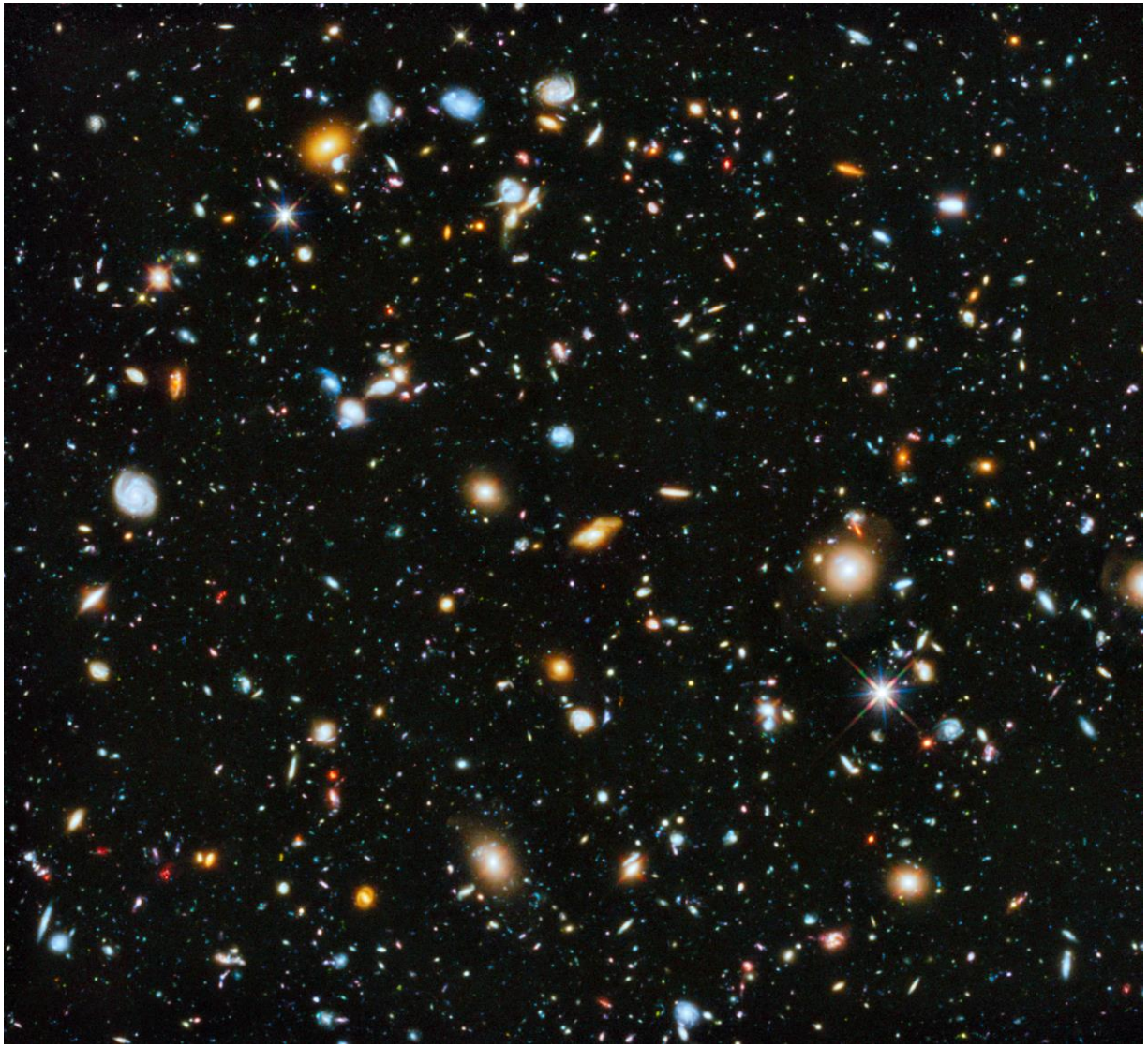
Unit 5
Stars & Celestial Objects

THE BIG BANG

Deep field view of the one region of the night sky showing hundreds of galaxies.

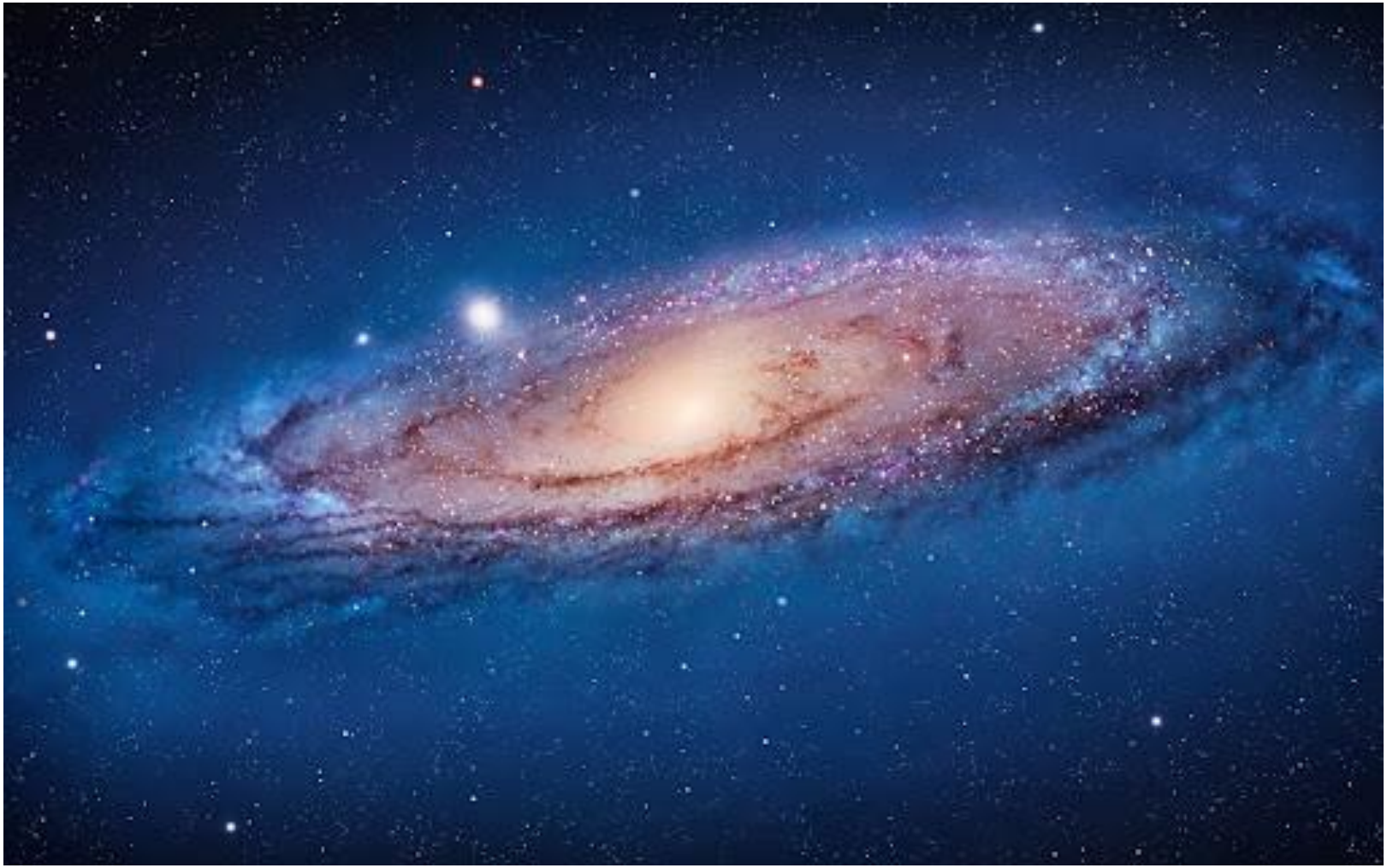


The **Milky Way Galaxy** is one of billions of galaxies in the observable universe. (taken by Hubble Space Observatory).

