

So, What All Is Out There, Anyway?

Imagine that, like Alice in Wonderland, you have taken a magic potion that makes you grow bigger and bigger. You get so big that soon you are a giant. You can barely make out your home, it has gotten so tiny. Yet you continue growing. Soon your hometown is just a little dot. Before long, you have gotten so large that when you look down you can see the whole Earth beneath your feet.

By now you have gotten so big that you can no longer stand on our planet, and you begin drifting in space. Soon you see another large body near Earth. It's the Moon, and it's orbiting our Earth. The Moon is very far away, around 240,000 miles away. If someone stood on Earth and shined a light on the Moon, it would take over a second for the light to get there. (Imagine turning on a flashlight and having to wait over a second to see what you were shining the light on.)



Earth has a circumference of just under 25,000 miles. A beam of light could travel all around the Equator in less than 1/7 of a second. (Image courtesy of NASA/JPL-Caltech.)

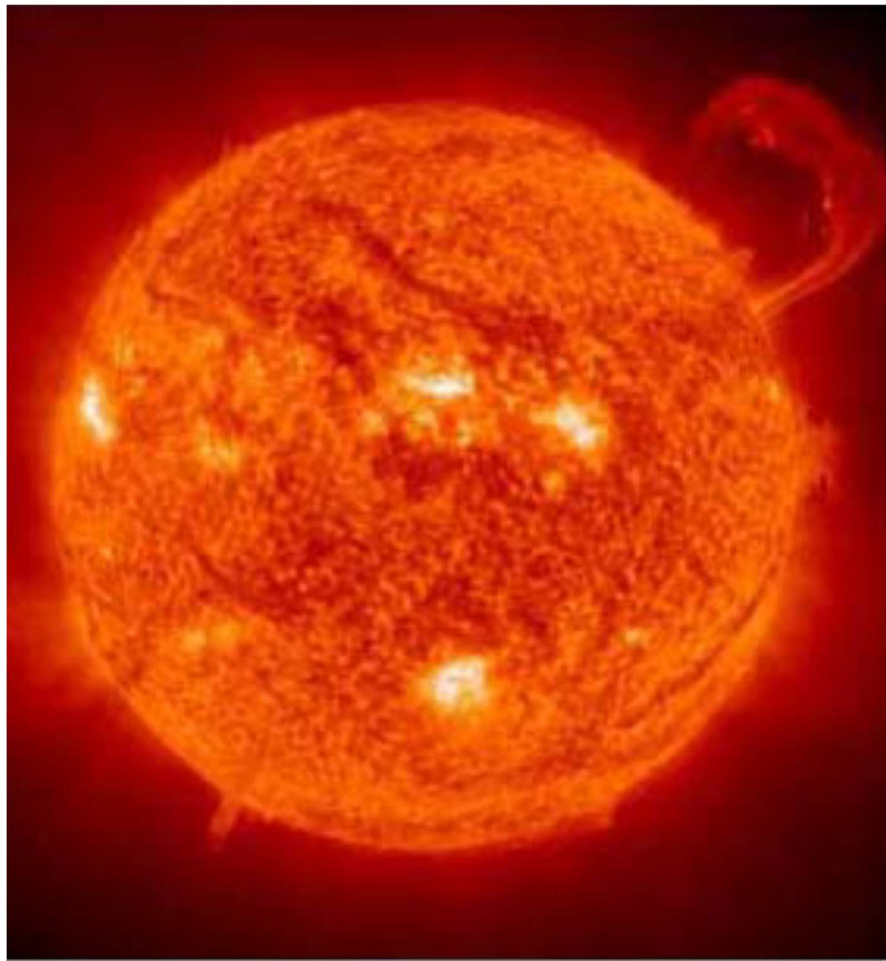


The Solar System

As you continue to grow you begin to notice some of the other planets of the solar system. The inner planets, Mercury, Venus and Mars, may start coming into view, depending on where they are in their orbits. But dwarfing all these planets, a million times as large as the Earth, is the Sun—a giant mass of extremely hot hydrogen and helium.

The Sun is around 93 million miles away from Earth. If you stood on Earth and pointed a light at the Sun it would take almost 8½ minutes for the light to get there.

