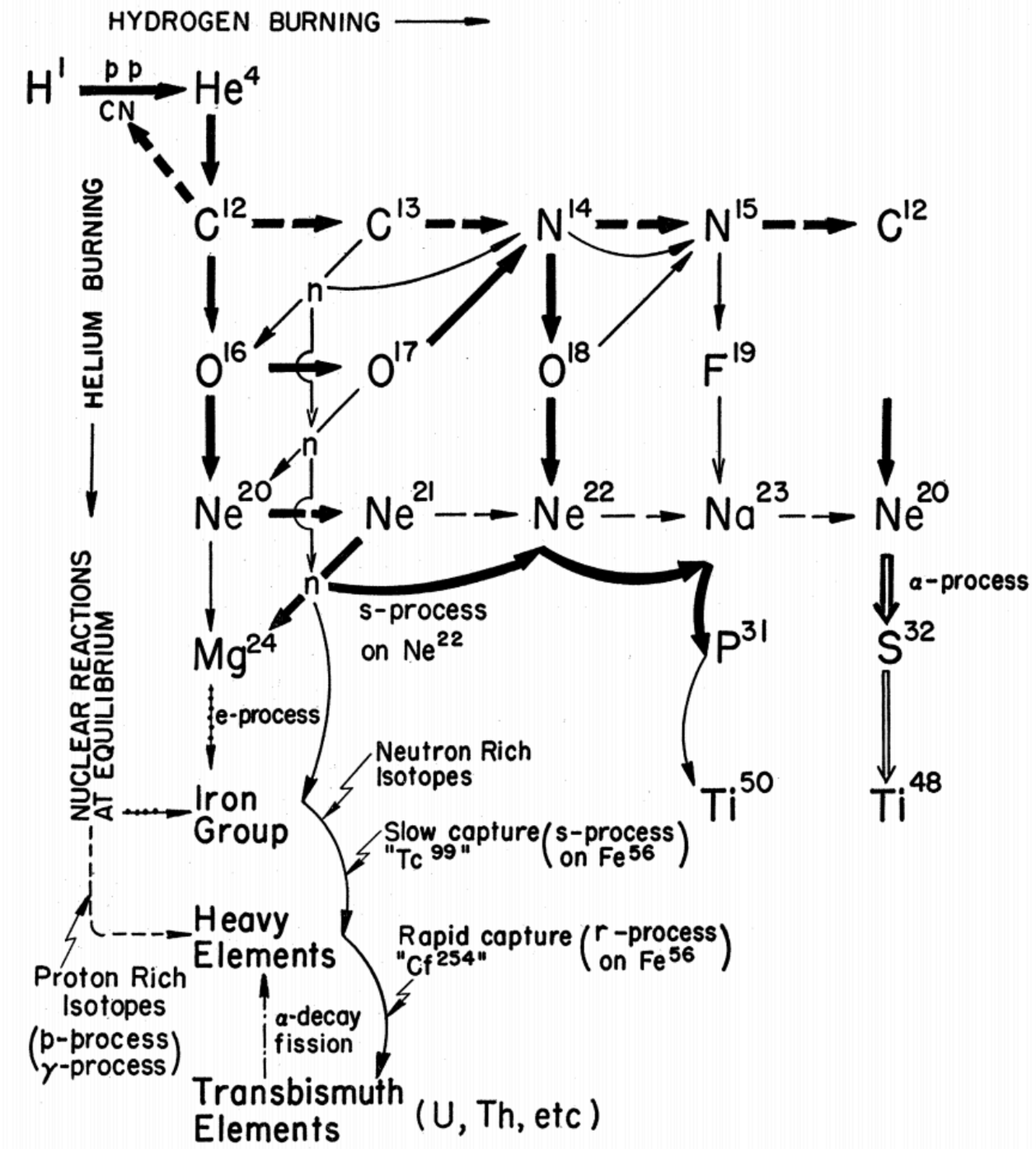
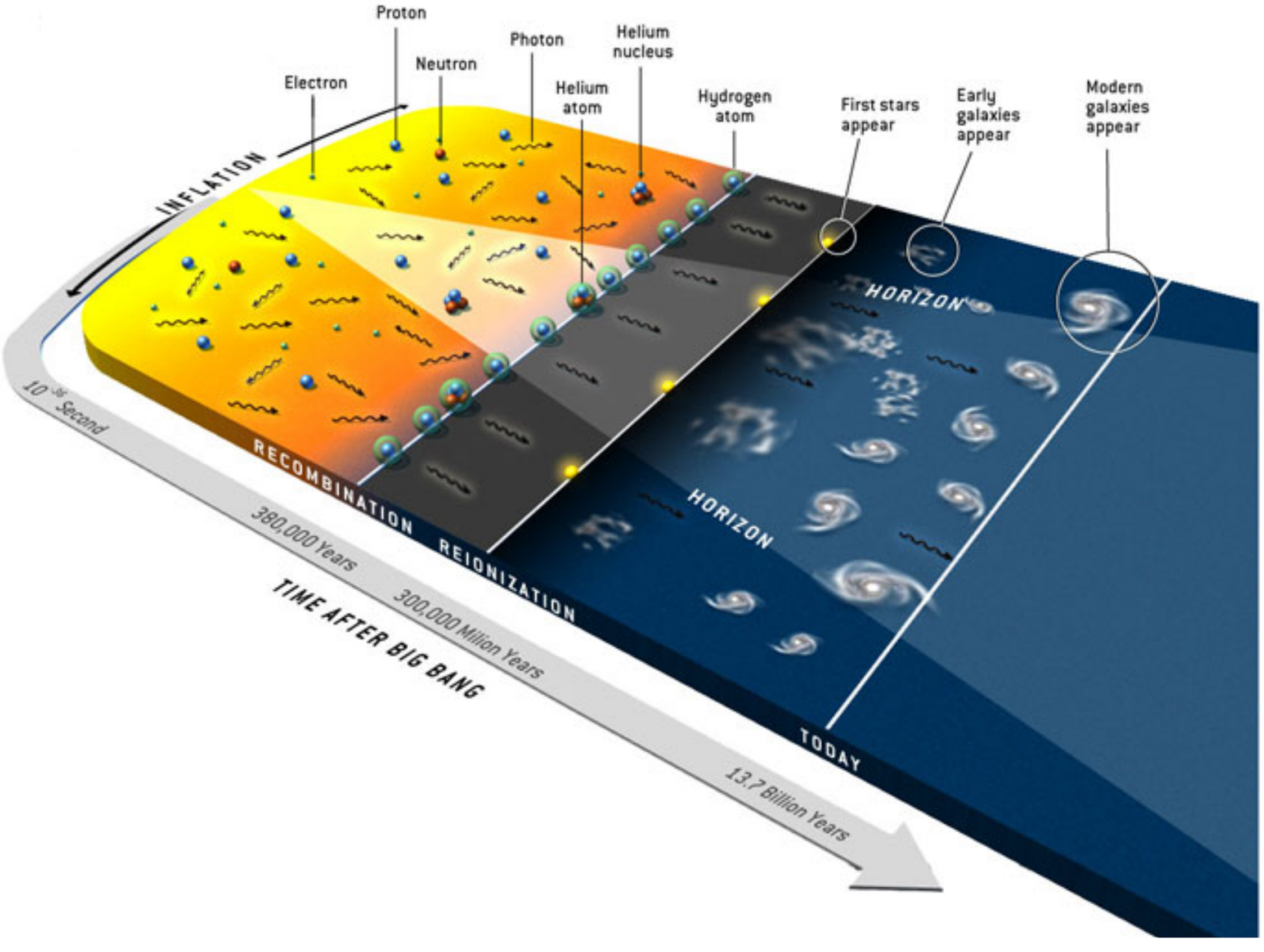