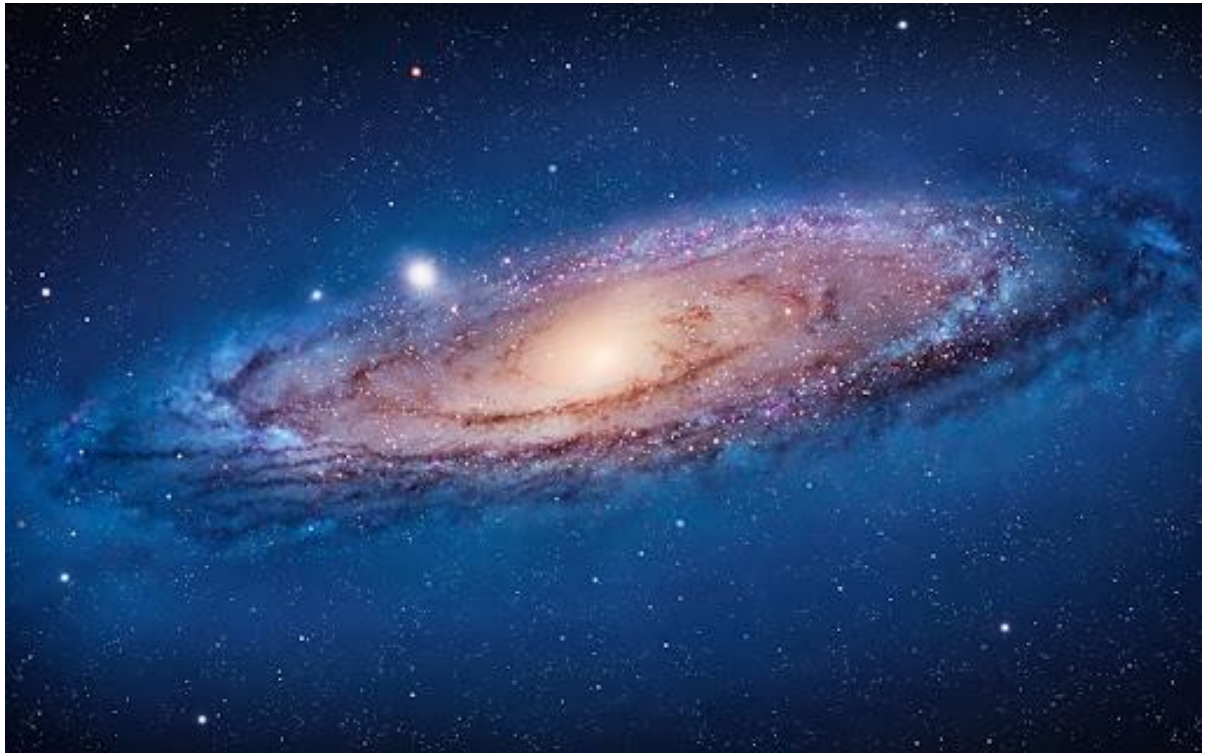
Dark Matter: A mysterious substance that has mass but does not have the traditional properties of known matter (solid, liquid, gas, plasma, atoms, etc).

- Has mass
- Creates gravity
- It cannot be seen (does not absorb light, does not create light)
- It far outnumbers the amount of normal matter in the universe.

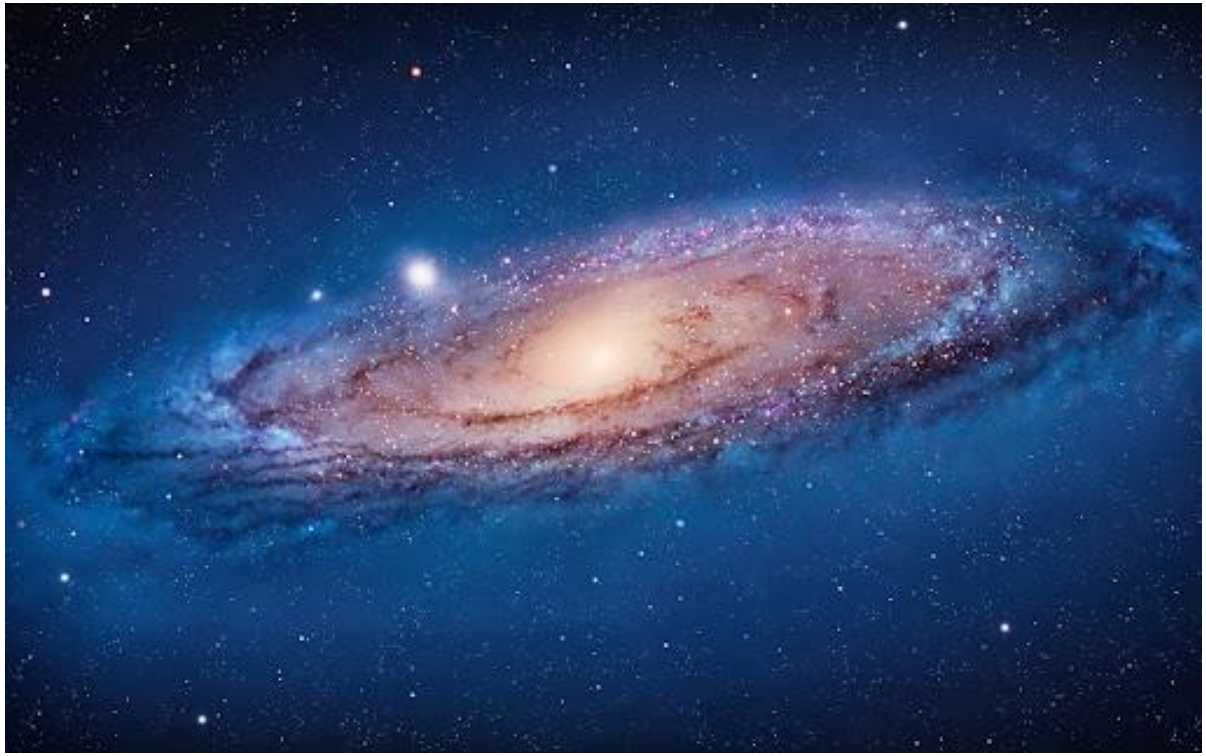
Remember: everything we know about the universe is based on observations of light. Visible matter is the stars, nebulae, black holes, and anything else that reflects light, emits light, or absorbs light.



Galaxies **rotate "too fast"** for the amount of "light and visible mass". Galaxies should be more massive to rotate as fast as they do.

