CHAPTER 1

HISTORICAL BACKGROUND

Early developments

Later developments

Present status quo

Problems

The ancient Greeks were probably first on record to practice science. They believed everything in our Universe was made up of four single entities; *Earth*, *fire*, *water* and *air*. Many thousand years have passed and today there are still only four known building blocks of nature namely *mass*, electric *charge*, *time* and *length* denoted by the symbols m, q, t and l. It is amazing to think that all secrets of our Universe can be unlocked by finding the right combinations of these four symbols. For example, we know that velocity is length per time or l/t while acceleration equals velocity per time v/t or l/t^2. Force, which is mass times acceleration, is written as ml/t^2 and energy becomes ml^2/t^2. In this way we should be able to describe any process in nature, whether it involves the smallest atom or the Universe as a whole.

1.1 Early developments

Looking at the stars many of us have asked, "Where does everything come from and how long has it been here? Does the Universe have boundaries and how long will it last?" There are no obvious answers to these questions, but it has not discouraged us to search for clues. Even if the over-all picture of the Universe has improved since ancient time, it is still too early to classify Cosmology as a true science, because despite all information obtained so far there are no exact numbers or exact mathematical solutions at hand which can describe the precise nature of our Universe.

It is interesting to note that some of the basic ideas of today are in fact rediscoveries from the past. For example, we learn from early records that Thales, 580 BC, believed the Moon to be illuminated by the Sun. About the same time Anaximander, 611?-547? BC, thought the Earth was round instead of flat. His contemporary, Anaximines, who at first agreed that the Earth is round and later changed his mind, was first to distinguish between planets and stars.

In the fourth century BC Heraclides of Pontus amazingly suggests that the planets Venus and Mercury circle the Sun (Helios) rather than the Earth and that the motion of the stars could be explained by the rotation of the Earth around its axis once in every twenty-four hours. However, a colleague of his, the great philosopher Aristotle, rejected Heraclides' rotational idea arguing that if the Earth was spinning around its axis then all heavenly bodies, including the planets, would appear to move around us at the same speed. But since the planets move with different velocities it would prove that the Earth is standing still and the planets, including all other heavenly bodies, are moving around us at their own chosen velocities. In fact Aristotle felt that all heavenly bodies were falling in towards the Earth's center which he also believed to be the center of the Universe (this is the first notion of a collapsing universe). In Aristotle's own words: "As evidence that all heavenly bodies move towards the center of the Earth, we see that weights falling towards the Earth do not fall in parallel lines but always at the same angles to it. Therefore, they are moving towards the same center, namely that of the Earth. It is therefore clear that the Earth must be the center and immobile. From these considerations it is obvious that the Earth does not move, neither does it lie anywhere but at the center of the Universe." The belief that we are at the center of the Universe is shared by many theoreticians even today who have adopted the theory of relativity and its cosmological principle.

Shortly after Aristotle's and Heraclides' deaths, Aristarchus of Samos extended Heraclides heliocentric idea so that all planets, including the Earth, were moving around the Sun just as we know it today

(Lovell, (1981)). Heraclides and Aristarchus heliocentric theories were short-lived, mainly due to religious opposition, but were rediscovered nearly two thousand years later by Copernicus.