Fig. 2. The nuclear reaction network used for big-bang nucleosynthesis; the most important reactions are numbered and have bold arrows. The broken boxes for mass 5 and 8 indicate that all nuclides of this mass are very unstable.

Big Bang Nucleosynthesis

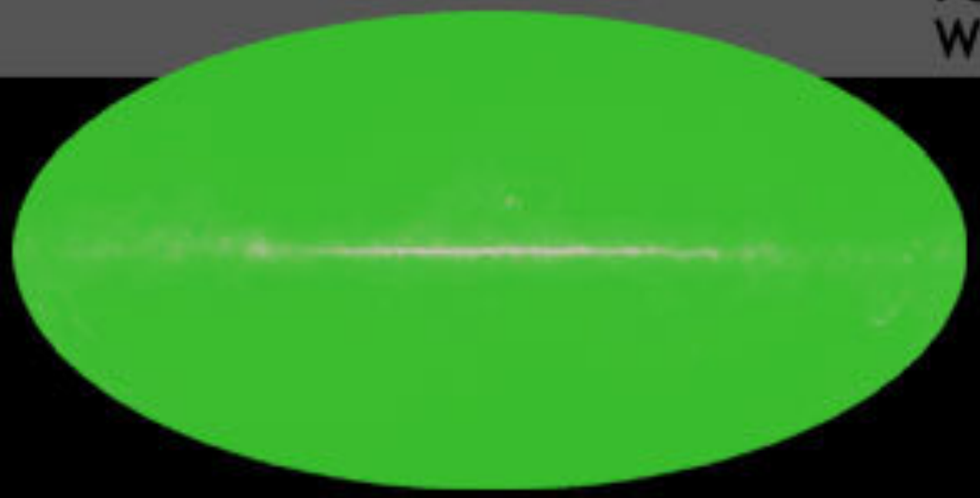
Stellar Nucleosynthesis




Proton
Photon
Helium nucleus
Electron
Neutron
Helium atom
Hydrogen atom
First stars appear
Early galaxies appear
Modern galaxies appear
INFLATION
HORIZON
10⁻³⁶ Second
RECOMBINATION
HORIZON
380,000 Years
REIONIZATION
300,000 Million Years
TIME AFTER BIG BANG
TODAY
13.7 Billion Years

