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Astronomy and Your Place in the World

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by Anthony Thompson

In the Beginning

When we consider sizes and distances in space we must think in a different mode. Different from what, you may ask? Different than our normal modes of measurement. We must think "cosmically". The sheer size of the universe almost defies human logic, understanding and experience.

We live in a very thin layer of air on a very small planet. There are more stars in the sky than all the grains of sands on all the beaches of the world. We are less than a speck in our solar system, less than a grain of sand on a very big beach. Our solar system is almost invisible on the scale of our Milky Way Galaxy. And even our galaxy is only a small point of light in an enormous, expanding universe.

It's Okay, You Belong

Yet, we are here! Even though our purpose is somewhat cloudy, we belong here! The anonymous poem Desiderata found in 1692, Old Saint Paul's Church, Baltimore beckons us to:

Desiderata

> Go placidly amid the noise and haste,
> and remember what peace there may be in silence.
> As far as possible without surrender
> be on good terms with all persons.
> Speak your truth quietly and clearly,
> and listen to others, even the dull and ignorant;

they too have their story.

Avoid loud and aggressive persons,
they are vexation to the spirit.
If you compare yourself with others,
you may become vain and bitter, for always
there will be greater and lesser persons than yourself.
Enjoy your achievements as well as your plans.
Keep interested in your own career, however humble;
it is a real possession in the changing fortunes of time.
Exercise caution in your business affairs,
for the world is full of trickery.
But let this not blind you to what virtue there is;
many persons strive for high ideals,
and everywhere life is full of heroism.
Be yourself. Especially, do not feign affection.
Neither be cynical about love;
for in the face of all aridity and disenchantment
it is perennial as the grass.
Take kindly the counsel of the years,
gracefully surrendering the things of youth.
Nurture strength of spirit to shield you in sudden misfortune.
but do not distress yourself with imaginings;
many fears are born of fatigue and loneliness.
Beyond a wholesome discipline, be gentle with yourself.
You are a child of the universe,
no less than the trees and the stars;
you have a right to be here.
And whether or not it is clear to you,
no doubt the universe is unfolding as it should.
Therefore be at peace with God,
whatever you conceive Him to be,
and whatever your labors and aspirations
in the noisy confusion of life, keep peace with your soul.
With all its sham, drudgery and broken dreams,
it is still a beautiful world.
Be careful. Strive to be happy.

One of my purposes in taking on this project is to tell students not to believe in the lie! The lie that only students in certain socio-economic conditions can understand and enjoy science. In fact if students learn nothing else, let them know science is not the complicated monster it is made out to be. It is the simple pursuit of knowledge by asking simple questions and proving them (where possible) with experiments.

In all the getting, get understanding! We shall begin with an inquiring mind and a willingness to work and our goal is to end up with knowledge. The more you know and understand your position, the more comfortable you will feel and the better you will be able to cope.

Let's review the scale of sizes and distance within our solar system, galaxy and the universe as a whole. We will accomplish this by completing the following activities taken from "Teaching With Space In-service" after reviewing the following facts.

Relative Sizes and Math Exercises

Earth has a diameter of approximately 8,000 miles (12,900 km), with a circumference near 24,000 miles (38,000 km). Our Moon has a diameter of about 2,170 miles (3,475 km), with a circumference of 6,800 miles (almost 11,000 km).

Our Sun has a diameter near 870,000 miles (1,390,00 km), which is over 100 times larger than the Earth! The circumference of the Sun is more than 2,700,00 miles (4,370,000 km).

Our Solar System is about 5.5 billion miles across (near 9 billion km). If we scaled down the solar system to the size of our classrooms, about 10 meters across, the Earth is smaller than a speck of sand (about 0.000014 meters, or 0.014 millimeter!), and the Sun is about the size of a piece of sand (about 0.0015 meters, or 1.5 mm)... albeit, a large bright piece of sand.

If we consider the Solar System to be disk, looking down at a 90-degree angle from the average ecliptic, then it's a disk with a circumference of 17.3 billion miles (27.6 billion-km). When we discuss distances of this size we usually discuss them in AUs (Astronomical Units), with 1 AU = average distance between the Earth and the Sun, or 93,000,000 miles (150,000,000 km). Thus, our Solar System is 59 AU across. For greater distances, we start using light years, the distance light travels in one Earth years. With light traveling at approximately 186,300 miles per second, a light year is about 6 trillion miles! Our Solar System is 0.0009 light years across.

We are about 30, 000 light years (180,000,000,000,000,000 miles) from the center of our Milky Way galaxy. The diameter of the Milky Way (across the disk) is about 100,000 light years!

We're about 2.2 million light years from the nearest similar galaxy to ours, the Andromeda Galaxy.

>GROUP ACTIVITY - 1: On the following chart, we have provided equatorial diameters for various space bodies. In groups, calculate the approximate equatorial circumference of each body and how long it would take you to walk around that body, assuming a walking rate of 20 miles per day. Note: all measurements are in kilometers, abiding by National Education Standards for Mathematics and Science.

