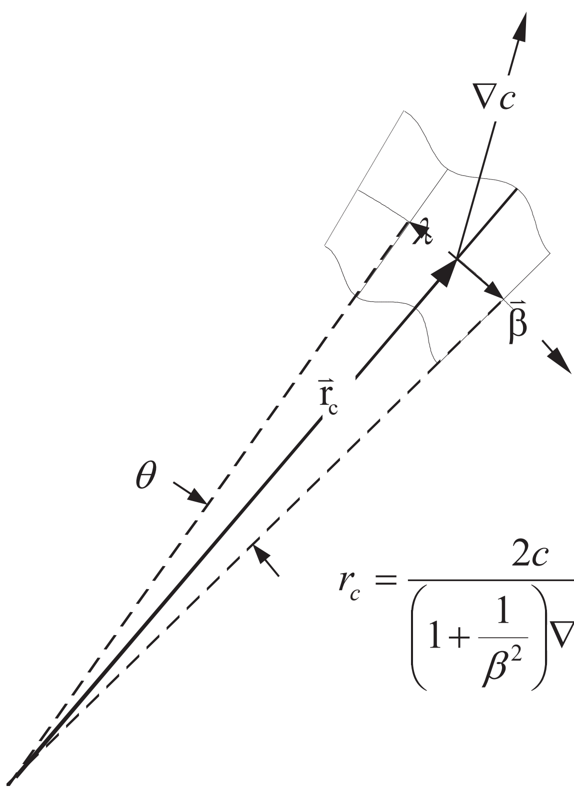
Time, Matter, and Gravity

Morris G. Anderson

Abstract

This work has four primary objectives. The **first** is to define the meaning and characteristics of time (see Section 2). The **second** is to define a standard unit of matter in terms of light to compliment similar standards for time and length (see Section 2.4). The **third** is to explain why motion and gravity influence the natural frequency of matter (see Section 5). The **fourth** is to explain what gravity is and to develop a method for predicting the motion of matter (see Section 7).

The result is a surprisingly simple concept based on The Position Definition of Time that defines time, matter, and gravity. In this approach, we combine wave mechanics with gravity by describing the curvature of motion in terms of wave propagation as presented in Figure 1. We demonstrate the validity of this method by comparing it with experimental evidence for objects such as photons, baseballs, and planets. A FORTRAN program is also included for calculating the trajectory of an object or wave of light, the orbit of a planet, and the precession of an orbit.



$$r_c = \frac{2c}{\left(1+\frac{1}{\beta^2}\right)\nabla c \bullet \hat{r}_c}$$

Figure 1 This figure presents an equation defining the radius of curvature for the motion of an object, represented by λ, based only on its wave characteristics. The important variables in this equation are the velocity of the object, the speed of light, and the gradient of the speed of light.

Preface

I have spent many years trying to understand what time is and how objects move. I have wondered about these things since I was a child. It has been a very rewarding experience to discover some of the answers.

I began this effort with a belief in the existence of natural law and that "Nothing comes from nothing." (from *The Sound of Music*). Beyond this I have generally accepted existing ideas until it seemed to me they did not work. It should be clear to most students of physics where I have made modifications in an effort to find a solution.

In 1992, as part of my work as an aerospace engineer, I began to think about the definition of a unit of mass. The advantage of using light to define standard units of length and time was clear. Therefore, it was natural to search for a method to define a unit of mass in terms of light. As I worked toward this objective, I found I could not achieve it until I had first developed a precise definition of time.

Existing theories were not sufficient to achieve this goal. Therefore, I have developed my own ideas based on a fundamental definition of time. In this effort, I have proceeded with the hope and belief that law governs all things.

We are not able to derive natural laws. However, if we hope they exist, then we can develop postulates to represent laws from which we derive basic relationships and equations. We accept these if they are in agreement with observations of nature.

For many weeks, I literally pondered the meaning of time until my mind got "sore." Finally, I had a brief insight on the morning of May 28, 1995. I can remember thinking to myself, "Oh so that's what time is!" I immediately felt that I had discovered a correct definition of time.

The Position Definition of Time is the result of my efforts. It provides the foundation needed to describe the motion of matter. In this work, I have drawn primarily from Newton's laws of motion, Einstein's photon concept of light, and wave mechanics.

One of the most significant discoveries presented in this book is a description of gravity in terms of the wave characteristics of matter. This makes it possible to describe the motion of matter, whether in the form of a photon, baseball, or planet, as wave propagation.

In developing these ideas, I have studied and been influenced by the works of others. However, I have tried to be independent in formulating my own concepts. My intent is not to prove or discredit any theory. It is merely to explain how things work in a simple and understandable manner. For this purpose, I have included equations in a readable format that most students who have completed one year of calculus and physics will be able to understand. I have also included a FORTRAN program for calculating the trajectory of an object or wave of light, the orbit of a planet, and the precession of an orbit.

When I started this project, I had no idea where it would lead. It has been a thrilling experience to start from scratch by establishing a fundamental set of definitions and postulates and develop these basic ideas into concepts which make it possible to derive equations that provide a good description of how things work.

My parents taught me as a child to gain a “knowledge of things as they are” through my own efforts. Hence, one of my favorite pastimes is to ponder and study a topic until it actually becomes part of me, which is how I am beginning to feel about this subject.

Morris G. Anderson
Mesa Arizona
April 15, 2004

Acknowledgments

My wife, Becky, has been a great support in this undertaking. She has shown a sincere interest and provided me with a much needed listening ear. Her encouragement has made it possible for me to complete this task.

My parents have been especially helpful. My father has encouraged me from the start, giving me useful insight and suggestions. My mother has given unfailing encouragement and support.

I also want to thank Annette Romei and Jack Rowse for their helpful suggestions and encouragement and for reviewing final drafts of this book.

Contents

Abstract i

Preface iii

Acknowledgments v

List of Symbols ix
List of Subscripts Applied To Symbols x

List of Constants x

List of Definitions xi

List of Postulates xv

List of Figures xvii

1 Introduction 1

2 Time, Length, And Matter 5
2.1 The Position Definition Of Time 5
2.2 Time, A Change In Position 7
2.3 Length, A Separation In Position 9
2.4 Matter, The Substance Of Existence 9
2.4.1 The Speed of light at the standard location 10
2.4.2 The Relationship Between Matter And Energy 11
2.4.3 The Kinetic Energy Of Motion 15
2.5 Light, A Universal Standard For Time, Length, and Matter 19
2.6 Calibrating A Secondary Standard In Terms Of Light 20

3 Rotational Force 21

4 Gravity 25
4.1 Gravitational Force Caused By A Gradient In The Speed Of Light 27
4.1.1 Calculation Of β From c For An Object Along Its Path Of Motion 31

5 Matter And The Speed Of Light 33
5.1 The Dependence Of Rest Matter And Charge On The Speed Of Light 33
5.2 Atomic Transition Energy 36
5.3 The Electron-Nucleus Wavelength Of Interaction 38
5.4 The Natural Frequency Of An Atom 40
5.5 The Mechanical Frequency Of A Spring-Mass System 45

6 Matter And Space 49
6.1 A Particle Consisting Of Electromagnetic Waves 49
6.2 Mass And The Increase In Matter Associated With A Change In Momentum 51
6.3 The Wavelength Of Interaction 53

6.4 Length Contraction, An Inherent Property Of The Wave Characteristics Of Matter 57
6.5 Another Look At How The Wavelength Of Interaction Increases With Velocity 61
6.6 The Density Of Rest Matter Is Inversely Proportional To The Speed Of Light 66

7 Motion In Space Is Governed By Wave Propagation 67

8 Experimental Verification Of The Wave Propagation Method 73
8.1 Wave Propagation Is Indistinguishable From Newtonian Mechanics At Low Velocities 73
8.2 Wave Propagation Accurately Predicts Planetary Orbits 75
8.3 Wave Propagation Accurately Predicts The Precession Of Orbits 77
8.4 Wave Propagation Accurately Predicts The Bending Of Light Past The Sun 79

9 Verification Of The Need To Modify Newton's Law Of Gravity 81

10 Future Considerations 85
10.1 The Influence Of Acceleration On Natural Frequency 85
10.2 Frame Dragging As Caused By A Governing Body Imparting Rotation To The Matter Of Space 85
10.3 The Speed Of Gravity Waves 85
10.4 The Density Of Space 85
10.5 Gravitational Force Between Galaxies 85

11 Conclusion 87

12 References 89

Appendix A PATH Fortran Program For Calculating The Path Of Motion 91
PATH Fortran Program Listing 92

Appendix B PATH Fortran Program Output Files 103
Output File - The Trajectory Example Presented In Figure 14 103
Output File - The Precession Example Presented In Figure 16 104
Output File - Orbital Precession Of Mercury - See Figure 17 105
Output File - Orbital Precession Of Venus - See Figure 17 106
Output File - Orbital Precession Of Earth - See Figure 17 107
Output File - Orbital Precession Of Mars - See Figure 17 108
Output File - The Bending Of Light Past The Sun - See Figure 18 109

About the Author ..... Error! Bookmark not defined.

List of Symbols

Symbol	Units	Description
ε	$C^2 s^2/(kg\ m)$	Permittivity constant of space
μ	$(kg\ m)/C^2$	Permeability of space
λ	m	Wavelength
$\rightharpoonup$	none	The harpoon over a variable, such as $\vec{r}$, indicates a vector
β	none	*v/c*
^	none	The hat over a variable, such as $\hat{r}$, indicates a unit vector
ρ	kg/m^3	Density
c	m/s	Velocity of light
c_s	m/s	Velocity of light at the standard location (see Definition 10)
e	Coulomb	Charge associated with an electron
e_s	Coulomb	Charge associated with an electron at the standard location
E	$kg\ m^2/s^2$	Energy
f	1/*s*	Frequency = (wave velocity) / wavelength
F	$kg\ m\ /s^2$	Force
ke	$kg\ m^2/s^2$	kinetic energy
L_n	m	Length of object normal to the direction of motion
L_p	m	Length of object parallel to the direction of motion
m	kg	Matter
M	kg	Matter of a governing body
n	none	Integer - Represents the number of wavelengths
n_λ	none	Equivalent number of photons of wavelength λ in a kilogram
p	kg m/s	Momentum
r_c	m	Radius of curvature
v	m/s	Velocity
Z	none	Atomic number of the atom
kg	kilogram	A unit of matter, see section 2.5
m	meter	A unit of length, see section 2.5
s	second	A unit of length & time, see section 2.5
t	s	Time, see section 2.5

List of Subscripts Applied To Symbols

Subscript	Description
i	Indicates interaction. For example: $\lambda_i =$ The wavelength of interaction.
o	Indicates value for $\beta = 0$. For example: $\lambda_{io} =$ The wavelength of interaction with respect to an object with a β of zero.
s	Indicates value for conditions where c is equal to c_s. For example: $\lambda_{ios} =$ The wavelength of interaction with respect to an object with a β of zero and for conditions where c is equal to c_s.
t	Indicates transition. For example: $E_t =$ Energy of transition

