Nov. 1, 2001
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Man and His Universe

Man and His Universe: is the title of a book by John Langdon-Davis published in 1930. In this book Langdon-Davis examines man's search for an understanding of the universe in which he lives and how this understanding has evolved. Richard Brasher's recent paper on the special nature of our earth reminded me of this book which I first read in the 1970's. At that time I was amazed at how much change had taken place in the 40 plus years since that book had been written.

Throughout the recorded history of Western Civilization, man has sought to understand who he was, how he came into being and who or what was responsible. He has asked similar questions about the earth, the sun, the moon and the stars. This search for understanding has, from the beginning, taken two paths: science and religion. At times, it has seemed that these two paths were in conflict with each other. Science, by its nature, can be revolutionary while religion tends to be conservative. This has led to the periods of conflict, but with time, the religious view adjusts to incorporate the new scientific view, and the scientific view always includes other beliefs contributed by religion.

I would like to look at the scientific search for an understanding of the universe. Pure science or what today is called theoretical science is, as Langdon-Davis says, "poetry carefully concealed from the knowledge of most people." "And yet the truth is that the urge which makes a man give himself to science is precisely the same as that which produces the poet or the composer. A passion for beauty and a desire to enjoy aesthetic pleasure." Johannes Kepler expressed this aspect of science when speaking of his discovery of the laws of planetary motion. He wrote: "The intense pleasure I have received from this discovery can never be told in words. I regretted no more the time wasted; I tired of no labor; I shunned no toil of reckoning day and nights spent in calculations, until I could see whether my hypotheses would agree with the orbits of Copernicus or whether my joy was to vanish in air." Most of us who work in the field of science are not composers of new theory but we do find immense satisfaction in the works of others.

Before looking at the development of man's view of the universe, I need to say a few things about the development of scientific theory. A viable scientific theory must preserve the phenomena. That is, it must explain observable facts. It also must withstand the testing of new phenomena deduced from its application. Also, the laws of a given theory will always include over-beliefs even though they may not be stated. By over-beliefs, I mean beliefs not needed to explain the phenomena but are beliefs contributed by our culture or our religion.

One of the earliest theories of the universe was that of Thales of Miletus. He was born of Phoenician parents about 640 B.C. and was educated in Egypt and the Near East. He was the personification of the academic. As founder of the school of natural philosophy (physics), he was interested in almost every thing. He investigated areas of history, science, mathematics, engineering, geography and politics. He is credited with proving many of the theorems we find in Euclidian (plane) geometry.

The earth in Thales universe was a flat disc surrounded by water. A hemispherical dome covered the earth and the water around it. The exterior of the dome was also surrounded by water. Thus, his universe was a hemispherical bubble in a vast sea. For Thales, water was the first principle of all things. Water was the most important and the most primitive of, what he believed to be the three forms of matter: liquid, gas, solid, and all things could be derived from water. To Thales all matter had vital power (a soul). Matter might change form but it's soul never died. He was once asked: "If it makes no difference, why did you choose life rather than death?" His reply: "Because it makes no difference."

Anaximander, a student of Thales, expanded on the Thales' theory by assuming the earth was a cylinder freely suspended and held in place by being equidistant from all things. The sun, moon, planets and stars revolved in circles around the earth. In his model, the sun's ecliptic was tilted at 23° to what today is the earth's equator, which is very close to the accepted value of today. Anaximander taught that the earth had been in a liquid state until dried by fire. The moisture, which had been driven off in the process, formed clouds.

In the fourth century B.C., Aristotle put forth a theory that was to last for almost 2,000 years. A spherical earth was the center of his universe or the cosmos. All of the heavenly bodies rotated around this center. Each one moved on a spherical shell. Moving outward from the earth, the heavenly bodies were arranged in the following order: Moon, Mercury, Venus, Sun, Mars, Jupiter, Saturn and, finally, the fixed stars.

The sublunary region was the natural abode of earth, water, air and fire. These four basic elements were arranged in spherical shells also, with earth being the lowest since it was the heaviest. Then came water, air and finally fire. Dry land, on which we live, was due to imperfections in the sublunary layers. The spherical shells that supported the heavenly bodies were constructed of an immutable substance, the aether or quintessence (fifth element). These aethereal shells were stacked with no space between adjacent shells, thus they all had a common center and they were all perfect since nothing hindered their motion. To the ancient Greek, the sphere was the perfect shape, for Aristotle, a required over-belief. Aristotle's model of the universe was able to explain, in a crude way, the motion of the heavenly bodies as seen by the eye by using 55 of these quintessence spheres.

