From the Field: Practical Applications of Research

Concepts of the Cosmos that High School Students Should Explore

By Edward Lyons, Ph.D.

Abstract

The purpose of this article is to provide teachers of science scientific definitions and illustrations to facilitate the teaching of cosmology. Secondary school science teachers can use the illustrations and their citations to pose questions to their students and to guide their students to accessible digital sites where the students can explore these concepts further. This article presents complex topics about the cosmos with illustrations that teachers of science can use to help their students to explore further. The purpose of this article is to provide teachers of science with a unified set of definitions related to elements of the cosmos that they can use as tools to motivate their students to engage in further investigations.

Introduction

The Cosmos is so enormous it is difficult to understand and appreciate. An analogy is to pick up a single grain of sand. That single grain represents our Earth; all other grains in Florida represent a small percentage of the celestial bodies in the Cosmos. The Cosmos is the 21st century's new FRONTIER.

Below are discussions concerning particle physics, subatomic particles, dark matter and dark energy. They are the building blocks of the universe. However, this description is a brief overview of very complex subject. There are fabulous resources from NASA and many other sources that provide more detailed descriptions of these topics. The definitions and illustrations in this document are meant to establish a baseline of understandings that teachers can use to excite students to learn about and explore the cosmos.

1. <u>DEFINITIONS</u>

A. Cosmos and universe - all existing material/matter in space; cosmos is an ordered or patterned universe following the laws of physics.

B. Galaxy - a system of billions of stars and their satellites, dark matter, dust, gas and other materials held together by gravitational force. The Earth is in the Milky Way galaxy.

C. Solar system - a star and related satellites.

D. Constellation - a number of stars that form a pattern that might be recognized - a scorpion for example. The patterns aid in navigation and locating a specific star.

2. <u>DISTANCE & SPEED OF LIGHT</u>

We are familiar with the concept of distance. A mile can be walked in 20 minutes or so. The circumference of our Earth is about 25,000 miles. Our moon is our closest natural planetary body; it is approximately 384,400 kilometers or 238,900 miles from the Earth. An Astronomical Unit (AU) is about 93 million miles approximating the distance between the Sun and the Earth. It takes about 8 minutes for the Sun's rays to reach Earth.

Here is a quick diversion to metric system. A meter is 39.37 inches in length. The prefix kilo means 1,000; the 'centi' prefix means 100. Although almost every other country in the world uses the metric system, this paper will use the imperial system we use in the USA. Thomas Jefferson promoted the metric system to no avail. It may be time for the USA to move to metric.

The light and warmth we feel at a point in time was emitted by the Sun 8 minutes earlier; it is an important realization that when we view distant celestial bodies what we are seeing today existed many years or centuries earlier.

The universe is so enormous that the concept of light year was conceived to explain this. A light year is the distance that a light ray travels in a year. Light travels in a vacuum at 300,000 kilometers/second equal to 186,282 miles/second. The symbol for the speed of light in a vacuum is 'c'.

A little math: 186,282 miles/second x 60 seconds/minute x 60 minutes/hour x 24 hours/day x 365 days/year. A light year is about 6 trillion miles (5.879 followed by 12 zeros) traveled in one Earth year.

Nothing in the visible world moves faster than the speed of light (the exception being dark energy, that is space itself and may expand faster than the speed of light.

This may also represent a concept known as tunneling). Of course, the same thing was said of the speed of sound until 1947 when U.S. Air Force Captain Chuck Yeager broke the sound barrier of about 770 mph.

3. ASTEROIDS, COMETS, METEORS

In the beginning of our solar system, about 4.6 billion years ago, there was just dust and gasses. Accumulation of the dust formed rocks and eventually planets. Many rocks (perhaps more than 1.5 million) became boulders which we now define as asteroids. Like a planet, they orbit the Sun.

Asteroids are irregularly shaped resembling a potato. Between Mars and Jupiter is the 'which is the home of most but not all asteroids. About 66 million years ago an asteroid impacted the Yucatan in Mexico creating the Chicxulub crater. It is estimated that 75% of all plant and animal life on Earth was destroyed and resulted in the extinction of non-avian dinosaurs (Wei-Haas. September 9, 2019. National Geographic). More recently, in 2013, a 7,000-ton asteroid crashed into Siberia with a force 30 times greater than the force of the atomic bomb dropped on Hiroshima.

There is an ongoing concern that an asteroid may either hit Earth or be destroyed miles above Earth that would create dangerous 'airblasts' or shock waves. NASA and the international community have defense programs underway, and they are examining different methods to either destroy or deflect asteroids in space. In 2021, NASA launched a spacecraft (about 1,200 pounds) as part of the Double Asteroid Redirection Test (DART) to determine if an asteroid can be diverted from its path.

36 million years ago an asteroid landed in what is now Maryland. The blast opened a gap 50 miles wide. Eventually, melted glaciers filled the hole and today we have the Chesapeake Bay.

A comet is an icy satellite (called a dirty snowball) composed of dust particles formed into a rock and gases. Gases include methane, ammonia, and water (hydrogen and oxygen). The comet heats up as it passes close to the Sun and releases gases. This produces a visible water trail or coma. The nucleus can be several miles across and the tail can be thousands of miles in length. It is speculated that comets crashing into the earth may be the source of our water and amino acids. Those compounds are the source of life as we know it.

Halley's Comet is named after Edmund Halley who in 1705 realized that the same comet was visible on Earth at 75-76 years intervals. The next time Haley's Comet can be observed on Earth is 2061.

A meteoroid is a small rock found in outer space. They vary in size from a dust particle to a small asteroid of perhaps a meter in diameter.