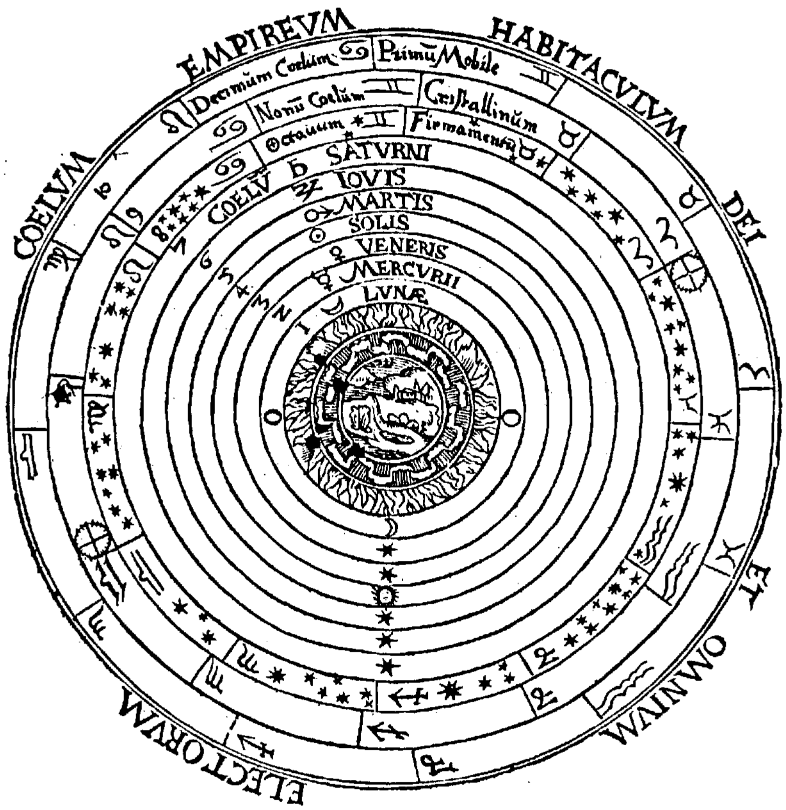


Fig. 1. The Earth as center of the Universe.

That the Earth is round was deduced in early time from the fact that new stars and constellations will rise above the horizon as one travels north or south. Also, while traveling north or south stars straight above move off at certain angles making it possible to calculate the radius and circumference of the Earth by triangulation. Land disappearing beyond the horizon at sea also gave a clue to the spherical shape of Earth.

In one of his essays, Aristotle wrote, "Mathematicians who tried to calculate the circumference of Earth put it at four hundred thousand stades" which is about 74,000 kilometers. It is believed that this written passage stimulated Columbus to undertake his famous new world voyage. Later, in the third and second century BC, the circumference of Earth was calculated more accurately by Archimedes who arrived at a value of 55,500 km; Eratosthenes and Hipparchus obtained 46,600 km; Posidonius 44,380 km (today's value is 40,000 km, Munitz (1962)). Eratosthenes is best known for his method of measuring the length and angles of shadows cast by vertical poles at different positions along the Earth's surface. By triangulation he then found the radius and circumference of the Earth.

All the above discoveries might not seem very impressive today. We take for granted that the Earth is round and that we belong to one of the planets that encircles the Sun. But two thousand years ago such discoveries were giant leaps in science. To find the first puzzle pieces of our physical world could be compared to the difficulty one would have to imagine a new color never seen before. It is true that many difficult problems have simple answers, but once there is an answer there is no longer a problem and often, once solved, little credit goes to the problem solver. An example of this is the early American township which had posted a $20,000 award to whomever could devise the means or method for removing a large boulder which had rolled down and blocked main street (dynamite could not be used because of nearby buildings). There were many unsuccessful attempts until a bright person appeared who claimed he had a workable solution. When he revealed his idea, "bury it", the towns people felt that such a simple answer was not worth the $20,000 previously offered.

Even today solutions and answers to scientific problems do not come easy, but the right answers usually turn out to be simple ones. It is easy to speculate, however, and often numerous and different theories appear about the same subject. This is especially true in the field of cosmology were exact measurements and exact mathematical solutions are not yet available thus making it difficult to rule out even the most exotic ideas.

In the 14th century Cardinal Nicholas of Cusa tried to break away from Aristotle's theory that for nearly 2,000 years held our Earth as the center of the Universe, a belief which was cherished by the church. Cardinal Nicholas of Cusa thought that the Earth was a moving star like all other stars and that the Universe was infinite in size, because God would not have created anything smaller. The Cardinal's ideas were criticized as being mystical and unscientific because in his infinite Universe, he claimed, each and all bodies would be at the center at the same time. Each body would also be at the periphery and in the interior at the same time. The reason for this is that in an infinite Universe everything can be said to be at the center since there is no limit to its radius. It is interesting to note that modern cosmology follows the same line of thought, namely that any observer on any galaxy in the Universe can consider himself to be at the center of the Universe. This is called the cosmological principle, see page 17. Awkward situations arise when infinity and zero are incorporated into physical phenomena. For example, a point source of energy with zero radius will contain an infinite amount of energy just as a boundless Universe with an infinite number of centers would have. Absurd questions can be asked such as; "What happens if an infinite force strikes an immobile object? What is the probability that another world like ours exists in an infinite Universe?" The answer is that the probability is 1:1 and the probability that an infinite number of other worlds exist just like ours with a person like oneself reading the same book *etc.*, is also 1:1. It is the author's opinion that infinity has no real meaning in physics. Nevertheless, many cosmological theories still incorporate infinity.

