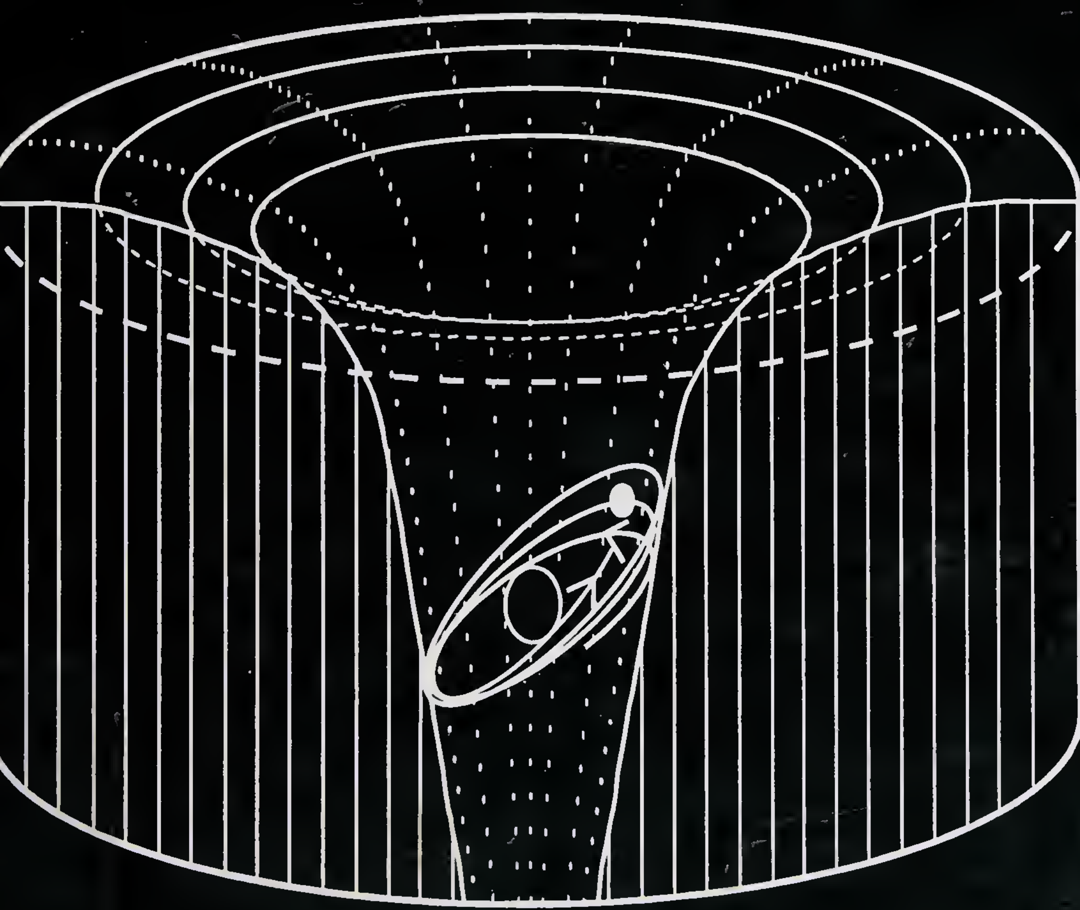
Paul Marmet

Einstein's Theory of Relativity versus Classical Mechanics



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By
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PREFACE

The aim of this book is to demonstrate that using "Conventional Wisdom" and "Conventional Logic", classical physics can explain all the observed phenomena attributed to relativity. The arbitrary principles of Einstein's relativity are thus useless.

It is very important to recognize the fundamental importance of the principle of mass-energy conservation. It took thousands of years of development for scientific thought to finally reject the magic of witchcraft. During the nineteenth century, scientists became convinced that matter cannot be created from nothing. Conversely, matter cannot be destroyed into nothing. It seems that even Einstein believed this, since he is the one who, at the beginning of the twentieth century, introduced the equation $E = mc^2$ implying mass-energy conservation. However, he later developed general relativity which is not compatible with that principle. Indeed, according to Straumann[1], the:

> "general conservation law of energy and momentum does not exist in general relativity".

Twentieth century science moved backward in accepting again the magical creation of matter or energy from nothing, even if this is hidden in complicated mathematics.

Contrary to what Einstein did, all the demonstrations in this book are compatible with the principle of mass-energy and momentum conservation. Using classical mechanics, we demonstrate that length contraction is a real physical phenomenon. We examine how this leads to the Lorentz equations. Then, we show how classical principles are sufficient to explain the advance of the perihelion of Mercury and derive Einstein's equation. The fundamental reason for this advance is illustrated with a classical

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[1] Straumann, N., General Relativity and Relativistic Astrophysics, Springer-Verlag, Berlin, 1991, page 146.

apparatus. We also study the Lorentz transformations in three dimensions and the Doppler phenomenon. Then we see how the problems brought by the relativity of simultaneity and by the principle of equivalence can be explained using conventional logic. We also show how classical mechanisms produce perturbations in the internal structure of atoms and molecules. Finally, we show that the presence of intense gravitational potentials leads to degenerate matter corresponding to Schwarzschild's black holes.

Einstein's relativity principles are not needed in these demonstrations. The only principles used are the ones already existing in classical mechanics. All the solutions are based on a physical model compatible with conventional logic.

Einstein's theory of relativity is a mathematical model which is not compatible with the physical models described in classical mechanics since it is not compatible with the principle of mass-energy conservation. This is a well-known fact. It is claimed that the theory of relativity is so advanced that it is not possible to give a Newtonian physical description of it. It is also often argued that abandoning classical scientific concepts leads to a scientific revolution. It is erroneous to believe that a new scientific revolution must abandon the fundamental principles brought up by Newton's classical mechanics and logic which gave birth to all our knowledge in physics.

As stated in several papers, Einstein's relativity implies "New Logic" which contradicts "Conventional Logic". Einstein's theory implies that because we can find some arbitrary mathematical relationships that fit some experiments, we must abandon conventional logic. History reports some rudimentary scientific models that also fitted experiments but which were based on nonsense. Those models were rejected. A new scientific revolution based on "New Non Conventional Logic" can lead to a scientific disaster or to a dead end. No scientific concept can be so advanced that it is no longer compatible with logic.

Einstein's relativity assumes new mathematical hypotheses and ignores completely the concept of models to describe physical reality. Einstein supposed that time and space can be distorted and that simultaneity is relative but he did not give any serious description of what this really means physically. In Newton's time, physical descriptions of phenomena were accompanied by mathematical equations giving quantitative predictions corresponding to those physical descriptions. Einstein's relativity claims that nature can be described with mathematical equations without any physical description. There is a complete abandon of all the physical models that made physics understandable in Newton's time.

Our main argument here is not whether Einstein's hypotheses are true or not. We believe that if Einstein's hypotheses are correct, they must correspond to a real physical mechanism. Such a real mechanism is described in this book using classical mechanics and classical logic.

With Einstein's new logic, contradictory results have appeared. For example, Gerald Feinberg developed the theory of tachyons which move faster than the speed of light. There are also mathematical models calculating wormholes, strings, multidimensional space, superluminal objects, time reversal and even time lines. Certainly, these claims do not make sense when we use conventional logic.

An expert in Einstein's relativity is described as an expert in the mathematics of relativity. Since the conventional wisdom of classical physics is not used in relativity, an expert in relativity is not trained to deal with Newtonian logic. Consequently, this book on relativity will be much more easily understood by an expert in classical physics since he or she already knows the mathematics and understands the classical mechanisms involved. It might appear surprising to some readers that relativity can be explained with classical principles. However, they will never escape out of their preconceived notions and learn how this is done unless they carefully read this book.

Acknowledgments.

The author wishes to express his gratitude to Christine Couture for writing the appendixes and for her skill in preparing the illustrations. As a physicist, she initiated many successful discussions regarding the content and the editorial work in this book. Some philosophical discussions with J.-C. Gille and A. St-Jacques were indispensable to develop the basic ideas leading to physical reality. The author is also grateful to Bruce Richardson for his interest in fundamental science and his financial support at a critical time. Collaboration was much appreciated from Drs Y. Varshni, M. LeBlanc and B. Hird. Various help related to programming, computer work or precious encouragements were received from Nancy Robertson, Nicolas Marmet, G. Y. Dufour and most importantly from my wife Jacqueline.

Chapter One
The Physical Reality of Length Contraction.

1.1 - Introduction.

In this first chapter, we will show that it is possible to establish links between quantum mechanics and mass-energy conservation. These links will help us calculate the interatomic distances in molecules and in crystals as a function of their gravitational potential. We will show that the natural interatomic distance calculated using quantum mechanics leads to the length contraction (or dilation) predicted by relativity. This result will be obtained here without using the hypothesis of the constancy of the velocity of light. It will appear instead as a consequence of quantum mechanics when mass-energy conservation is taken into account.

Since length contraction appears as a consequence of quantum mechanical calculations, the physical reality of those predictions can be verified experimentally. We will show that the results of the most precise quantum mechanical experiments prove that the change of length is real. Two different experiments which have been found to give sufficient accuracy to verify this change of length will be described in detail. We will show that the dimensions of matter really change naturally depending on its location in a gravitational potential.

1.2 - Mass-Energy Conservation at Macroscopic Scale.

The most reliable principle in physics seems to be the principle of mass-energy conservation: mass can be transformed into energy and vice versa. Without this principle, one would be able to create mass or energy from nothing. We do not believe that absolute creation is possible.

In order to understand the fundamental implications related to mass-energy conservation, let us consider the following example. Suppose momentarily that the Earth is not moving around the Sun, but has been pushed away with a powerful rocket and has reached interstellar space at location P (see figure 1.1). It now has a negligible residual velocity with respect to the Sun and except for the fact that the Sun has faded away, everything appears the same. The Earth is still made of about 10^{50} atoms, its center contains iron, is surrounded by oceans, deserts, cities and the atmosphere is the same. The planet is still populated by about the same five billion people.

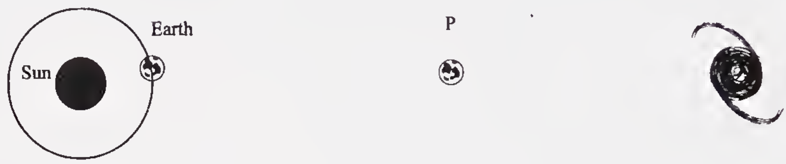

Figure 1.1

Let us assume that after a while, the planet starts falling slowly from P toward the Sun. Due to the solar attraction, the Earth accelerates until it reaches the distance of 150 million kilometers (from the Sun) corresponding to its normal orbit. At that moment, one can calculate that the Earth has reached a velocity of 42 km/s. This velocity is too large for the Earth to be in a stable orbit around the Sun as it is normally. It must be reduced to 30 km/s, the velocity for a stable orbit. The Earth must be slowed down.

It is decided that the velocity of the Earth can be reduced with the help of a strong rope attached to a group of stars at the center of our galaxy. The force produced by the rope will generate energy at the center of the galaxy while the Earth is slowed down to the desired velocity for a stable orbit around the Sun.

Knowing that the Earth has a mass of 5.97×10^{24} kg, it is easy to calculate the amount of work transferred to the center of the galaxy. It corresponds to slowing down the Earth from 42 km/s to 30 km/s. This represents an amount of work equal to 2.6×10^{33} joules. Therefore the Earth must get rid of 2.6×10^{33} joules to go back to its normal orbit and the center of the galaxy must absorb that same amount of energy. The rope used to slow down the Earth could then run a generator located at the center of the galaxy to produce 2.6×10^{33} joules of energy.

However, due to the principle of mass-energy conservation, the energy carried out to the center of the galaxy to slow down the Earth can be transformed into mass. Using the relation $E = mc^2$, we find that the mass corresponding to 2.6×10^{33} joules of energy is equal to 2.9×10^{16} kg. This means that 29 billions of millions of kilograms of mass have been transferred from the Earth to the center of the galaxy through the rope. This mass-energy is a very small fraction of the Earth's mass but it must be coming from the Earth and received at the center of the galaxy.

After the re-establishment of the Earth's orbit at one astronomical unit from the Sun, the inhabitants of the Earth find nothing changed. Other than the neighboring Sun, no difference can be noticed compared with when the Earth, still made of its initial 10^{50} atoms, was away from the Sun. The question is: How can the Earth not lose one single atom or molecule while 29 billions of millions of kilograms of mass have been lost and received at the center of the galaxy? There is only one logical answer. Since each atom on Earth was submitted to the force of the rope, each atom has lost mass in a proportion of approximately one part per one hundred million.

Note that this situation is equivalent to the formation of a hydrogen atom. When a proton and an electron come together to form a hydrogen atom, energy is released in the form of light. This light corresponds to the work transferred to the center of the galaxy in our problem.

1.3 - Mass-Energy Conservation at a Microscopic Scale.

The experiment described above takes place at a macroscopic scale. Each individual atom loses mass because a force interacts on all atoms when the Earth decelerates in the Sun's gravitational potential. It is normally assumed that atoms have a constant mass. For example we learn that the mass of the hydrogen atom is $m_o = 1.6727406\times10^{-27}$ kg. Can we have hydrogen atoms with less or more mass? From the thought experiment of section 1.2, we see that the principle of mass-energy conservation requires a transformation of mass into energy on each atom forming the

Earth, since each of them has contributed to generate energy transmitted to the center of the galaxy.

Let us study the following experiment. We first consider that an individual hydrogen atom is placed on a table on the first floor of a house in the gravitational field of the Earth, as shown on figure 1.2. The hydrogen atom is then attached to a fine (weightless) thread so that the atom can be lowered down slowly to the basement of the house, while the experimenter remains on the first floor. When the atom is lowered down, its weight produces a force F in the thread. That force is measured by the experimenter on the first floor. It is given by:

$$F = m_0 g. \tag{1.1}$$

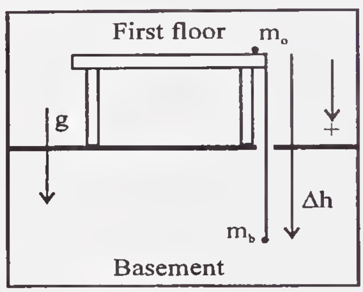

Figure 1.2

The slow descent of the atom attached to the thread is stopped every time a measurement is made, which means that the kinetic energy is zero at the moment of the measurement. When the atom has traveled a vertical distance Δh, the observer on the first floor observes that the energy ΔE produced by the atom and transmitted through the thread to the first floor is:

$$\Delta E = F\Delta h. \tag{1.2}$$

The work extracted from the descent of the atom is positive when the final position of the atom is under the first floor (Δh is positive). Then, according to the principle of mass-energy conservation, the energy produced at the first floor by the descent of the atom in the basement can be transformed into mass according to the relationship:

$$E = mc^2. \qquad 1.3$$

The important point that must be retained about equation 1.3 is that the energy E is proportional to the mass, independently of the fact that it just happens that the numerical value of the constant of proportionality is equal to the square of the velocity of light. From equations 1.1, 1.2 and 1.3, the amount of mass Δm_f generated at the first floor by the descent is:

$$\Delta m_f = \frac{\Delta E}{c^2} = \frac{m_o g \Delta h}{c^2}. \qquad 1.4$$

This amount of mass (or energy) carried by the thread is generated by the weight of the atom which slowly moves down to the basement. When the hydrogen atom lies on the table, its mass is m_o. However, during its descent, it produces work (corresponding to the mass Δm_f generated at the first floor). The initial mass m_o of the particle is now transferred into the mass-energy Δm_f generated at the first floor by the falling particle, plus the remaining mass m_b of the particle now in the basement. Using equation 1.4, we find:

$$m_b = m_o - \Delta m_f = m_o\left(1 - \frac{g\Delta h}{c^2}\right). \qquad 1.5$$

According to the principle of mass-energy conservation, the mass of the hydrogen atom in the basement is now different from its initial mass m_o on the first floor. It is slightly smaller than m_o and is now equal to m_b. Any variation of g with height is negligible and can be taken (with g) into account in equations 1.4 and 1.5.

Of course, the relative change of mass $\Delta m_f/m_o$ is extremely small. (It was equally small in the case of the Earth falling back to its normal orbit, as seen above in section 1.2.) The change of mass given by equation 1.5 is so small that it cannot be verified using a weighing scale. However, this reduction of mass must exist, otherwise, mass-energy would be created from nothing. We will see below that this change of mass has actually been measured.

It was quite arbitrary for us to assume that the initial mass of hydrogen on the first floor is m_o. Physical tables do not mention all the experimental conditions in which an atom is measured.

Furthermore, the accuracy of this value is quite insufficient now to detect Δm_f (equation 1.5). A change of altitude of one meter near the Earth's surface gives a relative change of mass of the order of 10^{-16}. Masses are not known with such an accuracy.

At this point, we must recall that in the above reasoning, we have made a choice between the principle of mass-energy conservation and the concept of absolute identical mass in all frames. It is illogical to accept both principles simultaneously since they are not compatible. We have chosen to rely on the principle of mass-energy conservation which is equivalent to not believing in "absolute creation from nothing" as defined in section 1.2. We must realize that without mass-energy conservation not much of physics remains. Physics becomes magic.

1.4 - Mass Loss of the Electron.

There is a way to measure experimentally the mass difference between a hydrogen atom in the basement and one on the first floor. In equation 1.5, we see that a mass Δm_f appears and increases when the atom moves down in the gravitational field. Due to mass-energy conservation, the mass m_b of the atom moving down decreases by the same amount, that is:

$$\Delta m_b = \Delta m_f \qquad 1.6$$

Since the hydrogen atom has lost a part of its mass due to the change of gravitational potential energy, we must expect (according to equation 1.5) that the electron as well as the proton in the atom have individually lost the same relative mass. Let us calculate the relative change of mass of the electron $(\Delta m_e/m_e)$ and of the proton inside the hydrogen atom due to its change of height.

From equations 1.5 and 1.6, we have:

$$\frac{\Delta m_e}{m_e} = \frac{g\Delta h}{c^2} \qquad 1.7$$

where

$$\Delta m_e = \Delta m_b. \qquad 1.8$$

When Δh is a few meters, equation 1.7 gives a relative change of mass of the order of 10^{-16}. Consequently, the first order term gives an excellent approximation. Let us use:

$$\frac{\Delta m_e}{m_e} = \frac{\partial m_e}{m_e}. \qquad 1.9$$

The electron mass m_e (as well as the proton mass) is not constant and decreases continuously when the atom is moving down. Equation 1.7 shows that independently of the mass of the particle, the relative change of mass is the same. This means that for the same change of altitude, the relative change of mass of the electron is the same as for the proton.

Due to the principle of mass-energy conservation, we must conclude that a hydrogen atom at rest has a less massive electron and a less massive proton at a lower altitude than at a higher altitude. The mass of an electron and of a proton can be tested very accurately in atomic physics. Quantum physics shows us how to calculate the exact structure of the hydrogen atom as a function of the electron and proton mass. From that, one can calculate the Bohr radius of an atom having a different mass. Fortunately, the Bohr radius can also be measured with extreme accuracy experimentally.

1.5 - Change of the Radius of the Electron Orbit.

It is shown in textbooks how quantum physics predicts the radius of the orbit of the electron in hydrogen for a given electronic state. This is given by the well known Bohr equation:

$$r_n = \frac{n^2\hbar^2}{Zm_e ke^2} \qquad 1.10$$

where r_n is the radius of the Bohr orbit of the electron with principal quantum number n, m_e is the mass of the electron (actually, m_e is the reduced mass, but it is approximately the same as the electron mass), h is the Planck constant (= $2\pi\hbar$), k is the Coulomb constant ($1/4\pi\varepsilon_o$), e is the electronic charge and Z is the number of charges in the nucleus (Z = 1 corresponds to atomic hydrogen). Furthermore when we choose n = 1 and Z = 1, r_n becomes a_o, which is called the Bohr radius. The Bohr radius is

5.291772×10^{-11} m at the Earth's surface (for the case of R_∞ for which the nucleus is very massive). Equation 1.10 illustrates a simple principle. It illustrates the fact that the circumference of the electron orbit is exactly equal to (or any multiple of) the de Broglie wavelength of the electron orbiting the nucleus.

Since, as we have seen above, the electron mass m_e changes with its position in a gravitational potential, let us calculate (using Bohr's equation) the change of radius r_n caused by that change of electron mass. This is given by the partial derivative of r_n with respect to m_e. From equation 1.10 we find:

$$\frac{\partial r_n}{r_n} = -\frac{\partial m_e}{m_e}. \qquad 1.11$$

Equation 1.11 shows that any relative decrease of electron mass is equal to the same relative increase of the radius of the electron orbit. According to the principle of mass-energy conservation, the electron mass decreases when brought to a lower gravitational potential. Consequently, quantum physics (Bohr's equation) shows that the radius of the electron orbit in hydrogen must increase when the atom is at a lower altitude. Using equation 1.10, quantum physics gives us the possibility to predict the size of the electron orbit r_n in an atom for different values of electron mass. Let us study the change of size of the electron orbit as a function of the altitude where the particle is located in a gravitational field.

1.6 - Change of Energy of Electronic States.

Since it has been observed and accepted that the laws of quantum physics are invariant in any frame of reference, let us calculate the energy states of atoms having an electron (and a proton) with a different mass. The consequences of the change of proton mass are easily calculated since the energy levels depend only on the reduced mass of the electron-proton system. In the Bohr equation, we take m_e as the reduced mass. This does not produce any relevant difference in the problem here.

The binding energy between the electron and the proton is a function of the electrostatic potential between the nucleus and the electron. Quantum physics teaches that the energy E_n of the n^{th} state as a function of the electron mass is:

$$E_n = \left(\frac{k^2 e^4}{2n^2\hbar^2}\right) m_e. \tag{1.12}$$

From equation 1.12, we can find the relationship between the change of electron mass and the change of energy:

$$\frac{\partial E_n}{E_n} = \frac{\partial m_e}{m_e}. \tag{1.13}$$

The Bohr radius a_0 is the average radius of the electron orbit for n = 1. According to quantum physics the energy of state n is:

$$E_n = \left(\frac{ke^2}{2n^2}\right)\left(\frac{1}{a_0}\right) \tag{1.14}$$

where a_0 is a function of the electron mass m_e, given by:

$$a_0 = \left(\frac{\hbar^2}{ke^2}\right)\left(\frac{1}{m_e}\right). \tag{1.15}$$

We know that the energy of electronic states of atoms can be measured very accurately in spectroscopy from the light emitted during the transition between any two states E_n and $E_{n'}$. Extremely accurate results can also be obtained in some nuclear reactions with the help of Mössbauer spectroscopy.

The frequency ν_n of the radiation emitted as a function of the energy E_n of level n is given by:

$$E_n = h\nu_n. \tag{1.16}$$

By differentiation of equation 1.16, we find:

$$\frac{\partial \nu_n}{\nu_n} = \frac{\partial E_n}{E_n}. \tag{1.17}$$

Differentiation of equation 1.14 gives:

$$\frac{\partial E_n}{E_n} = -\frac{\partial a_0}{a_0}. \tag{1.18}$$

Combining equations 1.11, 1.13, 1.17 and 1.18, we get:

$$\frac{\partial a_0}{a_0} = -\frac{\partial \nu_n}{\nu_n} = -\frac{\partial m_e}{m_e} = -\frac{\partial E_n}{E_n} = \frac{\partial r_n}{r_n}. \tag{1.19}$$

Since these quantities are extremely small but finite, we can write:

$$\frac{\Delta a_o}{a_o} = -\frac{\Delta \nu_n}{\nu_n} = -\frac{\Delta m_e}{m_e} = -\frac{\Delta E_n}{E_n} = \frac{\Delta r_n}{r_n}. \qquad 1.20$$

From equation 1.7, we have:

$$\frac{\Delta m_e}{m_e} = \frac{g\Delta h}{c^2}. \qquad 1.21$$

Equations 1.20 and 1.21 give:

$$\frac{\Delta E_n}{E_n} = \frac{\Delta \nu_n}{\nu_n} = -\frac{\Delta a_o}{a_o} = \frac{\Delta m_e}{m_e} = -\frac{\Delta r_n}{r_n} = \frac{g\Delta h}{c^2}. \qquad 1.22$$

Equation 1.22 shows that the relative change of size of the Bohr radius $\Delta a_o/a_o$ is equal to $-g\Delta h/c^2$.

This shows that following the laws of quantum physics, a change of electron mass due to a change of gravitational potential (which results necessarily from the principle of mass-energy conservation) produces a physical change of the Bohr radius.

We must notice here that using the relativistic correction given by Dirac's mathematics is irrelevant and does not solve this problem. Relativistic quantum mechanics introduces a relativistic correction due to the electron velocity with respect to the center of mass of the atom. The change in electron mass brought by the relativistic correction involved in this chapter is due to the gravitational potential originating from outside the proton-electron system. It is not due to any internal velocity within the atom. The use of the relativistic Dirac equation is not related to calculating how the Bohr radius changes between its value in the initial gravitational potential and its value in the final gravitational potential.

1.7 - Experimental Measurements of Length Dilation in a Gravitational Potential.

A measurement proving that there is a change of the Bohr radius due to the change of gravitational potential has already been made. The difference of energy for an atom corresponding to its change of size is observed as a red shift of its spectroscopic lines. The change of mass can be applied quite generally to any particle or subatomic particle in physics placed in a gravitational potential. It can also be applied to astronomical bodies like planets and galaxies since it relies on the principle of mass-energy conservation which is always valid.

1.7.1 - Pound and Rebka's Experiment.

A spectroscopic measurement of the highest precision has been reported by Pound and Rebka [1] in 1964 with an improved result by Pound and Snider in 1965. Since we have seen that the change of a_0 corresponds to a change of energy of spectroscopic levels, let us examine Pound and Rebka's experiment. They used Mössbauer spectroscopy to measure the red shift of 14.4 keV gamma rays from Fe^{57}. The emitter and the absorber were placed at rest at the bottom and top of a tower of 22.5 meters at Harvard University.

The consequence of the gravitational potential on the particles is such that their mass is lower at the bottom than at the top of the tower. Therefore an electron in an atom located at the base of the tower has a larger Bohr radius than an electron located 22.5 meters above, as given by equation 1.22. The same equation also shows that electrons orbiting with a larger radius have less energy and emit photons with longer wavelengths.

Pound and Rebka reported that the measured red shift agrees within one percent with the equation:

$$\frac{\Delta E}{E} = \frac{g\Delta h}{c^2} = 2.5 \times 10^{-15}. \qquad 1.23$$

Not only is the change of energy predicted by relativity and verified experimentally by Pound and Rebka (equation 1.23) numerically compatible with the change of energy predicted by the conservation of mass-energy, but the predicted relativistic equation is mathematically identical to the one predicting the increase of Bohr's radius (equation 1.22). Since the red shift measured corresponds exactly to the change of the Bohr radius existing between the source and the detector, we see that it cannot be attributed to an absolute decrease of energy of the photon during its trip in the gravitational field.

This result is exactly the one that proves that matter at the base of the tower is dilated with respect to matter at the top. It is clear that the Bohr radius has actually changed as expected which means that the physical length has really changed. Therefore, this phenomenon is not space dilation. The real physical dilation of matter is observed because electrons (as well as all particles) have a lower mass at the bottom of the tower which gives them a longer de Broglie wavelength. Space dilation is not compatible with a rational interpretation of modern physics. A rational interpretation has already been presented [3].

The equilibrium distance between particles is now increased because the Bohr radius has increased. When atoms are brought to a different gravitational potential, the electron and proton must reach a new distance equilibrium as required by quantum physics in equation 1.12. Quantum physics and the principle of mass-energy conservation lead to a real physical contraction or dilation. This solution solves the mysterious description of space contraction in relativity without involving any new hypothesis or new logic. Length contraction or dilation is real and is demonstrated here as the result of actual experiments. Let us also note that this length dilation is done without producing any internal mechanical stress in solid material. Finally, if the source were above the detector, we would observe a blue shift proving that the Bohr radius in matter above the detector has decreased with respect to the Bohr radius in matter at lower altitude. One can conclude that Pound and Rebka's experiment has shown that matter is contracted or dilated when it is moved to a different gravitational potential.

1.7.2 - The Solar Red Shift.

Other experiments also show the reality of length contraction or dilation. For example, the atoms at the surface of the Sun have been measured to show exactly the gravitational dilation due to the decrease of mass of the electrons in the solar gravitational potential. The gravitational potential at the Sun's surface is well known. As shown above, it is a change of electron mass in the hydrogen atom due to the gravitational potential that produces a change of the Bohr radius. It is that change of Bohr's radius that produces a change of energy between different atomic states. Brault [2] has reported such a change of energy between atomic states. It corresponds exactly to the change of Bohr's radius caused by the gravitational potential. The atoms on the Sun emit light at a different frequency because the electrons are lighter on the solar surface than on Earth, exactly as required by the principle of mass-energy conservation. The change of electron mass on the Sun produces displaced spectral lines toward longer wavelengths as given by equation 1.22. Since quantum physics is valid on the solar surface, we can understand that the electrons have less mass due to the solar gravitational potential. This leads to an increase of the Bohr radius for the atoms located on the solar surface which leads to atomic transitions having less energy, as observed experimentally.

The Mössbauer experiment as well as the solar red shift experiment prove that atoms are really dilated physically. This means that the physical length of objects actually changes. We also find that not only do protons and electrons lose mass in a gravitational potential but so do nuclear particles in the nucleus of Fe^{57}, as observed in the Mössbauer experiment of Pound and Rebka.

1.8 - The Crucial Influence of the Electron Mass on the Fundamental Laws of Relativity.

Macroscopic matter is formed by an arrangement of atoms. In molecular physics, we learn that quantum physics predicts that interatomic distances are proportional to the Bohr radius. Those distances are calculated as a function of the Bohr radius. According to quantum physics, a smaller Bohr radius will lead to a smaller interatomic distance between atoms in molecular hydrogen. The interatomic distance in molecules is known to be a function of the Bohr radius just as the interatomic distance in a crystalline structure is proportional to the Bohr radius. This means that since the Bohr radius changes with the intensity of the gravitational potential, the size of molecules and crystals also changes in the same proportion. This is true even in the case of large organic molecules. Therefore the size of all biological matter is proportional to the Bohr radius. This point is explained in more details in appendix I.

Because the size of macroscopic matter changes with the gravitational potential, the original length of the standard meter transferred to a location having a different gravitational potential will also change. To be more specific, mass-energy conservation requires that the standard meter made of platinum-iridium alloy becomes shorter if we move it to the top of a mountain. Furthermore, due to the increase of electron mass, an atomic clock will increase its frequency by the same ratio when it is moved to the top of the same mountain. However, since the velocity of light (or any other velocity) is the ratio between these two units, it will not change at the top of the mountain with respect to any frame of reference. This point will be discussed later. Because the relative changes of length and clock rate are equal, they will be undetectable when simply using proper values within a frame of reference. All matter, including human bodies, composed of atoms and molecules will change in the same proportion since the intermolecular distance depends on the Bohr radius and consequently on the electron mass which is reduced when located in a gravitational potential.

It is important to notice that length dilation or contraction is predicted and explained here without using the relativistic Lorentz equations nor the constancy of the velocity of light. Consequently, we must consider now that we have demonstrated experimentally (using Pound and Rebka's results) the physical change of length of an object in a gravitational potential. More demonstrations will be given in the following chapters.

The experiments reported here showing length dilation use atoms that are at rest. They are solely related to the potential energy. We will see that the problems of kinetic energy and velocities require new considerations in the next chapters.

1.9 - References.

[1] C. W. Misner, K. S. Thorne and J. A. Wheeler, Gravitation, W. H. Freeman and Company San Francisco. page 1056. See also: Pound R. V. and G. A. Rebka, Apparent Weight of Photons, *Phys.*

Rev. Lett., **4**, 337 1964. See also: Pound R. V. and Snider, J.L. Effect of gravity on Nuclear Resonance, *Phys. Rev. B*, **140**, 788-803, 1965. This has been measured in a rocket experiment by Versot and Levine (1976) with an accuracy of 2 x 10^{-4}.

[2] J. W. Brault, The Gravitational Redshift in the Solar Spectrum, Doctoral dissertation, Princeton University, 1962. Also Gravitational Redshift in Solar Lines, *Bull. Amer. Phys. Soc.*, **8**, 28, 1963.

[3] P. Marmet, Absurdities in Modern Physics: A Solution, ISBN 0-921272-15-4 Les Éditions du Nordir, c/o R. Yergeau, 165 Waller, Ottawa, Ontario K1N 6N5, 144p. 1993.

1.10 - Symbols and Variables.

ΔE energy produced by the atom and transmitted to the first floor

Δh distance travelled by the atom

Δm_b amount of mass lost by the atom

Δm_e amount of mass lost by the electron

Δm_f amount of mass generated on the first floor

E_n energy of the hydrogen atom in state n

F weight of the atom

m_o mass of the atom on the table

ν_n frequency of the radiation emitted corresponding to E_n

r_n radius of the orbit of the electron in hydrogen in state n

Z number of charges in the nucleus

Chapter Two
Transformation of Excitation Energy between Frames.

2.1 - Introduction.

We consider now the kinetic energy given to masses when there is no gravitational potential. The principle of mass-energy conservation requires that masses increase when given kinetic energy. This is expressed by the relationship:

$$m_v[rest] = \gamma m_s[rest] \qquad 2.1$$

where:

$$\frac{1}{\gamma^2} = 1 - \left(\frac{v}{c}\right)^2. \qquad 2.2$$

The index [rest] means that the measurement is made using the units of the rest frame. The subscripts v and s refer to masses having respectively a velocity v and no velocity (stationary). These indices will be explained in detail in section 2.6.

Since masses can be excited particles containing internal potential energy, we must study how to transform that potential energy between frames. The mass-equivalent of this internal potential energy has always been ignored in relativity. In order to be coherent, it must be taken into account. Let us show how this correction restores physical reality in relativity. To calculate the relationship between masses in different frames we use the principle of mass-energy conservation (equation 2.1). Let us find an equivalent relationship for the case of energy released by an excited atom.

2.2 - Difference between Time and What Clocks Display.

It has been suggested that time is what clocks measure. This definition is incomplete and misleading. We have seen in chapter one that due to mass-energy conservation, clocks in different gravitational potentials run at different rates. We must realize that "time" is not elapsed more slowly because a clock functions at a slower rate or because the atoms and molecules in our body function at a slower rate.

We have seen in equation 1.22 that in the case of a change of gravitational potential, the Bohr radius is larger when the electron mass is smaller. We also know that according to quantum mechanics, atomic clocks run more slowly when the electron mass is smaller. When we say that an atomic clock runs more slowly, we mean that for that atomic clock, it takes more "time" to complete one full cycle than for an atomic clock in the initial frame, where the electron has a larger mass. That slower rate can only be measured by comparing the duration of a cycle in the initial frame with the duration of a cycle in the new frame. It is the time rate measured in the initial frame at rest that is considered the "reference time rate". We will see that all observations are compatible with this unchanging "reference time rate".

The change of clock rate is not unique to atomic clocks. We recall that quantum mechanics shows that the intermolecular distances in molecules and in crystals are proportional to the Bohr radius (see appendix I). Consequently, due to velocity, the length of a mechanical pendulum will change. Therefore it can be shown that the period of oscillation of all clocks (electronic or mechanical) will also change with velocity.

We cannot say that "time" flows at the rate at which all clocks run because not all clocks run at the same rate. However, a coherent measure of time must always refer to the reference rate. That reference rate corresponds to the one given by a reference clock for which all conditions are fully described. It never changes. However, all matter around us (including our own body) is influenced by a change of electron mass (see appendix I) so that we are deeply tied to the rate of clocks running in our frame. Since our body and all experiments in our frame are closely synchronized with local clocks, it is much more convenient to describe the results of experiments as a function of the clock rate in our own frame. This is what we call the "apparent time".

We generally refer to the clock rate of our organism believing that we are referring to the "real time". What appears as a "time interval" for our organism is in fact the difference between two "clock displays" on a clock located in our own frame. "Difference of clock displays" (ΔCD) is a heavier phrase than "time interval" but it is necessary for an accurate description of nature. Of course, clocks are instruments measuring time but during the same time interval there is a difference by a factor of proportionality between the "differences of clock displays" of different frames. In order to avoid any misinterpretation, we must use the word "time" with great caution when we want to shorten the description. In that case, "time" is an apparent time interval corresponding to the difference of clock displays in a given frame when no correction has been made to compare it with the reference time. Since all our clocks and biological mechanisms depend on the electron's mass and energy, humans feel nothing unusual when going to a new frame. However, the time measured by the observer in that new frame is an apparent time and it must be corrected to be compared with a time interval on the fundamental reference frame.

2.3 - Description of the Reference Time Rate.

We do not know how to build a clock whose rate will not change when brought to a different gravitational potential or to a different velocity. However, using the mass-energy conservation principle, we have seen in equation 1.22 how to calculate the difference of clock rate between clocks without relative velocity and located in different gravitational potentials. This means that we can calculate the clock rate in one frame as a function of the clock rate in a different frame, as long as the gravitational potential and kinetic energies are fully described in both frames.

An absolute "reference time rate" can be defined using a clock located in a frame in which the velocity and the gravitational potential are well described. For example this could be a clock at rest with respect to the Sun and far enough from it so that the residual gravitational potential would be negligible. We could then arbitrarily define the "reference time rate" as the rate at which that clock operates in these particular conditions. Everywhere in the universe we would refer to that rate as the "reference time rate". If such a reference clock were brought from outer space to a location near the Sun, we have found in chapter one that due to mass-energy conservation, it would run more slowly because the electron would lose mass into energy that would escape away from its initial frame.

Let us assume that an observer near the Sun wants to measure the period of variation of light coming from a remote variable star. He uses his clock and records a clock display every time the star is at its maximum of brightness. The difference between two maxima will give him the period of variation of the star, using his clock rate. Let us represent by ΔCD_s (where s stands for Sun) the difference of clock displays for the clock near the Sun. In Einstein's relativity, since time is what clocks measure, ΔCD_s is interpreted as a time interval. However, we know that a difference of clock displays simply gives a pure number without any information on what the absolute time is. The subscript of ΔCD_s refers only to the location of the clock and not to an absolute time unit. We know however that another clock far away from the Sun (in a higher gravitational potential) will give a different difference of clock displays called $\Delta CD_{o.s.}$ (where o.s. stands for outer space) between each maxima because it runs at a different rate (that is equal to the "reference outer space clock rate"). Consequently, the ΔCD_s recorded near the Sun will not be the same as the $\Delta CD_{o.s.}$ recorded in outer space. The observer near the Sun will have the illusion of a "time interval" (that he might call Δt) that is different from the one measured by the observer located in outer space simply because the clock rate at his location is different due to a different electron mass. One must understand that the real time interval for a star to complete a cycle does not vary because the observer has moved somewhere else or because his clock runs at a different rate. Consequently, when we refer to ΔCD, we must always specify (with a subscript) in which frame the clock is located. Then a correction needs to be made to that number if we want to calculate the corresponding ΔCD given by a reference clock in outer space. We must remember that the ΔCD given by a local clock is a pure number that must be multiplied by a unit of time to give a "real time" interval. Therefore, an absolute reference of "time unit" must be defined. Furthermore, the absolute standard of unit of time will appear different in different frames since we have seen that local clocks run at different rates in different gravitational potentials.

We see that there is no time dilation nor time contraction. There is no magic. In order to be able to make a comparison between systems, it is absolutely necessary to compare the differences of clock displays (which are not time but numbers of units of time) instead of the time intervals.

This problem cannot be discussed properly using directly the parameter "time" because of the psychological impression on humans that time is the rate at which our own organism runs. This last rate depends on the electron mass in the frame in which we are located. Consequently, we must get familiar with the phrase "difference of clock displays" (ΔCD_{frame}) remembering that it corresponds to the "time interval" believed to be felt by an observer in that particular frame.

