Basics of the Universe

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Introduction:

The vast empty space surrounding the planets and stars is called as the Universe. It consists of dark matter, dark energy, stars and galaxies. Both cyclic and unpredictable processes are found to happen in the universe. The major reason is that no one can control or change the particular occurrences of the heavenly bodies that are happening in nature. These occurrences can't be managed or artificially created in any laboratory. Similarly, the processes that are happening in the universe are non-repeatable. During these processes, many factors like temperature, pressure, etc are found to be extremely high. Maintaining such high temperature conditions in the laboratories may be very risky. The only way to understand the universe is through the electromagnetic radiations coming from them. But. this is one of the most interesting subject in the world.

Astronomy and Cosmology:

Cosmology is the study of nature and origin of the Universe. The scientific aspects of composition, motion, and other related facts of the universe are studied under a multidisciplinay subject called Astronomy. It is not an experimental science but an observational science. Astronomy is one of the oldest sciences having practical importance. It may take generations to complete the census of space. About 100 billion galaxies with equal number of stars. Families of planets, satellites, asteroids and planetoids, all of them exist in a massive space.

Constellations:

The first thing one need to know is that constellations are not real. They are totally imaginary things that poets, farmers and astronomers have made up over the past 6,000 years. The constellations help by breaking up the sky into more manageable bits. At an early stage, the stars were divided up into constellations, each of which was given a name. Constellations are a group of stars forming a recognizable pattern that is traditionally named after its apparent form or identified with a mythological figure.

The oldest zodiacal constellations were traced by Babylonians. They divided them into 12 units. It is due this the twelve months were born. The Chinese and the Egyptians drew the maps of the sky with named constellations. The Greek did later which got survived. The Indians have also analyzed the position of celestial bodies and their impacts on earth. Significant contributions were also made by several ancient scholars.

Hipparchus, one of the greatest astronomers of classical period of Nicaea in 130 BC compiled the Star catalogues. It was used by Ptolemy of Alexandria for listing 48 constellations. He named them using mythological characters. Ptolemy in 141 A.D really developed the model of the Universe. The early men regarded the Sun and Moon as Gods. Ancient people identified the close relationship between the earth, the Sun and the seasons.

The Greek were the first people to identify three things:

- i) There are seven wanderers in the space called planets
- ii) There exist systematic movements of these bodies and
- iii) The Universe contain many stars.

The first Greek Philosopher was Thales who did extensive works during 624 BC.

Very significant ideas were promoted by many ancient philosophers.

1. Aristotle of 384-322 B.C said that the earth is spherical in shape.
2. Aristarchus of 312-230 B.C speculated that the Universe is Sun-centered.
3. Eratosthenes of 276-194 B.C found that the size of the Earth has some variations.

The following scientists who studied the earth in space were considered as the "founders of the modern astronomy".

1. Nicolaus Copernicus (1473-1543).
2. Tycho Brahe (1546-1601) Compiled the star catalogue-during pre-telescopic time.
3. Johannes Kepler (1571-1630) Planets more around the Sun in Orbits which are not circular but elliptical.
4. Galileo Galilei (1564-1642).
5. Sir Isaac Newton (1643-1727).

Their findings formed the basis for all present day astronomical and astrophysical studies and applications.

Nicolaus Copernicus, the Polish astronomer established three things:

i) The earth is a planet of Solar System.
ii) The Sun is at the centre of the Solar System
iii) There are other planets like Mercury, Venus, Mars, Jupiter and Saturn orbiting with in the same system.

J. Kepler was the first to identify that the path of each planet around the Sun is not circular and is elliptical. Galileo Galilei, the greatest Italian scientist supported the Sun-centred theory of Solar System. His contributions were related to

i) Behavior of moving objects.
ii) The weight of an object does not affect its rate of fall.
iii) Air resistance has a role to play for light object.