List of Constants

Constant (see Reference 1)	**Description**
$c_s = 299\,792\,458.0\,\dfrac{\mathrm{m}}{\mathrm{s}}$	Speed of light at the standard location (see Definition 10)
$\mathrm{C} = \dfrac{e_s}{1.602\,176\,53 \times 10^{-19}}$	Coulomb, a unit of electric charge
$\varepsilon_s = \dfrac{8.854\,187\,817 \times 10^{-12}\,\mathrm{C}^2\mathrm{s}^2}{\mathrm{kg} \cdot \mathrm{m}}$	Permittivity constant of space at the standard location
$G = 6.6742 \times 10^{-11}\,\dfrac{\mathrm{m}^3}{\mathrm{kg} \cdot \mathrm{s}^2}$	Universal gravitation constant
$h = 6.626\,0693 \times 10^{-34}\,\dfrac{\mathrm{kg} \cdot \mathrm{m}^2}{\mathrm{s}}$	Plank's Constant
$\mathrm{J} = \dfrac{\mathrm{kg} \cdot \mathrm{m}^2}{\mathrm{s}^2}$	Joule, a unit of energy
$\mathrm{N} = \dfrac{\mathrm{kg} \cdot \mathrm{m}}{\mathrm{s}^2}$	*Newton, a unit of force*
$\pi \simeq 3.14159$	*Ratio of the circumference to diameter of a circle*

List of Definitions

When we create a definition we develop a statement that gives meaning to a word, concept, or process. We do not derive it and it is not a law of nature. We simply state it to be so. Some concepts which we call laws are actually definitions. A good example is Newton's second law of motion. We use this relationship to give meaning to the word, force. Hence, we use it as a definition and not as a law!

The following definitions apply in this work.

Definition 1 *A **postulate** is a statement we believe to be true in our sphere of existence.* 5

Definition 2 *An **assumption** is a statement we believe to be true for a specific problem under consideration.* 5

Definition 3 ***Position** is where something is.* 6

Definition 4 ***TIME** is equal to position, which corresponds to where something is.* 6

Definition 5 ***TIME Past** is where you have been and where or the way things were.* 6

Definition 6 ***TIME Present** is where you are and where or the way things are.* 6

Definition 7 ***TIME Future** is where you will be and where or the way things will be.* 6

Definition 8 ***Time** is equal to a change in TIME and corresponds to a change in position.* 7

Definition 9 ***Length** is equal to a separation in TIME and corresponds to a separation in position.* 7

Definition 10 ***The standard location** is a place on the Earth, in a vacuum, where we define the units of time, length, and matter. The scientific community could define this to be the location of the current time standard for the United States and the Global Positioning System located at the U.S. Naval Observatory in Washington D.C.* 8

Definition 11 *A **vacuum** is a volume of space where there are no particles or electromagnetic waves.* 8

Definition 12 ***<u>One second of Time</u>*** *is equal to a change in TIME corresponding to a change in position of light equivalent to the separation in position, in a vacuum, of the first and last waves of a continuous band of* $9\,192\,631\,770$ *waves of the radiation corresponding to the transition between two hyperfine levels of the ground state of the cesium 133 atom at the standard location.* 8

Definition 13 ***<u>One meter of Time</u>*** *is equal to* $\frac{1}{299\,792\,458}$ *seconds of Time. In general, the second should be used as the standard unit of time.* 8

Definition 14 ***<u>One second of length</u>*** *is equal to a separation in TIME equivalent to the separation in position, in a vacuum, of the first and last waves of a continuous band of* $9\,192\,631\,770$ *waves of the radiation corresponding to the transition between two hyperfine levels of the ground state of the cesium 133 atom at the standard location.* 9

Definition 15 ***<u>One meter of length</u>*** *is equal to* $\frac{1}{299\,792\,458}$ *seconds of length. In general, the meter should be used as the standard unit of length.* 9

Definition 16 ***<u>Matter</u>*** *is the substance of existence.* 9

Definition 17 *The* ***<u>velocity</u>***, $\vec{\mathbf{v}}$, *of an object is equal to the change in position of the object in meters, divided by the corresponding magnitude of the change in position of light at the standard location in seconds.* 10

Definition 18 *The* ***<u>momentum</u>***, $\vec{\mathbf{p}}$, *of an object is a vector that is equal to the product of its matter, m, the standard speed of light,* c_s, *and* $\vec{\boldsymbol{\beta}}$ *(the ratio of velocity with the local speed of light). This is expressed mathematically as* $\vec{\mathbf{p}} = m\vec{\boldsymbol{\beta}}c_s$ *where* $\vec{\boldsymbol{\beta}} = \frac{\vec{\mathbf{v}}}{c}$ 12

Definition 19 ***<u>Force</u>*** *is a vector that we can define with Newton's second law of motion stated as "The summation of forces is equal to the rate of creation of momentum." expressed in equation form as* $\sum \vec{\mathbf{F}} = \frac{d\vec{\mathbf{p}}}{dt}$ 12

Definition 20 *The* ***<u>energy</u>*** *added to an object by a force,* $\vec{\mathbf{F}}$, *is equal to the vector dot product of the force and the change in the object's position vector,* $\vec{\mathbf{r}}$, *multiplied by* $\frac{c_s}{c}$ *and stated mathematically as* $E = \int \vec{\mathbf{F}} \bullet d\vec{\mathbf{r}} \frac{c_s}{c}$ 12

Definition 21 ***Plank's constant***, $h = 6.626\,0693 \times 10^{-34} \dfrac{\mathrm{kg} \cdot \mathrm{m}^2}{\mathrm{s}}$ *exactly.* *13*

Definition 22 ***One kilogram*** *of matter is equal to* n_λ *photons of light where* $n_\lambda = \dfrac{\lambda c_s^2}{hc}$. *15*

Definition 23 ***Kinetic energy*** *is equal to the difference between the total and rest matter of an object multiplied by the square of the standard speed of light.* *17*

Definition 24 *The* ***mass*** *of an object or particle is equal to the internal momentum of the object or particle divided by the standard velocity of light,* c_s. *52*

Definition 25 The ***Interaction Wavelength*** *(λ_i) between an electromagnetic wave and an object is the distance the wave must move through the medium of space for two maximum or minimum wave values to interact with the object.* *54*

List of Postulates

A postulate is a statement we believe to be true in our sphere of existence. In this context, Newton's third law of motion stated as "For every action there is an equal and opposite reaction" is a postulate. The following postulates apply in this work.

Postulate 1 *For any TIME (past, present, or future) the position of any object with respect to all matter is unique.* *7*

Postulate 2 *It is not possible to create or destroy matter.* *9*

Postulate 3 *The speed of light, c, is a function of the properties of space as defined by Maxwell's equations, and therefore independent of any force acting upon it.* *12*

Postulate 4 *The energy, E, of a single photon is inversely proportional to its wavelength, λ, according to Albert Einstein's photon concept as* $E = hf = \frac{hc}{\lambda}$. *13*

Postulate 5 *A body of matter distorts the medium of space causing the speed of light to be a function of position. Gravity is the influence of this gradient on matter.* *27*

Postulate 6 *The gravitational force of attraction between two objects under static conditions can be calculated as* $F = \frac{m_o MG}{r^2}\frac{c}{c_s}$. *We will refer to this as corrected gravity to distinguish it from Newton's law of gravity.* *28*

Postulate 7 *The ratio of the permittivity of space to the permeability of space in a vacuum is constant and independent of position.* *33*

Postulate 8 *The ratio of the rest matter to charge of an electron is constant or independent of location. The ratio of rest matter to charge of a proton is also constant.* *34*

Postulate 9 *The charge of an object distorts the medium of space. The interaction of these distortions causes the force of charge attraction or repulsion.* *37*

Postulate 10 *The force of interaction between an atomic nucleus and a single electron can be calculated as:* $F = \frac{Ze^2}{4\pi\varepsilon r_i^2}$ *38*

Postulate 11 *An electron-atomic nucleus system is stable when its structure corresponds to integer values of the wavelength of interaction.* *38*

Postulate 12 *Space and matter are mutually dependent upon each other. Where there is space there is matter, and where there is matter, there is space. One does not exist without the other.*.. *49*

Postulate 13 *All fundamental particles are formed out of electromagnetic waves.*.......... *51*

Postulate 14 *Total electromagnetic momentum is conserved. The change in the total electromagnetic momentum of a system is equal to the electromagnetic momentum in minus the electromagnetic momentum out.*... *52*

Postulate 15 *Particles can interact by exchanging momentum through an electromagnetic wave.*.. *53*

Postulate 16 *The wavelength of interaction of the electromagnetic waves that form a particle is independent of orientation.* *57*

Postulate 17 *If the wavelength of an object is a function of position, and there is no other influence, the motion of the object is a pure function of wave propagation.*.. *67*

List of Figures

Figure 1 — *This figure presents an equation defining the radius of curvature for the motion of an object, represented by λ, based only on its wave characteristics. The important variables in this equation are the velocity of the object, the speed of light, and the gradient of the speed of light.* .... *i*

Figure 2 — *The trajectory of a ball in the absence of friction.* *1*

Figure 3 — *This represents an electromagnetic wave passing through a medium with properties that cause the speed of light to be a function of position.* *11*

Figure 4 — *Vector,* $\vec{\mathbf{r}}$*, defined with magnitude, r, and direction* θ. *21*

Figure 5 — *Variation in the ratio of the rest to total matter of a object as a function of* β. *As the velocity of an object is increased ($\beta \to 1$) the ratio of the rest to total matter of the object is decreased* $\frac{m_o}{m} \to 0$. *26*

Figure 6 — *This figure depicts a particle with a total rest matter of* m_o. *It consists of electromagnetic waves confined in a spherical space in the form a standing wave with a group velocity of zero.* *50*

Figure 7 — *Relationship between internal momentum, linear momentum, and the total electromagnetic momentum of a particle or object.* *52*

Figure 8 — *This represents the interaction between two particles through the influence of an electromagnetic wave. The basic concept of this example is the same as a "Feynman diagram."* *53*

Figure 9 — *A wave with a velocity,* $\vec{c}$*, passes object, M, which is moving with a velocity of* $\vec{v}$. *The velocity of both the wave and M are with respect to the medium of space that supports the wave.* *54*

Figure 10 — *A particle formed out of electromagnetic waves for $\beta = 0$.* *57*

Figure 11 — *A particle formed out of electromagnetic waves for $\beta = 0.8$.* *58*

Figure 12 — *This figure represents a particle, that is moving to the right in the form of a standing wave consisting of waves,* λ_1*, and* λ_2 *with a group velocity corresponding to* β. *61*

Figure 13 *This figure presents the curvature of a particle's path defined in terms of its wavelength as* $r_c = \dfrac{\lambda}{\theta}$. *68*

