Astronomy

- Overview - Where Are We?
- Cosmology
- Stars and Galaxies
- The Solar System

Ron Robertson

Where Are We?

What's here?

We live on a piece of matter that is spherical and does not make visible light itself – a planet called earth. Relatively close around us are other objects that in some ways are similar to our world but very different in others. Also relatively close is an object that does make light and gives off so much light that it defines what we call daylight as it seems to move across the sky. It is the sun. Our sun, the earth, and the planets define a grouping of matter called our solar system.

Earth as viewed from space

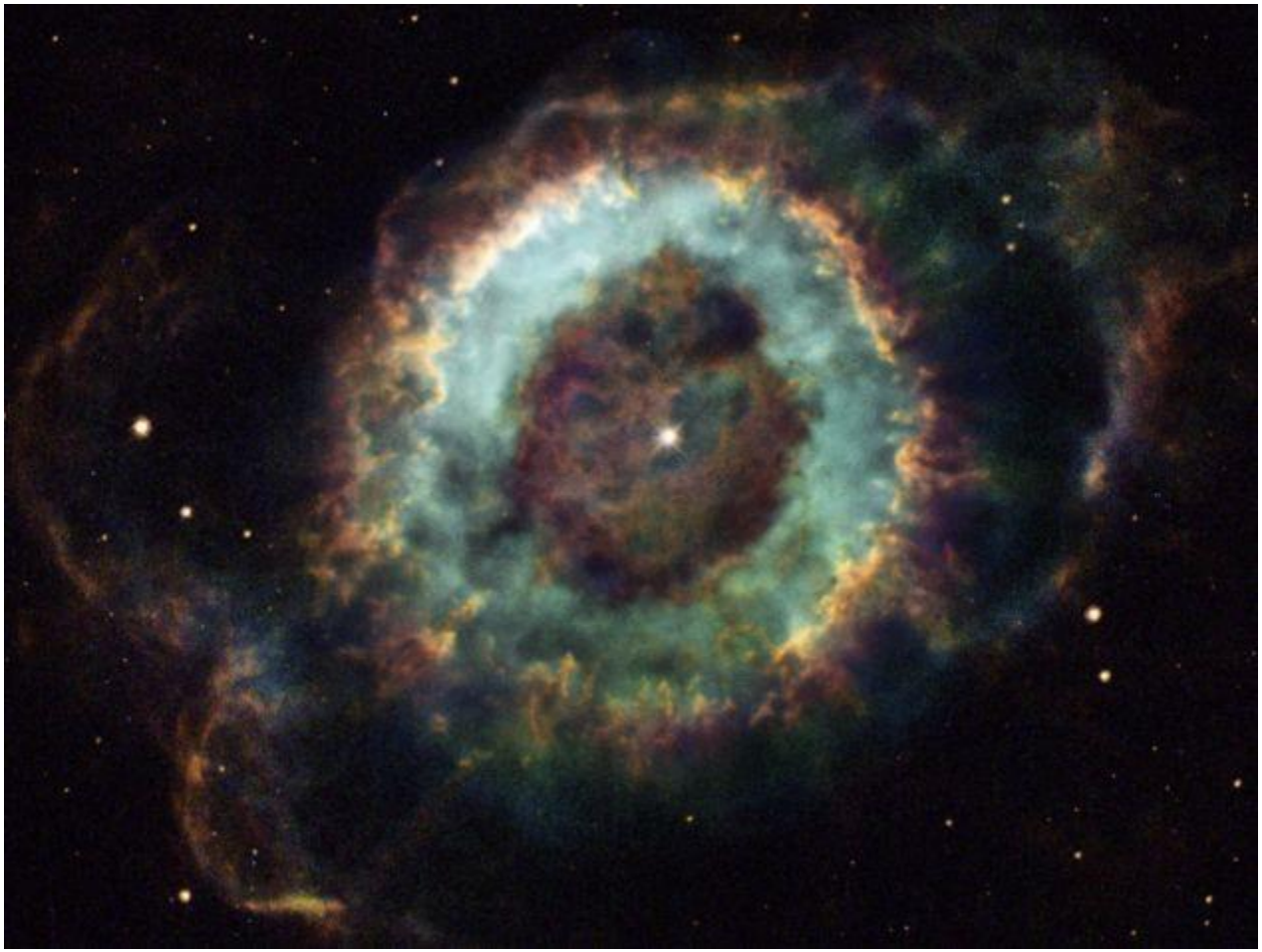
What's up?

As we look up at the night sky we see seemingly small objects (actually very large) which give off enough light for us to see with our eyes. These objects we call stars. Our sun is a star.