We have seen above that two clocks located in different gravitational potentials will not show the same difference of clock displays during the same real time interval. We will see now that quantum mechanics also predicts that clock rates are different when these clocks are carried in frames having different kinetic energy. We might assume that the relativistic correction could be made simply by taking into account the increase of electron mass due to the addition of kinetic energy, but this correction is too simple and incomplete (as we will see in sections 2.8 and 2.9) and disregards the need to consider the transfer of internal excitation energy between systems. In order to be able to calculate relative clock rates, we must first find the relationship between the excitation energy of atoms in frames having different velocities.

2.4 - Description of the Reference Meter.

The standard definition of length uses a unit called the "meter". In order to be coherent, we must define the meter in a way that can be reproduced in any frame. It is generally believed in physics that one can transfer, without any change of length, a standard meter from the rest frame to the moving frame. This is wrong because this is not compatible with the principle of mass-energy conservation and with quantum mechanics. When kinetic energy (or potential energy) is added to or removed from a rod, the electron mass and the Bohr radius change as required by the principle of mass-energy conservation. Consequently, the length of a rod will not be the same in frames having different velocities. The change of length of a standard rod which is one meter long in an initial frame can be calculated considering its kinetic and potential energies.

Even the most fundamental definition of the meter (which is 1/299 792 458 of the distance traveled by light in one second) suffers from the same error since it requires the use of the unit of time and since the "apparent second" in the moving frame (ΔCD(S)[mov]) is different from the "apparent second" in the rest frame (ΔCD(S)[rest]) due to the change of mass of the electrons in the atomic clock carried by the moving system. Consequently, to be able to compare lengths in different frames, we must complete the international definition of the reference meter and state its potential and kinetic energies.

We <u>define</u> here that the length of the reference meter corresponds to 1/299 792 458 of the distance traveled by light during one second <u>on a clock located at rest in outer space, far away from the Sun.</u>

2.5 - Definition of the Velocity of Light.

We want to point out that none of the above definitions depends on the experimental measurement of the velocity of light. The value of the parameter c is defined in equation 1.3 from the fundamental concept requiring an absolute constant K of proportionality between mass and energy:

$$E = Km. \qquad 2.3$$

However, it has been observed experimentally that the value of K is equal to the square of what is interpreted to be the velocity of light. Whatever c is, for practical reasons, we define it as:

$$c = \sqrt{K}. \qquad 2.4$$

Everywhere in this book, the meaning of c is fundamentally bound to equation 2.4. We believe that the fact that the velocity of light is equal to the square root of the constant K in the mass-energy relationship is not just a coincidence and results from a fundamental mechanism. However, it is very likely that the best method of measuring the mass-energy constant K is through the measurement of c.

2.6 - Need of Parameters with a Double Index.

From the above description, we realize that the observer's frame is submitted to several particular conditions like its gravitational potential and kinetic energies. However, an observer moving with his clock cannot measure the change of clock rate because all phenomena in the moving frame, including the clock rate, change in the same proportion.

The same can be said of masses. When an observer and some masses move at an identical velocity, the values of the masses (as measured by the observer inside the moving system) are indistinguishable from the values obtained before the common change of velocity. After claiming that a mass increases with velocity with respect to an observer at rest, it would be incoherent to claim that the same mass does not increase when the observer moves with it.

In order to make a clear and coherent description, one must use a suitable notation which gives a complete description of the units used. To do this, two independent indexes are necessary. The first index indicates the units used for the measurement. For example, we can measure the length of an object either with respect to a reference meter at rest or with respect to a moving meter. It must be realized that the reference meter at rest is a unit that has a different length than the same reference meter in motion. It is almost like using inches instead of centimeters. When we measure a length *l* and a mass m using the units of length and mass issued from the system at rest, the length is represented by *l*[rest] and the mass is represented by m[rest]. When we measure lengths and masses using the units of the system in motion, we represent the length by *l*[mov] and the mass by m[mov]. The indexes [rest] and [mov] do not tell us whether the mass is moving or not. They only tell us what units are used.

The second index indicates the state of motion of the system on which parameters (like length or mass) are measured. We describe the frame in which the particle is located using the subscript "v" when the particle is moving and the subscript "s" when the particle is stationary. For example, the mass of a stationary particle (using units of the rest frame) is represented by m_s[rest] and the mass of a moving particle (using units of the rest frame), by m_v[rest]. According to relativity, we must write:

$$m_v[\text{rest}] = \gamma m_s[\text{rest}]. \qquad 2.5$$

Similarly, the mass of a moving particle measured using moving units is represented by m_v[mov] and the mass of a stationary particle measured using moving units is represented by m_s[mov]. Consequently, the number of kilograms in m_s[rest] is identical to the number in m_v[mov] because they are both measured using proper parameters. However, the mass m_s[rest] is different from m_v[rest] as seen in equation 2.5.

The number "n" of meters of a rod does not change when the rod is moved to another frame as long as we measure proper values (number of proper meters). Then n_s equals n_v. However, the distance between the atoms changes. Since the interatomic distance *a* changes when a physical body is moved to another frame, the number of atoms N_s along a length of one meter[rest] in a stationary rod is different from the number of atoms N_v along the same length (one meter[rest]) when the rod is in motion at velocity v. Therefore when measuring the same absolute constant length in two frames we find:

$$\frac{N_s}{\text{meter[rest]}} \neq \frac{N_v}{\text{meter[rest]}}. \qquad 2.6$$

Of course, the indexes [rest] and [mov] are irrelevant with the numbers n_s, n_v, N_s and N_v because they are pure numbers.

The fundamental importance of the necessity of using a double index must not be underestimated because relativity cannot be explained properly without it. This is a consequence of having different units of mass and length in different frames. These double indices are irrelevant in Newtonian mechanics. In principle, a third index could be added giving the information about the gravitational potential energy. This third parameter will be considered separately.

2.7 - Apparent Lack of Compatibility for Fast Moving Particles.

When a body is accelerated, its mass increases according to the relationship given by equation 2.5. Therefore fast moving atoms possess more massive electrons. Using the Bohr equation, let us calculate the consequences of a heavier electron in the case of the hydrogen atom.

When the electron mass is larger and no other parameter is taken into account, then according to the Bohr equation (equation 1.12), all the atomic energy levels should have more energy (equation 1.13). Consequently, since E = hν, the atoms formed with those heavier electrons should emit electromagnetic radiation at a higher frequency ν. This means that an atomic clock located in the moving frame should run at a higher rate. However, we know from experiments that fast moving particles disintegrate at a slower rate and atoms emit a lower frequency. This has been clearly observed in the muon's and spectroscopic experiments. We conclude that the increase of electron mass that causes atoms to disintegrate at a higher rate in a gravitational potential does not appear to be compatible with the slower rate of disintegration of fast moving muons. This apparent contradiction is a very serious problem that requires a more careful study. Using the principle of mass-energy conservation, we will solve that problem by showing that one important parameter has been ignored.

In the next section, we will consider solely experiments in which the gravitational potential energy is always constant. This corresponds to the study of special relativity. Only the velocity (and therefore the kinetic energy) will change. The problem of combining gravitational potential energy with kinetic energy will be studied in chapters five and six.

2.8 - Demonstration of the Energy Relationship between Systems.

Let us consider a stationary particle M_{so} where the index s stands for stationary and the index o means that the particle is in its ground state of internal excitation. That particle can be a single hydrogen atom. When accelerated to a velocity v, its mass becomes:

$$M_{vo}[rest] = \gamma M_{so}[rest] \qquad 2.7$$

where the index v means that the particle has a velocity v.

Let us consider that an internal energy of excitation $E_{xs}[rest]$ is given to that particle before its acceleration. The index x refers to internal excitation energy. The total mass $M_{sxt}[rest]$ of the stationary excited atom is then:

$$M_{sxt}[rest] = M_{so}[rest] + \frac{E_{xs}}{c^2}[rest] \qquad 2.8$$

where the index t refers to the total mass-energy which includes rest mass, internal and kinetic energies when relevant. From equation 2.8, we calculate that the internal excitation energy $E_{xs}[rest]$ alone has a mass-equivalent $M_{xs}[rest]$ given by:

$$M_{xs}[rest] = \frac{E_{xs}}{c^2}[rest] = \frac{h\nu_s}{c^2}[rest] \qquad 2.9$$

where $h\nu_s[rest]$ is the energy E_{xs} measured using the units of time and length of the rest frame. Equations 2.8 and 2.9 give:

$$M_{sxt} = M_{so}[rest] + M_{xs}[rest]. \qquad 2.10$$

The particle of mass M_{sxt} can emit its energy of excitation according to equation 2.9. When that particle (M_{sxt}) is accelerated to a velocity v, its mass becomes M_{vxt} which is γ times its mass at rest as given by equation 2.5. This gives:

$$M_{vxt}[rest] = \gamma M_{sxt}[rest]. \qquad 2.11$$

Putting 2.10 in 2.11 gives:

$$M_{vxt}[rest] = \gamma M_{so}[rest] + \gamma M_{xs}[rest]. \qquad 2.12$$

If the particle does not possess any internal energy, then the second term of equation 2.12 vanishes and we get equation 2.7. Putting equation 2.7 in 2.12, we have:

$$M_{vxt}[rest] = M_{vo}[rest]+\gamma M_{xs}[rest]. \qquad 2.13$$

Equations 2.13 and 2.9 give:

$$M_{vxt}[rest] = M_{vo}[rest] + \frac{\gamma h\nu_s}{c^2}[rest]. \qquad 2.14$$

Equation 2.13 shows that the velocity of the excited particle leads to the mass component M_{vo}[rest]. The second term γM_{xs}[rest] gives the mass-energy equivalent of the excitation energy of the moving particle. This term is composed of the mass equivalent of the excitation energy of the particle (which is $h\nu_s/c^2$[rest]) and of the energy required to accelerate it (given by γ). From equations 2.13 and 2.14, we see that the principle of mass-energy conservation requires that the total energy of excitation combined with the energy necessary to accelerate that energy of excitation (or its mass equivalent) give:

$$E_n(\text{Excit.+acceleration of excit.}) = \gamma M_{xs}c^2[rest] = \gamma h\nu_s[rest]. \qquad 2.15$$

Equation 2.15 gives the total energy [rest] that the excited moving atom must lose (by emission of a photon) to go to its ground state.

However, when the observer moves with the excited atom and uses rest units, he will deduce from his measurements a frequency ν_v[rest] from which he will naturally decide that the energy of internal excitation is $h\nu_v$[rest]. Therefore:

$$E_n[rest](emitted) = h\nu_v[rest]. \qquad 2.16$$

The energy that was required to accelerate the mass-equivalent of that excitation energy may appear irrelevant to the moving observer. However, due to mass-energy conservation, that energy cannot disappear and be ignored. According to the principle of mass-energy conservation, since no other photon is emitted during the transition, the emitted photon must possess all the energy available which includes the energy of excitation plus the kinetic energy of the mass equivalent of that excitation energy.

Using the same units, it is clear that the total energy of equation 2.15 (excitation plus the energy required to accelerate the mass-equivalent of the energy of excitation) is equal to the energy of the photon received during the de-excitation by the observer at rest (equation 2.16). This gives:

$$\gamma M_{xs}c^2[rest] = \gamma h\nu_s[rest] = h\nu_v[rest]. \qquad 2.17$$

In equation 2.17, we have the Planck parameter h that comes from the measurement of $h\nu_s$ in a stationary frame. We also have the Planck parameter h that comes from a measurement of $h\nu_v$ in the moving frame (always using the same common units [rest]). In order to be coherent and since the Planck parameter comes from measurements from different frames, we must individually label each Planck parameter. Equation 2.17 becomes:

$$\gamma h_s\nu_s[rest] = h_v\nu_v[rest]. \qquad 2.18$$

Equation 2.18 is an important relationship that must be applied when the energy of excitation is given a new velocity.

2.9 - Relative Frequencies between Systems.

In order to solve equation 2.18, we need to find a relationship between ν_s[rest] and ν_v[rest]. Let us consider an electromagnetic wave of frequency ν_v[rest] emitted by an atom having a constant velocity v. That electromagnetic wave is measured by an observer in the rest frame. When the measurement of the frequency is made, he must consider two different phenomena that might change the frequency due to the velocity of the emitting atom. The first one is the change of clock rate of the emitter and the second is the classical Doppler effect due to the radial velocity between the stationary source of radiation and the moving observer. Let us study those two effects separately starting with the classical Doppler effect.

Let us suppose that the source of radiation moving at a velocity v is emitting in a direction perpendicular to its velocity. The observer at rest receives the radiation at a frequency ν_s[rest]. This special direction allows us to take the classical Doppler effect into account very easily. We know that the Doppler correction is given by the relationship:

$$\nu_v[\text{rest}] = \left(1 - \frac{v_r}{c}\right)\nu_s[\text{rest}] \qquad 2.19$$

where v_r is the radial velocity between the moving frame and the frame at rest. In the case of a tangential velocity, when $v_r = 0$, there is no Doppler correction. Consequently:

$$\left(1 - \frac{v_r}{c}\right) = 1. \qquad 2.20$$

Equation 2.20 in 2.19 shows that light received by the observer at rest from a moving source emitting radiation at 90° with respect to his velocity produces a Doppler effect equal to zero. At a different angle, when the Doppler effect is different from zero, we will see (chapter eight) that the change of frequency is completely due to the recoil produced by the emitting photon on the emitting particle. In that case, the recoil of the emitting particle gives to that emitting particle the energy lost or gained by the photon in agreement with mass-energy conservation.

Let us consider now the mechanism which changes the clock rate when particles move from a rest frame to a moving frame. We expect the frequency of the clock to change when moved from a rest frame to a moving frame. However, that consideration is totally irrelevant. It is true that a clock will emit a different frequency when it is carried to a moving frame but this is not the problem considered here. The problem here refers to a comparison between a frequency that is measured to be ν_v[rest] in the moving frame <u>using the rest frame units</u> and a frequency measured by an observer at rest ν_s[rest] (using also rest frame units). Of course, since the units are the same and there is no Doppler correction we have:

$$\nu_v[\text{rest}] = \nu_s[\text{rest}]. \qquad 2.21$$

Equation 2.21 shows that using the units of the rest frame, the moving and the stationary observers will observe the same absolute frequency when a wave is traveling between systems which have no radial relative velocity.

Combining equations 2.21 and 2.18 gives:

$$h_v[\text{rest}] = \gamma h_s[\text{rest}]. \qquad 2.22$$

Equation 2.22 means that when we use the Planck parameter h to determine the energy in a moving system we must make a correction (γ) because of the kinetic energy of the equivalent mass of the excitation energy $h_v\nu_v$[rest]. Keeping h identical between frames would be the same thing as claiming that masses do not change when they are accelerated.

Equation 2.22 is the relationship we were looking for in section 2.1. It is, for energy, the relationship equivalent to the mass-energy conservation principle:

$$m_v[\text{rest}] = \gamma m_s[\text{rest}]. \qquad 2.23$$

Equation 2.22 is a relationship previously ignored. However this equation, which is required by the principle of mass-energy conservation, is absolutely necessary when treating problems dealing with a change of velocity of internal energy. We will see in chapter three how equation 2.22 allows us to solve the apparent contradiction described in section 2.7.

2.10 - Cases of Relevance of the Relationship $h_v = \gamma h_s$.

We must notice that equation 2.22 (h_v[rest] = γh_s[rest]) results from the fact that the internal excitation energy of particles (that has a mass equivalent) acquires a velocity v that produces an increase of mass-energy equivalent. However, in the case of a change of gravitational potential energy, as seen in chapter one, the mass-equivalent of the internal excitation energy has no kinetic energy since it has no velocity. Therefore in the case of potential energy, the relationships h_v[rest]=γh_s[rest] and m_v[rest] = γm_s[rest] are irrelevant since $\gamma = 1$ when $v = 0$. In the case of gravitational potential, the changes of energy and length are given by equation 1.22 in chapter one.

Let us finally note that the relationship h_v[rest] = γh_s[rest] is absolutely necessary to satisfy the principle of invariance of physical laws in any frame of reference as will be seen in the rest of this book.

2.11 - Symbols and Variables.

ΔCD_{frame}	difference of clock displays on a clock located in a frame
$\Delta CD(S)[mov]$	ΔCD for the apparent second in the moving frame
$\Delta CD(S)[rest]$	ΔCD corresponding to the apparent second in the rest frame
$E_{xs}[rest]$	energy of excitation given at rest in rest units
$h_s[rest]$	Planck parameter on the rest frame in rest units
$h_v[rest]$	Planck parameter on the frame in motion in rest units
$m_s[rest]$	mass of an object at rest in rest units
$M_{so}[rest]$	mass of a particle at rest in its ground state in rest units
$M_{xs}[rest]$	mass of the excitation energy of a particle at rest in rest units
$M_{sxt}[rest]$	total mass of a particle at rest in its excited state in rest units
$m_v[rest]$	mass of an object moving at velocity v in rest units
$M_{vo}[rest]$	mass of a particle in motion in its ground state in rest units
$M_{vxt}[rest]$	total mass of a particle in motion in its excited state [rest units]
$\nu_s[rest]$	frequency of light measured by an observer at rest in rest units
$\nu_v[rest]$	frequency of light measured by a moving observer in rest units

Chapter Three
Demonstration of the Lorentz Equations without Einstein's Relativity Principles.

3.1 - Fundamental Physical Principle.

In this chapter, we will show that the Lorentz equations can be demonstrated using the principle of mass-energy conservation and quantum mechanics. The equations obtained are mathematically identical to the usual Lorentz transformations. There is no need for Einstein's relativity principles or for the hypothesis of the constancy of the velocity of light. In fact, no new physical principle is required and the constancy of the velocity of light appears as a consequence to mass-energy conservation.

We have seen in chapter one that the principle of mass-energy conservation implies that the mass of a particle changes with the gravitational potential. In this chapter, we will consider particles with kinetic energy. We will take into account that masses increase with kinetic energy, using Einstein's relativistic relationship $m_v[rest] = \gamma m_s[rest]$. This relationship shows that a moving particle has a larger mass than the same particle at rest (using rest mass units). However, as expected, when observed within the moving frame (using proper values), the mass does not appear to change.

In order to demonstrate the Lorentz equations using physical considerations instead of a mathematical transformation of coordinates, we must define accurately the physical meaning of the quantities used. We have seen that Einstein considered that time is what clocks display. We know that clocks run more slowly when they are located in a gravitational potential. However, time does not flow more slowly because clocks run at a slower rate.

Consequently, even if the equations that we will find are mathematically the same as the Lorentz equations, because of Einstein's interpretation, the parameter representing the time t in the equation will actually be a clock display CD. Therefore due to Einstein's confusion between clock display and time, the units (second) characterizing time t in Lorentz's equations should not exist because t is actually a clock display (which is a pure number).

When we compare Einstein's model of time dilation with the natural explanation in which the clock rate is simply slower, we are obliged to compare clock displays, which have no units, with real time, which needs to be expressed in seconds. In this chapter, since we wish to establish a comparison between Einstein's model and mass-energy conservation, it is impossible to avoid momentarily giving Einstein's units of time to quantities that represent only clock displays. Furthermore, we see that the relationship in which length *l* equals velocity times a time interval ($l = v\Delta t$), leads to an erroneous length because Einstein's definition of time is not time but a clock display. Therefore the length found is not a length but a pure number (of local meters). The length of a rod is a reality independent of the observer and does not depend on the rate at which a measuring clock is running. There is no change of length of a rod when the observer uses a clock running more slowly. Consequently, comparing our calculations with Einstein's theory is very subtle because Einstein confused the slowing down of clocks with time dilation.

3.2 - Change of Energy and Bohr Radius Due to Kinetic Energy.

We have explained that the Bohr equation (equation 1.12) gives a relationship between the parameters that describe the rate at which an atomic clock runs. The energy levels in the Bohr atom for each of the n quantum levels are:

$$E_{n,o}[rest] = \frac{2\pi^2 k^2 e^4}{n^2 h_o^2} m_o[rest] \qquad 3.1$$

where the subscript o means that the atom is at rest. When the hydrogen atom is given a velocity, the energy of each of the n levels changes as seen by an observer remaining at rest and using rest units.

We must notice that the frame in which the observer is actually located has no physical relevance. However, a description of the units (of mass, length and clock rate) used by the observer is necessary. Of course, one generally assumes that the observer uses the units that exist in his own frame. However, the description will be complete only when we specify the frame of origin of the units instead of assuming every time that the observer uses the units of his own frame.

The energy levels of the moving atom (using rest frame units) are given by putting equations 2.22 and 2.23 in equation 3.1. The Bohr equation becomes:

$$E_{n,v}[\text{rest}] = \frac{1}{\gamma} \cdot \frac{2\pi^2 k^2 e^4}{n^2 h_o^2} m_o[\text{rest}]. \qquad 3.2$$

Furthermore, since the Bohr radius a_o of an atom at rest is:

$$a_o[\text{rest}] = \frac{h_o^2}{4\pi^2 m_o e^2 k}[\text{rest}] \qquad 3.3$$

using equations 2.22, 2.23 and 3.3, the Bohr radius of a moving atom will be:

$$a_v[\text{rest}] = \gamma \frac{h_o^2}{4\pi^2 m_o e^2 k}[\text{rest}] = \gamma a_o[\text{rest}]. \qquad 3.4$$

This means that the Bohr radius a_o increases linearly with γ. This will be discussed in section 3.4. From equation 3.2, we see that the energy between atomic transitions of a moving atom (which determines the clock rate) decreases linearly as γ increases (using the units of the rest frame). We conclude that according to quantum mechanics, the rate of a moving clock slows down when its velocity increases.

This is compatible with the slower clock rate of moving atoms as observed experimentally and interpreted erroneously as time dilation. The popular phrase "time dilation" should be interpreted as meaning that the rate of the moving clock has slowed down and not that time has dilated. Combining the Bohr equation (equation 3.2) with solely the mass relationship (equation 2.23) and neglecting equation 2.22 would lead to a rate increase of the moving clock. This is contrary to observations and to mass-energy conservation, as seen in chapter two. The correction due to mass-energy must be applied to the Planck parameter h as given by equation 2.22. Consequently, the observed slowing down of the clock rate of moving clocks, which is implied by equation 3.2, is an experimental confirmation of equation 2.22. This also solves the apparent contradiction presented in section 2.7.

3.3 - The Lorentz Equation for Time.

From the relativistic Bohr equation presented above, let us calculate the energy of an atom located on a stationary frame. From equation 3.1 we see that the energy states of a stationary atom (using rest frame units) are:

$$E_o[rest] = \frac{2\pi^2 k^2 e^4}{n^2 h_o^2} m_o[rest] = h_o \nu_o[rest] \qquad 3.5$$

where $h_o\nu_o[rest]$ is the internal energy of excitation in the atom, using rest frame units. Due to its velocity, the atom located on the moving frame has a different internal energy. Equation 3.2 gives (using rest frame units):

$$E_v[rest] = \frac{1}{\gamma} \cdot \frac{2\pi^2 k^2 e^4}{n^2 h_o^2} m_o[rest] = h_o \nu_v[rest] \qquad 3.6$$

where $h_o\nu_v[rest]$ is the internal energy of excitation of the moving atom (using rest frame units) that can possibly be received on a frame at rest in order to be compatible with mass-energy conservation. Consequently, the radiation emitted from such an atom has a lower absolute energy and frequency. This can be seen from equations 3.5 and 3.6:

$$E_v[rest] = \frac{E_o[rest]}{\gamma}. \qquad 3.7$$

From equation 3.7, we see that using rest units, there is less internal energy $E_v[rest]$ in the moving atom (due to equation 2.22) than in the atom at rest ($E_o[rest]$).

The middle term of equation 3.6 represents the internal excitation energy of the moving atom in rest units while the right hand side term represents the same internal energy available that can be received by an observer at rest (also in rest units). Since the energy states of the moving atom have less energy (always in rest units), the observer at rest will detect a lower frequency (as measured using rest frame units) if that energy is emitted. We must notice that in both cases (equations 3.5 and 3.6), the constant h refers to a measurement done in the stationary frame (meaning that the measurement is made from a frame having zero velocity and using rest units) so that the parameter h must have the subscript o.

One must notice a fundamental physical mechanism implied in the decrease of internal energy in the hydrogen atom as given in equation 3.7 (using rest units). The internal potential energy in a hydrogen atom is given by equation 1.12. When the hydrogen atom is moving, equation 1.12 shows that due to the increase of velocity, the electron mass m_e and therefore the energy E_n increases by a factor γ. However, at the same time, the Planck parameter which is squared and located at the denominator also increases. The overall effect is that the internal energy E_n in the atom decreases when the velocity increases. One must then realize that when the velocity increases, the electron mass becomes larger but the decrease of the Planck parameter corresponds to a decrease of the force between the electron and the proton.

From equations 3.5, 3.6 and 3.7 we obtain that the ratio between the clock rates of the moving clock and the clock at rest is:

$$\frac{E_v[\text{rest}]}{E_0[\text{rest}]} = \frac{h_0\nu_v[\text{rest}]}{h_0\nu_0[\text{rest}]} = \frac{1}{\gamma} = \frac{\nu_v[\text{rest}]}{\nu_0[\text{rest}]}. \qquad 3.8$$

The last term $\nu_v[\text{rest}]/\nu_0[\text{rest}]$ of equation 3.8 gives the ratio between the frequencies (in rest units) of oscillation of two independent clocks having different velocities according to the Bohr equation. This relationship has nothing to do with the relative values of the frequencies of an electromagnetic wave as given in equation 2.21. In equation 3.8, there are two different frequencies emitted by two different clocks observed in a single frame. However, in the case of equation 2.21, we have a single clock emitting a single frequency observed by two independent observers located in different frames.

Let us consider figure 3.1 on which a moving clock M travels in front of a station (at rest) from A to B. Let us measure the difference of clock displays ΔCD_0 recorded on a clock located on the station at rest between the instants the moving clock M passes from A to B. We will also measure the difference of clock displays ΔCD_v recorded on the moving clock while it passes from A to B. It is clear that the absolute time (as defined in section 2.3) is the same for M to pass from A to be B in both observations.

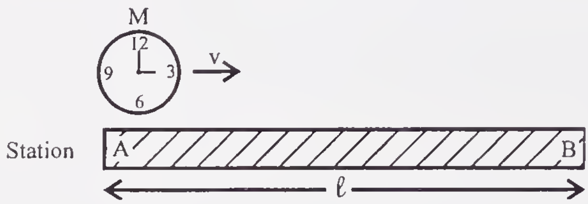

Figure 3.1

However the two clocks will not display the same difference because they do not run at the same rate. The ratio between those two differences of clock displays ΔCD_o and ΔCD_v is proportional to the ratio of the clock rates v_o[rest] and v_v[rest]. Therefore:

$$\frac{\Delta CD_v}{\Delta CD_o} = \frac{v_v[rest]}{v_o[rest]}. \qquad 3.9$$

Combining equation 3.9 with equation 3.8 gives:

$$\Delta CD_v = \frac{\Delta CD_o}{\gamma} \qquad 3.10$$

which is mathematically identical to:

$$\Delta CD_v = \frac{\gamma}{\gamma^2}\Delta CD_o. \qquad 3.11$$

From the usual definition of γ, equation 2.2:

$$\frac{1}{\gamma^2} = 1 - \frac{v^2}{c^2} \qquad 3.12$$

we find that, using equation 3.11:

$$\Delta CD_v = \gamma\left(1 - \frac{v^2}{c^2}\right)\Delta CD_o. \qquad 3.13$$

Einstein made the hypothesis that "time is what clocks are measuring". This means that the Δt in Einstein's relativity and in the Lorentz equations is only a difference of clock displays on a clock at rest to which the units of time were given:

$$\Delta CD_o = \Delta t. \qquad 3.14$$

In reality, since Δt is nothing more than a ΔCD, the units of ΔCD_o (which is a pure number) must be given to Δt. Let us give an example. It is believed that in Einstein's relativity and in the Lorentz equations, when an excited atomic state of a moving atom has not become de-excited after a classical time interval, it is because the time interval was shorter within the moving frame than in the rest frame. We have seen above that this explanation is incorrect and that the reason is that the principle of mass-energy conservation requires a change in the atom parameters and consequently, a slower internal motion inside atoms. This slower internal motion makes moving clocks function more slowly. Therefore, the Δt measured by Einstein's and Lorentz's clocks is not a time interval at all, but a difference of clock displays (ΔCD) of a clock running more slowly. The correct explanation is that when, in the Lorentz equation, we find that the $\Delta t'$ is different from Δt during the same time interval, we are fooled by clocks running at different rates in different frames. It is an error of interpretation to give time units to Δt and $\Delta t'$ in the Lorentz equations while they are no more than differences of clock displays as admitted by Einstein. Since the ΔCD is a pure number, the Δt in equation 3.14 is also a pure number. Similarly, the difference of clock displays ΔCD_v is called $\Delta t'$ in the Lorentz equations:

$$\Delta CD_v = \Delta t'. \qquad 3.15$$

A comparison with the Lorentz equations, as given with equations 3.14 and 3.15, is useful to examine some mathematical properties common to both interpretations. Equations 3.14 and 3.15 in equation 3.13 give:

$$\Delta t' = \gamma\left(\Delta t - \frac{v^2 \Delta t}{c^2}\right). \qquad 3.16$$

By definition, the number of units x representing the distance traveled during Δt (for Einstein corresponding to the time while a clock shows ΔCD_o) is:

$$x = v\Delta t \text{ or } x = v\Delta CD_o. \qquad 3.17$$

Of course, x is not a real distance, as explained in section 3.1. Let us substitute Δt from equation 3.17 to the second term Δt of equation 3.16. We get:

$$\Delta t' = \gamma\left(\Delta t - \frac{vx}{c^2}\right) \text{ or } \Delta CD_v = \gamma\left(\Delta CD_o - \frac{vx}{c^2}\right). \qquad 3.18$$

Equation 3.18 gives the relationship between Δt' (which is a difference of clock displays) displayed by a clock located at a distance x from the origin and moving at a velocity v and Δt displayed by a stationary clock. We observe that equation 3.18 is exactly the Lorentz equation for time and that it is compatible with Einstein's hypothesis that time is what clocks display. This equation is simply an exact mathematical description of mass-energy conservation in agreement with equations 2.22 and 2.23 and with the physical mechanism implied by equation 3.2 We notice finally that the Lorentz transformation for time has been demonstrated here without using the hypothesis of the constancy of the velocity of light nor any new hypothesis. We have used only the mass-energy relationship E = Km from equation 2.3. In fact, we have obtained the Lorentz equation for time without the use of any of Einstein's relativity principles.

One must conclude that the Lorentz transformation derived above is in reality a transformation of relative clock displays between frames. Then Δt and Δt' (when related to this Lorentz equation) represent differences of clock displays ΔCD.

3.4 - Length Dilation Due to Kinetic Energy.

Length dilation and contraction have been demonstrated in chapter one for matter placed in a gravitational potential. Using equation 3.4, we will now show that the Bohr equation also gives a change of length when matter acquires a velocity v. This will be done without involving the constancy of the velocity of light. According to equation 3.4, we have:

$$a_v[\text{rest}] = \gamma \frac{h_o^2}{4\pi^2 m_o e^2 k}[\text{rest}] = \gamma a_o[\text{rest}]. \qquad 3.19$$

Therefore, the relative size of the Bohr radius as a function of velocity is:

$$\frac{a_v[\text{rest}]}{a_o[\text{rest}]} = \gamma. \qquad 3.20$$

Let us consider a reference meter made of ordinary classical atoms. We see from equation 3.20 that the size of atoms, which is proportional to the Bohr radius or to the interatomic distance (see Appendix I), increases as a function of velocity. This means that the size of all material matter increases with velocity.

We know that the number of atoms N_a making up the length of a rod does not change with velocity. Furthermore, it is well established in modern physics that the interatomic distance φ_o is proportional to the Bohr radius a_o so that $\varphi_v[\text{rest}] = \gamma\varphi_o[\text{rest}]$. The length l_o of a rod is:

$$l_o[\text{rest}] = (N_a\text{-}1)\varphi_o[\text{rest}]. \qquad 3.21$$

At velocity v, the length l_v is:

$$l_v[\text{rest}] = (N_a\text{-}1)\varphi_v[\text{rest}] = (N_a\text{-}1)\gamma\varphi_o[\text{rest}]. \qquad 3.22$$

We note that the number of atoms N_a is much larger than unity. Therefore, using equations 3.21 and 3.22 we have:

$$l_v[\text{rest}] = \gamma l_o[\text{rest}] = \frac{l_o[\text{rest}]}{\sqrt{1 - \frac{v^2}{c^2}}}. \qquad 3.23$$

Equation 3.23 shows that there is length dilation of matter when its velocity increases (in a constant gravitational potential). Length dilation is a real physical phenomenon involving no stress nor any pressure, similar to length dilation and length contraction in a gravitational field, as shown in chapter one. It is just the natural equilibrium of matter given by quantum mechanics that makes it dilate at relativistic velocities. Space dilation or space contraction is meaningless.

The fact that we are led from our reasoning to length dilation instead of length contraction does not represent a problem since the assumed phenomenon of length contraction has never been observed experimentally in special relativity. On the contrary, we need length dilation to be compatible with the slowing down of clocks, which is also required by quantum mechanics and has been observed experimentally. In order to be coherent with quantum mechanics and mass-energy conservation, one must understand that there exists no length (nor space) contraction in special relativity because γ is always equal to or larger than one (equation 3.23). Only length dilation can be produced when there is an increase of velocity.

3.5 - The Lorentz Transformation for Lengths.

Let us consider two identical frames O-X at rest. The axis of those frames are constructed with many rods in series each having a length exactly equal to one reference meter (defined in section 2.4). A mass M is located at a distance x[rest] from the origin O[rest]. For a stationary observer using the reference meters located on the frame at rest, the coordinate of the mass M is:

$$x[rest] = n_o meter[rest] \qquad 3.24$$

where n_o is the number of times the meter rod, when defined at rest (meter[rest]) must be used to form the length x[rest]. The symbol n_o is a pure number measured in the stationary (subscript o) frame. We must recall that contrary to Newtonian physics, the simple use of the number n_o is not sufficient to represent a length. A length must necessarily be represented by a pure number multiplied by the length of the reference meter.

Let us give the velocity V to one of the frames that we now call O'-X'. At time t = 0, the origin O' of the moving frame coincides with the origin O of the rest frame. The axis O'-X' is arbitrarily displaced on figure 3.2 in order to avoid confusion. Before the frame O'-X' acquired its velocity, the distance between the origin O and the mass M was identical in both systems. After the frame O'-X' has reached velocity V, we have seen that the Bohr radius and all physical material on the moving frame are dilated as given by equation 3.23. Therefore the reference meters used to form the axis are longer. The mass M' on the moving frame is fixed with respect to that frame and does not move with respect to the particular segment of meter where it is fixed. Therefore the number n_v of those standard moving rods between M' and the origin O' is necessarily the same and $n_o = n_v$.

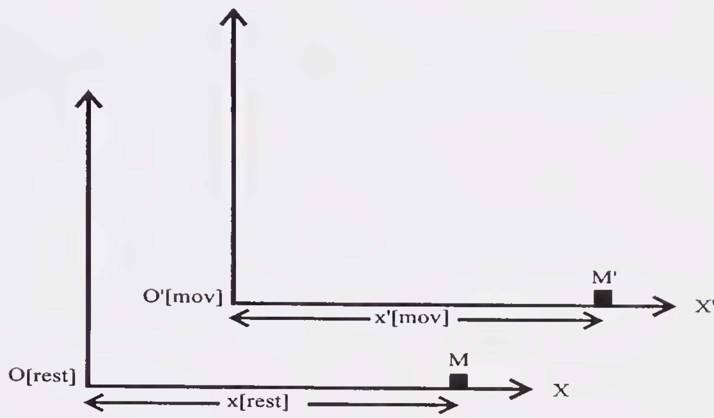

Figure 3.2

However, the absolute distance x'[mov] between M' and O' will increase because the length of the standard meter has increased due to the increase of the Bohr radius. The distance x'[mov] between M'[mov] and the origin O' is given by:

$$x'[mov] = n_v meter[mov] = n_o meter[mov] \qquad 3.25$$

with

$$n_v = n_o. \qquad 3.26$$

Using the notation x[rest] = l_o[rest] and x'[rest] = l_v[rest] equation 3.23 gives:

$$x'[rest] = \gamma x[rest] \text{ or } \Delta x'[rest] = \gamma \Delta x[rest]. \qquad 3.27$$

Equation 3.27 means that using rest frame units, the distance x' (which is O'-M') is γ times longer than the distance x (which is O-M) also using rest frame units even if the numbers of local meters n_o and n_v are the same.

3.5.1 - Apparent and Absolute Time.

In order to predict the consequences of the change of "clock" rate between systems, we must be able to compare predictions between different frames. Let us examine the relationship between the "apparent time" in different frames. In Einstein's relativity, the "time" is defined as what is perceived by each observer. It is equal to what a clock measures in its own frame. It is called t in the rest frame and t' in the moving frame.

Consequently, each frame has its own "time" but we know that it is only apparent. Real physical time does not flow faster because the local clock runs faster. For an observer at rest, Einstein's interpretation assumes that his "time" t is the one shown by his clock at rest. Similarly, the "time" t' is the apparent time in the moving frame. Since the moving clock runs at a different rate than the clock at rest (see equation 3.8), the time on the moving frame "appears" (as seen by an observer at rest) to elapse at a different rate giving:

$$t \neq t'. \qquad 3.28$$

We define the "absolute second" S_0[rest] as the time interval t taken by the atomic clock at rest (located away from any gravitational potential) to record a constant number N_s of oscillations. Since that clock at rest runs at a frequency ν_0[rest], the apparent rest second (called absolute second) will be elapsed when S_0 equals unity. This gives:

$$S_0[rest] = \frac{N_s}{\nu_0[rest]}. \qquad 3.29$$

On a moving frame, the "apparent second" S_v[mov] is equal to the time taken by the local clock moving at velocity V to record the same number of oscillations N_s. Therefore during one "apparent second" (S_v) on the moving frame (at velocity V), by definition, the clock must record the same number of oscillations as the clock on the rest frame does during one "absolute second" (S_0). This means that during one "apparent second" inside any frame, the local ΔCD is always the same number. Then, since clocks have different rates, in different frames, the "absolute duration" of the "apparent second" varies with the velocity of the frame carrying the clock.

It is arbitrarily decided that the rest second (in zero gravitational potential) is called the "absolute second of reference". Since the number of oscillations is the same for any local second, we have, for the case of apparent second S_v in a frame moving at velocity:

$$\Delta CD(S_0)[rest] = \Delta CD(S_v)[mov]. \qquad 3.30$$

From the definition of apparent seconds in a frame moving at velocity V, with equations 3.29 and 3.30, we find that the duration of one moving second is:

$$S_v[rest] = \frac{N_s}{\nu_v[rest]}. \qquad 3.31$$

In order to be able to compare "apparent seconds" generated in different frames, we must be able to express the "apparent time" duration using common units. We have from equation 3.8:

$$\nu_0[rest] = \gamma\nu_v[rest]. \qquad 3.32$$

Equation 3.32 in equations 3.31 and 3.29 gives:

$$S_v[rest] = \gamma\frac{N_s}{\nu_0[rest]} = \gamma S_0[rest]. \qquad 3.33$$

Equation 3.33 shows that the unit of time S_v in the moving frame is γ times longer than the unit of time S_0 in the rest frame.

Let us consider the "real time intervals" corresponding to the same numerical value of local apparent "x" seconds elapsed in both the rest frame and the moving frame. The ΔCD shown by either clock is the same in both frames. In Einstein's relativity, this was erroneously interpreted as the same time interval in both frames. In the rest frame, the real time t[rest] is equal to the number of seconds "x" times the duration of the apparent second S_0 at rest. This gives:

$$t[rest] = xS_0[rest]. \qquad 3.34$$

In the moving frame, the real time (in rest units) is called t'[rest]. It is equal to the number "x" of seconds times the duration of the apparent moving second S_v:

$$t'[rest] = xS_v[rest]. \qquad 3.35$$

Combining equations 3.33, 3.34 and 3.35 gives:

$$t'[rest] = \gamma t[rest] \text{ or } \Delta t'[rest] = \gamma\Delta t[rest]. \qquad 3.36$$

Equation 3.36 shows that when we consider the same number of local "apparent seconds" (i.e. the same difference of clock displays) in two different frames, the real absolute time spent on the moving frame is γ times longer that the absolute time spent on the rest frame.