Galileo, by using his telescope, made many discoveries like

1. Four satellites of Jupiter.
2. Planets are circular disc like bodies.
3. Venus, has phases like moon.
4. Moon's surface has mountains, craters and plains.
5. The Sun has both hot high temperature and dark low temperature spots.

Sir Isaac Newton the greatest genius of that time (1643-1727) was the first to explain why the planets move around the Sun. He proved the idea of Galileo that no force was needed to keep an object in motion. Newton’s first Law of motion was an outcome of this time. The force of gravity and the Law of universal gravitation were postulated by Sir Isaac Newton at his age of 23. It states that “Every body in the Universe attracts every other body with a force that is directly proportional to their masses and inversely proportional to the square of the distance between them.” This signifies that,

(i) the gravitational force decreases with distance.
(ii) The greater the mass of the object, greater is the gravitational force
(iii) The mass does not change unlike the weight.

It was a thought provoking time during which the theory was formulated about the origin of the Universe called Big Bang Theory (BBT). According to the Big Bang Theory, the Universe came into existence due to a huge explosion called “Big-Bang” occurred between 10 and 20 billion years ago. A very hot dense fireball of expanding cooling gas probably began to condense into localized clumps called Proto galaxies which due to further cooling released galaxies, stars and planets, many of them co-exist under the influence of gravity.

Content of the Universe:

Initially, astronomers thought that the universe was composed entirely of ordinary atoms, or "baryonic matter". During the recently years, more evidences obtained by global scientific bodies suggests that most of the ingredients making up the universe are in some forms which we cannot see. It shows that atoms only make up 4.6 percent of the universe. Of the remainder, 23 percent is made up of dark matter. This dark matter is composed of one or more species of subatomic particles that interact very weakly with ordinary matter. Almost 72 percent of the Universe is made of dark energy. This is the driving element which is accelerating the unpredictable distribution and expansion of the universe. According to NASA, hydrogen makes up about 75 percent, while helium makes up about 25 percent, with heavier elements making up only a tiny fraction of the universe's chemical content.

Structure of the Universe:

Scientists thought in the earliest periods, that the universe has no structure and the matter and energy are distributed nearly uniformly throughout. But later studies by NASA confirmed that the gravitational pull of small fluctuations in the density of matter gave rise to the vast web-like structure of stars and emptiness in the universe. The Dense regions pulled in more and more matter through gravity is responsible for the forming stars, galaxies and larger structures known as clusters, super clusters, filaments and walls. This is also responsible for the formation of "great walls" of thousands of galaxies. These are reaching more than a billion light years in length. Due to this reason, we call the universe as vast and dark. The less dense regions did not grow, evolving into an area of seemingly empty space called as voids.

Expanding Universe:

In the 1920s, astronomer Edwin Hubble discovered that the universe was not static but was expanding. This finding revealed that the universe was apparently born in a Big Bang. In 1998, the Hubble Space Telescope's observations of very distant supernovae revealed that a long time ago, the universe was expanding more slowly than it is today. In other words, the expansion of the universe was not slowing due to gravity, but instead inexplicably was accelerating. The name for the unknown force driving this accelerating expansion was called as dark energy.

The universe was born with the Big Bang which was an unimaginably hot, dense mass. When the universe was just 10^{-34} of a second in age. It has experienced an incredible burst of expansion known as inflation, in which the space itself got expanded faster than the speed of light. During this period, the universe doubled in its size at least 90 times, going from subatomic-sized mass to a golf-ball-sized mass almost instantaneously. According to NASA (National Aeronautics and Space Agency of the USA), this inflation and growth of the universe were continued but at a slower rate. As the space expanded, the universe cooled and the matter was formed. One second after the Big Bang, the universe was filled with neutrons, protons, electrons, anti-electrons, photons and neutrinos.

