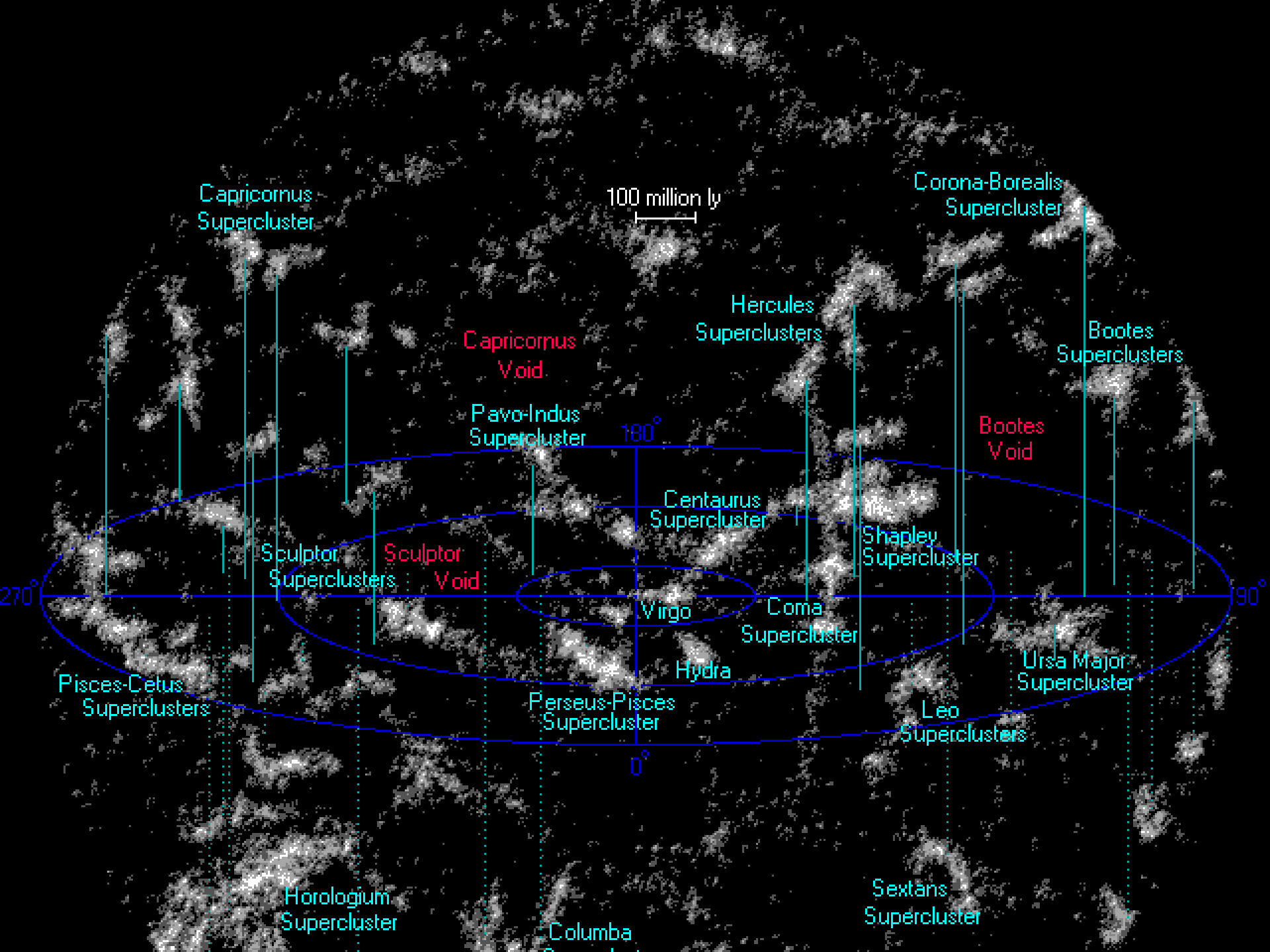
Astronomy Course Outline

Week 1: The Sky | Week 2: The Planets | **Week 3: The Stars** | Week 4: History of Astronomy | Week 5: Telescopes | Week 6: Deep Sky Objects | Week 7: Cosmology | Week 8: Alien Worlds

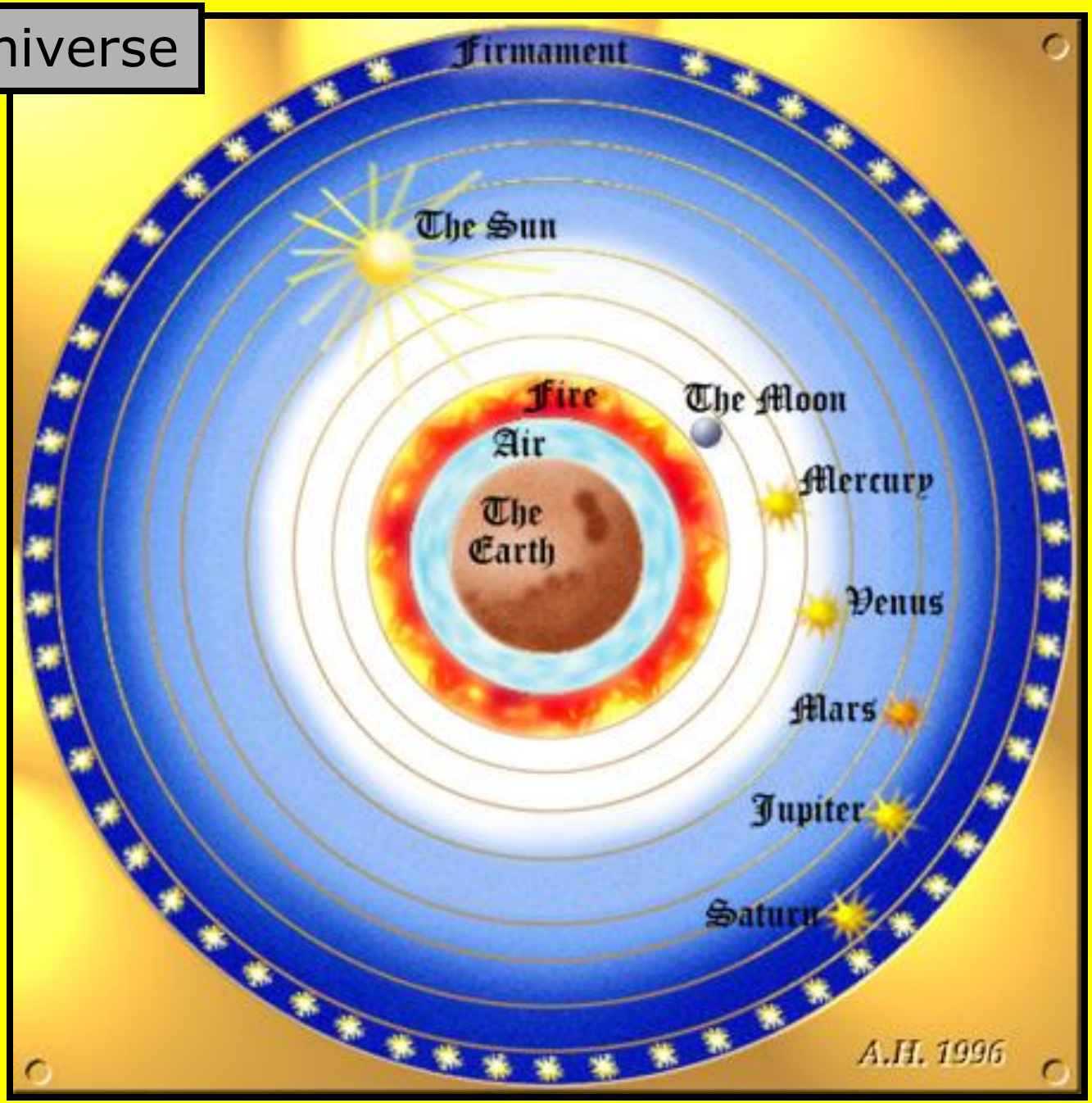

Capricornus Supercluster
100 million ly
Corona-Borealis Supercluster
Hercules Superclusters
Capricornus Void
Bootes Superclusters
Pavo-Indus Supercluster
180°
Bootes Void
Centaurus Supercluster
Shapley Supercluster
Sculptor Superclusters
Sculptor Void
270°
90°
Virgo
Coma Supercluster
Pisces-Cetus Superclusters
Hydra
Ursa Major Supercluster
Perseus-Pisces Supercluster
Leo Superclusters
0°
Horologium Supercluster
Columba
Sextans Supercluster

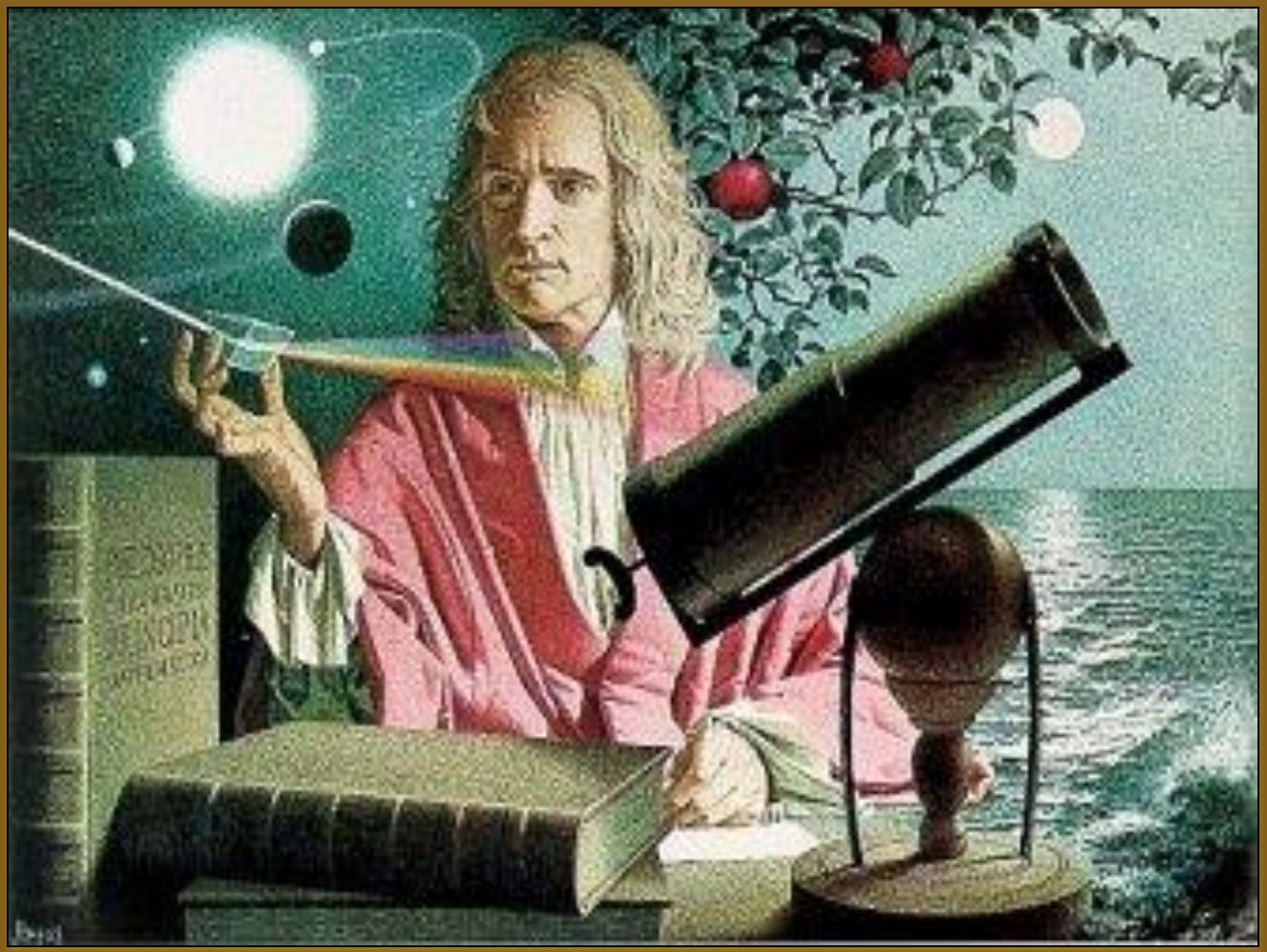
Cosmology

Week Seven

COSMOLOGY MARCHES ON

The Ancient Universe





Isaac Newton(1642-1727)

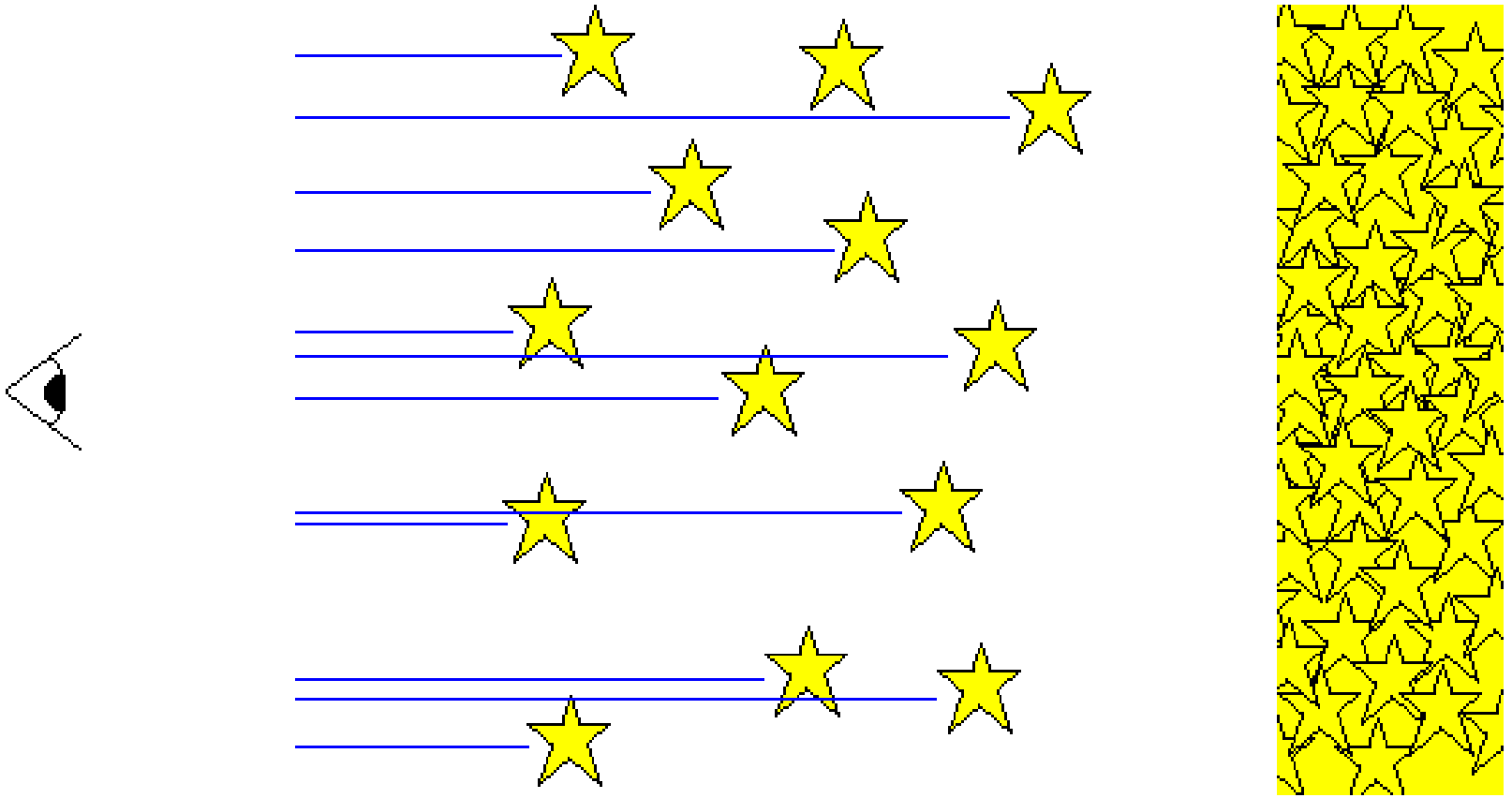
Newton's Universe -

Space & Time are a stage on which matter acts out the laws of motion.