Equation 3.36 is equivalent to equation 3.18 when time is measured at the same location (x = 0). However, one must understand that the change of time between systems suggested by Einstein is only apparent because clocks in different frames run at different rates. This has erroneously been interpreted as time dilation in the past, but we see now that it is nothing else than clocks running at different rates in different frames.

3.5.2 - Relationship between Velocities V and V'.

On figure 3.2, the right hand side direction of the axes O-X and O'-X' is positive in both frames. When the moving frame O'-X' has a velocity toward the right hand side, the coordinate of the location M' increases (in time) with respect to the rest frame O-X. Therefore location M' has a positive velocity with respect to the rest frame O-X. However, figure 3.2 shows that when the moving frame (with origin O') travels to the right hand side, location M moves to the left hand side with respect to the frame O'-X'. The coordinate of location M is getting more and more negative (in time) with respect to the frame O'-X', while the coordinate of location M' is getting more positive in time with respect to the frame O-X. This means that the velocity V' of point M' (with respect to O-X) has the opposite sign of the velocity V of point M with respect to O'-X'. This result comes out of pure geometrical considerations illustrated on figure 3.2. Therefore:

$$\frac{V}{|V|} = -\frac{V'}{|V'|}. \qquad 3.37$$

Equation 3.37 signifies that the velocities have opposite directions. We will show now that the velocities V and V' have the same magnitude.

3.5.3 - Relative Velocities within Systems.

Let us consider a rest frame and a moving frame. Both frames were identical before the moving frame started to move at velocity V[rest]. Inside both frames, we consider rods that had the same length when they were initially in the same frame at rest. This can be verified later if we count the same number of atoms in both frames for the length of either rods. The rod at rest extends from O to M and the moving rod extends from O' to M'.

There are at least two different ways to compare velocities between frames. One way consists of measuring directly the velocity in each frame using proper values and comparing numbers. Another way, the one we will use here, is to use a definition of velocity in each frame and to compare the corresponding elements of the definitions. The velocity u of a moving object across O-M with respect to the rest frame is <u>defined</u> as:

$$u[rest] = \frac{\Delta x[rest]}{\Delta t[rest]}. \qquad 3.38$$

With equation 3.38, we start dealing with a series of equations related to velocities. These velocities can have any direction in space and might be described by vectors. However, such a description would lead to a very heavy notation that could be confusing and would require useless efforts. This is avoided by defining that in every equation between 3.38 and 3.46, we consider that u and u' represent the magnitudes |u| and |u'| of these parameters. The appropriate mathematical sign of the velocities will be considered starting with equation 3.46.

Inside the moving frame, a similar slowly moving object moves from O' to M' (distance Δx'). During the time Δt' the slow moving object crosses the distance Δx' from O' to M'. The velocity of the slow moving object with respect to the moving frame is <u>defined</u> as:

$$u'[mov] = \frac{\Delta x'[mov]}{\Delta t'[mov]}. \qquad 3.39$$

We have seen that, before the moving rod (O'-M') started to move, it was similar to the rod in the rest frame (O-M) and that both clock rates were similar. Consequently, we can use equations 3.27 and 3.36. Let us put the transformation of coordinates given by equations 3.27 and 3.36 into the equation 3.38. We get:

$$u[rest] = \frac{\Delta x[rest]}{\Delta t[rest]} = \frac{\gamma \Delta x'[rest]}{\gamma \Delta t'[rest]} = \frac{\Delta x'[rest]}{\Delta t'[rest]}. \qquad 3.40$$

Let us use equation 3.23 to calculate the ratio between the units of length. If the length l_o is a unit of length equal to one meter using rest units, we see that this unit of length becomes γl_o on the moving frame. Therefore the relationship between the units of length is:

$$l_o[\text{mov}] = \gamma l_o[\text{rest}] \text{ or } \text{meter}[\text{mov}] = \gamma\text{meter}[\text{rest}]. \qquad 3.41$$

This means that when we move from the rest frame to the moving frame, the unit of length becomes γ times longer. Therefore, in order to represent the same physical length using longer units of length, the number of units Δx'[mov] must be smaller. This gives:

$$\Delta x'[\text{mov}] = \frac{\Delta x'[\text{rest}]}{\gamma}. \qquad 3.42$$

In the case of time, a corresponding phenomenon takes place. Let us consider equation 3.36. We see that a time interval Δt_o equal to one unit of time in the rest frame becomes γ times larger in the moving frame because it takes more time for the slower clock to show the same ΔCD. In that case, we see from equation 3.36 that the change of local units of time Δt_o between frames gives:

$$\Delta t_o[\text{mov}] = \gamma\Delta t_o[\text{rest}] \text{ or } \sec[\text{mov}] = \gamma\sec[\text{rest}]. \qquad 3.43$$

This means that when we move from the rest frame to the moving frame, the local unit of time becomes γ times larger. Therefore in order to represent the same absolute time interval using longer units of time, the number of units Δt'[mov] must be smaller. This gives:

$$\Delta t'[\text{mov}] = \frac{\Delta t'[\text{rest}]}{\gamma}. \qquad 3.44$$

Equations 3.39, 3.40, 3.42 and 3.44 give:

$$u[\text{rest}] = \frac{\Delta x[\text{rest}]}{\Delta t[\text{rest}]} = \frac{\Delta x'[\text{rest}]}{\Delta t'[\text{rest}]} = \frac{\Delta x'[\text{mov}]}{\Delta t'[\text{mov}]} = u'[\text{mov}]. \qquad 3.45$$

Equation 3.45 shows that the velocity u measured using the rest frame units is the same as the velocity u' using the moving frame units.

Among the values of velocities which can be given to u, we can choose the velocity V which is the velocity of the moving frame with respect to the rest frame (rest frame units). Symmetrically, let us call V' the velocity u' of the rest frame with respect to the moving frame (using moving frame units). Using equations 3.37 and 3.45 gives:

$$V = -V' \qquad 3.46$$

or

$$V_0[rest] = -V_v[mov]. \qquad 3.47$$

Equation 3.46 shows that the proper value of the velocity of the moving frame with respect to the rest frame is the same (negative) as the proper value of the velocity of the rest frame with respect to the moving frame.

Let us add that a velocity appears as a physical concept for a physicist. However, we have seen above that a comparison of velocities in two different frames having a relative velocity leads to the same numbers. We have seen that when we are in a moving frame, the ratio between the distance traveled and the time taken to travel it changes with respect to the rest frame. Both the numerator (the distance) and the denominator (time interval) change by the same ratio. Consequently, a constant velocity is nothing more that a constant ratio between two fundamental physical quantities. One can say that the constant velocity in different frames means the same thing as three oranges out of six is the same thing as four apples out of eight. Velocities are just ratios of physical quantities.

3.5.4 - Lorentz's Second Relationship.

In order to find the dynamical relationship between the coordinates x' and x, let us now combine the quantities x, V and t calculated above. In classical mechanics inside the moving frame we have:

$$x' = x_0' + V't' \qquad 3.48$$

where x_0' is the coordinate x at t = 0 and V' is the velocity between frames. In order to be more specific, in complete notation, equation 3.48 should be:

$$x_v[mov] = x_{ov}[mov]+V_v[mov]t_v[mov]. \qquad 3.49$$

Let us consider first in equation 3.49 the expression $t_v[mov]$. The term t_v represents the number of units that is multiplied by the length of the unit [mov]. Let us calculate what would be the quantity $t_v[mov]$ using the [rest] units of length instead of the [mov] units of length.

From equation 3.44, we have:

$$t_v[rest] = \gamma t_v[mov]. \qquad 3.50$$

In the case of the units of distance (x_v or x_{ov}) we use again the same method. With the help of equation 3.42 we find:

$$x_v[rest] = \gamma x_v[mov] \qquad 3.51$$

and

$$x_{ov}[rest] = \gamma x_{ov}[mov]. \qquad 3.52$$

From equation 3.49, transforming $x_v[mov]$ with 3.51, $x_{ov}[mov]$ with 3.52, and $t_v[mov]$ with 3.50, we get after multiplying both sides by γ:

$$x_v[rest] = x_{ov}[rest]+V_v[mov]t_v[rest]. \qquad 3.53$$

From equation 3.53, transforming $x_{ov}[rest]$ with 3.27, $V_v[mov]$ with 3.47, and $t_v[rest]$ with 3.36, we get:

$$x_v[rest] = \gamma(x_{oo}[rest]-V_o[rest]t_o[rest]). \qquad 3.54$$

Using a more conventional notation this is:

$$x' = \gamma(x-Vt). \qquad 3.55$$

Equation 3.55 gives the relationship between the coordinate x' on the moving frame and the coordinate x, the velocity V and the time t on the rest frame. This relationship results solely from mass-energy conservation and quantum mechanics without using any of Einstein's relativity principles. However, equation 3.55 is exactly identical to the Lorentz equation related to lengths. The demonstrations leading to equations 3.18 and 3 55 show the uselessness of Einstein's special relativity principles. Most importantly, this demonstration provides a way to give a logical interpretation to experiments without space or time contraction or dilation.

3.6 - Constant Velocity of Light within Any Frame of Reference.

We must notice that c is also a velocity obtained from the quotient of a distance by time within any frame. Let us consider that the internal velocity u is the velocity of light c. In the moving frame, the velocity u' equals c'. Therefore when the velocities u and u' considered are applied to light, equation 3.45 gives:

$$c = c'. \qquad 3.56$$

When we use the complete notation, we get:

$$c_v[mov] = c_o[rest]. \qquad 3.57$$

This means that following equations 3.45 and 3.56, one must conclude that the physical mechanism resulting from mass-energy conservation and quantum mechanics leads to the conclusion (not the hypothesis) that any velocity, including the velocity of light, is constant as measured within any frame (using proper values). Contrary to Einstein and Lorentz, we do not have to make the arbitrary hypothesis that the velocity of light is constant inside all frames. We have found that the constancy of the velocity of light is a necessary conclusion to mass-energy conservation and the quantum mechanical equations.

From another point of view, the value of c, called the velocity of light, has been defined in section 2.4 as the square root of K (the quotient between energy and mass) which is the fundamental basis of mass-energy equivalence. Any theory or experiment not compatible with the constancy of the velocity of light (using proper values) is therefore necessarily not compatible with quantum mechanics and mass-energy conservation. However, since the velocity of light is given as the quotient of two quantities (length and ΔCD) that are different in different frames, the physical meaning of that constant ratio is subtle.

3.7 - Non-Reality of Space Dilation, Contraction or Distortion.

The distance Δx traveled in a time interval Δt is defined as:

$$\Delta x = v\Delta t. \qquad 3.58$$

Let us assume an observer traveling between the ends of a long stationary rod having a length Δx. That length Δx is calculated from the velocity v times the time interval Δt necessary to travel between the ends of the rod. We know that the velocity v is the same on any frame. However, the difference of clock displays ΔCD_0 (which is interpreted as time Δt by Einstein) on the rest frame is different from ΔCD_v (interpreted by Einstein as time interval $\Delta t'$) on the moving frame. Consequently, according to Einstein's interpretation, the length $\Delta x'$ measured by the moving observer is different from the length Δx of the same rod measured by the observer at rest. At the velocity of light, the ΔCD_c decreases to zero so that the (apparent Einstein's) length $\Delta x'$ becomes zero for the moving observer because his moving clock has stopped running.

It is irrational to claim that the length of the stationary rod changes and even becomes zero just because the observer changes his velocity. How can the length of a rod logically change because a non interacting observer looks at it? The rod would become longer or shorter depending on the observer's own velocity. The length (and other properties) of the rod would not be a property that would belong to matter. It is the observer that would set the length of the rod and different observers would simultaneously find different lengths for the same rod depending on their observing conditions. Then, what would be the length of the rod if there were no observer? It is just like the statement that the moon is not there when nobody is looking at it. We believe that this is nonsense and that the length of matter is independent of the observer. This is the same irrationality that appears in quantum mechanics and which has already been discussed [1].

We have not yet defined how to measure space. This is because space is not measurable unless we fill it up at least partially with matter. Then, it is that matter that we measure, not space. Whether space is empty or full of matter, we generally refer to it as "space". We know several methods of measuring lengths of objects but there does not exist any method of measuring space without using matter as a reference. In relativity, space is often referred to as being contracted or dilated. How can it be contracted or dilated when there is no method of measuring it without assuming some matter in it? The properties of matter are then inadvertently attributed to or confused with space. The same comment applies to the belief of space distortion. How can there be space distortion when we cannot measure space directly in the absence of matter? The interpretation of space distortion is nothing more than a change of the Bohr radius in the measuring instrument or in the matter filling the space.

This problem is easily solved logically when we consider that the internal atomic mechanism of the observer runs at a different rate since electrons in motion have a different mass. This has nothing to do with the illusion of space dilation or distortion. One must conclude that the expressions "space contraction" and "space distortion" are irrational. They bring confusion and must be eliminated.

3.8 - Transformation of Units in Different Frames.

There are many other consequences to the relativistic changes of lengths and masses. For example, in chapter one we have seen that the mass of particles decreases when located at rest in a lower gravitational potential. In chapter three we have seen that masses increase with velocity due to the absorption of kinetic energy. This means that if we take an object of one kilogram on Earth and move it to a location at rest on the solar surface, about one millionth of its mass will disappear and be carried away by the energy generated during the slowing down of the object falling into the Sun. Even if there is exactly the same number of atoms in one Earth kilogram after it is carried on the Sun's surface, we see that the solar kilogram has less mass than the Earth kilogram using any common frame of comparison of mass units. Consequently, there is more energy (in Earth joules) in one Earth kilogram than in one solar kilogram. This is required by the principle of mass-energy conservation.

Similar considerations must be applied to most physical constants. Because of the principle of mass-energy conservation, the units must always be specified (kg[Earth], meter[Earth], joule[Earth], second[Earth]). However, the electric charge appears to be constant in any frame. This means that the ratio of the electron charge divided by the electron mass (e/m) is different in different frames. For example, e/m is smaller on Earth (when using Earth units) than on the solar surface (using Earth units). In order to be able to compare those quantities with the ones calculated in different frames, we must take into account the difference of gravitational potential or the difference of kinetic energy. To define accurately the reference kilogram, the reference meter, etc., we must know the exact altitude on Earth at which these units have been defined.

3.9 - Failure of the Reciprocity Principle.

We have studied above some of the differences existing between a frame in motion and a frame at rest. In a moving frame, clocks run at a slower rate, the Bohr radius is larger and so are masses because of their kinetic energy. Let us consider a body on the rest frame having a mass m_o[rest]. Its total energy is:

$$E_o[\text{rest}] = m_o[\text{rest}]c^2. \qquad 3.59$$

When m_o[rest] is accelerated to velocity v_o[rest] with respect to the rest frame, its mass becomes m_v[rest]. We get:

$$m_v[\text{rest}] = \gamma m_o[\text{rest}] = m_o[\text{rest}] + m_o \frac{v_o^2}{2c^2}[\text{rest}] + \ldots \qquad 3.60$$

Equation 3.60 shows that the moving mass m_v[rest] is larger than the rest mass m_o[rest]:

$$m_v[\text{rest}] > m_o[\text{rest}]. \qquad 3.61$$

Let us consider now a train moving at velocity v_o[rest] carrying an observer and the mass mentioned above. The mass of the train, of the observer and of the body described above becomes γ times larger than when at rest. However, since the units in the moving train have been modified by the same ratio γ, the changes of mass, clock rate and length are undetectable to the moving observer, even if they are real. Inside the moving train, an observer using Einstein's reciprocity principle will claim that the object of mass m_v[rest] is at rest with respect to him. He will thus call it M_o[rest]. Therefore:

$$M_0[rest] \equiv m_v[rest] = \gamma m_o[rest]. \qquad 3.62$$

It is because we use Einstein's hypothesis of reciprocity that we write [rest] after M_o in equation 3.62, since Einstein's hypothesis assumes that the mass that has been transferred to the train is now at rest for the observer moving with the train. Furthermore, the symbol ≡ used in equation 3.62 does not mean that we are defining a new quantity. The symbol ≡ means that M_o is the same object in the same physical condition as m_v[rest].

Now, the moving observer takes the object of mass M_0[rest] (that is stationary with respect to him) and throws it at velocity v_0[rest] with respect to his moving train (considered at rest in his frame) in the direction opposite to the direction of motion of the train. According to Einstein's principle of reciprocity, the mass projected at velocity v_0[rest] with respect to the moving frame acquires velocity and energy with respect to the moving frame (now considered at rest). Einstein's principle of reciprocity says that all frames are identical which means that mass M_0[rest] increases when accelerated with respect to the train to become M_v[rest]. In fact, the reciprocity principle implies that the passage of the object of mass M_0[rest] from zero velocity$_0$[rest] to v_o[rest] (with respect to the train) increases its mass by γ times, <u>independently of the direction of the velocity of the mass with respect to the train</u>. This gives:

$$M_v[rest] = \gamma M_0[rest]. \qquad 3.63$$

As expected from the relativity principle, equation 3.63 shows that mass M_v[rest] is larger than M_0[rest] giving:

$$M_v[rest] > M_0[rest]. \qquad 3.64$$

A physical representation of these changes of velocity shows that the mass M_v[rest] now has zero velocity with respect to the rest frame. It is back at rest on the rest frame. Mass M_v[rest] is then physically undistinguishable from mass m_0[rest] since it is the very same object having the same zero velocity with respect to the same rest frame. Therefore physically, we must have:

$$M_v[rest] \equiv m_0[rest]. \qquad 3.65$$

Combining equations 3.62, 3.63 and 3.65 gives:

$$m_o[rest] \equiv M_v[rest] = \gamma^2 m_o[rest]. \qquad 3.66$$

Obviously, equation 3.66 is correct only if γ equals unity so that the velocity must always be zero. This shows that the principle of reciprocity cannot be valid when we apply the principle of mass-energy conservation. We must conclude that Einstein's reciprocity principle is not coherent.

Contrary to Einstein's claim, the energy given to a mass accelerated with respect to the train must depend on the direction of its velocity with respect to the direction of the velocity of the train. When the directions are opposite, the two velocities (whose magnitudes are equal) cancel out and the mass of the body must come back to its original value in the rest frame. Otherwise we would discover that atoms of matter having traveled to another frame would have a different mass after their return to the initial frame. We must conclude that two frames cannot be equivalent when there exists a relative motion between them.

3.10 - References.

[1] P. Marmet, Absurdities in Modern Physics: A Solution, ISBN 0-921272-15-4, Les Éditions du Nordir, c/o R. Yergeau, 165 Waller, Ottawa, Ontario K1N 6N5, 144p. 1993.

3.11 - Symbols and Variables.

a_o[rest]	Bohr radius at rest in rest units
a_v[rest]	Bohr radius in motion in rest units
ΔCD_o	difference of clock displays on a clock at rest
$\Delta CD(S_o)$[frame]	ΔCD corresponding to an apparent second in any frame
ΔCD_v	difference of clock displays on a clock in motion
$E_{n,o}$[rest] = E_o[rest]	energy of the Bohr atom at rest in state n in rest units
$E_{n,v}$[rest] = E_v[rest]	energy of the Bohr atom in motion in state n in rest units
h_o[rest]	Planck parameter on the rest frame in rest units
h_v[rest]	Planck parameter on the frame in motion in rest units

l_o[rest]	length of a rod at rest in rest units
l_v[rest]	length of a rod in motion in rest units
ν_o[rest]	clock rate of a clock at rest in rest units
N_s	number of clock oscillations in an apparent second
ν_v[rest]	clock rate of a clock in motion in rest units
(S_o)[rest]	definition of the absolute second in rest units
(S_v)[rest]	duration of one moving second in rest units
u[rest]	definition of the velocity in the rest frame in rest units
u'[rest]	definition of the velocity in the moving frame in rest units
$V = V_o$[rest]	velocity of M with respect to the moving frame in rest units
$V' = V_v$[mov]	velocity of M' with respect to the rest frame in motion units
x[rest]	distance between O and M in rest units
x'[mov]	distance between O' and M' in motion units

Chapter Four
Fundamental Nature of the Mechanism Responsible for the Advance of the Perihelion of Mercury.

4.1 Definition of the Absolute Standard Units [o.s.].

In order to understand the mechanism responsible for the advance of the perihelion of Mercury, we need to explain the meaning of quantities such as an absolute standard of mass, time or length. The meaning of absolute standards is such that each of them must always represent the same and unique physical quantity in any frame. This condition is necessary since the absolute length of a rod does not change because it is measured from a different frame. This also applies to an absolute time interval and an absolute mass: they do not change when measured in different frames. However, an absolute length, time interval or mass can be described using different parameters (e.g. different units). One must conclude that lengths, time intervals and masses are absolute and exist independently of the observer. They never change as long as they remain within one constant frame. However, they appear to change with respect to an observer who moves to a different frame because they are then compared with new units located in a different frame.

In relativity, we always read an expression with respect to a frame "of reference". The phrase "of reference" gives the illusion that masses, lengths and clock rates really change as a function of the "reference" used to measure them. That there could be a real physical change of mass, length and clock rate because the observer uses a different "reference" does not make sense. This apparent change of length, clock rate or mass is simply due to the observer using different units of comparison. In this book, we avoid the words "of reference" because they are clearly misleading.

We have seen that when a rod changes frames, its absolute length changes. However, when an observer carrying his reference meter changes frames, the length of the rod that remains at rest corresponds to a different number of the observer's new reference meter. When a rod changes frames, the change of its length is real as seen in chapters one and three. However, when the observer changes frames (with his reference meter) and the rod does not, there is only a change in the number of measured meters; the rod does not change. Consequently, the change of frame of the rod and the change of frame of the observer (carrying his reference meter) are not symmetrical.

4.2 - The Absolute Reference Meter.

The usual definition of the meter is 1/299 792 458 of the distance traveled by light during one second. The local clock is used to determine the second. We recall from section 2.4 that this definition is not absolute because it depends on the definition of the second which is a function of the local clock rate which changes from frame to frame.

Unfortunately, there is no direct way to reproduce an absolute meter within a randomly chosen frame. We have seen that carrying a piece of solid matter from one frame to another one (in which the potential or kinetic energy is different) leads to a change of the Bohr radius and consequently to a change in the dimensions of the piece of matter. However, a local meter can apparently be reproduced in any other frame using a solid meter previously calibrated in outer space and brought to the local frame. Of course, the absolute length of that local meter in the new frame will not be equal to its absolute length when it was in outer space because the potential and kinetic energies may change from frame to frame.

One can also reproduce a local meter in any frame by calculating 1/299 792 458 of the distance traveled by light in one local second. However, the duration of the local second must be corrected with respect to the reference clock-rate existing in outer space (with $v = 0$). It is illusionary to believe that absolute time and absolute length can be obtained in any frame just by carrying a reference atomic clock and a reference meter to the new frame.

We define the absolute reference meter ($meter_{o.s.}$) as the distance traveled by light during 1/299 792 458 of a second given by a clock located at rest in outer space away from any mass. The subscript o.s. defines where the meter is located. This unit of length is equal to a number $B_{o.s.}$ times the length of the Bohr radius $a_{o.s.}$ in outer space. An absolute reference meter must have the same absolute physical length, independently of the frame where it is located (and of the frame where the observer is located). Consequently, an observer must make relevant corrections to his local meter to reproduce the absolute reference meter. The definition of the absolute reference meter is then:

$$\text{meter}_{o.s.} = B_{o.s.} a_{o.s.}. \qquad 4.1$$

The absolute meter can be reproduced in any frame but it is defined with respect to a length in outer space. The constant $B_{o.s.}$ (the inverse of the Bohr radius) is about 1.8897263×10^{10}. Since the Bohr radius a varies with the electron mass (which changes with potential and kinetic energies), the constant number $B_{o.s.}$ times the outer space Bohr radius a is not an absolute standard when the meter is not located in outer space. The Earth meter (meter_E) is different from the absolute reference meter ($\text{meter}_{o.s.}$) because the Bohr radius is longer on Earth. The length of the Earth meter is:

$$\text{meter}_E = B_{o.s.} a_E. \qquad 4.2$$

We see that the length of a meter at a Mercury distance from the Sun is also different from the length of a meter in outer space or on Earth. Let us study the example of Mercury since we wish to predict a phenomenon taking place at the distance from the Sun where Mercury is orbiting. The length of the Mercury meter (meter_M) is:

$$\text{meter}_M = B_{o.s.} a_M. \qquad 4.3$$

In order to avoid useless lengthy repetitions, we will shorten some of the descriptions. Instead of repeating that we refer to a location at the Mercury distance from the Sun which has zero orbital velocity, we will simply say "Mercury location" and the context will provide the supplementary information. The velocity component of Mercury will be considered separately later. All other parameters will be taken into account only later because they are not relevant in this chapter and would bring confusion. An absolute standard of reference will sometimes be called in short "absolute meter", "absolute time rate" or "absolute mass" when it corresponds to the standard established in outer space.

In the problems considered in these first chapters, the relative changes of length, time rate and mass will always be extremely small. In the case of Mercury, which is the closest planet to the Sun, these changes will be as small as about one part per billion. Consequently we will regularly simplify the calculations by using only the first order. This will be an excellent approximation. The derivative of the function will then become equal to the finite difference as used in chapter one. This does not change the fundamental understanding of the phenomenon as we will see below.

We have seen in equation 4.1 that the absolute reference meter is a constant number of times ($B_{o.s.}$) the Bohr radius in outer space ($a_{o.s.}$). However, the Bohr radius does not change solely with the gravitational potential. It also changes with velocity. We define the absolute outer space meter as being a meter in outer space with zero velocity. From equation 1.22, the relationship giving the Bohr radius a when there is no change of velocity is (using outer space units):

$$\frac{\Delta a}{a} = \frac{a_{o.s.} - a_M}{a_{o.s.}} = -\frac{g\Delta h}{c^2} \qquad 4.4$$

which gives:

$$a_M = a_{o.s.}\left(1 + \frac{g\Delta h}{c^2}\right) \qquad 4.5$$

where mgΔh is the change of potential energy (Pot.) of a mass m in a gravitational field across height Δh. In the case of a central force, Newton's laws say that the gravitational potential (Pot.) of a body decreases when the distance (R) from the central body increases. The gravitational potential of a body of mass M(M̲) (in the case of Mercury) at a distance R_M from the Sun of mass M(S̲) with respect to outer space is:

$$\text{Pot.} = \frac{GM(\underline{M})M(\underline{S})}{R_M} = M(\underline{M})g\Delta h[o.s.] \qquad 4.6$$

where G is the Cavendish gravitational constant and g is the gravitational acceleration where the mass is located (here in the solar gravitational field).

In previous chapters, we have used the brackets [rest] and [mov] to indicate the units. From now on, depending on whether we refer to the units of length, mass, clock rate, etc., located in outer space (free from a gravitational potential) or units in the gravitational potential of Mercury, we will use the indices [o.s.] or [M]. The units will always be "translated" in absolute units (e.g. Mercury second = 1.01 absolute seconds). Using equations 4.1, 4.3, 4.5 and 4.6, we find that the length of the Mercury meter ($meter_M$) compared with the absolute reference meter ($meter_{o.s.}$) is:

$$meter_{o.s.} = meter_M \left(1 + \frac{GM(\underline{S})}{c^2 R_M}\right)^{-1} . \qquad 4.7$$

We recall that the length of the meter ($meter_{o.s.}$) in outer space is the absolute standard reference. However, we know that when an observer is located on a different frame to measure a given length, he finds a different answer because his unit of comparison (his local meter) is different.

It is useless here to specify the units of $GM(\underline{S})/c^2R_M$. Logically, they should be coherent i.e. either [M] or [o.s.]. Physically, it makes no difference whether the units of G, $M(\underline{S})$ or R are the same or not since the error brought in this way is of the order of 10^{-9} on $GM(\underline{S})/c^2R_M$ which is itself of the order of 10^{-9} with respect to the meter.

4.3 - The Absolute Reference Second.

An equivalent transformation must be taken into account when time is defined. We can evaluate time on different frames using a local cesium clock. However, one must recall that the rate of such a clock (or of any other clock) changes with the electron mass and therefore with the potential and kinetic energies where the clock is located. Therefore a correction must be made if we want to know the absolute time.

For the case of zero gravitational potential, we now define an absolute time interval called the absolute reference second just as in section 3.5.1 where the second was defined for the case of zero velocity. During one absolute second, a cesium clock makes N(S) (where the index (S) refers to the definition of a second) oscillations that are counted from the number of cycles of electromagnetic radiation emitted. That cesium clock must be located outside the gravitational potential of the Sun and have zero velocity. By definition, that absolute time interval will be called the "outer space second". We have:

$$\text{absolute ref. second} \equiv N(S) \text{ Oscillations (cesium clock}_{o.s.}). \quad 4.8$$

During one absolute second, a cesium clock in outer space emitting N(S) cycles shows a difference of clock displays labeled $\Delta CD_{o.s.}(S)$. We must emphasize that $\Delta CD_{o.s.}(S)$ does not correspond to any value of ΔCD, it corresponds only to the number of counts on the outer space clock leading to the absolute second. This is shown by (S) following the ΔCD. Consequently, $\Delta CD_{o.s.}(S)$ representing the absolute reference second must not be confused with a simple value of ΔCD_{frame} (without (S)) which can be any number of seconds. We have:

$$1 \text{ abs. sec.} \equiv \Delta CD_{o.s.}(S) \equiv N(S) \text{ Oscillations(cesium clock}_{o.s.}). \quad 4.9$$

When an observer on Mercury observes that his cesium clock has emitted the same number N(S) of cycles, the absolute time interval elapsed is not the absolute second since the Mercury clock is slower. That time interval is called the Mercury second. We have:

$$1 \text{ Mercury sec.} \equiv \Delta CD_M(S) \equiv N(S) \text{ Oscillations(cesium clock}_M). 4.10$$

Therefore we define one "local second" as the time elapsed when the numerical value shown on a local frame is equal to $\Delta CD_{frame}(S)$. Of course, the Mercury second represented by $\Delta CD_M(S)$ lasts longer than the outer space second represented by $\Delta CD_{o.s.}(S)$ because even if the differences of clock displays $\Delta CD_{o.s.}(S)$ and $\Delta CD_M(S)$ are equal, the Mercury clock is slower. Consequently, during one local second, we have for the outer space clock the same ΔCD than for the Mercury clock:

$$1 \text{ local second} \equiv \Delta CD_{frame}(S). \quad 4.11$$

Since the principle of mass-energy conservation and Bohr equation teach us by how much the rates of two clocks located in outer space and on Mercury differ, an observer on Mercury can calculate the absolute time using his Mercury clock and making suitable corrections due to the gravitational potential at Mercury location (we will consider the velocity of Mercury later).

Let us consider that a clock in outer space records a difference of clock displays equal to the number $\Delta CD_{o.s.}$. The corresponding absolute time interval elapsed is called $\Delta\tau_{o.s.}[o.s.]$. That absolute time interval can be measured on different locations like Mercury or outer space. For a phenomenon taking place in outer space, a time interval can be written:

$$\Delta\tau_{o.s.}[o.s.] = \Delta CD_{o.s.}(o.s.)\Delta CD_{o.s.}(S) \qquad 4.12$$

where $\Delta\tau_{o.s.}[o.s.]$ is the absolute time interval, $\Delta CD_{o.s.}(o.s.)$ is the <u>number</u> of seconds shown by the outer space clock and $\Delta CD_{o.s.}(S)$ is the absolute unit of time in outer space given by the o.s. clock.

In equation 4.12, the symbol [o.s.] after $\Delta\tau_{o.s.}$ is due to the units of time $\Delta CD_{o.s.}(S)$. The parentheses in $\Delta CD_{o.s.}(o.s.)$ indicate the units used for the measurement. The subscript o.s. of $\Delta\tau_{o.s.}[o.s.]$ and $\Delta CD_{o.s.}(o.s.)$ refers to the location where the phenomenon takes place (this is different from what we did in chapter three). When an outer space phenomenon is observed using a Mercury clock, the absolute time interval $\Delta\tau_{o.s.}[M]$ measured on a clock on Mercury is given by the relationship:

$$\Delta\tau_{o.s.}[M] = \Delta CD_{o.s.}(M)\Delta CD_{M}(S) \qquad 4.13$$

where $\Delta CD_{o.s.}(M)$ is the <u>number</u> of Mercury seconds and $\Delta CD_{M}(S)$ is the unit of time of the clock located on Mercury, as described in equation 4.10.

Of course, a Mercury second is not equal to one real outer space second. The absolute second is defined in outer space. Therefore a Mercury second is not a real time interval. It corresponds to a difference of clock displays which can be described as an apparent time on Mercury.

If a phenomenon taking place in outer space is measured using a clock located in outer space, its duration will be represented by the absolute time interval $\Delta\tau_{o.s.}[o.s.]$ (equation 4.12). If this same phenomenon is measured using the Mercury clock, the same absolute time interval will be represented by $\Delta\tau_{o.s.}[M]$ (equation 4.13). Of course, one single phenomenon does not last a longer absolute time because it is observed from a different location using a different clock. The real absolute duration is the same in any frame. This gives:

$$\Delta\tau_{o.s.}[o.s.] = \Delta\tau_{o.s.}[M]. \qquad 4.14$$

Using equations 4.12 and 4.13 in 4.14, we find:

$$\Delta CD_{o.s.}(o.s.)\Delta CD_{o.s.}(S) = \Delta CD_{o.s.}(M)\Delta CD_{M}(S). \qquad 4.15$$

4.3.1 - Example.

In order to clarify this description, let us give a numerical example. Let us assume that an atomic clock located in outer space has emitted 20 times N(S) cycles of E-M radiation. After N(S) cycles, one more absolute second $\Delta CD_{o.s.}(S)$ has elapsed and this is repeated $\Delta CD_{o.s.}(o.s.)$ times (with $\Delta CD_{o.s.}(o.s.) = 20$). Consequently, the corresponding time interval $\Delta\tau_{o.s.}[o.s.]$ elapsed is 20 absolute (or outer space) seconds, as given in equation 4.12. That same clock is moved to a stationary location (for example Mercury) near a very massive star so that the relativistic electron mass decreases by 1.0% due to the change of gravitational potential. Quantum mechanics shows that the atomic clock will then run at a rate which is 1.0% slower (as explained in chapter one). Consequently, since the atomic clock on that planet is slower than when it was in outer space, it will take a longer absolute time to make the same number N(S) of oscillations. Since the Mercury second is defined (in equation 4.10) as the time required for the clock on Mercury to emit N(S) cycles, it is longer than the outer space second. This gives:

$$1 \text{ Mercury second} = 1.01 \text{ Absolute second}. \qquad 4.16$$

Consequently, during the time interval in which the outer space clock will record an absolute time interval $\Delta\tau_{o.s.}[o.s.]$ equal to 20 outer space seconds ($\Delta CD_{o.s.}(o.s.)$), the Mercury clock will record a smaller $\Delta CD_{o.s.}(M)$ because it runs at a slower rate. The $\Delta CD_{o.s.}(M)$ recorded on Mercury will be 1.0% smaller:

$$\Delta CD_{o.s.}(M) = \frac{\Delta CD_{o.s.}(o.s.)}{1.01} \qquad 4.17$$

giving the numerical value:

$$\Delta CD_{o.s.}(M) = \frac{20}{1.01} = 19.80198. \qquad 4.18$$

Therefore, in agreement with equation 4.14, since the Mercury second lasts longer, as seen in equation 4.16, the total absolute time elapsed on Mercury ($\Delta\tau_{o.s.}[M]$) is the same as the total absolute time in outer space. We find in equation 4.12:

$$\Delta\tau_{o.s.}[o.s.] = 20 \times 1 \text{ absolute second} = 20 \text{ absolute seconds}. \qquad 4.19$$

From equations 4.13, 4.16 and 4.18 we have:

$$\Delta\tau_{o.s.}[M] = 19.80198 \times (1.01 \text{ abs. seconds}) = 20 \text{ abs. seconds}. \qquad 4.20$$

Therefore, $\Delta\tau$ is a real absolute time interval in all frames.

4.3.2 - Relative Clock Displays between Frames.

We have seen that the clock used in each frame simply counts the number of cycles emitted by the local atomic clock. In all frames, the local second is equal to the count of N(S) cycles on the local clock. During one absolute time interval, the number of cycles is then proportional to the absolute clock rate which is its absolute frequency as given by equation 1.22 (when v = 0). Therefore, during one absolute time interval, the ratio of the differences of clock displays between frames is directly proportional to the ratio of the natural frequency of each clock. This gives:

$$\frac{\Delta CD_{o.s.}(o.s.)}{\Delta CD_{o.s.}(M)} = \frac{\nu_{o.s.}}{\nu_M}. \qquad 4.21$$

Equation 4.21 gives the relative frequencies of clocks located in different frames. Obviously, it does not matter whether the phenomenon measured is in outer space or on Mercury, as long as both clocks measure the same phenomenon. This means that the subscripts of the left hand side of 4.21 could both be M instead of o.s.. If there is a difference of kinetic energy between the frames, equation 3.9 must be applied. Any difference of clock rate is caused by the difference of gravitational potential and/or kinetic energy between an outer space location and the orbit of Mercury. In the case of pure potential energy, using equations 1.22 and 4.6, the relative clock rate is given by the relationship:

$$\frac{\Delta\nu}{\nu}=\frac{\nu_{o.s.}-\nu_M}{\nu_{o.s.}}=\frac{g\Delta h}{c^2}=\frac{M(\underline{S})G}{c^2R_M} \qquad 4.22$$

which gives:

$$\frac{\nu_{o.s.}}{\nu_M}=\left(1-\frac{GM(\underline{S})}{c^2R_M}\right)^{-1}. \qquad 4.23$$

Using equation 4.21 with equation 4.23, we see that during the same absolute time interval, the relative difference of clock displays is:

$$\frac{\Delta CD_M(o.s.)}{\Delta CD_M(M)}=\frac{\Delta CD_{o.s.}(o.s.)}{\Delta CD_{o.s.}(M)}=\frac{\nu_{o.s.}}{\nu_M}=\left(1-\frac{GM(\underline{S})}{c^2R_M}\right)^{-1}. \qquad 4.24$$

Let us note that these equations do not take into account a second order that might exist when the particle moves down in the gravitational potential. Since that second order effect is quite negligible in the first chapters of this book, we will consider it only if it becomes significant.

4.4 - The Absolute Reference Kilogram.

The absolute unit of mass is also defined in outer space. We have seen in chapter one that one absolute kilogram ($kg_{o.s.}$) in outer space contains a different amount of mass after it is carried to Mercury. When we carry a mass of one kilogram ($kg_{o.s.}$) from outer space to Mercury location (at rest), the amount of mass decreases (because it gives up energy during the transfer). However, the observer on Mercury will still call it one Mercury kilogram (kg_M) since the number of atoms has not changed. In fact, nothing appears to change for an observer moving with the kilogram and observing a physical phenomenon on Mercury. The relationship between two kilograms located in different potentials is given in equation 1.5. Using equations 1.5 and 4.6, we find:

$$kg_M=kg_{o.s.}\left(1-\frac{GM(\underline{S})}{c^2R_M}\right). \qquad 4.25$$

Equation 4.25 gives the mass of the outer space kilogram with respect to the Mercury kilogram.

4.5 - Space and Time Corollaries within the Action-Reaction Principle.

Let us discuss what happens inside a frame located at the position where Mercury interacts with the Sun's gravitational field. What is the behavior of Newton's laws at that location?

We believe in the principle of causality. The cause is the reason for the action. Newton applied this principle and stated that an action is always accompanied by a reaction. However, even if this has not been stated specifically, it becomes obvious that there are two corollaries to that principle. The first corollary is that both the action and the reaction take place at exactly the same location where the interaction takes place. The second corollary is that both the action and the reaction take place at exactly the same time the interaction takes place. The principle of causality implies that it is illogical and indefensible to believe that the cause of a phenomenon does not take place at the same location and at the same time that the effect does.