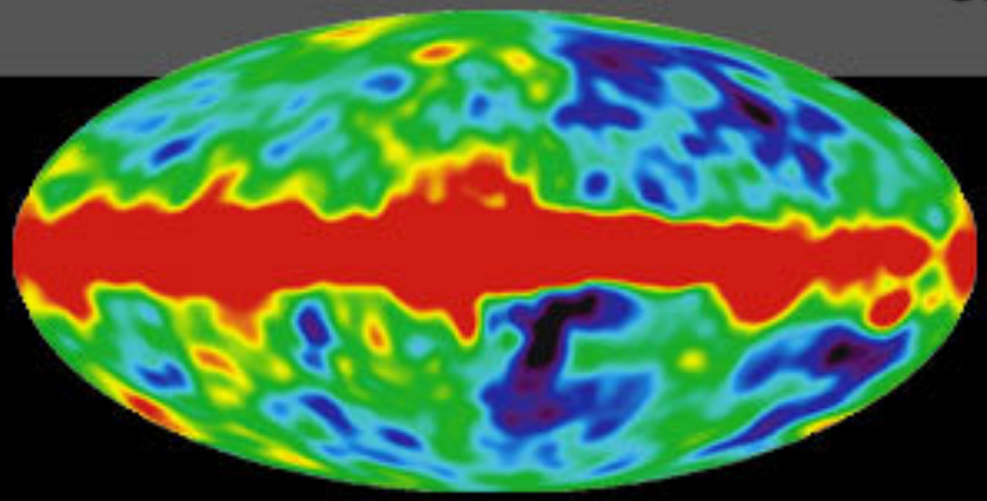
1965

Penzias and Wilson



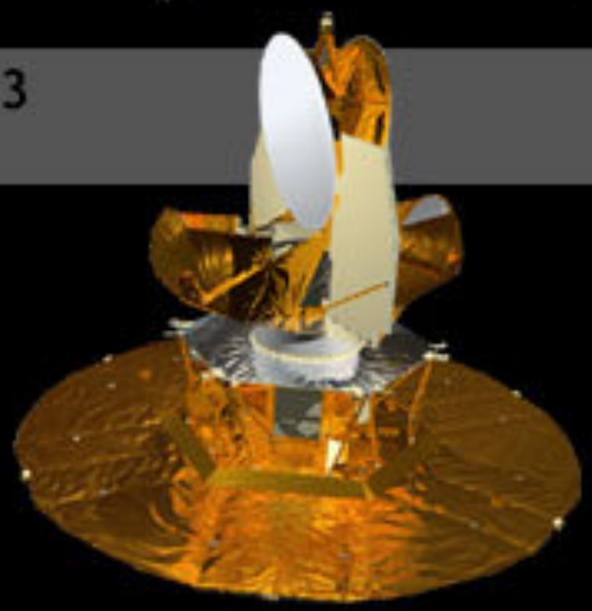
1992

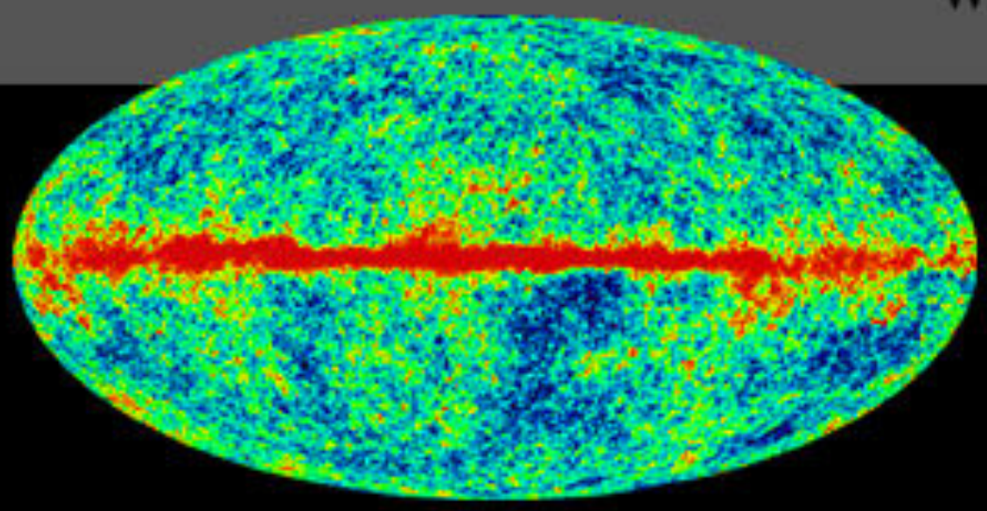
COBE