Giordano Bruno was burned at the stake in the year 1600 for supporting the cardinal of Cusa's idea that the Sun and Earth are in motion like stars. Giordano Bruno wrote his first publication on an infinite Universe while residing in England from 1583 to 1585. It is possible that he was influenced by Thomas Digges' treatise *Perfit Description of the Caelestiall Orbes*, which was first published in London 1576. Thomas Digges treatise is a translation of Copernicus' work into the English language with some of his own additions. His most important addition was that he believed the Copernican Universe must be infinite (Hoskin, (1997)). Nicolaus Copernicus himself saw his scientific work *De revolutionibus orbium coelestium* published as he was dying in 1543.

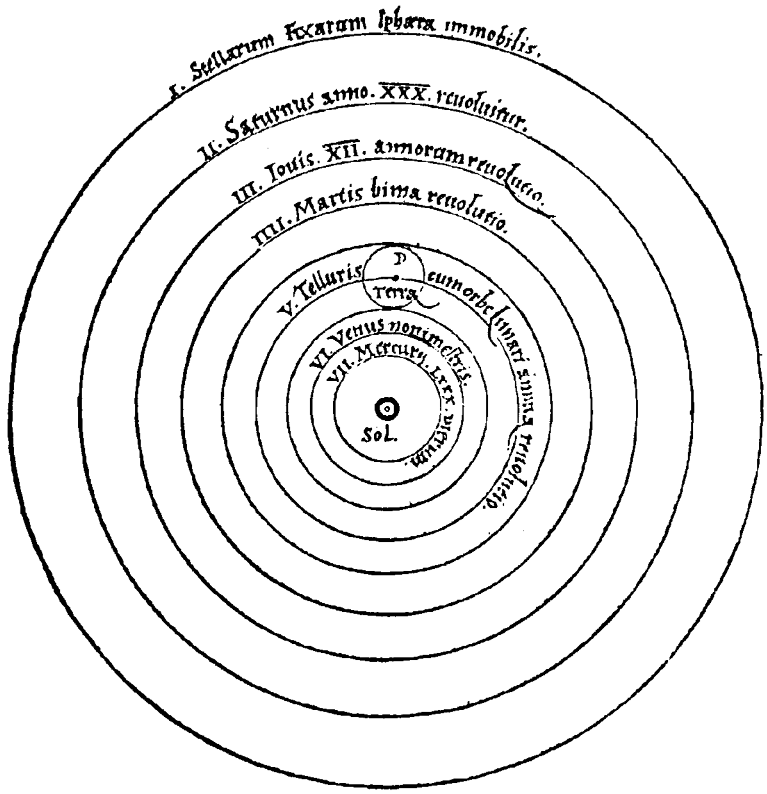


Fig. 2. The planetary system by Copernicus.

Copernicus arrived at the same idea as Aristarchus two thousand years earlier that the planets, including Earth, are orbiting the Sun. The work of Copernicus provides a picture of the solar system as it is described today. His orbital system has served as a model for many theories to follow, such as those involving the motion of stars and galaxies and theories dealing with the smallest atom to the structure of the entire Universe. At first there seemed to be some minor problems with Copernicus' theory because planetary orbits did not appear to be perfectly circular. The problems were solved in a most elegant way by Kepler, who discovered that orbits can be elliptical and during a period of 10 years, from the year 1609 to1619, Kepler established three laws of orbital motion that still stand:

1. Planets move in elliptical orbits around the Sun. One focal point of the ellipse coincides with the center of the Sun.