Let us apply those corollaries to relativity. When a mass moves in a gravitational field, its trajectory is modified by the action of the gravitational field. The interaction between a mass and a gravitational field takes place at the location of the mass and at the moment the mass is interacting with the field. Consequently, the relevant parameters during the interaction are the amount of mass and the intensity of the gravitational field at the location of the interaction. It would be absurd to calculate an interaction using quantities that exist somewhere else than where the interaction takes place. When we study the behavior of Mercury interacting with the solar gravitational potential, we must logically use the physical quantities existing where Mercury is located. This means that when we calculate the behavior of planet Mercury, we must use the units of length, clock rate and mass existing at Mercury location. This is the only logical way to be compatible with the principle of causality and with its natural corollaries leading to the principle of action-reaction. It would not make sense for the mass of Mercury involved in the interaction with the solar gravitational field to be the mass it has in outer space rather than its real mass where it is located at the moment it is interacting near the Sun.

Therefore the amount of mass, length and clock rate that must be used in the equations are the ones that appear at Mercury location, since they are the only relevant parameters logically compatible with the physics taking place on Mercury. At Mercury location, there is no other physics than the one using the local mass, length and clock rate. Logically, it must be so everywhere within any frame in the universe. This point is extremely important and is fundamental in the calculations below because it is the basic phenomenon that explains the advance of the Mercury perihelion around the Sun.

4.6 - Fundamental Mechanism Taking Place in Planetary Orbits.

In classical mechanics, it is demonstrated that planets revolve around the Sun in a circular or elliptical orbit. The complete period of an orbit can be defined as the time taken to complete a full translation of 2π radians around the Sun or as the time interval taken by the planet to complete its ellipse between the passages of a pair of perihelions. It is usually considered that these two definitions of a period of an orbit are identical. However, if the ellipse is precessing, the angle spanned between the two passages of a pair of perihelion is larger than for a non precessing ellipse i.e. larger than 2π radians. This means that the full translation of 2π radians is completed before the ellipse reaches the next perihelion. Therefore we expect the period of that precessing ellipse to be larger.

One of the fundamental phenomena implied in such an orbital motion is the gravitational potential decreasing as the inverse of the distance from the Sun where the planet is orbiting. When the orbit is circular, it is difficult to determine at what instant one full orbit is completed other than measuring a translation of 2π radians with respect to masses seen in outer space. However, in an elliptical orbit (as in the case of Mercury around the Sun), the direction of the major axis can be easily located in space from the instant Mercury is at its perihelion, i.e. its closest distance from the Sun.

4.6.1 - Significance of Units in an Equation.

In Galilean mechanics, when the units are identical in all frames, the pure number that multiplies the unit is undistinguishable from the quantity that includes the unit. For example, when someone reports that a rod is ten meters long, we can assume that either he has in mind that the rod is ten times the length of the standard meter (in which ten is a pure number separated from the unit of length), or he means a single global quantity with unit, corresponding to one single quantity ten times longer than the unit meter. Of course, the difference brings no consequence at all when we always use the same standard meter. However, the correct interpretation must be understood and specified here because the size of the reference meter (and all other units) changes from frame to frame.

If "a" represents the semi-major axis of the elliptical orbit of Mercury, we have to find whether "a" represents a pure number (to which a unit is added and considered separately) or a single global quantity (with units included). This can be answered if we study the fundamental role of a mathematical equation. In mathematics, we learn that an equation is a fundamental relationship between numerical quantities. The same mathematical equation can relate numbers (or concepts) having different units. This can be illustrated in the following way.

If an apple costs 50 cents, how many apples (N) will we buy with $10.00? We use the following equation:

$$N = \frac{a}{b}. \qquad 4.26$$

With a = $10.00, and b = $0.50 each, we find

$$N = 20 \text{ apples}. \qquad 4.27$$

Now, if we also find that an orange costs 50 cents, how many oranges will we have for $10.00? Using again equation 4.26 with a = $10.00 and b = $0.50 each, we find:

$$N = 20 \text{ oranges}. \qquad 4.28$$

We also want to buy peas. They cost 1 cent each. How many peas do we get for $10.00? Using again equation 4.26, we find that the number of peas is:

$$N = 1000 \text{ peas.} \qquad 4.29$$

Equations 4.27, 4.28 and 4.29 illustrate that the mathematical parameter N does not represent apples, oranges or peas. It represents only the numerical value of the unit. The unit must be specified separately. One must know that the units also follow a separate mathematical relationships. This is called a dimensional analysis which requires an analysis separate from the numerical analysis.

Therefore, "a" represents the number of units of length. The same remark must be applied to all physical quantities that are pure numbers obtained from a previous definition of other standard units. Furthermore, in order to be compatible with the principle of causality given above, the units of length, mass and clock rate must necessarily be the ones existing on Mercury where the phenomenon takes place. We will see below how this description leads to a perfect coherence.

In the solar system, the orbit of Mercury is very elongated and is an excellent example to study Kepler's laws. However, since there are several other planets moving around the Sun, there are other classical corrections due to the interactions between these other planets that need to be taken into account. Extensive classical calculations show that the interaction of the other planets of the solar system also produces an important advance of the perihelion of Mercury. After accurate calculations, data show that the advance of the perihelion of Mercury is larger than the value predicted by classical mechanics. The advance of the perihelion is observed to be 43 arcsec per century larger than expected from all classical interactions by all planets.

In order to solve this problem, we have to examine in more detail the conditions in which the equations must be applied. As we will see in chapter five, the number of seconds giving the period P is a function of the parameters a, G, M($\underline{S}$) and M($\underline{M}$). However, due to mass-energy conservation we have seen that the units of length, time and mass are different at Mercury distance from the Sun than in outer space. In section 4.5, we have also seen that the action of the gravitational potential on Mercury must be calculated using the number of units of mass (and all other parameters) that Mercury has at that location.

4.7 - Transformations of Units.

4.7.1 - a_M(o.s.) versus a_M(M).

When we measure the number of meters that constitute a given length, we find that this number depends on the length of the unit used in conjunction with it. We call a_M(o.s.), the number of outer space meters that represents the length of the semi-major axis of the orbit of Mercury when we use outer space meters. The absolute physical length L_M[o.s.] being measured using outer space meters is then:

$$L_M[o.s.] = a_M(o.s.)\text{meter}_{o.s.}. \qquad 4.30$$

The value of the absolute length L_M[o.s.] of the semi-major axis of the orbit of Mercury corresponds to measuring the number a_M(o.s.) of meters in the orbit times the outer space meter ($\text{meter}_{o.s.}$). We now have to determine the number a_M(M) of Mercury meters (meter_M) found in conjunction with Mercury units. a_M(M) represents the corresponding number of Mercury meters to measure the same length when we use Mercury meters. We find that the absolute physical length L_M[M] of the semi-major axis, is given by:

$$L_M[M] = a_M(M)\text{meter}_M. \qquad 4.31$$

Since a physical length does not change because we use a different reference meter to measure it, we must understand that the absolute physical length of the semi-major axis is the same whether it is measured using outer space or Mercury units. Therefore, the absolute length L_M[frame] of the semi-major axis of the orbit of Mercury is the same independently of the units used to measure it. Therefore, equations 4.30 and 4.31 are identical:

$$L_M[M] = L_M[o.s.] = a_M(o.s.)\text{meter}_{o.s.} = a_M(M)\text{meter}_M. \qquad 4.32$$

Equation 4.32 gives us the relationship between the number a_M(o.s.) of outer space meters and the number a_M(M) of Mercury meters to measure the same length. This gives:

$$a_M(\text{o.s.}) = a_M(M)\frac{\text{meter}_M}{\text{meter}_{\text{o.s.}}}. \qquad 4.33$$

Combining equations 4.7 and 4.33 gives:

$$a_M(\text{o.s.}) = a_M(M)\left(1 + \frac{GM(\underline{S})}{c^2 R_M}\right). \qquad 4.34$$

Equation 4.34 shows that the <u>number</u> a_M(M) of Mercury meters required to equal the semi-major axis of Mercury is smaller than the number a_M(o.s.) of outer space meters since the outer space meter is shorter. Therefore the outer space observer will record a larger <u>number</u> a_M(o.s.) of meters than the Mercury observer even if both observers are measuring the very same semi-major axis.

4.7.2 - M(S)(o.s.) and $M(\underline{M})_M$(o.s.) versus M(S)(M) and $M(\underline{M})_M$(M).

The symbols (S) and (M) represent respectively the Sun and Mercury. M(S)(o.s.) and $M(\underline{M})_M$(o.s.) represent the <u>numbers</u> of absolute outer space kilograms ($kg_{o.s.}$) for the Sun and Mercury respectively. The subscript M of $M(\underline{M})_M$(o.s.) indicates that the planet is at Mercury location. The numbers of Mercury units that give the same masses are represented by M(S)(M) and $M(\underline{M})_M$(M). The absolute solar mass $\mu(\underline{S})$[o.s.] using outer space units is:

$$\mu(\underline{S})[\text{o.s.}] = M(\underline{S})(\text{o.s.})kg_{\text{o.s.}}. \qquad 4.35$$

Using Mercury units, the same absolute solar mass is given by:

$$\mu(\underline{S})[M] = M(\underline{S})(M)kg_M. \qquad 4.36$$

Since the solar mass does not change because we measure it using Mercury units instead of outer space units, we have:

$$\mu(\underline{S})[\text{o.s.}] = \mu(\underline{S})[M]. \qquad 4.37$$

Similarly, the mass of Mercury measured with outer space units is:

$$\mu(\underline{M})_M[\text{o.s.}] = M(\underline{M})_M(\text{o.s.})kg_{\text{o.s.}}. \qquad 4.38$$

When the measurement is done with Mercury units, the same mass is given by:

$$\mu(\underline{M})_M[M] = M(\underline{M})_M(M)kg_M. \qquad 4.39$$

Since it is the same absolute mass of Mercury described using different units, we have:

$$\mu(\underline{M})_M[o.s.] = \mu(\underline{M})_M[M]. \qquad 4.40$$

Due to mass-energy conservation, the amount of mass contained in one local Mercury kilogram is different from the one in one outer space kilogram. From equations 4.35, 4.36 and 4.37 we have:

$$\frac{M(\underline{S})(o.s.)}{M(\underline{S})(M)} = \frac{kg_M}{kg_{o.s.}}. \qquad 4.41$$

The left hand side of equation 4.41 gives the ratio between the number of outer space kilograms and the number of Mercury kilograms needed to measure the same solar mass. From equation 4.25, we get:

$$\frac{kg_{o.s.}}{kg_M} = \left(1 - \frac{GM(\underline{S})}{c^2 R_M}\right)^{-1}. \qquad 4.42$$

Combining equations 4.41 and 4.42 gives:

$$M(\underline{S})(o.s.) = M(\underline{S})(M)\left(1 - \frac{GM(\underline{S})}{c^2 R_M}\right). \qquad 4.43$$

Equation 4.43 shows that the number of kilograms $M(\underline{S})(o.s.)$ found in the measurement of the solar mass is smaller when measured in conjunction with the outer space kilogram than when measured in conjunction with the Mercury kilogram. Combining equations 4.38, 4.39 and 4.40 with 4.42, we get for the case of the mass of Mercury:

$$M(\underline{M})_M(o.s.) = M(\underline{M})_M(M)\left(1 - \frac{GM(\underline{S})}{c^2 R_M}\right). \qquad 4.44$$

Consequently, the number $M(\underline{M})_M$ of kilograms giving the mass of Mercury is smaller using outer space kilograms than using Mercury kilograms.

4.7.3 - P_M(o.s.) versus P_M(M).

In equations 4.12 and 4.13, we have calculated absolute time intervals $\Delta\tau$ as measured from outer space location ($\Delta\tau_{o.s.}$[o.s.]) and Mercury location ($\Delta\tau_{o.s.}$[M]). Let us consider now that the time interval $\Delta\tau$ is the period of translation of Mercury to complete an ellipse around the Sun. The number of seconds P_M(o.s.) giving the period of Mercury when measured with an outer space clock is given by the relationship:

$$\Delta\tau_M[\text{o.s.}] = P_M(\text{o.s.})\ \Delta CD_{o.s.}(S) \qquad 4.45$$

and the period P_M(M) measured on Mercury using a Mercury clock (with Mercury units) refers to the relationship:

$$\Delta\tau_M[M] = P_M(M)\ \Delta CD_M(S). \qquad 4.46$$

The time intervals $\Delta\tau_M$[o.s.] and $\Delta\tau_M$[M] in equations 4.45 and 4.46 represent the absolute time interval for the period P of translation of Mercury around the Sun. An absolute time interval is not different because it is measured with a Mercury clock instead of an outer space clock:

$$\Delta\tau_M[\text{o.s.}] = \Delta\tau_M[M] = P_M(M)\ \Delta CD_M(S) = P_M(\text{o.s.})\ \Delta CD_{o.s.}(S). \qquad 4.47$$

We have seen in equation 4.24 the ratio of the numbers ΔCD_M(o.s.) and ΔCD_M(M) between two frames in different gravitational potentials. We see that the numbers P_M(o.s.) and P_M(M) displayed by the clocks correspond to ΔCD_M(o.s.) and ΔCD_M(M) during one period of translation. Therefore,

$$\frac{\Delta CD_M(\text{o.s.})}{\Delta CD_M(M)} = \frac{P_M(\text{o.s.})}{P_M(M)}. \qquad 4.48$$

Combining equation 4.48 with 4.24 gives:

$$\frac{P_M(\text{o.s.})}{P_M(M)} = \frac{\Delta CD_M(\text{o.s.})}{\Delta CD_M(M)} = \left(1 - \frac{GM(\underline{S})}{c^2 R_M}\right)^{-1}. \qquad 4.49$$

Equation 4.49 shows that even if the absolute time interval $\Delta\tau$ for the period is the same in both frames, the differences of clock displays are different because the clocks run at different rates.

4.7.4 - G(o.s.) versus G(M) .

Since lengths, clock rates and masses are not the same in different frames, we see now that the gravitational constant G is different when measured using Mercury units. The number of outer space units of the gravitational constant is called G(o.s.) and the number of Mercury units of the same gravitational constant is called G(M). The fundamental units corresponding to the gravitational constant G are called respectively $U_{o.s.}$ and U_M. The total gravitational constant G is called J[o.s.] when measured from outer space and J[M] when measured from Mercury orbit. Therefore we have:

$$J[o.s.] = G(o.s.)U_{o.s.} \qquad 4.50$$

and

$$J[M] = G(M)U_M. \qquad 4.51$$

Since the absolute gravitational constant does not change because we measure it from a different location, we have:

$$J[o.s.] = J[M]. \qquad 4.52$$

The relative number of units between G(o.s.) and G(M) is found using a dimensional analysis. The units of G can be obtained from Newton's well known gravitational law:

$$F = \frac{GMm}{R^2} \qquad 4.53$$

where the force F is in newtons, M and m are in kilograms and the radius R is in meters. From equation 4.53 and recalling that the units of G(o.s.) are called $U_{o.s.}$, we find:

$$U_{o.s.} = \frac{newton_{o.s.} meter^2_{o.s.}}{kg^2_{o.s.}}. \qquad 4.54$$

From the relationship

$$F = m\alpha \qquad 4.55$$

where α is the acceleration, we find that the units of F are:

$$newton_{o.s.} = \frac{kg_{o.s.} meter_{o.s.}}{sec^2_{o.s.}}. \qquad 4.56$$

Combining 4.54 with 4.56 we get:

$$U_{o.s.} = \frac{kg_{o.s.}meter^3_{o.s.}}{kg^2_{o.s.}\ sec^2_{o.s.}}. \qquad 4.57$$

From the definition of velocity, the units of v are:

$$v_{o.s.} = \frac{meter_{o.s.}}{sec_{o.s.}}. \qquad 4.58$$

Equation 4.58 in 4.57 gives:

$$U_{o.s.} = \frac{meter_{o.s.}v^2_{o.s.}}{kg_{o.s.}}. \qquad 4.59$$

We have seen in sections 3.5.3 and 3.6 that a velocity is represented by the same number within any frame. This means that the number representing a velocity is the same within any frame when it is measured using any coherent system of local units. Since a velocity is the quotient between a length and a time interval, this quotient stays constant even when switching between frames because the same correction is made on both lengths and clock displays. Consequently, we have:

$$v_{o.s.} = v_M. \qquad 4.60$$

Equations 4.7, 4.42 and 4.60 in equation 4.59 give:

$$U_{o.s.} = \frac{meter_M\left(1+\frac{GM(\underline{S})}{c^2R_M}\right)^{-1}v^2_M}{kg_M\left(1-\frac{GM(\underline{S})}{c^2R_M}\right)^{-1}}. \qquad 4.61$$

The first order expansion of equation 4.61 gives:

$$U_{o.s.} = \frac{meter_M v^2_M}{kg_M}\left(1-\frac{GM(\underline{S})}{c^2R_M}\right)^2. \qquad 4.62$$

By analogy with 4.59 for U_M, we have:

$$U_M = \frac{meter_M v^2_M}{kg_M}. \qquad 4.63$$

Equation 4.63 in 4.62 gives:

$$U_{o.s.} = U_M\left(1-\frac{GM(\underline{S})}{c^2R_M}\right)^2. \qquad 4.64$$

Equations 4.50, 4.51, 4.52 and 4.64 give the relationship between the number of units of G:

$$G(\text{o.s.}) = G(M)\left(1 - \frac{GM(\underline{S})}{c^2 R_M}\right)^{-2}. \qquad 4.65$$

Equation 4.65 shows that the gravitational constant G is represented by different numbers when measured with the units existing on Mercury and in outer space.

4.7.5 - F(o.s.) versus F(M).

From equation 4.56 we have:

$$\text{newton}_{\text{o.s.}} = \frac{\text{kg}_{\text{o.s.}}\,\text{meter}_{\text{o.s.}}}{\text{sec}^2_{\text{o.s.}}}. \qquad 4.66$$

Using equations 4.7, 4.15, 4.24 and 4.25, we find:

$$\text{newton}_{\text{o.s.}} = \frac{\text{kg}_M\left(1 + \frac{GM(\underline{S})}{c^2 R_M}\right)\text{meter}_M\left(1 - \frac{GM(\underline{S})}{c^2 R_M}\right)}{\text{sec}^2_M\left(1 - \frac{GM(\underline{S})}{c^2 R_M}\right)^2}. \qquad 4.67$$

To the first order, this is equal to:

$$\text{newton}_{\text{o.s.}} = \frac{\text{kg}_M\text{meter}_M}{\text{sec}^2_M}\left(1 + \frac{GM(\underline{S})}{c^2 R_M}\right)^2 \qquad 4.68$$

and:

$$\text{newton}_{\text{o.s.}} = \text{newton}_M\left(1 + \frac{GM(\underline{S})}{c^2 R_M}\right)^2. \qquad 4.69$$

Consequently, the relationship between the number of Mercury newtons and the number of outer space newtons is given by:

$$F(\text{o.s.}) = F(M)\left(1 + \frac{GM(\underline{S})}{c^2 R_M}\right)^{-2}. \qquad 4.70$$

4.8 - Symbols and Variables.

$a_{\text{frame}}[\text{o.s.}]$ length of the local Bohr radius in absolute units

$a_M(M)$	number of Mercury meters for the semi-major axis of Mercury
$a_M(o.s.)$	number of outer space meters for the semi-major axis of Mercury
$\Delta CD_M(M)$	ΔCD for the period of Mercury measured by a Mercury clock
$\Delta CD_M(o.s.)$	ΔCD for the period of Mercury measured by an outer space clock
$\Delta CD_M(S)$	apparent second on Mercury
$\Delta CD_{o.s.}(M)$	ΔCD in outer space measured by a Mercury clock
$\Delta CD_{o.s.}(o.s.)$	ΔCD in outer space measured by an outer space clock
$\Delta CD_{o.s.}(S)$	absolute second in outer space
$\Delta\tau_M[M]$	period of Mercury in Mercury units
$\Delta\tau_M[o.s.]$	period of Mercury in outer space units
$\Delta\tau_{o.s.}[M]$	time interval in outer space in Mercury units
$\Delta\tau_{o.s.}[o.s.]$	time interval in outer space in outer space units
$G(M)$	number of Mercury units for the gravitational constant
$G(o.s.)$	number of outer space units for the gravitational constant
$J[M]$	gravitational constant in Mercury units
$J[o.s.]$	gravitational constant in outer space units
kg_{frame}	mass of the local kilogram in absolute units
$L_M[M]$	length of the semi-major axis of the orbit of Mercury in Mercury units
$L_M[o.s.]$	length of the semi-major axis of the orbit of Mercury in outer space units
$meter_{frame}$	length of the local meter in absolute units
$M(\underline{M})_M(M)$	number of Mercury units for the mass of Mercury at Mercury location
$\mu(\underline{M})_M[M]$	mass of Mercury in Mercury units at Mercury location
$M(\underline{M})_M(o.s.)$	number of outer space units for the mass of Mercury at Mercury location
$\mu(\underline{M})_M[o.s.]$	mass of Mercury in outer space units at Mercury location
$M(\underline{S})(M)$	number of Mercury units for the mass of the Sun
$M(\underline{S})(o.s.)$	number of outer space units for the mass of the Sun

$\mu(\underline{S})[M]$	mass of the Sun in Mercury units
$\mu(\underline{S})[o.s.]$	mass of the Sun in outer space units
N(S)	number of oscillations of an atomic clock for one local second
$P_M(M)$	ΔCD for the period of Mercury measured by a Mercury clock
$P_M(o.s.)$	ΔCD for the period of Mercury measured by an outer space clock
R_M	distance between Mercury and the Sun
U_{frame}	unit of the gravitational constant in the local frame

Chapter Five
Calculation of the Advance of the Perihelion of Mercury.

5.1 - Mathematical Transformation of Units between Frames.

In this chapter we will deal with two kinds of transformations. The first kind is a mathematical transformation of units which brings no physical change to the quantities being described. In such a transformation, there is no physics, just mathematics. For example, let us suppose that we measure a rod on Mercury and find that it is 100 times longer than the local Mercury meter. Then we say that the length of the rod is 100 Mercury meters. However, if we know that on Mercury, the local meter is 1% longer than the local reference meter in outer space, we know that the same rod is actually equal to 101 times the outer space reference meter. These two descriptions by units of different frames are perfectly identical. The rod has not changed.

The observer on Mercury can also use his clock to measure a time interval. If the Mercury observer measures 100 units on his clock (i.e. 100 Mercury seconds), knowing that clocks on Mercury run at a rate which is 1% slower than clocks in outer space, we can calculate that during that absolute time interval the difference of clock displays on a clock in outer space will be 101 outer space units. No physics is involved in that transformation, only mathematics. The same physical phenomenon is described using different units.

Other units must also be transformed. For example, the absolute mass of the Sun does not change because we observe it from Mercury location near the Sun. However, measuring the same solar mass using the smaller Mercury unit of mass will lead to a larger number of Mercury units. Similarly, the physical amplitude of the absolute gravitational constant G does not change because the phenomenon takes place near the Sun. We have seen in chapter four that the absolute constant G is represented by different numbers of Mercury and outer space units. Again, no physics is involved.

5.1.1 - Consequence of a Simple Change of Units.

Let us suppose that using Newton's relationships, we want to calculate the period of Mercury using Mercury units. We must then compare this answer with the one obtained with the same relationships using outer space units. If we do so, we find that the numbers of units found for the period are different. However, when we take into account that the Mercury clock runs at a slower rate, we see that the absolute times obtained from either frame are the same.

In the next section we will see that in order to be compatible with the principle of mass-energy conservation, one must add another kind of transformations which are physical transformations. Contrary to the identical consequences resulting from the mathematical transformation explained above, different absolute results are found when Newton's laws are applied with the proper values belonging to different frames.

5.2 - Physical Transformations Due to Mass-Energy Conservation.

The second kind of transformations consists of real physical changes. We have seen in chapters one and three that when an object in outer space is moved to Mercury location, its absolute mass changes because of the change of gravitational potential and kinetic energies. (In the case of gravitational energy, the difference of mass is transformed into work). The object that remains at Mercury location is physically different from the object that existed in outer space because the dimensions of its atoms, their mass and clock rate have changed. This physical change of mass is quite different from the mathematical change of units mentioned above.

Here is an example. An observer on Mercury measures that a mass on his frame is 100 times larger that the unit of mass on Mercury. Another observer in outer space measures the mass of the same object after it has been carried out to outer space. In that new frame, the outer space observer finds the same number (100) of new units of mass. Both observers measure 100 local kilograms. However, the absolute mass of this object has changed when moved from Mercury location to outer space. The Mercury kilogram is not equal to the outer space kilogram. To realize this, we need to know the mass at Mercury location using outer space units. Applying the principle of mass-energy conservation, we find that using the same outer space units, the mass of the object is reduced to only 99 outer space kilograms when brought to Mercury location (since the Mercury kilogram is 1% lighter than the outer space kilogram). This is a real physical change. It is not a simple mathematical transformation of units like the one explained in section 5.1.

We will see in section 5.3 that these physical changes lead to results that are physically different when calculated using proper values in different frames. Using Newton's classical mechanics, we will find that the results obtained using the proper parameters in one frame are not coherent with the results obtained using parameters proper to another frame.

In order to clarify this description, in this chapter we will use the expression transformation of units to designate only a pure mathematical transformation of units. When a physical change is involved as a consequence of mass-energy conservation, we will speak of a transformation of parameters.

We consider that the interactions between physical elements (like fields, masses, lengths and clock rates) existing on Mercury, using Mercury parameters, must be the same as the ones that we calculate in outer space using outer space parameters. This means that the mathematical relationships so well-known in physics are the only ones that are valid but it is required that on Mercury we use the physical quantities (mass, length and clock rate) existing on Mercury while in outer space, we use the physical quantities (which are different) existing in outer space. In other words, we must always use proper values. It is totally illogical to use outer space physical parameters at Mercury location. On Mercury, we must necessarily use physical parameters that exist on Mercury.

5.3 - Incoherence between Outer Space and Mercury Predictions Using Newton's Physics.

In this book, we use Newton's equations which are always perfectly valid in all frames. However, there is a difference between Newton's equations and Newton's physics. Newton's physics is different from the physics described in this book because it is not compatible with the principle of mass-energy conservation. In Newton's physics, there is no place for changes of mass, length and clock rate. According to that physics, the mass of an object in outer space does not change if it is transported to Mercury location or to anywhere in the universe.

Let us suppose a Newtonian observer wants to measure the period of Mercury. He wishes to know its mass. To do this, he imagines the following thought experiment. He takes Mercury out of its orbit to outer space and puts the planet on a balance to measure its mass. Then he puts Mercury back on its orbit. Being a Newtonian observer using Newton's physics, the mass he will use in his calculations of Mercury's period will be the mass he just measured in outer space. However, we know this mass is wrong because of mass-energy conservation. We also know that other parameters (like length and clock rate) at Mercury location are modified due to the change of mass. Therefore this observer's Newtonian calculation of the orbit of Mercury will be wrong even when he uses the correct equations.

We will see that when the orbit of a planet moving around the Sun is calculated, using outer space physical parameters, we find a perfect ellipse. However, when we use the proper parameters existing on Mercury, we find a different orbit which is a precessing ellipse. This explains the advance of the perihelion of Mercury. When neglecting the changes of mass, length and clock rate on Mercury with respect to outer space, we find an erroneous prediction because we use outer space physical parameters instead of proper parameters.

5.4 - Incoherence of the Gravitational Force Using Newton's Physics.

Let us give an example that shows that the calculated force of gravity is different depending on what the physical parameters are used (outer space or Mercury). For the Newtonian observer, the gravitational force is:

$$F_G(o.s.) = G(o.s.)M(\underline{S})(o.s.)\frac{M(\underline{M})_{o.s.}(o.s.)}{R_M^2(o.s.)}. \qquad 5.1$$

For that observer, whether the subscript of $M(\underline{M})$ is o.s. or M makes no difference. We write o.s. because this observer uses Newton's physics which always assumes a constant mass. The relevant physical parameters at Mercury location are:

$$F_G(M) = G(M)M(\underline{S})(M)\frac{M(\underline{M})_M(M)}{R_M^2(M)}. \qquad 5.2$$

All physical parameters in equation 5.2 must be Mercury physical parameters because that is where the interaction takes place. We will now compare these two equations. We know that the number of Mercury units to measure the mass of Mercury at Mercury location is the same as the number of outer space units to measure the mass of Mercury in outer space. This gives:

$$M(\underline{M})_M(M) = M(\underline{M})_{o.s.}(o.s.). \qquad 5.3$$

The relationship between the number of units of mass of the Sun in outer space and Mercury units is given by equation 4.43:

$$M(\underline{S})(o.s.) = M(\underline{S})(M)\left(1 - \frac{GM(\underline{S})}{c^2 R_M}\right). \qquad 5.4$$

The relationship between the numbers of meters to measure the distance of Mercury from the Sun in outer space and Mercury units can be deduced from equation 4.34:

$$R_M(o.s.) = R_M(M)\left(1 + \frac{GM(\underline{S})}{c^2 R_M}\right). \qquad 5.5$$

Finally, the corresponding relationship for the gravitational constant G is given by equation 4.65:

$$G(\text{o.s.}) = G(M)\left(1 + \frac{GM(\underline{S})}{c^2 R_M}\right)^2. \qquad 5.6$$

Equations 5.3, 5.4, 5.5 and 5.6 in 5.2 give:

$$F_G(M) = G(\text{o.s.})M(\underline{S})(\text{o.s.})\left(1 + \frac{GM(\underline{S})}{c^2 R_M}\right)\frac{M(\underline{M})_{\text{o.s.}}(\text{o.s.})}{R_M^2(\text{o.s.})}. \qquad 5.7$$

In order to compare the gravitational force calculated using Mercury units, with the force calculated using outer space units, let us transform the number of units of force $F_G(M)$ into the corresponding number of outer space units. From equation 4.70, we have:

$$F_G(M) = F_G(\text{o.s.})\left(1 + \frac{GM(\underline{S})}{c^2 R_M}\right)^2. \qquad 5.8$$

Equation 5.7 with 5.8 gives:

$$F_G(\text{o.s.}) = G(\text{o.s.})M(\underline{S})(\text{o.s.})\left(1 + \frac{GM(\underline{S})}{c^2 R_M}\right)^{-1}\frac{M(\underline{M})_{\text{o.s.}}(\text{o.s.})}{R_M^2(\text{o.s.})}. \qquad 5.9$$

We must notice that equation 5.9 does not corresponds to a simple transformation of units. The physical parameters existing on Mercury at Mercury location have been taken into account.

Using the physical parameters existing on Mercury and outer space units, equation 5.9 shows that the absolute gravitational force on Mercury is different from the one calculated using the physical parameters existing in outer space and given in equation 5.1. The two results are not compatible. They predict different orbits. As explained above, the logical choice requires that we choose the equation obtained using the proper physical parameters existing at the location where the interaction of Mercury takes place with the gravitational field. We must reject the calculation obtained using outer space parameters when the experiment is taking place on Mercury. Finally, we now realize that equations 5.1 is the limit of equations 5.9 when $R_M \rightarrow \infty$.

There is another direct consequence of mass-energy conservation. Contrary to equation 5.1, we see in equation 5.9 that using the physical parameters existing on Mercury, the decrease of the gravitational force is no longer perfectly quadratic. We will see in chapter six that in classical mechanics the orbits of an object submitted to a non quadratic gravitational force must have a precession.

5.5 - Relevant Physical Parameters.

Let us assume that an object on Mercury has a length of 100 Mercury meters. This means that independently of the units used to describe it, this is the relevant physical length. If we find that the meter on Mercury is 1% longer that the outer space meter, that length will be represented by 101 outer space meters. However, a Newtonian observer in outer space would predict 100 outer space meters from his own (incorrect) calculation.

In the case of time, if the Mercury observer measures that a phenomenon lasts 100 Mercury seconds, this means that the outer space observer measuring the same time interval on his clock (that runs 1% faster) will measure 101 outer space seconds. For the outer space observer, this means that the physics taking place on Mercury is such that the phenomenon takes place more slowly. We must remember that this is not a simple transformation of mathematical units. The difference is due to the slowing down of the processes on Mercury in order to maintain the internal coherence within the Mercury frame. One must recall that if the phenomenon takes place in outer space, the outer space observer will also measure 100 of his seconds which are different from 100 Mercury seconds. However, since the phenomenon is taking place on Mercury, it takes one extra outer space second before being completed.

If one could observe a physical phenomenon from outer space taking place in a very deep gravitational potential, one would see that objects are bigger and react more slowly. Furthermore if the outer space observer calculates quite independently the phenomena taking place on Mercury using outer space parameters, he would find that the observations reveal that everything functions at an unexpected slower rate with respect to his frame since the physics at Mercury location must be compatible with Newton's laws when using proper physical parameters.

5.6 - Fundamental Phenomena Responsible for the Advance of the Perihelion of Mercury.

This section is very important to understand the phenomena responsible for the advance of the perihelion of Mercury. Let us consider that the orbit calculated by the Mercury observer has a length equal to 1000 kilometers as determined with Newton's equations using proper parameters on Mercury. Of course, an observer located in outer space, also using Newton's equations and proper values existing in outer space will calculate that the length of the orbit is 1000 outer space kilometers.

Using mass-energy conservation, let us assume that due to a different gravitational potential, the unit meter on Mercury is 1% longer than the unit meter in outer space. Consequently, in order to be coherent, we calculate that clocks in outer space will run at a rate which is 1% faster than the rate on Mercury.

From the above information, let us calculate the clock display measured on the outer space clock ΔCD(o.s.) while Mercury travels the distance of 1000 km_M. Since the distance traveled is 1000 km_M, equation 4.34 shows that due to the longer Mercury meter, the outer space observer will measure 1010 $km_{o.s.}$. The circumference of the orbit is:

$$\text{Circ}[M] = 1000\ km_M = 1010\ km_{o.s.} \qquad 5.10$$

This first correction on lengths ignores that while Mercury travels 1010 $km_{o.s.}$ the clock in outer space runs 1% faster that the clock on Mercury. Since we must refer to the parameters existing on Mercury where the phenomenon takes place, the ΔCD on the outer space clock must be increased by one per cent with respect to the Mercury clock because of the faster rate of that outer space clock. Consequently, there is an increase of 1% of length to be traveled because the real length is 1010 $km_{o.s.}$ plus another increase of 1% on the outer space clock because of its faster rate.

Consequently, in order to respect the physical laws existing on Mercury where the interaction with the gravitational potential takes place, we see that we must take into account two phenomena slowing down the completion of the ellipse in the frame where

Mercury interacts with the gravitational potential. One is due to the increase of length of the Mercury meter and the second is due to the slowing down of the physical mechanisms on Mercury. We will calculate these two quantities in detail in the next sections of this chapter.

Let us note that in the above description, we have seen that the exact distance 1000 km_M (or 1010 $km_{o.s.}$) originally planned has been traveled as expected. However, we might calculate that the $\Delta CD(M)$ expected from calculations is different from the one measured. This is because not only Mercury, but also the clock has changed location (at a certain velocity) between the first and the last readings. This leads to a drift in the synchronization of the moving clock as explained clearly in sections 9.4, 9.5 and 9.6. The reading of chapter nine is necessary to complete the explanation on the loss of clock synchronization of moving clocks.

5.7 - Change of Length from Outer Space to Mercury Location.

We have seen that the relevant parameters responsible for the physical interaction with the solar gravitational field are the ones at Mercury location even though the final results are observed by the outer space observer. Let us calculate the physical length observed in outer space corresponding to the length calculated using Mercury parameters where the interaction takes place. There are two physical phenomena that make the Mercury meter longer than the outer space meter. The first one is due to the gravitational potential as explained in chapter one. The second phenomena is due to the velocity of Mercury on its orbit as calculated in chapter three.

Let $a_M(o.s.)$ and $a_M(M)$ be the numbers representing the semi-major axis of Mercury. Using equation 4.34, we get the relationship:

$$\frac{a_M(o.s.)}{a_M(M)} = 1 + \frac{GM(\underline{S})}{c^2 R_M}. \qquad 5.11$$

Let us call l_M(o.s.) the number of outer space meters for the length of Mercury's elliptical orbit and l_M(M) the number of Mercury meters for the length of the same elliptical orbit. For a small eccentricity, l_M(o.s.) is about $2\pi a_M$(o.s.) and l_M(M) is about $2\pi a_M$(M). The eccentricity will be taken into account in section 5.10. We have from equation 5.11:

$$\frac{l_M(\text{o.s.})}{l_M(\text{M})} = \frac{a_M(\text{o.s.})}{a_M(\text{M})} = 1 + \frac{GM(\underline{S})}{c^2 R_M}. \qquad 5.12$$

We see in equation 5.12 that the number of meters measured by the observer in outer space for the length of the elliptical orbit is larger than the number of meters measured by the Mercury observer because the outer space meter is shorter.

Mercury is not only located in a gravitational potential, it also has a velocity. Because of this velocity v, there is a difference between the length of the moving meter and the length of the meter at rest, both at Mercury distance from the Sun (see equation 3.23). The moving Mercury meter is also the one that is relevant here since it is the one involved in the physics taking place on Mercury. The rest meter being shorter, the number of rest meters needed to describe the length of the orbit will be larger than the number of moving Mercury meters.

Let us call N_v the number of moving meters and N_o the number of rest meters to measure the Mercury orbit. Similarly to equations 4.30, 4.31 and 4.32, the absolute length L[rest] of the Mercury orbit is:

$$L[\text{rest}] = N_o \text{ meter[rest]} = N_v \text{ meter[mov]} \qquad 5.13$$

where meter[rest] and meter[mov] represent respectively the length of a meter at rest and the length of a meter in motion. In equation 5.13, the absolute physical length L[rest] of the Mercury orbit does not change because we measure it with smaller meters at rest. Using equations 5.13 and 3.41 we have:

$$\frac{N_o}{N_v} = \frac{\text{meter[mov]}}{\text{meter[rest]}} = \gamma \qquad 5.14$$

which is:

$$N_v = \sqrt{1 - \frac{v^2}{c^2}} N_o. \quad 5.15$$

Using the first term of a series expansion gives:

$$\frac{N_v}{N_o} = 1 - \frac{1}{2}\left(\frac{v}{c}\right)^2. \quad 5.16$$

In order to calculate the velocity of Mercury on its orbit, let us use a well-known relationship in classical mechanics. The centrifugal force (C.F.) on a moving mass $M(\underline{M})$ (Mercury) at a distance R_M from the center of translation is equal to:

$$C.F. = \frac{M(\underline{M})v^2}{R_M}. \quad 5.17$$

In the case of a stable orbit around the Sun, the gravitational force F(grav) is equal to the centrifugal force. This gives:

$$F(grav) = \frac{GM(\underline{M})M(\underline{S})}{R_M^2} = \frac{M(\underline{M})v^2}{R_M} \quad 5.18$$

and

$$v^2 = \frac{GM(\underline{S})}{R_M}. \quad 5.19$$

Putting equation 5.19 in 5.16 gives:

$$\frac{N_o}{N_v} = 1 + \frac{GM(\underline{S})}{2c^2 R_M}. \quad 5.20$$

Equation 5.20 shows that the number of rest meters is larger than the number of moving meters.

Equation 5.12 gives the relative increase of the number of outer space meters with respect to the number of Mercury meters due to mass-energy conservation in the static gravitational potential of the Sun. Equation 5.20 gives another relative increase of the number of meters at rest with respect to the number of moving meters as explained in chapter three. From these two causes, the total relative number $l_{o.s.,o}$ of outer space meters at rest with respect to the moving Mercury meters is given by the product of equations 5.12 and 5.20. This gives:

$$\frac{l_{o.s.,o}}{l_{M,v}} = \left(1 + \frac{GM(\underline{S})}{c^2 R_M}\right)\left(1 + \frac{GM(\underline{S})}{2c^2 R_M}\right). \qquad 5.21$$

The first term of a series expansion gives:

$$\frac{l_{o.s.,o}}{l_{M,v}} = 1 + \frac{3GM(\underline{S})}{2c^2 R_M} \qquad 5.22$$

which gives the total increase of distance in outer space units following the calculation of the length of the orbit using Mercury parameters, located in a gravitational potential at velocity v.