First Three Minutes of The Universe:

During the first three minutes of the universe, the light elements were born during a process known as Big Bang nucleosynthesis. Temperatures cooled from 100 nonillion (10^{32}) Kelvin to 1 billion (10^{9}) Kelvin, and protons and neutrons collided each other and made deuterium, an isotope of hydrogen. Most of the deuterium then combined together to form helium, and trace amounts of lithium were also generated. According to France's National Center of Space Research(CNES), for the first 380,000 years or so, the universe was essentially too hot for light to shine.

Era of Recombination:

The heat of creation smashed atoms together with enough force to break them up into a dense plasma, an opaque soup of protons, neutrons and electrons that scattered light like fog all around. This was called as the Era of recombination. Roughly 380,000 years after the Big Bang, the matter got cooled down well enough to form more atoms resulting in a transparent, electrically neutral gas as observed by the NASA. This set the initial flash of light created during the Big Bang, which is detectable today as cosmic microwave background radiation. It was found that after this situation, the universe was found to be plunged into a state of darkness, since no stars or any other bright objects had formed yet.

The epoch of Reionization:

About 400 million years after the Big Bang, the universe began to emerge from the cosmic darkness. During this time, clumps of gas collapsed enough to form the first stars and galaxies. At this time, the energetic ultraviolet light ionized and destroyed most of the neutral hydrogen. This episode lasted for more than a half-billion years period. This is called as the epoch of reionization.

The dark energy began:

NASA also found that the expansion of the universe gradually slowed down as the matter in the universe pulled on itself via gravity, about 5 or 6 billion years after the Big Bang. There was a mysterious force now called dark energy began speeding up the expansion of the universe once again, a phenomenon that is being continued even today. A little after 9 billion years after the Big Bang, our solar system was born.

The Age of the Universe:

The universe is currently estimated at roughly 13.8 billion years old, + / - 130 million years. In comparison, the solar system is only about 4.6 billion years old. This estimate came from measuring the composition of matter and energy density in the universe. This allowed researchers to compute how fast the universe expanded in the past. With that knowledge, they could turn the clock back and extrapolate when the Big Bang happened. The time between then and now is the age of the universe.

The Shape of the Universe:

The shape of the universe whether finite or infinite is yet to be understood. It depends on the struggle between the rate of its expansion and the pull of gravity. The strength of the pull in question depends in part on the density of the matter in the universe. If the density of the universe exceeds a specific critical value, then the universe is "closed" and "positive curved" like the surface of a sphere. According to NASA, the universe is not infinite but has no end, just as the area on the surface of a sphere. The universe will eventually stop expanding and start collapsing in on itself, the so-called "Big Crunch." If the density of the universe is less than this critical density, then the geometry of space is "open" and "negatively curved" like the surface of a saddle. If so, the universe has no bounds, and will expand forever. If the density of the universe exactly equals the critical density, then the geometry of the universe is "flat" with zero curvature like a sheet of paper. It is possible that the universe has a more complicated shape than a curved surface.

Helium in the early Universe:

A team lead by the European astronomer Peter Jakobsen investigated the nature of the gaseous matter that fills the vast volume of intergalactic space. By observing the ultraviolet light from a distant quasar, which would otherwise have been absorbed by the Earth's atmosphere, they found that the signatures of helium in the early Universe.

This was an important piece of supporting evidence for the Big Bang theory. It also confirmed scientists' expectation that, in the very early Universe, matter was not locked up in stars and galaxies, but was nearly / completely ionised (the atoms were stripped of their electrons). This was an important step forward is the field of cosmology. This investigation of helium in the early Universe is one of many ways that Hubble has used distant quasars as lighthouses. As light from the quasars passes through the intervening intergalactic matter, the light signal is changed in such a way as to reveal the composition of the gas. The results have filled in important pieces of the puzzle of the total composition of the Universe now and in the past.

Composition of the Universe:

According to the latest observational evidence, ordinary matter, including stars, planets, dust and gas, only make up a tiny fraction of the universe (5%). The rest is the elusive dark matter (~25%) and dark energy(~70%).