RELATIVE SIZES (for this exercise II = pi =3.14)

Space Body Equatorial Diameter Equatorial Circumference Walking Time (around)

(diameter = d) (c=2 II r or II d) (20 miles/day-32 km/day)

Earth 12,756 km 40,074 km 1,252 days

Moon 3,476 km km days

Sun 1,390,000 km km days

Mercury 4,850 km km days

Venus 12,033 km km days

Mars 6,754 km km days

Jupiter 141,974 km km days

Saturn 119,306 km km days

Uranus 50,506 km km days

Neptune 48,318 km km days

Pluto 2,982 km km days

>GROUP ACTIVITY - 2: Now, in groups, develop a scale picture comparing the sizes of the planets, the Sun, our Moon, and a Saturn V rocket like the type used to carry our Apollo missions to the Moon. Use the scale that one meter (1 m) = the diameter of the Sun. Complete the following table first, and then obtain a piece of butcher paper or drawing paper and draw out these scaled down images, starting with the Sun and working down.

Calculation: 1 m/1,390,00 km = x in meters/diameter x in meters = diameter / 1,390,00 km

SCALE DIAGRAM

Space Body Actual Equatorial Diameter Scale Diameter

Sun 1,390,000 km 1 m or 100 cm

Mercury 4,850 km m or cm

Venus 12,033 km m or cm

Earth 12,756 km m or cm

Moon 3,476 km m or cm

Mars 6,754 km m or cm

Jupiter 141,974 km m or cm

Saturn 119,306 km m or cm

Uranus 50,506 km m or cm

Neptune 48,318 km m or cm

Pluto 2,982 km m or cm

Saturn V Rocket 0.11 km (length) m or cm

The following table provides distances and travel times from Earth (not from the Sun) and has obvious uses in mathematics classes as well as science classes.

RELATIVE DISTANCES: Travel Distance & Time From Earth

Destination Distance Jet Rocket Light/Laser/Radio

Moon 250,000 miles 16.5 days 9.4 hours 1.2 seconds

Sun 93,000,000 miles 17.7 yrs 4 months 8.5 minutes

Mercury 57,000,000 miles 10.8 yrs 3 months 5 minutes

Venus 26,000,000 miles 5.4 yrs 1.5 months 2.5 minutes

Mars 49,000,000 miles 8.8 yrs 2.5 months 4 minutes

Jupiter 90,000,000 miles 74.25 yrs 1.75 yrs 35 minutes

Saturn 794,000,000 miles 150.4 yrs 3.6 yrs 1.2 hours

Uranus 1.7 billion miles 318.5 yrs 7.6 yrs 2.5 hours

Neptune 2.7 billion miles 513.2 yrs 12.25 yrs 4 hours

Pluto 3.6 billion miles 690.1 yrs 16.4 yrs 5.4 hours

Alpha Centauri 25.2 trillion miles 4.8 million yrs 114,155.2 yrs 4.2 yrs

(Nearest star after our Sun)

Sirius 50.4 trillion miles 9.6 million yrs 228,310.4 yrs 8.4 yrs

The Pie Method

Using the relative distance table students should be able to answer what types or variables of information are given in the table. The answer is two, distance and time. This can be expressed as a rate if we place distance over time, for example 60mi/hr. In my classes, I seldom use anything more complicated than a rate formula such as velocity = distance/time. Once a student realizes the proper units for each variable complicated word and formula problems can be simplified by use of what I call the pie method. Draw a circle and cut it into three parts, on the top and two on the bottom like so

Plug the equation into the pie exactly as it is given to you. If a variable is on top, division, put it on top. If it is next to each other, multiplication, put it in likewise. Ask students to devise a way to never plug it in wrong! The trick is to always plug the side with two variables in the first and then place the third variable in the remaining spot. Now that all the slots are filled, cover what you are looking for and solve the equation. For example, using the pie method to find the speed of a jet to Mercury, the first thing we would do is put the speed or velocity equation (velocity = distance)

Time

In to the pie diagram. Using the hint given earlier, I would then plug in distance first, since they

time

are on the side with two variables. Your pie should now look like this.

In the remaining space, plug in velocity.

Earlier, you were asked to cover what you are looking for. If we were to cover velocity, the resulting equation would be velocity = distance.

time

Using our distance/time table for Mercury in a jet form Earth, the result would be

velocity = distance or 5,700,000 miles or 5,277,777.8 miles

Time 10.8 yrs year I will ask students to use the pie method to find the speed or velocity for the moon, Sun, and Mercury for a jet, rocket, and different forms of light from the previous table of distance and time travel from earth.

It should be demonstrated, the faster the velocity, the less time it would take to travel! This statement seems intuitive, but most students don't take the time to process this fact. Have students ponder what would happen to time if an object traveled at the speed of light.

Partial List Formulas that can be Applied to the Pie Method

Area = Length x Width

Pressure = Force

Area

Density = Mass

Volume

% Rate = Base x Portion

Weight = Gravity x Mass

Force = Mass x Acceleration

Mechanical Advantage = Resistance Force

Effort Force

Voltage = Amperage x Resistance

Work = Force x Distance

Power = Work

Time

Potential Energy = Weight x Height

E = mc^2

Acceleration = Change in Speed

Time

Wave Speed = Frequency x Wave Length

Storytelling Using the Powers of Ten

As we discuss distances and properties of the planets the need for a concise and simplified way of handling very large and very small numbers becomes evident. Scientific notation and operation of numbers to a power are one method to achieve this.