Figure 14 *If we use wave propagation to calculate the path of motion for objects that we deal with everyday, the result is indistinguishable from classical Newtonian mechanics. Note: 100 iterations at 1.25° per iteration were used to obtain the wave propagation solution. The constants presented in Table 1 were used to calculate the classical Newtonian solution.* *74*

Figure 15 *Wave propagation accurately predicts orbital motion. The input values used with the PATH program to calculate these results are included in Appendix B. In this example we have ignored the mass of the planets and their influence on each other.* *76*

Figure 16 *Here we have an extreme case of orbital precession as calculated with wave propagation. This demonstrates how the elliptical form of an orbit rotates in the direction of orbital motion. Appendix B provides the input values that were used with the PATH program to create this example.* *77*

Figure 17 *This plot of numerical results, from the PATH program for the orbital precession of planets in our Solar System, demonstrates that the values presented in Table 2 represent converged solutions.* *78*

Figure 18 *This presents numerical results from the PATH program for calculating the bending of light past the Sun, demonstrating that the solution converges to a value of 1.75 arcseconds in agreement with published data.* *79*

Figure 19 *This presents the calculated path for a light wave as it grazes the surface of the Sun from a distant star on its way to the Earth. The scales of the "y" and "x" axis are different to emphasize the bending of light.* *80*

Figure 20 *The speed of light based on corrected gravity, as defined in Postulate 6, can approach zero but it can never become less than zero. However, equations based on Newton's original law of gravity can result in a negative or imaginary value for the speed of light.* *83*

Figure 21 *The radius of curvature, based on equation (7-12), is used to integrate the path of motion.* *91*

The beauty of nature stems from its adherence to natural law.

1 Introduction

Learning is wonderful. As we learn, things that at first seemed perplexing become simple and easy to understand.

One of the first lessons in physics is how to calculate the trajectory of an object similar to the ball presented in Figure 2. We learn that (in the absence of friction) the velocity of the ball in the x direction is constant, and that we can use Newton's laws of motion and gravity to calculate the velocity in the y direction. The result is a parabolic path that agrees very well with every day experience, and we are thrilled with our ability to solve this type of problem. However, do we really understand why the ball moves in a parabolic path? What is gravity and how does it apply a constant force of acceleration to the object? There is more to learn.

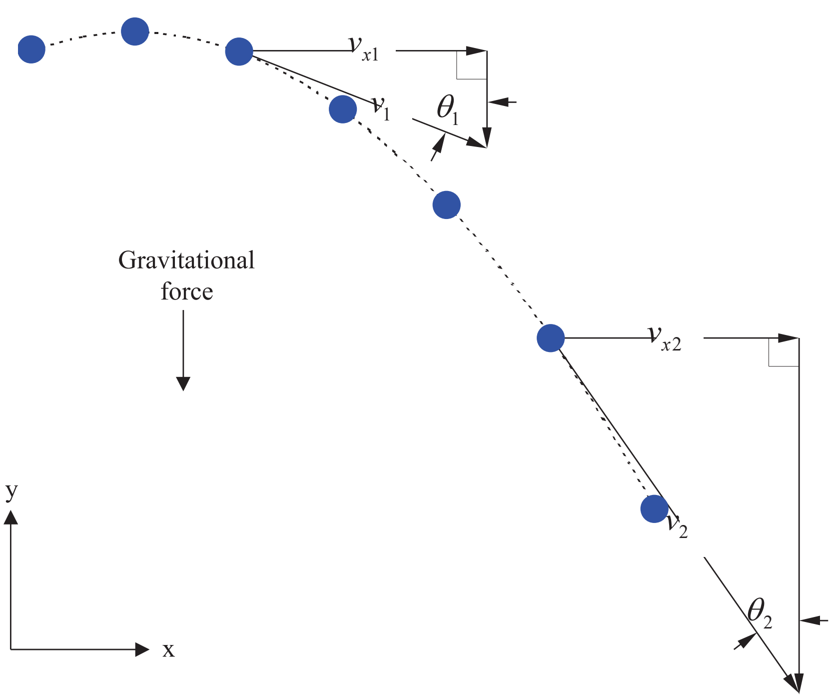


Figure 2 The trajectory of a ball in the absence of friction.

Let us take another look at this concept. If the velocity of the ball in the x direction is constant then:

$$v_{x1} = v_{x2}$$

Therefore:

$$v_1 Sin\theta_1 = v_2 Sin\theta_2 .$$

We can rearrange this equation as:

$$\frac{v_1}{v_2} = \frac{Sin\theta_2}{Sin\theta_1} \tag{1-1}$$

This is starting to look familiar. Where have we seen this type of equation before?

In another lesson, we learn that all objects have wave characteristics. Louis de Broglie postulated that the wavelength of any object is inversely proportional to its velocity. When we apply this concept to the ball presented in Figure 2, we obtain:

$$\frac{v_1}{v_2} = \frac{\lambda_2}{\lambda_1}$$

Substituting this into equation (1-1), we obtain:

$$\frac{\lambda_2}{\lambda_1} = \frac{Sin\theta_2}{Sin\theta_1} \tag{1-2}$$

We now recognize this equation as Snell's Law, which is used to calculate the path of wave propagation such as light passing through the atmosphere. This means we can calculate the trajectory of an object based only on its wave characteristics. What an amazing coincidence! Or is it? Could the wave characteristics of matter actually cause the trajectory motion that we are so familiar with on a day to day basis? This must be an important clue to the nature of gravity!

This book presents a method based on the concept that a governing body, such as the Earth, distorts space causing the speed of light to be a function of position which in turn causes the wavelength of an object to be a function of position. When we combine this influence with the wave characteristics of matter, we can describe the motion of objects such as a photon, baseball, or planet as wave propagation. This discovery flows naturally from the Position Definition of Time which is the foundation of this work.

Some of the fundamental ideas presented are:

- Time is equal to position.
- The definitions of momentum and energy must be consistent with the nature of light.
- Space and matter are dependent upon each other and cannot exist separately.
- A governing body distorts space causing the speed of light to be a function of position.
- Rest mass and charge are a function of the speed of light.
- All fundamental particles are formed out of electromagnetic waves.
- Particles interact by exchanging momentum through electromagnetic waves.
- The wavelength of interaction is a function of the momentum of interaction.
- The motion of both microscopic and macroscopic objects is governed by wave propagation.

These ideas lead naturally to the Lorentz-Fitzgerald contraction and the null result of the Michelson-Morley experiment. They also lead to:

- An increase in the matter of an object with the addition of momentum.
- Gravity.
- The influence of motion and gravity on natural frequency.
- The trajectory of an object.
- The bending of light in the presence of a governing body.
- The precession of an orbit.

We start from scratch by establishing a fundamental set of definitions and postulates and develop these basic ideas into concepts which make it possible to derive equations that provide a good description of how things work.

Appendix A presents the Fortran program, PATH, which is based on these equations. With this program and experimental evidence we demonstrate that the equations we have derived are valid for calculating the trajectory of an object, the orbit of a planet, the precession of an orbit, and the bending of light.

2 Time, Length, And Matter

We must understand the characteristics of time, length, and matter before we can establish a meaningful set of units and standards. Hence, we start by first defining what these characteristics are and then proceed to develop a set of units and standards based on the properties of light. Our approach is to build upon a foundation of definitions and postulates leading us to develop definitions of momentum and energy that are compatible with the nature of light.

When we create a definition we develop a statement that gives meaning to a word, concept, or process. We do not derive it and it is not a law of nature. We simply state it to be so. As such, a definition is also independent of any limitations associated with performing a measurement.

Some concepts which we call laws are actually definitions. A good example is Newton's second law of motion. We use this relationship to give meaning to the word, force. Hence, we use it as a definition and not as a law!

We begin with the following definitions:

Definition 1 *A **postulate** is a statement we believe to be true in our sphere of existence.*

Definition 2 *An **assumption** is a statement we believe to be true for a specific problem under consideration.*

2.1 The Position Definition Of Time

When we say the word, time, we usually know exactly what we are trying to communicate. For example, when a boy asks his mother, "What time is dinner?" and she responds with, "At 5 o'clock and we are having your favorite desert," there is no confusion. He will make every effort to be at the table when dinner is served. Therefore, from this perspective we all know exactly what time is. Hence, it is remarkable that there has been so much confusion in establishing a meaningful definition. The following statements provide a few examples of how it has been done.

1. "Absolute, true, and mathematical time, of itself, and from its own nature flows equably and without regard to anything external, and by another name is called duration." (From Newton's statement in the first pages of The Principia[2])
2. The measured or measurable period during which an action, process, or condition exists or continues. (Webster's New Encyclopedic Dictionary[3])
3. "Time is the essence of existence" (Loren R. Anderson[4])

These statements, while attempting to give meaning to the word, time, do not define it with a characteristic that we can use in the laboratory. Therefore, we must first gain a better understanding of what we mean when we use the word, time, before we can proceed.

In our daily activities, we apply two fundamental meanings to the word, time. Therefore, to avoid confusion we will use all capital letters for concepts similar to the question, "What **TIME** is it?" and we will use lower case or capitalize only the first letter for concepts similar to the question, "How much **Time** will it take?" In our effort to define these two concepts we will start by defining position as:

Definition 3 ***Position*** *is where something is.*

As we ponder the basic meaning of TIME, we realize that we can think of it as:

- Our position with respect to the orientation of the hands on a clock. Example: We can plan to be at the office when the hands on the clock indicate 8:00am.
- Our position with respect to the Sun, planets, and stars. Example: We can plan to meet on the top floor of the Empire State Building when the position of the Earth, Sun, and stars indicate that it is Tuesday, February 14, 2012, at 5:00pm.

On further examination, we find that we use TIME as a method to predict and confirm our position with respect to other things. We simplify this concept through recognizing that **TIME is where you are**. Hence, we can define it as follows.

Definition 4 ***TIME*** *is equal to position, which corresponds to where something is.*

This concept, to be known as the "Position Definition of TIME," provides an important foundation for a better understanding of the laws by which we are governed. It also leads to the following definitions of our relationship with the past, present, and future.

Definition 5 ***TIME Past*** *is where you have been and where or the way things were.*

Definition 6 ***TIME Present*** *is where you are and where or the way things are.*

Definition 7 ***TIME Future*** *is where you will be and where or the way things will be.*

These definitions lead to the following postulate:

Postulate 1 *For any TIME (past, present, or future) the position of any object with respect to all matter is unique.*

We are now able to investigate two additional characteristics of TIME or position defined as follows.

Definition 8 ***<u>Time</u>*** *is equal to a change in TIME and corresponds to a change in position.*

Definition 9 ***<u>Length</u>*** *is equal to a separation in TIME and corresponds to a separation in position.*

We now have a set of characteristics that we can use in the laboratory to define standard units for time, length, and matter.