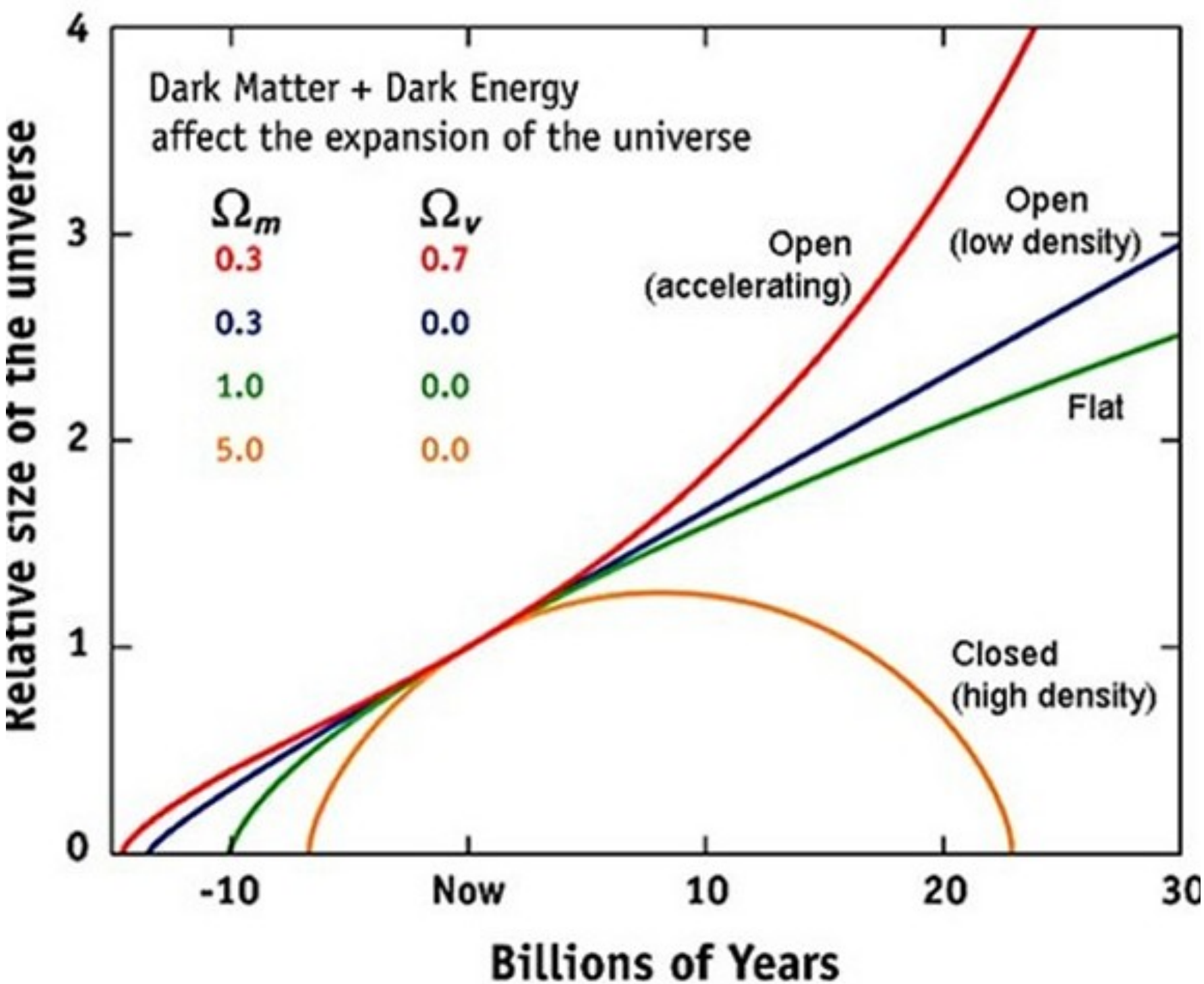
2003

WMAP

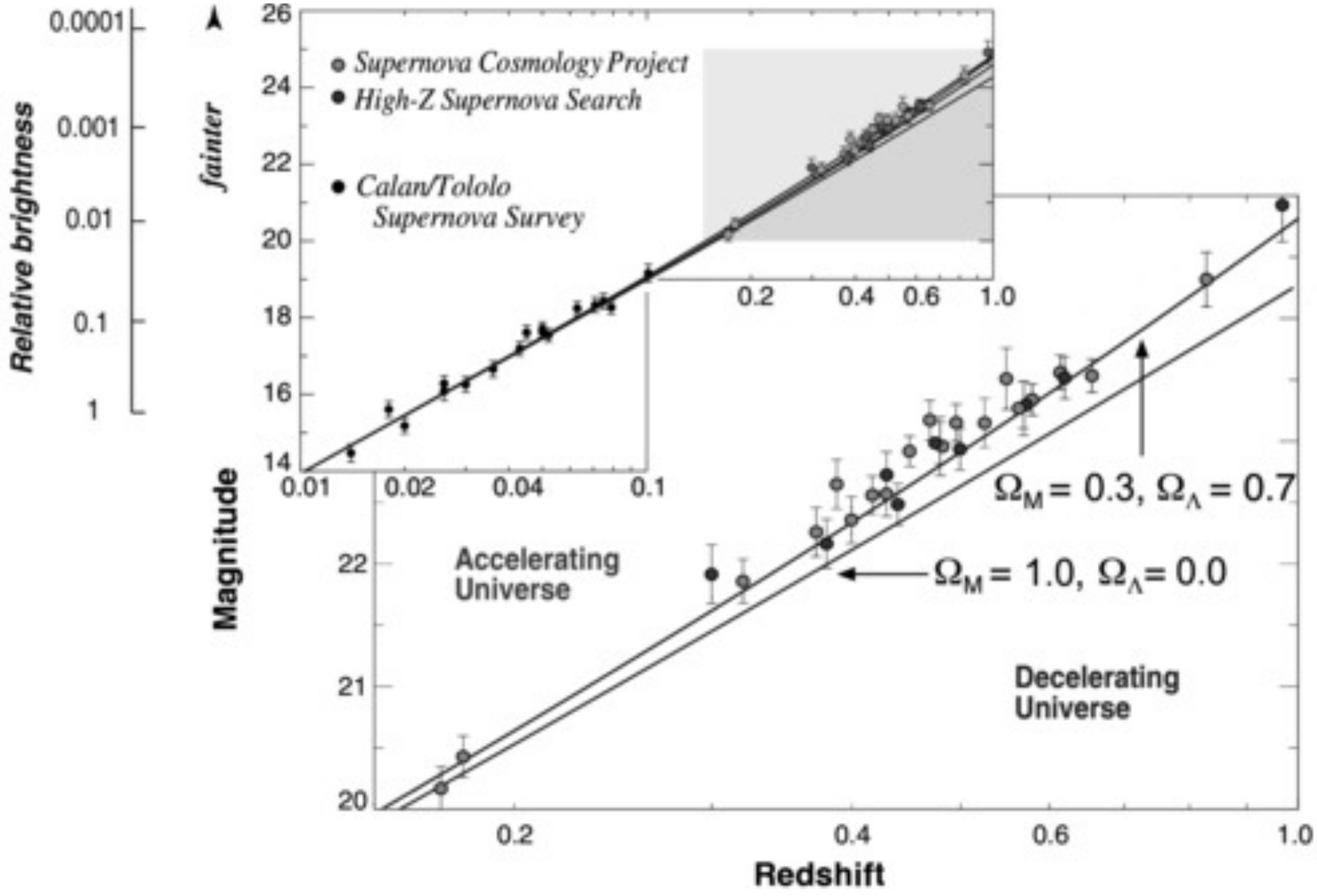




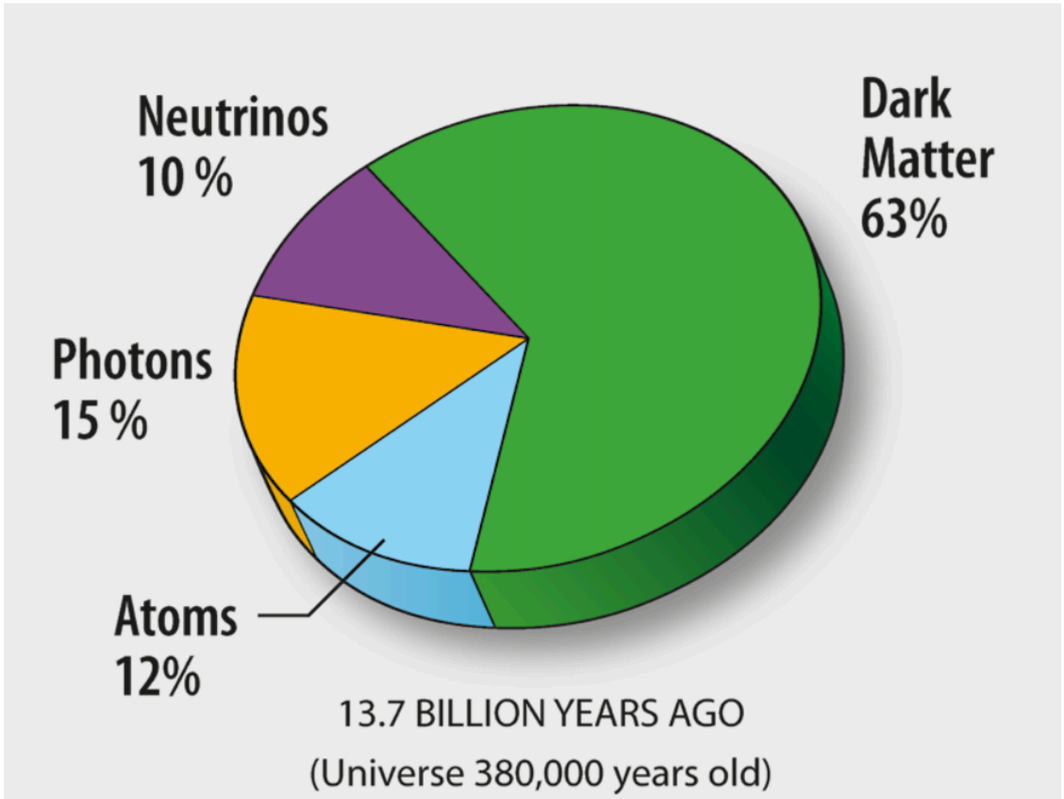
Dark matter & Dark Energy