When a meteoroid enters the earth's atmosphere it burns resulting in a meteor and what we describe as a shooting star. When a meteoroid hits the ground, it is called a meteorite. The study of meteorites gives us clues about the early universe. These space rocks, unlike the Earth, have not been altered by weather, plate movements and volcanoes.

NASA's web site provides outstanding descriptions, photos of the three 'space' rocks.

4. MOONS (NATURAL SATELLITES)

Moons are satellites that circumnavigate planets and other celestial bodies.

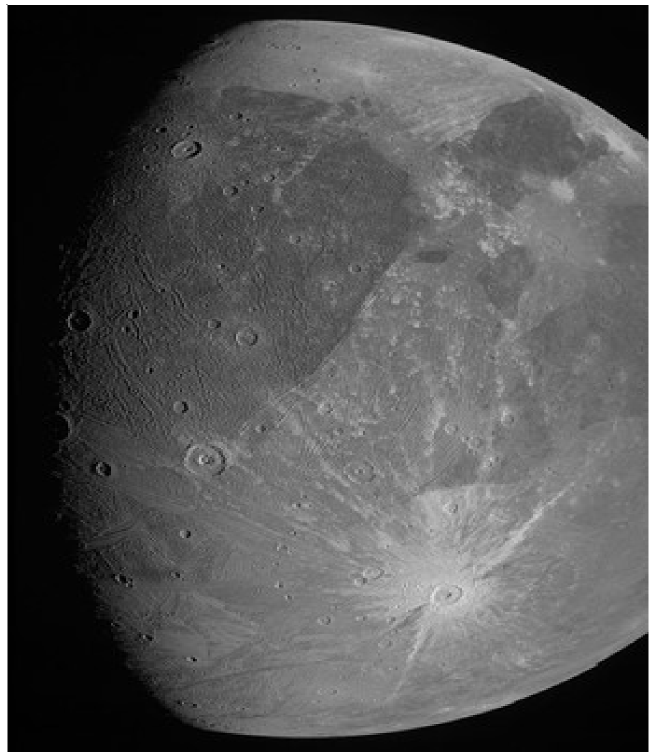
Image of Earth's moon
Credit: NASA/GSFC/Arizona State University

Earth has just one moon, although at one point there were two moons that combined to form our current moon. It is almost 245,000 miles from earth. It follows a 27 day orbit about the earth.

Moons of our solar system (provisional moons refer to observed satellite bodies whose orbits have not been fully documented):

Planet	Confirmed Moons	Provisional Moons	Total
Mercury	0	0	0
Venus	0	0	0
Earth	1	0	1
Mars	2	0	2
Jupiter	53	26	79
Saturn	53	29	82
Uranus	27	0	27
Neptune	14	0	14
Dwarf Planets			
Pluto	5	0	5
Eris	1	0	1
Haumea	2	0	2
Makemake	0	1	1
Ceres	0	0	0
Totals	**158**	**56**	**214***

SOURCE: https://solarsystem.nasa.gov/moons/in-depth/

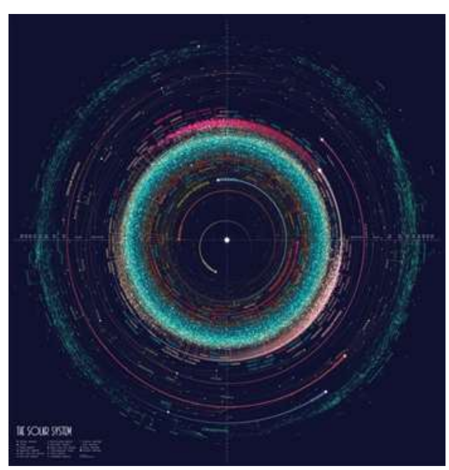


This image of Jupiter's enormous moon Ganymede was obtained by the JunoCam imager during the Juno spacecraft's flyby on June 7, 2021. Credit: NASA, JPL-Caltech, SwRI and MSSS

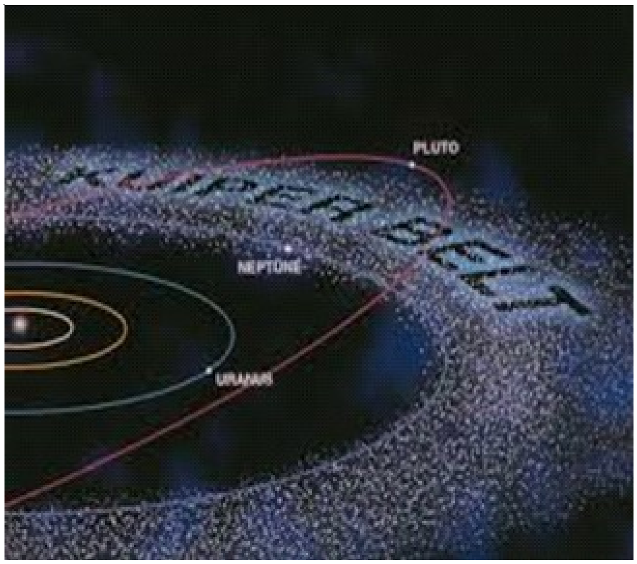
The Earth's moon is discussed later in this treatise.

5. BELTS: Kuiper, asteroid, and van Allen belt

A belt refers to an accumulation of asteroids and other outer space materials traveling in a defined orbit. Within and surrounding our solar system there are countless objects circling the Sun. Most can be defined as asteroids. Eleanor Lutz mapped out every known object in Earth's solar system (>10km in diameter) shown below. Source: output.com.



