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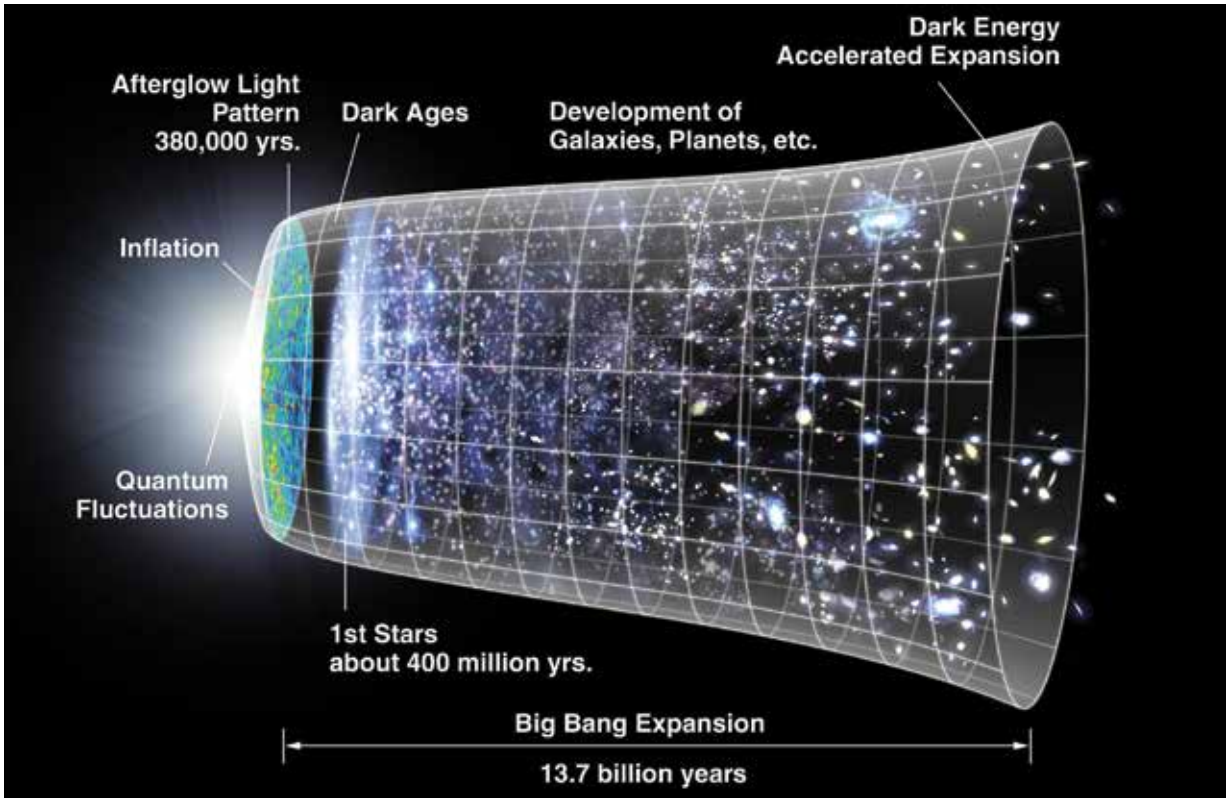
How Did the Universe Begin?

NASA.gov

https://apod.nasa.gov/apod/image/1103/ngc5584_hstr.jpg

The study of the Universe, its origin, its structure, and how it is evolving is called *cosmology*. Cosmologists are scientists who theorize about how the Universe formed and the processes and forces that govern its past, present, and future. Theories are constantly being tested and modified as new observations and data are discovered and shared.

Currently, the Big Bang theory is the most widely-accepted model for explaining how the Universe was formed. The Big Bang theory states that between 10 and 20 billion years ago all the matter and energy in the Universe was concentrated into a volume smaller than a grain of sand, and suddenly expanded outward from this central point. Space initially expanded at unmeasurable speeds but the rate of expansion then decreased. The cause of this sudden expansion remains unknown.



https://en.wikipedia.org/wiki/Big_Bang

In the first second after the Big Bang, the four fundamental forces of nature emerged. Gravity was the first, followed by the strong nuclear force that holds nuclei of atoms together. After this, a weak nuclear force emerged that is very important in the development of new elements in stars and finally electromagnetic forces emerged. These forces are all key to the development of the Universe as we know it.

1. When did time begin?

Time, space, and matter all began with the Big Bang

2. When did the first atoms form?

Right after the Big Bang gravity formed and then a nuclear force developed forming atoms

What is the Evidence for the Big Bang Theory?

Over the years technological advances have allowed scientists to collect and evaluate additional evidence relating to the origin of the Universe. This evidence supports the Big Bang theory over all other theories to explain how the Universe began. Scientists point to three major lines of evidence: the abundance of hydrogen and helium found in the Universe, the Cosmic Microwave Background, and the phenomenon of Redshift.