Another view of Earth, with the Moon in the background. (NASA/JPL-Caltech)

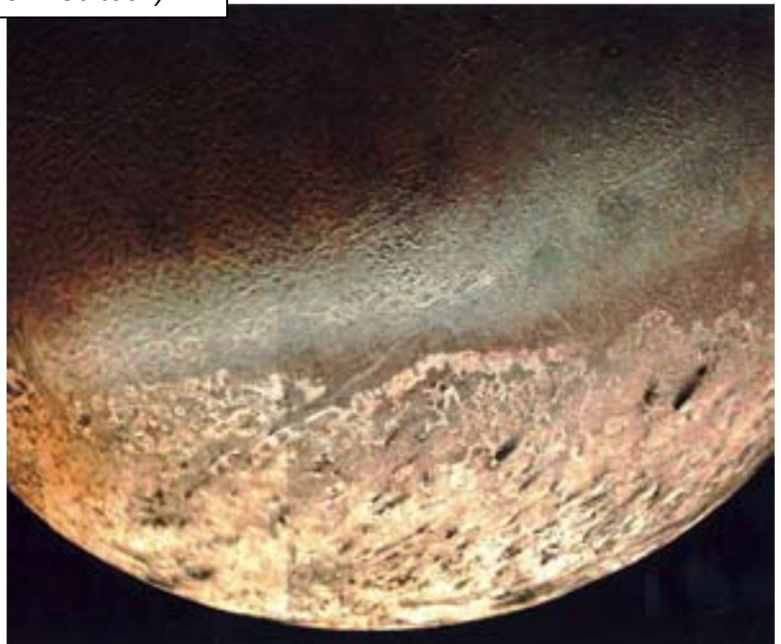


The Sun is powered by fusion reactions. This is the same type of energy that powers a hydrogen bomb. (NASA/JPL/Caltech)

You would probably notice that many of the planets have moons orbiting them, the same way that our Moon orbits Earth. Here's an important distinction: moons orbit planets, but planets orbit stars. Some planets—Jupiter, Saturn, Uranus and Neptune—have many moons orbiting them. You might also see a band of around 40,000 asteroids, many a half mile across or larger, going around the Sun between the orbits of Mars and Jupiter. This is the asteroid belt, and many scientists think it's there because when the planets formed, Jupiter's gravity kept these rocks and asteroids from clumping together to form a planet.

Eventually you become big enough that you can look down and see all the planets of the solar system—Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune—orbiting the Sun. Neptune is about 2.8 billion miles away from the Sun. Light from our Sun takes over 4 hours to reach Neptune. That means that if the Sun were to suddenly stop shining, someone on Neptune would still be receiving light from it 4 hours later.

Perhaps you have also heard of Pluto. Pluto is part of a band of small rocky bodies called the Kuiper (KIE-per) Belt. There are over 70,000 other objects like Pluto—most of them much smaller—in the Kuiper Belt, surrounding the 8 main planets.



Triton is one of Neptune's many moons. (NASA/JPL-Caltech)

Surrounding the Sun, the 8 planets and the Kuiper Belt is the Oort cloud—a large collection of billions of comets and tiny pieces of rock and ice. At least, they look tiny to you because you are so large, but some are larger than 100 miles across. This cloud of comets and ice balls surrounds our solar system.

The Milky Way Galaxy

As you get larger you start to notice that the planets become so faint and small you can barely see them, but the Sun is so much brighter than the planets that it's still visible. Soon you see other stars besides our Sun, but they are very far away. Although light from the Sun can reach Neptune in a little over 4 hours, that same light takes over 4 *years* to reach Proxima Centauri, [PROX-ee-ma cen-TOR-ee] the closest star to our Sun. That means that when we look at Proxima Centauri, we are actually seeing it as it looked over 4 years ago.