19th Century Problems with Newton's Universe

- Olber's Paradox
- 2nd Law of Thermodynamics
- Michaelson-Morely Experiment

Olber's paradox



observer

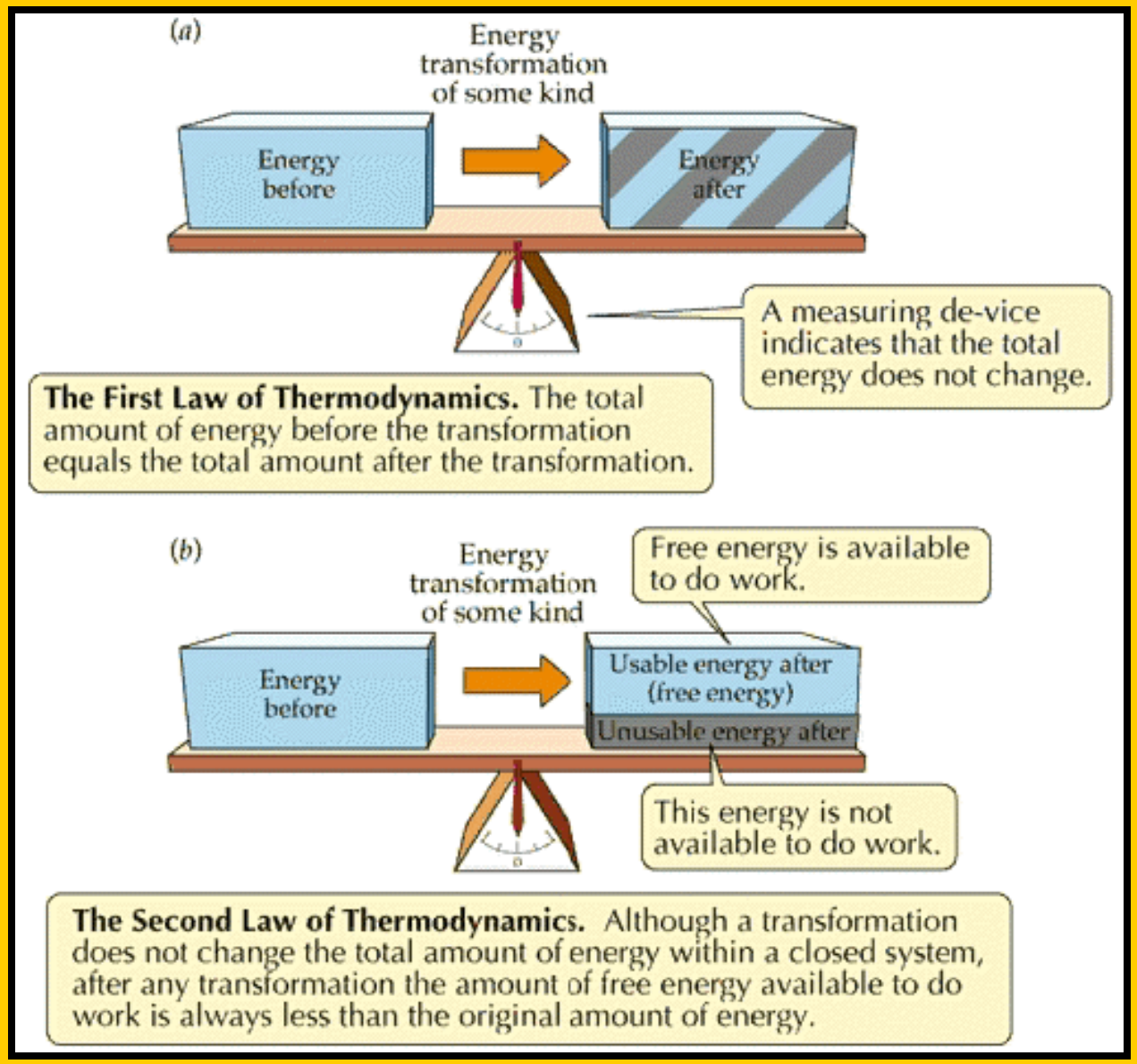
Universe of stars

night sky

19th Century Problems with Newton's Universe

- Olber's Paradox
- 2nd Law of Thermodynamics
- Michaelson-Morely Experiment

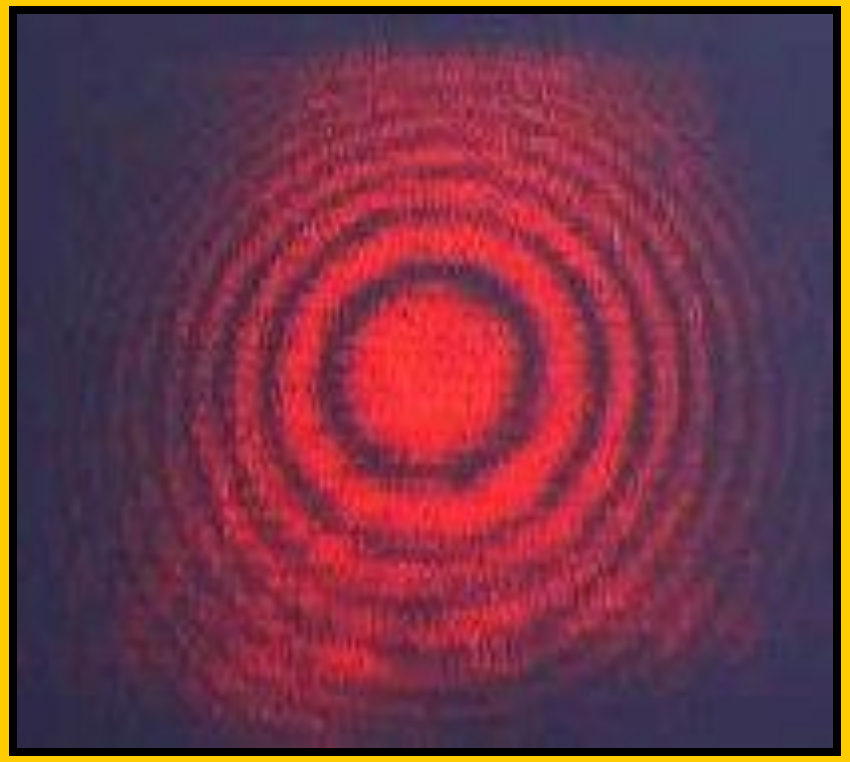
2nd Law of Thermodynamics

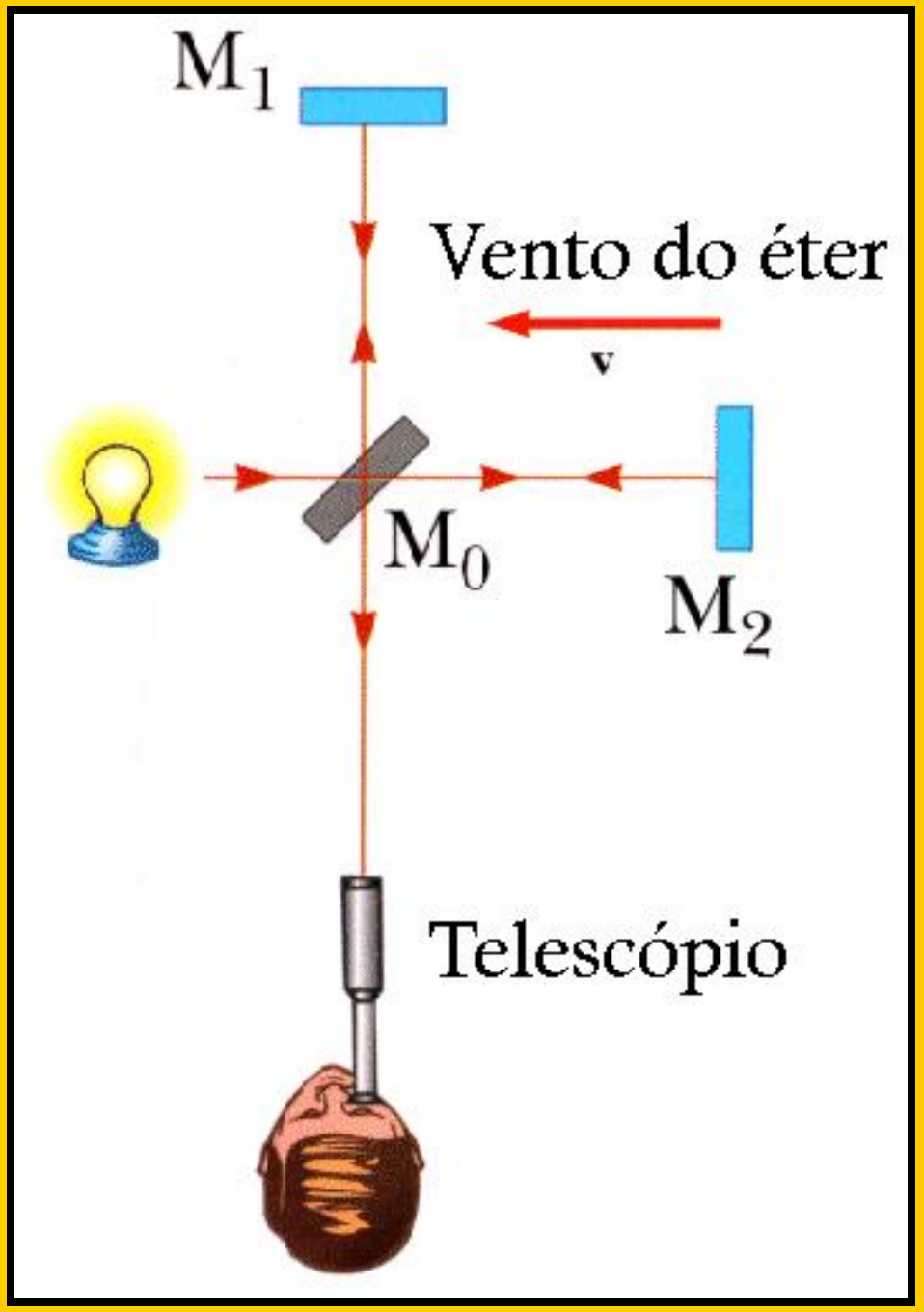


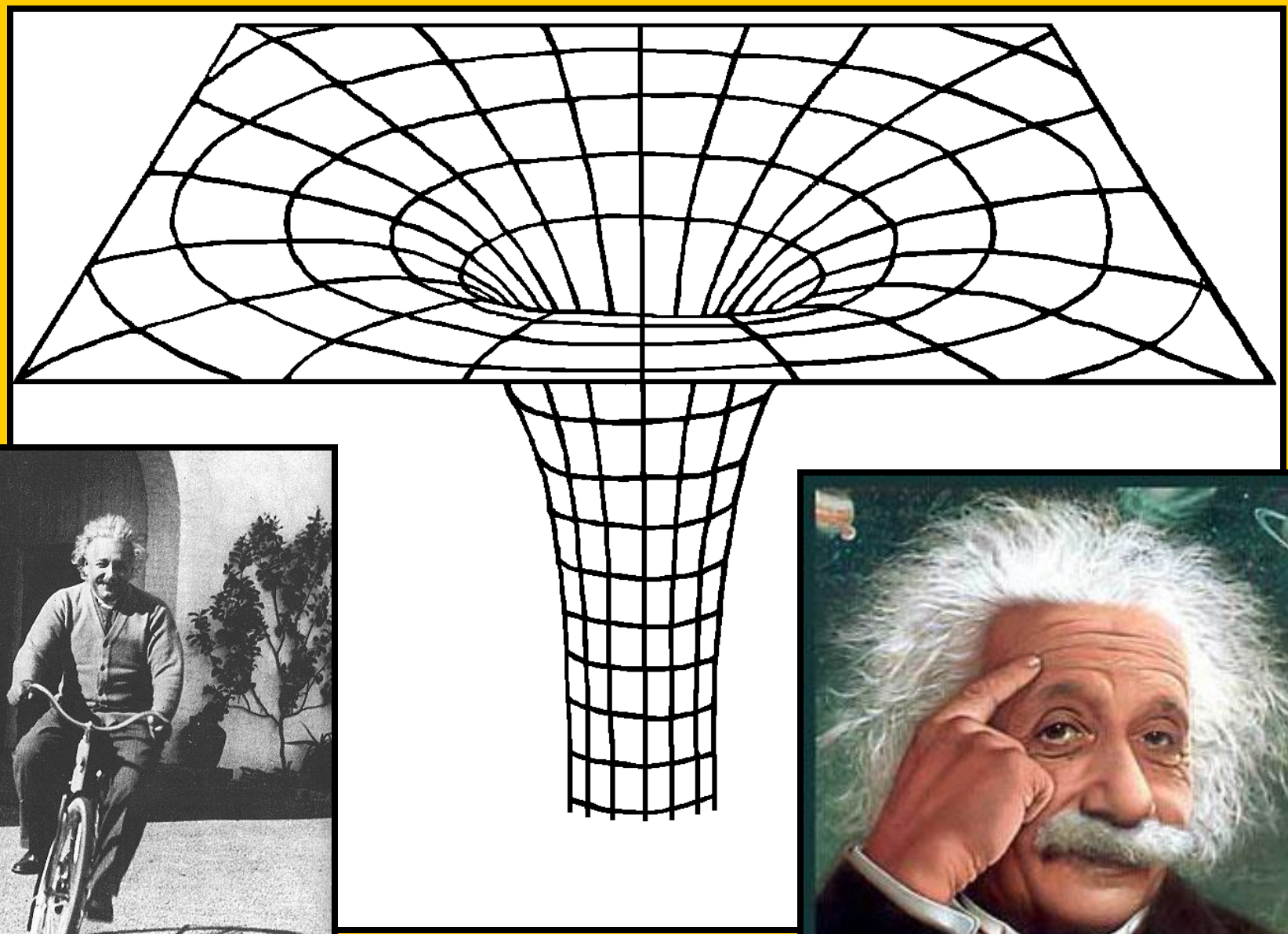
19th Century Problems with Newton's Universe

- Olber's Paradox
- 2nd Law of Thermodynamics
- Michaelson-Morely Experiment

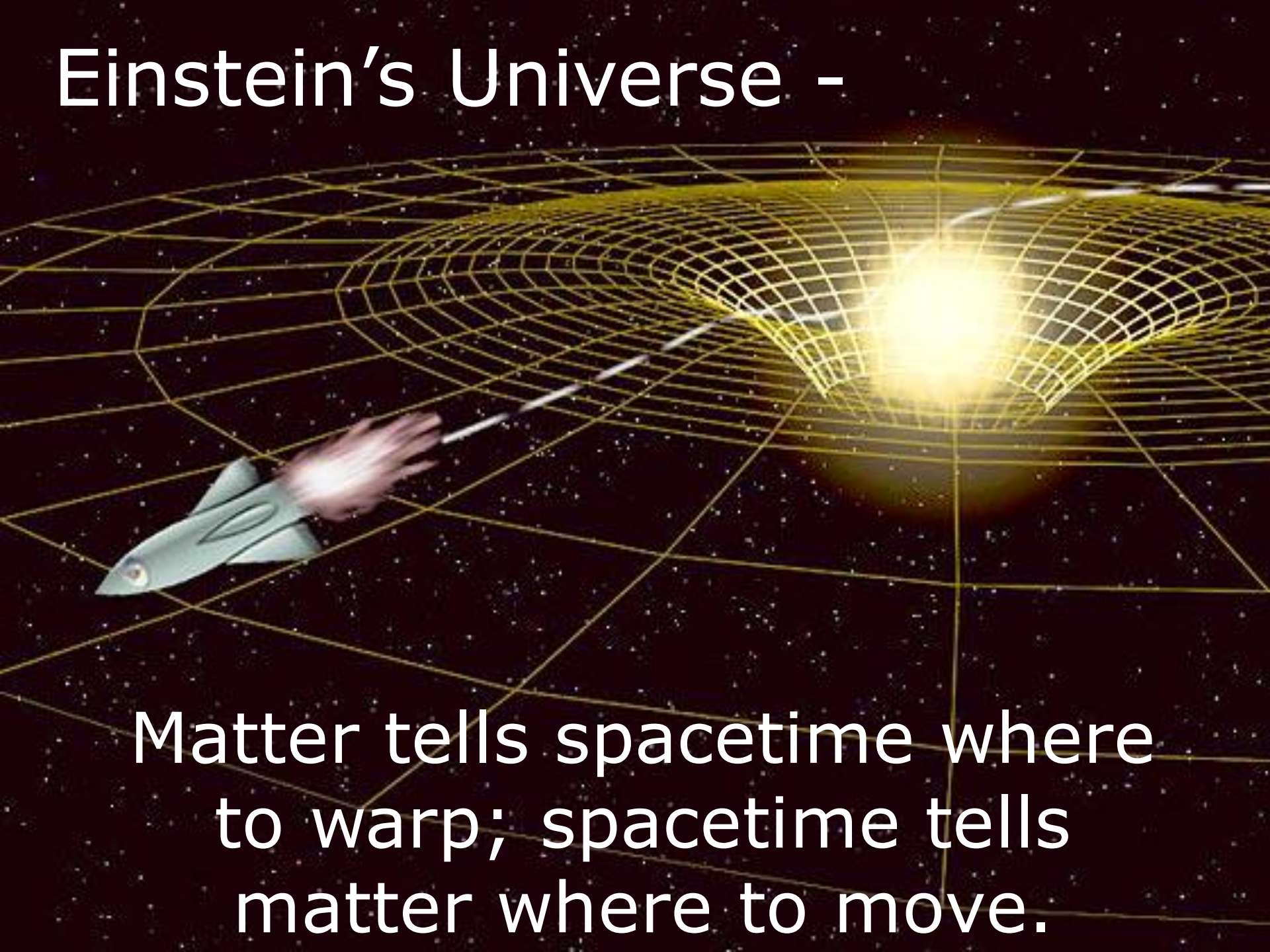
Michaelson-Morely Experiment







Einstein's Universe -



Matter tells spacetime where to warp; spacetime tells matter where to move.

Properties of our Universe

Cosmological Principle - The Universe is smooth on the large scale (100s of light-years).

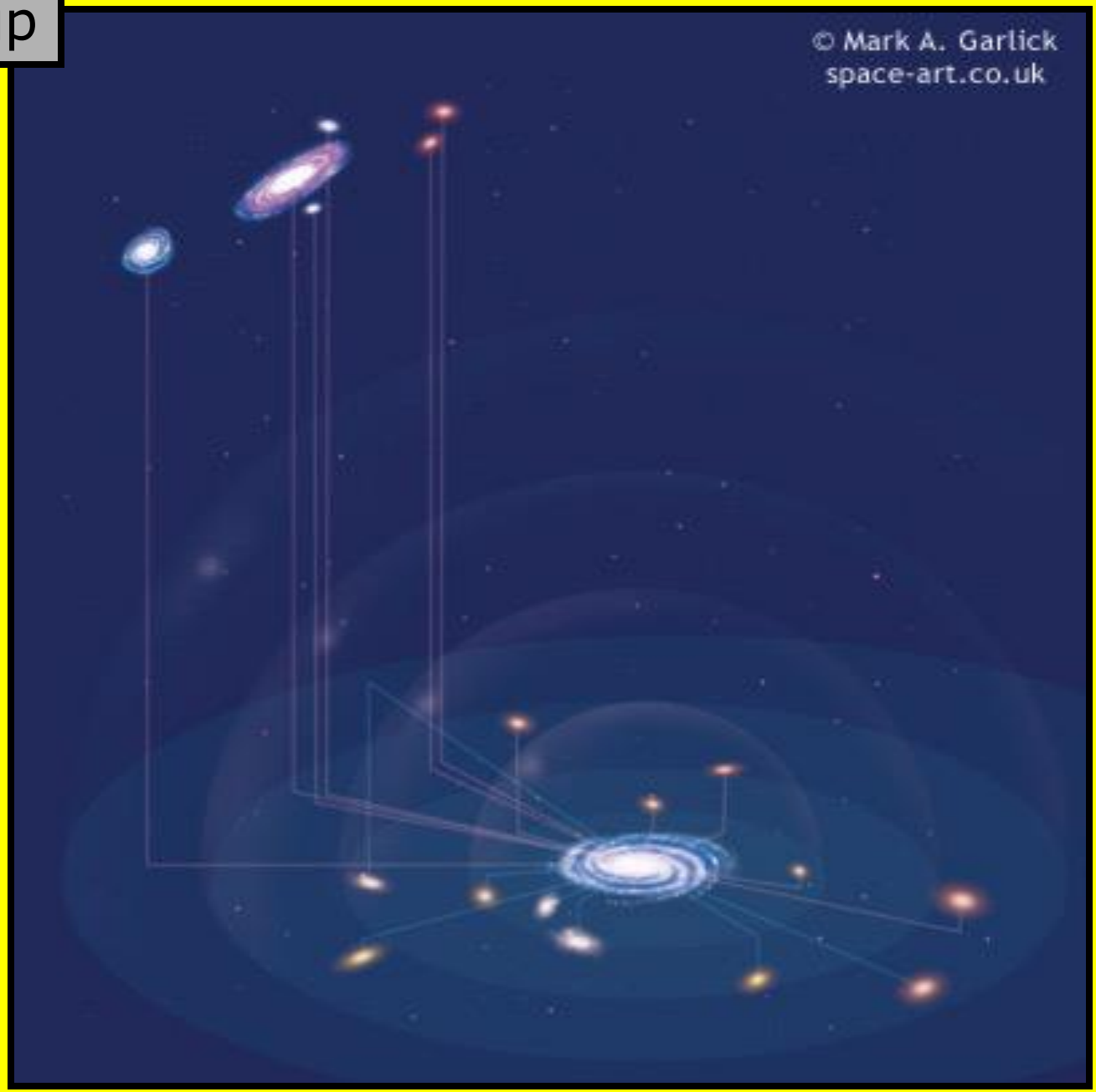
Homogeneity - The Universe looks the same at every *location*.

Isotropy - The Universe looks the same in every *direction.*

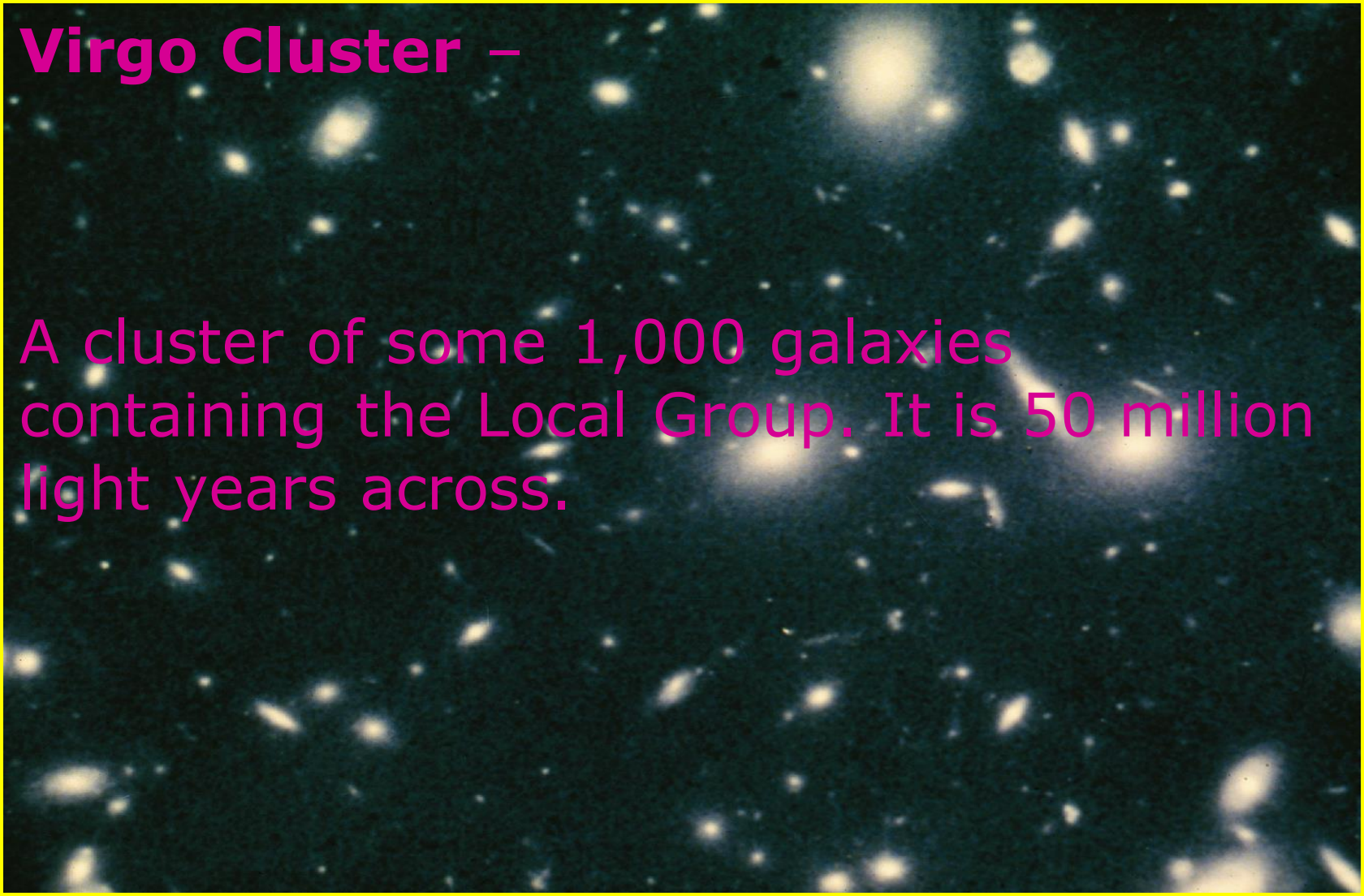
Omni-recessionality - On the large scale, everything is rushing away from everything else.