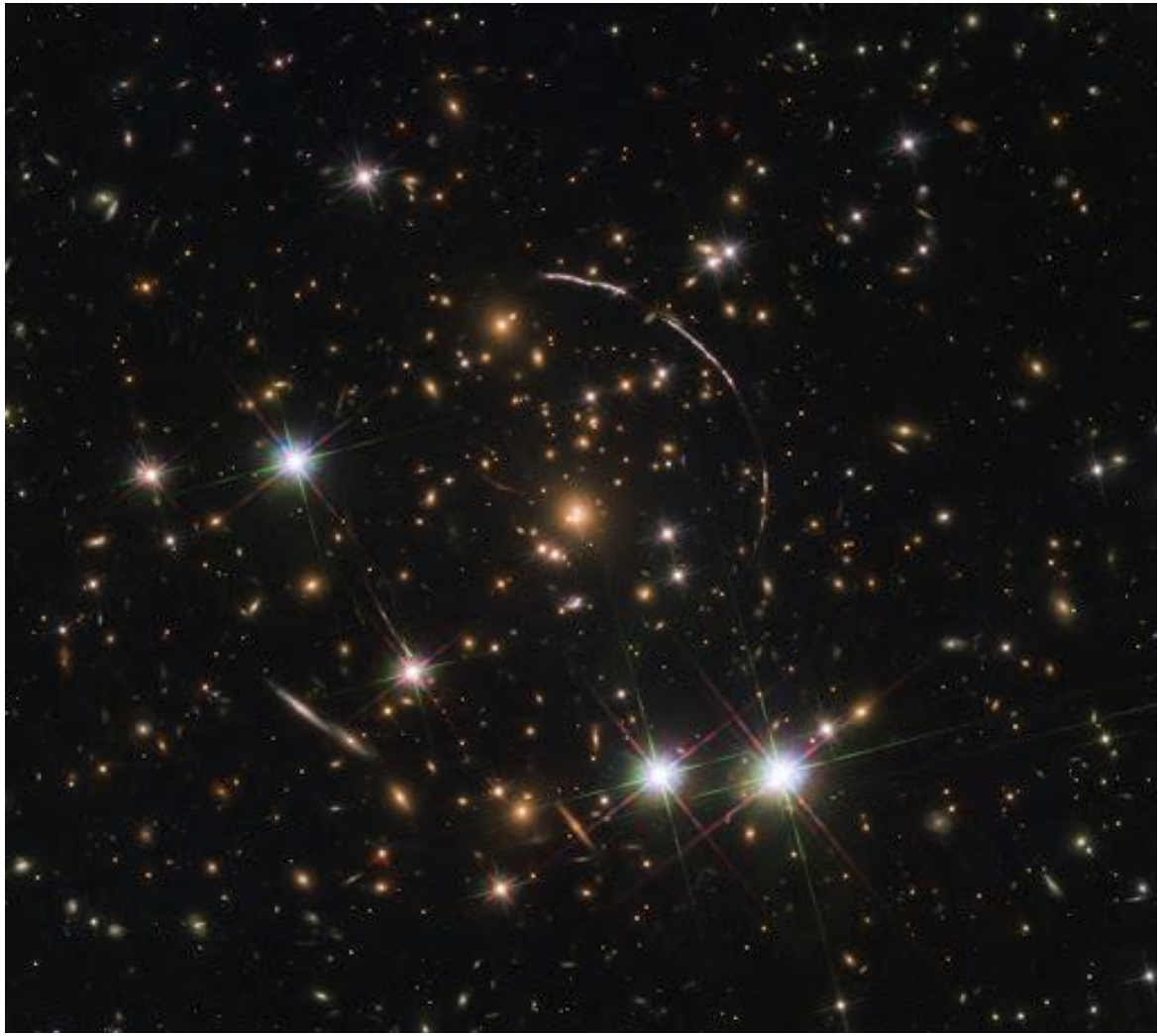


Dark matter is adding “mass” to the galaxies that cannot be seen, but must be there. There should be **approximately 5-times more dark matter in a galaxy than the “visible” matter** (stars) and the black holes.

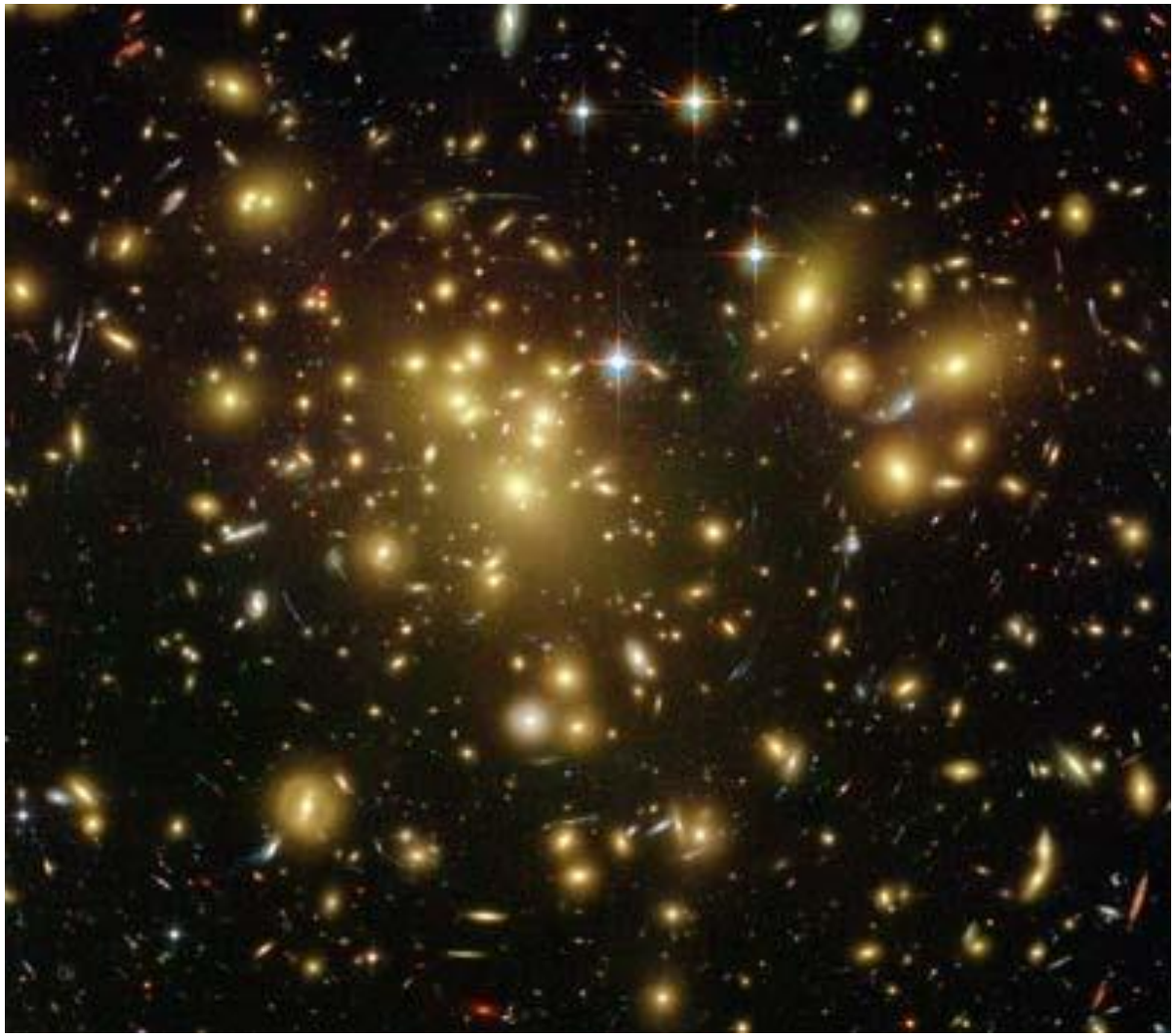


Dark matter is adding “gravitational attraction” to the galaxies. The gravitational pull of the “visible” matter and the supermassive black hole is not strong enough to keep all stars clustered together into a rotating galactic disk. Dark matter’s additional gravity keeps stars contained within the galactic disk.

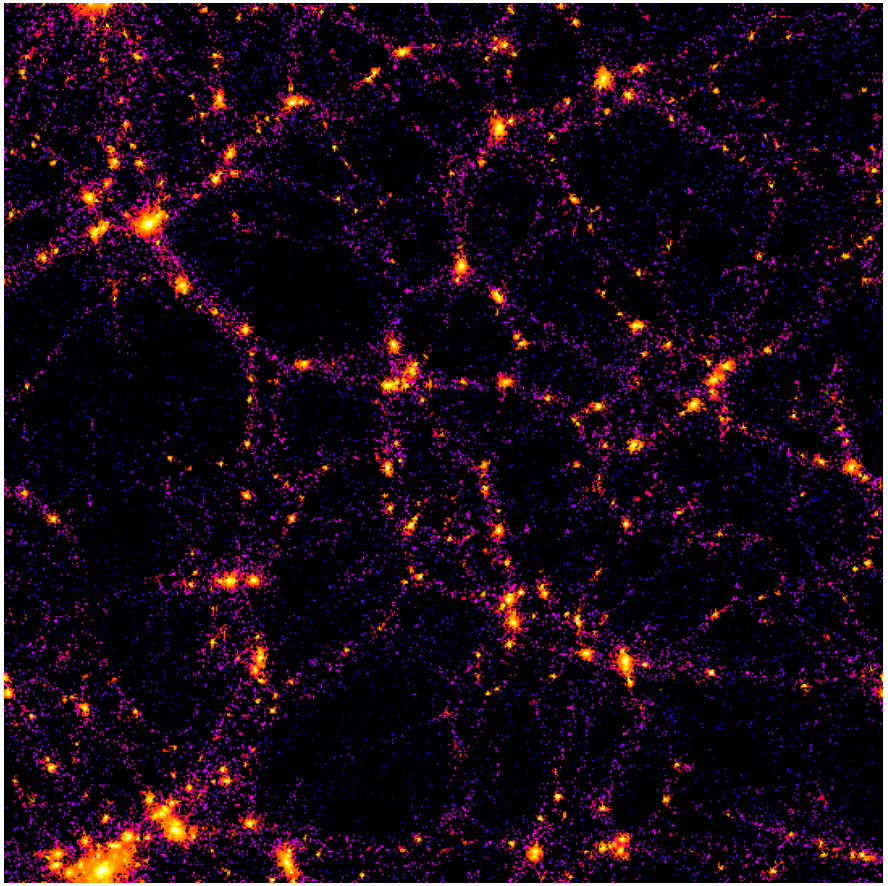
Galaxies have a lot of mass. Galaxies cause much stronger gravitational lensing than what is expected based on the amount of visible matter.