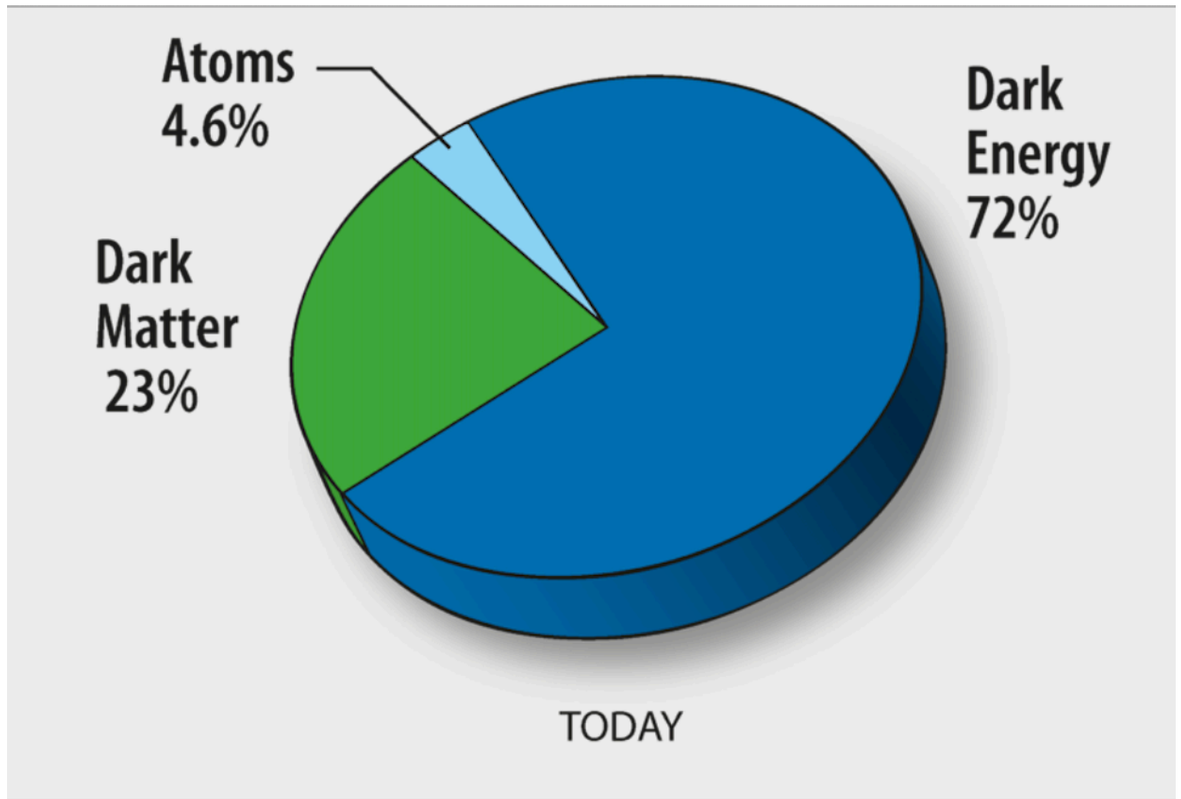


Acceleration of the universe

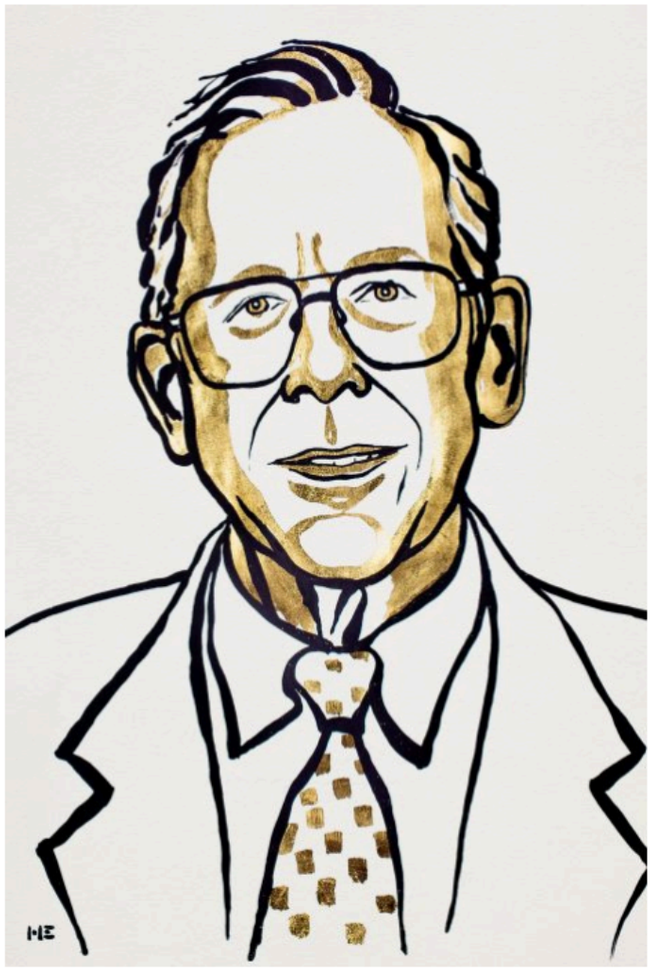


Energy Budget of the universe





James Peebles