The structure of the Universe

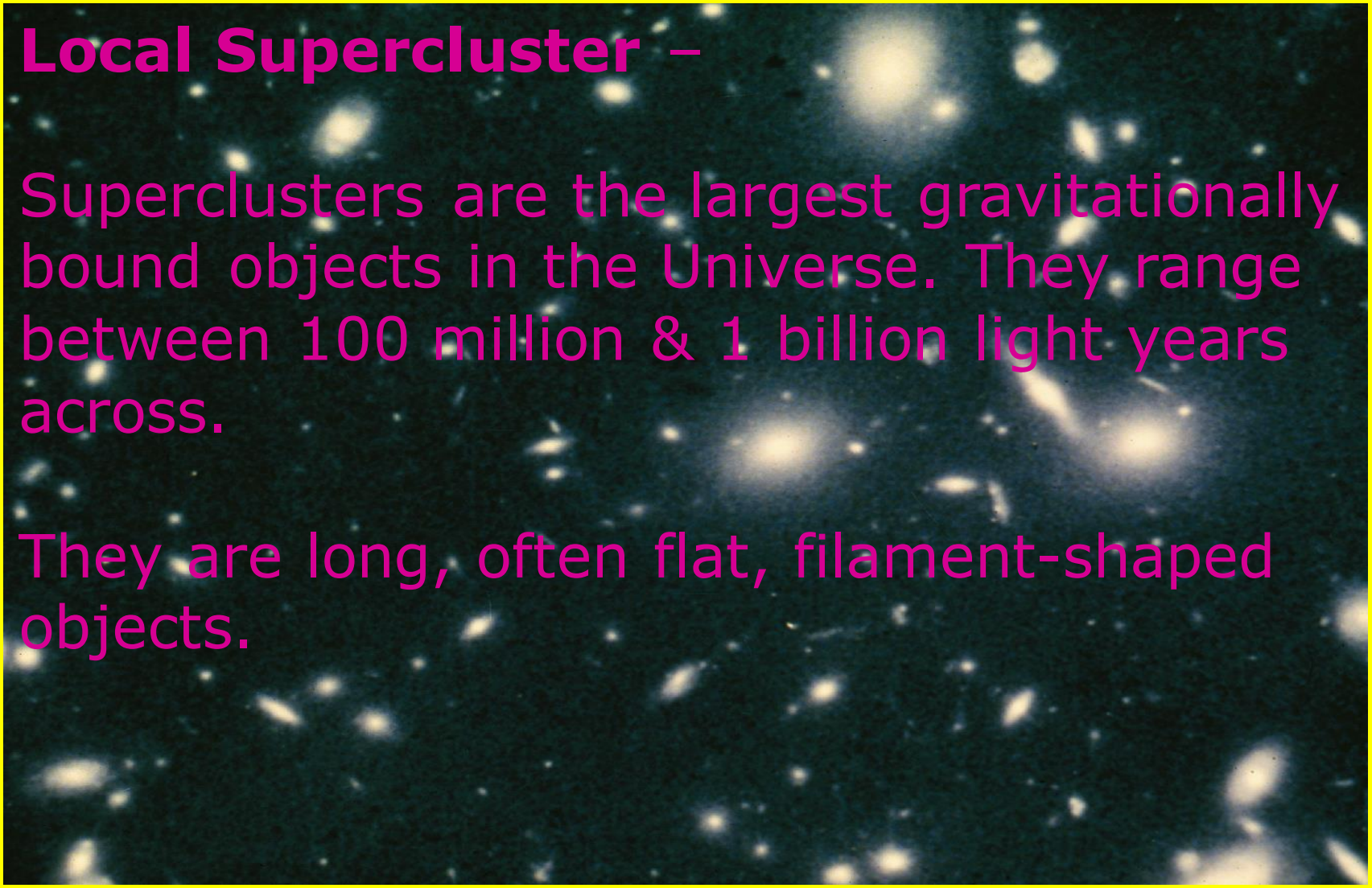
The Local Group



The structure of the Universe



The structure of the Universe

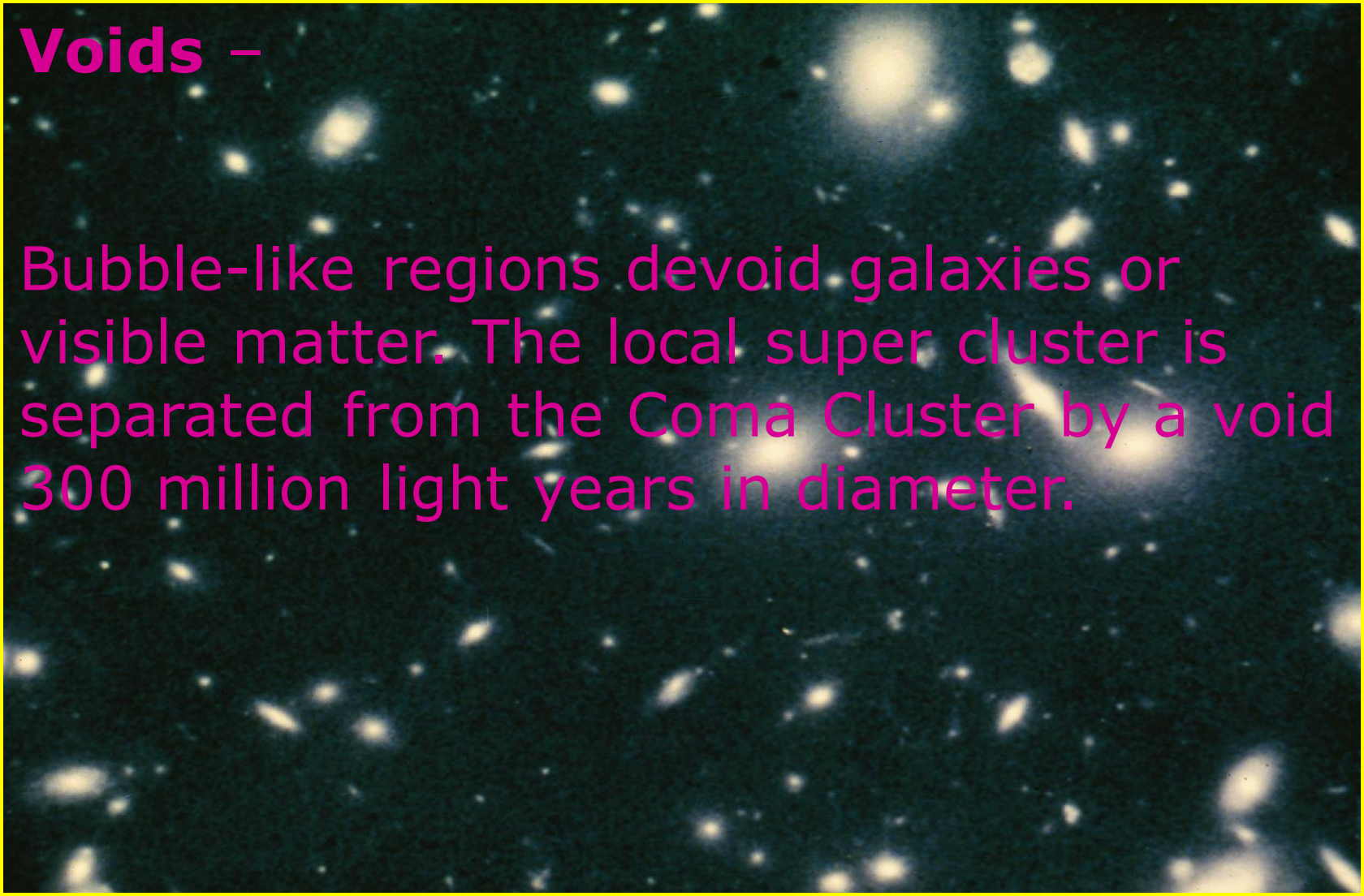


Local Supercluster –

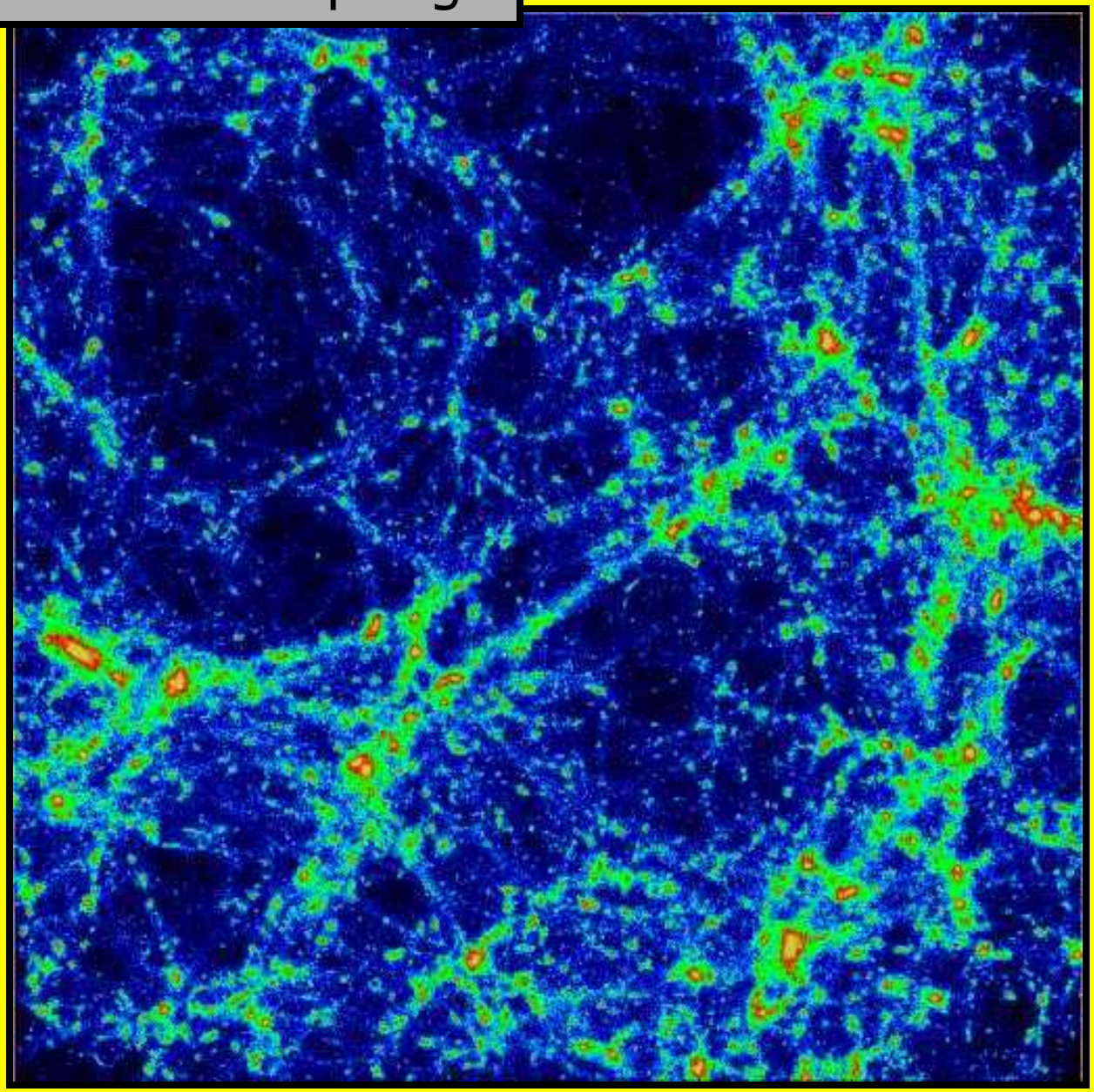
Superclusters are the largest gravitationally bound objects in the Universe. They range between 100 million & 1 billion light years across.

They are long, often flat, filament-shaped objects.

The structure of the Universe

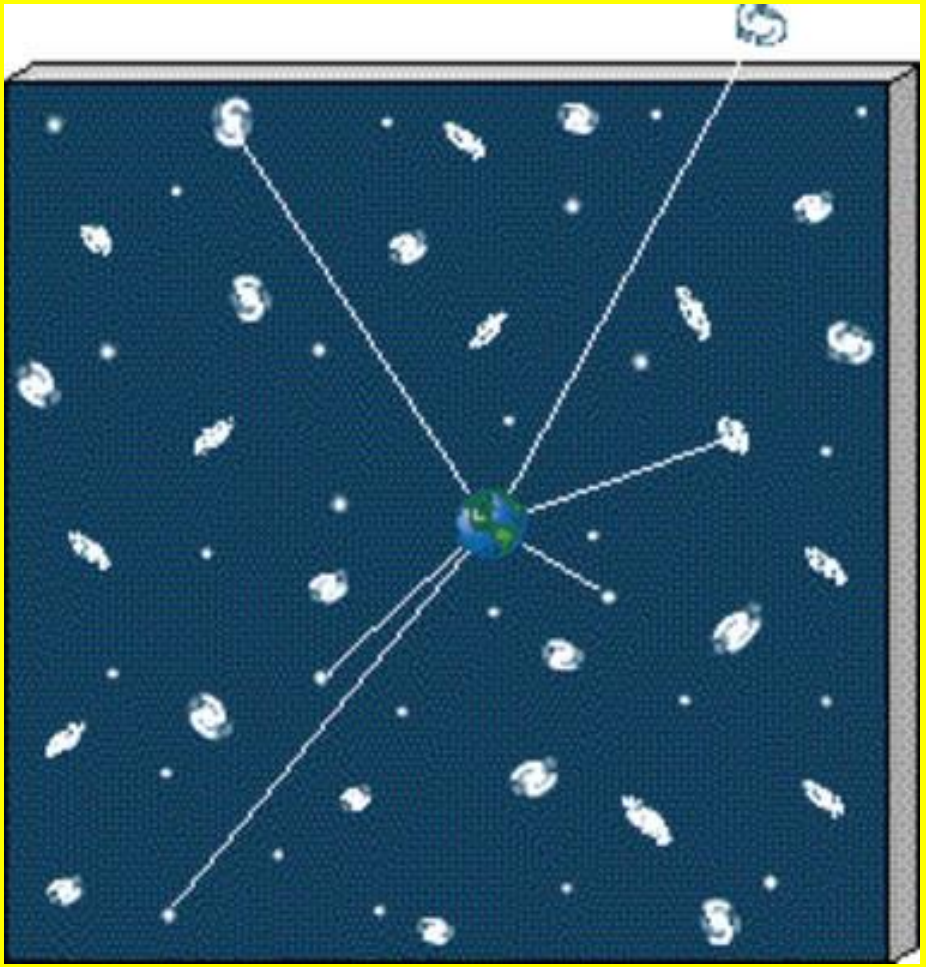


Our Universe is a cosmic sponge

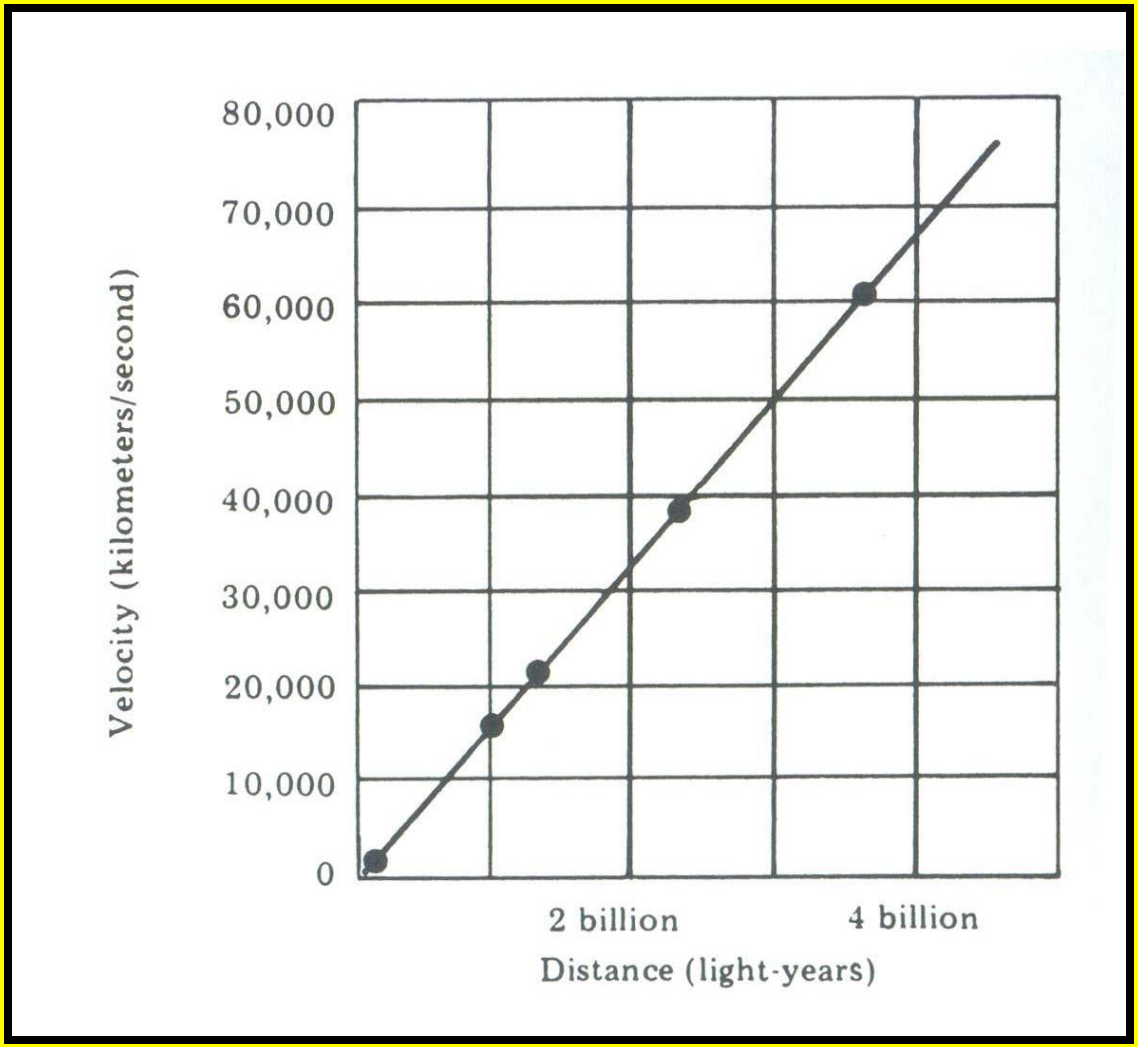


Hubble's Law - A galaxy's speed of reccesion from us is directly proportional to its distance.

Edwin Hubble



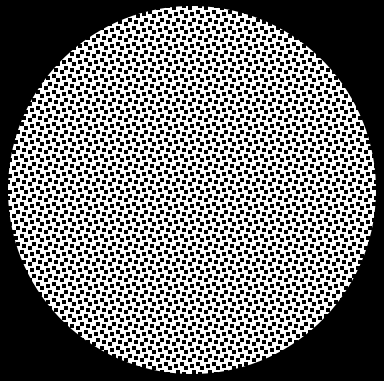
This linear relation is observed from all places - the Universe has no centre.



