
Astronomy

- **Cosmology**
- **Stars and Galaxies**
- **The Solar System**

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Cosmology

Cosmology is the study of the origins of the universe, using the scientific method and the physical laws we have discovered.

Early to recent major contributors

- Ptolemy – the earth is at the center of the universe (100 AD)
- Copernicus – the sun is at the center of the universe and the planets travel in circular orbits. Much opposition from the Church. (1500 AD)
- Galileo – developed refractor telescope
- Kepler – deduced that planets travel in elliptical orbits, not circular (1600 AD)
- Newton – developed reflector telescope and law of gravitation (1650 AD)
- Einstein – mass, time, and size depend on motion, space is curved, light is bent by gravity (1900 AD)

- **Hubble – discovered galaxies and their movement, universe is expanding**

Today's Ideas

Evidence suggests that the universe began some 10-15 billion years ago, with an explosion called the *Big Bang*. Within three minutes of this explosion large amounts of hydrogen and helium were created. About 3.2 million years later, galaxies formed from the condensation of this matter. Later solar systems formed. Our solar system did not form at this time and came from the material ejected in the “burning out” of other stars. It is thought that our solar system is about 5 billion years old.

In the 1930's Hubble discovered that the universe is expanding by looking at the *Red Shift* – light that is Doppler shifted from other galaxies. Today we know this expansion is slowing and one day the universe may start to contract.

In the 1960's the background radiation was discovered from the *Big Bang* itself. This radiation has been Doppler shifted down to microwave radiation that permeates the entire universe.

The Life of Stars

Protostar – mass of material in space many times the mass of our sun spread out over a volume many times our solar system.

Gravity causes this material to contract and the temperature increases until fusion begins. Elements heavier than helium are made in the core. Our sun is an “average” star that is expected to have a lifespan of 10 billion years and is now about 5 billion years old.

As stars burn fuel they can have several paths in their “old age”.

- **Stars like our sun (and with lower mass) will become *red giants* and expand. Our sun will engulf the earth and then later shrink to a *white dwarf*. White dwarfs may become *black dwarfs* as they cool or they may obtain fuel from a nearby star and explode or nova.**
- **More massive stars have enough gravity to cause the fusion of carbon atoms into heavier elements. After the carbon is fused still heavier elements are made up to the element iron, which has the most stable nucleus (least mass/nucleon). Since energy is not released past the production of iron, the core of the star collapses in a gigantic collision called a *supernova*. It is this explosion which can cause the production of elements greater than the atomic number of iron.**

- After a really massive star produces a *supernova*, its core collapses to form neutron star. If the star is 3-5 times the mass of the sun it collapses to form a *black hole*.

The *Hertzsprung-Russell diagram* is a chart of the brightness of stars versus their temperature. On this diagram bright stars are near the top and dim stars are at the bottom. Cooler stars are red and are toward the right. Hotter stars with white and blue-white colors are at the left. Most stars (90%) are along what is called the *main sequence*.

Constellations are groups of stars in the sky that have been named. Most of the names are holdovers from early Greek, Babylonian, and Egyptian astronomers.

Galaxies

A galaxy is a large assemblage of stars, nebulae, and interstellar gas and dust. We are in the Milky Way Galaxy. The average galaxy contains about 100 billion (10^{11}) stars. There are about 100 billion galaxies so there are roughly 10^{22} stars in our observable universe.

Galaxies are classified as being elliptical, spiral, and irregular. Our galaxy is a spiral. Galaxies also form larger groups called clusters and superclusters.

The brightest parts of our universe are called quasars. They emit radio waves and are thought to be at the center of young spiral galaxies.