Dark energy is a mysterious (and as yet hypothetical) form of energy which is spread out uniformly throughout space (and time). It has anti-gravitational properties. It is one of the possible explanations for the current accelerating rate of expansion of the universe.

Dark matter is the matter not visible to us because it emits no radiation that we can observe, but it is detectable gravitationally.

Hydrogen & helium gas: Hydrogen and Helium are the most abundant element in the universe. This element is found in great abundance in stars and gas giant planets.
Star: A ball of mostly hydrogen and helium gas that shines extremely bright. Our Sun is a star.

Neutrino: A small particle that has no charge and is thought to have very little mass. Neutrinos are created in energetic collisions between nuclear particles. The universe is filled with them but they rarely collide with anything. The distribution pattern is as follows:

Details	Percent
Dark energy	70%
Dark matter	25%
Hydrogen & helium gas	4%
Stars	0.5%
Neutrinos	0.3%
Heavy elements	0.03%

Abundance of elements in the Universe are shown in this table.

Ten most common elements in the Milky Way Galaxy estimated spectroscopically

Z	Element	Mass fraction in parts per million
1	Hydrogen	739,000
2	Helium	240,000
8	Oxygen	10,400
6	Carbon	4,600
10	Neon	1,340
26	Iron	1,090
7	Nitrogen	960
14	Silicon	650
12	Magnesium	580
16	Sulfur	440

The elements – that is, ordinary (baryonic) matter made of protons, neutrons, and electrons, are only a small part of the content of the Universe. Cosmological observations suggest that only 4.6% of the universe's energy (including the mass contributed by energy, $E = mc^2 \leftrightarrow m = E / c^2$) comprises the visible baryonic matter that constitutes stars, planets, and living beings. The rest is made up of dark energy (68%) and dark matter (27%). Hydrogen is the most abundant element in the Universe; helium is second. However, after this, the rank of abundance does not continue to correspond to the atomic number; oxygen has abundance rank 3, but atomic number 8. All others are substantially less common.

The Dark Matter:

Today astronomers believe that around one quarter of the mass-energy of the Universe consists of dark matter. This is a substance quite different from the normal matter that makes up atoms and the familiar world around us. Hubble has played an important part in work intended to establish the amount of dark matter in the Universe and to determine where it is and how it behaves. Dark matter only interacts with gravity, which means it neither reflects, emits or obstructs light (or indeed any other type of electromagnetic radiation). Because of this, it cannot be observed directly. In 2007 an international team of astronomers used Hubble to create the first three-dimensional map of the large-scale distribution of dark matter in the Universe. It was constructed by measuring the shapes of half a million galaxies observed by Hubble.

The Dark energy:

More intriguing still than dark matter is dark energy. Hubble studies of the expansion rate of the Universe have found that the expansion is actually speeding up. Astronomers have explained this using the theory of dark energy, that pushes the Universe apart ever faster, against the pull of gravity. As Einstein's famous equation, $E=mc^2$ tells us, energy and mass are interchangeable. Studies of the rate of expansion of the cosmos suggests that dark energy is by far the largest part of the Universe’s mass-energy content, far outweighing both normal matter and dark matter: it seems that dark energy makes almost 70% of the known Universe.

Other clustered objects in the Universe:

There are several clustered objects concentrated in the Universe as Galaxies, Nebulae, Stars, Black holes, and Novae.

The Galaxies:

A Galaxy is a huge mass of stars, nebulae and other interstellar objects co-existing as star families under the gravitational attraction of a giant single star. A Galaxy is a giant family of millions of stars. The Scientific observations say that there may be as many as 100 billion galaxies existing in the Universe, a fraction of it is alone known to human knowledge. There are different kinds of Galaxies as

- i) Spiral Galaxies
- ii) Elliptical Galaxies
- iii) Irregular Galaxies

The story of telescopic astronomy began in 1609. The first astronomical observations were made by Thomas Harriott, Galileo and Marius. It was Thomas Harriott has compiled a map of the moon which formed the foundation to Galileo’s contributions. Hans Lippershey of Holland made the first instrument which helped Galileo to invent the refracting telescopes. The year 1609 has shown spectacular discoveries on Moon, Jupiter, Venus and Sun. In 1663, reflecting telescope was invented by J. Gregory, to overcome the problems of rainbow colors in the Prisms used for refracting telescopes.