It should be noted that Pythagoras used the concept of the heavenly bodies revolving around the earth on crystalline spheres 200 years before Aristotle. The story is that Pythagoras, while passing a blacksmith shop, heard different tones or pitches when hammers of different weights struck an anvil. This led to his investigation of tones from plucked strings of different lengths. He then reasoned that the orbits of the heavenly spheres were in similar ratios to the ratios of stretched strings that produced the harmonious tones. Thus, the spheres produced harmonious tones and we have the music of the spheres that we find in the Hymn: "This is My Father's World."

In the third century A.D., the geometer Ptolemy expanded on Aristotle's theory by constructing a model of the universe based on the addition of small spheres to which the heavenly bodies were attached. These small spheres called epicycles then rotated on Aristotle's larger spheres. He also placed the larger spheres slightly off-center from earth's center, which he viewed as only a slight modification from the perfection of Aristotle's view. This slight shifting of the centers was called the eccentric of the orbits. Thus we have an eccentric person is one who is slightly off. Ptolemy's model was able to predict the motion of the sun, the moon and the planets as well as the fixed stars to the accuracy of measurements of his day.

I was taught in grammar school that Columbus and his crew feared falling off the edge of the world since they thought that the earth was flat. While it is true that many people of his day believed a theory developed by Lactantius in the fourth century A.D. based upon his belief that the tabernacle build by Moses was a model of the universe, most educated people held the view put forth by Aristotle. In fact, Eratosthenes had calculated the circumference of the earth in the third century. He had noted that, in the village of Syene in Egypt, on a given day the sun at it's highest point shined straight down into a well while on the same day, the shadow of an obelisk 500 miles north in Alexandria made an angle of approximately 7 ½ degrees. From this he calculated the circumference of the earth to be 24,662 miles. This is less than one percent smaller than the value we accept today of 24,847 miles.

Another interesting fact from the third century was the heliocentric, or sun centered, theory put forth by Aristarchus. He was unable to reconcile the motion of the planets and other heavenly bodies with the accepted belief that the orbits must be circular; therefore he abandoned this theory. In fact, he anticipated Copernicus by almost 1,300 years.

Nicholas Copernicus, a Polish monk, was troubled by the need for 88 spheres in the Ptolemy model. He developed a heliocentric model, which was as accurate as the model of Ptolemy, but now the earth was no longer the center of the universe but orbited the sun with the sun being located approximately 3 sun diameters from the center of the earth's orbit. He developed his model in 1514 but did not publish it. Since church doctrine taught that the earth was the center, Copernicus put forth his theory as an interesting mathematical exercise but not necessarily the truth. He also waited until he was on his deathbed to have the work published. To make his theory more palatable he dedicated it to the Pope.

Since Copernicus' theory was no more accurate than that of Ptolemy and since the church was opposed to it's teaching, it was not accepted until almost a hundred years after his death. Another monk, Tycho Brahe, had spent 25 years charting the positions of the planets and stars throughout the calendar year. Johannes Kepler, using Brahe's star charts, developed a heliocentric theory with the orbits of the planets being elliptical and the sun located at a focus of these orbits. Kepler's theory gave much better accuracy to the prediction of future locations of the planets against the background of the fixed stars, but his contemporaries were very slow to abandon Aristotle.

Galileo Galilei, a professor at the University of Pisa, had proven Aristotle wrong by showing that the speed at which objects fell did not depend upon the masses of the objects by dropping stones of different weights from The Leaning Tower of Pisa. Galileo corresponded with Kepler and supported the Copernican theory. In 1609 Galileo visited Venice where he heard of a curious instrument, developed by Lippershey, which magnified distant objects. The telescope was being used by Venetian merchants to watch for ships entering the harbor. Having several hours advanced notice of a ship's arrival gave these merchants commercial advantage. Galileo took the telescope and improved it. He first looked at the moon and saw that it was not a perfect sphere but was pock-marked. He next aimed his telescope at Jupiter and observed its moons in their orbits around the planet. Following these observations, he became a strong advocate for the theory of Kepler. The church forced him to recant his teaching of the new theory and eventually placed him under house arrest where he spent the rest of his life. Galileo also put forth laws of motion, which anticipated Newton's Laws.