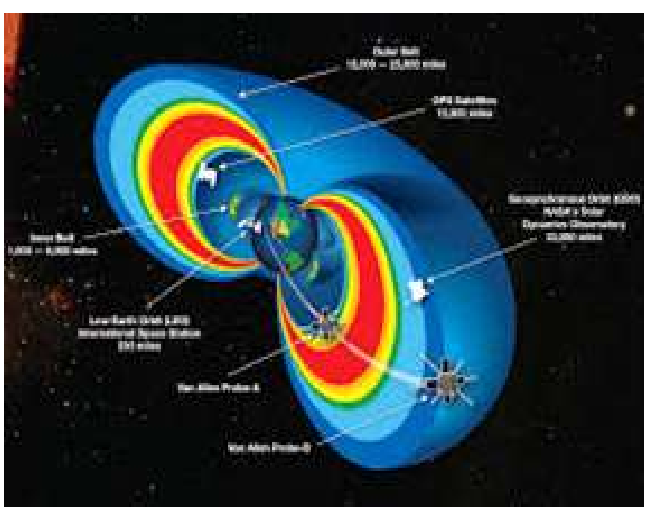
In 1951, Gerard Kuiper discovered a disc like belt of materials beyond Jupiter. Belt material takes 300 years to orbit the sun compared to 1 year for the Earth.



NASA Solar System Exploration

There are numerous asteroid belts. The so-called main belt asteroid (a different version of MBA) lies between Mars and Jupiter. It extends nearly 600 miles and contains more than a million pieces of debris.

In 1958 James Van Allen, a physicist at the University of Iowa, discovered a high energy field of charged particles (ions and electrons) that surround the earth. The belts are named for Van Allen; they protect the earth from radiation. The donut shaped belts are controlled or trapped by the magnetic field surrounding the earth.



Credit: NASA

6. GRAVITY

Gravity is that force that pulls things toward each other. It is invisible but we would be in big trouble without it. The amount of force is determined by two factors:

1. The mass of the objects; the greater the mass the greater the gravitational pull.

2. The distance between the objects, the closer they are to each other the greater the gravitational pull.

Isaac Newton is credited with the gravitational force formula: $F = G(M1 \times M2)/R\ 2$ where G =gravitational constant $= 6.67 \times 10^{-11}\ m^3kg^{-1}\ s^{-2}$, a very, very tiny number; M1 and M2 are masses of the bodies and R2 is the squared distance between the bodies. Supposedly Newton was curious why an apple falling from a tree fell straight down. Gravity is why the earth circles in an orbit around the sun. It is why you come back to land after you jump up. Viewing the formula, if your weight is Mass1 and a planet or moon is Mass2 your weight is given in the following table.

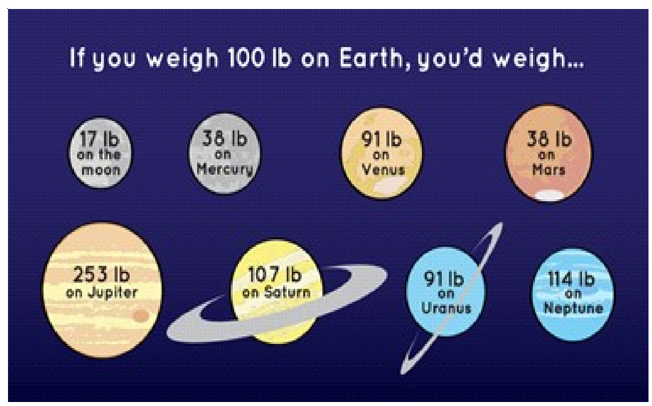


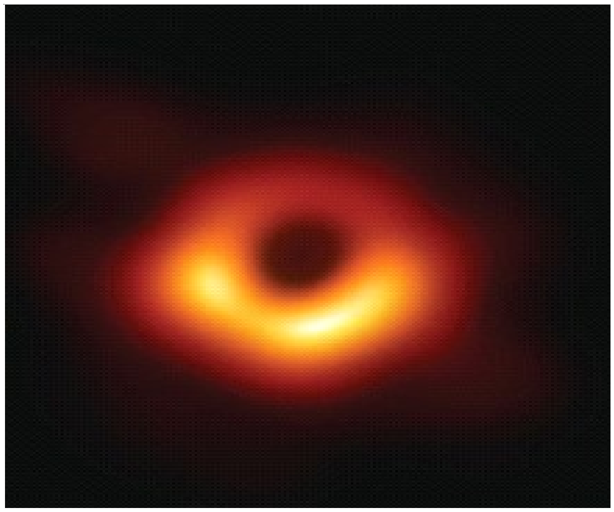
Image credit: NASA

We also experience the effects of gravity with the moon's gravity pulling on the oceans creating tides. Most intriguing is the role of gravity in forming stars and planets by pulling small materials together to form enormous planetary bodies.

In contrast to attractive gravity, Einstein and others) postulated that there is 'repulsive' gravity that pushes bodies away from each other. It is given as an explanation of an increasingly expanding universe due to repulsion of dark energy.

7. BLACK HOLES

When there are insufficient elements to sustain the fusion reaction*, a star dies. Smaller stars are transformed into white dwarfs or neutron stars. Larger stars, five times larger than our sun and larger, collapse and form a black hole.



https://creativecommons.org/LICENSES/BY/4.0
Simulated view of a black hole
(Image: © Alain R. | Wikimedia Commons)

While nuclear fission is the splitting of atoms used in nuclear power plants and bombs, nuclear fusion is the combining/fusion of two atoms (hydrogen isotopes) with the resulting release of energy. Fusion is the source of the Sun's power. In 2022 we may be close to commercial reality with the reaction producing more energy than it consumes. Advantages of fusion: clear, plentiful supply of raw materials, no waste and safe.