Throughout 18th century telescopes of various sizes were built. Uranus was identified using the telescope made by William Herschel in 1781. During the 19th Century both spectroscopy and photography were taken as separate schools of studies. Scientists of Astronomy and optics were emerging further. Concentration on spectroscopy made remarkable findings on Bohr's Atomic Theory in the first part of 20^{th} Century. The first basic understanding of the Electromagnetic spectrum came only after the invention of astronomical spectroscopes. The world's greatest scientific observations and mathematical analyses started growing after this period.

Tremendous inventions and discoveries on temperature, light, sound, radio waves, atomic structure, telescope; Radar astronomy and infra-red spectra were made during the early part of 20^{th} century.

Cosmic Radiation, Cosmic Rays

The following are the kinds of explanations given to cosmic radiation:

(a) High-speed particles that reach the Earth from outside the Solar System. Heavier cosmic ray particles - such as those sought in x-ray astronomy - are ordinarily filtered out by the Earth's upper atmosphere.

(b)Subatomic particles, primarily protons, that speed through space and strike the earth. The fact that they are massive, combined with their high velocities, means that they pack considerable energy - from 10^8 to more than 10^{22} electron volts.

(c) High-energy charged particles (about 85% protons, 14% α-particles, 1% electrons, << 1% heavy nuclei) which stream at relativistic velocities (mean energy ~ 2 GeV) down to Earth from space. The Sun ejects low-energy (10^7 - 10^{10} eV) cosmic rays during Solar flares (those of lower energy than this are unobservable from Earth because of Solar system magnetic fields). Those of intermediate energy (10^{10} - 10^{16} eV) have an isotropic distribution, and are apparently produced in the Galaxy.

(d) The light elements Li, Be, and B have a higher abundance ratio in cosmic rays than in the Solar System.

(e) High-energy particles of extraterrestrial origin which can be detected in observations made above the Earth's atmosphere. If the particles are of very high energy, they can give rise to air-showers when they penetrate into the atmosphere; these showers can be detected at ground level. The cosmic ray particles are mostly protons, electrons and helium nuclei with a few per cent of heavy elements, and are present throughout the disc of our Galaxy.

(f) Protons and some nuclei that are ejected from stars, especially supernova explosions, move throughout all space. These "cosmic rays" impinge on the earth from all directions. They normally collide with nuclei of atoms in the atmosphere, producing more "secondary" particles, mainly electrons, muons, pions, etc.

Dwarf

A dwarf is a small, faint galaxy, exemplified locally by such systems as Ursa Minor, Draco, Sculptor, Sextans, Carina, Fornax, Leo II, and Leo I, and the Andromeda dwarfs orbiting M31. These are Luminosity Class V stars, essentially defining the Main Sequence, that are currently supported by the fusion of hydrogen into helium in their cores.

Dwarf Galaxy

It is a galaxy at the faint end of the general lumisosity function and generally exhibiting low surface brightness.

Elliptical Galaxy

It is a galaxy that looks round or elliptical. One example is M87, in the constellation Virgo. Elliptical galaxy is a galaxy without spiral arms and with an ellipsoidal shape. Ellipticals have little interstellar matter and no blue giants - the only giants are red, and they give ellipticals a slightly redder color than spirals. The most massive galaxies known (about 1013 $M_{\odot}$) as well as some of the least massive known, are ellipticals.