One of my favorite ways to teach numbers to a power is to arrange the students in a group of three or four and "make believe" or create a story and present it to the class using the picture as a focal piece. Some restriction on vulgarity and language must be emphasized as imaginations do tend to run wild. If students buy into the process, it can be used as a tool to help them write. After each group has presented their fanciful tale, inform the students that all of these pictures are of the same subject at different perspectives (Heights!) When Archimedes could not solve the dilemma of the composition of the gold crown, he changed his perspective to achieve a rather revealing result. But that is another story for another day.

I have enclosed some sample pictures from the book *The Powers of Ten* . It shows the range dimensions from the micron of cells to the vastness of outer space. This difference is accomplished by the movement of a decimal point. For every space the decimal point is moved to the left, the exponent is increased by +1. For every space the decimal point is moved to the right, it is decreased by - 1. We use this information when we put numbers into scientific notation. Scientific notation is a form in which the decimal of a number is moved until there in one number to the left of the decimal point and the exponent is established by the rules above. For example, .00004 microns - 4x10^-5 microns and 800,000km = 8x10^5km. By placing numbers to a power into scientific notation a comparison or order can be established.

Rules to Operate a Number to the Power of Ten

Where does the author of *The Powers of Ten* get this title? A powerful way of using our ten fingers or toes to do Math. Here are the rules for addition, subtraction, multiplication, and division. Before we do our four math functions it is important to realize 8x10^5 = 8 8 x 10 10 x 10 x 10 x 10 and 4 x 10^-4 = 4.

10x10x10x10

Addition & Subtraction - If exponents are the same then add or subtract and keep the exponent. If the exponents are not the same, change them by moving the decimal point so that they are now the same, then add or subtract and keep the exponent.

For example,

5x10^3km + 65x10^3km = 70x10^3km

7x10^20km - 30x10^19km = 7x10^20km - 3x10^20km = 4x10^20km

Multiplication - Multiply the non-exponent portion of the number and add the exponent.

Example: (40x10^17km)(2x10^4km) = 80x10^21km

Division - Divide the non- exponent portion of the number and subtract the exponent

Example: 40x10^16km = 20x10^12

2x10^4km

I have enclosed a practice sheet to reinforce the concept of numbers to a power.

Contributions of Einstein

Albert Einstein once stated, "Do not worry about your difficulties with mathematics; I can assure you mine are greater".

Albert Einstein's was a patent clerk for Switzerland. He had wanted to be a physics professor but could not find a job. He alienated his professors and they would not give him a recommendation. As a patent clerk, he applied all of his knowledge of science to new inventions. He would sit down with a stack of documents and determine if the object violated central ideas of physics. Is the basic principle new or was it known? Einstein threw his self into the problem and stripped away all of its complications.

This same tenacity led him to question everyday events and fundamental laws that we take for granted. For example, we assume a mile is a mile everywhere. If there was a race, we assume the person who finished in four minutes was faster than the one who finished in five. Einstein questioned everything. He stated if we were able to catch up with light, it would not be light. In a series of thought experiments, which took place in his mind, he stated that if you were in a train that moves 186,000 mi/sec and it caught up to the light on the train, the person outside the train would measure distance short and time outside the train, slow. In the television series "Lost In Space", as the Robinsons traveled around the galaxy for a year when they returned, everyone they knew would have been dead for a thousand years. Time and distance are relative, E=mc^2. This is only applicable when the speed of an object nears the speed of light.

In another thought experiment, he imagined an elevator in a deep well with no window to connect you to the outside world. If the elevator accelerated uniformly, you could not tell if you were moving or not. He concludes acceleration and gravity are the same in curved space. An application of this is the Sun curves the space of planets orbiting it such as the Earth. Space and time are the same. This must be taken into consideration as you calculate the velocity from the table of Distance and Time.

Nothing is as it seems on a small scale either. Rutherford & Bohr postulates an atom is made up of mostly empty space. Therefore, the principle behind Honey I Shrunk The Kids, is true (in theory anyway). When we sit in a chair we don't actually sit on it. Your matter actually hovers angstroms above the chair. Why don't our hands pass through another when we clap? A field of charges (similar to the Robinson force field) prevents it. Nothing is as it seems!! Scientists discovered uncertainty is a principle in which the very nature of matter is written.

Applications of the Theory of Relativity

Everything in the universe emits radiation. A telescope can pick us its signal. In 1967, Jocelyn Bell operated a radio telescope outside Cambridge, England. She noticed a strange blip on the chart paper used to record what the telescope observed. An advisor told her the signal was interesting but probably man made. She returned to her chart and calculated when she should see it again. She discovered it was a string of pulse 1.3 seconds apart. This had never been seen before. Heavenly bodies don't pulse on and off that fast. She thought for a second it might have been little green men sending a signal. She found a second signal on the opposite side of the sky. This eliminated the little green men theory and heated up debate in the astro-physics community. It turns out that she was the first to discover the previously untested theory of what happens when a star dies. When a large enough star runs out of fuel, it will collapse and crush the atoms within it. What is left is a neutron star, every available space is squeezed out. If matter that makes up the sun, would squeeze down to a section of New Haven, a spoonful would weigh 2x10^11 lbs. Neutron stars can rotate 700 times per second while they blast powerful radio waves outward. It is this signal that Jocelyn Bell picked up with her telescope. Theory had predicted the existence of neutrons stars but most scientists thought they were too weird to be real. The universe is strange and more fantastic than we can begin to realize.