2.2 Time, A Change In Position

When we speak of time we generally refer to a change in TIME represented by the words, second, hour, day, and so forth. Therefore, based on our definition of TIME we can also define a change in TIME as given in Definition 8, which we repeat again here for emphasis. Time is equal to a change in TIME and corresponds to a change in position.

In our attempt to confirm and predict our position with respect to other things, it helps to know our position with respect to a standard. This makes it possible for us to coordinate our activities such as working or meeting together at a specific location.

Therefore, when we speak of a change in TIME we relate that change to a standard. For example, to the average individual one day is generally referred to as the Sun appearing at the eastern horizon, changing position with respect to us until it sets in the west, and then appearing at the eastern horizon again. With this definition, we are able to plan our activities with respect to the Sun. We can get out of bed when the Sun rises in the east, eat lunch when it is over head, and go to sleep when it sets in the west. By this standard we all experience one day as measured by the Sun. However, on an individual basis, not all objects are in the same position or experience the same local changes in position. Therefore, although a change in TIME is equal to or corresponds to a change in position, each object can experience a unique local change in position that can be measured with respect to a standard.

In the previous example we used a day as a standard of time. We now consider using light as a standard of time. In doing so we first establish "the standard location" as presented in Definition 10. We will use the subscript, s, to identify properties at this location.

Definition 10 ***<u>The standard location</u>*** *is a place on the Earth, in a vacuum, where we define the units of time, length, and matter. The scientific community could define this to be the location of the current time standard for the United States and the Global Positioning System located at the U.S. Naval Observatory in Washington D.C.*

In this context we apply the meaning presented in Definition 11 to the word vacuum.

Definition 11 *A* ***<u>vacuum</u>*** *is a volume of space where there are no particles or electromagnetic waves.*

It is not possible to find a location on Earth where the properties in a vacuum are constant. The dynamics of the solar system and space prohibit a constant state of conditions. The Earth is also dynamic with a significant amount of geological activity that can alter local gravitational fields. However, it should be possible to find a location on the Earth where all of these influences, as a function of TIME, are small enough to neglect for most of our needs. The importance of this location will become obvious as we develop the methods presented in this book.

In 1967, the 13th General Conference on Weights and Measures defined the second based on the cesium clock as "the duration of $9\,192\,631\,770$ periods of the radiation corresponding to the transition between two hyperfine levels of the ground state of the cesium 133 atom." We adopt a similar method here and define two separate units of Time, a "meter of Time" and a "second of Time," in terms of light as follows:

Definition 12 ***<u>One second of Time</u>*** *is equal to a change in TIME corresponding to a change in position of light equivalent to the separation in position, in a vacuum, of the first and last waves of a continuous band of* $9\,192\,631\,770$ *waves of the radiation corresponding to the transition between two hyperfine levels of the ground state of the cesium 133 atom at the standard location.*

Definition 13 ***<u>One meter of Time</u>*** *is equal to* $\dfrac{1}{299\,792\,458}$ *seconds of Time. In general, the second should be used as the standard unit of time.*

Thus, we can define time in terms of light.

2.3 Length, A Separation In Position

Length is a simple concept to understand. It defines the separation between two points or positions. Therefore, we may conclude that length is a characteristic of TIME as presented in Definition 9.

In October of 1983, the international standard of length was defined in terms of the speed of light as the distance light travels in $\frac{1}{299\,792\,458}$ second. We use a different method here and define two separate units of length, a “meter of length” and a “second of length,” in terms of light as follows:

Definition 14 ***One second of length*** *is equal to a separation in TIME equivalent to the separation in position, in a vacuum, of the first and last waves of a continuous band of* $9\,192\,631\,770$ *waves of the radiation corresponding to the transition between two hyperfine levels of the ground state of the cesium 133 atom at the standard location.*

Definition 15 ***One meter of length*** *is equal to* $\frac{1}{299\,792\,458}$ *seconds of length. In general, the meter should be used as the standard unit of length.*

Thus, length is a characteristic of TIME and can be defined in terms of light.

2.4 Matter, The Substance Of Existence

We can think of matter as the stuff things are made of. In this context, matter encompasses all that exists including space, energy, and even human thought. Hence, we define matter as presented in Definition 16 along with its companion, Postulate 2.

Definition 16 ***Matter*** *is the substance of existence.*

Postulate 2 *It is not possible to create or destroy matter.*

Postulate 2 is an essential part of our foundation in deriving equations to represent the laws of nature. It means that if we add to or take away from the matter associated with an object it must come from or go to somewhere else. As such this postulate is fundamental to our definitions of momentum and energy that we develop in Section 2.4.2.

In our effort to define a standard unit of matter, we also define velocity as presented in Definition 17.

Definition 17 *The* ***velocity****,* $\vec{\mathbf{v}}$*, of an object is equal to the change in position of the object in meters, divided by the corresponding magnitude of the change in position of light at the standard location in seconds.*

We can express this mathematically as follows:

$$\vec{\mathbf{v}} = \frac{d\vec{\mathrm{x}}}{dt} = \operatorname*{limit}_{t \to 0} \frac{\vec{\mathrm{x}}}{t} \tag{2-1}$$

Where:

$\vec{\mathrm{x}}$ = the change in position of the object in units of meters (vector).

t = the magnitude of the change in the position of light at the standard location in units of seconds (scalar).

Hence, based on our convention, velocity is a vector with units of m/s.

2.4.1 The Speed of light at the standard location

We can combine equation (2-1) with Definition 13 to calculate the velocity of light, c_s, at the standard location. We recognize that at the standard location, light is the standard. Therefore, the change in the position of light is equal to a change in position of the standard. Hence:

$$c_s = \left. \frac{\text{change in position of light}_{\text{ in units of meters}}}{\text{change in position of light}_{\text{ in units of seconds}}} \right|_{\text{at the standard location}}$$

$$c_s = 299\,792\,458.0 \frac{\mathrm{m}}{\mathrm{s}}$$

This is the speed of light at the standard location. We shall also refer to this value as "the standard speed of light."

2.4.2 The Relationship Between Matter And Energy

Our goal here is to gain an understanding of what we mean by the word, energy, and how energy is a form of matter as required by Definition 16. To this end, let us consider what happens when light passes through a medium where the speed of light is a variable as illustrated in Figure 3.

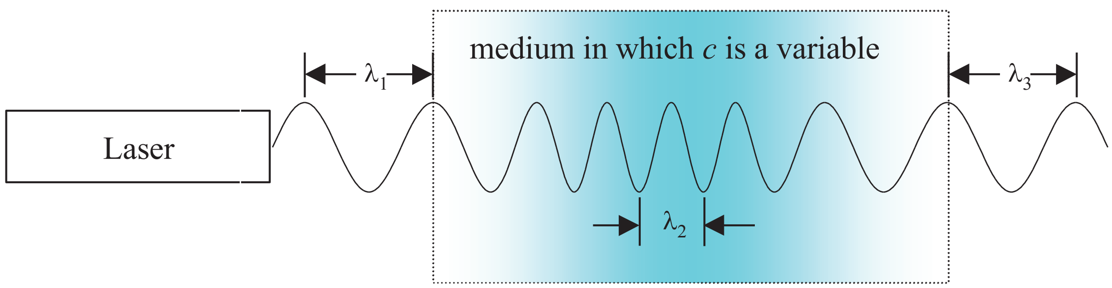


Figure 3 This represents an electromagnetic wave passing through a medium with properties that cause the speed of light to be a function of position.

We assume, based on our understanding of light, that we can verify the following conclusions by experiment.

- The wavelength and speed of light at the locations of λ_1 and λ_3 are the same.
- The wavelength and speed of light at the location of λ_2 are less than the wavelength and speed of light at the locations of λ_1 and λ_3.
- The frequency of the light does not change when it moves from the location of λ_1 to the location of λ_2 and on to the location of λ_3.
- A photon at the location of λ_3 possesses the same amount of energy and momentum as it did at the location of λ_1.
- Based on Definition 16 and Postulate 2 we conclude that photons at the location of λ_2 possess the same amount of matter as they do at the locations of λ_1 and λ_3.

Our definitions and postulates of momentum and energy must be compatible with these observations if they are to be valid for light. The reader can verify that the following definitions and postulates meet this requirement.

Definition 18 *The **momentum**, $\vec{\mathbf{p}}$, of an object is a vector that is equal to the product of its matter, m, the standard speed of light, c_s, and $\vec{\boldsymbol{\beta}}$ (the ratio of velocity with the local speed of light). This is expressed mathematically as $\vec{\mathbf{p}} = m\vec{\boldsymbol{\beta}}c_s$ where $\vec{\boldsymbol{\beta}} = \frac{\vec{\mathbf{v}}}{c}$.*

Therefore:

$$d\vec{\mathbf{p}} = \vec{\boldsymbol{\beta}}c_s dm + mc_s d\vec{\boldsymbol{\beta}} \tag{2-2}$$

For the special case where c is equal to c_s, the equation $\vec{\mathbf{p}} = m\vec{\boldsymbol{\beta}}c_s$ is equivalent to the familiar form of:

$$\vec{\mathbf{p}} = m\vec{\mathbf{v}}$$

Definition 19 ***Force** is a vector that we can define with Newton's second law of motion stated as "The summation of forces is equal to the rate of creation of momentum." expressed in equation form as $\sum \vec{\mathbf{F}} = \frac{d\vec{\mathbf{p}}}{dt}$.*

Definition 20 *The **energy** added to an object by a force, $\vec{\mathbf{F}}$, is equal to the vector dot product of the force and the change in the object's position vector, $\vec{\mathbf{r}}$, multiplied by $\frac{c_s}{c}$ and stated mathematically as $E = \int \vec{\mathbf{F}} \bullet d\vec{\mathbf{r}} \frac{c_s}{c}$*

For a simplified one dimensional problem we can write this as:

$$dE = Fdr\frac{c_s}{c} \tag{2-3}$$

For the special case where $c = c_s$ this equation is equivalent to the familiar form of:

$$dE = Fdr$$

Postulate 3 *The speed of light, c, is a function of the properties of space as defined by Maxwell's equations, and therefore independent of any force acting upon it.*

Postulate 4 *The energy, E, of a single photon is inversely proportional to its wavelength, λ, according to Albert Einstein's photon concept as* $E = hf = \frac{hc}{\lambda}$.

In Postulate 4 we change Plank's constant from an experimentally derived value to an exact number as presented in Definition 21. This change is necessary to allow us to define matter in terms of light.