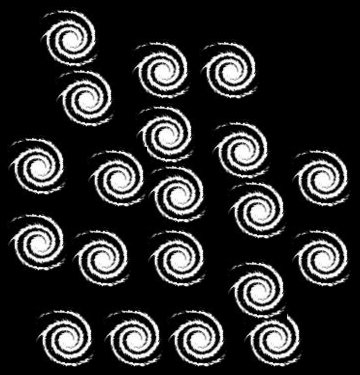
The Big Bang - Universe is Born

The Big Bang - Universe Expands & Cools

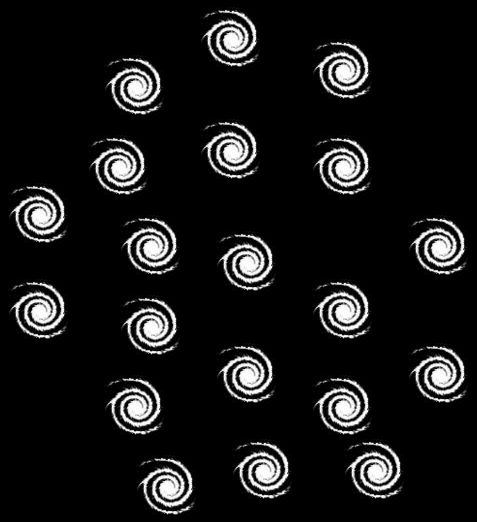
1/2 million years - Matter & Radiation Separate

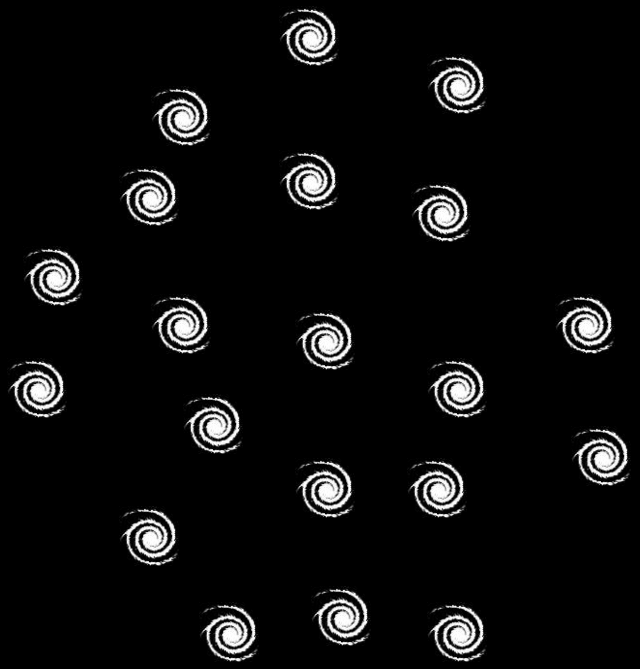


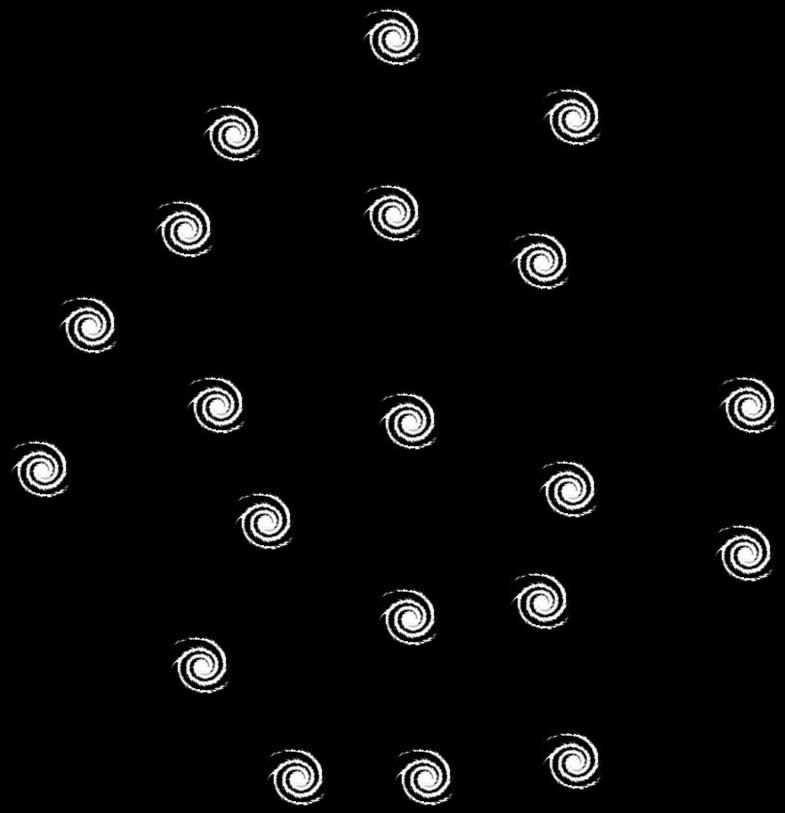
1 billion years - Galaxies Form

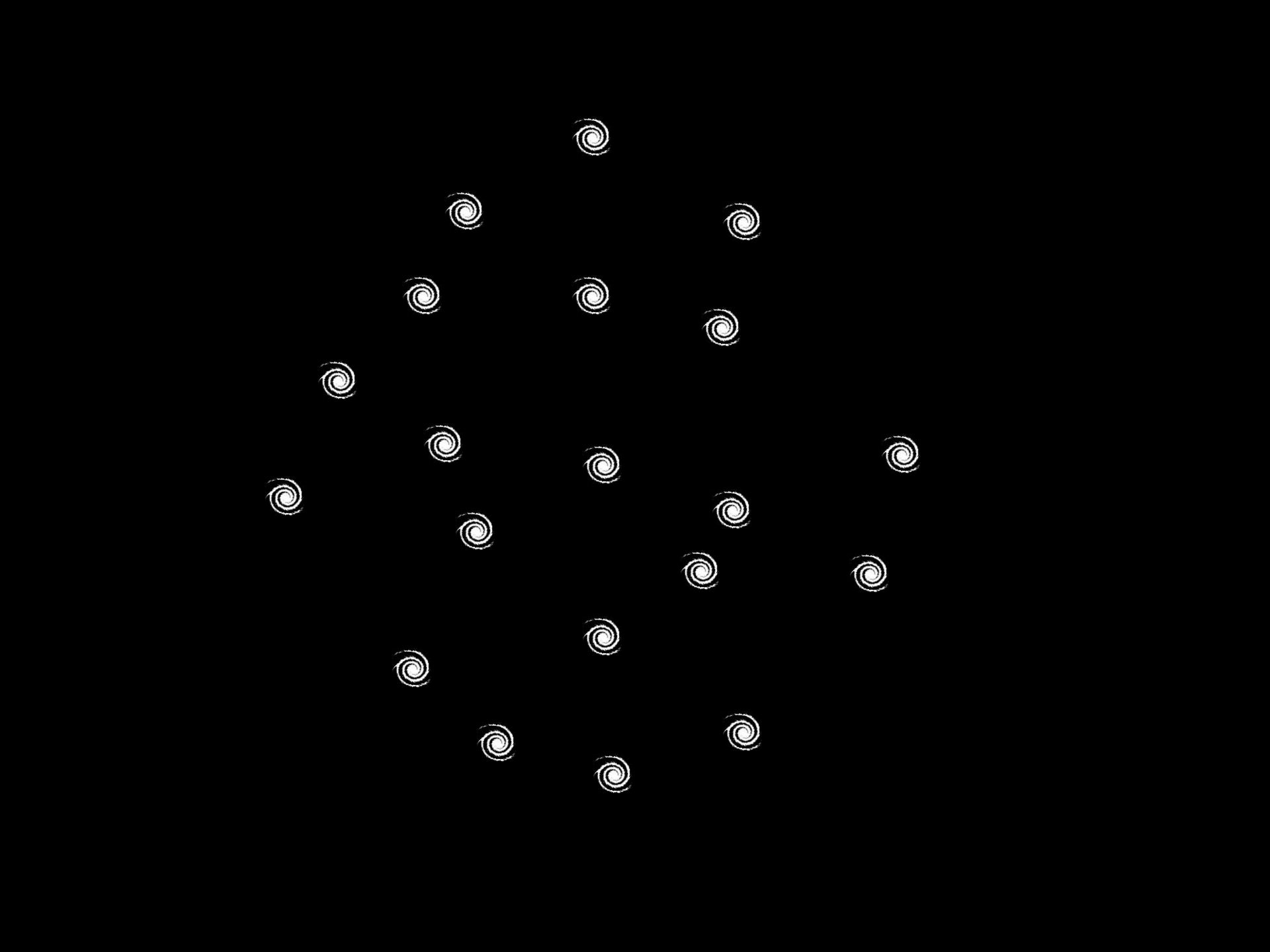


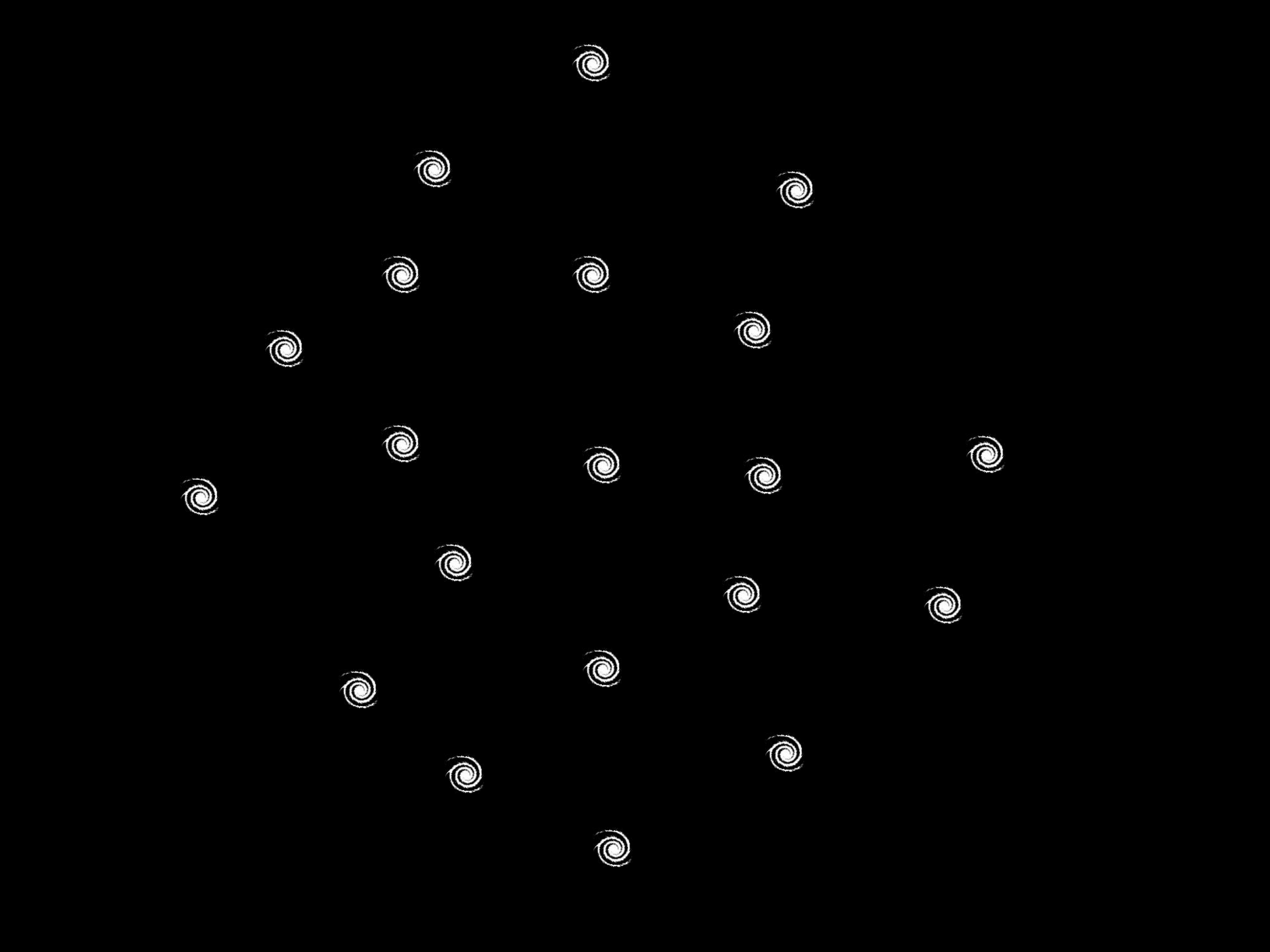
As the Universe expands, galaxies appear to rush away from each other