2 The radial vectors which connect the Sun with each planet sweep out the same area at the same time.

3. The cube of the average distance between each planet and the Sun is proportional to the square of their periods.

Kepler's laws are laws of harmonic motion. Kepler has been criticized for having an extraordinary or mystical belief in the harmonics of the world. For example, he tried in vain to find a periodic relationship between the planetary orbits similar to that of the harmonic overtones in music. *i.e.* Kepler had the idea that orbits might be quantized which in fact is a possibility still open to question. That orbits can be quantized was later proven by quantum physics which describes the organized orbits of electrons in atoms.

Acceleration: The year 1590 was a very important year in physics because it was then that Galileo Galilei discovered and measured acceleration. He found that test bodies dropped from a height were falling with increasing speed toward the Earth's surface. Each second the velocity increased by 9.8 meters per second, so that in three seconds, for example, the velocity had tripled to 29.4 meters per second. In mathematical terms the Earth’s acceleration can be expressed as $g = 9.8\ \text{m/s}^2$, where g is the acceleration due to the Earth's gravitational attraction. Although acceleration is an everyday occurrence, it was never before thought of as a separate event or physical property. It was merely considered a motion. Why is acceleration so important?

Because nothing will happen without acceleration. It is not possible to go to work at the office, for example, without having to accelerate and decelerate. Acceleration, which is the same as change in velocity, leads to a change in energy. Acceleration causes bodies to fall toward the center of the Earth with increasing speed due to the Earth's gravitational field and it generates radiation when electrons accelerate into faster and closer orbits in atoms where the electrons are attracted by the electric field of the atomic nucleus. In fact the whole Universe is in a constant state of acceleration which is evident from the fact that galaxies are receding from each other with velocities that increase with distance (since the distance between galaxies increases with time then velocity must also increase with time which is acceleration).

Galileo found the key to a completely new branch in physics called "dynamics". It must also be mentioned that Galileo was one of the first to use the telescope, a Dutch invention, for astronomical observations. Through the use of the telescope it became clear to Galileo that the old view held by the church that the Earth is the center of creation was wrong and that we are in fact orbiting the Sun. Galileo eventually landed in jail or house arrest for supporting the heliocentric doctrine and was ordered to decant.

Mass and inertia: Another important observation made at the time, which relates to acceleration, was the concept of inertia. Inertia, which is matter's resistance to acceleration, was an idea invoked by the Frenchman Renè Descartes in 1644. Descartes concluded that a material body in motion will keep its velocity in a straight line unless deflected by another body. The more massive a body is, the more it will resist deflection and consequent acceleration. Mass should not be confused with weight. For example, we know that a bowling ball weighs much less on the Moon than on Earth. Some might think that one should be able to roll a ball faster down a bowling lane on the Moon than on Earth but that is not so. To accelerate the bowling ball to a given velocity on the Moon will take the same effort as on Earth because the resistance to acceleration, or inertia of mass, remains the same. Inertia of mass (or simply mass) as we know it today is one of the fundamental entities of nature. The two most basic ingredients in physics, "inertia of mass" and "acceleration", had been discovered but their relationship was not yet fully understood. It was Isaac Newton who put it all in the right perspective when he showed that the product of inertial mass and acceleration is force (force = mass × acceleration or $F = ml/t^2$).

1.2 Later developments

Force: Galileo was born in 1564 the year when Michelangelo died. Galileo died the year 1642, when Isaac Newton was born. The concept of force was not new in Newton's time. Aristotle was aware of the gravitational force that pulled everything towards the center of the Earth including the planets and stars. Kepler realized that by placing the Sun in the center instead of the Earth, the Sun must have an attractive force superior to that of Earth. Attractive and repulsive forces were known to the Greeks who discovered that by rubbing amber (electron), fragments of paper *etc.* became attracted and sometimes repelled by the amber due to some mysterious force. In the year 1600 William Gilbert published his work *On the Magnet* which dealt with the repulsive and attractive forces of magnetism and in which the Earth for the first time is being described as a large magnet, which is why we today can talk about the Earth's magnetic north and south poles. It is believed that Kepler thought magnetism might be the force that caused the planetary orbits to be elliptical. He also visualized the attractive force of the Sun to fall off in intensity with distance.