The term 'black hole' was coined in 1967 to describe a cosmic donut hole. This hole is not empty, on the contrary, it is an extreme concentration of matter. Can you imagine 10 suns compacted into an area the size of Chicago? The density, and therefore gravity, within the hole is so great that we believe nothing can escape the BLACK HOLE even light. The term 'event horizon' defines the outer boundary of a black hole. Any object, including light, that passes the event horizon into a black hole cannot return; it is the point of no return.

The concept of a black hole was theorized by Einstein in 1916. He conceived the idea of 'SPACETIME' defined as the combination of the three dimensions of matter (length, width and depth) with time. The four dimensions interactions were first developed in 1907 by Hermann Minkowski.

The theory of relativity suggests that when very large stars die, the remnant is a dense core that becomes a black hole. Steven Hawking in the 1970s stated that black holes emit radiation. Accepting that fact allows indirect observation of black holes. The other rationale for black holes is gravitational pull (accretion) on planetary bodies. It is speculated that a black hole is at the center of every galaxy.

Black holes emit radiation and over billions of years evaporation (decay) results in the disappearance of a black hole. It is speculated that 'worm holes' exist. That is a story for a future volume. A description can be found: https://www.scientificamerican.com/video/decoded-what-are-black-holes/?utm

8. ANTIMATTER

Let's start with matter. We know of solids, gases and liquids. There are also exotic materials such as super conductors, topological insulators and other forms of matter. You can see, feel, and touch matter. So, antimatter is the opposite. At the atomic level each constituent of the atom has its opposite. For example, a negatively charged electron matter has an opposite charge, an anti-matter positron also referred to as an antielectron.

Antimatter theory was first introduced in 1927 by Paul Dirac. Today, the structure of atoms is studied at physics facilities around the world such as Fermi in the USA and CERN's (the Organization for Nuclear Research) Large Hadron Collider on the Switzerland/France border.

The author only mentions antimatter in this tutorial because it is believed to be produced at the same level as matter at the time of the Big Bang. Where is it today? The Standard Model, discussed later, does not explain antimatter. The future is a moving target with respect to anti matter; there is much to learn.

9. DARK (nonluminous) MATTER

Dark matter (DM), also referred to as the missing mass, is so dark it cannot be seen visually. It emits neither energy nor light. We know it is there because of its gravitational pull. OK, roughly the mix of matters (precise but not necessarily accurate; the figures vary by source; note the pie charts in the next section):

Dark Matter	30.1%
Dark Energy	69.4%
Visual matter	0.5%

A distinction between dark matter and dark energy is that dark matter restrains expansion of the universe while dark energy is responsible for the expansion.

In 1933, Swiss/American astronomer Fritz Zwicky discovered that analyzing a system of stars and galaxies that visual matter represented only 1% (0.5% today's estimate) of the mass required to keep the galaxy together.

There are two types of Dark Matter:

1. Baryons - neutrons, protons and atomic nuclei. What we see in the heavens.

2. Non-Baryons are heavy particles that are not well understood. Weakly Interacting Massive Particles (WIMPs) are particles accounting for the bulk of DM. This is an area under investigation.

galaxy cluster 1E0657-56 (cdn.britanica.com) Composite image showing the galaxy cluster 1E0657-56, the Bullet cluster.

The only constant is change and that is true of matter-energy as shown below.

"Don't shoot for the stars, we already know what's there," she once said. "Shoot for the space in between because that's where the real mystery lies." Vera Rubin (Yeager, A. August 17, 2021. Scientific American).

10. DARK ENERGY

Dark matter pulls 'things' together while Dark Energy (DE) pushes them apart which is referred to as cosmic inflation. It is credited with the expansion* of the universe. The universe is expanding today. The theory is that DE consists of neutrinos and other subatomic particles. It is a topic not well understood by physicists and certainly not by me. Any interest beyond this please check sources such as NASA.

The Hubble constant measures this expansion, about 46,200 mph per million light-years, or 67.4 kilometers per second per megaparsec in cosmologists' units. (A megaparsec is equal to 3.26 million light years. (Source: Mann, A. July 7,2021. New measurement may resolve cosmological crisis. Live Science)