The reality of a neutron star also begs the question is a black hole possible? Carl Swartzchild was fighting on the Russian Front in WWI when Einstein's theory of relativity was published. He noticed that Einstein equations allowed for the possibility of a star so dense even light could not escape it. He made some calculation of his own and mailed them to Einstein. Unfortunately, a week after receiving Einstein's reply, Swartzchild died in battle. Though Einstein marveled at his work, he did not accept it, stating, "...It just doesn't smell right". Yet the same theories that allow for neutron stars allow for black holes. It is just a matter of taking it a step further to over shooting. Sometimes the collapse of neutron stars is so powerful that it over shoots and becomes a black hole. Professor Walter Lewin of MIT, states, "if you take the earth and squeeze it in a large vice to 3cm, it would become a black hole!"

Finding something that does not give off radiation is difficult. In the 1970s, there is indirect evidence found by Paul Merten and Louise Webster of a black hole. In the constellation Cygnus, they saw a super giant star circling something they could not see. They supposed that it must be circling a small, denser star because its gravity was sucking huge amounts of matter from its large neighbor. The only explanation is a black hole.

Big Bang or Steady State

How did the universe begin? Most scientists believe that at one point, all matter was together if we could go back far enough in time. It had infinite density. At some point, it exploded, sending matter throughout the universe as we see it today. This belief is called the Big Bang Theory.

Why should this theory be accepted? Were there others? Not everyone believes in the Big Bang Theory. Some believe in a universe that has not changed since the creation of time-the Steady State Theory.

In 1960 Robert Dicke proposed a way to settle this argument. He stated that if the universe was created with a big bang, it should be filled with radiation. He believed this because it had to be very dense and hot and there was no way to get rid of the radiation. This heat is converted to radio static.

Robert Wilson and Arnold Penzias worked on a seemingly unrelated problem 30 miles away. They wanted to study our galaxy and make a contribution to astronomy. Although he believed in the Steady State Theory, he neither set out to prove or disprove either theory. The radio telescope they used was specifically set up to exclude all non-specific signals. Yet every time and in every direction he pointed his radio telescope, all he picked up was radiation, in agreement with Robert Dicke's theory. It should be noted that Einstein equations show that the universe is expanding. Einstein did not believe his own equations, as he did in the previously mentioned Swartzchild application of the theory of relativity. He inserted a constant in the equation to reflect a steady state universe. He latter called this the biggest blunder he ever made!

In the beginning, some 15 billion years ago, the universe exploded from a single point. Less than 1 minute later, it was a million billion miles across. Though it was cooling rapidly, it had an average temperature of a billion degrees. Over time, the universe continues to cool. Gravity formed clumps of atoms to form stars, (time lapsed: a billion yrs). Eventually planets formed and on the third planet from our Sun, life began.

Science. Non-science and the Scientific Method

As fantastic as the reality of science is, some things can not be tested by the scientific method. I learned in this astronomy course that the scientific method is used to disprove a result based on laws and experiments, rather than proving it. Albert Einstein states, "What hopes and fears does the scientific method imply for mankind? I do not think that this is the right way to put that question. Whatever this tool in the hand of man will produce depend entirely on the nature of the goals lived in this mankind. Once these goals exist, the scientific method furnishes means to realize them. Yet it cannot furnish the very goals. The scientific method itself would not have led anywhere, it would not even have been born without a passionate striving for clear understanding".

Astrology is a practice followed by many on a daily basis. Based on constellations, many would take risks where, usually, they would not. This would no more withstand the scrutiny of science than a fortune cookie reading. Yet certain predicted events may come true.

In 1910, Haley's comet returned to Earth. In this return of the comet, the Earth was said to pass perilously close to the tail. French astronomer Erin Delant warned of disastrous weather. Comets were always linked with catastrophes such as the fall of kings and kingdoms. Sure enough, just before the arrival of the comet, Paris experienced the worst flooding in thirty years. Delant's colleagues predicted an even direr situation. He postulated the comet's tail contains enough nitrous oxide, (laughing gas) to produce extreme joy, then widespread madness and death.

In the end its up to science to determine fiction from fact. Scientists analyzed the photographic and spectrographic data of the tail of the comet and determined it was to diffuse to have any effect on the Earth.

Telescopes

One of the questions asked in this astronomy course was "What type of experiment do astronomers perform?" None, was the answer. An astronomer's lab is his observatory. Astronomy is an observing science. Sight is the primary sense used in this science. The instrument that enhances this endeavor is the telescope.

Dutch optician Hans Lippershay invented the first telescope. Before this time, even as far back as the 1200's scientists experimented with magnifying lenses. After all his efforts, unfortunately, Lippershay was not granted a patent on his invention. (Obviously the patent clerk was not Einstein.)