Facts



Ill. Niklas Elmehed. © Nobel Media.

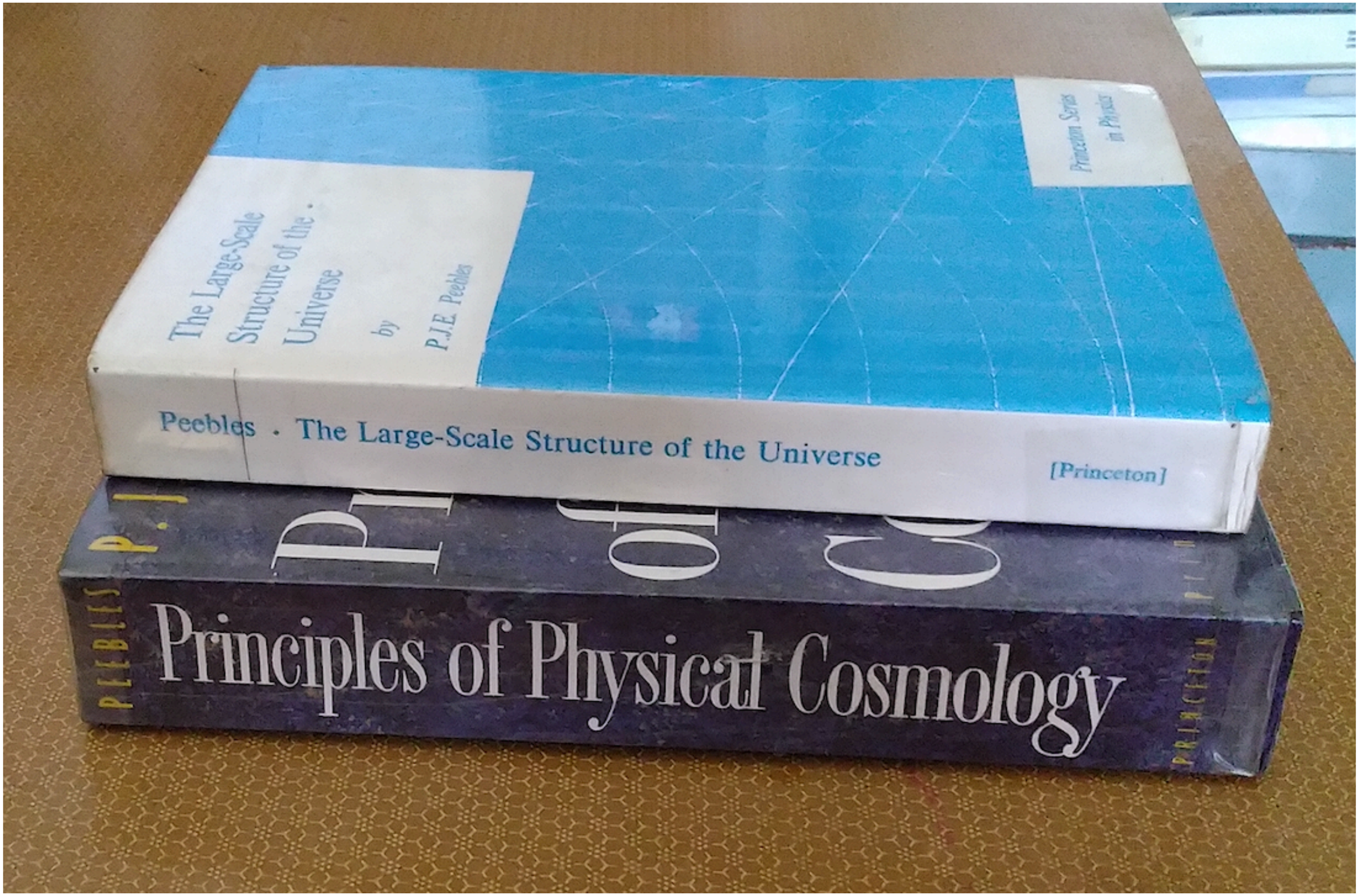
James Peebles
The Nobel Prize in Physics 2019

Born: 25 April 1935, Winnipeg, Canada

Affiliation at the time of the award: Princeton University, Princeton, NJ, USA

Prize motivation: "for theoretical discoveries in physical cosmology."