5.8 - Change of Clock Rate from Outer Space to Mercury Location.

There are two independent phenomena that slow down the clocks on Mercury's orbit. One is due to its gravitational potential, the other is due to its velocity. On the Mercury clock, during the period required to complete one full revolution, the difference of clock displays called $\Delta CD_M(M)$ is smaller than the difference of clock displays $\Delta CD_M(o.s.)$ in outer space since the physical mechanisms and clocks in outer space run at a faster rate. Let us calculate $\Delta CD_M(o.s.)$ with respect to $\Delta CD_M(M)$ during the same absolute time interval. From equation 4.49 we have:

$$\frac{\Delta CD_M(o.s.)}{\Delta CD_M(M)} = \left(1 - \frac{GM(\underline{S})}{c^2 R_M}\right)^{-1}. \qquad 5.23$$

Let us now study the effect of velocity on clock rates. We have seen that due to mass-energy conservation, moving clocks are slower than clocks at rest. Using equation 3.10, we find:

$$\Delta CD_v = \frac{1}{\gamma} \Delta CD_o \qquad 5.24$$

where:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}. \qquad 5.25$$

ΔCD_v is the difference of clock displays on a clock having a velocity v and ΔCD_o is the corresponding difference of clock displays on a clock at rest (both clocks at the same distance from the Sun). Equations 5.24 and 5.25 give:

$$\frac{\Delta CD_v}{\Delta CD_o} = \frac{1}{\gamma} = \sqrt{1 - \frac{v^2}{c^2}}. \qquad 5.26$$

Since v/c is very small with respect to unity, we consider the first term of a series expansion of equation 5.26. We get:

$$\frac{\Delta CD_v}{\Delta CD_o} = 1 - \frac{1}{2}\left(\frac{v}{c}\right)^2 \qquad 5.27$$

or again,

$$\frac{\Delta CD_o}{\Delta CD_v} = 1 + \frac{1}{2}\left(\frac{v}{c}\right)^2. \qquad 5.28$$

Equation 5.19 in 5.28 gives:

$$\frac{\Delta CD_o}{\Delta CD_v} = 1 + \frac{GM(\underline{S})}{2c^2 R_M}. \qquad 5.29$$

The clock moving with Mercury is the one submitted to the interaction between the planet and the solar gravitational field. From equation 5.29, we see that the moving clock on Mercury runs more slowly than the clock at rest (at a constant distance from the Sun). Consequently, as explained above, the physical mechanism taking place at Mercury location is slower.

We have seen in equation 5.23 that clocks (and therefore the absolute physical mechanisms) slow down on Mercury as a consequence of the gravitational potential at that location. Equation 5.29 also shows a slowing down of the clocks due to the velocity of Mercury on its orbit. Let us calculate the total slowing down of clocks on Mercury due to both the gravitational potential and the velocity of Mercury on its orbit. The total difference of clock displays $\Delta CD_{M,v}$ on moving Mercury with respect to the difference of clock displays $\Delta CD_{o.s.,o}$ in outer space (at rest) is obtained using equations 5.23 and 5.29. We get:

$$\frac{\Delta CD_{o.s.,o}}{\Delta CD_{M,v}} = \left(1 - \frac{GM(\underline{S})}{c^2 R_M}\right)^{-1}\left(1 + \frac{GM(\underline{S})}{2c^2 R_M}\right). \qquad 5.30$$

The first order gives:

$$\frac{\Delta CD_{o.s.,o}}{\Delta CD_{M,v}} = 1 + \frac{3GM(\underline{S})}{2c^2 R_M}. \qquad 5.31$$

5.9 - Total Interaction Due to the Physical Changes of Length and Clock Rate.

We have seen in sections 5.7 and 5.8 how the changes of length and clock rate modify the period of translation of Mercury around the Sun. The first phenomenon given by equation 5.22 gives the relative length of the orbit as measured in outer space when the phenomenon is calculated using the parameters existing on Mercury where the interaction with the gravitational field of the Sun takes place. The circumference of the orbit $l_{M,v}$ using Mercury parameters corresponds to a longer length of the orbit as measured using outer space parameters. Therefore, the outer space observer will measure more than a full circumference using his own outer space units. Furthermore, we have seen in equation 5.31 that in order to be compatible with mass-energy conservation, clock rates and physical mechanisms taking place on Mercury must be slower than the ones measured in outer space. Consequently, it will take a larger number of seconds on the outer space clock to complete the circumference than on the Mercury clock.

Each phenomenon makes an independent contribution to modify lengths and clock rates on moving Mercury with respect to the ones at rest in outer space. Consequently both phenomena will contribute to the larger number of units for the period of Mercury as measured by an outer space observer.

Let us call $P_{l,\Delta CD}$ the period of the orbit of Mercury taking into account the combined effects of the change of length and the change of clock rate. In $P_{l,\Delta CD}$(M,mov), "M,mov" is in round parentheses since $P_{l,\Delta CD}$ is a pure number without units. Then $P_{l,\Delta CD}$(M,mov) is the <u>number</u> of Mercury units for completing the ellipse measured with a clock moving at velocity v at Mercury location and $P_{l,\Delta CD}$(o.s.,rest) is the <u>number</u> of outer space units to complete the period of the ellipse measured with a clock in outer space having zero velocity. For clarity, we have dropped the subscript M indicating the location of the planet since we consider Mercury at its normal position in the Sun's gravitational field.

Let us add the contribution of the two phenomena described above. The correction on the period will be the product of the contributions given by equations 5.22 and 5.31. This gives:

$$\frac{P_{l,\Delta CD}(\text{o.s.,rest})}{P_{l,\Delta CD}(\text{M,mov})} = (\text{equation 5.22})(\text{equation 5.31}) \qquad 5.32$$

$$\frac{P_{l,\Delta CD}(\text{o.s.,rest})}{P_{l,\Delta CD}(\text{M,mov})} = \frac{l_{\text{o.s.,o}}}{l_{\text{M,v}}}\frac{\Delta CD_o}{\Delta CD_v} \qquad 5.33$$

$$\frac{P_{l,\Delta CD}(\text{o.s.,rest})}{P_{l,\Delta CD}(\text{M,mov})} = \left(1+\frac{3GM(\underline{S})}{2c^2R_M}\right)\left(1+\frac{3GM(\underline{S})}{2c^2R_M}\right). \qquad 5.34$$

The first order gives:

$$\frac{P_{l,\Delta CD}(\text{o.s.,rest})}{P_{l,\Delta CD}(\text{M,mov})} = 1+\frac{3GM(\underline{S})}{c^2R_M}. \qquad 5.35$$

Equation 5.35 shows that the number of units for the total period of Mercury is larger when measured using outer space units. Let us transform this result to calculate the relative increase of the period of Mercury as recorded by an observer using an outer space clock and an outer space meter. We find that the relative increase is given by the derivative of equation 5.35. This gives:

$$\frac{\Delta P_{l,\Delta CD}(\text{o.s.,rest})}{P_{l,\Delta CD}(\text{M,mov})} = \frac{3GM(\underline{S})}{c^2R_M}. \qquad 5.36$$

Equation 5.36 shows that when Mercury has completed its full elliptical orbit, the observer using an outer space clock will monitor a period of translation larger by $3GM(\underline{S})/c^2R_M$ times $P_{l,\Delta CD}$ (M,mov).

Before completing this section, we must notice that following Newton's law, the advance of the perihelion of Mercury given by equation 5.36 can be written in a more simple form. Let us consider the gravitational potential "Pot" as a function of the distance R_M from the Sun. Contrary to the definition of potential in electricity, in mechanics the potential is defined as the energy. Let us consider the energy per unit of mass. Using Newton's law of gravitation, we see that this ratio (which corresponds to the concept of potential in electricity) is independent of the mass of Mercury.

Writing differently Newton's law we find that the gravitational potential is:

$$\frac{\text{Pot}}{M(\underline{M})} = \frac{GM(\underline{S})}{R_M}. \qquad 5.37$$

Combining 5.36 with 5.37, we get:

$$\frac{\Delta P_{l,\Delta CD}(\text{o.s.,rest})}{P_{l,\Delta CD}(\text{M,mov})} = \left(\frac{\text{Pot}}{M(\underline{M})}\right)\left(\frac{3}{c^2}\right). \qquad 5.38$$

Equation 5.38 shows that the total advance of the perihelion of Mercury depends only on the constant $3/c^2$ times the change of gravitational energy per unit of mass. Equation 5.38 takes into account both the gravitational potential and the velocity of Mercury.

5.10 - Correction for an Elliptical Orbit.

There is one more term that needs to be taken into account to get a better accuracy. We know that Mercury travels on an elliptical orbit. However, in our calculation we have always considered the distance of Mercury from the Sun (R_M) as a constant. In an elliptical motion, the distance from the Sun is not constant but varies according to a relationship characteristic of an ellipse. From geometrical considerations, it is demonstrated [1] that the distance R_M of the orbiting body (Mercury) from the occupied focus (where the Sun is located) of an ellipse is given by the relationship:

$$R_M = \frac{a(1-e^2)}{1+e\cos\theta} \qquad 5.39$$

where a is the length of the semi-major axis, e is the eccentricity of the ellipse and θ is the angle between the value of the perihelion minus the argument of the perihelion. From equation 5.39, we see that when the eccentricity e is equal to zero, the distance of the orbiting planet to its center of translation is equal to a constant "a". Therefore equation 5.36 is valid when the eccentricity of the orbit of the planet is zero (or negligible). This is not the case for Mercury for which the eccentricity is e = 0.2056.

The orbiting body is sometimes at a closer distance from the Sun where the gravitational potential is larger. At those times, the velocity of the planet is larger. Of course, there are other parts of the orbit where the planet moves more slowly in a shallower gravitational potential. However, we can see that the smaller gravitational potential does not compensate completely for the larger one. The eccentricity must be taken into account. The clock rate and the unit of length must be taken into account at every point of the elliptical orbit. We have calculated above that the change of gravitational potential and of velocity produce an average effect represented mathematically by an "effective potential" Pot/M($\underline{M}$) in equation 5.38. Combining equations 5.39 and 5.37 we find:

$$\frac{Pot}{M(\underline{M})} = GM(\underline{S})\frac{1+e\cos\theta}{a(1-e^2)}. \qquad 5.40$$

Equation 5.40 shows that the potential per unit of mass is not constant during an elliptical orbit (contrary to a circular orbit). Therefore the advance of the perihelion of Mercury after a full translation depends on the integral of that potential (Pot/M($\underline{M}$)) over a full translation of Mercury around the Sun. This integral gives the average equivalent gravitational potential during a full elliptical orbit. It is equal to 1/2π of the integral of the angle θ over 2π. Using equation 5.40, we get:

$$\frac{\overline{Pot}}{M(\underline{M})} = \frac{1}{2\pi}GM(\underline{S})\int_0^{2\pi}\frac{1+e\cos\theta}{a(1-e^2)}d\theta. \qquad 5.41$$

This gives:

$$\frac{\overline{Pot}}{M(\underline{M})} = GM(\underline{S})\frac{1}{a(1-e^2)}. \qquad 5.42$$

The average gravitational potential obtained when the eccentricity e_M for Mercury is:

$$\frac{\overline{Pot}}{M(\underline{M})}(e = e_M) = GM(\underline{S})\frac{1}{a(1-e_M^2)}. \qquad 5.43$$

The average of Pot/M($\underline{M}$) gives the correction to Mercury's elliptical orbit with respect to a circular orbit. In order to apply that correction, let us substitute the equivalent potential of Mercury by the average potential given by equation 5.43. Equation 5.43 into 5.38 gives:

$$\frac{\Delta P_{l,\Delta CD}(\text{o.s.,rest})}{P_{l,\Delta CD}(\text{M,mov})}(\text{all effects}) = \frac{3GM(\underline{S})}{c^2 a(1-e_M^2)}. \qquad 5.44$$

Equation 5.44 shows that an outer space clock takes an extra fraction of a circumference to complete the ellipse when corrections include ellipticity. This extra fraction of a circumference Δ(circ) per unit circumference is:

$$\Delta(\text{circ}) = \frac{3GM(\underline{S})}{c^2 a(1-e^2)}. \qquad 5.45$$

Equation 5.45 is usually presented in radians instead of a fraction of a circumference. If the advance of the perihelion is represented by the angle $\Delta\phi$, equation 5.45 becomes 2π times larger and gives:

$$\Delta\phi = \frac{6\pi GM(\underline{S})}{c^2 a(1-e^2)}. \qquad 5.46$$

Equation 5.46 is the final equation for the advance of the perihelion of Mercury in radians per translation of Mercury as calculated using classical mechanics and mass-energy conservation.

5.11 - Mathematical Identity with Einstein's Equation.

Einstein presented a mathematical relationship for the advance of the perihelion of Mercury. Many books report that result. Straumann's [2] equations 3.1.11 and 3.3.7 give:

$$\Delta\phi = \frac{6\pi GM(\underline{S})}{c^2 a(1-e^2)}. \qquad 5.47$$

This equation is perfectly identical to our equation 5.46. Consequently, all the physical principles that have been used to find equation 5.46 are sufficient since we get a prediction identical to the experimental observations and Einstein's equation. We add that the experimental value for the advance of the perihelion of Mercury has been well-known for more than a century. Le Verrier's calculations of the observational data found such an advance as early as 1859 [3]. Roseveare published a very interesting historical account of reliable observations and calculations of Mercury's perihelion [4].

5.12 - References.

[1] Kenneth R. Lang, Astrophysical Formulae, Springer-Verlag, ISBN 3-540-09933-6. second corrected and enlarged edition, p. 541, 1980.

[2] Norbert Straumann, General Relativity and Relativistic Astrophysics, Springler-Verlag, second printing, 1991.

[3] U. J. J. Le Verrier, Théorie du mouvement de Mercure, Ann. Observ. imp. Paris (Mémoires) **5**, p. 1 to 196, 1859.

[4] N. T. Roseveare, Mercury's Perihelion from Le Verrier to Einstein, Clarendon Press, Oxford, 208 p. 1982.

5.13 - Symbols and Variables

a_M(M)	number of Mercury meters for the semi-major axis
a_M(o.s.)	number of outer space meters for the semi-major axis
ΔCD_M(M)	ΔCD for the period of Mercury measured by a Mercury clock
ΔCD_M(o.s.)	ΔCD for the period of Mercury measured by an outer space clock
$\Delta CD_{M,v}$	ΔCD for the period of Mercury measured by a moving Mercury clock
$\Delta CD_{o.s.,o}$	ΔCD for the period of Mercury measured by an outer space clock at rest
ΔCD_o	ΔCD for the period of Mercury on a clock at rest
ΔCD_v	ΔCD for the period of Mercury on a clock in motion
$\Delta P_{l,\Delta CD}$(o.s.,rest)	relative increase of the number of absolute seconds for the period of Mercury
$\Delta\phi$	advance of the perihelion of Mercury in radians
F_G(M)	number of Mercury newtons for the gravitational force on Mercury
F_G(o.s.)	number of outer space newtons for the gravitational force on Mercury

G(M)	number of Mercury units for the gravitational constant
G(o.s.)	number of outer space units for the gravitational constant
km_{frame}	length of the local kilometer in a frame
$l_M(M)$	number of Mercury meters for the orbit of Mercury
$l_M(o.s.)$	number of outer space meters for the orbit of Mercury
$l_{M,v}$	number of Mercury moving meters for the orbit of Mercury
$l_{o.s.,o}$	number of outer space rest meters for the orbit of Mercury
L[rest]	length of the orbit of Mercury in rest units
meter[frame]	length of the local meter in a frame
$M(\underline{M})_M(M)$	number of Mercury kilograms for Mercury at Mercury location
$M(\underline{M})_{o.s.}(o.s.)$	number of outer space kilograms for Mercury in outer space
$M(\underline{S})(M)$	number of Mercury units for the mass of the Sun
$M(\underline{S})(o.s.)$	number of outer space units for the mass of the Sun
N_o	number of rest meters for the orbit of Mercury
N_v	number of moving meters for the orbit of Mercury
$P_{l,\Delta CD}(o.s.,rest)$	number of outer space (rest) seconds for the period of Mercury taking into account the gravitational potential and the velocity of Mercury
$P_{l,\Delta CD}(M,mov)$	number of Mercury (motion) seconds for the period of Mercury taking into account the gravitational potential and the velocity of Mercury
$R_M(M)$	distance of Mercury from the Sun in Mercury units
$R_M(o.s.)$	distance of Mercury from the Sun in outer space units

Chapter Six
Geometrical Illustration of the Advance of the Perihelion of Mercury.

6.1 - Conditions Controlling the Geometrical Shape of an Orbit.

The advance of the perihelion of Mercury given in equation 5.46 was calculated using perturbations of individual parameters. This advance can also be illustrated using geometrical considerations. Newton stated the universal law of gravitation which predicts an exact quadratic gravitational field around a mass. Newton has shown that in the gravitational field around a central body, all masses move in elliptical orbits independently of the mass of the orbiting body. According to classical mechanics, the necessary condition to get an exact elliptical orbit is for the mass to move in a gravitational field whose intensity decreases exactly as the inverse of the square of the distance R from the central mass:

$$\text{Field} \propto \frac{1}{R^2}. \qquad 6.1$$

There are several measurements showing that this quadratic decrease of the gravitational field is followed quite accurately in nature. At a distance R_M(o.s.) from M(S)(o.s.), the field is given by:

$$\text{Field} = \frac{G(\text{o.s.})M(\underline{S})(\text{o.s.})}{R_M^2(\text{o.s.})} \qquad 6.2$$

where G(o.s.) is the number of outer space units of the gravitational constant and M(S)(o.s.) is the number of outer space units of the solar mass. Equation 6.2 implies that the Sun generates an exact quadratic gravitational field (in outer space units) in which Mercury is submerged.

Although the inverse quadratic law is generally accepted, a very slight deviation of that law was first suggested by Aseph Hall in 1894 [1]. Since we have seen that the mass of a body changes when it is moved into a gravitational potential, we can show that such a slight change of mass leads to an effect equivalent to the slight change of the quadratic function suggested by Hall.

Classical mechanics shows that a massive body travels in an elliptical orbit when the force F rather than the field between the central mass and the orbiting mass decreases as the square of the distance. Let us consider Newton's equation (written in a correct way, contrary to equation 5.1):

$$F_M(o.s.) = \frac{G(o.s.)M(\underline{S})(o.s.)M(\underline{M})_M(o.s.)}{R_M^2(o.s.)}. \qquad 6.3$$

Since the mass of Mercury changes with its distance from the Sun, it is incorrect to believe that the force between the Sun and Mercury still follows an inverse quadratic function of that distance. Even if the gravitational field around a central mass decreases exactly as the square of the distance, the total force between Mercury and the Sun does not decrease at the same rate as the field. The trajectory of a planet whose mass decreases when it gets deeper in a gravitational field corresponds exactly to the problem of a non quadratic force around a central mass. Using classical mechanics we can calculate the new geometrical shape of the orbit when the force (not the field) between the Sun and Mercury is non quadratic.

However, when we consider the proper parameters of the observer moving to different distances from the Sun, the gravitational field (defined as the force divided by the proper mass) calculated from equation 5.9 is not quadratic for the observer traveling between different locations from the Sun. Consequently, using the parameters existing where Mercury interacts with the gravitational field leads to an apparent non quadratic field (since the proper mass of Mercury is constant for a Mercury observer).

Using either the non quadratic force as seen by an outer space observer that takes into account the change of mass of Mercury or the apparent non quadratic force given by equation 5.9 (with constant proper mass) leads to a similar advance of the perihelion of Mercury. However, these calculations are incomplete because other fundamental phenomena, like the change of mass as a function of the velocity of Mercury on its orbit, are not taken into account. Changes of length and clock rate due to Mercury's velocity and gravitational potential should also be taken into account.

Since we have already calculated the total precession in equation 5.46, we will limit our demonstration here to the change of one parameter using only the change of mass of Mercury as a function of its distance from the Sun. We will use only the perturbation of this parameter and show that it is one of the contributions to the geometrical precession of the ellipse which can be illustrated in a classical experiment that can be done in a laboratory using a simple apparatus.

6.2 - The Change of Mass of Mercury.

Let us consider the change of force on Mercury due to its change of mass as a function of its distance from the Sun. Equation 4.25 shows how the absolute mass of a kilogram decreases when getting closer to the Sun. Consequently, the total mass of Mercury decreases by the same ratio. From equations 4.39, 4.40 and 4.41, the mass of Mercury (in outer space units) follows the relationship:

$$\frac{\mu(\underline{M})_M[\text{o.s.}]}{\mu(\underline{M})_{\text{o.s.}}[\text{o.s.}]} = \frac{\text{kg}_M}{\text{kg}_{\text{o.s.}}}. \qquad 6.4$$

Equations 6.4 and 4.25 give:

$$\mu(\underline{M})_M[\text{o.s.}] = \mu(\underline{M})_{\text{o.s.}}[\text{o.s.}]\left(1 - \frac{G(\text{o.s.})M(\underline{S})(\text{o.s.})}{c^2 R_M(\text{o.s.})}\right). \qquad 6.5$$

or:

$$M(\underline{M})_M(\text{o.s.}) = M(\underline{M})_{\text{o.s.}}(\text{o.s.})\left(1 - \frac{G(\text{o.s.})M(\underline{S})(\text{o.s.})}{c^2 R_M(\text{o.s.})}\right). \qquad 6.6$$

Using equation 6.6 in 6.3 gives a force equal to:

$$F_M(\text{o.s.}) = \frac{G(\text{o.s.})M(\underline{S})(\text{o.s.})M(\underline{M})_{\text{o.s.}}(\text{o.s.})\left(1 - \frac{G(\text{o.s.})M(\underline{S})(\text{o.s.})}{c^2 R_M(\text{o.s.})}\right)}{R_M^2(\text{o.s.})} \qquad 6.7$$

which is equal to:

$$F_M(\text{o.s.}) = G(\text{o.s.})M(\underline{S})(\text{o.s.})M(\underline{M})_{\text{o.s.}}(\text{o.s.})\left(\frac{1}{R_M^2(\text{o.s.})} - \frac{G(\text{o.s.})M(\underline{S})(\text{o.s.})}{c^2 R_M^3(\text{o.s.})}\right). \qquad 6.8$$

Let us define:

$$k_1 = \frac{G(o.s.)M(\underline{S})(o.s.)}{c^2}. \qquad 6.9$$

Equation 6.8 becomes:

$$F_M(o.s.) = G(o.s.)M(\underline{S})(o.s.)M(\underline{M})_{o.s.}(o.s.)\left(\frac{1}{R_M^2(o.s.)} - \frac{k_1}{R_M^3(o.s.)}\right). \qquad 6.10$$

Equation 6.10 shows that the gravitational force is the difference between a quadratic and a cubic function. It is known that in a quadratic field, an elliptical orbit with a small eccentricity (first order expansion) follows the equation $r = a(1 + e\cos\theta)$ (a is the semi-major axis and e is the eccentricity). This equation implies two components: a tangential component of constant radius a and a radial component of amplitude $ae\cos\theta$. Since Kepler's third law predicts the same period (first order) for orbits having the same average radius with or without eccentricity, both the tangential and the radial components lead to the same period in a quadratic field.

However, in the case of a non quadratic field (cubic term in equation 6.10), the period of oscillation of the radial component becomes longer than the period of the circular tangential component. Of course, a circular component does not 'feel' the field gradient. Because the cubic radial component of oscillation has a longer period, there is a continual shift of phase between the periods of the tangential and of the radial components.

Consequently, the cubic term in equation 6.10 which does not follow Kepler's quadratic gradient of force, is responsible for the precession of the ellipse because the radial component, having a longer period, becomes out of phase with the circular component. It is the difference of period between the tangential and the radial components of motion that produces the precession of the ellipse. We also notice that it is the radial component of oscillation which is most affected by the change of parameters resulting from mass-energy conservation.

Let us examine the bracket on the right hand side of equation 6.10. Using a series expansion, we can show that it is mathematically equivalent to a simple exponential form given by:

$$\frac{1}{R^2} - \frac{k_1}{R^3} = \frac{1}{R^{2+\varepsilon}} \qquad 6.11$$

in which the exact value of ε is:

$$\varepsilon = \sum_{n=1}^{\infty} \frac{k_1^n}{nR^n \ln R}. \qquad 6.12$$

A very good approximation to the first order (with n = 1) gives:

$$\varepsilon = \frac{k_1}{R \ln R}. \qquad 6.13$$

Combining equations 6.10 and 6.11 gives:

$$F_M(\text{o.s.}) = G(\text{o.s.})M(\underline{S})(\text{o.s.})M(\underline{M})_{\text{o.s.}}(\text{o.s.})R_M^{-(2+\varepsilon)}(\text{o.s.}) \qquad 6.14$$

where ε is always positive. Equation 6.14 shows that, because of the decrease of mass due to mass-energy conservation, the force F between Mercury and the Sun no longer decreases exactly as the square of the distance. The change of mass of Mercury as a function of its distance from the Sun is responsible for the change of power of R_M from 2 to 2+ε. Therefore even if the gravitational field affecting Mercury decreases exactly as the inverse of the square of the distance as written in equation 6.2 (as in a perfect Newtonian field), the gravitational force is not Newtonian as shown in equation 6.14. Let us reconsider now the trajectory of bodies submitted to a force decreasing with a function which is slightly different from $1/R^2$.

6.3 - Orbital Shapes and Gravitational Force Gradients.

We have calculated in equation 6.10 the force on Mercury as a function of the distance R_M. The corresponding gravitational potential V_M(o.s.) is obtained by the integral of equation 6.10. This gives:

$$V_M(\text{o.s.}) = G(\text{o.s.})M(\underline{S})(\text{o.s.})M(\underline{M})_{\text{o.s.}}(\text{o.s.})\left(\frac{-1}{R_M(\text{o.s.})} + \frac{k_1}{2R_M^2(\text{o.s.})}\right). \qquad 6.15$$

The orbit followed by a mass submitted to the potential described by equation 6.15 has already been calculated [2, 3].

Using temporarily Goldstein's notation [2], the solution of equation 6.15 is a precessing ellipse with a velocity of precession equal to:

$$\Omega(\text{sec}) = \frac{2\pi m h}{l^2 \tau} \qquad 6.16$$

where Ω(sec) is in radians per second of time. Transforming Goldstein's notation into ours, we have $m = M(\underline{M})_{o.s.}(o.s.)$ and $h = (G(o.s.)M(\underline{S})(o.s.)M(\underline{M})_{o.s.}(o.s.)k_1)/2$. τ is the period of translation of Mercury around the Sun. The angular momentum l in equation 6.16 is:

$$l = M(\underline{M})_{o.s.}(o.s.)R_M^2(o.s.)\frac{d\theta}{dt} = \frac{2\pi M(\underline{M})_{o.s.}(o.s.)R_M^2(o.s.)}{\tau} \qquad 6.17$$

where dθ/dt is the angular velocity. Therefore, from equation 6.9 and the definitions above, we have:

$$h = \frac{G^2(o.s.)M(\underline{S})^2(o.s.)M(\underline{M})_{o.s.}(o.s.)}{2c^2}. \qquad 6.18$$

From equations 6.16, 6.17 and 6.18, we have:

$$\Omega(\text{sec}) = \frac{G^2(o.s.)M(\underline{S})^2(o.s.)\tau}{c^2 R_M^4(o.s.)4\pi}. \qquad 6.19$$

Let us transform the precession Ω(sec) given in radians per second for radians per circumference Ω(circ). We obtain:

$$\Omega(\text{sec}) = \frac{G^2(o.s.)M(\underline{S})^2(o.s.)\tau^2}{c^2 R_M^4(o.s.)4\pi}. \qquad 6.20$$

By definition, the period τ equals:

$$\tau = \frac{2\pi R_M(o.s.)}{v}. \qquad 6.21$$

Equation 6.21 in 6.20 gives:

$$\Omega(\text{circ}) = \frac{\pi G^2(o.s.)M(\underline{S})^2(o.s.)}{c^2 R_M^2(o.s.)v^2}. \qquad 6.22$$

Newton's law shows that the force of gravity F_G is equal to the centrifugal force F_C in a circular orbit (the eccentricity has not yet been taken into account). We have the fundamental equations:

$$F_C = \frac{M(\underline{M})_M(o.s.)v^2}{R_M(o.s.)} = F_G = \frac{G(o.s.)M(\underline{S})(o.s.)M(\underline{M})_M(o.s.)}{R_M^2(o.s.)}. \qquad 6.23$$

Equation 6.23 gives:

$$v^2 = \frac{G(o.s.)M(\underline{S})(o.s.)}{R_M(o.s.)}. \qquad 6.24$$

Equations 6.24 and 6.22 give:

$$\Omega(circ) = \frac{\pi G(o.s.)M(\underline{S})(o.s.)}{c^2 R_M(o.s.)}. \qquad 6.25$$

Equation 6.25 gives the velocity of precession of an ellipse for the case of a perfect quadratic field in which the orbiting mass changes with its position in the gravitational potential, due to mass-energy conservation.

6.4 - Identity of Mathematical Forms.

We find that the advance of the perihelion of Mercury obtained with the perturbation method used by Einstein and by us in equation 5.46, has the same mathematical form as equation 6.25 which clearly corresponds to the precession of an elliptical orbit. There are two obvious differences. Since we have not taken into account the eccentricity of the orbit, the term $1\text{-}e^2$ is naturally missing in equation 6.25 as explained in section 5.10. Other similar parameters are ignored here since we do not take into account the perturbations explained in section 6.1. If we take into account these perturbations, other similar terms will be added and the full precession will be found as obtained in chapter five. The aim of the present demonstration is only to illustrate the reality of the classical precession of the ellipse in the case of a non quadratic force.

6.5 - Illustration of Trajectories in Potential Wells.

When the force on a planet moving around the Sun decreases as the square of its distance from the Sun, it travels on a perfect ellipse. However, due to mass-energy conservation, the exact intensity of the force does not decrease as the square of the distance. As seen in equation 6.14 the force follows the relationship:

$$F_M(\text{o.s.}) = G(\text{o.s.})M(\underline{S})(\text{o.s.})M(\underline{M})_{\text{o.s.}}(\text{o.s.})R_M^{-(2+\varepsilon)}(\text{o.s.}). \qquad 6.26$$

The trajectory of a particle submitted to equation 6.26 is an ellipse as illustrated on figures 6.1 and 6.2. In figure 6.1, a smooth conic surface is built (in the Earth gravitational field) in such a way that the height above the ground increases as the negative of the inverse of the square of the distance from the central axis. This corresponds to $\varepsilon = 0$ in equation 6.26. In this case, the potential energy of a ball sliding (without friction) on the surface increases according to the inverse quadratic function from the center. If we throw a ball on the surface, we can get a circular orbit at various distances from the center. Using a different initial angular momentum, one can observe a stationary elliptical orbit as drawn on figure 6.1.

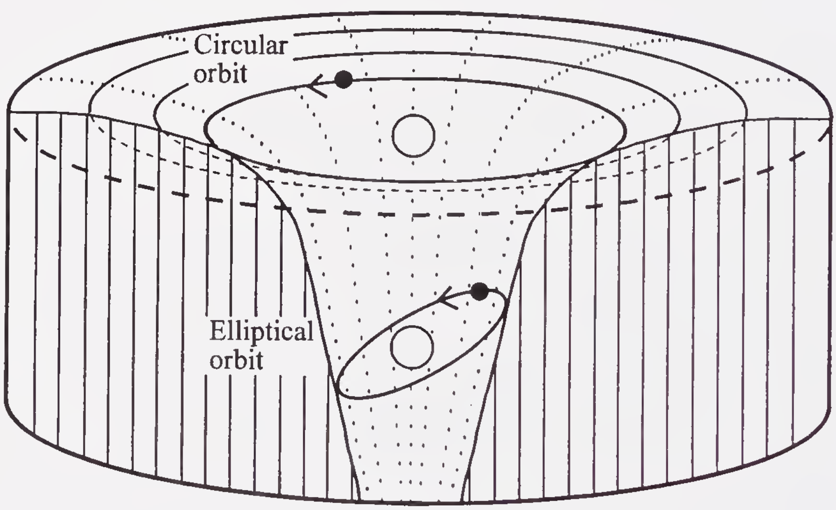

Figure 6.1

DEMONSTRATION OF A MASS MOVING IN AN ELLIPTICAL ORBIT IN A QUADRATIC POTENTIAL WELL CHANGING AS $1/R^2$.

However, if the shape of the cone is different (see figure 6.2) so that the potential increases more rapidly than the inverse square of the distance (corresponding to equation 6.26 with $\varepsilon \neq 0$), after throwing a ball, we see that the axis of the elliptical orbit precesses just as observed for Mercury in its orbit around the Sun. The cause of that classical precession on that apparatus is (in part) the same as the cause of the precession of 43 arcsec per century of Mercury. Of course, this demonstration assumes that the friction and the rotation of the ball are negligible.

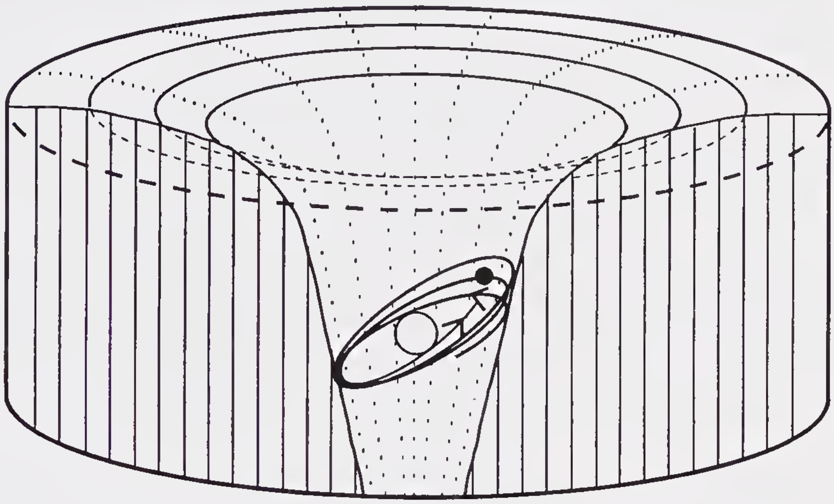

Figure 6.2

DEMONSTRATION OF THE PRECESSING ORBIT OF A MASS MOVING IN A POTENTIAL WELL CHANGING AS $1/R^{(2+\varepsilon)}$.

This shows that the advance of the perihelion of Mercury is not caused by space or time distortion. It is simply a beautiful demonstration of classical mechanics that predicts precessing orbits giving the shape of a rosette.

6.6 - Validity of the Classical Model.

We have found above that there is a perfect mathematical agreement between the result calculated in equation 5.46 and the result predicted using Einstein's mathematics. Moreover, those results are in perfect agreement with the observations of the advance of the perihelion of Mercury.

In order to arrive to his equation, Einstein, needed several new hypotheses called Einstein's relativity principles. Let us compare the hypotheses used by Einstein with the ones used in this book to find the Lorentz transformations and the equation for the advance of the perihelion of Mercury. This comparison is important if we wish to apply Occam's razor which gives a preference to the theory that requires the minimum number of hypotheses. Einstein's theory requires many new hypotheses, for example:

1) the reciprocity principle which is not compatible with mass-energy conservation as showed in section 3.9;

2) the hypothesis that the acceleration produced by a change of velocity is undistinguishable from the acceleration due to gravity (see chapter ten);

3) the non conservation of mass-energy in general relativity.

Einstein then arrived at the consequences that space and time can be distorted, contracted and dilated. In fact, Einstein's model not only requires new physical hypotheses, it also requires "new logic" which is not compatible with the natural understanding of nature. Classical logic can no longer be applied in relativity. In this book, we use the Bohr model of the atom which is so familiar everywhere in physics. We also find that using proper values, the physical relationships are valid in all frames as in Einstein's relativity. At the same time, a rational explanation is given. No time nor space distortion is required and the new interpretation is compatible with classical logic. There is certainly an extremely strong preference in favor of this new model when we apply Occam's razor.

6.7 - References.

[1] A. Hall, A Suggestion in the Theory of Mercury, Astr. J. **14,** 49-51, 1894.

[2] H. Goldstein, Classical Physics, Addison-Wesley, Reading, Mass., second Edition, p. 123, 1980.

[3] E. T. Whittaker, A Treatise on the Analytical Dynamics of Particles and Rigid Bodies , Cambridge University Press, Fourth Edition, Chapter 4, 1937. (also Dover, New York, 1944).

6.8 - Symbols and Variables.

F_M(o.s.)	number of outer space newtons for the gravitational force on Mercury
G(o.s.)	number of outer space units for the gravitational constant
kg_{frame}	mass of the local kilogram in absolute units

$M(\underline{M})_M(o.s.)$	number of outer space kilograms for Mercury at Mercury location
$M(\underline{M})_{o.s.}(o.s.)$	number of outer space kilograms for Mercury in outer space
$\mu(\underline{M})_M[o.s.]$	mass of Mercury in outer space units at Mercury location
$\mu(\underline{M})_{o.s.}[o.s.]$	mass of Mercury in outer space units in outer space
$M(\underline{S})(o.s.)$	number of outer space units for the mass of the Sun
$R_M(o.s.)$	number of outer space units for the distance of Mercury from the Sun
$V_M(o.s.)$	number of outer space units for the gravitational potential on Mercury

Chapter Seven
The Lorentz Transformations in Three Dimensions.

7.1 - Basic Principles of a Transformation.

The Lorentz transformations are usually considered as nothing more than a transformation of coordinates between a rest frame and a moving frame. They appear as geometrical transformations of coordinates. Let us consider the fundamental meaning of such transformations. Let us first have a look at the geometrical transformation of Cartesian coordinates into spherical coordinates. We find that the equation of a sphere in spherical coordinates is:

$$\rho = \text{constant.} \qquad 7.1$$

In Cartesian coordinates, the same sphere is represented by:

$$x^2+y^2+z^2 = r^2. \qquad 7.2$$

Equations 7.1 and 7.2 represent the same physical or geometrical object. Such a transformation does not change anything to the physical system described. Absolutely no physics is involved in such a change of coordinates because these transformations are purely mathematical. However, one system of coordinates (the spherical coordinates) can be more suitable mathematically to study rotational motion or a particular orientation in space.

Geometrical transformations used to transform coordinates between a moving frame (at velocity u_x) and an initial frame supposedly at rest are called Galilean. When the velocity of an object is given by V_x, V_y and V_z with respect to a frame at rest, the velocity components V_x', V_y' and V_z' of the same object with respect to the moving frame are:

$$V_x' = V_x - u_x \qquad 7.3$$

$$V_y' = V_y \qquad 7.4$$

$$V_z' = V_z. \qquad 7.5$$

The description given by the parameters V_x', V_y' and V_z' is quite identical to the description given by V_x, V_y and V_z knowing that the moving frame has velocity u_x. Therefore these transformations of coordinates involve no physics at all. They represent the same physical object using a different system of coordinates. They are just mathematical transformations.

However, in some other cases, physical phenomena necessarily accompany a change of coordinates meaning that some physical changes are related to a change of frame of reference. Let us consider an example of transformation of coordinates in which there is a physical phenomenon taking place at the same time as a change of coordinates. This is the case of a boat sinking at sea. Inside the boat, there are five spherical balloons inflated with air, glued to each other along a vertical line (Y axis). At the surface of the sea, the diameter "y_0" of each balloon is one meter. Therefore the row of balloons is five meters long. As the boat sinks to great depths, due to the increase of pressure the gas inside the balloons is compressed and the diameters get smaller as a function of depth. Consequently, the length of the row gets more and more contracted with depth. We know that the relationship between the volume of a gas and its pressure at a constant temperature is given by:

$$PV = \text{constant}. \qquad 7.6$$

We also know that the volume of a constant amount of air as a function of pressure (and therefore depth D) is given by:

$$V = V_0\left(\frac{A}{A + D}\right) \qquad 7.7$$

where D is the depth in meters from the surface, V_0 is the volume of the balloon at atmospheric pressure when located at the surface of the sea and V is the volume of the gas at different depths. At normal atmospheric pressure, the value of A equals 9.8. The relationship between the diameter y and the volume V is:

$$\frac{V}{V_0} = \left(\frac{y}{y_0}\right)^3. \qquad 7.8$$

From equations 7.7 and 7.8, we get:

$$y = y_0\left(\frac{9.8}{9.8 + D}\right)^{\frac{1}{3}}. \qquad 7.9$$

Equation 7.9 gives the relationship between the diameter y of each balloon as a function of the depth D.