Seyfert Galaxy

Seyfert Galaxy is a type of spiral galaxy first discovered by Karl Seyfert in the 1940s. The central region of a Seyfert galaxy is distinguished by powerful radiation, much of it focused into narrow frequencies. These are one of a small class of galaxies (many of which are spirals) of very high luminosity and very blue continuum radiation with small, intensely bright nuclei whose spectra show strong, broad, high-excitation emission lines probably caused by discrete clouds moving at velocities that are higher than the escape velocity.

Spiral Galaxy

Spiral Galaxy is a galaxy with a prominent nuclear bulge and luminous spiral arms of gas, dust, and young stars that wind out from the nucleus. Masses span the range from 1010 to 1012 $M_{\odot}$.

Spiral Nebula

Spiral Nebula is a spiral galaxy - not really a nebula at all (although many do appear nebulous).

Interstellar Dust

These are dust particles in the space between the stars. These are responsible for the dark patches of obscuration seen on astronomical photographs. The particles are composed of common heavy elements such as carbon and silicon but there is no agreement about the exact composition of the dust grains. Typically, the particles have size about 1 µm but there must be a wide range of particle sizes present to explain the interstellar extinction curve. The dust plays a key role in giant molecular clouds in protecting the fragile molecules from intense interstellar ionising and dissociating radiation. The energy absorbed by the grains is emitted in the far-infrared waveband, and this form of dust emission is one of the most important energy loss mechanisms for regions of star formation. The particles are polarized, needle-shaped grains. Interstellar dust affects the entire spectrum, and leads to dimming and reddening of starlight.

Nova

Nova is a star that brightens suddenly and to an unprecedented degree, creating the impression that a new star has appeared where none was before. Hence the name, from nova for "new". All known common novae are found in close binary systems with one component a cool red giant and the other a hot, less massive object which is the seat of the instability. A star that undergoes an explosion during which its brightness increases by up to ten magnitudes.

Planetary Nebula

Planetary Nebula is a bubble of gas surrounding a hot, dying star. The star is so hot that it makes the planetary nebula glow, which allows astronomers to see it. The star was once the core of a red giant, which ejected its outer atmosphere and created the planetary. A planetary nebula has nothing to do with a planet, but through a small telescope, it looks like a planet's disk, hence the misleading name. The planetary nebula stage lasts for less than 50,000 years. During the core contraction that terminates the red-giant stage, the helium-burning shell is ejected at a velocity so high that it becomes separated from the core.

Protogalaxy

Protogalaxy is a galaxy in the process of formation. None are observed nearby, indicating that all or most galaxies formed long ago. A galaxy during the early phase, before it has developed its present shape and mix of stars.

Pulsar

A Pulsar is a fast-spinning neutron star that emits radiation toward Earth every-time it rotates. Neutron stars that spin rapidly and have strong magnetic fields, which produce electromagnetic radiation. All pulsars are characterized by the general properties of dispersion, periodicity, and short duty cycle. Pulsars are believed to be rotating, magnetic neutron stars which are the end products of supernovae.

Black Hole

A Black Hole is a region of space-time which cannot be seen by distant observers because light is trapped by a strong gravitational field. The boundary of this region is called an event horizon because it separates events (i.e. those in the hole) that cannot be seen from events outside the hole, which can. Black holes might form, for example, from the gravitational collapse of a massive star. When the star shrinks inside an event horizon, it will collapse without known limit, leaving the surrounding space empty, Thus the designation `hole'. Spherical black holes (without electric charge) are known as Schwarzschild black holes. Rotating holes are non-spherical: they are known as Kerr black holes.

A Black hole is an object that is maximally gravitationally collapsed, and from which not even light can escape. An object with such a strong gravitational field that even light cannot escape. Matter can fall into a black hole, but according to classical physics no matter or energy can leave it. It is a mass that is sufficiently compact that not even light can escape its intense gravity. Thus it appears black from the outside.