In 1635, seven years before Isaac Newton's birth, Robert Hooke was born on the Isle of Wight. Hooke is said to be first to arrive at the idea of universal gravitation when in 1674, he published his work on the Earth's and the planets' motion around the Sun. Hooke was convinced that the force holding the planets in their orbits around the Sun was the same as the gravitational force which pulls a stone towards the center of the Earth. He also maintained that the gravitational force of the Sun decreased with distance. Hooke is also credited with the discovery that the planets Jupiter and Mars are rotating around their axis and that double stars exist. He was first to observe the phenomenon of star aberration and that tails of comets always point away from the Sun. Star aberration is explained as follows: when the Earth is moving around the Sun the positions of stars seem to shift in the direction of our motion. The light rays from the stars could be compared to that of rain falling on the windshield of a moving car. The rain appears to hit the windshield in steep angles although it is falling straight down. The same thing happens to light rays and as the Earth swings around the Sun and starts to move in the opposite direction the position of the stars shift the other way.

Force was more or less an intuitive concept until Newton formulated it into a mathematical law of physics and today the unit of force bears his name (if one kilogram is being accelerated so that its velocity increases by 1 m/s every second it will be subject to a force of one newton). Newton's law of universal gravitation marked the beginning of a new era in astronomy and physics. Newton's law states that the gravitational force between two masses m_1 and m_2 separated by a distance r is $F = Gm_1m_2/r^2$, where G is the Universal gravitational constant.

Newton pictured gravitational force as action over distance in a stationary medium which can be called the ether since at the time, and even now, it is hard to visualize a force acting over a medium of nothingness. Newton's action over a distance can be thought of as field lines of force interacting between bodies where the intensity of the force is proportional to the number of field lines that perpendicularly cut through a unit surface area (F = number of field lines per square meter). There are certain interesting questions connected with a fixed ether or absolute space, because it puts the Earth and all the stars in specific positions relative to absolute space. What would happen for example, if all matter in the Universe was removed except for our Earth, could we still say that it rotates and if so, relative to what? Would we still be able to register a centrifugal force at the equator? Since the Earth and stars are moving through space at different velocities, should light waves not reach us at different velocities depending on which direction they come from?

Relativity: The above questions have been pondered by many and several new ideas evolved, most noteworthy is the theory of relativity. The first on record to present such a theory was Bishop George Berkeley in 1705. From his writings in *The principle of Human knowledge* we read:

> "If every place is relative then every motion is relative, and as motion cannot be understood without the determination of its direction which in its turn cannot be understood except in relation to our or some other body, up, down, right, left. All directions and places are based on relations and it is necessary to separate a stationary body distinctly from a moving one. Let us imagine two globes, and that besides them nothing else material exists, then the motion in a circle of these two globes round their common center cannot be imagined. But suppose that the heaven of fixed stars was suddenly created and we shall be in a position to imagine the motion of the globes by their relative position to the different parts of the heaven."

In 1893 Ernst Mach, perhaps not knowing about Berkeley's writings, formulated a physical principle along the same lines which is called “Mach’s Principle”. Mach questioned the nature of inertia (resistance to acceleration) and especially motions that give rise to centrifugal forces. Mach statement reads as follows:

> "For me only relative motion exists. When a body rotates relative to the fixed stars centrifugal forces are produced. When it rotates relatively to some different body but not relative to the fixed stars, no centrifugal forces are produced. I have no objection to calling the

first "rotation" as long as it be remembered that nothing is meant except relative rotation with respect to the fixed stars." This is called the “Mach Principle”.