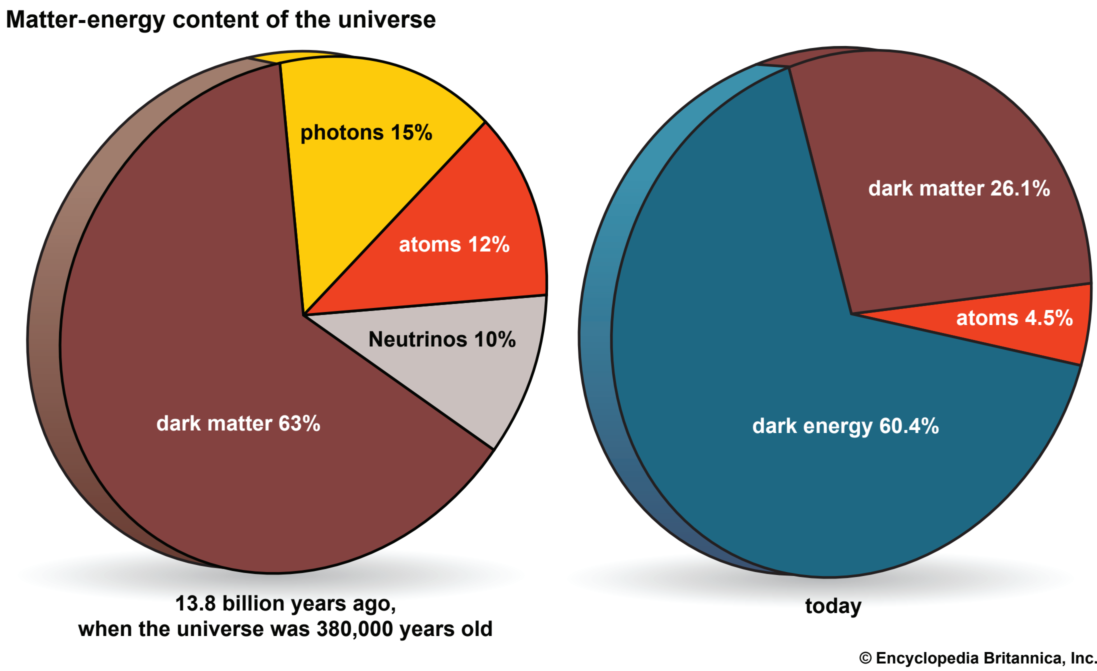
11. BOSONS

Named after Indian physicist S. N. Bose, Bosons are a family of particles that carry a charge. The family includes photons (an element of electromagnetism), gluons (strong force elements), w and z (weak force elements) and the now famous Higgs. The existence of Higgs was postulated by Peter Higgs in 1964 and confirmed in 2103 at CERN (discussed further under Section 16, Standard Model).

The Higgs boson is associated with the Higgs field that gives mass to other particles such as electrons and quarks. This is a complex topic.

12. NEBULA (NEBULAE)

Nebulae are made of dust and gases. They are particles left from a dying star. In turn, as they aggregate because of gravity, they begin to form satellites that includes new stars.

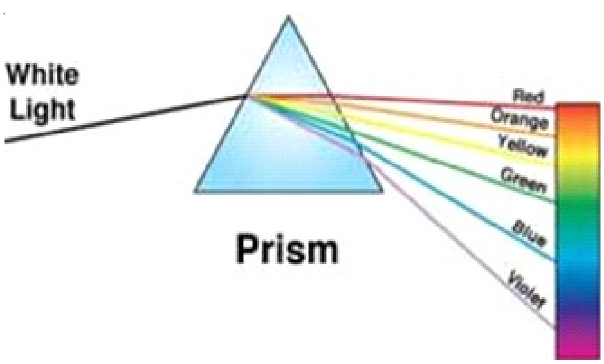


The Eagle Nebula is called the Pillar of Creation.
Credits: NASA, ESA and the Hubble Heritage Team (STScI/AURA)

13. LIGHT

We think of light as a continuous wave or beam. Alternatively, light consists of photons that are light energy particles.

The sun emits 'white' light that is composed of all the colors of the rainbow. When the sun's light passes through a prism or rain drop the light is refracted (bent). The light components are released at different wavelengths separating into different colors.



Source: NOAA SciJinks - All About Weather" https://scijinks.gov/blue-sky/

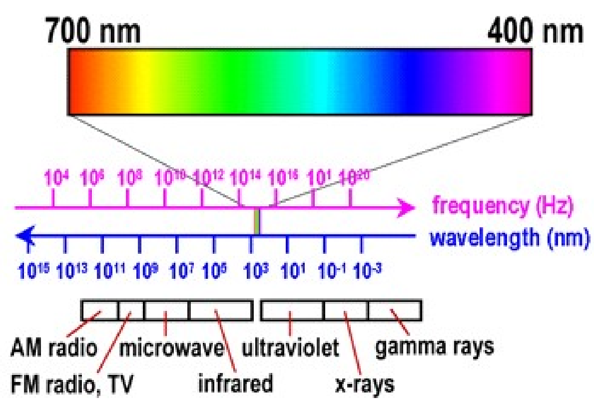
What is a wave? Envision a series of the letter VVVVV...as a wave, the wavelength is the distance between like points on adjoining waves (example, peak to peak). Red components of light have long wavelengths (long distance between peaks) while the blue component is much shorter (about half the wavelength of the red).

In contrast to the extraordinarily large numbers when discussing the cosmos, wavelength is extraordinarily small. Wavelength is measured in nanometers, a nm symbol. A nanometer is one billionth of a meter; a meter is 39.37 inches in length (one inch is equal to 25.4 million nanometers).

Frequency is proportionally the inverse of wavelength. Frequency is a measure of the cycles per second and the measure is the Hertz, named after Heinrich Hertz who in the late 1800s proved the existence of electromagnetic waves. Short wavelengths have high frequency and long wavelengths have low frequencies.

Red sky in the morning or evening is the result of sun light traveling further in the atmosphere. In that passage there are contaminants in the air - water vapor, dust and particulate that scatter the blue light and allow the reds to pass through to a human's eyes.

Earlier we discussed the speed of light, but there is more to understand. First, light is an electromagnetic wave moving at 186,282 miles/second. Second, light consists of a broad range of wavelengths. Humans see only a narrow window of the wavelength - visible light (chart below) from about 400nm to 700nm. Some animals have a broader range of sight than humans. Third, we humans utilize other wavelength ranges (non-visual) such as ultraviolet light for disinfection, lasers and X-Rays for medical examinations. Fourth, astronomers and cosmologists use light to examine the expansion of the universe and the chemical composition of the universe.



www.graphics.lcs.mit.edu/classes/6.837/F01/Lecture01/index.html

Both UV light and visual light are examples of radiant energy (energy from high temperatures to receiving body without the use of an intermediate material). The regions of the electromagnetic wave that are not visual are extremely important such as X-Rays for assessing medical bone damage, radio waves for communication, microwaves for cooking and UV light for disinfection. In addition to optical telescopes that we use, there are telescopes using other electromagnetic waves such as radio, UV, gamma and X-Ray.