Light year

The **light-year** is a unit of length used to express astronomical distances. It is equivalent to the distance that light travels in one year, which is 9.4607×10^{12} km (nearly 6 million million miles). As defined by the International Astronomical Union (IAU), a light-year is the distance that light travels in vacuum in one Julian year (365.25 days). Because it includes the word "year", the term light-year is sometimes misinterpreted as a unit of time.

The light-year unit appeared a few years after the first successful measurement of the distance to a star other than the Sun, by Friedrich Bessel in 1838. The light-year unit appeared, however, in 1851 in a German popular astronomical article by Otto Ule. The light-year is most often used when expressing distances to stars and other distances on a galactic scale. The abbreviations used for light years and multiples of light years are

- "ly" for one light year
- "kly" for a kilolight-year (1,000 light years)
- "Mly" for a megalight-year (1,000,000 light years)
- "Gly" for a gigalight-year (1,000,000,000 light years)

Speed of light

The Speed of light is c = 299 792 458 m s−1
Light moves at a velocity of approximately 300,000 kilometers (km) each second. So in one year, it can travel about 10 trillion km. More precisely, one light-year is equal to 9,500,000,000,000 kilometers. In our solar system, we tend to describe distances in terms of the Astronomical Unit (AU). The AU is defined as the average distance between the Earth and the Sun. It is approximately 150 million km (93 million miles). Mercury can be said to be about 1/3 of an AU from the Sun and Pluto averages about 40 AU from the Sun. The AU, however, is not big enough of a unit when we start talking about distances to objects outside our solar system.

For distances to other parts of the Milky Way Galaxy (or even further), astronomers use units of the light-year or the parsec . The light-year we have already defined. The parsec is equal to 3.3 light-years. Using the light-year, we can say that :

Astronomical unit

The term astronomical unit refers to the approximate distance from the Sun to the Earth which is equal to 150,000,000 kilometers. In our solar system, we tend to describe distances in terms of the Astronomical Unit (AU). The AU is defined as the average distance between the Earth and the Sun. It is approximately 150 million km (93 million miles). Mercury can be said to be about 1/3 of an AU from the Sun and Pluto averages about 40 AU from the Sun. The AU, however, is not big enough of a unit when we start talking about distances to objects outside our solar system.
The Crab supernova remnant is about 4,000 light-years away.
The Milky Way Galaxy is about 150,000 light-years across.
The Andromeda Galaxy is 2.3 million light-years away.

Distance Information

NASA(National Aeronautics and Space Administration) gives the following method. Proxima Centauri, the closest star to our own, is still 40,208,000,000,000 km away. (Or about 268,770 AU.) When we talk about the distances to the stars, we no longer use the AU, or Astronomical Unit; commonly, the light year is used. A light year is the distance light travels in one year - it is equal to 9.461 x 1012 km. Alpha Centauri A & B are roughly 4.35 light years away from us. Proxima Centauri is slightly closer at 4.25 light years. One of the most accurate methods astronomers use to measure distances to stars is called parallax. If you hold your finger in front of your face and close one eye and look with the other, then switch eyes, you'll see your finger seem to "shift " with respect to more distant objects behind it. This is because your eyes are separated from each other by a few inches - so each eye sees the finger in front of you from a slightly different angle. The amount your finger seems to shift is called its "parallax".

Astronomers can measure parallax by measuring the position of a nearby star very carefully with respect to more distant stars behind it, then measuring those positions again six months later when the Earth is on the opposite side of its orbit. If the star is close enough to us, a measurable parallax will be seen.

The Cosmic Calendar

The Cosmic Calendar is a scale in which the 13.7 billion year lifetime of the universe is mapped onto a single year. This image helps to put cosmology, evolution, and written history in context. At this scale the Big Bang took place on January 1 at midnight, and the current time is mapped to December 31 at midnight. At this scale, there are 434 years per second, 1.57 million years per hour, and 37.7 million years per day. The concept was popularized by Carl Sagan in his book The Dragons of Eden and on his television series Cosmos as a way to conceptualize the vast amounts of time in the history of the universe.