Definition 21 ***Plank's constant***, $h = 6.626\,0693 \times 10^{-34}\,\frac{\mathrm{kg}\cdot\mathrm{m}^2}{\mathrm{s}}$ *exactly.*

We can now use these definitions and postulates to derive the relationship between mass and energy to show that $E = mc_s^2$**.** We simplify this effort with a one-dimensional case as follows:

$$dr = vdt$$

Substituting this into equation (2-3) we obtain:

$$dE = F\frac{v}{c}c_s dt$$

Substituting in the equation, $\vec{\boldsymbol{\beta}} = \frac{\vec{\mathbf{v}}}{c}$, and Definition 19:

$$dE = \frac{dp}{dt}\beta c_s dt$$

Substitute in equation (2-2):

$$dE = \beta c_s\left(\beta c_s dm + mc_s d\beta\right) \tag{2-4}$$

We can solve this equation by evaluating it at a boundary conditions where $v = c$. For example, if we use this equation to calculate the result of a force applied to a photon of light, then based on Postulate 3, β is equal to a constant value of one, and $d\beta$ is equal to zero. Therefore, at this boundary condition, equation (2-4) becomes:

$$dE = c_s^2 dm \qquad \text{(For a photon)}$$

Upon integration we obtain:

$$E = mc_s^2 \tag{2-5}$$

Thus, we have achieved our goal and demonstrated that energy is a scalar property of matter as required by Definition 16.

Now that we have derived $E = mc_s^2$, we can establish a standard unit of matter in terms of light. If we set equation (2-5) equal to Postulate 4, we obtain:

$$mc_s^2 = \frac{hc}{\lambda}$$

$$m = \frac{hc}{\lambda c_s^2} \tag{2-6}$$

It is interesting to note that we can combine this equation with Definition 18 to calculate the momentum of a single photon as follows:

$$p = m\beta c_s = \frac{hc}{\lambda c_s^2}\beta c_s = \frac{hc}{\lambda c_s} \quad \text{(For a photon)} \tag{2-7}$$

By examining the units of equation (2-6) we find that:

$$\text{The units of matter} = \frac{\left(\frac{\text{kg}\cdot\text{m}^2}{\text{s}}\frac{\text{m}}{\text{s}}\right)}{\text{m}\left(\frac{\text{m}}{\text{s}}\right)^2} = \text{kg}$$

Thus, we can define matter in terms of light, and the resulting unit is a kilogram. It follows that one kilogram of matter is equivalent to n_λ photons of light where n_λ is calculated by the inverse of equation (2-6) as:

$$n_\lambda = \frac{\lambda c_s^2}{hc}$$

This enables us to define a standard unit of matter as presented in Definition 22 and completes our second primary objective to develop a standard unit of matter in terms of light.

Definition 22 ***One kilogram*** *of matter is equal to* n_λ *photons of light where* $n_\lambda = \dfrac{\lambda c_s^2}{hc}$.

Where:

λ = the photon wave length in meters.

$c_s = 299\,792\,458.0 \dfrac{\text{m}}{\text{s}}$ (See Section 2.4.1).

c = the local velocity of light .

h = Plank's constant $= 6.626\,0693 \times 10^{-34} \dfrac{\text{kg} \cdot \text{m}^2}{\text{s}}$

Therefore, we can link all the fundamental units of time, length, and matter to light!

2.4.3 The Kinetic Energy Of Motion

We now turn our attention to how an object is changed when we add momentum to it. In the end we will show that this leads to the concept of kinetic energy and the familiar equation of $ke = \dfrac{mv^2}{2}$ for the special case where $v << c$ and $c = c_S$.

In section 2.4.2 we derived the relationship between matter and energy. This provides the foundation for determining the influence of a change in velocity or momentum on the total matter of an object.

From equation (2-4) we have:

$$dE = \beta c_s \left(\beta c_s dm + m c_s d\beta \right)$$

We have also determined (for the boundary condition of v=c) that:

$$dE = c_s^2 dm \qquad \text{(Matter moving at speed of light)}$$

If we assume that this relationship between energy and matter is true in general then we can combine these equations to obtain:

$$c_s^2 dm = c_s^2 \beta^2 dm + m c_s^2 \beta d\beta$$

$$dm = \beta^2 dm + m\beta d\beta$$

$$dm\left(1 - \beta^2\right) = m\beta d\beta$$

$$\frac{dm}{m} = \frac{\beta d\beta}{1-\beta^2} \tag{2-8}$$

We can solve this equation by substitution as follows:

Let:

$$u = 1-\beta^2 \tag{2-9}$$

Then:

$$du = -2\beta d\beta$$

$$\beta d\beta = \frac{-du}{2} \tag{2-10}$$

Substituting equation (2-9) and (2-10) into equation (2-8), we obtain:

$$\frac{dm}{m} = \frac{\beta d\beta}{1-\beta^2} = -\frac{du}{2u}$$

$$\int_{m_1}^{m_2} \frac{dm}{m} = \int_{u_1}^{u_2} -\frac{du}{2u}$$

$$\ln m_2 - \ln m_1 = \frac{1}{2}\left(\ln u_1 - \ln u_2\right)$$

$$\ln \frac{m_2}{m_1} = \ln\left[\left(\frac{u_1}{u_2}\right)^{\frac{1}{2}}\right]$$

Substitute back in the value for *u* as defined by equation (2-9):

$$\frac{m_2}{m_1} = \frac{\sqrt{1-\beta_1^2}}{\sqrt{1-\beta_2^2}}$$

$$m_2 = m_1 \frac{\sqrt{1-\beta_1^2}}{\sqrt{1-\beta_2^2}} \tag{2-11}$$

There is a multitude of experimental evidence to support this equation. This provides further confirmation that energy is a scalar property of matter as defined by equation (2-5).

If we set $\beta_1 = 0$, $\beta_2 = \beta$, $m_1 = m_o$, $m_2 = m$, then equation (2-11) becomes the familiar form generally associated with Albert Einstein's concept of Special Relativity.

$$m = \frac{m_o}{\sqrt{1-\beta^2}} \tag{2-12}$$

$$m_o = m\sqrt{1-\beta^2} \tag{2-13}$$

Where:

m = the total matter of an object.

m_o = the rest matter of an object or the matter that an object would posses when at rest with respect to the medium of space. We shall also refer to this value as mass. However, we will develop a more fundamental definition of mass in section 6.2.

We shall use this convention throughout the remainder of this book.

We have now demonstrated that equation (2-13) is a natural result of the definitions and postulates we have established for time, matter, momentum, force, and energy. Equations (2-5) and (2-13) provide the foundation for our concept of kinetic energy as presented in Definition 23.

Definition 23 ***Kinetic energy*** *is equal to the difference between the total and rest matter of an object multiplied by the square of the standard speed of light.*

In equation form this becomes:

$$ke = c_s^2\left(m - m_o\right) \tag{2-14}$$

Substitute in the value for m_o from equation (2-13):

$$ke = c_s^2\left(m - m\sqrt{1-\beta^2}\right)$$

$$ke = mc_s^2\left(1 - \sqrt{1-\beta^2}\right) \tag{2-15}$$

Therefore, the kinetic energy of an object is a function of its matter, velocity, and the local speed of light. We can also write equation (2-15) as:

$$ke = mc_s^2\left(1-\sqrt{1-\frac{v^2}{c^2}}\right)$$

We can expand this equation with the Binomial Series as:

$$ke = mc_s^2\left(1-\left(1-\frac{v^2}{2c^2}-\frac{v^4}{8c^4}-\cdots\right)\right)$$

$$ke = mc_s^2\left(\frac{v^2}{2c^2}+\frac{v^4}{8c^4}+\cdots\right) \tag{2-16}$$

Hence, at very low velocities:

$$ke = \frac{mv^2}{2}\frac{c_s^2}{c^2};\ \text{for } v << c \tag{2-17}$$

For the special case where c is equal to c_s, equation (2-17) becomes the familiar form of:

$$ke = \frac{mv^2}{2};\ \text{for } v << c \tag{2-18}$$

Thus, we have shown that the definitions and postulates we have established are consistent with the traditional concept of kinetic energy. We have also demonstrated that kinetic energy can be defined in the simple form of Definition 23.

2.5 Light, A Universal Standard For Time, Length, and Matter

We have now achieved our first and second objectives and demonstrated that the characteristics of TIME are essential in describing all that exists.

Our first objective was to define the meaning and characteristics of time. We have achieved this goal by showing that our definition of time is consistent with what we mean when we say the word, time. We have also demonstrated that this definition is easy to use in the laboratory to define a unit of time.

Our second objective was to define a standard unit of matter in terms of light to compliment similar standards for time and length. We have accomplished this goal by defining a unit of matter in terms of the wavelength of light [see equation (2-6)].

In summary, we can use light as a universal standard to define units for time, length, and matter as follows:

TIME TIME is equal to position, which corresponds to where things are. We define the characteristics of TIME as follows:

TIME Past	TIME Past is where you have been and where or the way things were.
TIME Present	TIME Present is where you are and where or the way things are.
TIME Future	TIME Future is where you will be and where or the way things will be.
A change in TIME	A change in TIME (commonly referred to as Time) is equal to or corresponds to a change in position.
A separation in TIME	A separation in TIME (commonly referred to as length) is equal to or corresponds to a separation in position.

Time Time is equal to a change in TIME corresponding to a change in position. We define a unit of time as:

Second: One second of Time is equal to a change in TIME corresponding to a change in position of light equivalent to the separation in position, in a vacuum, of the first and last waves of a continuous band of $9\,192\,631\,770$ waves of the radiation corresponding to the transition between two hyperfine levels of the ground state of the cesium 133 atom at the standard location.

Meter: One meter of Time is equal to $\frac{1}{299\,792\,458}$ seconds of Time. In general, the second should be used as the standard unit of time.

Length Length is equal to a separation in TIME corresponding to a separation in position. We define a unit of length as:

Second: One second of length is equal to a separation in TIME equivalent to the separation in position, in a vacuum, of the first and last waves of a continuous band of $9\,192\,631\,770$ waves of the radiation corresponding to the transition between two hyperfine levels of the ground state of the cesium 133 atom at the standard location.

Meter: One meter of length is equal to $\frac{1}{299\,792\,458}$ seconds of length. In general, the meter should be used as the standard unit of length.

Matter: Matter is the substance of existence. We define a unit of matter as:

Kilogram: One kilogram (kg) of matter is equal to n_λ photons of light where:

$$n_\lambda = \frac{\lambda c_s^2}{hc}$$

λ = the photon wave length in meters.

c_s = the speed of light at the standard location $= 299\,792\,458.0 \frac{\text{m}}{\text{s}}$.

c = the local velocity of light.

$\text{h} = \text{Plank's Constant} = 6.626\,0693 \times 10^{-34} \frac{\text{kg} \cdot \text{m}^2}{\text{s}}$

Section 2.6 presents a possible method of calibrating a secondary standard for use in a laboratory.

2.6 Calibrating A Secondary Standard In Terms Of Light

We have now established a unit of matter based on the wavelength of light. However, a secondary standard is needed for everyday use in the laboratory. One method could be to measure the matter of a free atom of carbon 12 by bouncing a photon off it. In doing so, we could use Newton's second law (see Definition 19) to determine the matter associated with a single atom of carbon 12. We could then use a sample of pure carbon, such as a diamond, as a secondary standard if we could find a way to count the number of atoms in the sample.