The stars, of course, are not fixed but move with extreme velocities relative to us. The vast distance between us and the stars make them appear stationary in the same manner that fast going ships at sea seem nearly stationary at far distances. If the motion of all stars in the Universe is governed by Newton's law of universal gravitation then this must imply that all things must move about a common center, the center of mass of the Universe, which of course brings us back to a Newtonian absolute space. The concept of an absolute space, the constancy of the speed of light and the argument that an infinite Universe would create an infinite gravitational force led to severe conflicts at the end of the19th century and beginning of the 20th century. The search for an absolute space or ether was culminated by the Michelson-Morley experiments which started in 1887 and which showed that the speed of light relative to the Earth is constant in all directions thus disregarding the Earth's orbital motion through a possible ether (see page 121).

The constancy of the speed of light on Earth and the inference of Lorentz and Pointcaré that no velocity can exceed the speed of light led Einstein to formulate a different kind of relativity which he named Special and General Theories of Relativity and which forms the basis for scientific thinking of today. In his Special Theory of Relativity Einstein (1905) deals with the constancy of the speed of light in rigid mathematical terms and he also formulated the following postulates:

1. The laws of physics take the same form in all inertial frames.

2. In any given inertial frame, the velocity of light c, is the same whether the light be emitted by a body at rest or by a body in uniform motion.

The second postulate simply rejects the existence of an ether, and in Einstein's General Theory of Relativity (1915) the nonexistence of absolute space and ether again brings us back to the Cardinal of Cusa's infinite Universe where observers anywhere can consider themselves to be at its center. In Einstein's Universe, which has no reference point or common center of mass, inertial forces such as centrifugal forces for example, are generated even in the absence of the fixed stars, in contrast to the earlier relativity theories of Berkeley and Mach. A spinning Earth would, in a mysterious way, generate centrifugal force at the equator even if all other matter in the Universe was removed. This reverts back to Berkeley's argument, "How then can we say that the Earth is spinning and relative to what?" The problem that an infinite Universe must generate an infinite gravitational force field was avoided in Einstein's General Relatively when he proposed that the Universe is bounded but yet infinite. This is explained by introducing a curvature on space allowing the Universe to somehow curve back on itself.

Einstein's curvature of space can perhaps be explained as follows: It is an established fact that light rays, which are massless, bend inward as they pass near massive gravitational bodies, such as the Sun. One reason for this is that time slows down with increasing gravitational tension. This means that all physical processes slow down including the propagation of light. Light rays will therefore travel slower as they encounter an increase in gravity. When a beam of light grazes the surface of a gravitational body it will bend. A light ray, if it could travel forever would therefore never leave the Universe since it must bend and eventually curve back on itself due to the immense gravitational field of the Universe. Einstein reasoned that the curvature of space is caused by gravitational fields in which both time and speed of light change to form a combined space time dimension in which not just light rays, but everything curves, such as measuring rods, world lines, *etc*.

The infinite but bounded Universe has often been pictured as follows: If two-dimensional beings which can only conceive two dimensions and therefore are unaware of a third dimension, were living on a spherical planet and were traveling in a straight line, they would never find an end to their world since they would move in an infinite number of circles, which would make them believe they are living in an infinite but bounded world. Also, triangles drawn on a spherical surface would never total 180 degrees because of their curved world lines. Einstein's relativity is a mathematical model, in contrast to a conceptual theory, describing changes in rate of time as well as bent world lines by applying geometry. It can be compared to one explaining the stock market using bar graphs and pie charts, but how it exactly works is still a mystery.

1.3 Recent status quo

The General theory of Relativity, which is based on geometry and curved world lines was, in its earlier stages, describing a static Universe where the overall gravitational force was counteracted by some imaginary repulsive force in order to prevent the Universe from gravitational collapse. The repulsive force was later replaced by the expansion process in the Big Bang theory where the Universe is believed to have originated from a primeval explosion that started from a singular point. The discovery that light waves from surrounding galaxies become more and more red-shifted the farther away the galaxies are, led Edwin Hubble to believed that the Universe must be expanding in all directions.