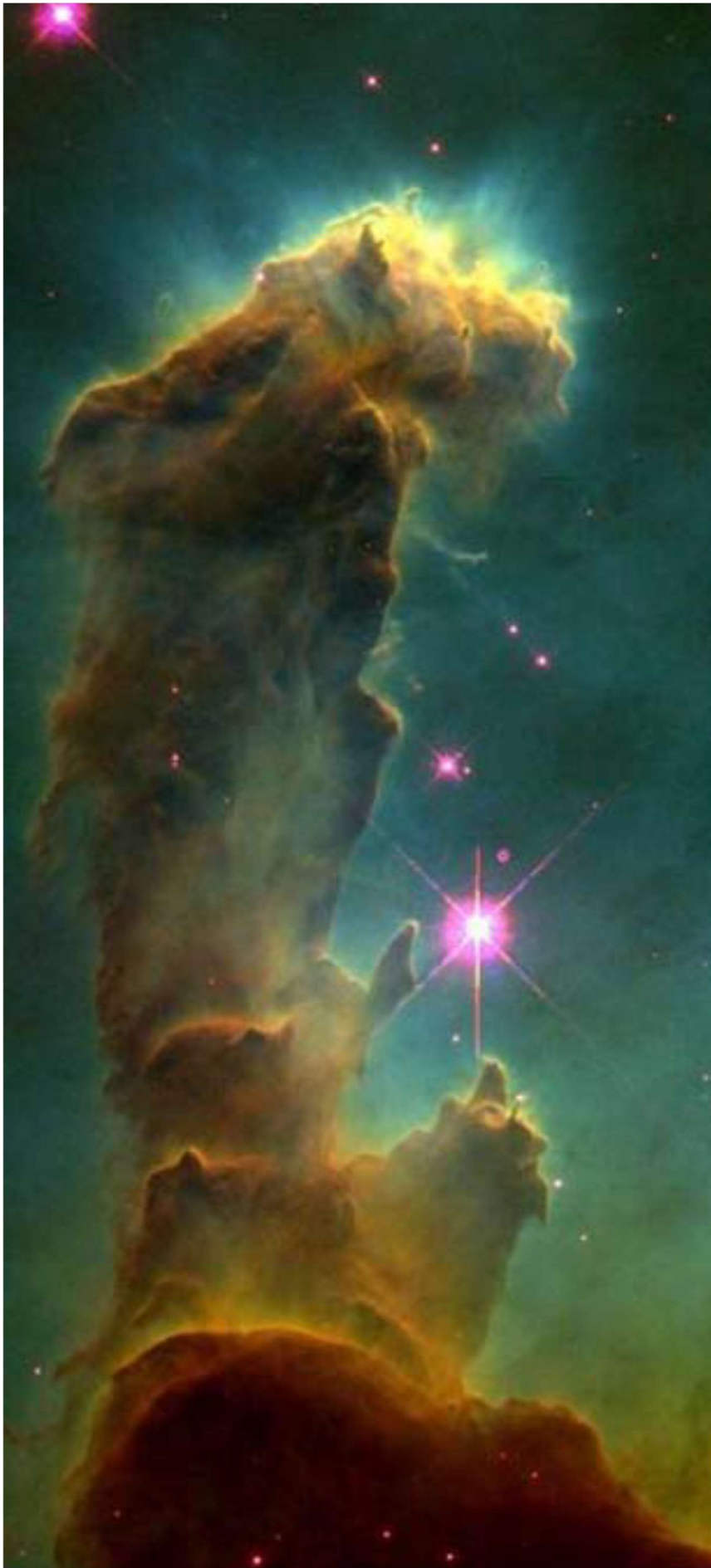
Stars, clouds of gas and dust, and other objects in the Milky Way galaxy. The Milky Way galaxy contains over 200 billion stars. (© 2004 Russell Croman, www.rcastro.com)

All the other stars in our Milky Way galaxy are so far away that when we talk about the distances between them we talk about how long it takes light from Earth to reach them. Because it takes 4 years for light to travel from Earth to Proxima Centauri, we say that Proxima Centauri is 4 light years away. Remember that light takes a little over a second to travel from the Earth to the moon. That means that the next closest star after our Sun is almost 100 million times farther away than the moon!



The Pleiades is a small cluster of stars that you can see at night in the northern hemisphere. (Image by Robert Gendler)

As you get bigger, you see more and more stars. Many stars have planets orbiting them, the same way the planets in our solar system orbit our Sun. In fact, you see dozens, and then hundreds, and then thousands of other stars and their planet systems. You see stars so far away that light from Earth wouldn't take just 4 years to reach them, but many thousands of years. You also see many other interesting things. Some stars seem to have partners, other nearby stars that they travel around. There are even star clusters—groups of many stars that travel through space together.