14. FORCES

We can't feel forces. We do not feel the force when we drop an apple; we do not see or feel the magnetic field.

GRAVITY is discussed above. In summary, gravity is force that attracts or pulls two objects to each other. The greater the mass of the objects and the shorter the distance between the objects the higher the gravitational force. It keeps us from falling off the Earth as well as keeping planets and satellites in orbit.

ELECTROMAGNETISM is the combination of electricity (the flow of electrons and protons) and a magnetic field. Fundamentally, this force is the key to all chemistry; it is the force that ties all the components of an atom together. It is used in both generating electricity and driving motors. A generator creates electricity that we use in our home. The motor uses electricity in running an electric vehicle, like a Tesla, or a sewing machine.

For our purposes, know that light is a form of electromagnetic radiation and is a fundamental force in understanding the cosmos. Visible light to humans is an electromagnetic radiation wave with a very narrow range. Electromagnetic radiation is analyzed by astronomers to deduce the composition of the early universe, determine the expansion of the universe and to define the chemical composition of cosmic objects.

Number 3 is the WEAK NUCLEAR FORCE. It is enough to state that the weak force, consisting of Z and W bosons, is responsible for radioactive decay, fusion in the sun and in general, the decomposition of atoms
.

Number 4 is the STRONG NUCLEAR FORCE. Not surprising, its role is to keep the atomic structure together; a gluon is the force particle serving that function. It is considered the strongest of the four forces.

The relative strengths of the forces are extreme, with gravity being a minute fraction of other forces. (Source: https://courses.lumenlearning.com/physics/chapter/33-2-the-four-basic-forces/)

- Strong force 1
- Electromagnetic force 1/100
- Weak force 1/10,……(13 zeroes)
- Gravity 1/10,……(38 zeroes)

Gravity is an extremely weak force as masses increase and distance between the two objects decrease the Force of Gravity increases (refer to Gravity section below).

There are discussions suggesting a fifth force - force carrier particles. The discussion concerns decay of the 'beauty' or 'bottom' quark into electrons and muons at differing rates. This is the area of bosons, gluons and other subatomic particles. Accepting this force would aid us in better understanding the universe.

15. PARTICLE ACCELERATOR

Particle accelerators generate a beam of charged particles such as electrons, protons and ions to study nuclear forces and the structure and interactions of subatomic particles. By understanding the fundamental elements of atoms, we understand the universe because the universe is composed of these fundamental particles.

Force	Approximate relative strength	Range	Carrier particle
Gravity	10^{-38}	∞	Graviton (conjectured)
Electromagnetic	10^{-2}	∞	Photon (observed)
Weak force	10^{-13}	$<10^{-18}$ m	W^+, W^-, Z^0 (observed[2])
Strong force	1	$<10^{-15}$ m	Gluons (conjectured[3])

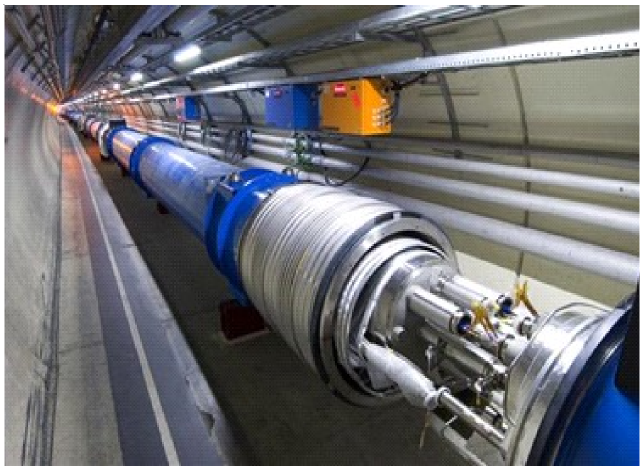
Reference: OPENSTAX.ORG, "23.1 The Four Fundamental Forces"

The components of an accelerator include:

- a tubular enclosure to encase the particles with very little air or particles, in a vacuum environment;
- a generator that produces a beam of charged particles;
- an accelerator that is an electric field that that moves the particles at close to the speed of light;
- a magnetic field that manages the path of the particles. They can bend a beam in a circular accelerator;
- Instruments that measure the particle components, mass, energy levels, etc.;
- a detector that is either a target the beam hits and displays an image of subatomic particles or an image when two particles collide.

There are two basic types of accelerators: circular and linear. Fermilab National Laboratory in Batavia, IL (near Chicago) is home to the circular Tevatron accelerator. Fermi scientists discovered two leptons and a quark (discussed below in the Standard model). Fermi is also home to a linear accelerator as well as research on neutrinos, muons and much more. Circular colliders are generally used to analyze heavy proton and ion structures and can be curved by magnets. Linear colliders analyze very light weight electrons.

A few miles from Fermilab is Argonne National Lab. It is the home of a 'synchrotron' that generates electrons at extremely high speed - close to the speed of light. Electrons enter a ring and generate X-Ray light (photons) to be investigated. X-Ray diffraction is applied in analyzing the structure of materials, biological elements from toxins to amino acids and many other applications.