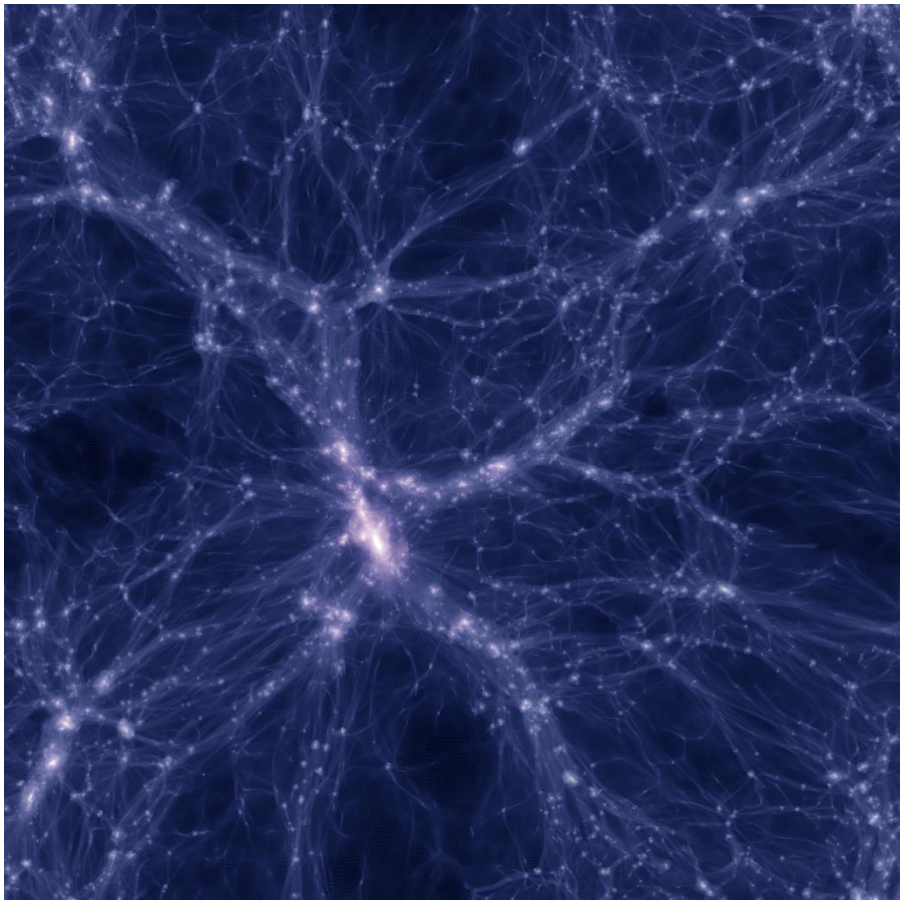


Galaxy clusters (sometimes called groups or superclusters depending on size) are groups of galaxies, hundreds to thousands, associated by gravity.

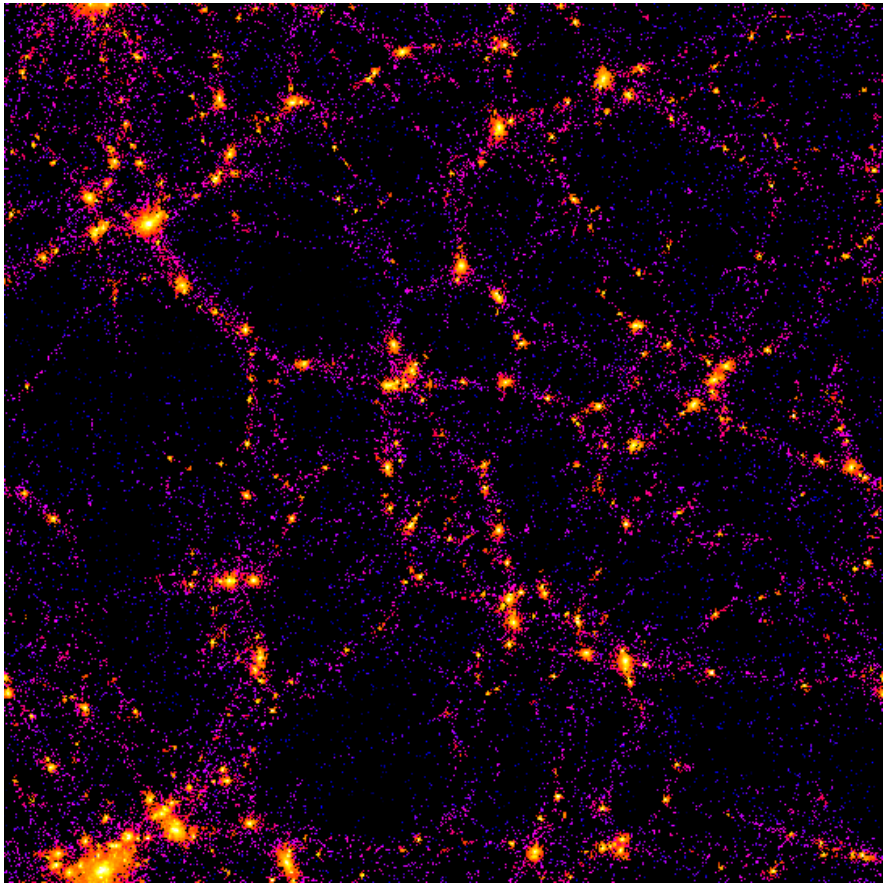


Galactic superclusters are grouped together and lie within the web-like arrangement in the observable deep field view. The web-like arrangements of galactic clusters are called **filaments.**