Let us consider a moving frame of reference y' going down with the sinking ship and having its origin at one end of the row of balloons. Since the initial length (at D_0=0) of the row of balloons is $Y_0 = 5$ meters, the length Y' of the axis at depth D is given by:

$$Y' = Y_0 \left(\frac{9.8}{9.8 + D} \right)^{\frac{1}{3}}. \qquad 7.10$$

The important point to notice is that when the balloons sink into the sea, there is not only a change of coordinates of the balloons with respect to the original frame, there is also a change in the length of the row of five balloons due to the compression of the gas which is a function of the distance of the balloons from the surface. This is an example where the relationship giving a transformation of coordinates is necessarily related to a physical phenomenon.

Let us now complete these considerations for the other axes. We need again to consider the physical phenomenon involved to show that the X and Z diameters of the balloons decrease simultaneously when the pressure contracts the gas. This gives:

$$X' = X_0 \left(\frac{9.8}{9.8 + D} \right)^{\frac{1}{3}} \qquad 7.11$$

$$Z' = Z_0 \left(\frac{9.8}{9.8 + D} \right)^{\frac{1}{3}} \qquad 7.12$$

where X_0 and Z_0 are equal to one meter. Equations 7.11 and 7.12 can be written only because we know the exact physical phenomenon taking place (a compressed balloon contracts equally on all three axes). A mathematical transformation of coordinates alone cannot describe whether the other axes X and Z will also be contracted. Physics is needed to give information about what happens in the X and Z directions. Equations 7.11 and 7.12 are quite conclusive because we know the physical phenomenon that accompanies the mathematical transformation.

7.2 - The Lorentz Transformations.

Let us now consider the case of the Lorentz transformations. We have seen that they are not pure geometrical transformations since there are physical conditions involved with the transformations. There is a change of mass of the electron due to the kinetic energy of the particle. Of course, the experiment with the balloons is quite different from the change of size of atoms when they acquire kinetic energy. However, both experiments have in common that the size of the objects depends on a well identified physical phenomenon and not on a simple change of coordinates. For the balloons, the pressure changes their size by compressing the gas in them. For atoms, the change of kinetic energy changes their size and the inter atomic distance in molecules.

Quantum mechanics predicts that the distribution of the wave function of an electron around the nucleus does not get flattened when the electron mass increases. The increase of the electron mass changes the size of the wave function equally in all directions.

The hypothesis of Lorentz and Einstein that the other axes do not change and that the transformations are purely geometrical is not compatible with the physics implied in the calculations of quantum mechanics. It is quite clear that the change of the electron mass changes the distribution along all three directions. Nobody in quantum mechanics has ever suggested flatter wave functions (and flatter atoms and molecules) when the electron mass is larger. Consequently, when an atom is accelerated in one direction, the size of the atom or the length of the intermolecular distance changes in all three directions. Therefore the assumption in relativity that there is no change of size of the coordinates Y and Z while the coordinate X is changing is an error that must be corrected.

7.3 - The Equations.

We have seen that in the direction of the velocity (the X direction) there is a physical mechanism leading to the Lorentz equation for the X axis given in equation 3.55:

$$x' = \gamma(x-u_x t). \qquad 7.13$$

Since this result comes from quantum mechanics which predicts a symmetry in all three directions when the electron mass (which is a scalar) changes, we must conclude that the phenomenon of length dilation is just as valid in the transverse directions than in the longitudinal direction. Using Lorentz and Einstein's choice of coordinates x, y and z, let us write the transformation of coordinates for the transverse directions y and z due to the change of the Bohr radius as given by quantum mechanics. From equation 7.13 with $u_y = 0$ and $u_z = 0$, we find:

$$y' = \gamma y \qquad 7.14$$

and

$$z' = \gamma z. \qquad 7.15$$

We conclude that the previous description given by Lorentz and Einstein which assumes a transformation in only one dimension (which has never been observed in any experiment) is erroneous because it is not compatible with quantum mechanics and with the principle of mass-energy conservation.

7.4 - Symbols and Variables.

D depth of the balloon
V volume of the balloon
V_o volume of the balloon at sea level
y diameter of the balloon
y_o diameter of the balloon at sea level

Chapter Eight
The Doppler Effect.

8.1 - Fundamental Principles of the Doppler Effect.

In chapter two, we considered the special case of zero Doppler effect. This means that the source was moving in a direction perpendicular to the direction of propagation of light. The change of frequency due to the Doppler effect was zero because the radial velocity between the source and the detector was equal to zero. When there is a relative radial velocity between the source and the detector, the Doppler effect must be taken into account. Unfortunately, this phenomenon does not seem to be completely well understood in physics.

There have been many discussions about the question of the conservation of energy in the Doppler effect. For example, Weiss and Baez wrote an article [1] entitled: "Is Energy Conserved in General Relativity?"

They consider the case of the cosmic radiation that has been redshifted over billions of years. "Each photon gets redder and redder. What happens to this energy?" They report that:"... the energy is simply lost".

Such an answer is not acceptable since we believe in mass-energy conservation. We do not believe that any kind of energy can ever be lost whatever the circumstances are. If this were possible, energy would be created from nothing when an emitter moves toward an observer because of the Doppler effect.

Of course, an increasing radial velocity necessarily produces a reddening but one sees that a reddening is not a proof of a Doppler effect since it can be produced by other ways. It has been shown [2] that the reddening of the cosmic radiation can be better explained by a different phenomenon in which mass-energy is conserved. The reddening results from the energy lost following numerous interactions of photons on interstellar gases during billions of years. In that case, the residual energy is scattered elsewhere so that there is no difficulty to be compatible with the principle of mass-energy conservation.

8.2 - Mass-Energy Conservation in the Context of the Doppler Effect.

Doppler reddening is a real phenomenon which can occur in some cases and which is always compatible with mass-energy conservation. For example, let us consider the case of a hydrogen atom excited to 10.2 eV (the Lyman state) moving away from a stationary source. If the hydrogen atom moves at half the velocity of light, the theory of the Doppler effect (using the wave property of light) teaches us that we will receive only half of the frequency of the excited state. This means that the photon received from the moving particle will have only half the energy of excitation. The question is: Where does the difference of energy (5.1 eV) go? It has been claimed in several papers that the energy is missing.

The demonstration using the change of frequency of a wave due to the relative velocity does not take into account all the energy available in the experiment. Let us calculate the Doppler effect without using waves but using only the principle of mass-energy conservation.

8.3 - The Doppler Effect without Using Waves.

Let us consider a mass m_o (at rest) moving away at velocity V with respect to an observer at rest. Let us assume that the mass is a hydrogen atom. This moving atom has a total energy of:

$$E_v = \gamma m_o c^2 = m_o c^2 + \frac{1}{2} m_o V^2 + \frac{3}{8}\frac{m_o V^4}{c^2} + \ldots \qquad 8.1$$

Let us consider the case when that hydrogen atom is excited at the Lyman α atomic state with an energy $h\nu_o$ of 10.2 eV. The total energy (potential plus kinetic) of that excited atom (neglecting the higher order terms) is:

$$E_v^* = m_o c^2 + \frac{1}{2} m_o V^2 + h\nu_o . \qquad 8.2$$

Let us use the moving frame of the particle from which the photon is emitted. To be detected in the rest frame, the photon must be emitted backward (-x axis) from the moving atom, in the direction of the rest frame where the observer is located. When the photon is emitted, the atom gets a recoil in the forward (+x axis) direction giving it an increase of velocity Δv. Of course, the total change of momentum ΔP of the moving system (photon plus atom) is zero. At the moment of emission, considering the photon's momentum, we have:

$$\Delta P = \frac{-h\nu_o}{c} + m_o \Delta v = 0 \qquad 8.3$$

or

$$\Delta v = \frac{h\nu_o}{cm_o}. \qquad 8.4$$

With respect to the rest frame, the velocity of the hydrogen atom was V before the emission of the photon. After the emission of the photon, the final velocity V_f of the atom with respect to the rest frame becomes:

$$V_f = V + \Delta v. \qquad 8.5$$

Equation 8.4 in 8.5 gives:

$$V_f = V + \frac{h\nu_o}{cm_o}. \qquad 8.6$$

The total (mass plus kinetic) energy of the de-excited hydrogen atom after the emission of the photon is (neglecting the higher order terms):

$$E'_v = m_o c^2 + \frac{1}{2} m_o V_f^2. \qquad 8.7$$

Using equation 8.6 gives:

$$E'_v = m_o c^2 + \frac{1}{2} m_o \left(V + \frac{h\nu_o}{cm_o} \right)^2. \qquad 8.8$$

The change of kinetic energy of the hydrogen atom due to the recoil of the photon is:

$$\Delta(K.E.) = E'_v - E_v. \qquad 8.9$$

From equations 8.8 and 8.1, neglecting the second order, we have:

$$\Delta(\text{K.E.}) = \left(m_o c^2 + \frac{1}{2} m_o \left(V + \frac{h\nu_o}{c m_o} \right)^2 \right) - \left(m_o c^2 + \frac{1}{2} m_o V^2 \right). \qquad 8.10$$

$$\Delta(\text{K.E.}) = \frac{V h\nu_o}{c}. \qquad 8.11$$

Equation 8.11 gives the increase of kinetic energy of the atom due to its recoil. According to the mass-energy conservation principle, the increase of kinetic energy of the atom must come from the photon energy. Since the excitation energy initially available was $h\nu_o$, and since equation 8.11 gives the energy transferred to the atom (as kinetic energy), the residual photon energy $h\nu_f$ is:

$$h\nu_f = h\nu_o - h\nu_o \frac{V}{c} \qquad 8.12$$

which is:

$$h\nu_f = h\nu_o \left(1 - \frac{V}{c} \right). \qquad 8.13$$

Equation 8.13 is exactly identical to the Doppler equation.

We have demonstrated the Doppler equation using no wave model but only mass-energy conservation. The energy apparently lost in the Doppler phenomenon is simply transferred as kinetic energy to the emitting atom whose velocity has increased due to the recoil momentum. It is also important to notice that the amount of kinetic energy lost in equation 8.11 is independent of the mass of the particle.

The above demonstration solves the problem discussed by Weiss and Baez and others. We conclude that the energy redshifted by the Doppler mechanism is not lost. It is simply transmitted as kinetic energy to the emitting atom due to recoil at the moment of emission. We must notice that this explanation has nothing to do with relativity.

8.4 - References.

[1] http://www-hpcc.astro.washington.edu/mirrors/physicsfaq/energy_gr.html

[2] P. Marmet, A New Non-Doppler Redshift, Physics Essays, **1**, 1, P. 24-32, 1988.

8.5 - Symbols and Variables.

E_V energy of a mass m_o moving at velocity V

E^*_V energy of a mass m_o moving at velocity V and excited to 10.2 eV

E'_V energy of a mass m_o moving at velocity V after losing its energy of excitation

ν_o frequency corresponding to the excitation energy

ν_f frequency emitted by the atom

Chapter Nine
Simultaneity and Absolute Velocity of Light.

9.1 - Simultaneity versus Identical Clock Displays.

The problem of simultaneity has been much studied in relativity. According to Einstein, simultaneous events in one frame cannot be simultaneous in another. This is known as Einstein's principle of relativity of simultaneity.

When two events take place at the same time, we say that they are simultaneous. We know that Einstein always considered that time is what clocks show. Therefore when he writes that two events are simultaneous in two different frames, he means that they occur at the moment when the clocks of observers in both frames show the same display. Since we understand that time does not flow more slowly because clocks run more slowly, Einstein's statement brings much confusion. Instead of saying that two events simultaneous in one frame are not simultaneous in another, he should have said that there is no identity of clock displays between clocks in different frames. Two clocks moving independently at different velocities do not maintain identical clock displays after a time interval. This means that even if both observers see the events at the same absolute time they will record different clock displays. Einstein's relativity of simultaneity becomes understandable only if he means that the clocks can show different displays at one given time.

9.2 - Thought Experiment on Clocks Synchronization.

In order to study this problem in more detail, let us consider figure 9.1 illustrating Einstein's thought experiment.

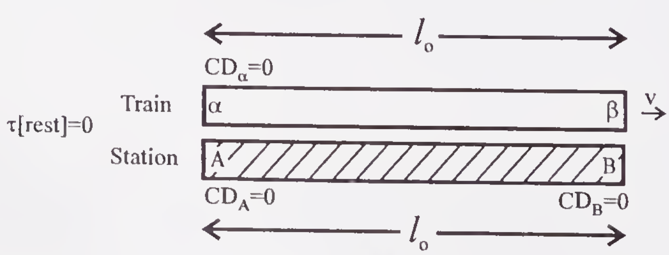

Figure 9.1

Identical clocks labeled A and B are located at rest at each end of a station A-B having a length l_0[rest]. There is no gradient of gravitational potential in this experiment. In front of the station A-B, a moving train α-β has a length such that when in motion, the clock labeled α located at one end of the train passes in front of clock A at the same time as clock β, located at the other end of the train, passes in front of clock B. Clocks α, β, A and B were built identically on the station. Clocks α and β were later put in motion. The synchronization of the clocks is described below.

9.3 - Synchronization of Clocks A and B.

9.3.1 - Method #1.

Clocks A and B on the station are synchronized in the following way. A pulse of light is emitted from A and reflected on a mirror at B toward A. The observer in A records on his clock a difference of clock displays ΔCD_A for the return trip of the light.

When the traveling clock α passes near A, we arbitrarily synchronize clocks α and A together at zero. At that moment, the absolute time τ[rest] on the frames is defined as zero:

$$\tau[\text{rest}] = 0 \text{ and } CD_A = CD_\alpha = 0. \qquad 9.1$$

In the second part of the experiment, a pulse of light emitted by A is received at B. At that moment, the observer at B synchronizes his clock at:

$$CD_B = \frac{\Delta CD_A}{2}. \qquad 9.2$$

Of course the absolute time is the same everywhere. This synchronization method gives a clock display on clock B equal to zero when time τ[rest] equals zero:

$$\tau[\text{rest}] = 0 \text{ when } CD_B = 0. \qquad 9.3$$

The synchronization of clock β at time τ[rest] = 0 will be determined in section 9.5.

9.3.2 - Method #2.

Nobody ever proved experimentally that the velocity of light is the same when moving from A to B than when moving from B to

A. Michelson's experiment has shown that the time taken for light to make a return trip between two points oriented in a different direction in space is the same. However, his experiment has nothing to do with the measurement of any difference of transit time during each half of the trip. Some researchers wishing to investigate more deeply this problem have realized that the method of synchronization described in section 9.3.1 is not appropriate if the velocity of light is not identical in both directions. Consequently, other methods of synchronization have been suggested in hopes of taking into account the possibility of a non constant velocity of light in different directions. A very original method [1] consists in using a new reference clock labeled μ, which carries the display shown by A at a very small velocity ε (of the order of 10^{-9} of the velocity of light) on the station from A to B and later from B to A. In this way, the stationary clocks A and B can be synchronized independently in each direction with the traveling clock μ. This method of synchronization is quite interesting since, as we will now show, any shift of display on clock μ due to its passage from A to B (or B to A) is negligible at very low velocity.

The time taken by clock μ to move from A to B is:

$$\tau(\text{A to B})[\text{rest}] = \Delta CD_A[\text{rest}] = \frac{l_o}{\varepsilon}[\text{rest}]. \qquad 9.4$$

Let us compare the difference of clock displays ΔCD_μ recorded on clock μ during its travel time from A to B with the difference of clock displays ΔCD_A recorded on the stationary clock A during the same time interval. Using equation 3.10, we have:

$$\Delta CD_\mu = \frac{\Delta CD_A}{\gamma_\mu} = \Delta CD_A\sqrt{1-\frac{\varepsilon^2}{c^2}}. \qquad 9.5$$

The first two terms of a series expansion give:

$$\Delta CD_\mu = \Delta CD_A\left(1-\frac{\varepsilon^2}{2c^2}\right). \qquad 9.6$$

From equations 9.4 and 9.6, we have:

$$\Delta CD_{A-\mu} = \Delta CD_A - \Delta CD_\mu = \frac{l_o\varepsilon}{2c^2}. \qquad 9.7$$

Since ε is very small compared with c^2 ($\approx 10^{-18}$), we can approximate ε/c^2 to zero. This gives:

$$\Delta CD_{A-\mu} = \Delta CD_A - \Delta CD_\mu = 0. \qquad 9.8$$

Consequently, clocks A and B can effectively be synchronized using a third clock μ carrying the display of clock A at very low velocity from A to B. Similarly, we find that the difference of displays between clocks μ and B is not significant when clock μ moves from B to A. This is the result obtained when clock μ moves with respect to a rest frame. In the case of clock μ moving on a moving frame, the calculations will be done in section 9.7.

9.4 - Loss of Synchronization of Clock α on the Moving Frame.

Let us calculate the difference of clock displays on clock α moving across distance l_0[rest] from A to B as shown on figure 9.2.

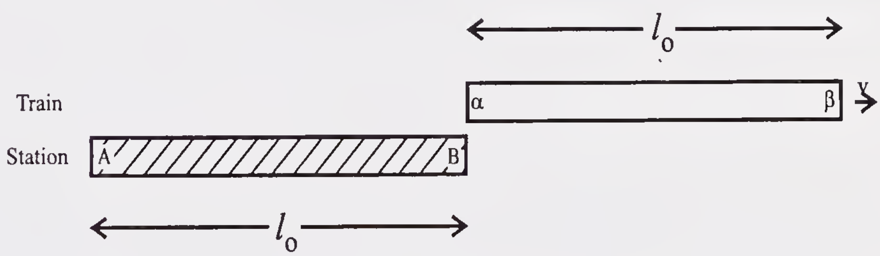

Figure 9.2

Since the train moves at velocity v[rest] and the distance traveled by α is l_0[rest], the time interval $\Delta\tau_1$[rest] for clock α to reach B will be :

$$\Delta\tau_1[\text{rest}] = \frac{l_0}{v}[\text{rest}]. \qquad 9.9$$

Therefore clock α will be in front of B when:

$$\tau[\text{rest}](\alpha \text{ at B}) = \tau_1[\text{rest}] = \frac{l_0}{v}[\text{rest}] \text{ and } CD_A = CD_B = \frac{l_0}{v} \qquad 9.10$$

where τ_1 is the absolute time (after the initial synchronization) when α arrives at B.

However, the moving clock α runs at a slower rate than clock A. From equation 3.10 we find that after the time interval $\Delta\tau_1$[rest] taken by clock α to reach point B, the display on clock α is:

$$CD_\alpha(\alpha \text{ at B}) = \frac{CD_A}{\gamma_v} = \frac{l_o}{\gamma_v v} \qquad 9.11$$

where γ_v is the value of γ corresponding to velocity v. From equation 9.11, we see that even if clock α is initially synchronized with clock A (and with clock B), the synchronization is lost when α travels the distance l_o[rest] (or any distance). The display of clock α becomes late with respect to clocks A and B at rest, as shown by equations 9.10 and 9.11. Let us calculate the difference of clock displays between clocks α and B when α is at B (see figure 9.2).

$$CD_B - CD_\alpha = \Delta CD_{B-\alpha} = \frac{l_o}{v} - \frac{l_o}{\gamma_v v} = \frac{l_o}{v}\left(1 - \frac{1}{\gamma_v}\right). \qquad 9.12$$

The first two terms of a series expansion give:

$$\Delta CD_{B-\alpha} = \frac{l_o v}{2c^2}. \qquad 9.13$$

Equation 9.13 shows that in order to be compatible with the different clock rates of α and A and with the synchronization of α and A, the moving clock α must show a clock display which is different from CD_B when clock α is just besides B.

9.5 - Synchronization between Moving Clocks α and β (Method #1).

In section 9.3.1, we described the synchronization of clock B with clock A. It consists in setting clock B when light is received at B, to one half of the interval ΔCD_A taken by light to go from A to B then back to A. We now calculate the consequences of applying the same synchronization method inside a moving frame. Let us consider a pulse of light emitted from x on figure 9.3 at time τ[rest] = 0. At that moment, we have:

$$\tau[\text{rest}] = 0,\ CD_\alpha = CD_A = CD_B = 0. \qquad 9.14$$

Let us calculate at what absolute time τ_2[rest] light emitted from α reaches clock β as illustrated on figure 9.3.

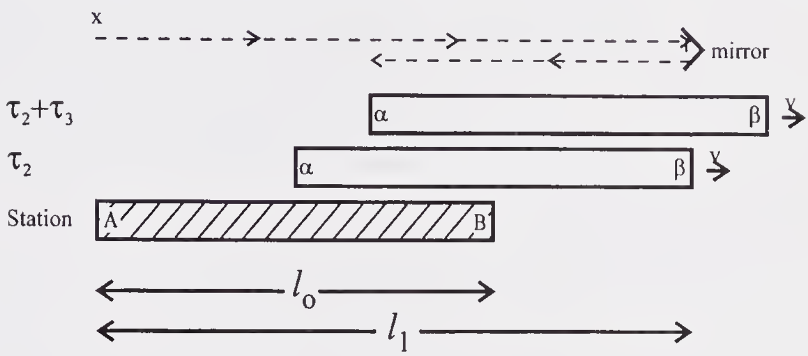

Figure 9.3

We see that light approaches clock β at a relative velocity of c-v. For the observer in the moving frame, the distance to be traveled is l_o[rest]. The absolute time interval $\Delta\tau_2$[rest] to reach clock β is:

$$\Delta\tau_2[\text{rest}](\text{A to }\beta) = \frac{l_o}{c-v}[\text{rest}] \text{ with } CD_A(\text{light at }\beta) = \frac{l_o}{c-v}. \qquad 9.15$$

When light arrives at clock β, the display on clock α is:

$$CD_\alpha(\text{light at }\beta) = \frac{CD_A(\text{light at }\beta)}{\gamma_v} = \frac{l_o}{\gamma_v(c-v)}. \qquad 9.16$$

After being reflected on clock β at time τ_2[rest], the light goes back to clock α. Since clock α and light now travel in opposite directions, light approaches clock α at a relative velocity of c+v. The absolute time interval $\Delta\tau_3$[rest](β to α) for light to pass from β to α is:

$$\Delta\tau_3[\text{rest}](\beta \text{ to } \alpha) = \frac{l_o}{c+v}[\text{rest}]. \qquad 9.17$$

Therefore the total time interval for light to travel from A to β and back to α is:

$$\Delta\tau[\text{rest}](A \to \beta \to \alpha) = \Delta\tau_2[\text{rest}](\text{A to }\beta) + \Delta\tau_3[\text{rest}](\beta \text{ to } \alpha). \qquad 9.18$$

Using equations 9.15 and 9.17, we find:

$$\tau[\text{rest}](A \to \beta \to \alpha) = \frac{l_o}{c-v}[\text{rest}] + \frac{l_o}{c+v}[\text{rest}] = \frac{2l_o c}{c^2 - v^2}[\text{rest}]. \qquad 9.19$$

Neglecting v^2 compared to c^2 gives:

$$\tau[\text{rest}](A \to \beta \to \alpha) = \frac{2l_o}{c}[\text{rest}]. \qquad 9.20$$

Since clocks α and β are moving, their clock rate is γ_v times slower than the clock rate of clocks A and B. Consequently, from equation 9.20, after the return trip of light ($A \to \beta \to \alpha$) the display on clock α is:

$$CD_\alpha(A \to \beta \to \alpha) = \frac{2l_o}{\gamma_v c}. \qquad 9.21$$

Let us now synchronize clock β with clock α using method #1. Since light is emitted from α at $CD_\alpha = 0$, using equation 9.21, at the moment light arrives at β, clock β must be synchronized to:

$$CD_\beta(\text{light at } \beta) = \frac{1}{2}CD_\alpha(A \to \beta \to \alpha) = \frac{l_o}{\gamma_v c}. \qquad 9.22$$

However, we have seen in equation 9.16 that at the same moment, clock α shows a different display. Therefore this method of synchronization gives different clock displays at the same instant on clocks α and β. This difference is given by equations 9.16 and 9.22:

$$CD_\alpha - CD_\beta = \frac{l_o}{\gamma_v}\left(\frac{1}{c-v} - \frac{1}{c}\right) = \frac{l_o v}{\gamma_v c^2}. \qquad 9.23$$

Therefore at $\tau[\text{rest}] = 0$ (when $CD_\alpha = 0$) clock β must not be synchronized to the same display as clock α. Using equation 9.23, synchronization method #1 shows that at $\tau[\text{rest}] = 0$ we must have:

$$\tau[\text{rest}] = 0,\ CD_\alpha = 0,\ CD_\beta = -\frac{l_o v}{\gamma_v c^2}. \qquad 9.24$$

The phenomenon calculated in equation 9.24 is required for a complete explanation of the mechanism of the advance of the perihelion of Mercury as mentioned in section 5.6.

9.6 - Asymmetric Relative Velocity of Light.

We have seen that the time interval $\Delta\tau_2[\text{rest}]$ (equation 9.15) for light to go from α to β is larger that the time interval $\Delta\tau_3[\text{rest}]$ (equation 9.17) for the return from β to α. However, the locations α and β between which light moves, are always separated by the constant distance $l_o[\text{rest}]$.

Because we used the synchronization method #1 on clocks α and β, the differences of clock displays recorded on those local clocks when light travels from α to β and from β to α are identical. Consequently, Einstein's synchronization method leads to a difference of synchronization between clocks α and β such that it prevents the moving observer from being able to detect that the absolute time for light to move from α to β is different from the time to move from β to α. It is this difference of synchronization between clocks α and β that prevents the observers in α and β to realize that the light that approaches them has a relative velocity different from c. The expression "velocity of light" is too vague. It is much more significant to describe the velocity at which light approaches an observer or recedes from him. Using that description, the velocity of light with respect to an observer can be different from c.

We see that this constant number representing the absolute velocity of light in any frame (in [frame] units) is just a mathematical illusion. We have shown that it is due to the different clock rate on the moving frame and to the clock synchronization of the moving observer. In fact, the velocity of light is an absolute constant in an absolute frame at rest but due to the different clock rate on the moving frame and to the synchronization, it appears constant in any frame.

One must conclude that inside a moving frame, a difference of clock displays always exists at one given instant between two clocks (α and β) located on that frame. Consequently, synchronization method #1 inside a moving frame satisfies the condition of an apparent constant velocity of light inside that frame but leads to a different setting of clocks α and β at one instant. In fact everything appears the same in the moving frame as everywhere else because the local parameters change in the exact same way to make it appear so. We will show that this apparent absoluteness of parameters within individual frames also appears when other synchronization methods are used. One can say that the observer is fooled whatever technique he uses to detect his motion.

9.7 - Synchronization of Clocks α and β (Method #2).

We have seen in sections 9.5 and 9.6 that inside the moving frame, synchronization method #1 does not lead (at a given time τ[rest]) to the same clock display on clocks α and β, even if they are attached to the same frame. A moving observer might believe that he could detect this difference of clock displays using synchronization method #2 which consists in moving a third clock μ at low velocity from α to β. We have seen in section 9.3.2 that there is no drift of clock display on clock μ when it moves slowly across a frame at rest from A to B. Let us study now what happens when we move clock μ within the moving frame α-β.

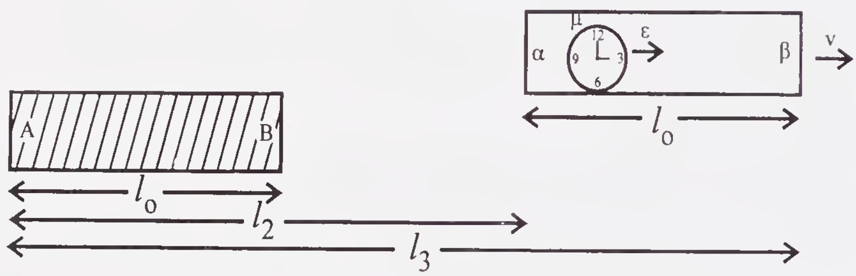

Figure 9.4

Figure 9.4 illustrates a train moving at velocity v with respect to the station. Its length is l_o[rest]. Clock μ inside the train moves at a very small velocity with respect to the train (using rest units). The observer on the station measures the velocity of clock μ to be ε[rest] larger than the velocity v[rest] of the train. The total velocity u[rest] of clock μ with respect to the station is then:

$$u[rest] = v[rest] + \varepsilon[rest]. \qquad 9.25$$

Let us calculate the time interval Δτ[rest] for clock μ to move from α to β. Inside the train, clock μ must travel the moving distance l_o[rest] at a relative velocity of ε[rest]. The time interval $\Delta\tau_4$[rest] for clock μ to travel across the moving distance l_o[rest] is:

$$\Delta\tau_4[rest] = \frac{l_o}{\varepsilon}[rest]. \qquad 9.26$$

The distance l_2[rest] traveled by the train during that time interval $\Delta\tau_4$[rest] is:

$$l_2[\text{rest}] = v\Delta\tau_4[\text{rest}] = v\frac{l_o}{\varepsilon}[\text{rest}]. \qquad 9.27$$

The total distance l_3[rest] traveled by clock μ is then:

$$l_3[\text{rest}] = l_2[\text{rest}] + l_o[\text{rest}]. \qquad 9.28$$

The difference of clock displays on clock α traveling distance l_2[rest] is:

$$\Delta CD_\alpha = \frac{\Delta CD_A(l_2)}{\gamma_v} = \frac{l_o}{\gamma_v \varepsilon} \qquad 9.29$$

where $\Delta CD_A(l_2)$ is the difference of clock displays on clock A (or B) corresponding to $\Delta\tau_4$[rest]. The difference of clock displays on clock μ travelling l_o[rest] aboard the train is:

$$\Delta CD_\mu = \frac{\Delta CD_A(l_2)}{\gamma_\mu} = \frac{l_o}{\gamma_\mu \varepsilon} \qquad 9.30$$

where γ_μ is the value of γ corresponding to the velocity v+ε of clock μ. The difference of clock displays between clock α (or β) and clock μ is, using equations 9.29 and 9.30:

$$\Delta CD_\alpha - \Delta CD_\mu = \frac{l_o}{\varepsilon}\left(\frac{1}{\gamma_v} - \frac{1}{\gamma_\mu}\right). \qquad 9.31$$

Using the first two terms of series expansions we find:

$$\frac{1}{\gamma_v} = 1 - \frac{v^2}{2c^2} \qquad 9.32$$

and

$$\frac{1}{\gamma_\mu} = 1 - \frac{(v+\varepsilon)^2}{2c^2} = 1 - \frac{v^2 + 2v\varepsilon + \varepsilon^2}{2c^2}. \qquad 9.33$$

Equations 9.32 and 9.33 give, to the first order:

$$\frac{1}{\gamma_v} - \frac{1}{\gamma_\mu} = \frac{v\varepsilon}{c^2}. \qquad 9.34$$

Therefore, the difference between the ΔCD_μ on the moving clock inside the train and ΔCD_α on the clock moving with the train is:

$$\Delta\Delta CD_{\alpha-\mu} = \Delta CD_\alpha - \Delta CD_\mu = \frac{l_o}{\varepsilon}\frac{v\varepsilon}{c^2} = \frac{l_o v}{c^2}. \qquad 9.35$$

We see that the difference of clock displays $\Delta\Delta CD_{\alpha\text{-}\mu}$ given by equation 9.35 is directly proportional (first order) to the velocity v of the train independently of the velocity ε of clock μ. Consequently, a slow moving clock μ inside a moving train is submitted to a slowdown of its clock rate so that when reaching clock β, its display is no longer the same as clock α as shown in equation 9.35. Let us compare this shift of display (due to velocity ε) with the difference of clock displays between clocks α and β given in equation 9.23 due to the synchronization of α with β. We have seen in equation 9.23, that the difference of clock displays (to the first order) between clocks α and β at one given instant is:

$$CD_\alpha - CD_\beta = \frac{l_o v}{\gamma_v c^2} = \frac{l_o v}{c^2}\sqrt{1-\frac{v^2}{c^2}} = \frac{l_o v}{c^2}\left(1-\frac{v^2}{2c^2}\right) = \frac{l_o v}{c^2}. \qquad 9.36$$

Equation 9.36 (or 9.23) is identical to equation 9.35. Consequently, the drift of clock display on clock μ when moving from α to β is identical to the initial difference of synchronization between clocks α and β. When clock μ arrives at β from α, supposedly carrying the display from α, its display will be identical to the display on clock β.

To study the case when clock μ moves in the opposite direction, we just have to substitute v+ε in equation 9.33 by v-ε and replace ΔCD_α in equation 9.31 by ΔCD_β. This is correct because equation 9.29 gives not a clock display but a difference of clock displays. Equation 9.34 stays the same except for a negative sign and we get for 9.35:

$$\Delta\Delta CD_{\beta-\mu} = -\frac{l_o v}{c^2}. \qquad 9.37$$

We see then that when clock μ moves slowly in the opposite direction from β to α, it will run at a faster rate so that when it arrives besides clock α, its display will be the same as the one already existing on clock α. We see that clock μ shows the display of clock α when located near α and the display of clock β when located near β. One must conclude that synchronization method #2 is totally unable to reveal the difference of clock displays between α and β inside a moving frame generated by synchronization method #1.

All the above explanations show that the velocity of light is absolute in a frame at rest. Furthermore, we have also shown that, due to the change of clock rate, of the unit of length and of clocks synchronization in a moving frame, the velocity of light always appears constant in any frame (using proper values).

Consequently, the experiments described everywhere in the book show that in order to be compatible with the principle of mass-energy conservation, we must conclude that there exists an absolute frame of reference at rest. Inside a moving frame, the absolute velocity of the frame can be determined experimentally. For example, using figure 9.4, the clock μ will show a different rate with respect to the moving frame, depending on the direction of the velocities +ε or -ε. Also, a rod moving with clock μ will have a different length with respect to the moving train at velocity v, depending on the direction of the velocities +ε or -ε. Only when the absolute velocity of the frame v equals zero, the clock rate and the length of that rod will give symmetric results independently of the directions of the velocities +ε or -ε.

9.8 - References.

[1] This method is often used by F. Selleri, Universita di Bari, Dipartimento di Fisica, Sezione, INFN, Via Amendola, 173, I70126 Bari, Italy.

9.9 - Symbols and Variables.

CD_A	clock display on clock A
CD_α	clock display on clock α
CD_B	clock display on clock B
CD_β	clock display on clock β
l_o[rest]	length of the station and the moving train in rest units
τ[rest]	absolute time (in rest units)

Chapter Ten
The Principle of Equivalence.

10.1 - Introduction.

Among numerous postulates, Einstein proposed the equivalence principle which states that no experiment can distinguish the acceleration due to gravity from the inertial acceleration due to a change of velocity. To illustrate that principle, Einstein used thought experiments involving elevators. He compared different phenomena related to accelerations observed inside an elevator. He purposely limited the range of observations to the frame of the elevator, excluding other predictable consequences that should logically take place inside other frames. The principle of equivalence being a postulate, the reasons for which Einstein did not take into account the motion of his own frame were not explained.

In physics as in logic, a principle is valid only when it is coherent with all the facts. An exception always disproves the rule. It is surprising to read how the equivalence principle has been generally accepted while it is so easy to prove that it is not coherent with the behavior of bodies located in other frames, as we will see below.

10.2 - Deflection of Light in an Elevator Moving at Constant Velocity.

Experiments describing a constant relative transverse velocity between a source and an elevator are generally ignored. Let us consider a horizontal parallel beam of light (or particles, as on figure 10.1) projected on an elevator (of negligible mass) moving upward at a constant velocity v with respect to the source. The experiment takes place in outer space far away from any gravitational field.

Because momentum must be conserved, the beam of light must move in a straight line. On figure 10.1, the dotted line inside the elevator shows where the photons can be detected with respect to the moving elevator at different times. The relative location of the photons with respect to the elevator moving at a constant velocity v is:

$$\tan\theta = \frac{v}{c}. \qquad 10.1$$

This problem of constant velocity is simple but rarely considered. Obviously, the beam will not appear to move horizontally for the observer inside the elevator. However, as seen on the external frame, the beam of particles travels horizontally. This shows that the relative transverse velocity between the source and the elevator is measurable.

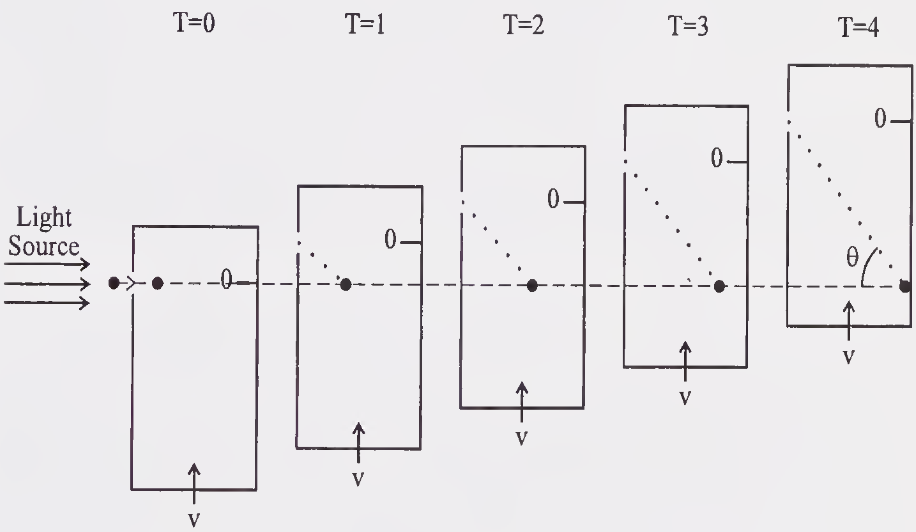

Figure 10.1

10.3 - Inertial versus Gravitational Acceleration of Masses.

Before considering the problem of photons moving with respect to an accelerated frame, let us study a mass μ moving horizontally. The mass enters an elevator which has an upward acceleration α in outer space at the moment its vertical velocity with respect to the source of the mass is zero. The elevator is accelerated by a rocket placed under it to produce a force F (shown by upward arrows on figure 10.2A). Due to that force F, the elevator (and the observer) accelerates following Newton's law:

$$F = M\alpha \qquad 10.2$$

where M is the mass of the elevator (including the observer's mass) and α is its acceleration given by:

$$\alpha = \frac{dv}{dt}. \qquad 10.3$$

After a time interval Δt, the mass will hit the opposite wall. It will have traveled a vertical distance Δh_A relative to the moving elevator. Obviously, the mass will have traveled an absolute vertical distance of zero since there is no gravitational field.

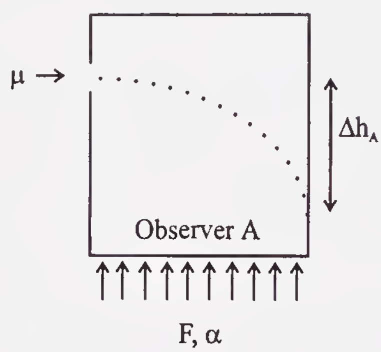

Figure 10.2A

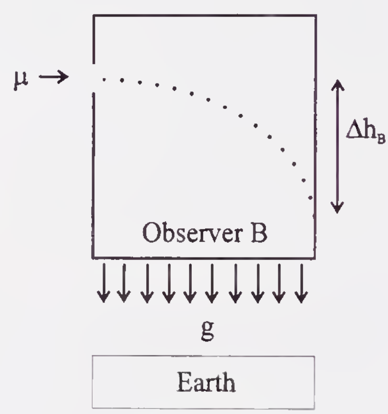

Figure 10.2B

Let us consider a similar elevator located at rest on Earth as illustrated on figure 10.2B. The Earth's gravitational field accelerates the mass μ toward the Earth's center. After a time interval Δt, when the mass hits the opposite wall of the elevator, it will have traveled an absolute vertical distance Δh_B.