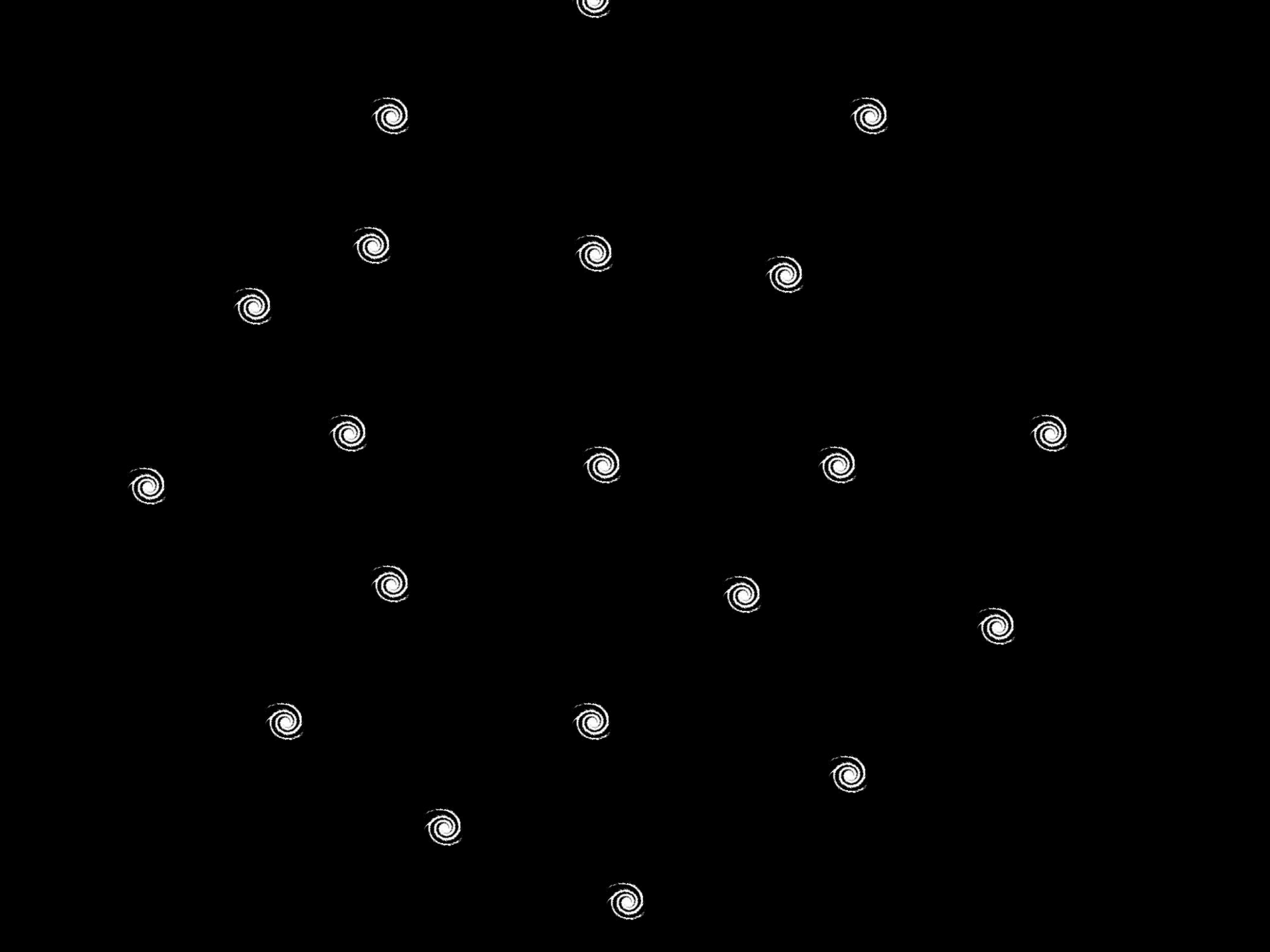


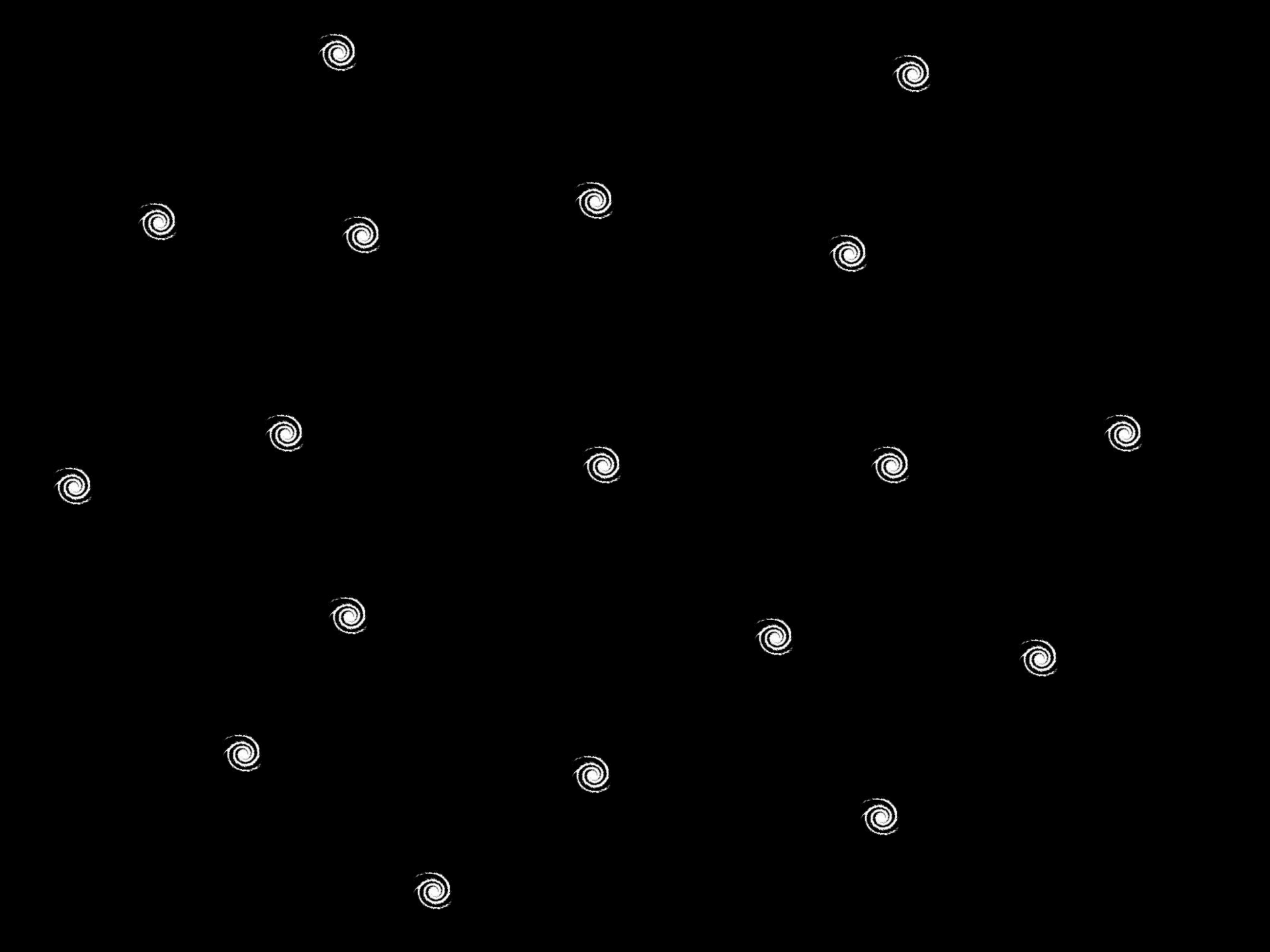


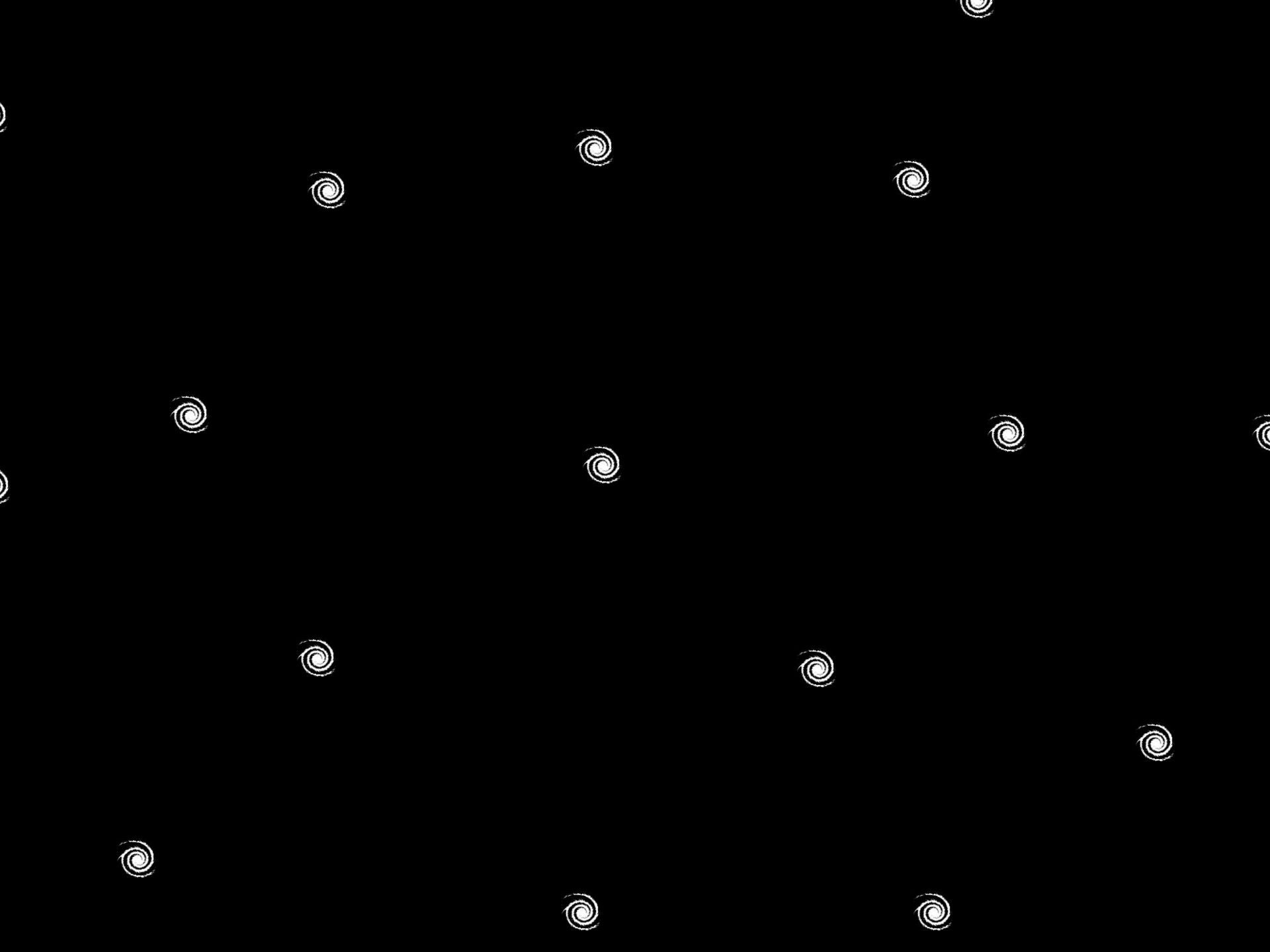




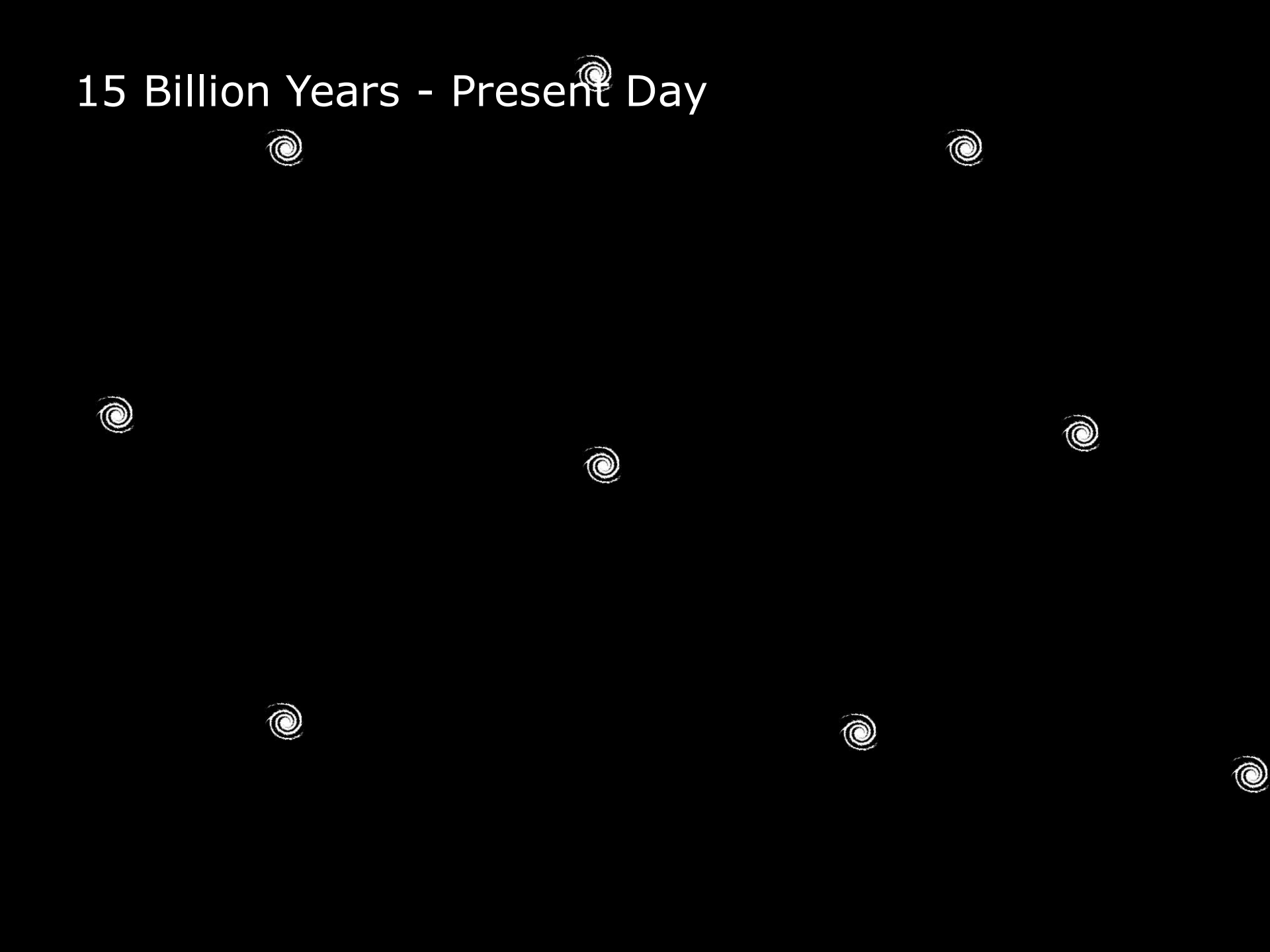




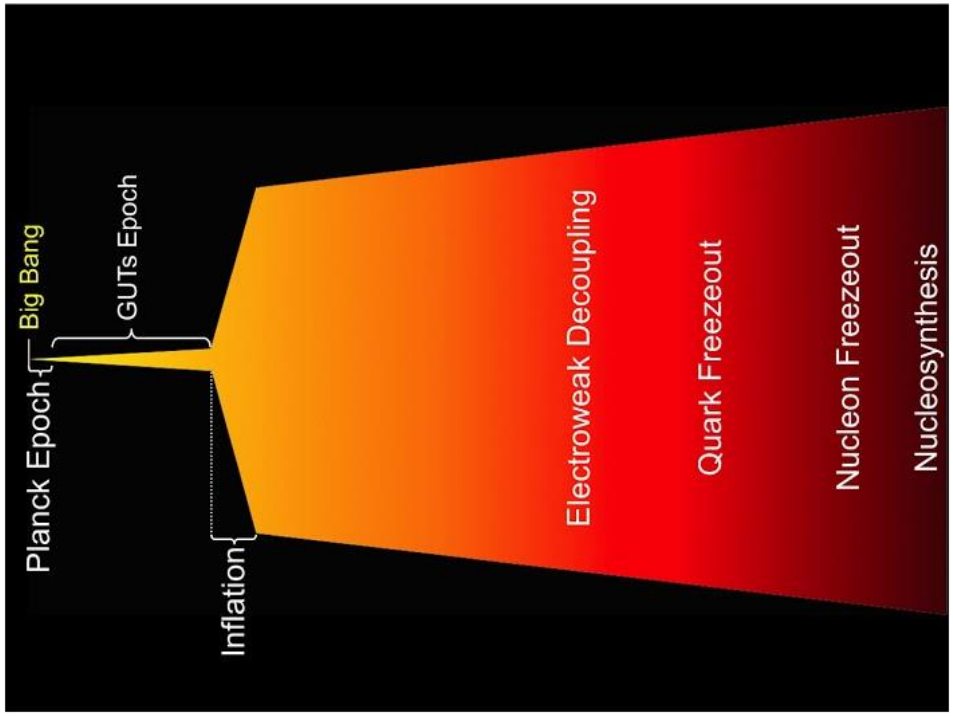




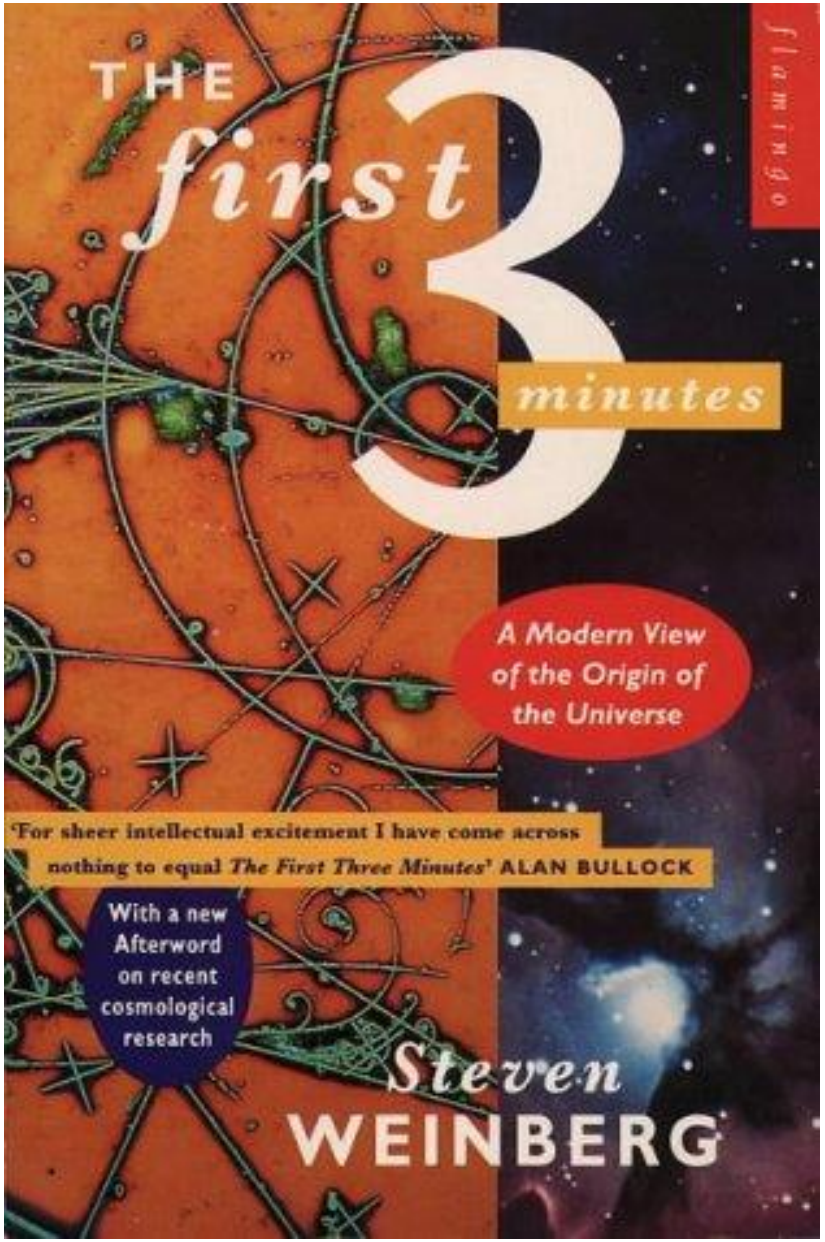
15 Billion Years - Present Day

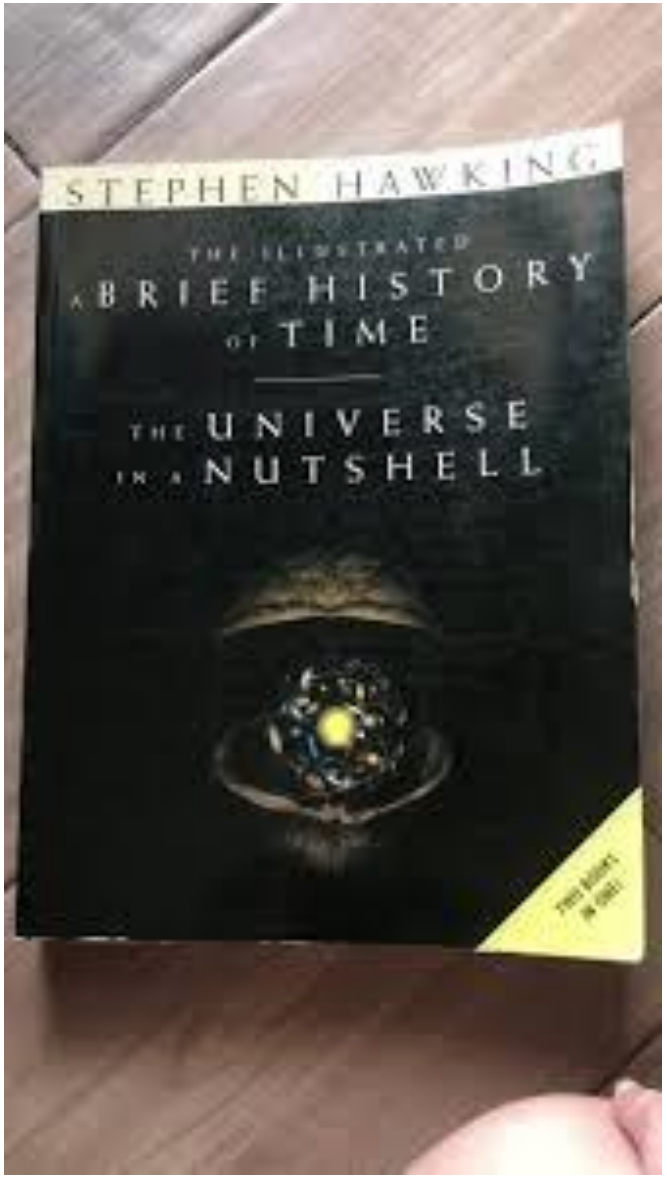


The First Three Minutes

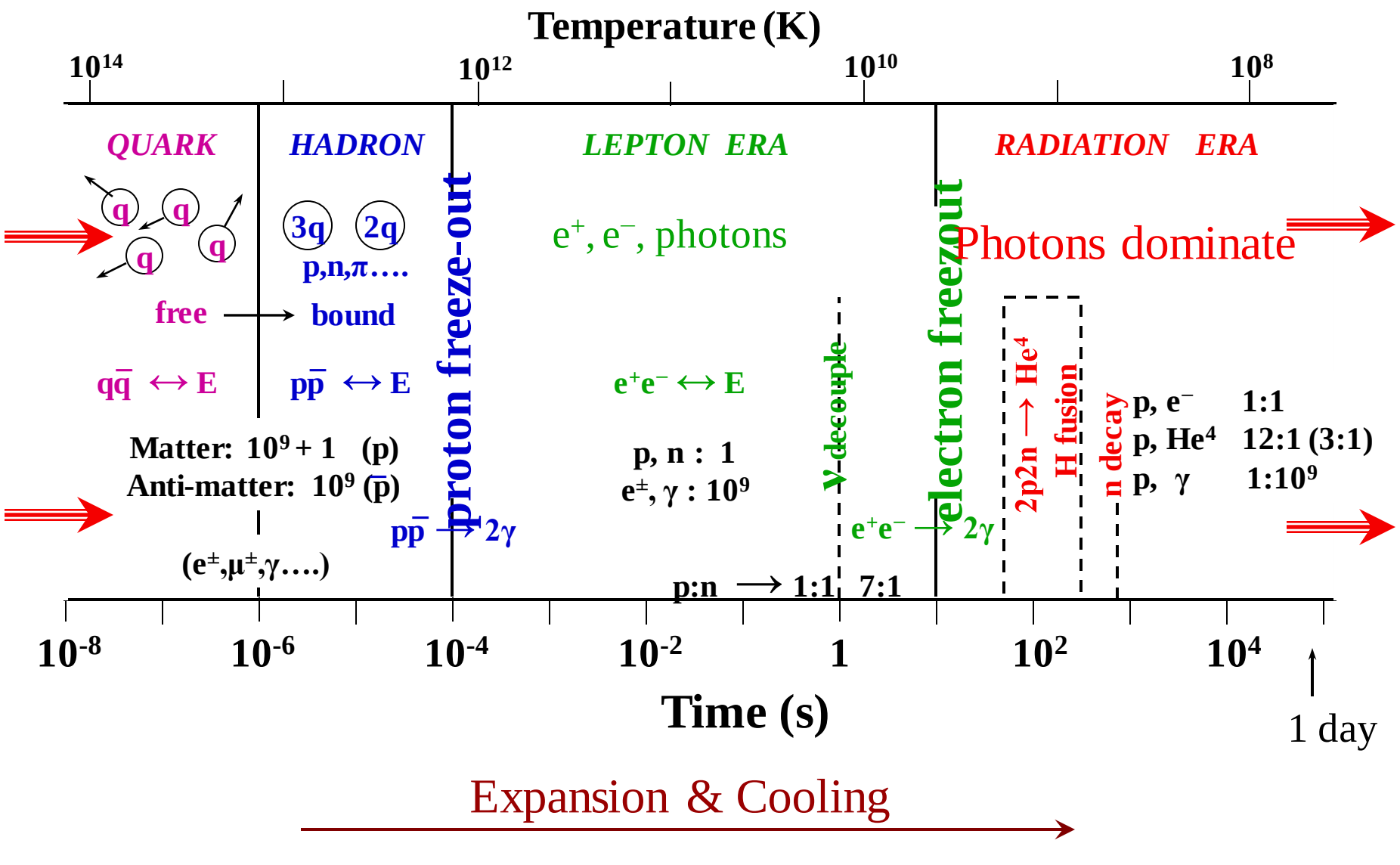


Astronomy 1101


THE first 3 minutes
flamingo
A Modern View of the Origin of the Universe
'For sheer intellectual excitement I have come across nothing to equal *The First Three Minutes*' ALAN BULLOCK
With a new Afterword on recent cosmological research
Steven WEINBERG


STEPHEN HAWKING
THE ILLUSTRATED
A BRIEF HISTORY OF TIME
THE UNIVERSE IN A NUTSHELL

The First Day



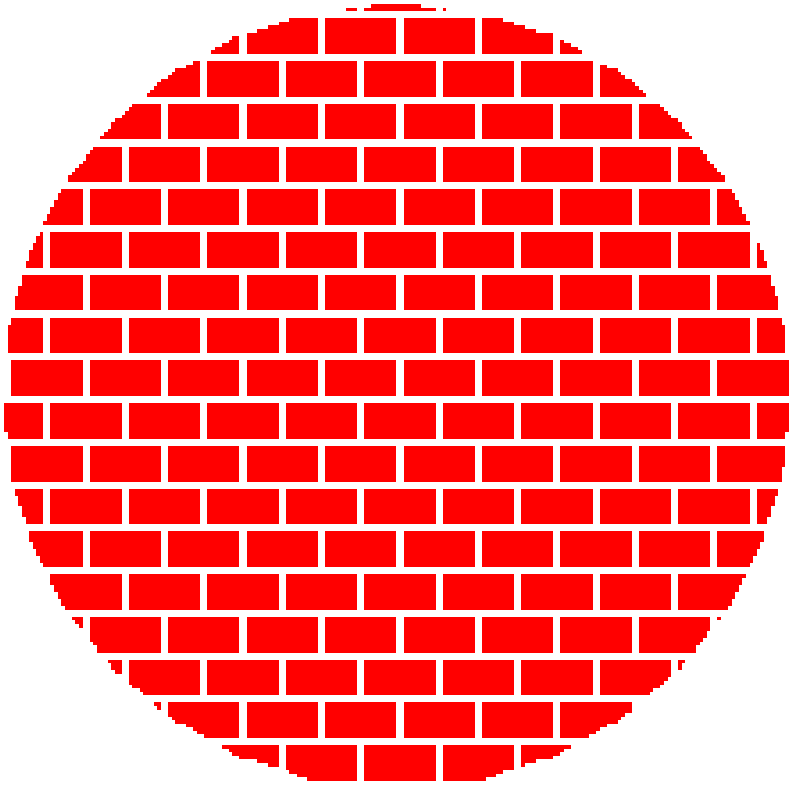
Expansion & Cooling

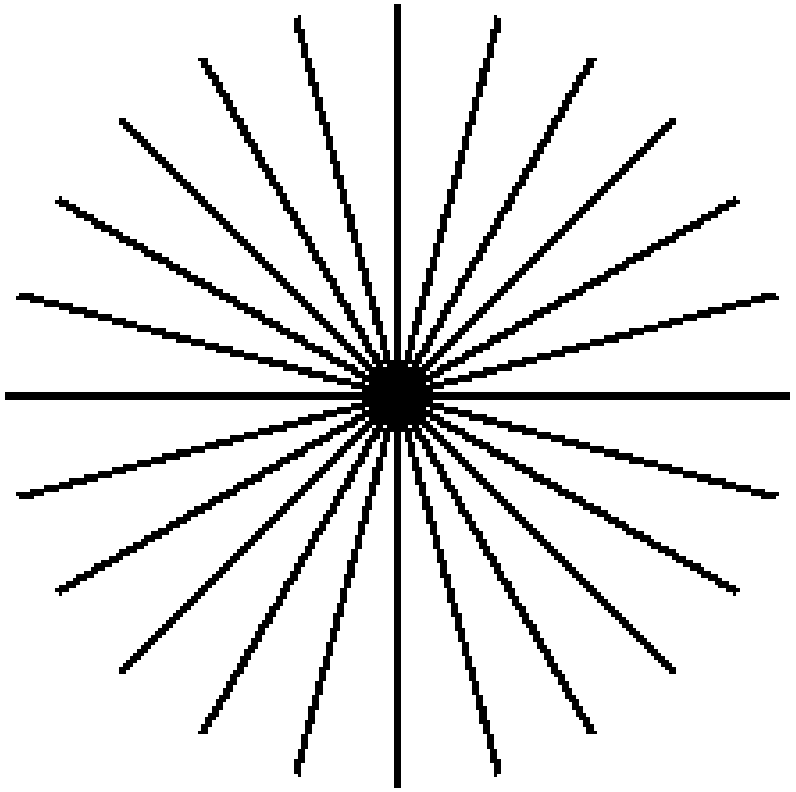
Predictions of Big Bang Theory

- The Universe is homogeneous and isotropic (very smooth)
- But not too smooth…
- The ratio of H/He (about 75% H, 25% He)
- Trace abundances of D, ^{3}He, Li, Be
- The cosmic microwave background radiation