The red-shift is interpreted as a Doppler shift where the wavelength of light waves become stretched out towards the red side of the spectrum as the source of light is receding from us. A popular belief today is that the Universe is expanding and that space, according to General Relativity, curves in on itself in such a fashion that the original center, the center of the primeval explosion, occupies the periphery of the Universe and that the periphery of the Universe is the center of the expansion. This is not exactly a conceptually clear picture, but if we allow ourselves to deviate slightly from our standard way of thinking we can perhaps picture such an inside-out world. Many cosmologists of today would be offended if we ask them to point their telescopes to the point in heaven where the primeval explosion took place. It would be explained to us that when we look at far away galaxies we are also looking back in time to the beginning when the Universe was born. Therefore, since far away galaxies can be observed in all directions around us, one can conclude that the birth place of the Universe must also be all around us at the periphery and that we, 10 billion years later, are still at the center of the expansion.

Energy: Two very important energy relations were established in the beginning of the 20th century. They are Einstein's (1906) energy-mass equation $E = mc^2$ and Plank's (1900) constant of radiation h which is energy divided by frequency $h = E/n$. At first it was very difficult to justify how energy stored in mass equals mc^2 and not $\frac{1}{2}mc^2$ according to conventional Newtonian physics and why it is impossible for a mass to reach a velocity of c since its energy E then would reach infinity. There is no problem with the mathematics, but theoretically it is awkward. The same is true of Max Planck's discovery that energy of radiation divided by its frequency is a constant. The problem is that Plank's constant h has the dimensions of energy multiplied by time (Et) or momentum p ($p = \text{mass} \times \text{velocity}$) multiplied by a certain length x. Momentum multiplied by length $px = h$ has no meaning and was believed by many physicists to violate the laws of conservation of energy, because whether a particle with constant velocity and momentum traveled one or two meters (px, $p2x$, *etc.)* does not change its energy or state of affairs, but according to Planck's discovery it will.

Heisenberg tried to find the meaning of Planck's constant by showing that it can be written as $\frac{1}{2}h = \Delta p \Delta x$ which shows that any change in momentum is inversely proportional to a change in distance and that the product of these variables equals $\frac{1}{2}h$. The intriguing fact is that if we were to determine the momentum of a particle to the highest precision (that is with smallest possible error Δp) then it will be difficult to pinpoint the particle's position, because the smaller we make Δp the larger Δx becomes (the error in determining its position). The opposite is true when we try to fix a particle's position to a high degree of precision because then the value of its momentum becomes uncertain. Heisenberg's Uncertainty Principle plays a powerful role in atomic physics and is also believed to have important cosmological consequences, especially in the early Big Bang creation of the Universe. Both Einstein's energy relation $E = mc^2$ and Planck's constant h were great discoveries in modern science but are still not yet well understood.

The accidental discovery by Penzias and Wilson (1965) that cosmos is filled with a uniform microwave radiation did establish the fact that the average temperature of the Universe is only about 2.76 degrees Celsius above absolute zero. The microwave radiation is believed to be the remnant radiation from the hot Big Bang explosion. However, the background radiation, which has a blackbody distribution just like a baking oven, can also be explained by the combined heat or scattered radiation from all cosmic heat sources such as stars, galaxies, *etc.*

1.4 Problems

There are many problems associated with our understanding of the Universe. Most serious is the fact that we don't have any exact mathematical solutions for how big it is, its mass or mass density or how much energy it contains and what the nature of time is to mention a few. We should, in the author's opinion, have enough good data collected from astronomical measurement to be able to piece together good a working theory. Presently the most commonly accepted cosmological picture is that of an infinite but expanding Universe. Cosmic red-shifts are interpreted as galaxies receding from us in all directions with speeds that increase with distance and we are believed to be in the center of the expansion and at relative rest. The very unlikely fact that only we should be so privileged as to occupy the center of the Universe, is remedied by resorting to an infinitive Universe. We have seen that General Relativity has adopted Cardinal Nicholas of Cusa's idea that "in an infinite Universe observers on any galaxy will be at the center the same time". The mathematical reasoning is that an infinite radius must have an infinite number of centers and that in an infinite Universe all bodies can be thought of as occupying both the center and the periphery at the same time, which contradicts common sense for most of us..