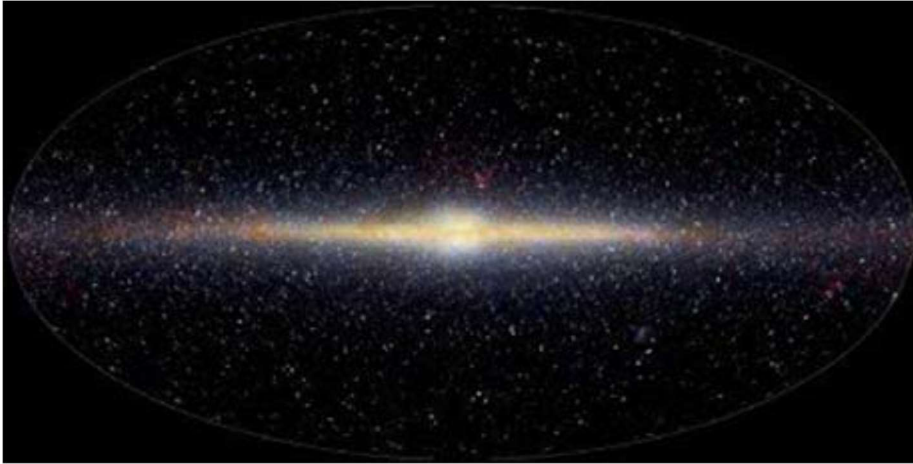


You see huge dark clouds of dust stretching light years across, or beautiful glowing clouds of gas, called nebulas, spreading out and speeding away from dying stars. The larger you get, the more stars you see. It seems the whole universe is filled with stars. But eventually, you grow large enough that you start seeing vast areas of space where there are very few stars, and once you finally get big enough you see that most of the stars are grouped together in a large, flat disk with long arms reaching out into space in a spiral. This beautiful collection of planets, moons stars, star clusters, and nebulas, is slowly rotating. At its center is a black hole, a mass of matter that is so dense not even light can escape the clutches of its gravity if it gets too close. All these objects together make up our galaxy, which we call the Milky Way. The Milky Way galaxy is enormously huge—so huge, that light would take almost 100,000 years to travel all the way across our galaxy.

The Milky Way contains over 200 billion stars, and many of these stars have are orbited by planets, comets and asteroids just like our Sun. Imagine how many other planets and moons there must be in our galaxy! Surely this must be the whole universe.

But it's not.

The "Pillars of Hercules" are part of the Eagle Nebula. There are stars forming in this cloud of dust and gas. (Jeff Hester and Paul Scowen [Arizona State University]/NASA)



Left: From the side, the Milky Way galaxy looks like a flat disk that bulges out in the middle. (COBE/DIRBE/NASA)

If you could look down on it from above you would see the spiral arms. It would look a lot like the galaxy below, called NGC 1232. (European Southern Observatory)



The Universe

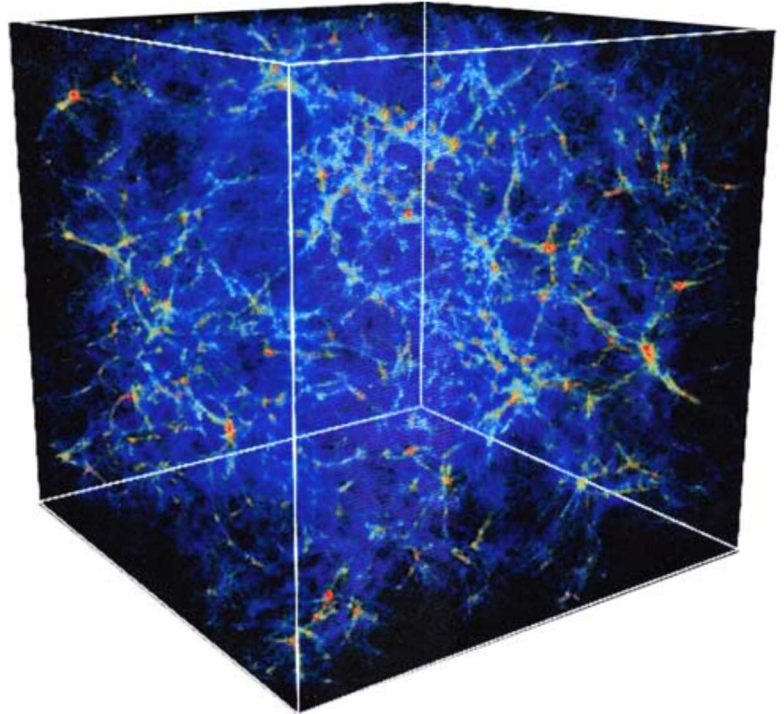
You continue to grow and you start to notice other galaxies nearby. Many of these galaxies have hundreds of billions of stars just like our Milky Way, and others have even more. It is likely that many of these stars have orbiting planets and moons. One or 2 galaxies seem close enough to touch, but most are unbelievably far away. One of these galaxies, the Andromeda (An-DROM-ee-da) galaxy, is at least 2 million light years away. It is so far away that when we look at it, we are seeing it how it looked 2 million years ago, when our human ancestors were first learning to use stone tools! As you get larger you notice that about 30 to 40 other small galaxies seem to be clustered around the Milky Way and Andromeda galaxies. Scientists call this cluster of nearby galaxies the “Local Group.”