Georges LeMaitre
George Gamow
Ralph Alpher
YLEM
LIQUEUR
COINTREAU

The Universe is Homogeneous and Isotropic

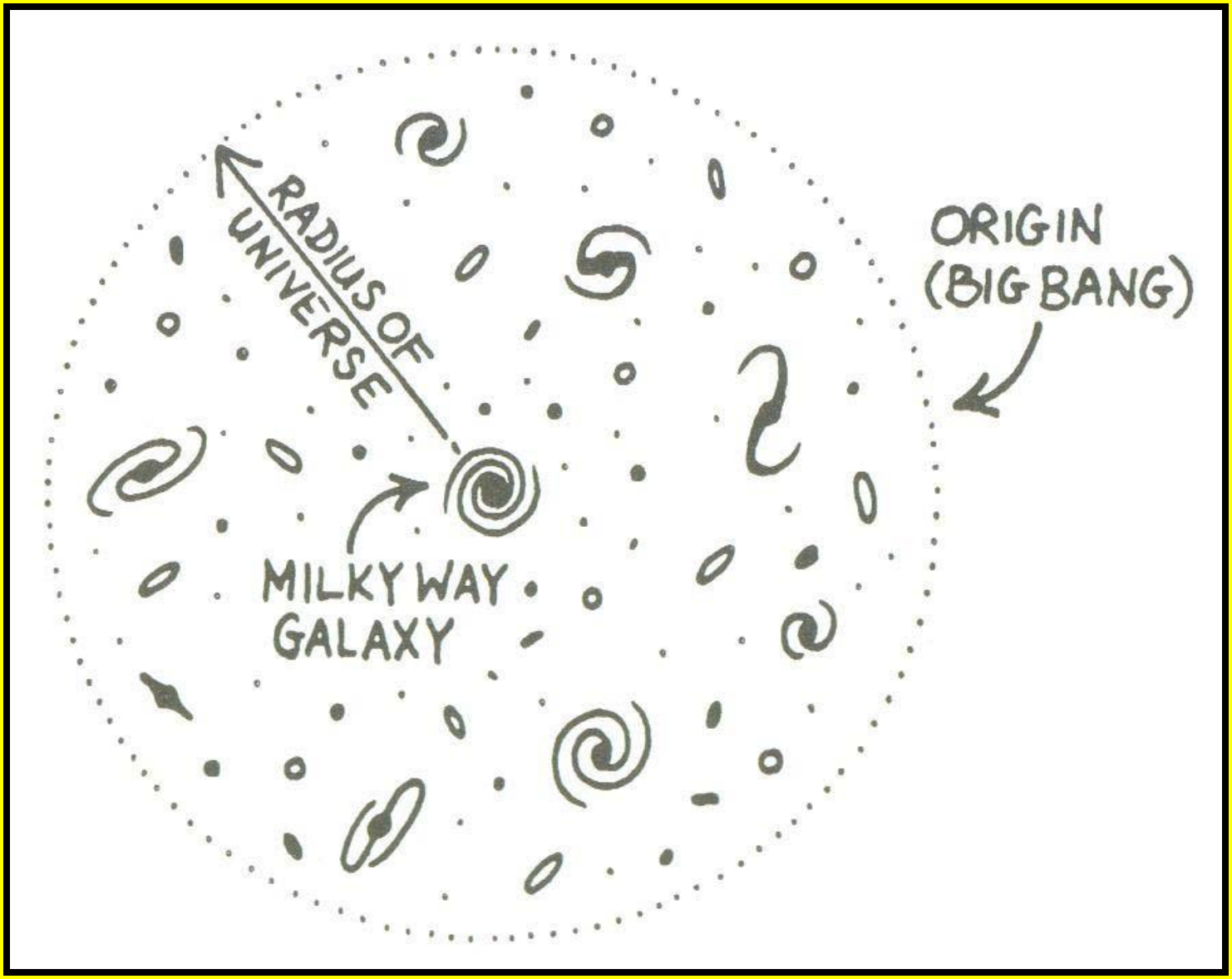




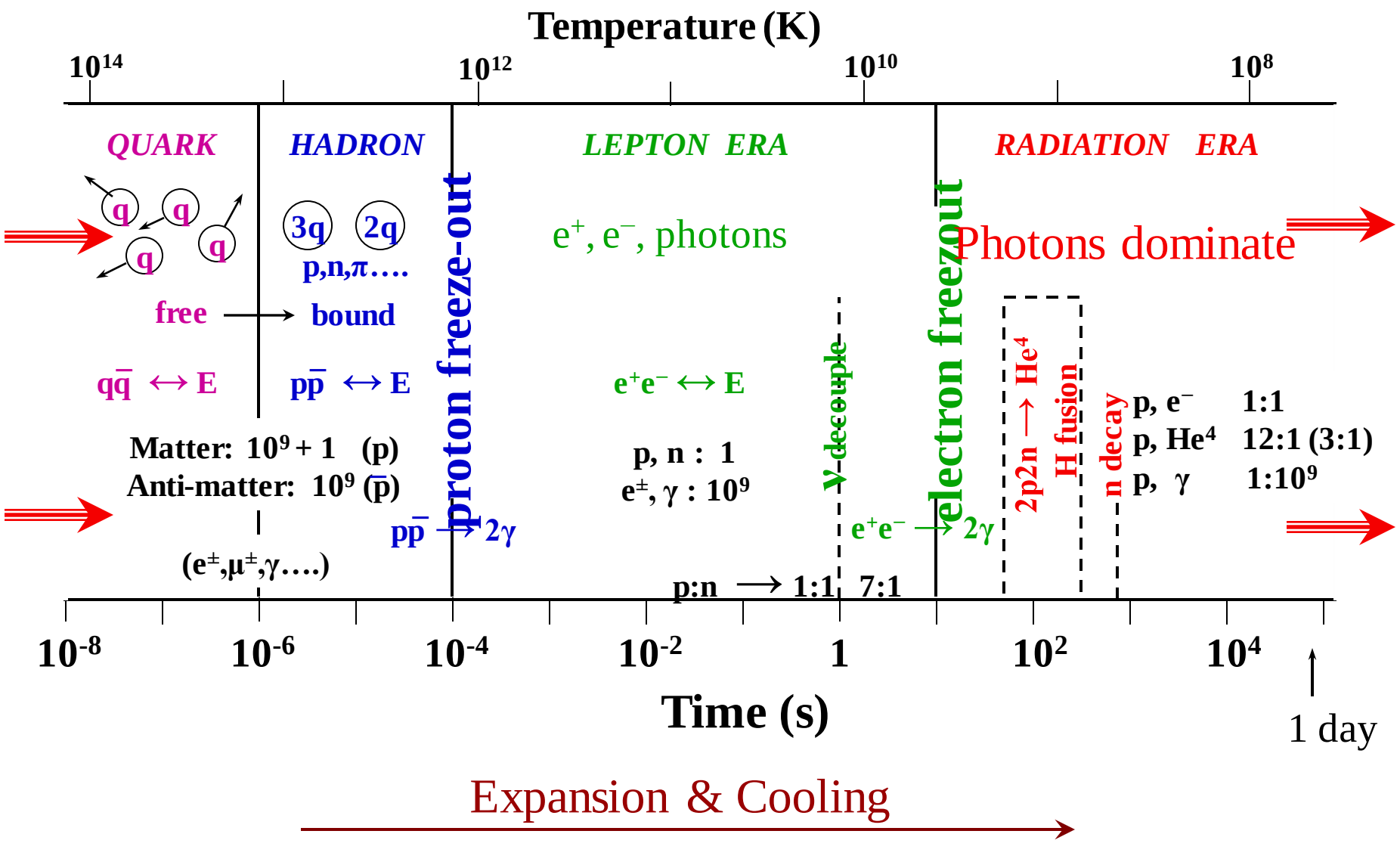
Homogeneous: looks the same at all locations
Not isotropic

Isotropic: looks the same in all directions
Not homogeneous

Looking afar is looking far back in time



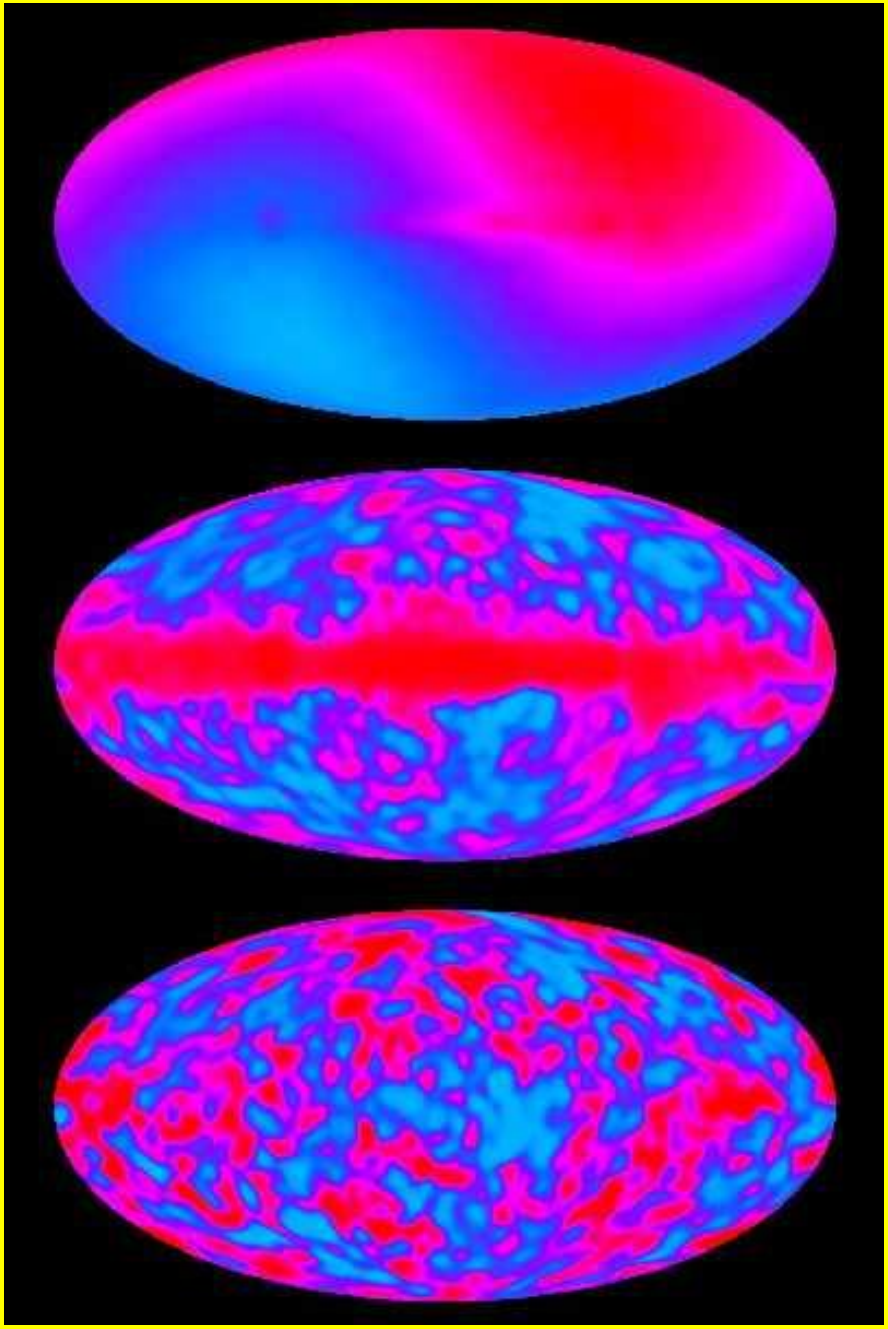
The First Day

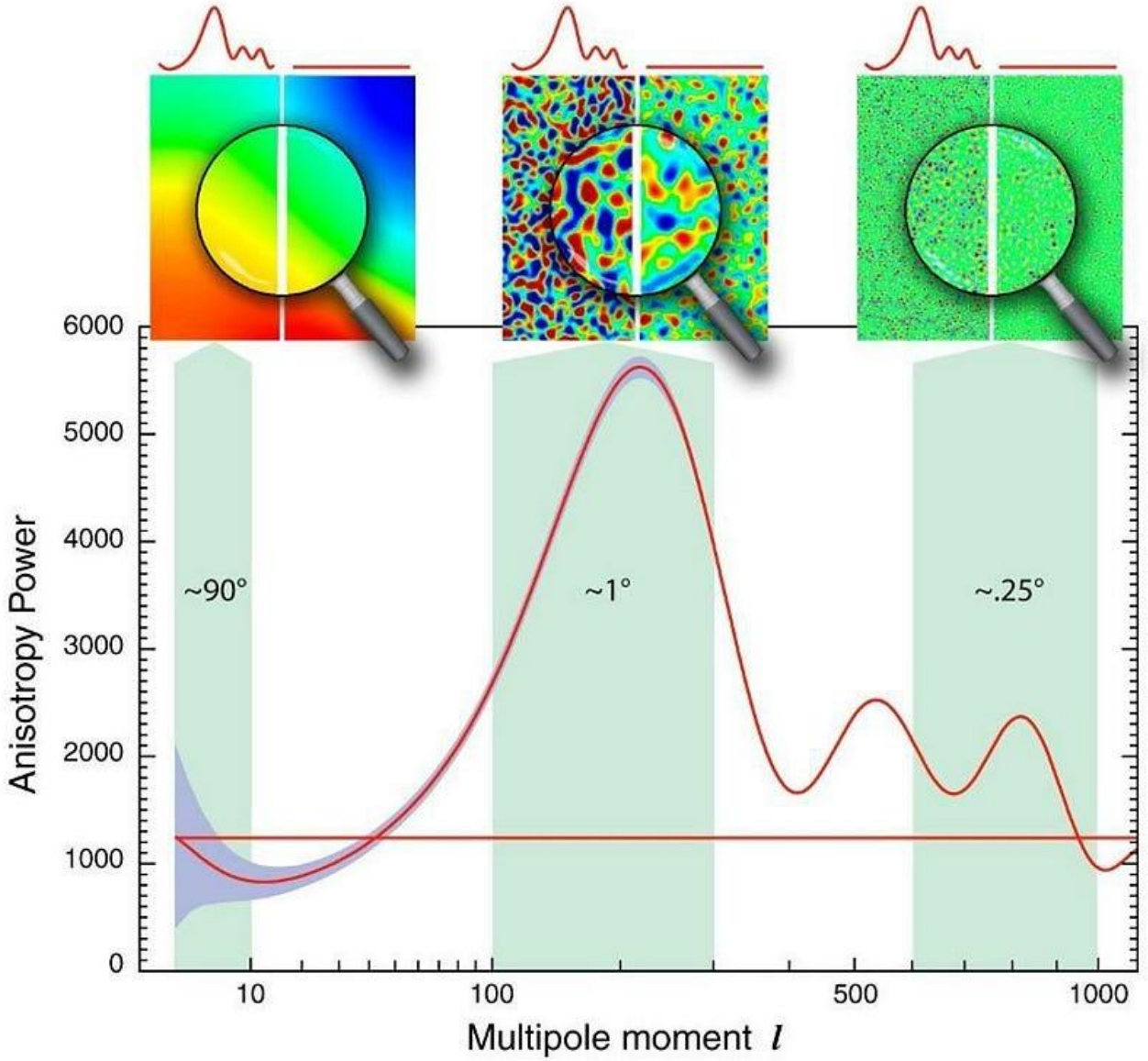


Expansion & Cooling

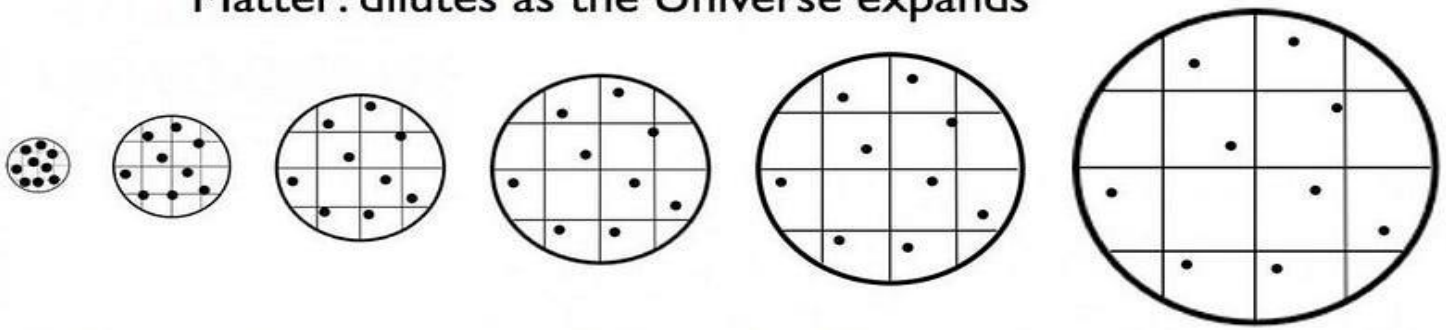
How did the Universe get *clumpy* on the small scale?