If the scientific community can find a way to implement this type of method, then the units of time, length, and matter can all be linked to the wavelength of cesium 133.

3 Rotational Force

In this section we demonstrate that our definitions of momentum and force are consistent with the traditional concept of rotational force. We will also use the resulting equations in our investigation of the natural frequency of matter.

We start by using complex numbers to represent vectors for certain operations as outlined in Reference 6. A vector is defined by a magnitude, $\vec{\mathbf{r}}$, and direction, θ, as presented in Figure 4.

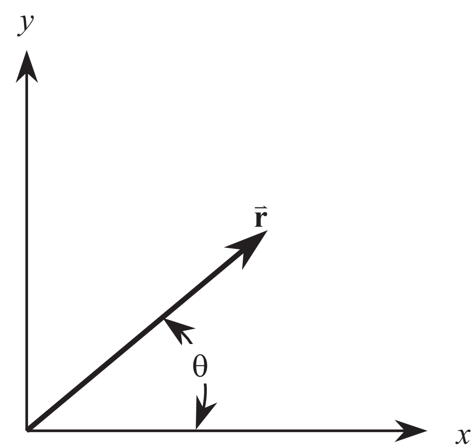


Figure 4 Vector, $\vec{\mathbf{r}}$, defined with magnitude, r, and direction θ.

We can also describe vector $\vec{\mathbf{r}}$ in complex form as:

$$\vec{\mathbf{r}} = re^{j\theta}$$

Where:

$$j^2 = -1 \tag{3-1}$$

$$e^{j\theta} = Cos\theta + jSin\theta$$

$$\text{For, } \theta = \frac{\pi}{2};\ e^{j\theta} = Cos\frac{\pi}{2} + jSin\frac{\pi}{2} = j$$

$$j = e^{\left(j\frac{\pi}{2}\right)}$$

$$je^{j\theta} = e^{\left(j\frac{\pi}{2}\right)}e^{j\theta} = e^{j\left(\theta+\frac{\pi}{2}\right)} \tag{3-2}$$

We can use these equations to calculate $\vec{\mathbf{v}}$ and $\vec{\boldsymbol{\beta}}$ as follows:

$$\vec{\mathbf{v}} = \frac{d\vec{\mathbf{r}}}{dt} = \frac{d\theta}{dt} jre^{j\theta} + \frac{dr}{dt} e^{j\theta}$$

$$\vec{\boldsymbol{\beta}} = \frac{\vec{\mathbf{v}}}{c} = \frac{d\vec{\mathbf{r}}}{cdt} = \frac{d\theta}{cdt} jre^{j\theta} + \frac{dr}{cdt} e^{j\theta} \tag{3-3}$$

Our goal here is to derive an equation that we can use to calculate the force required to support steady state circular motion. If we combine equations (2-2) and Definition 19, we obtain:

$$\sum \vec{\mathbf{F}} = \frac{\vec{\boldsymbol{\beta}} c_s dm + mc_s d\vec{\boldsymbol{\beta}}}{dt}$$

The force required to sustain the circular motion of an object is perpendicular to the velocity of the object. As such, the dot product of the force and motion vectors is equal to zero. Therefore, the force does not do any work on the object. Hence, *dm* is also equal to zero allowing us to simplify this equation as follows.

$$\vec{\mathbf{F}} = \frac{md\vec{\boldsymbol{\beta}} c_s}{dt} \tag{3-4}$$

Hence, we proceed as follows to solve for $\frac{d\vec{\boldsymbol{\beta}}}{dt}$ by starting with equation (3-3).

$$\frac{d\vec{\boldsymbol{\beta}}}{dt} = \frac{d^2\theta}{dt^2} \frac{jre^{j\theta}}{c} - \frac{d\theta}{dt} \frac{dc}{dt} \frac{jre^{j\theta}}{c^2} + \left(\frac{d\theta}{dt}\right)^2 \frac{j^2 re^{j\theta}}{c} + \frac{d\theta}{dt} \frac{dr}{dt} \frac{je^{j\theta}}{c} + \frac{d^2 r}{dt^2} \frac{e^{j\theta}}{c} - \frac{dr}{dt} \frac{dc}{dt} \frac{e^{j\theta}}{c^2} + \frac{d\theta}{dt} \frac{dr}{dt} \frac{je^{j\theta}}{c}$$

$$\frac{d\vec{\boldsymbol{\beta}}}{dt} = \frac{d^2\theta}{dt^2} \frac{jre^{j\theta}}{c} - \frac{d\theta}{dt} \frac{dc}{dt} \frac{jre^{j\theta}}{c^2} + \left(\frac{d\theta}{dt}\right)^2 \frac{j^2 re^{j\theta}}{c} + 2\frac{d\theta}{dt} \frac{dr}{dt} \frac{je^{j\theta}}{c} + \frac{d^2 r}{dt^2} \frac{e^{j\theta}}{c} - \frac{dr}{dt} \frac{dc}{dt} \frac{e^{j\theta}}{c^2} \tag{3-5}$$

Substitute equations (3-1) and (3-2) into (3-5):

$$\frac{d\vec{\beta}}{dt}=\frac{d^2\theta}{dt^2}\frac{re^{j\left(\theta+\frac{\pi}{2}\right)}}{c}-\frac{d\theta}{dt}\frac{dc}{dt}\frac{re^{j\left(\theta+\frac{\pi}{2}\right)}}{c^2}-\left(\frac{d\theta}{dt}\right)^2\frac{re^{j\theta}}{c}+2\frac{d\theta}{dt}\frac{dr}{dt}\frac{e^{j\left(\theta+\frac{\pi}{2}\right)}}{c}+\frac{d^2r}{dt^2}\frac{e^{j\theta}}{c}-\frac{dr}{dt}\frac{dc}{dt}\frac{e^{j\theta}}{c^2}$$

For steady state circular motion in a constant *c* environment, we know that:

$$\frac{d^2\theta}{dt^2}=\frac{dr}{dt}=\frac{d^2r}{dt^2}=\frac{dc}{dt}=0$$

Hence, it follows that we can simplify our equation for circular motion as:

$$\frac{d\vec{\beta}}{dt}=-\left(\frac{d\theta}{dt}\right)^2\frac{re^{j\theta}}{c}$$

$$\frac{d\vec{\beta}}{dt}=-\left(\frac{rd\theta}{cdt}\right)^2\frac{ce^{j\theta}}{r} \tag{3-6}$$

Now let us take another look at equation (3-3) and limit it to circular motion as follows:

$$\vec{\beta}=\frac{d\theta}{cdt}jre^{j\theta}$$

In scalar form we have:

$$\beta=\frac{rd\theta}{cdt}$$

If we substitute this into equation (3-6), we obtain:

$$\frac{d\vec{\beta}}{dt}=-\frac{c\beta^2}{r}e^{j\theta} \tag{3-7}$$

In scalar form equation (3-7) becomes:

$$\frac{d\beta}{dt}=\frac{c\beta^2}{r} \tag{3-8}$$

Finally, if we substitute this into equation (3-4) we obtain:

$$F = \frac{m\beta^2 c_s c}{r} = \frac{m^2 \beta^2 c_s^2 c}{mc_s r} = \frac{p_i^2}{mr}\frac{c}{c_s} \tag{3-9}$$

Where:

$p_i = m\beta c_s$ which we refer to as the momentum of interaction.

For the special case when $c = c_s$ this equation reduces to the familiar form of:

$$F = \frac{mv^2}{r} \tag{3-10}$$

Thus, we see that our definitions of force and momentum are consistent with the traditional concept of rotational force.

4 Gravity

We will now investigate three methods by which we can change the velocity of an object. This will lead to a concept that the speed of light near a governing body is a function of position (see Section 4.1) causing a corresponding variation in the rest matter of an object (see Section 5.1). The result is a concept of gravitational force under static conditions (see Section 4.1) and the ability to calculate the path of an object based on its wave characteristics as presented in Section 7.

The three methods by which we can change the velocity of an object are as follows:

1. Change the total matter of the object in such a way that the ratio of the total to rest matter of the object is also changed.
2. Change the speed of light.
3. Change the rest matter of the object in such a way that the ratio of the total to rest matter of the object is also changed.

The first two methods are an inherent result of the meaning we have applied to momentum as presented in Definition 18. Therefore, we will leave the exercise of proving this up to the reader.

We will now investigate the third method. Let us suppose that a location in space exists where the rest matter of an object is a function of position. From equation (2-12) we have determined that:

$$m = \frac{m_o}{\sqrt{1-\beta^2}}$$

In this equation, m represents the total matter of the object, and m_o represents the matter of the object at rest or under static conditions. We can also write this equation as:

$$\left(\frac{m_o}{m}\right)^2 + \beta^2 = 1 \tag{4-1}$$

This equation defines a circle with a radius of one as presented in Figure 5.

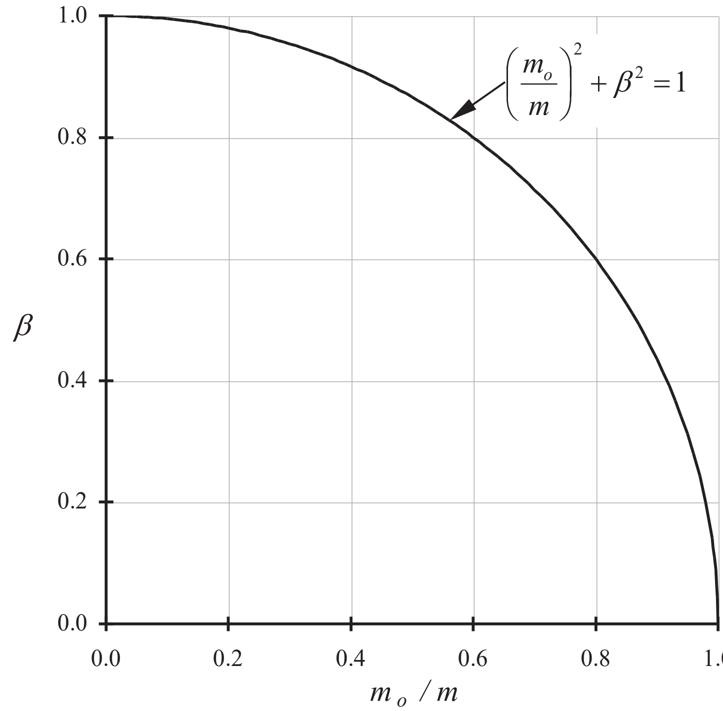


Figure 5 Variation in the ratio of the rest to total matter of a object as a function of *β*. As the velocity of an object is increased ($\beta \to 1$) the ratio of the rest to total matter of the object is decreased $\frac{m_o}{m} \to 0$.

