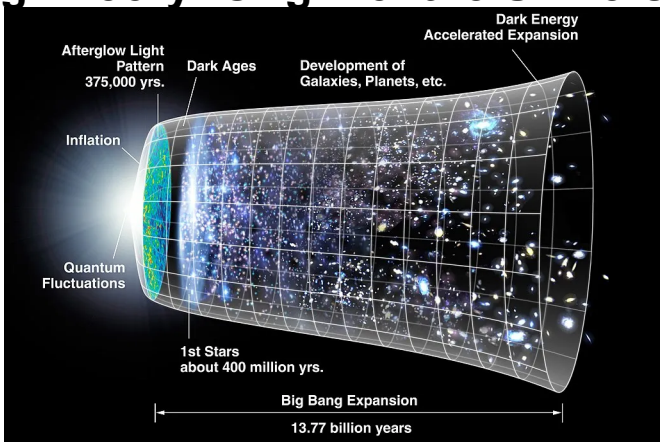
Astronomy Reviewer

The Origin of the Universe and the Solar System

Cosmology is the study of the origin and evolution of the universe. In this article, we'll focus on the basics of cosmology to explore the two theories that explain how our universe–and the solar system–formed billions of years ago.

The Big Bang Theory: Origin of the Universe



The constructed timeline of how the Universe began according to CMB (cosmic microwave background).
Credit: NASA/WMAP Science Team/Creative Commons

The **Big Bang Theory (BBT)** is currently the most accepted theory explaining the origin of the universe.

According to the BBT, before the universe (or *anything and everything*) existed, all matter and energy were condensed into high-temperature and high-density states. Suddenly, rapid expansion took place resulting in an explosion (hence the name, Big Bang) which generated all matter and energy, including space and time.

After the explosion, the Universe was in a hot and dense state. As expansion continued, the temperatures cooled down and allowed for the formation of light elements such as hydrogen and helium. The energy was readily available and encouraged **nuclear fusion**, generating other slightly heavier elements.

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Due to the force of gravity, clumps of matter began to form and grow through the process of **accretion**. Accretion would eventually produce large masses of matter which would form into the first stars 400 million years after the Big Bang.

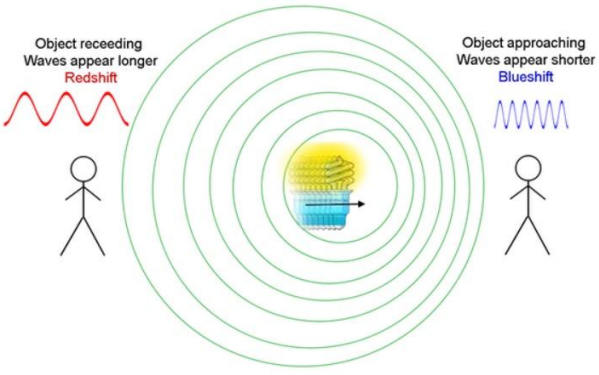
At the end of a star's life cycle, a supernova would occur.

Supernovas occur when a star's core collapses and generates spectacularly powerful explosions. They are the primary source of heavier elements such as nickel and iron. Other large masses would eventually form into planets, asteroids, and other space bodies. These space bodies would also be affected by gravity and come together to form **galaxies**.

Based on the joint effort of NASA and ESA, **the most accepted age of the Universe is 13.8 billion years old**. They determined this by measuring the left-over radiation left by the Big Bang called **cosmic microwave background (CMB)**.

Even though the universe is billions of years old already, expansion has not stopped and still persists. This is what **Edwin Hubble**, an American astronomer, observed. He noted that galaxies seem to be moving away from each other and did so with incredible velocity.

He also noted that galaxies that are farther away from the Earth move away at a greater velocity. By observing the visible spectra of light, he noted that galaxies moving away from us produce a **redshift**, meaning that the wavelength becomes longer. This phenomenon is different from when something moves towards us and produces a **blueshift** or a shorter wavelength.



A diagram showing the effects of redshift/blueshift to an observer.
Credit: Imagine the Universe/NASA

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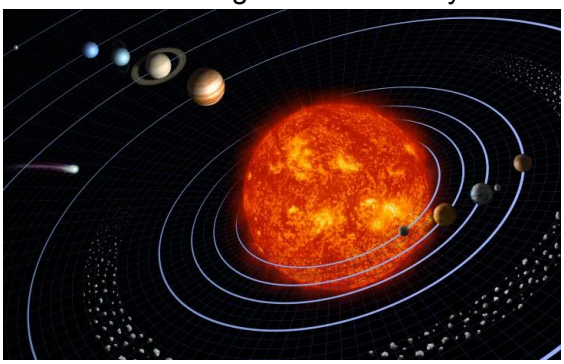
To God be the glory!

A popular thought experiment used to understand this is the **Doppler Effect**: Imagine an ambulance passing by. As the ambulance approaches you, the pitch of the siren becomes lower meaning the wavelength is getting longer. As it passes you, the pitch of the siren becomes higher, signaling that the wavelength is becoming shorter.

The Nebular Theory: Origin of the Solar System.

The Nebular Theory was proposed and developed by several proponents (namely Emanual Swedenborg, Immanuel Kant, Pierre-Simon Laplace, and Victor Safronov) throughout the years until it became the accepted model of the origin of the solar system in the 20th century.



Artist's depiction of the Solar System (not to scale). Credit: NASA/JPL

According to the theory, our solar system formed from an enormous rotating cloud of dust and gas called the **solar nebula** nearly 4.6 billion years ago.

Over time, the solar nebula began to contract and flatten due to gravity. As contraction continues, gravitational energy is converted into thermal energy, generating high temperatures. High temperatures and the inward pull of gravity in the center of the cloud led to the formation of a proto-Sun.

As contraction declined, the temperatures began to cool and led to the condensation of rock-forming elements such as Fe, Ni, Si, Ca, Na, and others. Particles began to collide and accrete into masses called **planetesimals** (proto-planets) which eventually formed planets.

Due to higher temperatures within the center of the solar system, heavier rock-forming elements condensed to form the inner planets (**terrestrial planets**). Planets within the outer ring of the solar system are called inner planets (**jovian** or **gaseous planets**) formed with small, rocky cores but are mostly composed of ice and gas such as CO_2, H_2O, NH_3, and CH_4.