This is the big-question in cosmology today

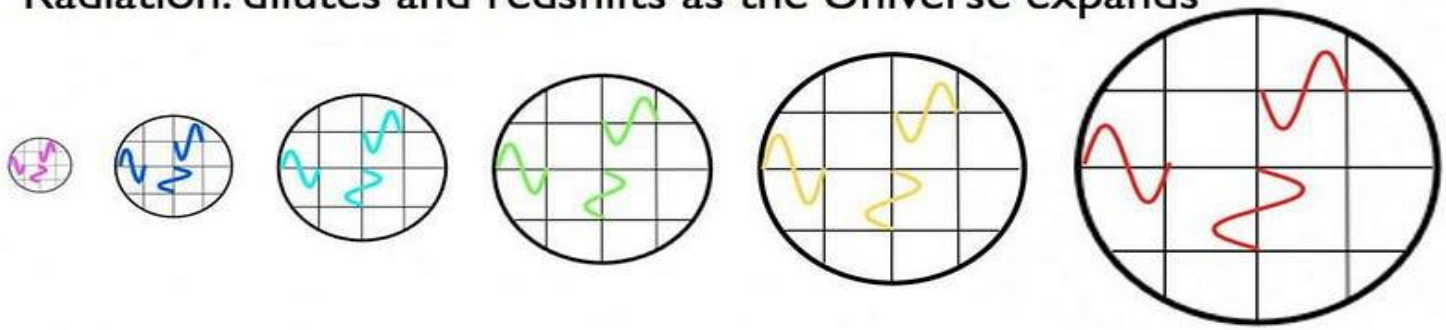


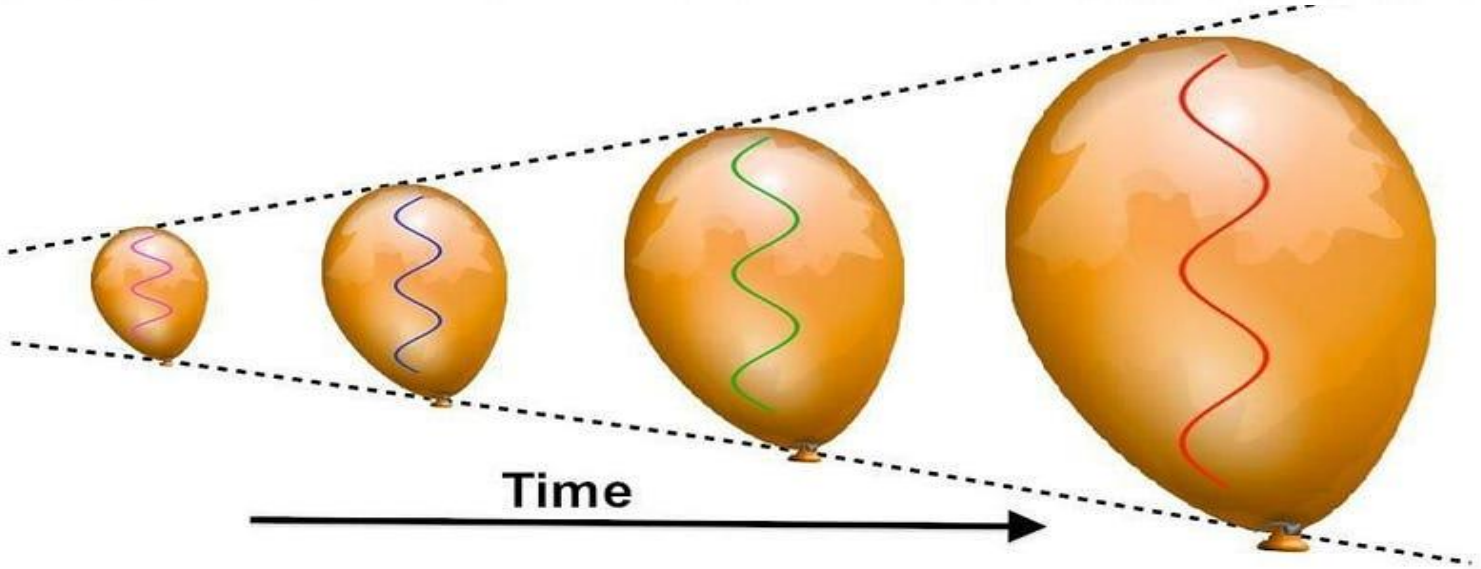

6000
5000
4000
3000
2000
1000
0
Anisotropy Power
~90°
~1°
~.25°
10
100
500
1000
Multipole moment l

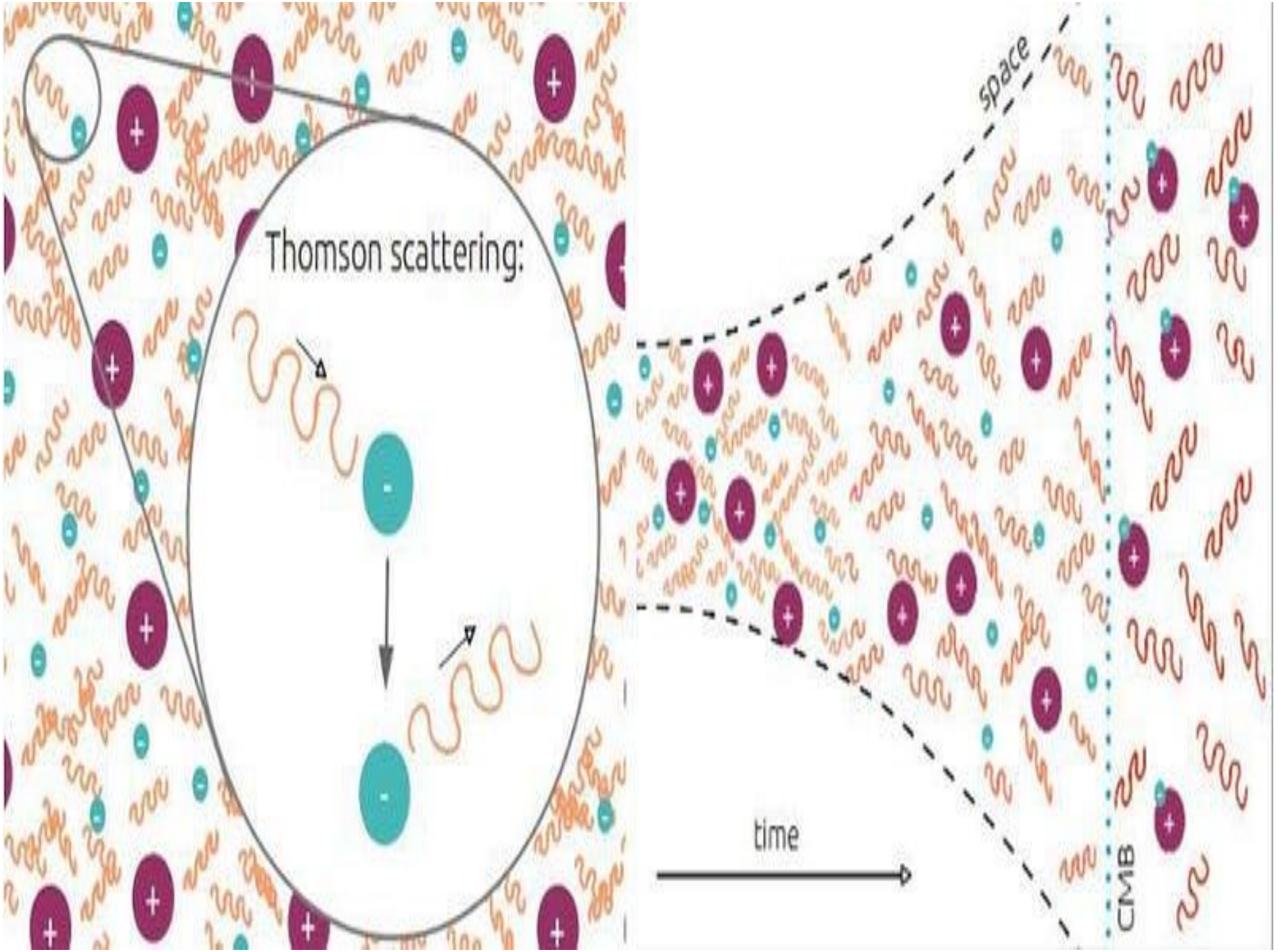
Matter: dilutes as the Universe expands

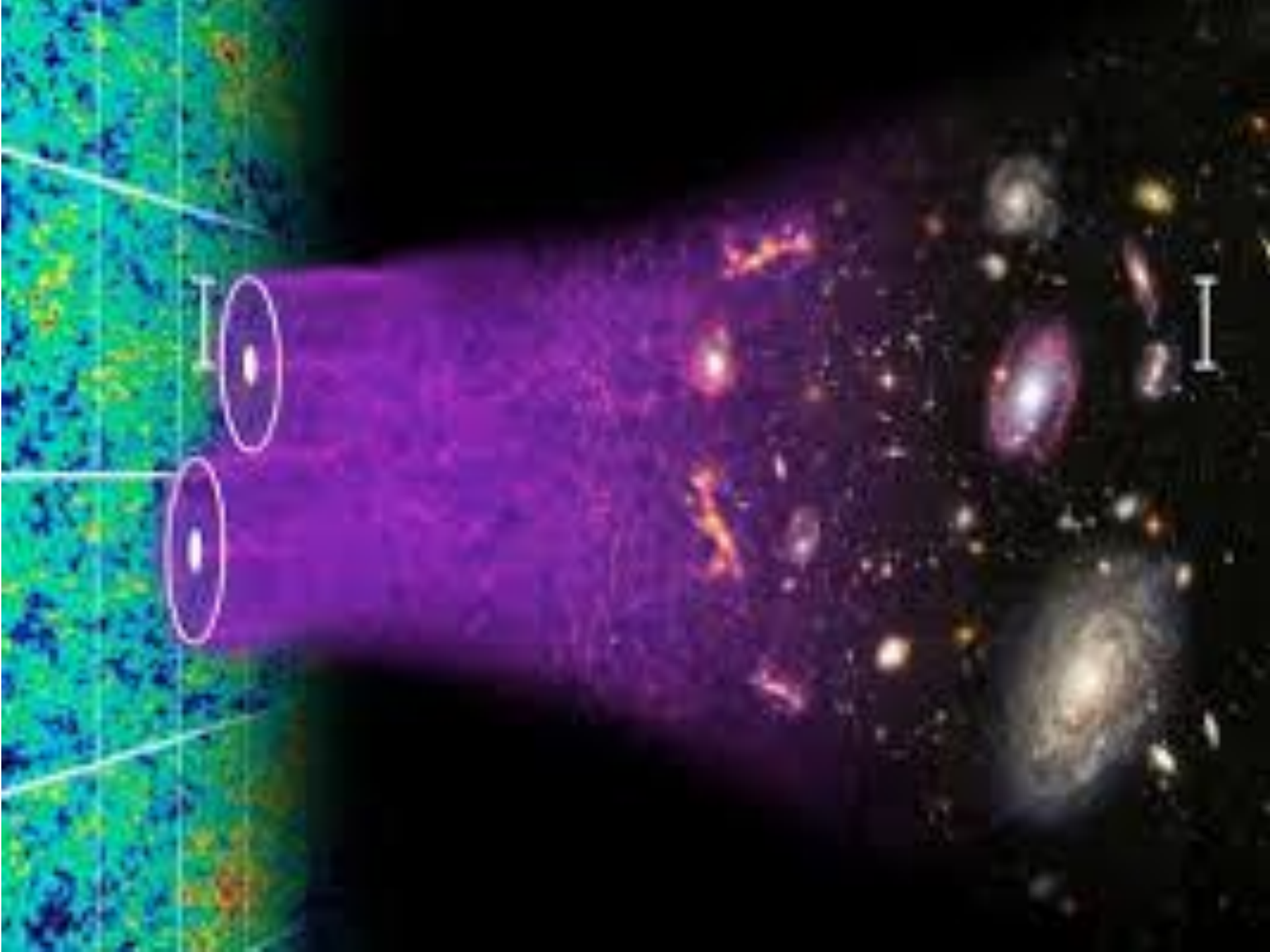


Radiation: dilutes and redshifts as the Universe expands

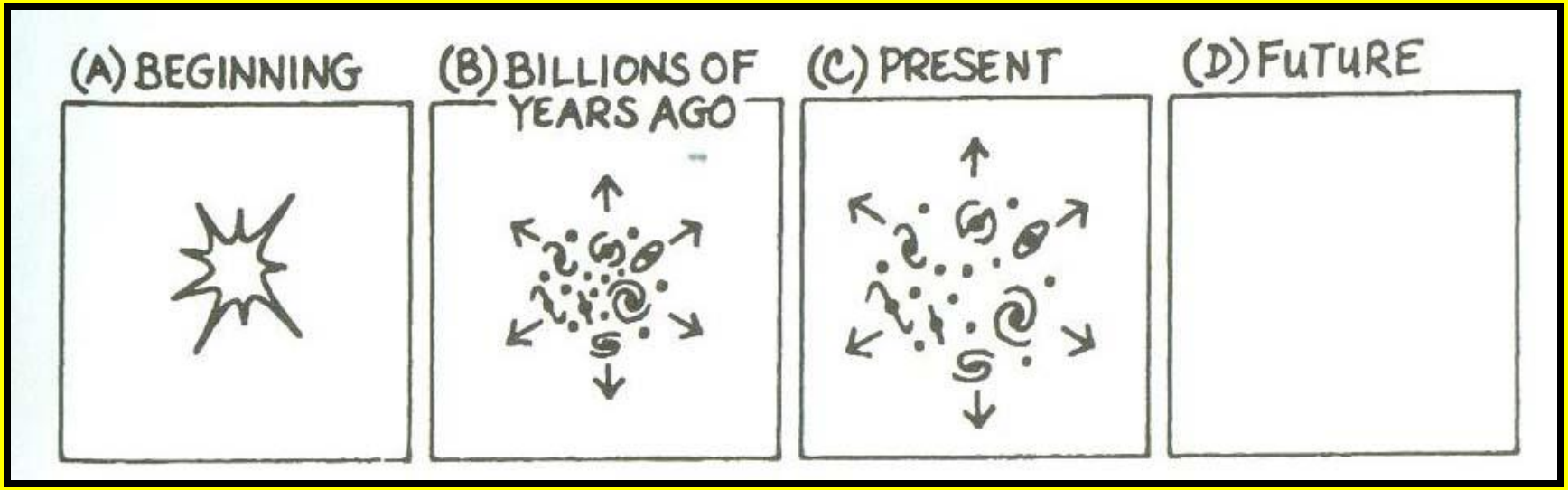





Thomson scattering:
space
time
CMB



An ‘Open Universe’…

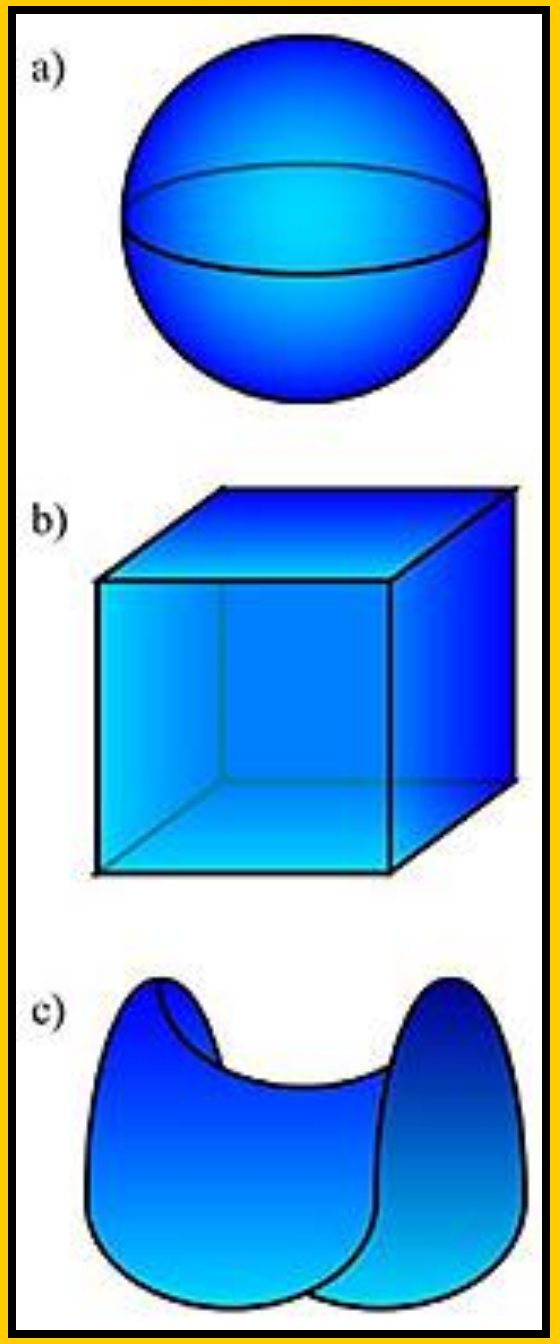


…the expansion goes on forever.