3. What three pieces of evidence support the Big Bang theory as the most accepted explanation for how the Universe began?

Scientists point to three major lines of evidence: the abundance of hydrogen and helium found in the Universe, the Cosmic Microwave Background, and the phenomenon of Redshift.

How Did The Universe Develop Elements like Hydrogen and Helium?

For the first few hundred thousand years, the Universe existed as an enormous expanding cloud of high-energy particles of matter and electromagnetic radiation. Due to the strong nuclear force, these high-energy particles of matter formed the beginnings of atoms as nuclei of hydrogen, helium, and other light elements. It took another 380,000 years for electrons to be trapped in orbits around nuclei, forming the first atoms. These first atoms were mostly hydrogen and some helium. The Big Bang theory suggests that at this point the entire Universe was acting like the core of a star, fusing hydrogen into helium. It predicts that the ratio of hydrogen to helium was 75% to 25%. Using special telescopes, scientists have collected data from distant, ancient galaxies which shows that hydrogen indeed makes up 74% of the mass, helium 25% of the mass, and heavier elements less than 1%.

Gravity gradually drew matter together to form the first stars and the first galaxies. Galaxies were eventually collected into groups, clusters, and superclusters. As time went on some stars died in supernova explosions, leaving chemical remnants that gave way to new generations of stars and enabled the formation of rocky planets like Earth.

4. Why did it take over 300,000 years to form the first atoms?

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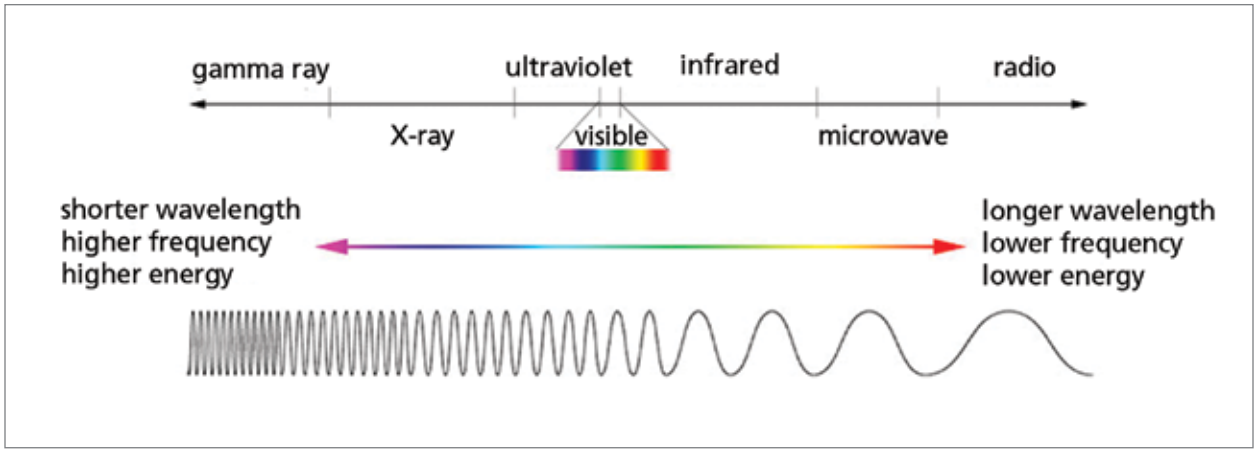
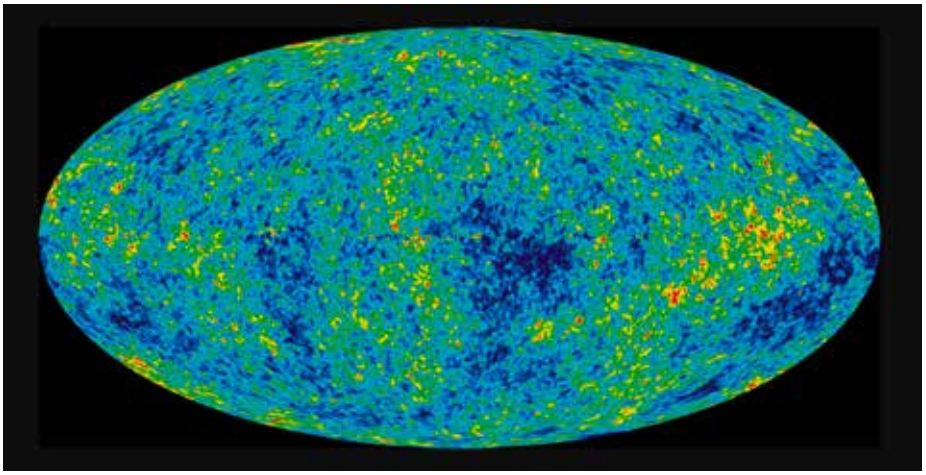
What is Cosmic Microwave Background?