In 1906, Italian scientist, Galileo, after hearing of Lippershey's invention, made a crude telescope. His telescope could only magnify objects thirty times and only had a small field of view. Although the principle of his telescope is only applied to opera glasses today, he is credited as the first human to see the rings of Saturn, four of Jupiter's moons, and the mountains and craters of Earth's moon.

Types of Telescopes

Radio Telescope

Although a radio telescope is used less

Frequently than an optical telescope, it can

be used in any type of weather. It can also

tune in on stars that give off no light at all.

Types of Telescopes

Exercise: How to Make a Simple Telescope

The number of times an object is magnified can be calculated by knowing the focal length of the objective, light rays are bent until they come to the focal length. The distance between the center of the lens and the focal point is the focal length. The magnification (cm) of a telescope can be found by dividing the focal length of the focal objective (fl) by the focal length (f2) of the eye piece or m = fl

f2

Using the above diagram, I will have the students calculate the magnification of the telescopes they have made.

Some Great Accomplishments of Astronomers

For centuries since antiquity, the night sky has been the greatest show on Earth. Part of its allure is its mystery.

Many men and women have worked to reveal the mysteries of the heavens. Their pursuits did not dim the beauty of the midnight sky, but only deepen our appreciation for it. This is not unlike removing the veil of and incredibly beautiful woman. My words do not do the process justice.

George Hale set out in 1919 to build the world's biggest telescope. It was to be twice as big as any that had existed at that time.

He was ahead of his time in vision and in terms of technology available. His enthusiasm overshadowed the fact that no one was able to pour that much glass at one time. There were no roads on the proposed mountain site. Some pieces of equipment were so big that they had to be shipped by boat. The glass they poured for the mirror cracked twice. Rather than replacing the glass, he had it ground and polished. This process of removing the cracks from the glass took four years.

He was beset by so many problems, he stated little green men visited him and gave him advice. On November 2, 1917, his trials, tribulations (and the advice of the little green men) paid off and the observatory opened to prove the worth of his efforts. It's 9,000 ton mirror could detect a candle 5,000 miles away. It would be the dream of astronomers (of that time) to spend a night on Mt. Wilson. Astronomers stated that the dome opened like thunder and it would be you and God alone, to enjoy the night sky. The air was described as crisp and sometimes so cold it would freeze a teardrop. Though the temperatures were brisk, he would not allow coffee nor women in the observatory. He must have though both were poisonous to the system. He stated that wives were a distraction to their monk-like scholarly pursuits.

Ironically, without the discovery of a woman Henrieta Leavitt, we would not be able to calculate the distance of the most far off stars. If a star is close, then parallax can be used to ascertain the distance. However, if a star is more than 10 parsecs, the Leavitt method must be employed. This was the first great discovery using a 100-inch telescope. Women were hired to do the menial tasks at the Harvard College Observatory. She noticed a pattern in a class of stars called Cepheids and realized the time it took to reach their maximum brightness can be used to judge their distance. It is a measure by which out stars distances are judge and without it astronomers would be clueless. She discovered four novae and more than 2,400 variable stars.

Henrietta Leavitt's discovery was of particular use to Edwin Hubble. Hubble was a star athlete and won a Rhode Scholarship to study law at Oxford. Upon his return to the U.S., he decided to study astronomy rather than law. Hubble attempted to put away his Missouri roots and become the quintessential English Scholar. Because, he was an excellent astronomer, and had the propensity to ask the right questions, he became a respected member of the Mt. Wilson Team. Hubble wanted to unlock the secret of the nebulae, faint smears of light that have puzzled astronomers for a thousand years. Their true nature eluded him for four years, even with Hales' 100 in telescope. In October of 1923, he took a forty-minute plate and developed it. He thought he saw a "nova" - stars that brighten unexpectedly. The next night, he took a deeper photographic plate. This plate had what he thought were three novae. When he began to compare the plates, he discovered that one of the three novae was not a nova at all. He discovered that it was a Cepheid and it was a Eureka moment. Thanks to Leavitt's discovery about Cepheids, he realized that this star and the system that it is part of must be larger than any he had dreamed. We now know that there are billions of galaxies, each containing billions of stars. He discovered that Andromeda was not a part of our galaxy. It is about 2 million light years away. Andromeda galaxy and others are big systems equaled to or surpassing the Milky Way.

Like Newton before him, this discovery alone would have assured his place in halls of science. Not satisfied to rest with his prior accomplishments, he makes an even greater discovery, the ratio between the distance of a galaxy and its speed. For five years he gathered information on galaxies, speed and direction. If a galaxy is moving away the wavelengths of its light are stretched and its frequency is decreased. Its light appears to redden. The faster it moves, the redder the light. If a galaxy is moving towards the earth, the frequency of its light is increased and it appears bluer. He then plotted the nebula's motion again the distance and found a straight line! This means a galaxy's distance is proportional to its velocity. If a galaxy is twice the distance from another, it is moving twice as fast.

This also means that the universe is expanding. In the entire history of man, the universe had been seen as a fixed quantity. Hubble's discovery drastically shifted the way the universe was viewed. If you have an expanding universe it means that it may have had a beginning and that it also may have an end.