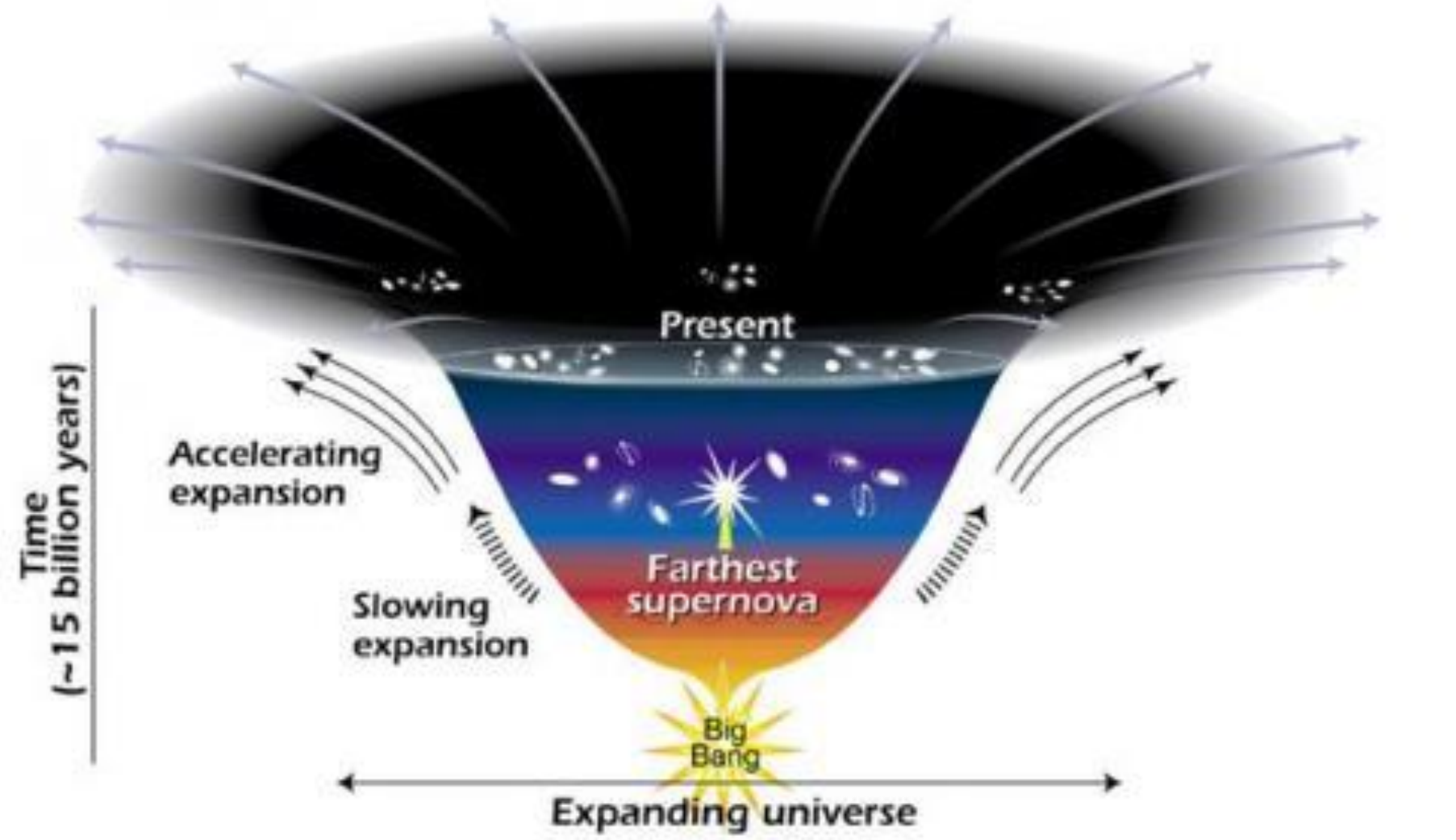


Galactic cluster filaments are not evenly distributed. They form interwoven webs with large void areas. The galactic clusters are held in these filaments by waves of **dark matter**.



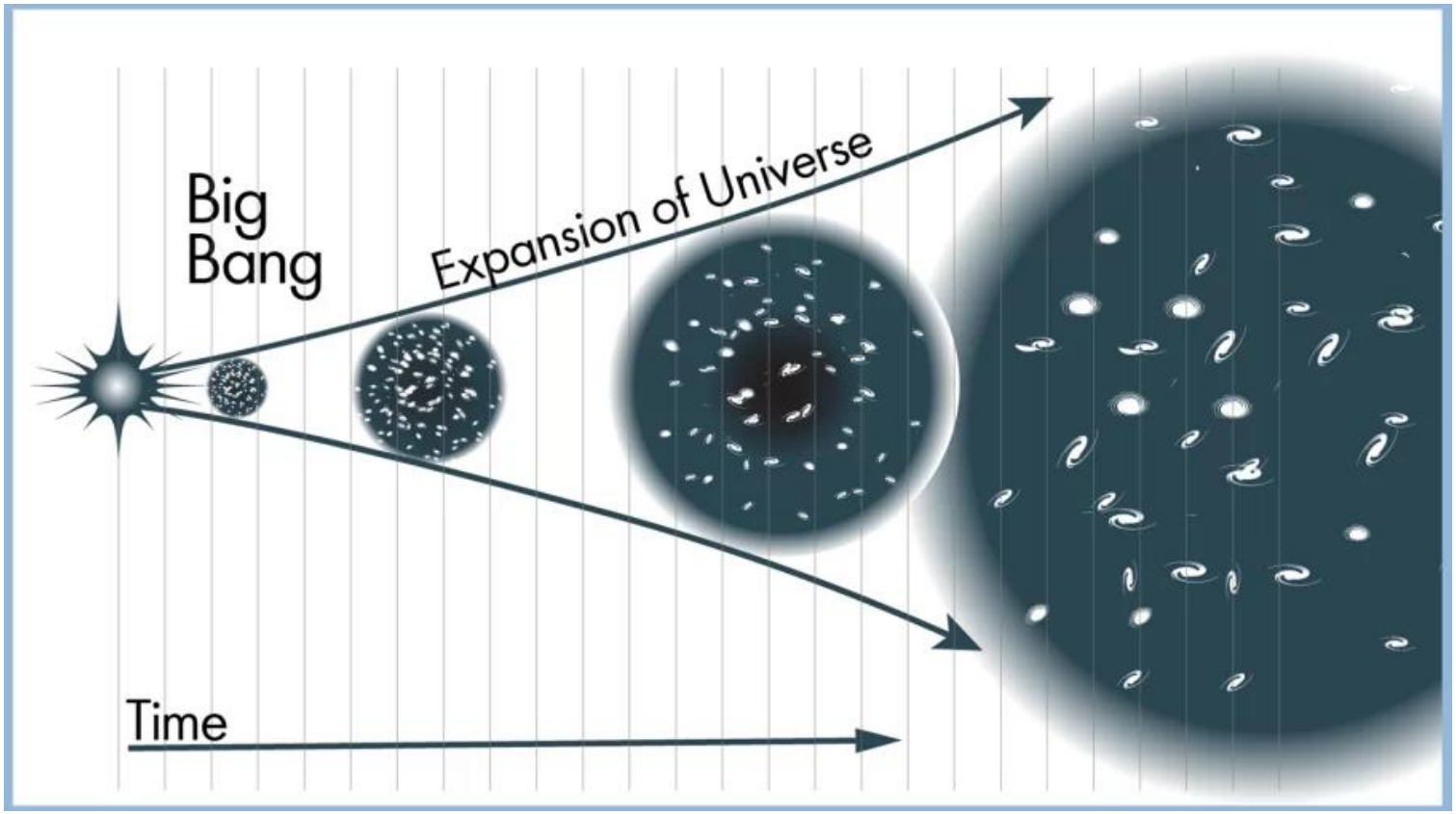
Dark matter is not evenly distributed through the universe. Its more concentrated in some places and less concentrated in other places.

Visible “traditional” matter = 5%
Dark matter = 27%
Dark energy = 68%



Dark energy is created as space-time increases in size and volume.

Dark energy is responsible for **accelerating the inflation of the universe** and **accelerating the velocity** of receding galaxies.



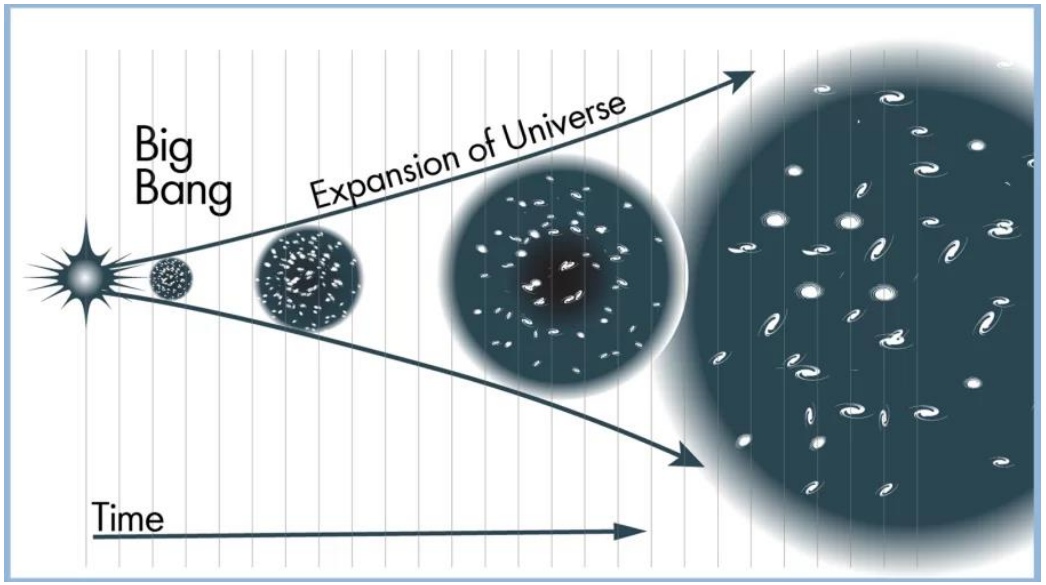
What is the Big Bang?