We can rearrange this equation to determine the velocity of an object as a function of its total to rest matter as follows:

$$\frac{v}{c} = \beta = \sqrt{1 - \left(\frac{m_o}{m}\right)^2}$$

$$v = c\sqrt{1 - \left(\frac{m_o}{m}\right)^2} \tag{4-2}$$

By examining equation (4-2) and Figure 5, we confirm that the three methods by which we can change the velocity of an object are:

- Change the <u>total</u> matter of the object in such a way that the ratio of the total to rest matter of the object is also changed.

- Change the speed of light.
- Change the rest matter of the object in such a way that the ratio of the total to rest matter of the object is also changed.

Therefore, if rest matter is a function of position, then an object, independent of external force, will experience a change in velocity, or in other words, it will accelerate. We also recognize that this type of acceleration results from a change in the ratio of rest to total matter of the object without energy addition. We will demonstrate the validity of this concept in the following section.

4.1 Gravitational Force Caused By A Gradient In The Speed Of Light

Our goal here is to solve for the influence of a governing body on the speed of light. We will also show that the force required to counteract a gravitational field can be equated to the influence of a variation in the speed of light on the rest matter of an object.

In Section 5 equation (5-10), we establish that the rest matter of an object is a function of the local velocity of light. Therefore, a variation in the speed of light with position would cause an object that possesses rest matter to accelerate in the absence of an external force as outlined in the previous section.

Let us investigate this type of influence and then equate it to a gravitational system to determine how the velocity of light varies with distance from a governing body. We base this approach on the following postulate.

Postulate 5 *A body of matter distorts the medium of space causing the speed of light to be a function of position. Gravity is the influence of this gradient on matter.*

From Definition 20 we have established that:

$$dE = Fdr\frac{c_s}{c}$$

Rearranging this equation we see that a force caused by a change in energy with position must be scaled by the ratio of the local velocity of light with the standard value as follows:

$$F = \frac{c}{c_s}\frac{dE}{dr} \tag{4-3}$$

Newton postulated that the force of gravity could be expressed as:

$$F = \frac{mMG}{r^2} \tag{4-4}$$

However, based on the work presented in Section 2.4 and equation (4-3) it is reasonable to postulate that Newton's law of gravity must be modified by the ratio of the local velocity of light with the standard value. We also know that Newton's law of gravity has been verified within experimental accuracy in the laboratory under static conditions. Hence, in our effort to determine the variation in the speed of light with respect to position we modify Newton's law of gravity as presented by the following postulate.

Postulate 6 *The gravitational force of attraction between two objects under static conditions can be calculated as* $F = \frac{m_o MG}{r^2}\frac{c}{c_s}$. *We will refer to this as corrected gravity to distinguish it from Newton's law of gravity.*

We demonstrate in Section 9 that this postulate, when combined with the equations presented in this book, provides the correct results in contrast to Newton's original expression which does not.

We emphasize again that Newton's Law of Gravity has been verified within experimental accuracy in the laboratory under static conditions. In this book we apply it to a static condition only as modified in Postulate 6. It is not valid for a dynamic system such as planetary motion or light propagation. We will not use it for this purpose. Instead, we will develop equations for motion in a gravitational field based on wave propagation as outlined in Section 7.

We can combine equations (4-3) and Postulate 6 to obtain:

$$\frac{dE}{dr} = \frac{m_o MG}{r^2} \tag{4-5}$$

Our primary goal here is to calculate the speed of light as a function of position with respect to a governing body. Therefore, let us evaluate equation (4-5) based on Postulate 5 and the following assumptions.

Assumptions:

1. We evaluate equation (4-5) with respect to an object that is lowered very slowly in a gravitational field such that the influence of velocity is negligible.
2. The energy, dE, extracted from the system comes from the total matter of the object, m_o. As such, the total matter of M remains unchanged. This is reasonable for the case where m_o is much less than M, such as a child taking a toy off a shelf and placing it on the floor. The energy extracted from the toy-Earth system comes primarily from the toy.

From equation (2-5) we have:

$$dE = c_s^2 dm_o$$

By substituting this into equation (4-5) we obtain:

$$\frac{c_s^2 dm_o}{dr} = \frac{m_o MG}{r^2} \tag{4-6}$$

In order to integrate this equation we need to know how rest matter varies with the speed of light. In Section 5 equation (5-10), we show that the rest matter of an object is a function of the local velocity of light as follows:

$$m_o = m_{os}\sqrt{\frac{c}{c_s}}$$

As a reminder, m_{os} is the rest matter the object would possess if placed at the standard location where the speed of light is equal to c_s as outlined in Definition 10.

$$m_o c^{-1/2} = m_{os} c_s^{-1/2}$$

By convention m_{os} and c_s are standard values and are not variables. Therefore, when we take the derivative of this equation we obtain the following:

$$dm_o c^{-1/2} + \frac{-m_o c^{-1.5} dc}{2} = 0$$

$$dm_o = \frac{m_o dc}{2c} \tag{4-7}$$

We can substitute equation (4-7) into (4-6) to obtain:

$$\frac{c_s^2 \dfrac{m_o dc}{2c}}{dr} = \frac{m_o MG}{r^2}$$

$$\frac{dc}{c} = \frac{2MG}{c_s^2 r^2} dr \tag{4-8}$$

$$\int_{c_1}^{c_2} \frac{dc}{c} = \int_{r_1}^{r_2} \frac{2MG}{c_s^2 r^2} dr$$

$$\ln c_2 - \ln c_1 = \frac{2MG}{c_s^2}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$\ln\left(\frac{c_2}{c_1}\right) = \frac{2MG}{c_s^2}\left(\frac{r_2 - r_1}{r_1 r_2}\right) \tag{4-9}$$

$$c_2 = c_1\, e^{\left(\frac{2MG}{c_s^2}\left(\frac{r_2 - r_1}{r_1 r_2}\right)\right)} \tag{4-10}$$

If we set $c_1 = c_\infty$ for $r_1 = r_\infty$ this equation becomes:

$$c = c_\infty\, e^{\left(\frac{-2MG}{c_s^2 r}\right)} \tag{4-11}$$

Based on equation (4-10), the velocity of light is a function of position with respect to a body of matter such that it increases with distance from the body. We shall see later that $(c_1 - c_2)$ is an important value in determining β. Therefore, it is desirable to reduce numerical truncation errors when calculating values of (c_1 - c_2). We can achieve this goal with equation (4-10) as follows:

$$c_1 - c_2 = c_1\left(1 - e^{\left(\frac{2MG}{c_s^2}\left(\frac{r_2 - r_1}{r_1 r_2}\right)\right)}\right) \tag{4-12}$$

Let: $$\phi = \frac{2MG}{c_s^2}\left(\frac{r_2 - r_1}{r_1 r_2}\right)$$

Substitute this into equation (4-12):

$$c_1 - c_2 = c_1\left(1 - e^{\phi}\right) \tag{4-13}$$

We can approximate this equation numerically with the following series:

$$c_1 - c_2 = c_1\left(-\frac{\phi}{1!} - \frac{\phi^2}{2!} - \frac{\phi^3}{3!} - \cdots\right) \tag{4-14}$$

We can minimize numerical truncation errors by using equation (4-14) for values of ϕ that approach zero and equation (4-13) for values of ϕ that are much less than zero.

We will show later that equation (4-10) in the form of (4-14) provides an accurate description of data (see Section 7). Therefore, the assumptions used to arrive at this result appear to be valid.

We have now demonstrated how a governing body influences the speed of light. We have also shown that the force required to counteract a gravitational field can be equated to the influence of a variation in the speed of light on the rest matter of an object in agreement with Postulate 5.

4.1.1 Calculation Of β From c For An Object Along Its Path Of Motion

Our objective here is to rearrange the equations we have derived into a form that we can use to calculate β for an object at any location along its path of motion. In this section, we will assume that the total matter of the object is constant along the path of motion.

If we know β at one point in space we can calculate it at all points in space if we know the speed of light as a function of position as follows:

From equation (2-13) we calculate β as:

$$\beta^2 = 1 - \left(\frac{m_o}{m}\right)^2 \tag{4-15}$$

Therefore, at our starting point we know the following:

$$\beta_1^2 = 1 - \left(\frac{m_{o_1}}{m}\right)^2$$

$$m_{o_1} = m\sqrt{1-\beta_1^2} \tag{4-16}$$

From equation (5-10) we also know that:

$$m_o = m_{o_1}\sqrt{\frac{c}{c_1}} \tag{4-17}$$

Substitute equation (4-16) into (4-17) and the result into (4-15)

$$\beta^2 = 1 - \left(\frac{m\sqrt{1-\beta_1^2}\sqrt{\frac{c}{c_1}}}{m}\right)^2$$

$$\beta^2 = 1 - \frac{c}{c_1}\left(1-\beta_1^2\right)$$

$$\beta = \sqrt{\frac{c_1 - c + c\beta_1^2}{c_1}} \tag{4-18}$$

Therefore, we see that if the total matter of an object is constant, β is a pure function of the local velocity of light. We have also formulated Equation (4-18) to minimize numerical truncation errors.

5 Matter And The Speed Of Light

We now investigate the natural frequency of an atom through concepts developed by Bohr combined with the wave characteristics of matter. This approach will lead us to the relationship between the speed of light and some fundamental properties of matter. In particular we will see that the rest matter and charge of matter is proportional to the square root of the speed of light. We will also achieve our third primary objective by explaining why motion and gravity influence the natural frequency of matter.

5.1 The Dependence Of Rest Matter And Charge On The Speed Of Light

We can use Maxwell's equations to calculate the speed of light in terms of the permittivity and permeability of space as:

$$c = \frac{1}{\sqrt{\mu\varepsilon}} \tag{5-1}$$

Based on this equation, a change in the speed of light must be caused by a change in μ or ε. Hence, we propose the following postulate to enable us to proceed with our derivation.

Postulate 7 *The ratio of the permittivity of space to the permeability of space in a vacuum is constant and independent of position.*

We can use Maxwell's equations to calculate the speed of light at the "standard location" described in Definition 10 as:

$$c_s = \frac{1}{\sqrt{\mu_s \varepsilon_s}}$$

$$c_s \frac{c}{c_s} = c = \frac{1}{\sqrt{\mu_s \varepsilon_s}} \frac{c}{c_s}$$

$$c = \frac{1}{\sqrt{\mu_s \frac{c_s}{c} \varepsilon_s \frac{c_s}{c}}}$$

If we compare this with equation (5-1) and hold Postulate 7 to be true, it follows that:

$$\varepsilon = \frac{\varepsilon_s c_s}{c} \tag{5-2}$$

$$\mu = \frac{\mu_s c_s}{c} \tag{5-3}$$

We still do not know the relationship between the speed of light, charge, and rest matter. However, it is reasonable to assume that the charge of an electron or proton is an inherent property of its structure. Therefore, we establish the following postulate.