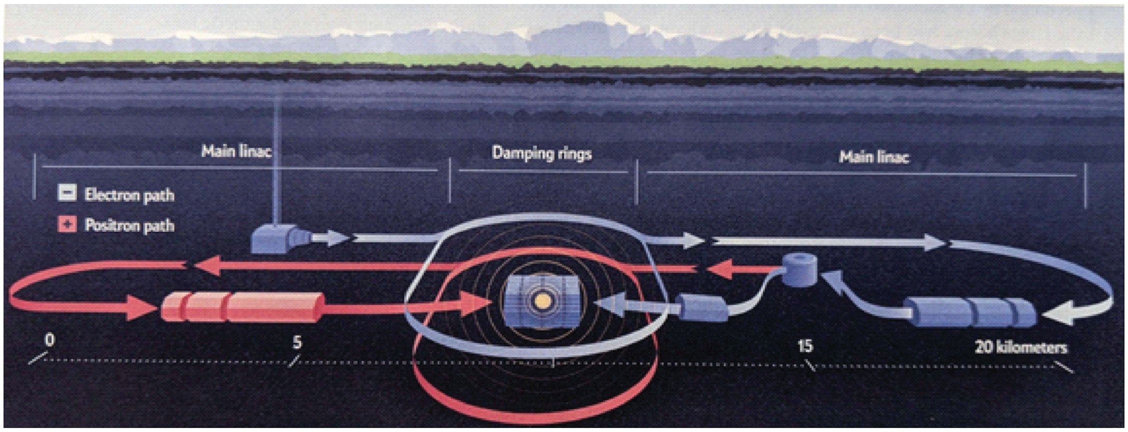
https://cds.cern.ch/images/CERN-EX-0510029-03

The current state of the art accelerator is the Large Hadron Collider (LHC) in CERN on the Swiss French border (mentioned above under anti-matter). The LHC has a circumference of 27 kms (almost 17 miles) and is the largest and highest energy collider.

In 2012, the LHC collided two proton and discovered the Higgs Boson (see Standard Model section). On the planning table is the future Circular Collider at CERN; it is a 100 km (62 miles) circular accelerator handling proton-proton and electron-positron (the antimatter counter to an electron) particles. In addition, the International Linear Collider, a linear accelerator (most likely located in Japan) is under consideration to analyze electrons and positrons. A plasma collider is also being planned.

ON DECK: THE INTERNATIONAL LINEAR COLLIDER (ILC)

This proposed linear acceletator would collide electrons with their antimatter counterparts, positrons. The 20-kilometer-long machine would operate at a lower energy level (250 giga electron volts) that the LHC but would produce cleaner data. Yet its cost has been estimated to be around $10 billion, and no country has agreed to host it to date.



16. STANDARD MODEL

The Standard Model (SM) generally refers to particle physics and the formation of the universe. In doing so, its function is to explain the forces noted above. There is one glaring problem, the current model does NOT explain gravity.

It is believed that dark matter accounts for 25% of the universe and dark energy 70%. The remaining 5% concerns particles.

For centuries it was assumed that the atom was the ultimate structure of all matter including a blade of grass, the human body, the stars and planets. The word atom was proposed by the Greek Democritus in 400BC; it means indivisible and it defines the unique chemical properties of elements. Of the 118 elements, 92 are naturally occurring elements such as hydrogen, helium, oxygen and nitrogen.

There are also, to date, 26 synthetic or artificial elements that are not found in nature. They are formed by human intervention by adding protons to an atom via nuclear reactions or using particle accelerators.

In 1869, Dimitri Mendeleev developed the periodic table of elements based on an element's mass and recurring properties. Today the table includes many more elements and isotopes of elements and is based on the atomic number - the number of protons in an atom - not mass.

Backtracking a bit, in 1897 a Cambridge physicist and Nobel laureate Sir Joseph Thomson discovered electrons. Negatively charged electrons are the mechanism to combine elements to produce molecules. In 1911 the nucleus, the core of the atom, was discovered followed in 1932 by discovering the neutron followed by the proton. In basic chemistry class we learned that the negatively charged electron represented a tiny fraction of an atom's mass. The positively charged proton and uncharged neutron represent the mass of the atom. All matter is composed of combinations of atoms including us (humans).

The current SM enters another layer of depth with respect to subatomic particles (17 have thus been defined). In the mid-1960s **quarks** were described as the ingredients in making protons and neutrons; the six quarks are: up, down, charm, strange, top and bottom. There are six **leptons,** three of which carry a charge; they are electron, muon and tau. The remaining three are neutral: electron neutrino, muon neutrino and tau neutrino.

A diagram of the standard model would show 6 leptons and 6 quarks surrounding the 4 forces and the bull's eye is the Higgs boson (also known as the 'God Particle). Peter Higgs, Nobel laureate, predicted an unknown particle in the 1960s; it was only confirmed in 2012. The theory is that the Higgs boson promotes the joining of particles to form stars and other celestial bodies. A decaying Higgs forms charm quarks.

The Standard Model defines the relationships among the elementary particles and the forces (Section 13 discussed above) that influence them. In summary:

- The elementary particles of matter (called Fermion particles) are: electron, a proton consisting of 2 up and 1 down quark; neutron consisting of one up and 2 down quarks. A caveat is that a neutrino, a near massless particle, is also a component of matter.

- The other 4 quarks are: top, bottom, charm and strange.

- There are 3 charged leptons: electron, muon and tau.

- The neutral leptons are: electron neutrino, muon neutrino and tau neutrino.