There are many kinds and classes but they all produce light from nuclear fusion (a type of "burning" in which elements like hydrogen, helium, and others change identities and give off energy of visible and nonvisible light in the process). These stars all have a birth, go through an aging process, and finally die in different ways.

With a telescope, photography, and other instruments we can also "see" other matter such as nebulae, gas, and dust that is giving off light of various colors.

The Pleides Star Cluster
(also known as the “7 sisters”)

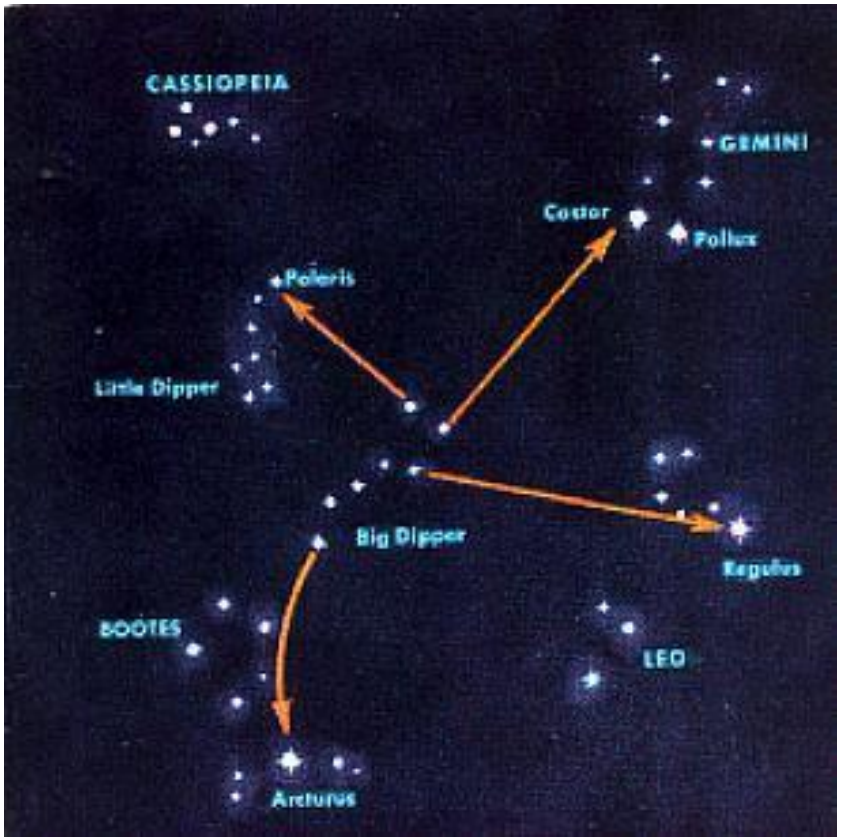


The “Little Ghost” Nebula

Stars and other matter seem to forms groups that we call galaxies. 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 also form larger groups called clusters and superclusters. Below is a type of spiral galaxy.

The “Pinwheel Galaxy”

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.



What is moving?

Everything. . . . . Our earth is spinning on its axis at about 1,000 miles an hour. One complete spin defines a day – 24 hours.

Our earth revolves around the sun at a speed of 67,000 miles an hour and completes a revolution around the sun in 365 days – our definition of a year. The moon rotates on its axis at the same rate that it revolves around the earth – 29 days.

Our entire solar system is moving as a whole at 490,000 mph around the center of the Milky Way galaxy.

Finally our galaxy is moving away from other galaxies and that movement appears to be increasing. Our universe itself is getting bigger every day!

Do we know how big the universe is?

The universe is so big that we often talk about distances in terms of how long it would take the fastest thing known (light) to travel from there to here.

Since light travels in space at 186,000 miles per second, it takes light 1.3 seconds to reach us from the moon and it takes sunlight 8.3 minutes to travel the 93 million miles from the sun to us.

Receiving light from the next closest star would require about 4.4 years (Alpha Centauri). When you look up at night you are seeing star light that was emitted hundreds, thousands and millions of years ago. You are indeed looking back in time!

The universe appears to be billions of light years across in size!

The Andromeda Galaxy – the closest galaxy to earth but still 2 million light years away

Since we don't have any space ships that can travel at the speed of light lets see how long it would take to travel to nearby planets or Alpha Centauri.

At a speed of about 35,000 mph (spacecraft speed) it would take over 85,000 years to reach our nearest star. (It would take a year or more to reach our closest planet neighbors in our own solar system.) To put this in perspective human civilization appears to be about 6,000 years.

So let's go back and see how scientists view how the universe got to be what it is today. . .

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)
- Hubble – discovered galaxies and their movement, universe is expanding (1930)

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.