The modern hypothesis (or theory) of the creation of the visible universe.

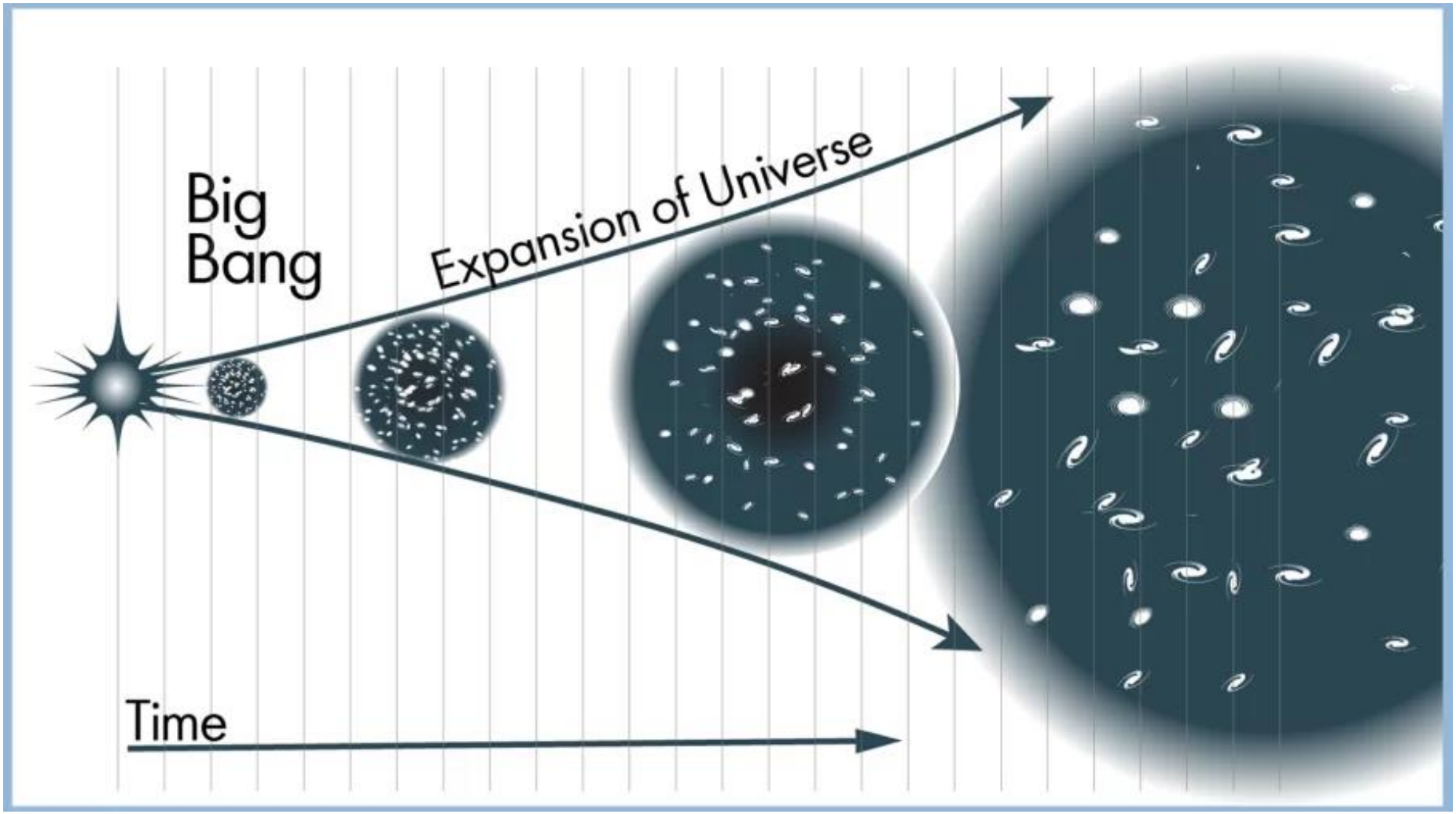
- All matter and energy began as a **singularity**—a infinitely dense point in space.
- The singularity rapidly and violently **inflated** (expanded outward in all directions).
- Time and space was created and began to grow in size.
- All contents at the start of the inflation was in the form of superheated energy.

- Temperatures cooled as the energy, space, and time expanded. Energy condensed into matter and antimatter.
- Antimatter got annihilated leaving only matter behind (subatomic particles).
- As temperatures cooled more, subatomic particles formed atoms of hydrogen. In the beginning only hydrogen existed.
- 150 million to 200 million years after the big bang, the first stars formed.
- 1 billion years after the big bang, the first galaxies formed.

- The observable universe is NOT static in size.
- Galaxies are moving farther and farther apart with time.
- Galaxies are moving away from each other faster and faster with time.
- The volume of space is also expanding with time.
- There must have been a centralized “point” in space where everything began.
- The proposed age of the observable universe is 13.7 BY.

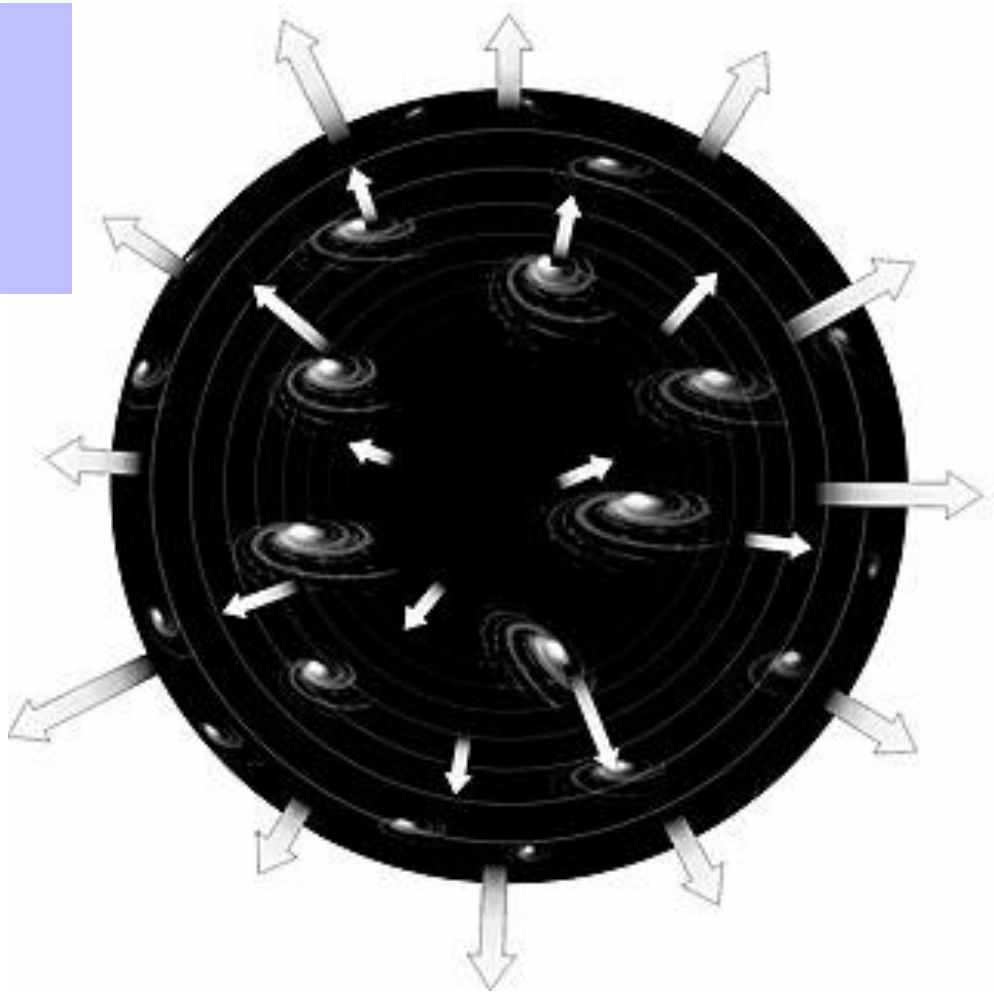


Hubble's observations provide indirect and foundational evidence of the ***Big Bang Hypothesis*** and the modern **theory of the expanding universe**.