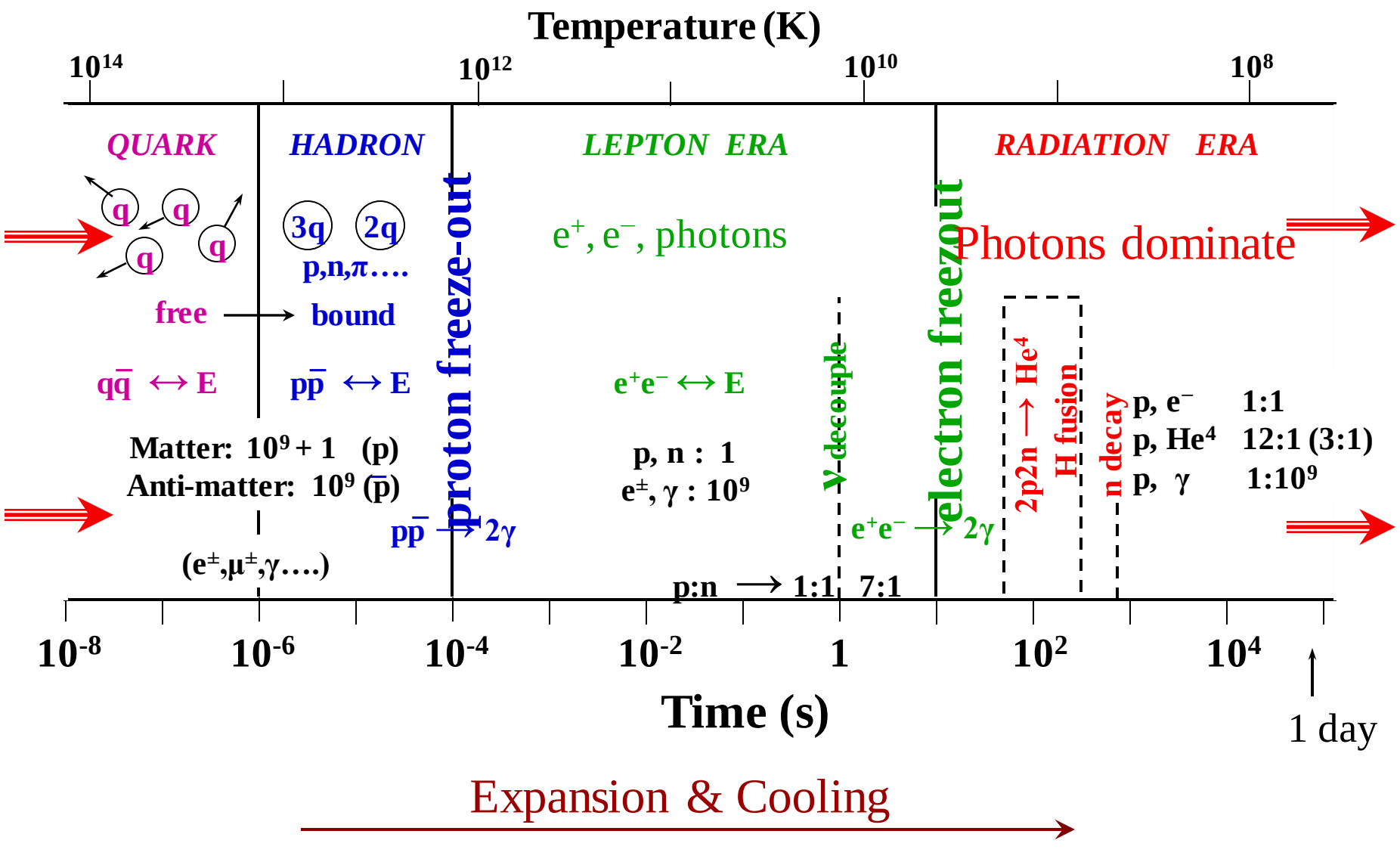
Closed Universe

Flat Universe

Open Universe

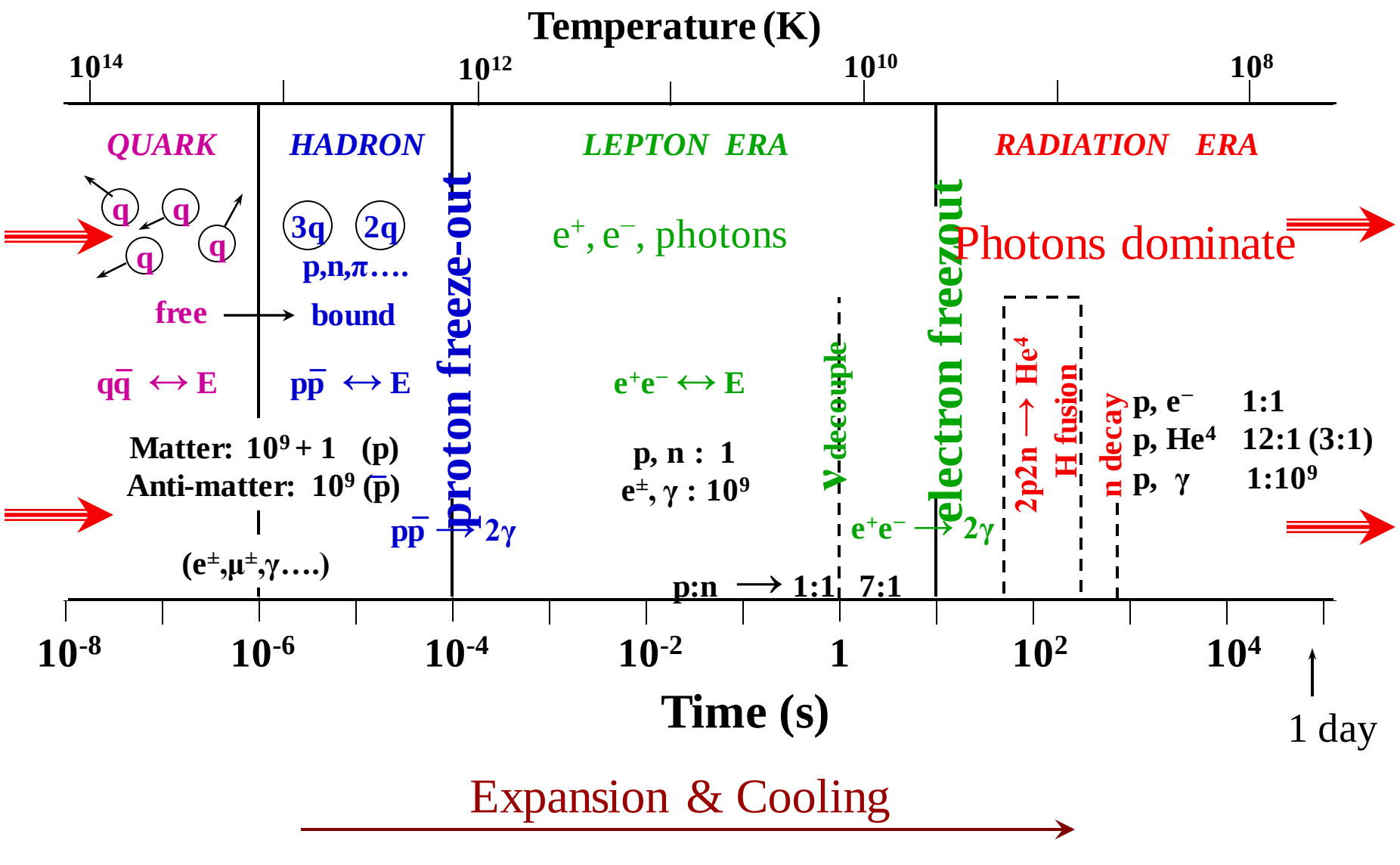


The First Day



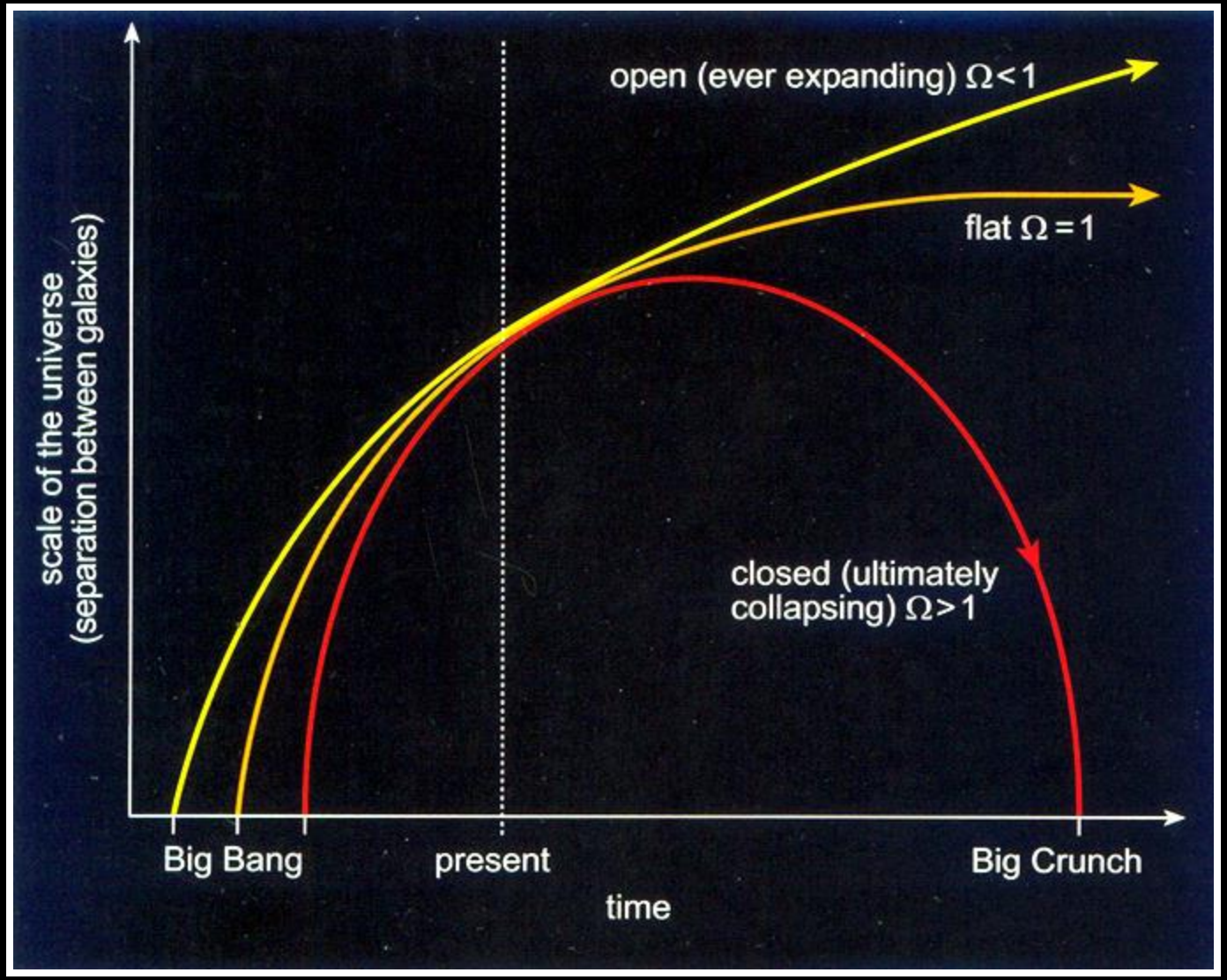
Expansion & Cooling

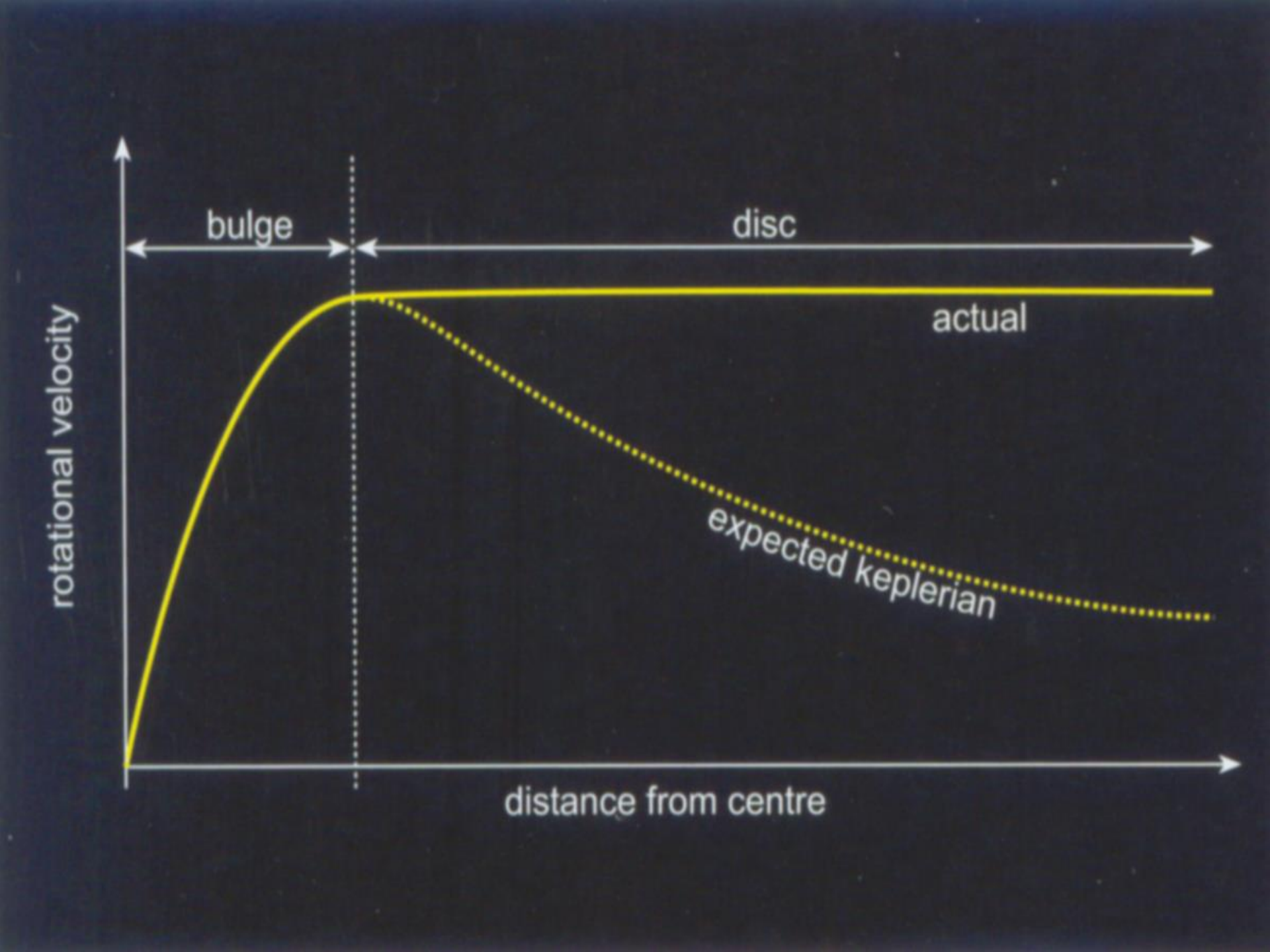
The First Day

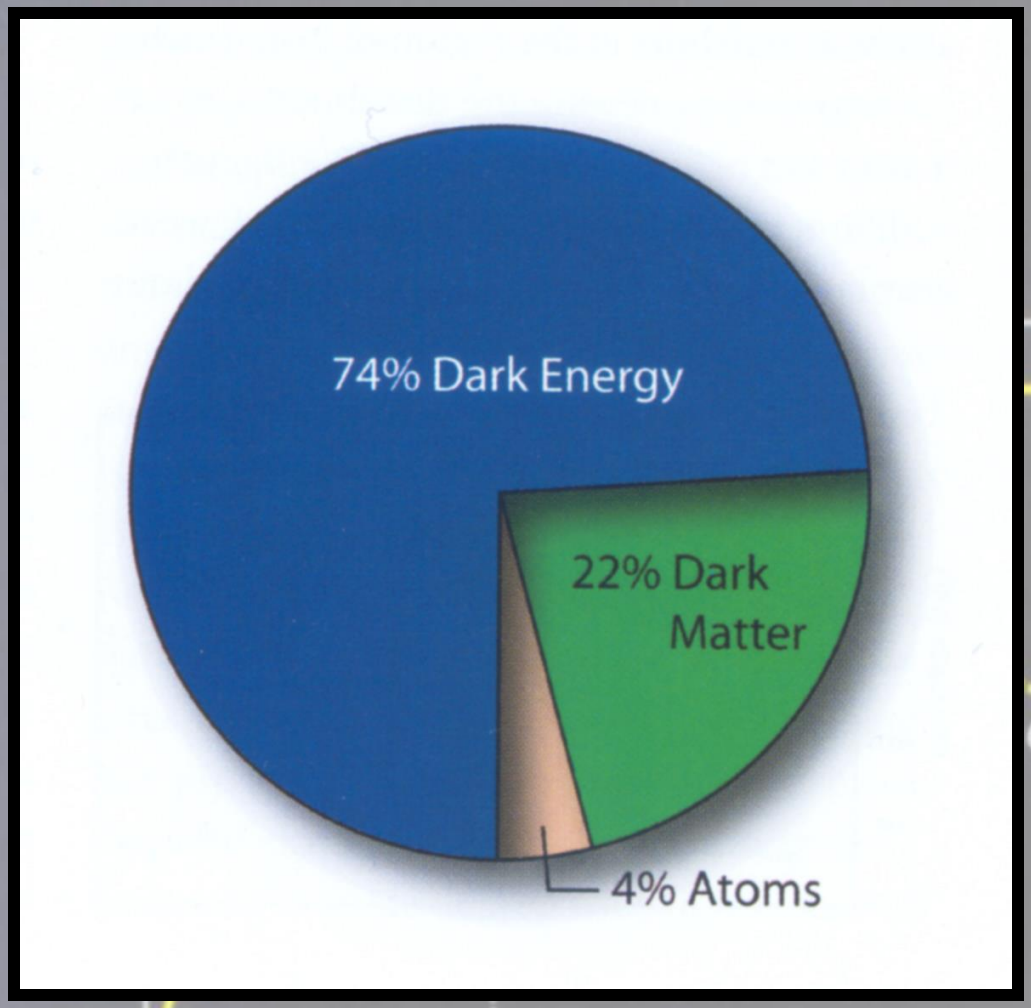


Expansion & Cooling

Traditional view of the fate(s) of the Universe




bulge
disc
actual
expected keplerian
rotational velocity
distance from centre



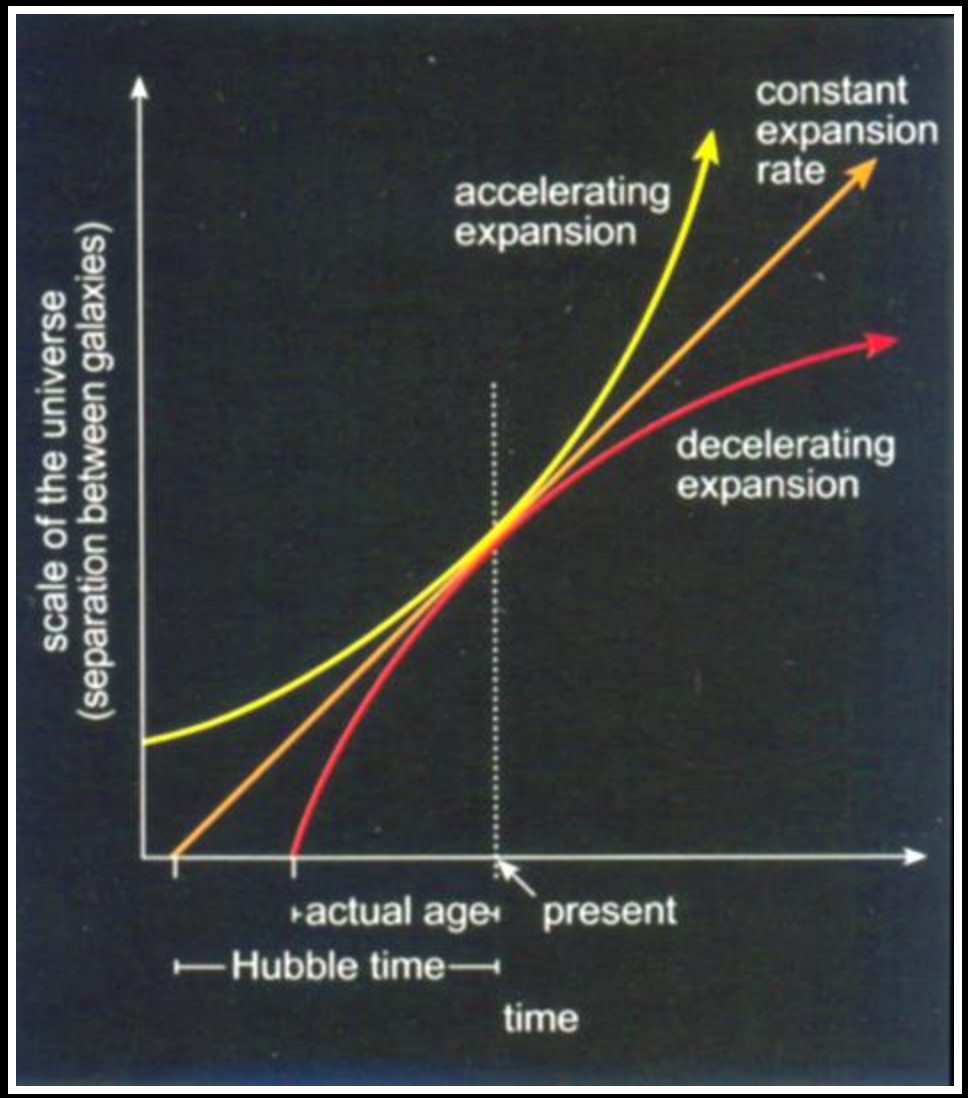
disc

actual

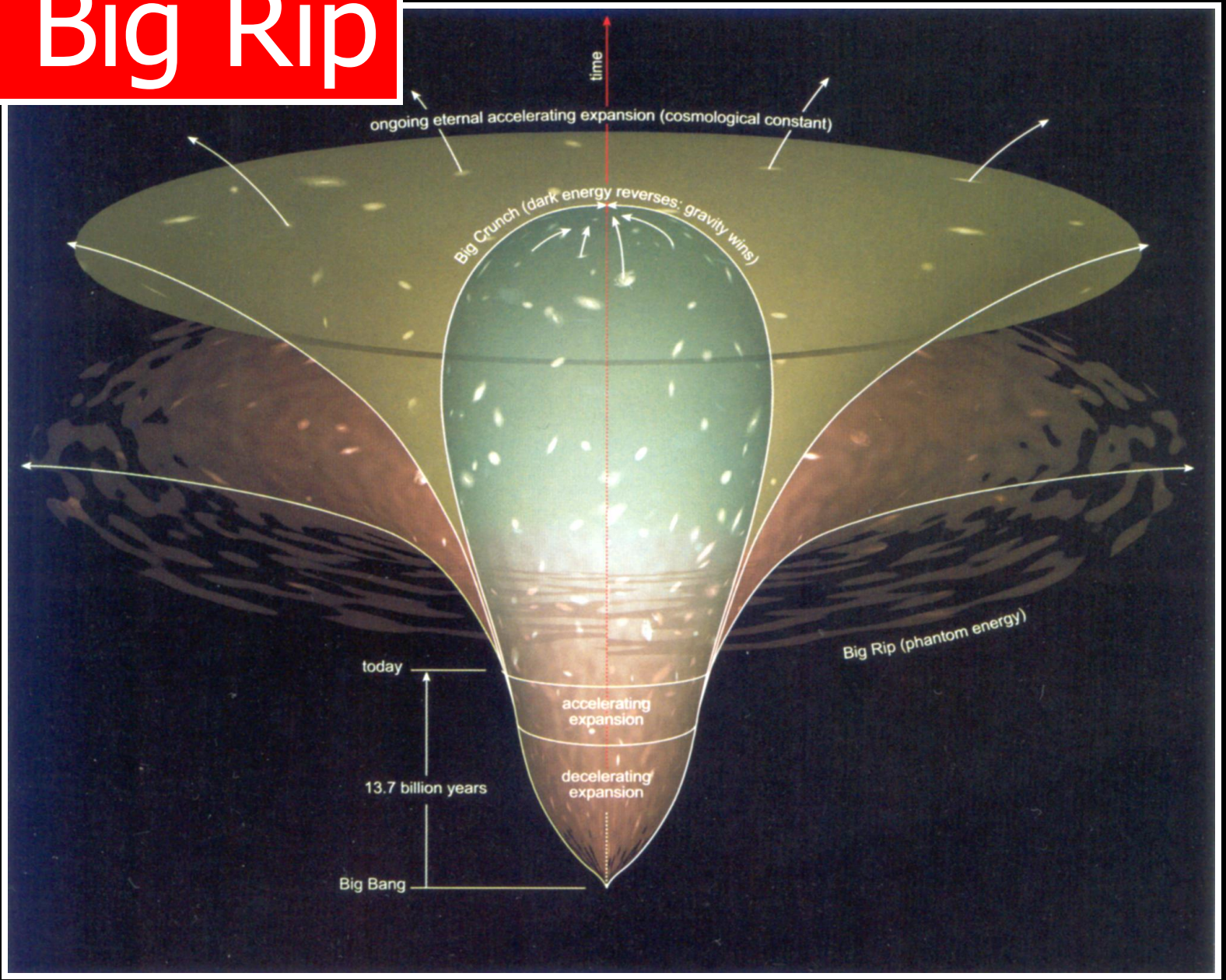
expected keplerian

distance from centre

In 1998 it was discovered that the rate of expansion is accelerating.



The Big Rip


time
ongoing eternal accelerating expansion (cosmological constant)
Big Crunch (dark energy reverses: gravity wins)
Big Rip (phantom energy)
today
accelerating expansion
decelerating expansion
13.7 billion years
Big Bang


The End