Isaac Newton was born in the year that Galileo died. He is perhaps the most influential contributor to what is today known as classical physics. His laws of motion indicated that a force was required to change the direction of a body in motion and that the required force was proportional to the mass of the body. A good story, although not true, is that Newton discovered his law of universal gravitation while sitting in an orchard and observing an apple falling. He had returned to his family's estate to avoid the plague when he first discovered this theory and an apple might have played a role. An apple falling from a tree falls toward the center of the earth due to the gravitational attraction of the two bodies. If one now throws the apple horizontally to the earth's surface, the gravitational force will still cause it to fall toward the earth's center and the apple will follow a parabolic trajectory. If thrown with enough velocity, the apple will still fall toward the earth's center but could return to its original location. Thus, Newton reasoned that it was this gravitational attraction between the earth and the moon, which held the moon in its orbit. The moon was constantly falling toward the earth. Similar forces held the earth in its orbit around the sun. Newton was able to show that he could derive Kepler's Laws of Planetary Motion by use of his gravitational theory. With this, the solar system and the universe became, to many, like a large clock, which had been wound and put into motion. This led to a deterministic philosophy that many of Newton's contemporaries railed against. The poet, William Blake, was one of these. He said of Newton: "…we both read the Bible day and night, he reads black while I read white."

Newton also did a lot of work in the field of optics. He viewed light as being composed of tiny particles called corpuscules. These particles striking our eyes gave rise to our vision. Later workers in the field of optics developed a wave theory of light that deposed Newton's theory.

Little was done toward advancing the theory of our universe from the time of Newton until just before the turn of the twentieth century. By then, A.A. Michelson had greatly improved the accuracy of the measurement of the speed of light. He and Morley devised an experiment to measure the speed of the earth through the aether. Yes, the aether was still around since it was believed that some medium was required for the conduction of light through space. In their experiment they were comparing the speed of light parallel to the direction of the earth's rotation to its speed perpendicular to this direction. They expected to find a very slight difference between these two. None was found. They improved their apparatus by increasing the distance over which the light traveled in order to increase the accuracy, and still no difference in speed was found between the two directions the light traveled. Many tried to explain why the experiment failed. Lorentz and Fitzgerald proposed that the pressure of the aether against it shortened the arm of the instrument moving parallel with the earth's velocity. Albert Einstein proposed a different solution. He said that if one assumes the speed of light is independent of reference frame then the problem goes away since whether you are on the earth or traveling with the aether the speed of light will be the same. Later work did away with the need for the mysterious aether.

About this same time, Max Planck explained blackbody radiation by assuming that light was made up of individual packets of energy that he called quanta. Einstein, in explaining the photoelectric effect made use of this theory of radiation. Today we speak of light in terms of its dual nature: in some cases it behaves as a wave and in others as a particle. Newton was not so far off after all.

During this time, much was also going on in developing a better understanding of the makeup of matter. J.J. Thompson had discovered the electron; Chadwick had discovered the neutron and Rutherford had determined the size of the nucleus of an atom. Anderson had discovered the positron (an electron having a positive charge) and Bohr had developed his theory of the hydrogen atom. (DeBroglie) had shown that electrons behave, in some cases, as a particle and in other cases as a wave. This discovery led to, what is known today, as quantum mechanics. Quantum mechanics must be used in order to understand the interactions of nuclear forces and of particles interacting over short distances.

An interesting aside involves Rutherford's determination of the size of the nucleus. He accomplished this by bombarding a thin gold film with alpha particles and measuring the scattering angle for the alpha particles. Two of his graduate students spent many nights working one hour on and one hour off observing the impingement of alpha particles on a detector which gave off a faint burst of light when struck. One of these students was a fellow by the name of Geiger. As Paul Harvey would say: "Now you know the rest of the story." The Geiger counter was invented.

While observing nuclear decays, Paul Anderson discovered the positron by not discounting tracks that turn the wrong way in a Wilson's Cloud Chamber. Others had observed these same tracks and discounted them.