Star Classification

Stars to the human eye appear to crowd the midnight sky, but in terms of population density, they are less dense than the population of the most desolate regions of the earth, for example, the Antarctic or the Great Sahara plains. Neil McAleer makes the comparison, if our Sun were represented by a basketball in New York City, then on the same scale the solar system, would have a diameter of about 2 miles and the next star would be a basketball 5,000 miles away, in Hawaii.

The next star to our Sun is Alpha Centauri, 4.3 light years away. A light year is defined as the distance it takes light to travel in one year at a speed of 186,000 miles/hr or 3x10 m/s. It would take an Apollo spacecraft 850,00 years to reach Alpha Centauri.

It is because of these great distances between stars that light from all the stars equals about 1/15 the light of the full moon or 1/6,000,000 the light of the sun. It would be equal to shining a 100-watt bulb about 614 ft away, which are approximately two football fields away.

A star's lifetime is determined by its mass, which is determined by the size and dynamics of the parent gas cloud from which it was made. In the animal kingdom sometimes the larger the animal, the longer the lifetime. McAleer states the opposite is true in the celestial kingdom. Massive stars burn out quickly and have short lifetimes, while less massive stars live the longest.

Stars lifetime's range from one million or 1x10 years for the most massive stars to 100 billion years or 100x10 years for the least massive stars. Comparing these stars lifetimes is like comparing a single afternoon to the lifetime of seventy two-year-old humans. (average life span)

If I state (as I have previously) that the number of stars far outnumber the grains of sand on all the beaches in the world, or one of the other billions of references when it comes to stars, who would be mad enough to try to categorize them? Astronomers Meg Nad Saha and Russell.

Probably the largest amount of information that is attainable for a single star is obtained from it's spectrum. Spectra secured with a slit spectrograph can reveal whether the star is a member of a close binary system, if it is a highly luminous supergiant, a moderately bright giant or a dwarf star likes the sun. The main purpose of spectrograms is to determine the chemical composition of a star. They will also tell if the star is in a rapid rotation and if it has a strong magnetic field.

The multitude of stars falls in a small number of spectral classes ranging from hottest to coolest. In 1920 Saha arranged the categories O, B, A, F, G, K, M. R and N stars (sometimes referred to as the carbon or C stars) and the S stars supplement this group.

I learned a rather humorous pneumonic to remember the order as stated above. Oh Be A Fine Girl Kiss Me Right Now, Smack!

The O-M spectral sequence represents a group of stars of the same chemical composition but different temperatures and pressure. The R, N and S stars are different from others in chemical composition and are giant or super giants.

O and B are the bluest and the hottest. The M, R, N and S stars are the reddest and coolest.

In 1913 Henry N. Russell was the first to plot the absolute magnitude vs. the spectral types. He latter collaborated with Eignar Hertzberg to develop Russell - Hertzberg diagram which relates the brightness of stars to it's temperature. Russell found that the stars do not randomly fall on the graph, but tend to congregate in restricted domains.

Most of the congregational stars are dwarfs belonging to what is called the main sequence. They range from hot blue objects 10,000 or more times brighter than the Sun, down through the A stars such as Procyon, through the sun down to K stars and finally to the faint red dwarfs thousands of times fainter than the Sun.

Extensive astronomical research has been based on this diagram.

OUR STAR

Stars are self-luminous objects shining from energy sources within themselves. By contrast planets shine by reflected light.

By all measure our star, the sun, is a typical star. It has a mass more than 3x10 times that of the earth, 1.99x10 kg, a radius of 696,000 km (about 432,200 mi.) and a power output of

3.8x10 x 10 erg. For comparison purposes, these quantities masses, radius and luminosity are usually

sec

expressed in terms of the Sun.

One of the best known facts about our Sun is its distance, 93 million miles. This is called an (au) astronomical unit. I will have students use the pie method to compare the length of time to arrive at the sun from earth traveling at a speed of a) A plane traveling at 500 mph b) A car traveling at 55 mph c) Walking at a speed of 5 mph.

Some of the lesser known facts are the following: Sunlight has weight! If a square mile of sunlight could be held in your hand it would weigh 3 lbs. All the sunlight falling on the Earth's surface weighs about 87,700 tons. Although this weight is equivalent to the weight of an ocean liner, it is negligible when compared to the Earth's weight.

98.98% of all energy passing through the atmosphere originates in the Sun's core. The light from a chunk of burning coal is really sunlight. Leaves on ancient trees collected sunlight. The ancient trees over time became coal. It is the combustion of coal that liberates the hibernating heat.

The sun is made up approximately 78.4% hydrogen, 19.8% helium and 2% heavy metal such as nickel and iron.

The temperature of the sun at the core is 29x10 Fahrenheit. Under the right pressure the basic fusion reaction is 4 hydrogen atoms fusing into 1 helium atom, and releasing energy (E= m c^2)

Because of tremendous temperature and pressures on the Sun no one from earth could visit it. If an imaginary journey could take place, to leave the Sun, because of it's great mass, an escape velocity of 1.4x10 mph would have to be reached!

MERCURY

Mercury is the planet closest to the sun and has the greatest velocity on average 107,00 mph. This speed was found by taking the perihelion speed of 127,000 mph and it's apogee speed of 87,000 mph.