The theories of relativity do not only allow us to be at the center and periphery at the same time but it also allows us to say that we are either moving with near light velocity with respect to distant galaxies or that distant galaxies move with velocities approaching that of light relative to us. This dual character of nature in relativity theory is called the Cosmological Principle. To add to an already confusing picture we also have to deal with the fact mentioned earlier that when looking at the most distant galaxies, we also look back in time to the birth place of our Universe. Since all distant galaxies appear at the horizon all around us, we must be surrounded by the point where the creation took place. Great efforts have been made to determine whether the expansion is slowing down or not. If so, it would indicate that we are still bound by the laws of mutual gravitation where everything could conceivably collapse back to a singular point. This would be analogous to a stone thrown straight up in the air which, according to the laws of falling bodies, will slow down to a stand-still and accelerate back towards the Earth’s center again.

It is the author’s opinion that most of the difficulties mentioned above can be untangled if we simply invert our present picture of the Universe by turning things around. For example, if Hubble had carefully considered the recession of galaxies according to the laws of falling bodies, he could have concluded that the Universe is in a state of infall or contraction rather than expansion. Using the example of the stone thrown up in the air and falling back, one can picture galaxies instead accelerating with increased velocity as they fall toward the center of the

Universe due to its mutual gravitational attraction. Since galaxies falling ahead of ours have reached a higher speed they will appear to pull away from us and if we look back in the opposite direction we find ourselves moving away from galaxies that are still in an early state of fall. Had the Universe been expanding, a blue-shift would have occurred since we would be gaining on galaxies ahead of us that are slowing down, while galaxies behind would try to catch up with us. We can also argue, that if all galaxies rush away towards the periphery and origin of our Universe, as claimed by the modern cosmologists, we must in fact be collapsing back to the central point from where the Big Bang creation took place.

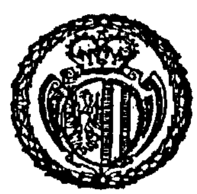
If what has been discussed in the two last sections appears to be confusing that is because it is. Cosmology as a science is still in its cradle and a solid scientific path to follow has not yet been found. Most of our ideas about the Universe are developed from light spectra and optical observations performed at our remote point of reference here on Earth. What makes it so difficult is that we cannot go out there and test our ideas. The purpose of this work is to take important pieces of knowledge, on the subject of cosmology, and try to piece them together into a possible working theory based on harmonic motion (Wåhlin (1981,1985)). Using simple laws of harmonic motion can in fact, produce simple and understandable equations that yield exact solutions in, until now, the elusive science of cosmology. The text that follows deals with an expanding-collapsing Universe, which obeys the laws of harmonic motion, and should rightfully be dedicated to Kepler who was unfairly criticized for being obsessed by his belief in the harmonics of the worlds. Page 19 shows the front page of Kepler's work *The harmonics of the worlds* published the year 1619.

IO. KEPLERI
HARMONICES MUNDI
LIBER I.

DE FIGVRARVM REGVLA-
RIUM, QUÆ PROPORTIONES HAR-
monicas pariunt, ortu, claſsibus, or-
dine & differentijs, causâ ſcientiæ
& Demonſtrationis.

PROCLUS DIADOCHUS
Libro I. Comment. in I. Euclidis.

Πρὸς δὲ τὴν φυσικὴν θεωρίαν (ἡ μαθηματικὴ) τὰ μέγιστα
συμβάλλεται, τήν τε τῶν λόγων εὐταξίαν ἀναφαίνουσα, καθ᾽ ἣν
δεδημιούργηται τὸ ΠΑ͂Ν, &c: καὶ τὰ ἁπλᾶ καὶ πρωτουργὰ στοι-
χεῖα, καὶ πάντῃ τῇ συμμετρίᾳ καὶ τῇ ἰσότητι συνεχόμενα δείξα-
σα, δι᾽ ὧν καὶ ὁ πᾶς οὐρανὸς ἐτελειώθη, σχήματα τὰ προσ-
ήκοντα, κατὰ τὰς ἑαυτοῦ μερίδας ὑποδε-
ξάμενος.

Cum S. C. M^tis. Pri-  *vilegio ad annos XV.*

LINCII AUSTRIÆ
Excudebat Johannes Plancus,
ANNO M. DC. XIX.

Title page of Kepler’s work.