In the experiment described on figure 10.2A, the mass μ is completely free of any field and any force and therefore cannot gain any absolute energy when the floor of the elevator approaches it. An atomic clock bound to that free mass μ will maintain a constant rate since no acceleration (therefore no energy) is given to the electrons or particles of the atomic clock. However, the elevator with the observer will gain kinetic energy (and therefore mass) due to the momentum transferred by the rocket. The observer's clock located on the floor of the elevator will slow down (absolute time) due to its increase of velocity in free space as given in equation 3.9. Consequently, the observer using the moving clock will observe a relative blue shift on light emitted from mass

μ. Let us note that the Doppler effect is considered separately and has not been taken into account.

In the experiment described on figure 10.2B, the elevator and the observer cannot gain any energy as a function of time since no work is produced on them. Neither the potential of the observer nor its velocity change. Therefore, the atomic clock of the stationary observer will keep giving a constant rate as a function of time. However, the clock on the falling mass will slow down for two reasons (independent of the Doppler effect): First, because of its increase of velocity (equation 3.10) and second, because of its decrease of potential energy (equation 1.22). Consequently, the observer standing in the elevator will observe a red shift on light emitted by the falling mass μ.

The Doppler contribution to the shift of frequency is identical in figures 10.2A and 10.2B (if $\alpha = g$). Its amplitude is much more important than the one due to the change of internal mass. However it can be subtracted out to show the difference explained above.

We see that the principle of mass-energy conservation implies that there is a fundamental difference between an inertial acceleration and an acceleration due to gravity since the consequences of each acceleration are just opposite. In the case of inertial acceleration (figure 10.2A) the clock located on the apparently falling mass will run faster than the observer's clock because of the slowing down of the observer's clock. On the contrary, in the case of gravitational acceleration (figure 10.2B), the falling clock will run more slowly than the observer's clock. One must conclude that the physical properties of the gravitational acceleration are different from the ones of inertial acceleration which means that the gravitational acceleration is not equivalent to the inertial acceleration.

10.4 - Bremsstrahlung Due to Inertial and Gravitational Accelerations.

To illustrate the difference between inertial and gravitational accelerations, let us consider another thought experiment in which electric charges are placed in a gravitational field. One or more electrons are deposited on a stationary insulator in the Earth's normal gravitational field. This is static electricity. It is well known that Maxwell's equations predict that any accelerated electric charge must emit radiation called bremsstrahlung. According to Einstein's principle of equivalence, charges at rest in the Earth's gravitational field should emit bremsstrahlung because of the gravitational acceleration. However, no experiment has ever detected the emission of bremsstrahlung due to the gravitational acceleration of static electricity. The emission of radiation due to gravitational acceleration has been overlooked.

There is a way to prove that charges submitted to a gravitational acceleration do not emit bremsstrahlung. The principle of mass-energy conservation requires that energy must be given to an electric charge in order to compensate for the electromagnetic energy emitted during its acceleration. Let us try to identify the origin of the energy responsible for the bremsstrahlung predicted by Maxwell's equations and Einstein's principle of equivalence.

If bremsstrahlung is emitted when electric charges are submitted to gravity, there must be an energetic mechanism available to compensate for the energy lost by radiation. That continuous emission of radiation due to gravitational acceleration must necessarily extract energy from a source. Therefore, after a long period of time, the accumulated loss of energy in the source will be more easily detectable than the weak bremsstrahlung emitted. In the case of individual electrons stationary in a gravitational field, the only source of energy available is their mass. Consequently, the electron mass should decrease as a function of time to compensate for the electromagnetic energy bound to be emitted. If the electron mass decreases when standing in a gravitational field, one should eventually find electrons with different masses depending on the time they have been submitted to the Earth's gravitational acceleration.

However, it is observed that electrons maintain their full integrity and do not lose any mass while standing in a gravitational field. All electrons have the same mass. Due to the principle of mass-energy conservation, the absence of any source of energy shows that no bremsstrahlung can be emitted from gravitationally accelerated electrically charged particles. However, in the case of inertial acceleration, the mechanical energy required is well identified and compensates for the electromagnetic energy emitted as bremsstrahlung.

These considerations show again that gravitational acceleration is different from inertial acceleration. Bremsstrahlung is emitted only when submitted to inertial acceleration. Since Einstein's general relativity is based on Maxwell's equations and the principle of equivalence, we must reexamine Einstein's predictions.

10.5 - Behavior of Light.

10.5.1 - Light Path in an Accelerated Elevator.

Let us now consider the experiment described in section 10.3 but using light instead of masses (figure 10.3A). Due to the conservation of momentum, light keeps moving in a straight line (as on figure 10.1) and takes a time interval Δt to go across the elevator. Because of the elevator's increasing upward velocity, during the time interval Δt, light seems to travel a vertical distance Δh:

$$\Delta h = \frac{1}{2}\alpha \Delta t^2. \qquad 10.4$$

Therefore, as illustrated on figure 10.3A, for the accelerated observer, the beam of light will appear to follow a curve and will hit the opposite wall at a distance Δh below the entrance height.

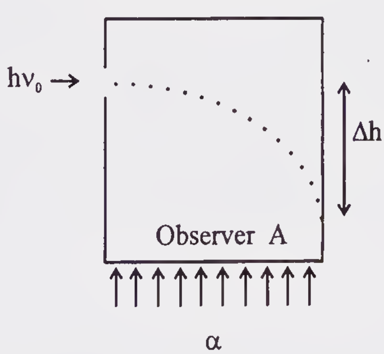

Figure 10.3A

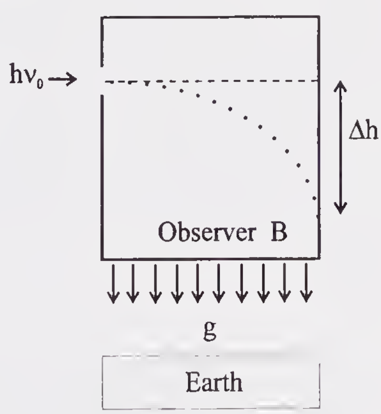

Figure 10.3B

Let us assume that the acceleration due to the rocket produces a change of velocity dv/dt equal to g = 9.8 m/s which is the gravitational acceleration on Earth. Observer A will feel that the upward force of the floor produces the same downward path on the photon as for a massive particle accelerated in the Earth's gravitational field (figures 10.2A and 10.2B).

However, the accelerated observer A gains velocity and energy due to his increase of velocity. Therefore, his clock will slow down between the time light enters the elevator and the time light reaches the opposite wall of the elevator. Consequently, even if we do not take into account the Doppler blue shift due to the increase of relative velocity of the observer with respect to light, the observer detecting the apparently deflected light will measure an apparent increase of its frequency (blue shift) because of the absolute slowing down of his clock.

10.5.2 - Light Path in a Gravitational Field.

Let us assume momentarily that the equivalence principle is valid. Therefore, with respect to observer B on figure 10.3B, light entering the room horizontally would be deflected as illustrated. This hypothesis implies that light is attracted by gravity. However, to be valid, we must verify that such an hypothesis is compatible with mass-energy conservation. If light is deflected, let us calculate the energy relationship caused by that deflection.

Let us call F the hypothetical gravitational force on a photon in the direction of the gravitational acceleration. During its passage across the elevator, we assume that the photon is deflected on a distance Δh in the direction of the force F, as shown on figure 10.3B. Mass-energy conservation requires that a displacement Δh in the same direction of a force F gives an increase of energy ΔW equal to:

$$\Delta W = F\Delta h. \qquad 10.5$$

The photon affected by the gravitational force F will then reach the opposite wall with an energy increase of ΔW at a distance Δh below its initial height. We have seen that the absolute photon energy is proportional to its absolute frequency. Therefore the photon should gain absolute energy and frequency (blue shift) and this should be seen by observer B.

However we have seen in chapter one that the absolute energy of a photon moving downward does not increase. The Mössbauer experiment shows that there are local changes of clock rate at different altitudes but the absolute energy of the photon does not change. An absolute change of photon energy in a gravitational field is contrary to mass-energy conservation. Consequently:

$$\Delta W = 0. \qquad 10.6$$

From equation 10.5, since F and Δh have to be in the same direction, the only way to produce a deflection ($\Delta h \neq 0$) with $\Delta W = 0$ is to have Δh different from zero when F = 0. This means a deflection of photons when there is no force acting on them. This is contrary to Newton's second law on inertia.

Consequently, to be compatible with mass-energy conservation, there is either no deflection or no force (which leads to no deflection anyway). The curved trajectory on figure 10.3B is erroneous, light must move in a straight line in a gravitational field. We have then:

$$\Delta W = 0, F = 0 \text{ and } \Delta h = 0. \qquad 10.7$$

An observer located straight in front of the entrance aperture on figure 10.3B will observe the beam reaching him at that location without any change of frequency. We conclude that light is apparently deflected with respect to an accelerated observer with an inertial acceleration as illustrated in figure 10.3A. However, as given in equation 10.7, light cannot be deflected by gravity because of mass-energy and momentum conservation. We must conclude again that Einstein's equivalence principle is erroneous which means that the behavior of light is perceived differently by observers subjected to gravitational acceleration and inertial acceleration.

It has been claimed in the past that such a deflection (by a gravitational field) has been measured experimentally during solar eclipses. The reliability of such results are generally claimed only by those who have never read seriously the original articles describing those experiments. The report given in appendix II gives a shocking proof of the weakness of the experiment. A small deflection of starlight by a gravitational field has been predicted by Einstein. However, it has never been seriously proved experimentally.

10.5.3 - The Equivalence Principle and Light Deflection.

It has been well recognized that the deflection of light rays is closely related to the equivalence principle discussed above. According to the paper "The Equivalence Principle with Light Rays"[1]:

> "This [the equivalence principle] led Einstein to predict that light is bent by a gravitational field around the Sun"

Since the equivalence between inertial and gravitational acceleration assumed by Einstein is erroneous as shown above in several independent ways, it is not surprising that its consequence (light deflection) is also erroneous.

It is well known that Einstein predicted in 1911 that light should be deflected due to the solar gravitational field. In fact, this prediction is almost identical to the one given by Soldner in 1801 using Newton's law. This demonstration can be understood easily. In classical mechanics, the amount of deviation of any massive object passing near the Sun at velocity v is totally independent of the mass of the object. Also, it was assumed that the velocity of light c could be treated as any velocity v. The principle of equivalence implies the equivalence between the inertially accelerated elevator (figure 10.3A) and the gravitationally accelerated photon on figure 10.3B. Due to the force on the elevator and on observer A, the photon hits the opposite wall of the elevator after the elevator has moved up the distance Δh. This apparent deviation, which corresponds to 0.87" near the solar limb (see Figure 10.3A) is clearly the one required in the case of inertial acceleration of the elevator. Assuming the principle of equivalence, the same value should be found in general relativity. However, Einstein's general relativity predicts a deviation of 1.74". That is twice as much as drawn on figure 10.3A).

The reliability of the apparent deviation illustrated on figure 10.3A is so great that one cannot believe that this amount of deflection could be doubled to satisfy Einstein's predictions of general relativity and the principle of equivalence. Einstein's claim is astonishing. If the opposite wall of that elevator on figure 10.3A is open, that double amount of deflection means that there would be an absolute deflection in a rest frame, even in the absence of any gravitational field. There is no logical way to explain that the amplitude of the deviation in the elevator submitted to inertial acceleration could be twice as much as the one illustrated on figure 10.3A, since the crossing light is subjected to no interaction in a space having zero field and the observer A has certainly moved only through the distance Δh. One cannot claim that light is deflected just because there exists an observer. If that doubled amount of deviation cannot exist in the case of inertial acceleration, it cannot exist either in a gravitational field without contradicting the equivalence principle on which is based the theory leading to the deviation of light in a gravitational field (1.74").

Consequently, Einstein's prediction giving a deviation of 1.74" is self contradictory and cannot be compatible with the principle of equivalence.

10.6 - Gravitational Lenses.

There are several consequences to the fact that light is not deviated in a gravitational field. The deviation of light by a gravitational field gave birth to the claim that rings in space are caused by the focusing of light coming from remote sources by the gravitational mass of intervening galaxies. This explanation is certainly erroneous since light is not deviated by a gravitational field.

These rings can be explained more logically by the presence of large quantities of ions moving in the magnetic field of a galaxy. It is well known that ions spread naturally into rings in a magnetic field. This is a rational interpretation of a phenomenon that has been erroneously interpreted as Einstein's rings.

10.7 - Attracting Force between Parallel Beams of Charged Particles.

We have seen in section 10.4 that electrical phenomena can be used to demonstrate that gravitational acceleration is different from inertial acceleration. To end this chapter, we will give an example using electricity disproving the principle of reciprocity (for another proof, see section 3.9).

In elementary physics, Ampere's law teaches how to calculate the force between two parallel straight conductors carrying currents in the same direction. We learn that a force F between parallel conductors spaced by a distance Δx is induced because the current i' in the second conductor passes in the magnetic field generated by the current i in the first conductor. The force F by unit of length (in MKS units) is:

$$F = \frac{\mu_o i' i}{2\pi \Delta x}. \qquad 10.8$$

That force is so well recognized in physics that it was used "as the basis of the definition of the ampere in the MKS system" [2]. The force between these conductors is attractive when the currents are in the same direction and repulsive when the currents are in opposite directions.

With the modern development of accelerators and intense beams of charged particles, the electric conductor is no longer necessary to observe this phenomenon and the interaction of independent electric charges in the magnetic field generated by comoving electric charges has been observed directly. In fact, the magnetic field produced by comoving electric charges produces a focusing that reduces the dispersion of the beam of particles. One can clearly observe particles all having the same velocity in a parallel beam attracting each other due to the magnetic field produced by the velocity of the neighboring charges.

Let us now consider an observer moving with that beam of particles. In his frame of reference, the particles appear stationary with respect to him. Then, no magnetic field is produced. Using Einstein's principle of reciprocity within that moving frame, the charged particles should repel each other according to the electrostatic repulsion of charges having the same polarity. However, they attract each other as calculated above and observed experimentally. This is clearly not acceptable. Other experiments involving Maxwell's equations exist which are not compatible with the reciprocity principle. However, the ones described above suffice to disprove this principle.

10.8 - References.

[1] http://altair.syr.edu:2024/lightcone/equivalence.html

[2] F. W. Sears, Principles of Physics, Addison-Wesley, p. 267, 1946

Chapter Eleven
Internal Phenomena inside Atoms.

11.1 - Introduction.

In this chapter, we will give a physical description of the absolute changes that happen inside an hydrogen atom when it is accelerated to a high velocity. We have seen that an increase in the electron mass and in the Bohr radius results from this acceleration. We also notice from chapter three that the principle of mass-energy conservation is respected inside the hydrogen atom without having to involve any change of electric charge when the hydrogen atom is brought to high velocity. We will now show how the absolute parameters of the hydrogen atom change when it acquires kinetic energy. We will present some considerations to the problem of enormous internal potentials inside the nucleus of atoms. Finally, we will see how the nature of the interactions taking place inside nuclei can be predicted using these considerations.

11.2 - Transformations inside Fast Moving Atoms.

We have seen in equation 3.4 that when the velocity of the hydrogen atom increases, the absolute value of the Bohr radius a increases according to:

$$a_{\mathrm{v}}[\mathrm{rest}] = \gamma a_{0}[\mathrm{rest}] \qquad 11.1$$

where a_0[rest] is the Bohr radius at rest in rest units and a_{v}[rest] is the Bohr radius at velocity v also in rest units. The units in this chapter will always be rest units so that we will drop the index [rest]. Let us use a numerical example to illustrate some of the absolute changes taking place inside atoms accelerated to a high velocity. When an hydrogen atom moves at v = 0.866c, then $\gamma = 2$. We will consider the hydrogen atom in its ground state but one can see that the transformations can be applied in a similar way for any excited state. From equation 11.1, when v = 0.866c, we have:

$$a_{\mathrm{v}} = 2a_{0}. \qquad 11.2$$

We know from equation 2.23 that the electron mass increases when it moves:

$$m_v = \gamma m_0. \qquad 11.3$$

Therefore the absolute electron mass of a hydrogen atom moving at velocity v = 0.866c becomes:

$$m_v = 2m_0. \qquad 11.4$$

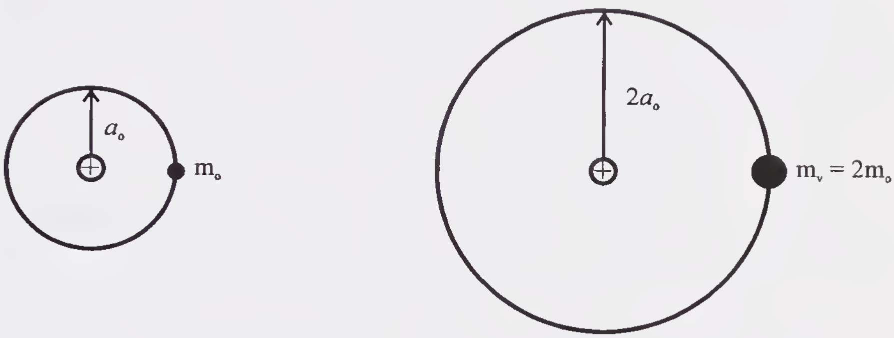

Figure 11.1

Figure 11.1, illustrates the simultaneous increase of the Bohr radius and of the electron mass when $\gamma = 2$. Let us examine how these results are compatible with the Bohr model; the de Broglie wavelength of particles and quantum mechanics.

11.3 - Electric Potentials.

Let us examine first the compatibility of the description given above with the laws regulating the electron and the proton in the hydrogen atom. We recall that when an atom is accelerated to a high velocity, the electric charges and the absolute electric field around those charges do not have to change in order to remain compatible with the principle of mass-energy conservation. The electric energy E_0 of the electron in the electric field of the proton is:

$$E_0 = \frac{ke^+e^-}{a_0} \qquad 11.5$$

where k is the Coulomb constant, e^+ and e^- are the electric charges of the proton and the electron and a_0 is the average distance between the electron and the proton which corresponds to the Bohr radius. Putting equation 11.2 in 11.5, we find that the internal electric energy E_v inside the moving hydrogen atom is:

$$E_v = \frac{ke^+e^-}{a_v} = \frac{ke^+e^-}{2a_o}. \qquad 11.6$$

Since the compatibility between observations and mass-energy conservation has been obtained without modifying the electric charge when a particle is accelerated, we can write:

$$e_o^-[\text{rest}] = e_v^-[\text{rest}]. \qquad 11.7$$

When an electron is carried into the gravitational potential of the Sun, where Mercury is located, from a location in outer space, its charge does not change. This can be written:

$$e_M^-[\text{o.s.}] = e_{o.s.}^-[\text{o.s.}]. \qquad 11.8$$

We recall that in order to be able to establish comparisons, all parameters are calculated using rest units. According to the Bohr model of the atom, when the electron of the hydrogen atom moves in an electric field (i.e. the field of the proton), one must have an equilibrium between the attracting electric force and the centrifugal force. This is compatible with quantum mechanics. The following condition is required:

$$F(\text{electric}) = \frac{ke^+e^-}{a^2} = F(\text{centrifugal}) = \frac{m_e v_e^2}{a} \qquad 11.9$$

or

$$m_e v_e^2 = \frac{ke^+e^-}{a}. \qquad 11.10$$

For the hydrogen atom at rest, the distance a is equal to the Bohr radius a_o. We have:

$$m_o v_o^2 = \frac{ke^+e^-}{a_o}. \qquad 11.11$$

For the hydrogen atom at velocity v, $a = a_v$ and we have:

$$m_v v_v^2 = \frac{ke^+e^-}{a_v}. \qquad 11.12$$

We recall that the parameters v_o and v_v here are the electron velocities with respect to the proton. The velocity of the hydrogen atom is expressed using γ (and v without a subscript). Using equations 11.2 and 11.4 in equations 11.11 and 11.12 gives (for $\gamma = 2$):

$$v_v = \frac{v_o}{2} \qquad 11.13$$

where v_o is the electron velocity with respect to the proton when the hydrogen atom is at rest and v_v is the electron velocity with respect to the proton when the hydrogen atom has the velocity $v = 0.866c$. From equation 11.13, the electron velocity (with respect to the nucleus) is reduced by half when the hydrogen atom is accelerated to a velocity $v = 0.866c$.

In order to be compatible with the Bohr equation and quantum mechanics, the length of the circumference of the orbit of an electron around a proton must be equal to an integer number of the wavelength of the electron. In the case of the hydrogen ground state, the electron wavelength must be equal to the length of one circular orbit. The de Broglie wavelength λ is given by:

$$\lambda_o = \frac{h_o}{m_o v_o}. \qquad 11.14$$

Putting equations 2.22, 2.23 and 11.13 in 11.14, the wavelength λ_v in the moving frame is :

$$\lambda_v = \frac{h_v}{m_v v_v} = \frac{2h_o}{2m_o\left(\frac{v_o}{2}\right)} = 2\lambda_o. \qquad 11.15$$

Equation 11.15 shows that the electron wavelength of the moving atom is twice as long as the electron wavelength of the atom at rest. This satisfies the wave condition of the constructive interference of the electron wave after each translation since the radius of the orbit (therefore its circumference) of the moving atom is twice as large as the radius for the atom at rest as illustrated on figure 11.1.

Furthermore, when all these fundamental conditions are perfectly satisfied, the frequency of emission of light between electronic transitions is reduced by two since the energy between the states is reduced by two when the atom is moving, exactly as observed experimentally from the red shift of spectral lines and from the slowdown of moving atomic clocks. It is that absolute reduction of frequency of a moving clock located in a moving frame that has been erroneously interpreted by Einstein as time dilation.

We must then conclude that the predicted absolute change of parameters inside a moving frame resulting from mass-energy conservation is coherent inside moving atoms. We must also note that all the transformations given above are in perfect agreement with constant absolute electric charges in all frames (see equations 11.7 and 11.8). We recall that this absolute electric field is similar to the absolute gravitational field shown in chapters four and five. This agreement proves the invariability of the electric forces as well as the quadratic decrease of the electric field around charges in all frames. This result agrees perfectly with the well observed experiment showing that electric charges moving at high velocity in a magnetic field travel along a larger radius of curvature corresponding to a different value of e/m. This smaller ratio of electric charge over electron mass is due to an increase of mass (due to the velocity) while there is no change of electric charge of a particle in a moving frame.

11.4 - Sommerfeld Fine Structure.

The prediction of the advance of the perihelion of Mercury seen in chapter five is not the sole example of the success of the principle of mass-energy conservation and classical mechanics. There is also a well documented example in atomic and molecular physics in which it is clearly observed that the principle of mass-energy conservation influences the electronic structure inside atoms. There are many similarities between Mercury moving inside the gravitational field of the Sun and the electrons of atoms orbiting inside the electric potential of the proton. However, an important difference is that the electron mass is not concentrated into a relatively small location with respect to the size of the atom contrary to the case of Mercury and the Sun.

Since electrons exist as waves, the electric potential between the electron cloud and the proton can be calculated using the wave distribution given by quantum mechanics. This leads to the same average energy and distance a_0 that we would find if all the electron was concentrated at a distance equal to the Bohr radius from the proton. Consequently, one can calculate the potential of that electron cloud using quantum mechanics as if it were located at a distance from the proton equal to the Bohr radius. That electron cloud can either oscillate through the proton if the angular momentum is zero or around it if the angular momentum is not zero.

When the electron cloud is trapped into the electric field of a proton, an hydrogen atom is formed. During its formation, energy is given up as emitted radiation. This is similar to the energy that Mercury must release when it is trapped into the Sun's gravitational potential. The electron cloud can be distributed according to many configurations having different energies corresponding to different quantum states. Consequently, during the formation of each of those states, the electron loses mass the same way Mercury does when it is trapped in the Sun's gravitational potential.

Let us use the Bohr model in which an electron moves on an orbit around the nucleus. We know that the Rydberg states of hydrogen correspond to electrons traveling on an orbit whose circumference is exactly equal to an integer number of the wavelength of the electron. Then, there is a constructive interference of the electron wave when moving to the next orbit around the nucleus. The number of wavelengths forming the orbit is equal to the principal quantum number. This model is compatible with the energies calculated by quantum mechanics.

Experimentally, after the Rydberg states were measured, it was noticed that the transitions between these states are not as simple as originally expected. It was discovered that the transitions between each pair of states are generally made of several very close spectral lines. Sommerfeld carried out calculations using general relativity and he discovered that instead of simple transitions between quantum states, there should be multiple transitions due to the fine structure.

Due to the change of electron mass as a function of its distance from the proton, the wavelength of the electron changes. Consequently, the radius of the orbit changes because it is necessary to have an integer number of wavelengths in a circumference. Due to that change of the distance from the proton, the electrostatic potential changes so that the electron energy becomes different. Consequently, the force between the electron and the proton does not follow exactly a quadratic function. Therefore the electron orbit around the proton precesses as in the case of Mercury around the Sun as given in equation 5.52. Due to this precession, the transitions between different quantum states have slightly different energies depending on the relative direction of the velocity of the electron around the nucleus involved in the quantum transition.

Experimentally, the fine structure is well known. The Sommerfeld fine structure constant is equal to:

$$\alpha = \frac{2\pi e^2}{ch} = 7.297 \times 10^{-3} \cong \frac{1}{137} \qquad 11.16$$

where h is the Planck parameter.

This fine structure term is observed between all quantum states as long as transitions are allowed by the selection rules. Sommerfeld's fine structure is explained in many textbooks [1]. It is often illustrated by precessing ellipses forming rosettes identical to the path of Mercury on figure 6.2.

The Sommerfeld fine structure constant can be explained more accurately using the principle of mass-energy conservation as done in the case of the orbit of Mercury. However, this is beyond the scope of this book. We will limit our explanations to this qualitative description. We understand now that the fine structure inside atoms is due to the principle of mass-energy conservation. Of course, Sommerfeld's calculations do not lead to a complete agreement in the case of an electron, because one must consider the electron spin. However, this last correction is irrelevant in the case of Mercury.

11.5 - Atomic Structure inside Free Falling Atoms.

Let us study a hydrogen atom falling freely in a gravitational field. We can assume that the atom was initially located in outer space before it slowly started to drift and accelerate gradually toward the Sun. After a while, the hydrogen atom acquires a high velocity. An observer accompanying the falling mass would not feel any internal acceleration. We will now calculate the absolute rate of the falling clock.

Let us examine this problem separating mathematically the two components of energy acting on the falling mass. With respect to a rest frame in outer space, the speeding hydrogen atom is now at a location where there exists a gravitational potential. We have seen that to calculate the exact mass of the particle, this potential must be taken into account. Furthermore, the falling hydrogen has acquired a velocity which must also be taken into account.

We have seen in equation 1.22 that the gravitational potential where the atom is now located is such that the mass of the particle has decreased and is now different from its mass in outer space. We also know that the kinetic energy increases the mass of the particle by an amount which we expect to be equal to the mass lost due to the potential energy.

This can be easily calculated and we see that the decrease of mass due to the gravitational potential cancels out exactly the increase of mass due to kinetic energy. Consequently, the absolute mass of the particle (proton and electron) does not change while it is falling. However the relevant Planck parameter for the falling mass increases (see equation 2.22) so that the Bohr radius in the falling clock becomes larger. Consequently, when a body travels freely in a deeper gravitational field, its resultant absolute mass does not change, the Bohr radius increases and the falling clock runs more slowly. More particularly, the absolute clock rate inside the elliptical orbit of a comet around the Sun is slower when it is located nearer to the Sun. We recall that this perturbation of clock rate is one of the terms involved to calculate the advance of the perihelion of Mercury.

11.6 - High Potentials and Higher Order Terms.

Contrary to Einstein, in this book we have not arbitrarily postulated that physical quantities are invariant in all frames. We have used only the principle of mass-energy conservation. However, we have found that when we consider the zero and first orders of v/c (or of the gravitational potential), the physical laws appear (almost) invariant in all frames as arbitrarily assumed by Einstein. In that particular case, the physical consequences are almost all identical to what Einstein found with his arbitrary postulate. However, our results are obtained using solely the principle of mass-energy conservation. The physical laws derived from the use of the first order of v/c are not perfectly invariant since there are higher order terms in $(v/c)^2$ and other higher terms (however small) that have been neglected.

One could repeat all the above calculations without neglecting the higher order terms. Then, one could have an exact answer to the problem of extreme energies. We can foresee that if we dealt with physical phenomena in which the higher terms were not negligible (correction due to velocity), the physical laws observed would be different. Within those physical limiting conditions, at high energy, the behavior of matter would not correspond to the description we are used to see in a rest frame and in a frame in which the ratio v/c is not too high.

We have to realize that the experimental conditions that correspond to such high energies are quite common in physics. It is clear that when the nucleus of an atom emits particles having energies of millions of electron volts, the second and third order terms of the potential involved are not negligible. Consequently, we expect that the internal phenomena taking place in the nucleus of atoms at such high potential taking into account the higher order terms lead to physics we are not accustomed to see. It is for that reason that nuclear forces are not familiar to us and to classical mechanics. We believe that the principle of mass-energy conservation is one of the ultimate principles in physics that possesses the wonderful power of informing us, in a logical way, on the correct physical nature of the forces involved in nuclear and particle physics. Mass-energy conservation is relevant everywhere in physics and can be applied everywhere in nature especially when enormous potentials are involved as in the nucleus of atoms and at the center of the stars.

A general study of physics in which the principle of mass-energy conservation is fully applied is beyond the scope of this book. However, we are convinced that a physical and realistic description of our physical world can be logically achieved without having to involve the non realistic, the non conservation of mass-energy and the contradictory hypotheses used in modern physics [2].

11.7 - References.

[1] H. Semat, Introduction to Atomic and Nuclear Physics, Holt, Rinehart and Winston, Forth edition, P. 245, 1962.

[2] P. Marmet, Absurdities in Modern Physics: A Solution, Les Éditions du Nordir, c/o R. Yergeau, 165 Waller Street, Simard Hall, Ottawa, On. Canada K1N 6N5, 144p. 1993.

11.8 - Symbols and Variables.

The units used in this chapter were all rest units, therefore the index[rest] has been omitted.

a_0 Bohr radius of the atom at rest

a_v Bohr radius of the moving atom

E_0 Electric energy of the atom at rest

E_v Electric energy of the moving atom

λ_0 de Broglie wavelength of the atom at rest

λ_v de Broglie wavelength of the moving atom

m_0 mass of the atom at rest

m_v mass of the moving atom

v_0 velocity of the electron relative to the proton of the atom at rest

v_v velocity of the electron relative to the proton of the moving atom

Chapter Twelve
On the Formation of Pseudo Black Holes.

12.1 - Formation of a Protostar.

In this chapter, we will consider what happens to a large volume of gas when taking into account the gravitational field of each individual atom. As an example, we use a nebula containing N atoms of hydrogen. Due to Newton's universal law of gravitation, all these individual electrically neutral particles attract each other. Consequently, each atom slowly drifts toward the center of the system. The gas becomes more and more compact as a function of time and the nebula occupies a gradually smaller volume of space.

During the collapse of the nebula, the velocity of the particles increases due to the increasing gravitational potential created by the increasing concentration of matter. The density and the velocity of individual atoms augment so that the temperature increases while the radius of the volume of gas decreases. Consequently, the gas becomes very hot. These high temperature and density produce a high pressure that reduces the collapsing rate.

Due to Planck's law of radiation, the gas emits its thermal energy as electromagnetic radiation to outer space. This phenomenon causes a reduction of the internal temperature and pressure so that the star can progress with further shrinking. These two processes go on simultaneously as long as the star has enough mass to produce a gravitational force sufficiently large to produce further shrinking. The shrinking rate of the star depends on the rate of emission of energy of the star through radiation. An equilibrium exists between the atomic, molecular or nuclear forces which provoke emission of radiation at high temperature and the gravitational forces.

In the above qualitative description, we consider that the number N of hydrogen atoms does not change during the contraction of the nebula into a star. However, a large amount of energy has to be emitted from the star through radiation in order to get rid of the thermal energy. One must take into account the principle of mass-energy conservation requiring the mass of the star to decrease because of the radiation emitted due to Planck's law of radiation.

12.2 - Mass-Energy Conservation in Clusters of Atoms.

In order to satisfy the principle of mass-energy conservation, let us calculate quantitatively the amount of energy that must be emitted from the protostar when it is transformed from a nebula to a high density star. Let us start with an initial very large diffuse nebula. We will calculate the change of gravitational energy when the nebula takes the shape of a hollow sphere of radius R.

Let us calculate the gravitational energy when N hydrogen atoms coming from the nebula have all reached the distance R from the center of mass. When the first atoms reach that distance, the sphere is infinitely thin. The potential energy met by each new individual atom increases with the number of atoms (mass) that has already reached the distance R. This process goes on until all atoms have formed a sphere of radius R. We have then a spherical protostar.

In order to calculate the total internal gravitational potential of such a star, let us use the building up principle and accumulate individual hydrogen atoms, one by one. In the case of the Sun, the number of hydrogen atoms needed is about 1.2×10^{57}. Each individual atom is systematically brought from a large distance in outer space to the location at a distance R from the center of the stellar mass being formed. We consider the approximation of a hollow sphere because we want to keep the potential constant inside the star.

The very first step in the formation of the star is to bring two hydrogen atoms together at a distance R. At that distance, the atoms have acquired gravitational energy E{1} due to the gravitational potential between them. This gravitational energy is given by:

$$E\{1\} = \frac{Gm_H m_H}{R} \qquad 12.1$$

where m_H is the mass of the hydrogen atom. The two particles remain trapped at a distance R in this gravitational potential if the amount of electromagnetic energy emitted is equal to E{1}. The equivalent loss of mass to stabilize this interaction is equal to:

$$\Delta M\{1\} = \frac{E\{1\}}{c^2}. \qquad 12.2$$

Therefore, after stabilization by the emission of radiation, using equations 12.1 and 12.2, we find that the remaining mass M{1} of the pair of hydrogen atoms (at distance R) is:

$$M\{1\} = 2m_H - \frac{Gm_H^2}{c^2 R}. \qquad 12.3$$

After the formation of the first pair of hydrogen atoms, let a new hydrogen atom fall (at a distance R) into the gravitational field produced by the new pair. The new hydrogen atom of mass m_H interacts at a distance R from the pair of mass M{1} previously formed and described in equation 12.3. Using Newton's law, the gravitational energy between the pair of hydrogen atoms with mass M{1} and the individual hydrogen m_H atom is:

$$E\{2\} = \frac{Gm_H M\{1\}}{R}. \qquad 12.4$$

We might want to explain how the new hydrogen atom can be at an effective distance R from the previous pair of atoms. The distance R mentioned here means that the new atom is located at a distance R from the previously formed pair so that the gravitational potential between the new atom and the pair is equivalent to the potential that would exist if the previously formed pair of atoms were close together and the new atom were at a distance R from the pair. This description is supported mathematically by a theorem (used in electrostatics) which shows that the potential created at the surface of a spherical distribution of charges is the same as if all the charges were located at the center of the sphere. We will apply this same theorem here for the case of the gravitational potential of particles approaching the spherical distribution of matter forming the star.

In equation 12.4, the mass ΔM{2} lost after emitting thermal energy is:

$$\Delta M\{2\} = \frac{E\{2\}}{c^2}. \qquad 12.5$$

The total mass M{2} of the three hydrogen atoms is then:

$$M\{2\} = M\{1\} + m_H - \Delta M\{2\} \qquad 12.6$$

$$M\{2\} = M\{1\} + m_H - \frac{G m_H M\{1\}}{c^2 R}. \qquad 12.7$$

Equations 12.7, 12.3 and 12.4 give:

$$M\{2\} = 3m_H - \frac{3Gm_H^2}{c^2 R} + \frac{G^2 m_H^3}{c^4 R^2}. \qquad 12.8$$

Of course, when a star is formed, the energy does not have to be emitted immediately after the addition of each individual atom. When particles are brought together, they form a hot gas in their gravitational potential which cools down later by the emission of radiation. There is no difference of energy if the radiation is emitted immediately or later.

Repeating the operation and adding a fourth hydrogen atom to the set of three atoms gives:

$$M\{3\} = M\{2\} + m_H - \frac{G m_H M\{2\}}{c^2 R}. \qquad 12.9$$

Equations 12.8 and 12.9 give:

$$M\{3\} = 4m_H - \frac{6Gm_H^2}{c^2 R} + \frac{4G^2 m_H^3}{c^4 R^2} - \frac{G^3 m_H^4}{c^6 R^4}. \qquad 12.10$$

Adding another hydrogen atom to the growing mass gives:

$$M\{4\} = M\{3\} + m_H - \frac{G m_H M\{3\}}{c^2 R}. \qquad 12.11$$

Equations 12.10 and 12.11 give:

$$M\{4\} = 5m_H - \frac{10Gm_H^2}{c^2 R} + \frac{10G^2 m_H^3}{c^4 R^2} - \frac{5G^3 m_H^4}{c^6 R^4} + \frac{G^4 m_H^5}{c^8 R^6}. \qquad 12.12$$

Let us define:

$$Z = \frac{G}{c^2 R}. \qquad 12.13$$

Then:

$$M\{4\} = 5m_H - 10m_H^2 Z + 10m_H^3 Z^2 - 5m_H^4 Z^3 + m_H^5 Z^4. \qquad 12.14$$

Adding another hydrogen atom gives:

$$M\{5\} = 6m_H - 15m_H^2 Z + 20m_H^3 Z^2 - 15m_H^4 Z^3 + 6m_H^5 Z^4 - m_H^6 Z^5. \qquad 12.15$$

The seventh hydrogen atom gives:

$$M\{6\} = 7m_H - 21m_H^2 Z + 35m_H^3 Z^2 - 35m_H^4 Z^3 + 21m_H^5 Z^4 - 7m_H^6 Z^5 + m_H^7 Z^6. \qquad 12.16$$

Going on with more individual atoms but limiting our calculations to the fourth power of m_H gives:

$$M\{7\} = 8m_H - 28m_H^2 Z + 56m_H^3 Z^2 - 70m_H^4 Z^3 \qquad 12.17$$

$$M\{8\} = 9m_H - 36m_H^2 Z + 84m_H^3 Z^2 - 126m_H^4 Z^3 \qquad 12.18$$

$$M\{9\} = 10m_H - 45m_H^2 Z + 120m_H^3 Z^2 - 210m_H^4 Z^3 \qquad 12.19$$

$$M\{10\} = 11m_H - 55m_H^2 Z + 165m_H^3 Z^2 - 330m_H^4 Z^3 \qquad 12.20$$

$$M\{11\} = 12m_H - 66m_H^2 Z + 220m_H^3 Z^2 - 495m_H^4 Z^3. \qquad 12.21$$

The coefficients of the equations above can be generalized to give:

$$M\{N\} = (N+1)m_H - \frac{(N+1)N}{2} m_H^2 Z + \frac{(N+1)N(N-1)}{6} m_H^3 Z^2$$

$$- \frac{(N+1)N(N-1)(N-2)}{24} m_H^4 Z^3 + \ldots \qquad 12.22$$

For a star like the Sun, the value of N is about 10^{57}. Then for N>>1 equation 12.22 gives:

$$M\{N\} = Nm_H - \frac{N^2 m_H^2}{2} Z + \frac{N^3 m_H^3}{6} Z^2 - \frac{N^4 m_H^4}{24} Z^3 + \ldots \qquad 12.23$$

which is identical to:

$$M\{N\} = Nm_H - \frac{N^2 m_H^2}{2!} Z + \frac{N^3 m_H^3}{3!} Z^2 - \frac{N^4 m_H^4}{4!} Z^3 + \ldots \qquad 12.24$$

$$M\{N\} = Nm_H \left(1 - \frac{Nm_H Z}{2!} + \frac{(Nm_H Z)^2}{3!} - \frac{(Nm_H Z)^3}{4!} + \ldots \right). \qquad 12.25$$

Let us define:

$$Y = Nm_H. \qquad 12.26$$

Equation 12.25 becomes:

$$M\{N\} = Y\left(1 - \frac{YZ}{2!} + \frac{Y^2Z^2}{3!} - \frac{Y^3Z^3}{4!} + \ldots\right). \qquad 12.27$$

This can be written (N is so large that it can be approximated to ∞):

$$M\{N\} = -\frac{1}{Z}\sum_{n=1}^{\infty}(-1)^n\frac{Y^nZ^n}{n!} = \frac{1}{Z}\left(1 - e^{-YZ}\right). \qquad 12.28$$

We recall that $Y = Nm_H$ is the total mass of the nebula that formed the star. This would be the mass of the star if there were no energy (mass) lost through radiation during the formation. M{N} is the final mass of the star made of N hydrogen atoms after taking into account the thermal energy emitted as explained above.