The fact that surprises most people is that Mercury is not the hottest planet. Mercury rotates once every 58.65 days. That is two thirds of the orbital period. So it would be logical to say a year on Mercury is three days long. (each of those days would correlate to 58.65 earth day lengths.). This is because Mercury lost it's atmosphere billions of years ago. Because there is no atmosphere to contain heat, it is lost to outer space. Only a thin envelope of helium remains. The surface of Mercury resembles the moon so closely that some times even experts are fooled.

Unfortunately the Sun will become a red giant, five billion years from now, Mercury will be engulfed by the Sun's expanding outer layer, so will Venus and Earth.

VENUS

Venus is brighter than any other planet or star except the Sun. As viewed from earth, Venus like Mercury and the moon goes through phases. When we see it completely round, it is at full phase. When it is in it's crescent phase, it is at it's closest point to the earth 25x10 miles. When it is in it's full phase it is 160x10 miles away from the earth. Therefore, because of it's increased distance it appears to be 1/6 of it's crescent view.

Venus rotates once every 243 earth days. It's revolution is 225 earth days. This means that a day is longer than a year on Venus! The rotation also in the reverse direction of earth! Which means the Sun rises in the west and sets in the east on Venus.

The real weather on Venus begins in it's cloud layers about 20 miles high. In comparison that's like having weather in our stratospheres where no clouds or weather exists at all.

Venus is the hottest planet. It's atmosphere is 96% carbon dioxide, a greenhouse house gas which holds in heat. A fact that may explain why Venus water, thought to be originally to be equal to that of the earth, boiled off.

EARTH

Students will be asked of their knowledge in this third planet from The Sun Quiz.

Life as we know it is carbon based, Why? you may ask: Carbon has an affinity for hydrogen and oxygen. This planet has the ideal temperature and pressure range for water, an apparently essential molecule for life. In this solar system no other planet has it.

If we wanted to leave the planet earth to explore other planets we would have to escape the pull of gravity and travel at a speed called escape velocity. Gravity is the weakest of the four forces, yet it is ubiquitous and the most far reaching.

Galileo proved at the Tower of Pisa, that air resistance did not affect two objects dropped from the same height at the same time. They would hit the ground at the same time, regardless of their mass. Newton went a step further by comparing two identical objects one dropped and one thrown horizontally from the same height at the same time. They both hit the ground at the same time. The object that was thrown was further away. The curvature of the Earth is stated as a downward curve of 5m for every 8-km. If a super human were able to throw an object into orbit how fast would it have to travel? The answer may be difficult to arrive because of the square root and metric conversions. It is 17,500 mph. It is the escape velocity for earth.

The formula for Escape Velocity is Ve = 2GM

R

Where G is the gravitational constant, m is the mass of the Earth, and r the radius of the Earth.

I have included a rocket launch lab from the U.S. Space Foundation. One might also find the lab making a theodolite, helpful for ascertaining altitude. The task of making a rocket should take about a week and half in a fifty-minute class. After the rocket is finished and properly decaled, special care should be taken to make sure each student has a turn at the delegated positions, such as, launch master, rocket retriever, and official measure. The Theodolite is used to find the angle the rocket traveled. By measuring the distance from the launch site to the observer, the altitude of the rocket can be determined by multiplying the tangent of the angle by the observer/launch site distance.

MARS

Even though Mars is much smaller than Earth, because it has no bodies of water, its land area is 56 million square miles, almost equal to equal to Earth's, 57.5 million square miles. Mars's highest peak, is also the largest known volcano in the solar system, 79,000 ft, compared to Earth's Mt. Everest at 29,020 ft.

Because of its orbit, a year on Mars takes 66.9 Earth days. A day on Mars, is 24 hours, 37 minutes, it is almost the same as Earth's, 24 hours.

The temperature on Mars is just too cold for creatures of the Earth. Temperature range from -128° F in the summer to -220° F in the winter.

Mars has an atmosphere that is 95% carbon dioxide, 2.7% nitrogen and 1.6% argon. Although, as we mentioned previously, it is extremely cold, an astronaut stepping out without protection would suffocate even faster than they would freeze.

Mars has two tiny moons. Phobos orbits only 3,718 miles above Mars. Astronomers predict in about 100 million years, the effect of gravity will plunge it to Mars's surface. Deimos gravity is so weak, if a person was able to run 7 miles/hour along it's surface, they would reach Escape Velocity and could lift into space.

JUPITER

Jupiter is know as the giant and contains 71% of the total mass of all the planets.

The great red spot of Jupiter is an area of a cyclic storm that has been raging for at least 300 years. It has an area three times the diameter of the Earth. This is the largest storm system in the solar system.

As previously mentioned, Galileo discovered Jupiter's four moon. Jupiter is a gaseous sphere with no solid surfaces. It has a composition of 89% hydrogen and 11% helium. It has a density of 1.3. The rapid rotation of Jupiter helps maintain an almost constant temperature of -216° F.

SATURN

Saturn, like Jupiter, is composed mostly of hydrogen and helium. However, deep into its core is a composition of iron. It is estimated to be twice the size of Earth. However, Saturn has the lowest density of any planet in our solar system! (0.69)

Like Jupiter, Saturn has an internal source of energy and generates twice as much energy as it receives from the Sun.