Prize share: 1/2



Peebles' classics

Peebles's scientific contributions

- Primordial nucleosynthesis
- Dark matter
- Cosmic microwave background
- Structure formation

REVIEW ARTICLE

The case for the relativistic hot Big Bang cosmology

P. J. E. Peebles, D. N. Schramm, E. L. Turner & R. G. Kron

The relativistic hot Big Bang model for the expanding Universe has yielded a set of interpretations and successful predictions that substantially outnumber the elements used in devising the theory, with no well-established empirical contradictions. It is reasonable to conclude that this standard cosmology has developed into a mature and believable physical model.

REVIEW ARTICLE

A cosmic book of phenomena

P. J. E. Peebles & Joseph Silk

A comparison of the merits of five general theories for the origin of galaxies and large-scale structure in the Universe with 38 observational constraints from extragalactic astronomy produces no clear winner. Two theories, cold dark matter in an inflationary cosmology and baryonic dark matter in a low-density Universe, emerge slightly ahead of the pack.

The mean mass density of the Universe

P. J. E. Peebles

Joseph Henry Laboratories, Princeton University, Princeton, New Jersey 08544, USA

Vol 465|3 June 2010|**doi:10.1038/nature09101**

nature

REVIEWS

Nearby galaxies as pointers to a better theory of cosmic evolution

P. J. E. Peebles[1] & Adi Nusser[2]

The great advances in the network of cosmological tests show that the relativistic Big Bang theory is a good description of our expanding Universe. However, the properties of nearby galaxies that can be observed in greatest detail suggest that a better theory would describe a mechanism by which matter is more rapidly gathered into galaxies and groups of galaxies. This more rapid growth occurs in some theoretical ideas now under discussion.

Conclusions

WMAP Cosmological Parameters

Model: lcdm

Data: wmap9+bao+h0

$10^9\Delta^2_{\mathcal{R}}$	$2.427^{+0.078}_{-0.079}$	H_0	69.33 ± 0.88 km/s/Mpc
$\ell(\ell+1)C_{220}/(2\pi)$	5746 ± 33 μK^2	$d_A(z_{\rm eq})$	14143 ± 93 Mpc
$d_A(z_*)$	13977 ± 94 Mpc	$D_v(z=0.57)/r_s(z_d)$	13.39 ± 0.12
η	$(6.20 \pm 0.12) \times 10^{-10}$	$k_{\rm eq}$	0.01010 ± 0.00018
$\ell_{\rm eq}$	141.1 ± 1.7	ℓ_*	302.33 ± 0.59
n_b	$(2.545 \pm 0.048) \times 10^{-7}$ cm^{-3}	n_s	0.971 ± 0.010
Ω_b	0.0472 ± 0.0010	$\Omega_b h^2$	0.02266 ± 0.00043
Ω_c	$0.2408^{+0.0093}_{-0.0092}$	$\Omega_c h^2$	0.1157 ± 0.0023
Ω_Λ	0.712 ± 0.010	Ω_m	0.288 ± 0.010
$\Omega_m h^2$	0.1383 ± 0.0025	$r_s(z_d)$	151.68 ± 0.92 Mpc
$r_s(z_d)/D_v(z=0.106)$	0.3416 ± 0.0044	$r_s(z_d)/D_v(z=0.2)$	$0.1866^{+0.0022}_{-0.0023}$
$r_s(z_d)/D_v(z=0.35)$	0.1123 ± 0.0012	$r_s(z_d)/D_v(z=0.44)$	0.09224 ± 0.00091
$r_s(z_d)/D_v(z=0.54)$	$0.07795^{+0.00070}_{-0.00071}$	$r_s(z_d)/D_v(z=0.57)$	0.07467 ± 0.00066
$r_s(z_d)/D_v(z=0.6)$	0.07173 ± 0.00062	$r_s(z_d)/D_v(z=0.73)$	0.06186 ± 0.00048
$r_s(z_*)$	145.24 ± 0.76	R	1.7338 ± 0.0061
σ_8	0.830 ± 0.018	$\sigma_8\Omega_m^{0.5}$	0.445 ± 0.015
$\sigma_8\Omega_m^{0.6}$	0.393 ± 0.014	$A_{\rm SZ}$	< 2.0 (95% CL)
t_0	13.750 ± 0.085 Gyr	τ	0.088 ± 0.013
θ_*	0.010391 ± 0.000020	θ_*	0.5954 ± 0.0012 °
$\tau_{\rm rec}$	282.9 ± 1.3	$t_{\rm reion}$	452^{+63}_{-64} Myr
t_*	374612^{+2092}_{-2088} yr	z_d	1020.9 ± 1.1
$z_{\rm eq}$	3311 ± 59	$z_{\rm rec}$	$1088.26^{+0.61}_{-0.62}$
$z_{\rm reion}$	10.5 ± 1.1	z_*	$1091.09^{+0.55}_{-0.54}$

Thank You !