1. All galaxies are **receding** from Earth. All galaxies are moving away from Earth. The emission spectra were "redshifted".

2. Galaxies are **diverging**. All galaxies are moving apart from each other

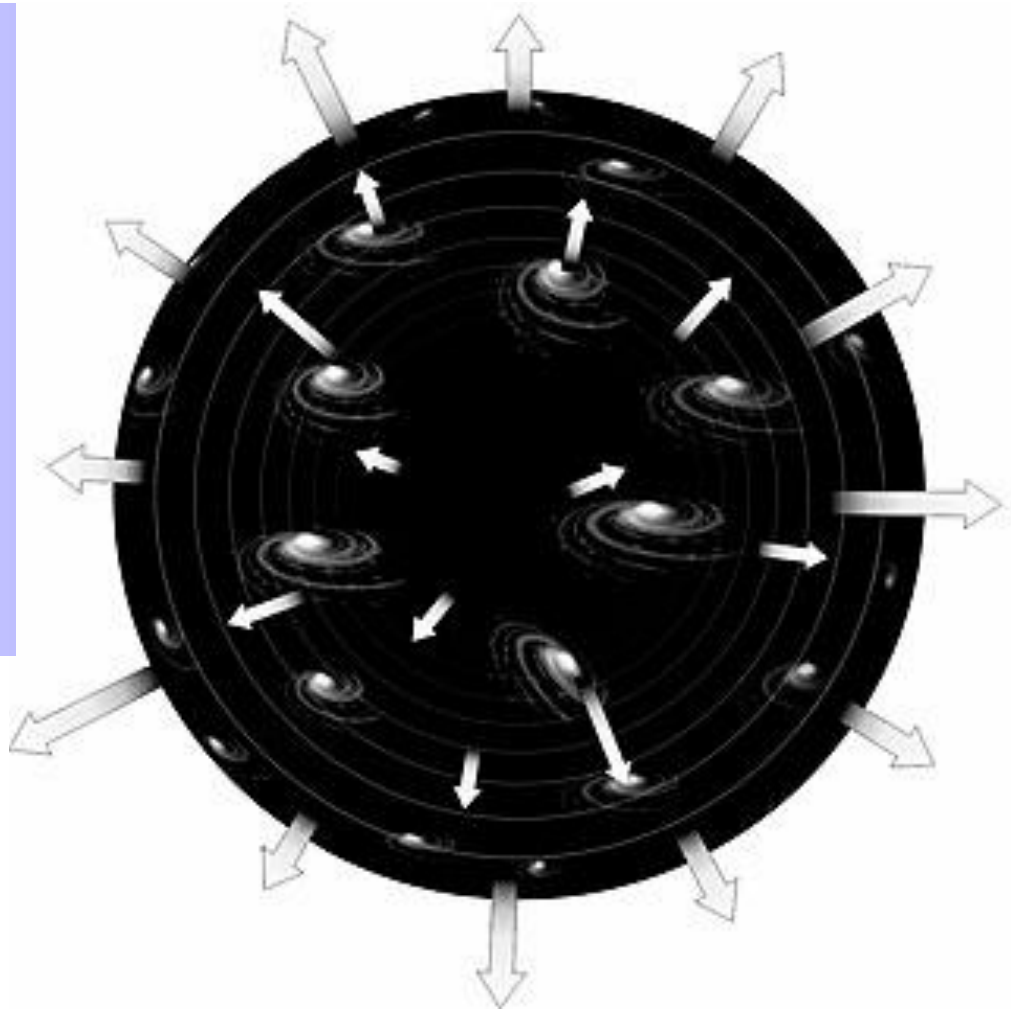


3. Galaxies that are closer to Earth are moving away at slower velocities.

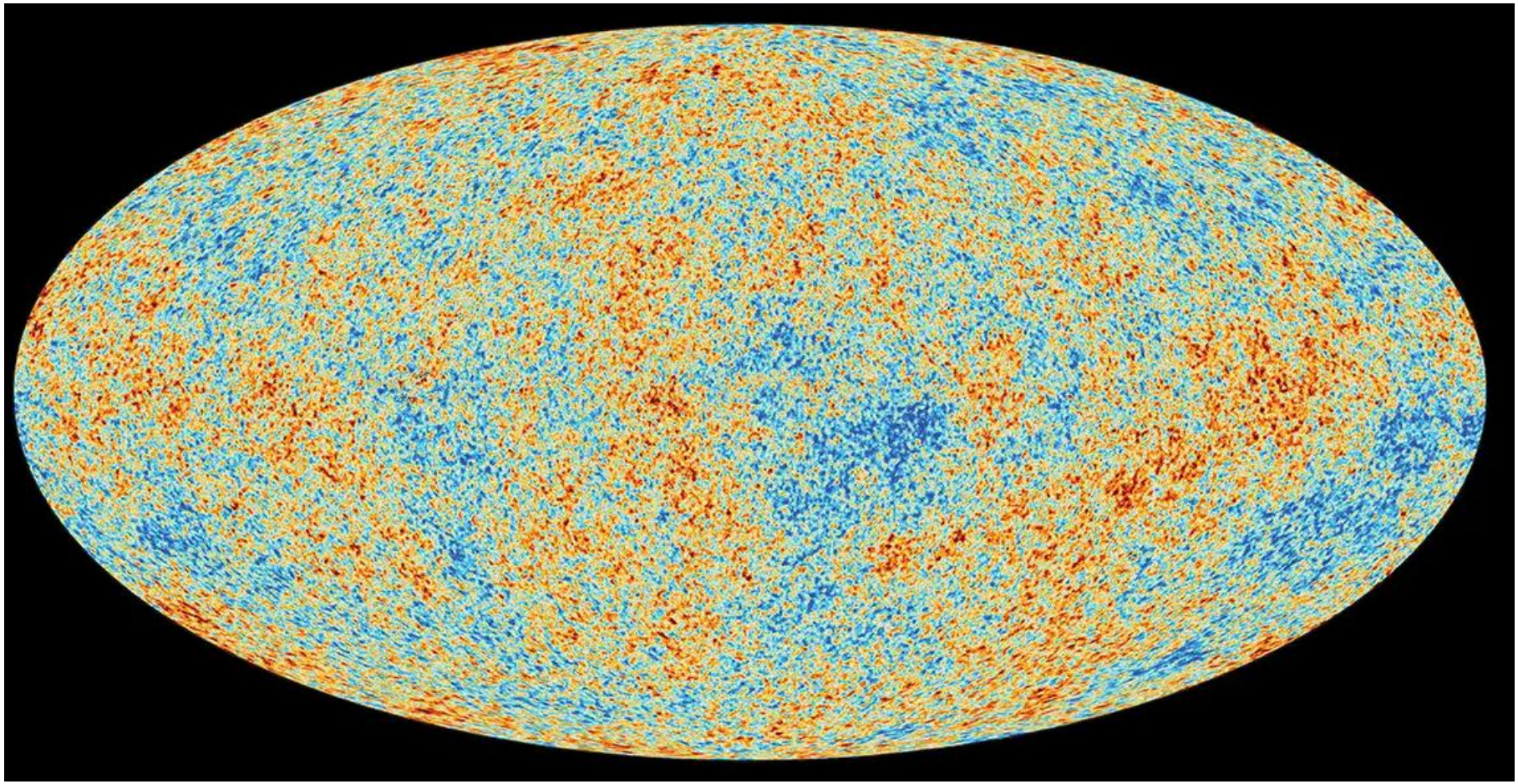
4. Galaxies farther from the Sun are moving away at faster velocities.