Saturn revolves around the sun once every 29.5 Earth years. In an average life of a human on Earth, Saturn would revolve 2.4 times.

Saturn is often called the ringed planet. The rings are composed of water and ice, and come in all sizes, from dust specks to boulder size chunks. There are up to one thousand ringlets extending some 47,500 miles into space. Saturn is among the most beautiful of the nine planets.

Saturn has some fifteen moons and boast of the second largest moon behind Jupiter's Ganymede.

URANUS

Uranus is often called the emerald planet of our solar system. It is called this because its atmosphere contains hydrogen and helium, like the two previously mentioned planets, but it also contains about.4% methane. Since methane strongly absorbs red light, the reflected light from the planet is mostly blue, green, and yellow light. The result is that Uranus appears green.

In 1977 at least nine rings were discovered around Uranus. They were all very thin and similar to the single rings around Jupiter. The rings are composed of dark material which reflects less light than a blackboard.

At 21 years in length, Uranus, has the longest known winter in the solar system. The harsh winter temperature is -363° F. The 23.5° tilt that gives us our four seasons, is 98° on Uranus, thereby giving Uranus the dubious title longest winter/summer in the solar system. Uranus has five known moons.

NEPTUNE

Neptune not Pluto is the most distant planet for 20 years of its' orbit. This twenty year period happens once every 248 years. Then its' orbit swings closer to the Sun and Pluto takes the title.

One year (one revolution) on Pluto takes 164.8 Earth years.

Neptune has two moons. Both moons have unusual motion, which aren't quite understood. Triton the larger of the two moons orbits backwards once every 5 days, 21 hours. It is the only large moon in the solar system to do so. Nereid's unusual orbit is said to be more like a comet than a moon. It is postulated this motion may allow Nereid to escape and wander the solar system.

PLUTO

Pluto, which is named for the god of the underworld, is 3.7 billion miles away from the Sun. Many astronomers think Pluto should be labeled as an asteroid rather than a planet. One of the reasons for the bust in rant is its' orbit. All planets circle the Sun in about the same plane, Pluto disobeys this rule a difference of 17 degrees of other orbiting planets. This highly elliptical odd orbit takes it as far as 4,582 billion miles from the Sun and as close as 2,750 billion miles to it.

The greatest distance between two planets in our solar system is the distance between Neptune and Pluto. At their maximum separation the distance is 7,404 billion miles!

A day on Pluto is equal to 6 days, 9 hours and 16 minutes on Earth. This is almost one week. One year on Pluto equals 247.7 Earth years.

When the ratio of moon to planet is considered, the Charon (Pluto's moon)/ Pluto's ratio is the largest. Pluto diameter at 1,800 miles is the smallest for a planet in the solar system.

Reinforcement of Numbers to a Power

1.) Why do we use numbers to a power?

2.) What is the rule to put a number into scientific notation?

3.) Change the following into scientific notation:

93,000,000 mi. = .00003 cm =

4.) State the rule for addition/subtraction of a number to a power -

5.) Add or subtract the following:

3 x 10^7m + 17 x 10^6m =

5 x 10^6au - 30 x 10^5au =

6.) State the rules for multiplication of a number to a power -

7.) Multiply the following:

(40 x 10^2m) x (7 x 10^3m) =

(30 x 10^18m) x (2 x 10-5m) =

8.) State the rule for division of a number to a power -

9.)Divide the following:

(40 x 10^5m) x (3 x 10^2N) =

(5 x 10^2 sec)

Making a Theodolite

Purpose - To make a device which will measure angles, and aid in calculating altitude.

Materials

Tube from paper towels, thread, report holder, thin cardboard, protractor and glue.

1. Cut tube to the length of the protractor
2. On one end of the tube insert a ring ¼ down
3. Glue the report holder on the tube to determine the center
4. On the opposite end of the ring place two holes on each side of the holder
5. String thread to make X at the center of the tube
6. Photo copy protractor and glue on to cardboard and cut to form
7. Slide the cardboard into holder. Tie a string on to washer and hand underneath the holder above the zero angle mark.

Overview of Astronomy and Your Place in the World.

I began my examination with a poem to let students who have problems with science and life problems know "it's okay", you belong.

The equatorial distances were given as an exercise to give students a sense of size and how long it would take to walk these distances.

Students are then asked to make a scale drawing of the planets based on the Sun as 1.

I then ask students to find velocity using a method that does not require algebra. I call this method pie. I made a list of some other equations that could be used with this pie method.

The scientific method and the rules to add, subtract, multiply and divide a number to the power of ten were reviewed. A method of having students make up a story using some of the same subjects at different heights and reinforcement sheet was included.

A short paragraph was dedicated to the contributions of Einstein and his theories including relativity.

An equally brief paragraph was made on the application of Einstein's theory to neutron stars and black holes.

In science not nonsense, I attempted to state the purpose of the scientific method.

Section on telescope and satellites were included with a short section on how to make a telescope and how to find the magnification of a telescope.

In the section some accomplishments of Astronomers. I list a few achievements that they have made that help us see the universe differently.

I then introduce giants whose methods help us classify the stars.

I ended my examination with an overview of our solar system. Included in this overview is a rocket lab, a how to make a theodolite and an Earth quiz.

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