The Cosmic Microwave Background is the oldest and most distant light - electromagnetic radiation - left over from when the Universe began. At first, the Cosmic Microwave Background was very energetic X-ray light but over time, it lost energy and is now lower energy microwaves.



Lesson 11 Reading One in Module 8.1 *https://www.miniphysics.com/electromagnetic-spectrum*

The Cosmic Microwave Background tells us information about what the Universe was like long ago. According to the Big Bang theory, the early Universe would have been intensely hot and full of radiation. As the Universe expanded and cooled down, this radiation would eventually be released. You can't see the Cosmic Microwave Background with your naked eye, but it is everywhere in the Universe.



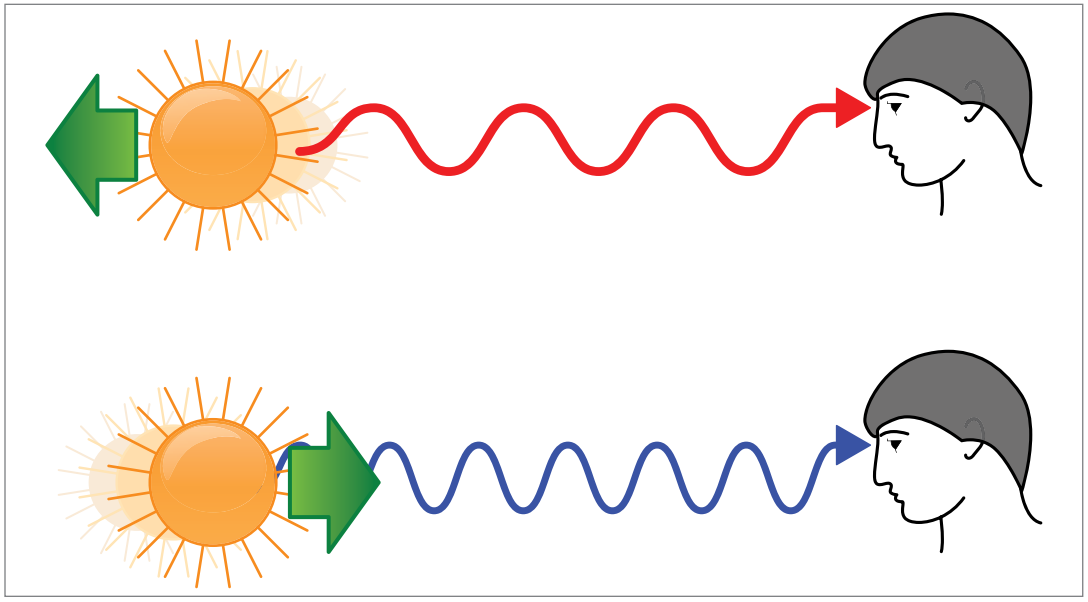
An image of the Cosmic Microwave Background in outer space. The colors show the temperatures of different areas.

https://www.nasa.gov/sites/default/files/thumbnails/image/wmap.png

What is Redshift?

Galaxies, stars, and planets formed throughout the expanding Universe continue to move not only as orbits of planets in a star system but also on a larger scale. Galaxies, including Earth's galaxy, the Milky Way, continue to expand and move apart from other galaxies. Astronomers use redshift to measure how the Universe is expanding and to determine the distance to our Universe's most distant (and therefore oldest) objects.

Redshift is often compared to the high-pitched (high frequency) sound waves of an ambulance siren coming at you, which drops in pitch (and frequency) as the ambulance moves past you and then away from you. That change in the sound of an ambulance is due to what is called the Doppler Effect. It is a good comparison because both sound and light travel in waves, which are affected by their movement through air and space. In the case of light, we perceive changes in wave frequency as changes in color, not changes in pitch. For example, if a lightbulb emitting white light were to move very rapidly through space, the light would appear blue as it approaches you and then appears red after it passes. Astronomers have observed that light from distant galaxies shows a shift in the frequency of light toward a red color. Therefore we know that the Universe is expanding in all directions.



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Similar to sounds from a moving vehicle, as a star moves away from us, the light becomes redder. As it moves towards us, the light becomes bluer.

The Big Bang theory is supported by observations made using telescopes such as the Hubble Space Telescope and other advanced technologies such as the recent launch of the James Web Space Telescope, so scientists mostly agree that the Big Bang does a good job of describing the history of the Universe. However, we still don't know why the Universe expanded so quickly in the first second and then slowed down. We don't know why the expansion of the Universe is now speeding up. We don't know why we only have a certain number of forces that control the Universe. We don't know what started the Big Bang in the first place.

Most space exploration is about understanding our place in the Universe. Humans are curious, and this is the greatest mystery.

5. What are your thoughts about the future of the Universe?