5. Galaxies are **accelerating with time**. The velocity that they recede with is getting faster. Galaxies are moving apart faster and faster.

6. Galaxies that are at the ***edge of the observable universe (~13.7 billion light years away)*** are accelerating to velocities approaching the speed of light.

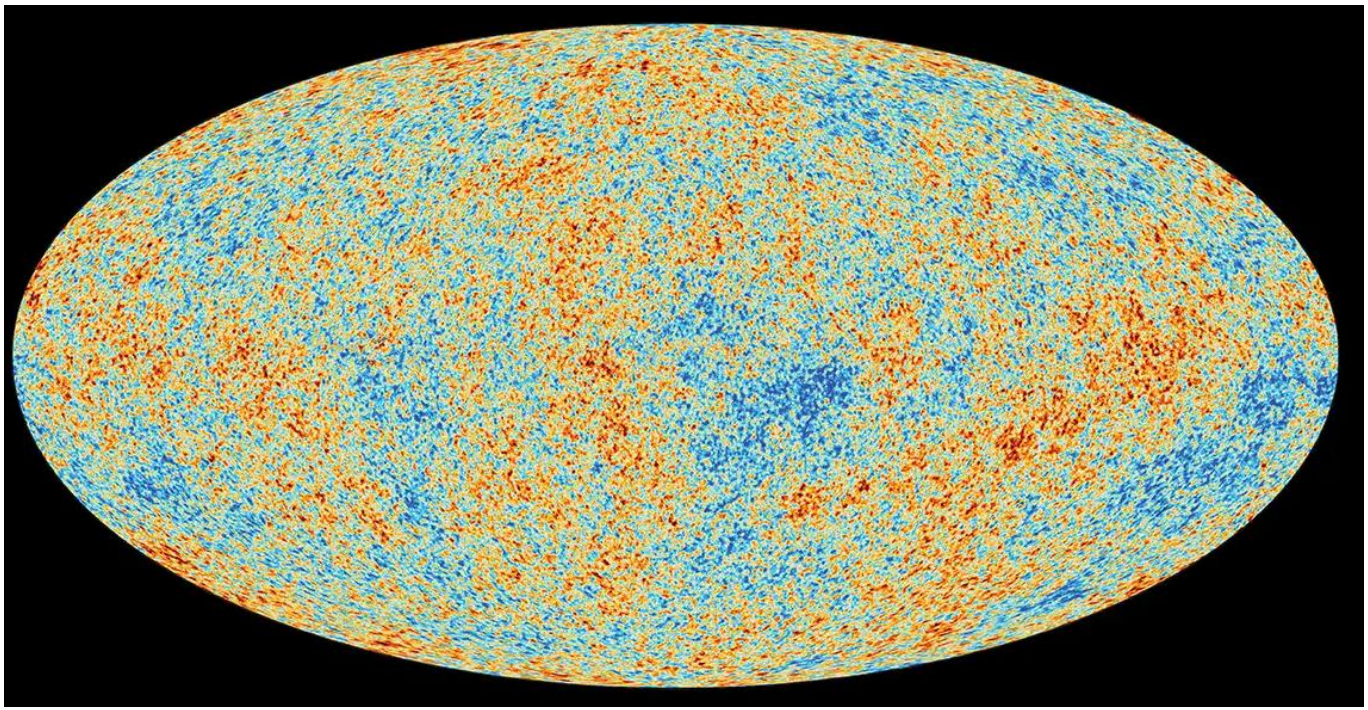


Intergalactic space is filled with **cosmic background radiation**—microwaves. Based on the current volume of the universe (space), the average temperature of intergalactic space is **~ 3 Kelvin**.



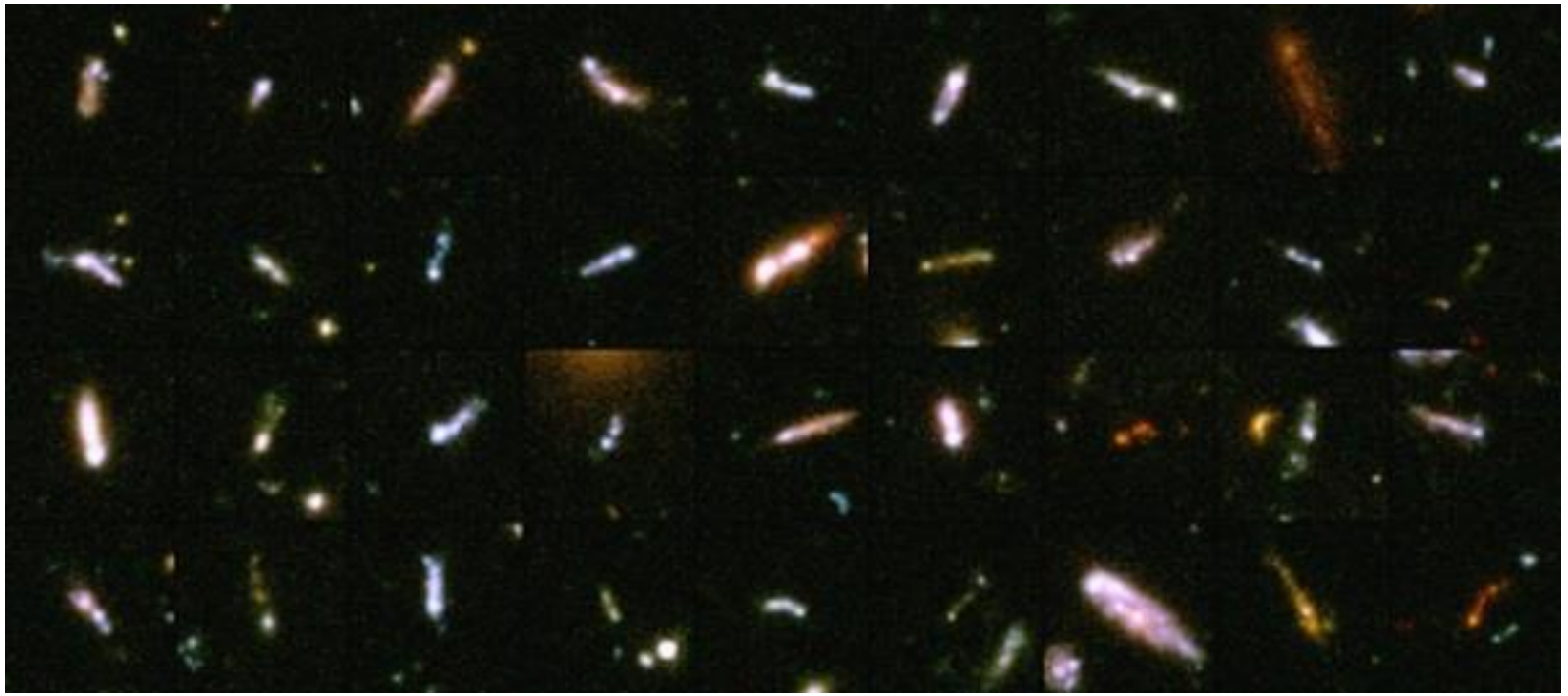
There is energy in the dark, black intergalactic space in the form of microwave light.

The energy in the universe must have been much, much hotter in the past when the universe was smaller. A starting amount of energy and temperature can be backtracked if everything started at a single point.



The galaxies at the very edge of the universe's view (12-13 billion years old) appear to be elongated and clumpy rather than spiral and elliptical. These are primitive first galaxies.

--Remember, light takes12-13 billion years to travel to Earth. We see those galaxies as they were 12-13 billion years ago.



The farther galaxies are away from Earth, the more primitive they appear. Galaxies that are 13 billion light years away are the most primitive. It is like seeing the “galaxies” a short time after their formation