This is an image of two spiral galaxies that are slowly colliding. They may eventually combine to form one larger galaxy. Astronomers think that our Milky Way galaxy crashed into and absorbed many smaller galaxies a long time ago. In fact, the Milky Way and Andromeda galaxies are likely to collide and merge together many billions of years from now. (Hubble Heritage Team/NASA/STScI/AURA)



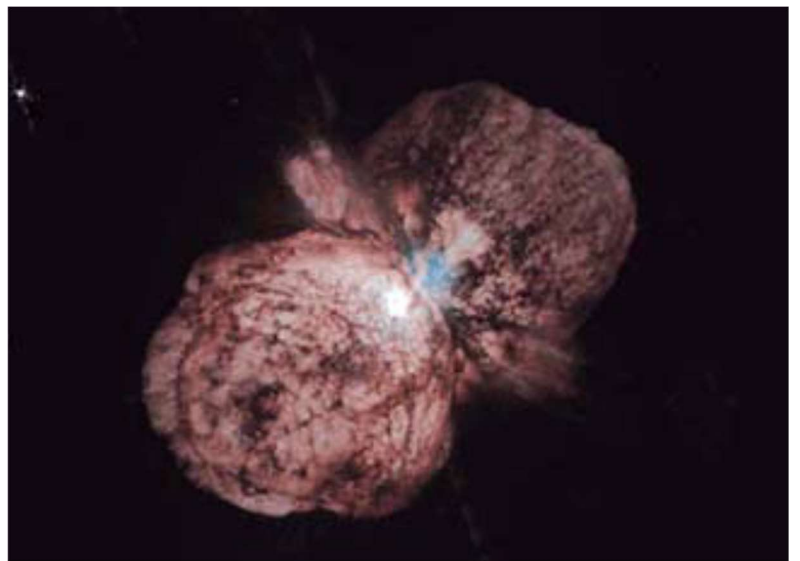
Left: This is the Coma Cluster of Galaxies. The cluster contains thousands of galaxies, and each galaxy contains billions of stars. Light from the Coma Cluster of Galaxies takes hundreds of millions of years to reach the Earth. (Omar Lopez-Cruz & Ian Shelton/NOAO/AURA/NSF)



Right: This view of the universe was drawn by a computer. Each individual dot is a galaxy. You can see how the galaxies tend to cluster together. These clusters form long strings, or “filaments,” that stretch throughout the universe. (Andrey Kravtsov [University of Chicago] and Anatoly Klypin [New Mexico state University]/Chandra/NASA)

How can anyone call something 2 million light years away “local”? As you get bigger, you find out, because in the distance you see other groups of galaxies just like our Local Group, and as you grow larger and larger you see these groups, or clusters, of galaxies start to blend together to form long strings twisting and turning through space. Each cluster of galaxies looks like a large, shimmering pearl in a jumble of gigantic pearl necklaces, except that these necklaces can be over a billion light years long. We call these “filaments” of galaxies. The lumps where the filaments cross are called “superclusters” of galaxies. Finally, you stop growing, and from a distance you look down over an incredibly beautiful collection of sparkling strings of pearls stretching out 13.7 billion light years from Earth in every direction.

Below: The nebula around Eta Carina--a large star 150 times the mass of the Sun, and 4 million times brighter. Stars this large often have short life times and die in incredibly violent eruptions of plasma and gas. (Chandra Science Center/NASA)



This is the Visible Universe, and this is all we can see. Is there anything beyond this? Are there other universes out there? We have no way of knowing. Your guess is as good as mine!

Now that you have seen the entire universe, here are some things to think about:

- 1) What are some things that you might find in a galaxy but not in a solar system?
- 2) What are some things you might find in a solar system?
- 3) Which is larger:
 - a) a filament of galaxies or a cluster of galaxies?
 - b) a planet or a star?
 - c) a universe or a solar system?
 - d) a moon or a nebula?
 - e) a galaxy or a black hole?



The beautiful Horsehead Nebula. Thick clouds of gas and dust block light from stars behind it, creating the unusual horsehead shape in the center of this photo. (© 2004 Russell Croman, www.rc-astro.com)

4) A planet is part of a solar system. But since a solar system is part of a galaxy, then you could also say that a planet is part of a galaxy. But since a galaxy is part of the universe, then you could also say that a planet is part of the universe. Place each of the following objects in any group that it can be part of. Many objects will be in more than of group.

Groups: solar system, galaxy, universe.

Objects: you, asteroids, clusters of galaxies, moons, comets, the Local Group, star clusters, Proxima Centauri, your home, the Sun, Venus, the Pillars of Hercules.



The Cat's Eye nebula. Some scientists think that there may be a binary star system (a pair of stars orbiting each other) in the center of this cloud of glowing gas. (J.P. Harrington and K.J. Borkowski [University of Maryland]/ NASA/STSci)