Hubble had noted in 1929 that most of the objects observed through telescopes are moving away from us. Just as we hear a higher frequency in a train whistle approaching us than is heard when the train is receding, light is shifted toward the blue end of the spectrum when emitted from an object approaching and toward the red end of the spectrum when the object is moving away. Hubble found that the more distant an object

10

was, the faster it was moving away. This finding gave rise to two theories: One, an oscillating universe and the second, a constantly expanding universe. The total amount of matter in the universe would determine which of these two was the best option. The oscillating theory would be the most appropriate if only visible matter was considered. People who supported the expanding universe theory began looking for what is called dark matter. Enough such matter has now been found and most people only look at a universe that will continue expanding.

We now have a universe that is somewhere between ten and twenty billion light years across. Our sun is a medium size star in the Milky Way Galaxy that contains at least 100 billion stars and about 100 thousand light years across. The Milky Way Galaxy is a spiral galaxy with a dense center and two arms protruding from this center much as water would be sprayed from a rotating sprinkler. The Milky Way Galaxy is rotating in space with a period of approximately 250 million years. Our sun is approximately 30,000 light years from the center in one of the arms. In the universe, there are at least 100 billion galaxies or globular clusters. Some galaxies are elliptical while some are spiral and others are ring like.

Many have wondered when and how did the universe come into existence. One outgrowth of the expanding universe theory has been the Big Bang. We now know that stars have a life cycle just as we do. Our sun's energy is produced by the fusion of hydrogen to form helium. This is the same process found in the hydrogen bomb. The forces produced by fusion are tending to increase the size of the sun while gravitational

11

attraction is trying to decrease it. Once most of the hydrogen has been burned, helium will combine to form heavier atoms up to carbon, nitrogen and oxygen. Much more energy will be given off in these reactions and our sun will expand and become what is called a red giant. At that time, the diameter of the sun will be greater than the radius of the earth's path around the sun. Not to worry, it is estimated that approximately 4 billion years of hydrogen fuel is still available in our sun.

Once our sun has expended its helium and other lighter atoms, it will contract and become what is called a white dwarf. Stars, several times larger than our sun, can combine heavier atoms to form even heavier elements as they near their life's end. This results in an enormous amount of energy being released and a star can literally explodes. In this explosion, the heavier elements are formed. These explosions are seen as what we call super novas. When the outer shell is blown off, the star, if heavy enough becomes a neutron star or perhaps a black hole. A neutron star is one in which the gravitational forces are so strong that atomic forces are overcome and electrons and protons are squeezed so tightly that they become neutrons. A teaspoon of matter from such a star would weight as much as one or two elephants. If the star is slightly larger, matter is contracted even more and the gravitational forces are so strong that not even light can escape. John Wheeler gave these bodies the name black hole.

Taking this concept a little further and combining it with the expanding universe, one sees a point in time (its beginning) where all of the matter in the universe was concentrated at a single point. A tremendous explosion occurred, the big bang, and the universe came into being. And God said, "Let there be light." If this is true, the universe has been in existence for somewhere between six and twelve billion years. Our sun, which is a second-generation star, that is, it is made up of hydrogen and material left over from a previous super nova, is approximately four and one half billion years old.

Einstein spent the last few years of his life trying to develop a unified field theory, which would combine gravitational, electromagnetic, and nuclear forces. His general theory of relativity explains many, but not all, of the observed phenomena of our universe. Steven Hawkins and others have tried to further unify theory by incorporating quantum mechanics with Einstein's general theory. This has given rise to string theory, that is, particles don't exist as individual points but as open ended or looped strings. These last developments have happened since I left school and I must say of them, I have no understanding.

Isaac Newton said when asked about his work: "If I have seen further than others, it is because I have stood on the backs of giants." Steven Hawkins in his book, <u>A Brief History of Time</u>, tells the story of an astronomer who was giving a lecture on the universe. At the end of his lecture, a little old lady stood and said: "Young man, you should be ashamed of yourself. You know the earth is flat and it rests on the back of a giant tortoise." The astronomer asked: "And madam, on what does the tortoise stand." To which she replied: "Its turtles all the way down." I say that it is not turtles, but giants all the way down.