The 13.7 billion year lifetime of the universe was pictorially mapped onto a single year. At this scale the Big Bang takes place on January 1 at midnight, the current time is December 31 at midnight, and each second is 434 years. The scale was popularized by Carl Sagan in his book The Dragons of Eden.

Cosmic Evolution

The following includes Cosmological time and the start of Geological Time (Chaotian and Hadean).

Date / time	bya	Event
1 Jan	13.7	Big Bang, as seen through cosmic background radiation
11 May	8.8	Milky Way Galaxy formed
1 Sep	4.57	Sun formed (planets and Earth's moon soon thereafter)
16 Sep	4.0	Oldest rocks known on Earth

Evolution of life

Date / time	bya	Event
21 Sep	3.8	first life (prokaryotes)
12 Oct	3	photosynthesis
29 Oct	2.4	Oxygenation of atmosphere
8 Nov	2	complex cells (eukaryotes)
5 Dec	1	first multicellular life
14 Dec	0.67	simple animals
14 Dec	0.55	arthropods (ancestors of insects, arachnids)
18 Dec	0.5	fish and proto-amphibians
20 Dec	0.45	land plants
21 Dec	0.4	insects and seeds
22 Dec	0.36	amphibians
23 Dec	0.3	reptiles
26 Dec	0.2	mammals
27 Dec	0.15	birds
28 Dec	0.13	flowers
30 Dec	0.065	K-T mass extinction, non-avian dinosaurs die out

Human evolution

The following continues with Geological Time, which then becomes Quaternary Time.

Date / time	mya	Event
30 Dec	65	Primates
31 Dec, 06:05	15	Apes
31 Dec, 14:24	15	hominids
31 Dec, 22:24	2.5	primitive humans and stone tools
31 Dec, 23:44	0.4	Domestication of fire
31 Dec, 23:52	0.2	Anatomically modern humans
31 Dec, 23:55	0.11	Beginning of most recent glacial period

31 Dec, 23:58	0.035	sculpture and painting
31 Dec, 23:59:32	0.012	Agriculture

The purpose of Cosmic Calendar

To give us a better idea of the time scale involved in human evolution, it is interesting to compare the numbers involved with something a little more familiar. Here, the history of the universe has been scaled down to one year, That is, one month is equivalent to one billion year, one day to 30 million years, one hour to 1.2 million year and one minute to 20 000 years.

Importance of studying the universe:

Human beings possess an intrinsic need to explore the world. Through exploration, people have discovered new continents, found treatment methods to cure diseases, advanced in technology, communication and innumerable aspects. Studying the origins of the Universe and exploring it helps us build our civilization. Exploring how our civilization came into existence has evolved our ability of thinking and understanding our surrounding and also the universe in a better way. Our curiosity to get the answer to every query in relation to the origin and existence of universe has helped us to discover and build better technology that we so ungratefully enjoy in all walks of life. Humans have managed to advance in every field of technology, medicines, energy and telecommunication.

The ideas of Space Travel, Rockets, and artificial Satellites got emerged with outstanding contributions. The first sets of Liquid-propellant rockets were launched in 1926 and 1949. Probing the planets really started after the launch of Sputnik-I in 1957 and Lunik-1 in 1959 by the Russians. The first manned space flight was achieved on 12th April 1961, while using Vostok-1, by reaching 203 miles in one hour and 48 minutes. Alan Shepard became the first American in Space. Apollo-II was the first successful landing of man on the moon in 1969.

During this time, two planets, Venus and Mars were concentrated, for various studies. The nearest was Venus. Artificial satellites with sophisticated and sterilized probes were used to explore all the planets and satellites. The Moon is the only satellite of Earth and its closest associate. Moon has a special position in the heart of every human being on earth. Lunar charting, with photographic systems and mapping of Moon Maria, Moonquakes and Moons Mountains, volcanic craters were the efforts of those days, in History.