- The Standard Model consists of three forces with four elementary particles:

  o Electromagnetism - a photon is the elementary particle producing light and radio waves.

  o Strong force - gluon is the elementary particle that reacts with quarks and keeps them together. It is the particle that controls nuclear fission.

  o Weak force - W and Z bosons are the elementary particles that transmit the weak force. It is the force of radioactive decay.

- Last but not least is the Higgs Boson discussed earlier.

- 17 elementary particles: 6 quarks, 6 leptons, 4 force particles (photons, gluons, W &Z bosons) and Higgs.

There is this alphabet soup of particles including mesons, baryons, bosons, gluons, gravitons, W & Z bosons and how many others yet to be defined.

In summary, there is a sublime simplicity in the relationships among the essential particles and the forces that influence them. There remain puzzles. The Standard Model is incomplete in that it does not address gravity, dark matter and the mass of neutrinos.

17. THEORY OF EVERYTHING OR UNIFIED THEORY

It has long been sought and discussed that there should be a theory, a grand unifying theory (GUT), that brings together to explain all physical elements of the universe. We are NOT there yet. An issue is reconciling quantum theory (focus on the atomic level) and relativity (focus on gravitational influences). String theory and M-theory of 11 dimensions perhaps will provide the answer. As has so often been the case, mother nature has her own timetable and methods of discovery.

18. RED AND BLUE SHIFTS

The Doppler effect or shift is named after Christian Doppler who in 1842 referred to the change in frequency and pitch of sound (and light) as an emitted sound wave from a source such as a train or ambulance when it approaches a person and then passes. As the train approaches you the sound increases in pitch and as it passes you the pitch decreases. In approaching a person or object, the waves are compressed - the blue shift- as the train passes the waves are lengthened - the red shift.

That same red shift is used by astronomers to estimate the expansion speed of the universe.

In our daily lives we often see red skies in the morning and evening. Light from the sun travels further those times of the day. The sun's blue rays are scattered and the red rays can penetrate the atmosphere.

There are many other topics for you to ponder such as: worm holes, singularity, string theory, event horizon, beauty quarks, odderons (tripe glue balls), muons, cosmic waves, fifth force (https://www.livescience.com/fifth-force-could-exist.html), gravitational waves, swirlons (https://www.livescience.com/swirlonic-matter-unusual-behavor.html), matter-antimatter symmetry, gravitons and many others. Another question is whether the laws of physics as we understand them apply to anti-matter and dark holes.

19. THE EARTH'S MAGNETIC FIELD

The magnetic field is a shield against extreme radiation from the Sun. The shield disperses solar winds. The winds contain charged particles, electrons, that would destroy the ozone layer. That is significant because the ozone layer protects 'us' from harmful ultraviolet rays. Aurora Borealis (northern lights) and Aurora Australis (the southern lights) are a result of the electrons hitting the upper atmosphere as they approach the Earth's magnetic fields.

The magnetic field is created by the heat induced movement of molten iron and nickel in the Earth's outer core. The core is approximately 1,800 miles below the surface, and the magnetic field extends into the outer atmosphere.

The magnetic field is not fixed; every several thousand years the poles reverse where north becomes south and south becomes north.

CONCLUSION:

It is the author's hope that this exploration of the cosmos and the concepts examined in this article will promote a deeper understanding of science. In addition, this explanation enables teachers to have another tool that offers them ways to motivate their students to explore the cosmos, biology, physics and chemistry.

The awe the study of the cosmos engenders, explorations of human existence, and the pursuit of scientific knowledge are aspects of our education that we should cherish. Our teachers are guides who work every day to show us what we do not know already.

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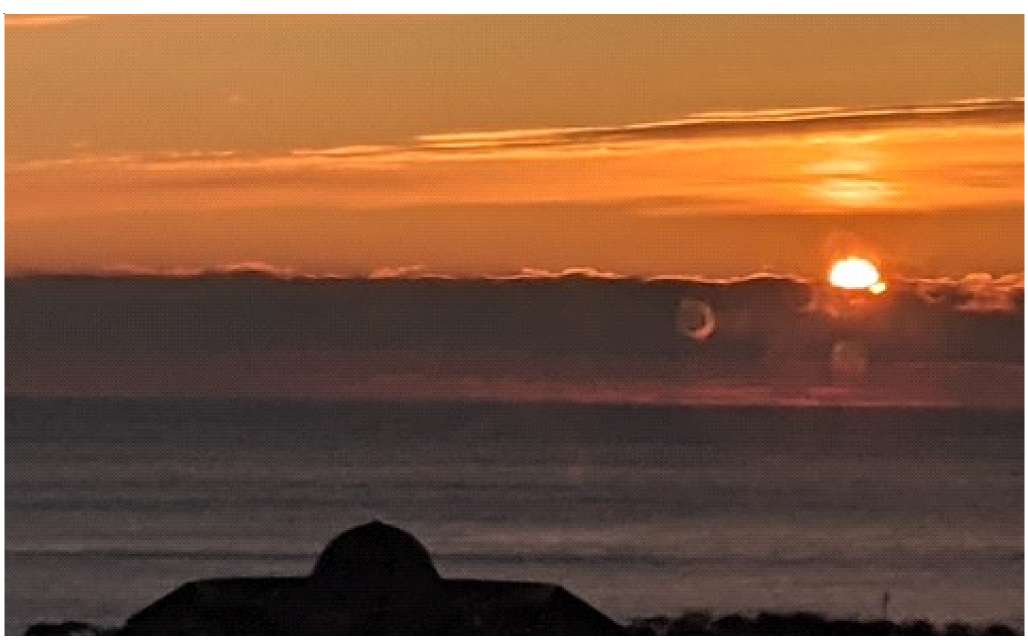

EFL 2021