12.3 - Mass of a Star versus the Amount of Matter Used for Its Formation.

Equation 12.28 gives the mass of the star as a function of the amount of matter Y used to form it. Of course, when a larger amount of matter falls into the gravitational potential, thermal energy is emitted and the amount of mass lost into radiation increases. In these calculations, the value of Z (from equation 12.13) is kept constant when we study a star having a fixed radius R. Figure 12.1 shows the final mass of the star (after temperature stabilization) as a function of the total mass falling on it, using Z = 1 in equation 12.28.

We see on figure 12.1 and from equation 12.28, that for a very small amount of hydrogen atoms, the total mass of the star is almost the same as the mass of the atoms used before the formation. However, when the number of atoms accumulated in the star becomes larger, the gravitational potential acting on each newly added hydrogen atom becomes increasingly important.

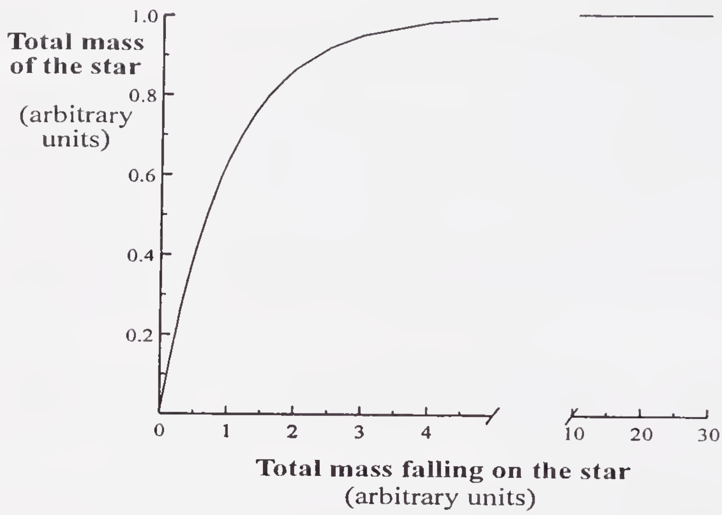

Figure 12.1

More energy is lost in thermal radiation after each new hydrogen atom is added. Consequently, an increasing fraction of the new mass is lost when the star becomes more massive.

Here is a numerical example obtained from equation 12.28. When the total input of mass from the nebula is 0.01 (YZ = 0.01), independently of the value of Z, about 99.5% of that mass remains in the star. For one unit (YZ = 1.0) of input mass, the final mass is 63% of the initial matter. When the input mass is ten units (YZ = 10.0), only 0.005% of the new mass is added to the star. Finally, when the amount of matter given by the nebula to form the star becomes much larger, the new mass added to the star becomes almost completely transformed into energy due to the gigantic gravitational potential. Therefore the mass of the star no longer increases when the value of YZ gets very large (as shown on figure 12.1).

12.4 - Mass of a Star versus its Radius.

Within the limits explained above, let us now consider a different way to build a star. Instead of increasing the amount of matter from outer space while forming the star at a constant radius, we use a constant number of hydrogen atoms from the nebula but all matter is contracted into a star of radius R.

When the star is initially very big, the gravitational potential at its surface is negligible. A very large star appears almost like a concentrated nebula without an intense gravitational potential. However, when the radius gets smaller, the high density star generates a much higher gravitational potential so the increase of temperature generates radiation which causes a loss of mass-energy of the shrinking star. Using equation 12.28, we can calculate the radius of the star formed from a contracting nebula containing a constant number of atoms of matter. During the decrease of the radius, the star is maintained at a relatively low temperature (of a few tens of thousand degrees), due to Planck's emission of radiation.

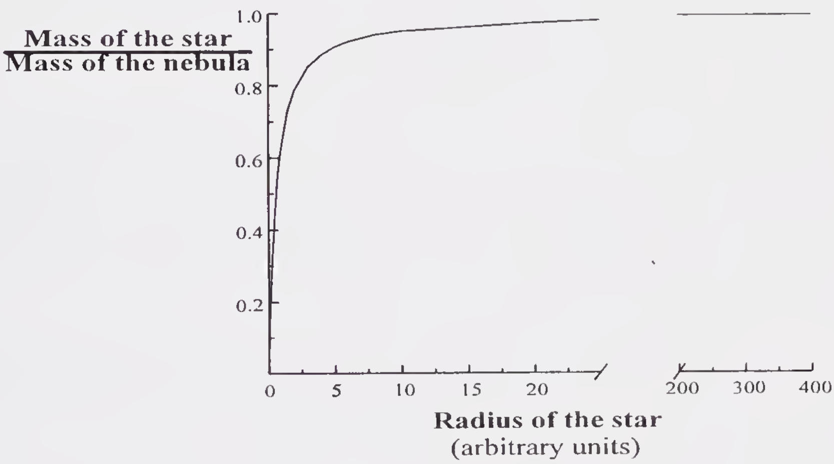

Figure 12.2

When the total number of particles N (= Y/m_H) coming from the nebula is kept constant, Z(R) becomes the variable (see equation 12.13). For Y = 1, let us calculate the residual mass of the star as a function of its radius R. After temperature stabilization, the relative mass of the star (with respect to the mass of the initial nebula) as a function of the radius R is given by equations 12.13 and 12.28. This is illustrated on figure 12.2.

We see that when the radius of the nebula (or the star) decreases, the star loses mass as electromagnetic radiation more and more rapidly.

12.5 - Maximum Mass of a Star versus Its Radius.

Let us assume now that the mass available Y is so large that the product YZ is always larger than 10. In that case, the value of the bracket in equation 12.28 reaches a maximum of 1.0. Let us substitute equation 12.13 in equation 12.28. This gives:

$$M\{N\} = \frac{c^2R}{G}\left(1 - e^{-YZ}\right). \tag{12.29}$$

Since the maximum value of the bracket in equation 12.29 is 1.0, the maximum value of M{N} as a function of R is:

$$M\{N\} = \frac{c^2R}{G}. \tag{12.30}$$

Equation 12.30 shows that the maximum mass of a star increases linearly with its radius R. Above this limit, any mass falling freely on the star reaches a kinetic energy equal to its mass so that the same amount of radiation energy is freed and there is no net increase of mass of the star. The incoming particle is totally transformed into radiation which totally escapes from the star.

12.6 - Complete Transformation of Mass into Energy.

There is another way to find the maximum mass of a star of radius R. We have seen that the gravitational energy E(Pot) of a particle of mass m at a distance R from the surface is given by:

$$E(Pot) = \frac{GMm}{R}. \tag{12.31}$$

We know that independently of their masses, all particles reach the same velocity when they fall from outer space to the surface of the same star. During their fall, particles acquire kinetic energy. The kinetic component of energy of a particle moving at velocity v is given by (γ-1)m in the equation:

$$m_v = \gamma m \tag{12.32}$$

where

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}. \tag{12.33}$$

During the fall of a particle in the gravitational potential of a star, no energy is coming from outside the system. Consequently, the total energy of the falling particle remains constant during an unperturbed fall.

This result is different from the inertial acceleration of a mass absorbing energy given by an external independent source. Due to that external source of energy, the total energy of the particle increases as given by equation 12.32. However, when falling freely in a gravitational field, the kinetic energy increases at the expense of the gravitational energy of the particle.

Let us consider a particle reaching the surface of a star (of maximum mass). The velocity corresponds to $\gamma = 2$ ($v = 0.866c$). Then the kinetic energy E_k is equal to the initial mass at rest:

$$E_k = mc^2. \qquad 12.34$$

When the particle hits the surface of the star, the kinetic energy is released and emitted toward outer space (either immediately as gamma rays or later as thermal energy). When this happens, the loss of mass Δm is equal to the mass of the particle m. At the surface of the star, the kinetic energy of the particle is equal to the gravitational energy it has lost. We have:

$$E_k = \frac{GMm}{R} = mc^2. \qquad 12.35$$

Therefore, in that limit case, the mass M_{lim} of the star is:

$$M_{lim} = \frac{R_{lim}c^2}{G} \text{ when } \frac{\Delta m}{m} = 1. \qquad 12.36$$

Consequently, any mass falling from outer space to the distance R_{lim} from the star of mass M_{lim} will be totally annihilated into radiation. As expected, this result is identical to equation 12.30. Consequently, when the surface of the star is at such a deep gravitational potential, there is no possibility of increasing the mass of the star any further. Finally, if a particle has an initial velocity toward the star when entering the outer limits of the gravitational field, more energy will be removed from the star through radiation than the amount added by the particle. The mass of the star then decreases since more mass escapes by radiation than the amount of mass added by the particle.

Of course, near the surface of a star (which has a maximum mass), the gravitational potential is enormous so that clocks run at a very slow rate. Matter located in this extreme gravitational field will interact according to the proper parameters existing at that location. Consequently, the spectrum of the Planck radiation emitted from this deep potential will be emitted according to the local clock which runs very slowly. The spectrum will be displaced toward longer wavelengths with respect to outer space where clocks run more rapidly as explained in chapter one. However, after its emission from the location in the deep gravitational potential, light will not be redshifted again while traveling against the gravitational field as explained in chapters one and ten.

If we consider a particle reaching the ultimate potential at a distance R_{lim} from the center of the star, there is no possibility for it to move deeper inside that radius because there is nothing left of the particle. It would be absurd to discuss the behavior of particles at or inside that extreme radius since they no longer exist and all their energy and mass have been transformed completely into radiation.

Comparison.

This relationship for the maximum mass of a star can be compared with the Schwarzschild radius. Let us note that the Schwarzschild radius R_S has an incomprehensible meaning in our context. Just as for general relativity, it is not compatible with the principle of mass-energy conservation. It is given by the relationship:

$$M = \frac{R_S c^2}{2G}. \qquad 12.37$$

12.7 - Proper Values in Extreme Gravitational Potentials.

Let us consider that an observer in outer space measures the distances between the center of a star (having the maximum mass M_{lim}) and different bodies stationary at different distances. Using his proper units, the outer space observer can measure the distances between the center of the star and the closest body existing around it (which is near R_{lim}) up to the more distant masses. However, the observers located on each of those bodies will use their proper units to make their measurements of their own distance from the center of the star. They must use these proper values in order to apply correctly the well-known physical relationships. We have seen that the absolute length of the meter is longer for an observer located closer to the star. Consequently, when measuring the same absolute radius, the number of proper meters will be smaller for the observer close to the star than for the outer space observer.

Using the equations given in chapter four, we see that when the distance from the star is large (in the Newtonian limit), the number of proper meters measured by an outer space observer is almost identical to the number obtained by an observer not too close to the star. However, when the observer is close to the extreme minimum radius R_{lim}, the use of the extremely dilated proper meter will give a number of proper meters approaching zero (and not R_{lim}(o.s.)). For this reason, physical phenomena taking place near location R_{lim} (using internal proper values) appear very strange to an outer space observer.

Near that location (R_{lim}), the Bohr and nuclear radii get very large and the corresponding energy inside particles becomes extremely small with respect to the external mechanical forces. In outer space, we are used to see internal (atomic and nuclear) forces of matter being much larger than the mechanical and gravitational forces. Near a degenerate star, nuclear forces are much weaker. This phenomenon favors reactions between particles.

Let us also recall that in the first chapters of this book, we were calculating very small relativistic interactions (i.e. Mercury precessing around the Sun). It was then enough to consider the first order of a series expansion. However, when we consider bodies with kinetic energy in a very deep gravitational potential, these approximations are no longer accurate.

12.8 - Beyond the Extreme Gravitational Potential.

Let us consider a star having a maximum mass and therefore surrounded by an extreme potential. We have seen that when an hydrogen atom gets closer to the surface of the star, its mass decreases when brought to rest and its clock slows down in the same proportion. We have seen that the same maximum gravitational potential can exist at the surface of stars having different radii. When the nucleus of this star approaches that extreme limit of gravitational potential, the number of particles forming that star approaches infinity while the mass of each atom approaches zero. The product of these two parameters approaches a constant (for a given radius) as shown in equation 12.30.

Finally, extrapolating (to a smaller radius) beyond this extreme potential, the mass of the falling hydrogen atom disappears at the same time as the clock becomes infinitely slow and finally stops running at R_{lim}. In fact, one can say indifferently that the clock has stopped running or that the clock has disappeared and no longer exists. Therefore clocks become infinitely slow at the same time as they disappear completely out of existence. In physics, it is absurd to study matter inside the critical radius R_{lim}.

12.9 - Formation of Matter in a Deep Gravitational Potential versus the Formation of Matter and Anti-Matter.

We have seen above that mass can be transformed into radiation in a deep gravitational potential without requiring a reaction between matter and anti-matter. In physics, there is another well-known mechanism transforming mass into radiation: the annihilation of a particle with its anti-particle. For example, we know that an electron and a positron can be annihilated into radiation. As expected, the corresponding inverse mechanism is also known from the interaction of photons creating a pair of matter and anti-matter. It is important to notice that the reaction of annihilation of matter with anti-matter is extremely rapid so that matter formed at the same time (and at the same location) can survive only during an extremely short time before being annihilated. Particles and anti-particles destroy each other at a very high rate. This system is quite unstable. Furthermore, since matter and anti-matter are formed simultaneously at the same location, it is ultimately improbable that they could separate out to form independent galaxies. Consequently, another mechanism of formation of matter without involving anti-matter is required to explain our universe if we want to avoid ad hoc hypotheses.

12.9.1 - Inverse Gravitational Mechanism.

We have seen in this chapter how matter falling in a deep gravitational potential is finally transformed into radiation. This mechanism cannot be maintained forever in the universe because all matter would be transformed into radiation. We have explained above how the formation of matter through the mechanism of matter and anti-matter cannot lead to the formation of huge clusters of galaxies of matter in the universe as we observe them. There must be an equilibrium between the formation and the annihilation of matter in the universe. Mass-energy conservation is not compatible with the creationist theory that claims that the universe was formed from nothing ten or fifteen billion years ago.

It is well known in physics that for every mechanism, an inverse mechanism exists. The simple absorption of radiation by matter is to some extent an intermediate mechanism of transformation of energy into mass without involving anti-matter. However, in that case, atoms become more massive but no new atoms are formed.

A simplistic description of the inverse mechanism corresponding to the annihilation of matter in a gravitational field is the following. Since radiation is emitted when atoms hit a surface located in a deep gravitational potential, we can foresee that energetic radiation hitting the surface of the same star could generate particles with sufficient kinetic energy so that they could reach the escape velocity v_{esc} (= 0.866c) of a star with extreme mass and be freed in outer space. Of course, other mechanisms involving gravity can be suggested but are beyond the discussion of the present book.

When matter falls into an extreme gravitational potential, it is transformed into energy without involving a reaction between matter and anti-matter. Consequently, the inverse reaction must equally correspond to the formation of matter without the creation of anti-matter. We have seen that a reaction generating matter plus anti-matter is not acceptable to explain the origin of matter in the universe, because of the extremely fast inverse reaction returning matter into radiation. We see now that a mechanism using gravity can explain the transformation of matter in the universe.

The transformation of matter into radiation (and its inverse reaction) is an extremely slow process since the time for a star to emit the thermal energy during its formation depends on its size but generally takes at least a few hundred million years. One can expect that the inverse reaction transforming radiation into neutral particles can take a few billion years before forming nebulae which later evolve into stars and later into other bodies with a very deep gravitational potential. Such mechanisms would finally form a complete cycle transforming matter into radiation and vice versa. On the average this cycle would repeat itself every ten or fifteen billion years. In such a case, after a full cycle, the information about the exact previous structure of the universe would be lost. From this mechanism, matter of the universe could be recycled periodically. During that cycle, since there would be large variations in the time taken by concentrations of masses to evolve, the universe would always look more or less the same through time. The possibility of such a mechanism becomes highly probable when taking into account the red shift mechanism taking place in our universe as demonstrated [1] in previous papers.

12.10 - References.

[1] P. Marmet, A New Non-Doppler Redshift, Physics Dept. Laval University, Québec, Canada, 64p., 1981.

also:

P. Marmet, A New Non-Doppler Redshift, Phys. Essays, **1**, 24-32, 1988.

also:

P. Marmet, Redshift of Spectral Lines in the Sun's Chromosphere, IEEE, Transactions on Plasma Science: Space and Cosmic Plasma **17,** 238-243, 1989.

also:

P. Marmet and Grote Reber, Cosmic Matter and the Non-Expanding Universe, IEEE, Transactions on Plasma Science, **17**, 264-269, 1989.

also:

P. Marmet, Non-Doppler Redshift of Some Galactic Objects, IEEE, Transactions on Plasma Science, **18,** 1, P. 56-60, 1990.

Appendix I
The Dependence of the Size of Matter on Electron Mass.

INTRODUCTION - As seen in chapter one, the size of the hydrogen atom depends directly on the Bohr radius, which itself varies with the mass of the electron. Is that the case for all atoms? And what about molecules and crystals? Before we answer these questions rigorously, let us try to answer them intuitively.

Consider for example the hydrogen molecule, H_2. It is made of two hydrogen atoms sharing their electrons. Since the size of the two hydrogen atoms taken separately varies with the Bohr radius, it would be reasonable to expect the size of the hydrogen molecule to do the same. If the radius of all atoms depended on the Bohr radius, we could apply the same reasoning to all molecules and crystals. Intuitively, we would arrive to the conclusion that the dimensions of matter depend on the Bohr radius. If this were to be the case, then according to chapter one, the size of any object would be different depending on its location in a gravitational potential. In this appendix, we will see how the dimensions of matter are predicted to vary theoretically. We will first look at all atoms. We will then study molecules which will be followed by crystals and metals.

THE BOHR RADIUS - Before we start our study of the dimensions of matter, a comment needs to be made about the Bohr radius and its use. Until now, a_o has always been considered a constant because $\hbar$, ε_o, e and m_e have been supposed constants. With this in mind, most experimentalists present their results in units of bohrs using 1 bohr = $a_o = 5.29177\times10^{-11}$ m [1] (page 349). For an experimentalist, by definition, that numerical value is equal to one bohr unit whether the electron orbit in hydrogen is constant or not.

For theoretical results, this is different. Theoreticians could decide to give the results of their calculations in function of a_o (i.e. in units of a_o) to be able to compare them to the experimentalists' results. For the theoreticians, a_o is defined as a combination of parameters. Therefore a_0 is constant only if all the parameters are constant. One then has to be careful in reading theoretical results and look at the method used to see if there really is a dependence of a_0 or if it is just a unit. Let us make sure that the physics is not lost in those calculations.

Most authors do their calculations in atomic units. In those units, $m_e = e = \hbar = 1$. This means that the unit of mass is the electron mass. When the Schrödinger equation (or the Dirac equation) is expressed in those units, we end up with an equation that seems independent of m_e. The authors then go on with numerical calculations to solve the equations. But if the mass of the electron is not a constant, then it is not necessarily equal to one in atomic units (with respect to the initial frame of reference). This changes the Schrödinger (or Dirac) equation which changes its solution which changes the value of the parameter we are looking for (e.g. the bond length or the radius of an atom in the initial frame of reference). All the results in this appendix being theoretical, we made sure that their dependence in a_0 was real.

ATOMS - It is easy to derive the radius of all hydrogenlike atoms by supposing that they are just like a hydrogen atom with an electron orbiting a nucleus of charge Z. According to Levine [1] (page 525):

> "The average radius of a hydrogenlike atom is proportional to the Bohr radius a_0, and a_0 is inversely proportional to the electron mass".

The radius of all other atoms has been well investigated [2, 3] and the results given are proportional to the Bohr radius. The method used in [2] was the Hartree-Fock method [4] and in [3], the Dirac-Fock method which is just the Hartree-Fock method with relativistic corrections due to the mass of the electron with respect to the nucleus frame of reference. The Dirac-Fock method gives no relativistic correction of the electron mass with respect to an external gravitational potential.

THE HYDROGEN MOLECULE ION - The hydrogen molecule is composed of two hydrogen atoms, each made of one electron and one proton. Its positive ion, H_2^+, made of two protons and one electron, is a system that can easily be solved [1, 5, 6]. Upon finding its wave function and the potential of the nucleus (in the Born-Oppenheimer approximation), it is possible to calculate the distance between the two protons. This gives $2.00a_0$. (The variational method is used to solve this problem [5]. It uses wave functions of the hydrogen atom which depend on the Bohr radius.) The internuclear distance of a molecule is in direct relationship with the size of that molecule. We see then that the size of the hydrogen molecule ion is proportional to a_0.

This means that when we change the mass of the particle moving about the nucleus, the size of the hydrogen molecule ion also changes. This has already been realized by Levine [1] (page 355):

> "The negative muon (symbol μ^-) is a short-lived (half-life 2×10^{-6} s) elementary particle whose charge is the same as that of an electron but whose mass m_μ is 207 times m_e. When a beam of negative muons (produced when ions accelerated to high speed collide with ordinary matter) enters H_2 gas, a series of processes leads to the formation of muomolecular ions that consist of two protons and one muon. This species, symbolized by $(p\mu p)^+$, is an H_2^+ ion in which the electron has been replaced by a muon. Its R_e [the distance between the two protons] is $2.00\hbar^2/(m_\mu e^2) = 2.00\hbar^2/(207m_e e^2) = (2.00/207)$ bohr = 0.0051Å."

It is about one hundred times smaller than the Bohr radius. If one day we are able to produce a molecule with a proton and an anti-proton, the internucleus distance of that molecule will be amazingly small. It is obvious from this result that the size of the hydrogen molecule ion depends on the electron mass.

OTHER MOLECULES - A lot of calculations have been done to find the size of molecules (i.e. the length of the bonds in the molecule) [7, 8, 9]. Some of the molecules studied include F_2, Cl_2, LiCl, Ni , HF and HCl. For heavier molecules, the calculations were done using internal relativistic corrections [10, 11, 12] because of the higher mass of the electron. Relativistic corrections due to an external gravitational potential were never taken into account. Some of the molecules studied in this way are N_2, N_2^+, Au_2, AuH, AuCl, Cl_2, F_2, Xe_2, Xe_2^+, TlH and Bi_2. The table published by Pyykkö [10] is extensive and covers more than one hundred molecules. All the results cited in the references are in units of a_0 or in units that are related to a_0 and are proportional to a_0.

CRYSTALS AND METALS - According to Zhdanov [13] (page 201), the equilibrium distance between particles in a crystal is proportional to the equilibrium spacing in a diatomic molecule having the same parameters for the potential energy. (The constant of proportionality depends only on the structure of the crystal.) This means that the size of crystals is proportional to the Bohr radius since we have seen in the previous section that the size of all molecules (and thus the distance between the nuclei in diatomic molecules) is proportional to the Bohr radius. Furthermore, the same author [13] (pages 208-209) develops an ionic model for metals. According to this model, the atomic radius in a metallic crystal (which is defined as half the shortest interatomic distance) can be expressed as:

$$r_0 = \frac{h^2}{8Ame^2}\frac{1}{z^{1/3}}$$

where h is Planck's constant, A is Madelung's constant, m is the electron mass, e is the charge of the electron and z is the valency of the atom. We see then that the size of metals is proportional to the Bohr radius as defined in chapter one.

CONCLUSION - It is obvious that the size of all matter is strongly dependent on the Bohr radius and therefore the mass of the electron. Even if relativistic corrections are applied internally using Dirac's calculations, this correction does not take into account the relativistic effect caused by an external gravitational potential. This means that, since every object we know is made of either atoms, molecules, crystals or metals, the results of chapter one concerning the dilation and contraction of the Bohr radius in the hydrogen atom apply to all matter including humans. Finally, we conclude that this dilation or contraction is real.

REFERENCES

[1] Levine, Ira N., Quantum Chemistry, Prentice Hall, Englewood Cliffs, New Jersey, 1991, 629 pages.

[2] Froese Fischer, Charlotte, Average-Energy-of-Configuration Hartree-Fock Results for the Atoms Helium to Radon, *Atomic Data and Nuclear Data Tables*, volume 12, page 87, 1973.

[3] Desclaux, J. P., Relativistic Dirac-Fock Expectation Values for Atoms with Z=1 to Z=120, *Atomic Data and Nuclear Data Tables*, volume 12, page 311, 1973.

[4] Froese, Charlotte, Numerical Solution of the Hartree-Fock Equations, *Canadian Journal of Physics*, volume 41, page 1895, 1963.

[5] Cohen-Tannoudji, Claude, Bernard Diu et Franck Laloë, Mécanique quantique, Hermann, Paris, 1986, 1518 pages.

[6] McWeeny, Roy, Coulson's Valence, Oxford University Press, Oxford, 1979, 435 pages.

[7] Christiansen, Phillip A., Yoon S. Lee and Kenneth S. Pitzer, Improved Ab Initio Effective Core Potentials for Molecular Calculations, *Journal of Chemical Physics*, volume 71, number 11, page 4445, 1979.

[8] Noell, J. Oakey, Marshall D. Newton, P. Jeffrey Hay, Richard L. Martin et Frank W. Bobrowicz, An Ab Initio Study of the Bonding in Diatomic Nickel, *Journal of Chemical Physics*, volume 73, number 5, page 2360, 1980.

[9] Hay, P. Jeffrey, Willard R. Wadt et Luis R. Kahn, Ab Initio Effective Core Potentials for Molecular Calculations. II. All-Electron Comparisons and Modifications of the Procedure, *Journal of Chemical Physics*, volume 68, number 7, page 3059, 1978.

[10] Pyykkö, Pekka, Relativistic Effects in Structural Chemistry, *Chemical Reviews*, volume 88, page 563, 1988.

[11] Ziegler, Tom, Calculation of Bonding Energies by the Hartree-Fock Slater Transition State Method, Including Relativistic Effects, in *Relativistic Effects in Atoms, Molecules and Solids*, G. L. Malli editor, Plenum Press, New York, page 421, 1981.

[12] Ermler, Walter C., Richard B. Ross et Phillip A. Christiansen, Spin-Orbit Coupling and Other Relativistic Effects in Atoms and Molecules, *Advances in Quantum Chemistry*, volume 19, page 139, 1988.

[13] Zhdanov, G. S., Crystal Physics, Academic Press, London, 1965, 500 pages.

Appendix II
The Deflection of Light by the Sun's Gravitational Field: An Analysis of the 1919 Solar Eclipse Expeditions.

INTRODUCTION - According to Einstein's general theory of relativity published in 1916, light coming from a star far away from the Earth and passing near the Sun will be deviated by the Sun's gravitational field by an amount that is inversely proportional to the star's radial distance from the Sun (1.745" at the Sun's limb). This amount (dubbed the full deflection) is twice the one predicted by Einstein in 1911, using Newton's gravitational law (half deflection). In order to test which theory is right (if any), an expedition led by Eddington was sent to Sobral and Principe for the eclipse of May 29, 1919 [1]. The purpose was to determine whether or not there is a deflection of light by the Sun's gravitational field and if there is, which of the two theories mentioned above it follows.

The expedition was claimed to be successful in proving Einstein's full deflection [1,2]. This test was crucial to the general approval that Einstein's general theory of relativity enjoys nowadays.

However, this experimental result is obviously not in accordance with the result found in chapter ten. This is not a problem, as we will show that the deflection was certainly not measurable. We will see that the effect of the atmospheric turbulence was larger than the full deflection, just like the Airy disk. We will also see how the instruments could not give such a precise measurement and how the stars distribution was not good enough for such a measurement to be convincing. Finally, we will discuss how Eddington's influence worked for Einstein's full displacement and against any other possible result.

ABOUT THE EXPERIMENTAL RESULTS - Atmospheric turbulence is a phenomenon due to the atmosphere which causes images of stars as seen by an observer on Earth to jump, quiver, wobble or simply be fuzzy. This is a well-known phenomenon to any astronomer, amateur or professional. In fact [3] (page 40),

> Rare is the night (at most sites) when any telescope, no matter how large its aperture or perfect its optics, can resolve details finer than 1 arc second. More typical at ordinary locations is 2- or 3-arc-second seeing, or worse.

The problem becomes even worse during the afternoon due to the heat of the ground. Tentative solutions to this seeing problem have only recently been experimented [4].

For anyone unacquainted with atmospheric turbulence, an easy way to observe a similar phenomenon is by looking over a hot barbecue. In this case, the distortion of the images (of the order of 10') is due to the heat coming from the barbecue.

Eddington, an astronomer, was certainly aware of this problem. If it was difficult in 1995 [3], to see details finer that 1", how much more difficult was it in the jungle in 1919? The supposed effect (full and half deflection) decreases with the distance of the star from the Sun. During the 1919 eclipse, the stars closest to the Sun's limb were drowned in the corona and could not be observed [1]. Of the stars that were not drowned in the corona, Einstein's theory predicts that κ^2 Tauri should have the largest displacement, with 0.88". In Sobral, the displacement for that star was reported to be 1.00" [2]. How could Eddington and Dyson claim to observe that if at best, their precision due to atmospheric turbulence in daytime heat was several seconds? And they were not at best, near noon at Sobral and 2 p.m. at Principe, when the seeing is the worst, with small telescopes that were less than ideal.

The error caused by the atmospheric turbulence is large enough to refute any measurement of the so-called Einstein effect. However, there are other reasons.

Two object glasses were used during the expedition at Sobral, a 4-inch object glass and an astrographic object glass. Assuming a perfect optical shape, which means perfect correction for sphericity and chromaticity, for the 4-inch telescope, the size of the central spot (which is surrounded by the ring system of the diffraction pattern) can never be smaller than 1.25". This central spot is called the Airy disk. Since some of the results were presented with a claimed accuracy of the order of 0.01" [2] (page 391), that relatively big diffraction ring pattern (125 times the claimed accuracy) should have been easily seen. Since no mention is made of it, we must understand that it was not observable because various aberrations (chromatic of spheric) were larger than 1.25" and/or because, as expected, the atmospheric turbulence was larger than 1.25", which is the theoretical limit of resolution of that telescope when there is no aberration and no turbulence.

The focus of the telescopes was determined and fixed many days before the eclipse [1] (page 141). But the elements of a telescope are very sensitive to temperature [1] (page 153):

> "when the [astrographic] object glass is mounted in a steel tube, the change of scale over a range of temperature of 10° F. should be insignificant, and the definition should be very good".

During the team's stay at Sobral, the temperature ranged from 75°F during the night to 97°F in the afternoon. This change in temperature must have affected the astrograph, but what about the the mirrors and the 4-inch telescope?

The photographs of the eclipse taken with the astrograph were very disappointing [1] (page 153). It appears that the focus had changed from the night of May 27 to the moment of the eclipse. After the eclipse, the team left Sobral and came back in July to take comparison plates. They discovered that the astrograph had returned to focus! They blamed this change of focus on the effect of the Sun's heat on the mirror, but they could not say whether this effect caused a change of scale or if it only blurred the images.

What about the 4-inch telescope? The Sun's heat could have affected its scale without blurring the images. We know that there is a zone around the focal length where the image will look as if it were in focus but where the scale will be changed. To the best of our knowledge, nothing has ever been said about that possible problem.

If we plot the value of Einstein's deflection against the angular distance of the star from the Sun (as done in [5] page 50), we see that the part of the hyperbola where the slope changes the most lies under a distance of two solar radii from the Sun's center. That part is thus crucial to a good interpretation of the results. Looking at page 60 of the same article, we see that only two of the stars used by the teams at Principe and Sobral are in this area. It is thus very difficult to fit a hyperbola when only two of the stars are in that zone. These observations (and most of the others studied in von Klüber's article which reviews all observations done before 1960) could easily be fitted by a straight line instead of Einstein's deflection equation. Therefore they do not prove any of Einstein's deflections (full or half).

In one of the meetings of the Royal Astronomical Society [6] (page 41), Ludwik Silberstein pointed out that the displacements found were not radial, as Einstein's theory states, but sometimes deviated from the radial direction by as much as 35°! Nothing was said about that in Dyson's article. According to Silberstein:

> "If we had not the prejudice of Einstein's theory we should not say that the figures strongly indicated a radial law of displacement."

This brings us to our next point, which is to what degree social circumstances influenced the acceptation of Einstein's theory.

ABOUT EDDINGTON'S INFLUENCE - The results from the 1919 expedition were quickly accepted by the scientific community. When preliminary results were announced, Joseph Thomson (from the Chair) said [2] (page 394):

> "It is difficult for the audience to weigh fully the meaning of the figures that have been put before us, but the Astronomer Royal [Dyson] and Prof. Eddington have studied the material carefully, and they regard the evidence as decisively in favor of the larger value for the displacement."

Thomson makes it look like only Eddington and Dyson are able to understand the results. It seems that they have such a reputation that the general and the scientific public should blindly believe them.

It is Dyson who presented the results of the Sobral expedition at a meeting of the Royal Astronomical Society [2] (page 391). Some of the displacements presented were very small, sometimes of the order of 0.01". In another meeting [6] (page 40), Oliver Lodge asked if it were possible to measure a deviation of 1/60" (approximately 0.02") to which Dyson responded:

> "I do not think that it would be possible to measure so small a quantity."

We clearly see that Dyson contradicted himself.

Furthermore, Eddington said himself he was in favour of the full deflection before doing the experiment. Writing about the results of the expedition, he said [7] (page 116):

> "Although the material was very meager compared with what had been hoped for, the writer (who it must be admitted was not altogether unbiased) believed it convincing."

Moreover, according to Chandrasekhar [8] (page 25),

> "had he been left to himself, he would not have planned the expeditions since he was fully convinced of the truth of the general theory of relativity!"

Eddington was a Quaker and like other Quakers, he did not want to go to war (WWI). In England, Quakers were sent to camps during the war, but because of Dyson's intervention [8] (page 25),

> "Eddington was deferred with the express stipulation that if the war should end by May 1919, then Eddington should undertake to lead an expedition for the purpose of verifying Einstein's predictions! "

The circumstances of the war forced Eddington to do an experiment that he would have never done had he had a choice because he was so convinced of its outcome.

Why was the theory so quickly, widely and easily accepted? After all, it was radically changing the common view of the universe, curving space and dilating time. Furthermore, the British were accepting a theory from a German man, right after a bitter war with Germany.

It seems that the theory was widely accepted only after the eclipse expedition [9] (page 50). According to Earman and Glymour, Dyson and Eddington played a great influential role in the acceptation of the general theory of relativity by the British. In fact, it is Eddington who, convinced of the truth of the theory, convinced Dyson. In the few years before 1919, they made the measurement of the "Einstein effect" a challenge and after the expeditions of May 1919, they helped give the impression that the data had confirmed Einstein's theory.

Aside from the fact that Eddington was convinced that the theory was right, another reason pushed him to advocate it [9] (page 85). He hoped that a British verification of a German theory might reopen the lines of communication and collaboration between the scientists of both countries, lines that had been closed during World War One.

Finally, before 1919, no one had claimed to have observed shifts of the size required by Einstein's theory. Probably because the theory was thought to be proved by the 1919 eclipse observations, a lot of scientists, maybe throwing out some of their data, reported finding the right shift [9] (page 85).

After 1919, other expeditions were undertaken to measure the deflection of light by the Sun. Most of them obtained results a bit higher than Einstein's prediction, but it did not matter anymore since the reputation of the theory had already been established.

Jamal Munshi in reference to his "Weird but True" reports on the internet at:

http://munshi.sonoma.edu/jamal/physicsmath.html:

> Dr. F. Schmeidler of the Munich University Observatory has published a paper [49] titled "The Einstein Shift An Unsettled Problem," and a plot of shifts for 92 stars for the 1922 eclipse shows shifts going in all directions, many of them going the wrong way by as large a deflection as those shifted in the predicted direction! Further examination of the 1919 and 1922 data originally interpreted as confirming relativity, tended to favor a larger shift, the results depended very strongly on the manner for reducing the

> measurements and the effect of omitting individual stars.
>
> So now we find that the legend of Albert Einstein as the world's greatest scientist was based on the Mathematical Magic of Trimming and Cooking of the eclipse data to present the illusion that Einstein's general relativity theory was correct in order to prevent Cambridge University from being disgraced because one of its distinguished members was close to being declared a "conscientious objector"!

CONCLUSION - Much of the popularity of Einstein's general theory of relativity relies on the observations done at Sobral and Principe. We see now that these results were overemphasized and did certainly not consecrate Einstein's theory. It is interesting to think of what would have happened if the results had been deemed not good enough or if they had clearly showed that there is no deviation of light by the Sun. Einstein's theory might not have enjoyed the popularity it now does and a new more realistic theory might have been found years ago.

REFERENCES

[1] Dyson, F. W., A. S. Eddington and C. Davidson, A Determination of the Deflection of Light by the Sun's Gravitational Field, from Observations Made at the Total Eclipse of May 29, 1919, in *Philosophical Transactions of the Royal Society of London*, series A, **220**, p. 291-333, 1920. (See also: *Annual Report of the Board of Regents of the Smithsonian Institution Showing the Operations, Expenditures, and Conditions of the Institution for the Year Ending June 30 1919*, Government Printing Office, Washington, p. 133-176, 1921.

[2] Joint Eclipse Meeting of the Royal Society and the Royal Astronomical Society, 1919, November 6, *The Observatory*, **42**, 545, p. 389-398, 1919.

[3] MacRobert, Alan M., Beating the Seeing, *Sky & Telescope*, **89**, 4, p. 40-43, 1995.

[4] Fischer, Daniel, Optical Interferometry: Breaking the Barriers, *Sky & Telescope*, **92**, 5, p. 36-41, 1996.

[5] von Klüber, H., The Determination of Einstein's Light-Deflection in the Gravitational Field of the Sun, *Vistas in Astronomy*, Pergamon Press, London, **3**, p. 47-77, 1960.

[6] Meeting of the Royal Astronomical Society, Friday, 1919, December 12, in *The Observatory*, **43**, 548, p. 33-45, Jan. 1920.

[7] Eddington, A., Space, Time and Gravitation: An Outline of the General Relativity Theory, Cambridge University Press, Cambridge, 218 pages, 1959.

[8] Chandrasekhar, S., Eddington: The Most Distinguished Astrophysicist of His Time, Cambridge University Press, Cambridge, 64 pages, 1983.

[9] Earman, J. and C. Glymour, Relativity and Eclipses: The British Eclipse Expeditions of 1919 and Their Predecessors, in *Historical Studies in the Physical Sciences*, **11**, p. 49-85, 1980.

Appendix III
Physical Constants.

Bohr Radius	$a_o = 5.29\times10^{-11}$ m
Coulomb constant	$k = 1/4\pi\varepsilon_0 = 8.988\times10^{9}\ N\cdot m^2/C^2$
Eccentricity of Mercury's orbit	$e = 0.2056$
Electronic charge	$e = 1.602\times10^{-19}$ C
Electron mass	$m_e = 9.109\times10^{-31}$ kg
Gravitational acceleration on Earth	$g = 9.8\ m/s^2$
Gravitational constant	$G = 6.6726\times10^{-11}\ N\cdot m^2/kg^2$
Mass of the Earth	$M(\underline{E}) = 5.9742\times10^{24}$ kg
Mass of the hydrogen atom	$m_o = 1.6727406\times10^{-27}$ kg
Mass of Mercury	$M(\underline{M}) = 0.33022\times10^{24}$ kg
Mass of the Sun	$M(\underline{S}) = 1.9834\times10^{30}$ kg
Muon mass	$m_\mu = 207m_e = 1.886\times10^{-28}$ kg
Planck constant	$h = 2\pi\hbar = 6.626\times10^{-34}$ J·s
Semi-major axis of Mercury	$a = 5.791\times10^{10}$ m
Sommerfeld fine structure constant	$\alpha = 7.297\times10^{-3} \cong 1/137$
Velocity of light	$c = 2.99792458\times10^{8}$ m/s

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