Postulate 8 *The ratio of the rest matter to charge of an electron is constant or independent of location. The ratio of rest matter to charge of a proton is also constant.*

Based on Postulate 8 and equations (5-2) and (5-3) it is reasonable to assume that the charge and rest matter of an object are also functions of the speed of light as follows:

$$e = e_s \left(\frac{c_s}{c} \right)^x \tag{5-4}$$

$$m_o = m_{os} \left(\frac{c_s}{c} \right)^x \tag{5-5}$$

As a reminder, m_{os} is the rest matter the object would possess if placed at the standard location where the speed of light is equal to c_s as outlined in Definition 10.

Substitute equation (5-5) into (2-12) to obtain:

$$m = \frac{m_o}{\sqrt{1-\beta^2}} = \frac{m_{os}}{\sqrt{1-\beta^2}} \left(\frac{c_s}{c} \right)^x \tag{5-6}$$

An atom can exist at rest with its electrons in various energy states. Therefore, for this type of condition the transition energy of an electron is part of the rest matter of the atom.

It follows that the transition energy of an atom must vary in the same manner as the rest matter of the atom. Therefore:

$$E_t = E_{ts}\left(\frac{c_s}{c}\right)^x \tag{5-7}$$

We can now solve for the relationship of the speed of light to the rest matter and charge of an atom by using equation (5-23) as derived in section 5.4.

Substitute equations (5-2), (5-4), (5-6), and (5-7) into (5-23):

$$E_{ts}\left(\frac{c_s}{c}\right)^x = \frac{-Z^2\left(e_s\left(\frac{c_s}{c}\right)^x\right)^4 \frac{m_{os}}{\sqrt{1-\beta^2}}\left(\frac{c_s}{c}\right)^x\left(1-\beta^2\right)}{8\left(\frac{\varepsilon_s c_s}{c}\right)^2 n^2 h^2}\left(\frac{c_s}{c}\right)^4$$

$$E_{ts}\left(\frac{c_s}{c}\right)^x = \frac{-Z^2 e_s^4 m_{os}\sqrt{1-\beta^2}}{8\varepsilon_s^2 n^2 h^2}\left(\frac{c_s}{c}\right)^{(5x+2)} \tag{5-8}$$

For the special case where c is equal to c_s we obtain the standard energy of transition as:

$$E_{ts} = \frac{-Z^2 e_s^4 m_{os}\sqrt{1-\beta^2}}{8\varepsilon_s^2 n^2 h^2}$$

If we substitute this back into equation (5-8) we obtain:

$$\left(\frac{c_s}{c}\right)^x = \left(\frac{c_s}{c}\right)^{(5x+2)}$$

$$x = 5x + 2$$

$$x = -\frac{1}{2}$$

Hence, equations (5-4), (5-5), (5-6), and (5-7) become:

$$e = e_s \sqrt{\frac{c}{c_s}} \tag{5-9}$$

$$m_o = m_{os} \sqrt{\frac{c}{c_s}} \tag{5-10}$$

$$m = m_{os} \sqrt{\frac{c}{c_s\left(1-\beta^2\right)}} \tag{5-11}$$

$$E_t = E_{ts} \sqrt{\frac{c}{c_s}} \tag{5-12}$$

Therefore, we have now demonstrated that the rest matter and charge of matter is a function of the square root of the speed of light.

5.2 Atomic Transition Energy

In our effort to derive an equation for the natural frequency of an atom we start with the assumption that the energy emitted from an atom comes from a reduction in the total matter of the atom. This makes it possible for us to calculate the maximum energy of transition when an atomic nucleus captures an electron. We have established through equation (2-3) that:

$$dE = Fdr\frac{c_s}{c} \tag{5-13}$$

Coulomb's law states that the force of interaction between an atomic nucleus and a single electron can be calculated as:

$$F = \frac{Ze^2}{4\pi \varepsilon r^2} \tag{5-14}$$

Where:

Z = the atomic number of the atom.

e = the charge of an electron.

ε = the permittivity constant of space.

r = the distance of the electron from the atomic nucleus.

As a companion to Postulate 5 we establish the following:

Postulate 9 *The charge of an object distorts the medium of space. The interaction of these distortions causes the force of charge attraction or repulsion.*

We do not associate this type of distortion with a variation in the speed of light. We simply assume that it is a different type of influence.

The characteristic velocity of the medium of space is equal to the speed of light. Therefore, when we set a particle in motion, such as an atom, the distance of interaction, r_i, between the nucleus and electron increases as described in section 6 with equation (6-33) by the amount:

$$r_i = \frac{r}{\sqrt{1-\beta^2}} \tag{5-15}$$

Where:

r = the maximum distance of separation perpendicular to the path of motion.
r_i = the distance of interaction.

The distance of interaction is equal to 1/2 the distance required for an electromagnetic wave to travel through the medium of space from the center of the electron charge to the center of the nucleus charge and back to the center of the electron charge again. Therefore, if the force of charge interaction is a function of this distance we must modify equation (5-14) as presented in Postulate 10.

Postulate 10   The force of interaction between an atomic nucleus and a single electron can be calculated as: $F = \dfrac{Ze^2}{4\pi\varepsilon r_i^2}$

If we combine equation (5-13) with Postulate 10, we obtain:

$$dE = \frac{Ze^2 c_s}{4\pi\varepsilon r_i^2 c} dr$$

Upon integration, for conditions where c, ε, and e are constants, we obtain:

$$E = \frac{Ze^2 c_s}{4\pi\varepsilon c}\left(\frac{1}{-r_{i_2}} - \frac{1}{-r_{i_1}}\right) \tag{5-16}$$

If we set r_{i_1} = infinity and r_{i_2}=r_i we can calculate the maximum energy of transition as:

$$E_{t\,\mathrm{max}} = -\frac{Ze^2 c_s}{4\pi\varepsilon r_i c} \tag{5-17}$$

This is the maximum possible energy that can be released when an electron is moved closer to an atomic nucleus. The negative sign indicates that the electron-nucleus system releases the energy of transition into its surroundings.

5.3 The Electron-Nucleus Wavelength Of Interaction

Niels Bohr postulated that an electron orbited the nucleus of the atom without emitting radiation and could only occupy orbits corresponding to specific values of angular momentum. With the advent of wave mechanics it was discovered that these values correspond to integral wavelengths of the electron. We shall carry this concept a little further with the following postulate.

Postulate 11   An electron-atomic nucleus system is stable when its structure corresponds to integer values of the wavelength of interaction.

We now solve for the radius of interaction corresponding to a circular waveform. We shall use the simple concept that is prevalent in textbooks showing a circular standing wave. It should be possible for a skilled mathematician to obtain the equivalent solution with the Schrödinger wave equation.

Based on Postulate 11 the circumference of electron cloud or orbit is equal to the wavelength of interaction. Therefore, for a circular waveform we obtain the following:

$$2\pi r_i = n\lambda_i$$

$$r_i = \frac{n\lambda_i}{2\pi} \tag{5-18}$$

Where:

λ_i = the wavelength of interaction between the electron and the atomic nucleus.

n = an integer representing the number of wavelengths.

Based on equations (6-14) and (6-33) we can calculate the wavelength of interaction between the electron and the atomic nucleus as:

$$\lambda_i = \frac{ch}{p_i c_s \sqrt{1-\beta^2}} \tag{5-19}$$

Where:

p_i = the momentum of interaction between the electron and nucleus and β corresponds to the motion of the atom.

Substitute equation (5-19) into (5-18):

$$r_i = \frac{nch}{2\pi p_i c_s \sqrt{1-\beta^2}}$$

$$r_i^2 = \frac{n^2 c^2 h^2}{4\pi^2 p_i^2 c_s^2 \left(1-\beta^2\right)} \tag{5-20}$$

Substitute equation (5-20) into equation (5-14) which represents the force of attraction between the nucleus and the electron.

$$F = \frac{Ze^2}{4\pi\varepsilon \dfrac{n^2c^2h^2}{4\pi^2 p_i^2 c_s^2\left(1-\beta^2\right)}}$$

$$F = \frac{Ze^2 \pi p_i^2 c_s^2\left(1-\beta^2\right)}{n^2c^2h^2\varepsilon} \tag{5-21}$$

Set equation (5-21) equal to equation (3-9) which represents the force associated with circular motion:

$$\frac{Ze^2 \pi p_i^2 c_s^2\left(1-\beta^2\right)}{n^2c^2h^2\varepsilon} = \frac{p_i^2 c}{m r_i c_s}$$

$$r_i = \left(\frac{n^2h^2\varepsilon}{Ze^2\pi\, m\left(1-\beta^2\right)}\right)\left(\frac{c}{c_s}\right)^3 \tag{5-22}$$

This yields the radius of interaction between an electron and an atomic nucleus. Hence, we can calculate the radius of interaction if we can first discover the relationship between each of the variables in equation (5-22) and the speed of light.

5.4 The Natural Frequency Of An Atom

Based on Postulate 4 and equation (5-17), the natural frequency of an atom is a function of the transition energy of the electron from one state to another. In order to determine how much energy is released from the atom, we must first know how much energy is stored in the momentum of interaction.

We draw upon Postulate 10 for charge attraction, and equation (3-9) for the force associated with circular motion to obtain:

$$F = \frac{Ze^2}{4\pi\varepsilon r_i^2} = \frac{m\beta^2 c_s c}{r_i}$$

$$\frac{Ze^2}{8\pi\varepsilon r_i} = \frac{m}{2}\frac{v^2}{c^2}c_s c$$

$$\frac{Ze^2}{8\pi\varepsilon r_i}\frac{c_s}{c} = \frac{mv^2}{2}\frac{c_s^2}{c^2}$$

By comparing this with equations (2-17) and (5-17) we see that the rotational energy is approximately equal to 1/2 the total energy of charge attraction for a given radius of interaction. Hence, for a circular energy state the energy of transition from infinity to that radius is also approximately equal to:

$$E_t = -\frac{1}{2}\frac{Ze^2 c_s}{4\pi\varepsilon r_i c}$$

Substitute in equation (5-22) for r_i:

$$E_t = \frac{-Ze^2}{8\pi\varepsilon\left(\frac{n^2h^2\varepsilon}{Ze^2\pi\, m\left(1-\beta^2\right)}\right)\left(\frac{c}{c_s}\right)^3}\left(\frac{c_s}{c}\right)$$

$$E_t = \frac{-Z^2e^4m\left(1-\beta^2\right)}{8\varepsilon^2n^2h^2}\left(\frac{c_s}{c}\right)^4 \tag{5-23}$$

If we substitute equations (5-2), (5-9), and (5-11) as derived in section 5.1 into equation (5-23), we obtain:

$$E_t = \frac{Z^2\left(e_s\sqrt{\frac{c}{c_s}}\right)^4\left(m_{os}\sqrt{\frac{c}{c_s\left(1-\beta^2\right)}}\right)\left(1-\beta^2\right)}{8\left(\frac{\varepsilon_s c_s}{c}\right)^2 n^2h^2}\left(\frac{c_s}{c}\right)^4$$

$$E_t = \frac{Z^2 e_s^4 m_{os}}{8\varepsilon_s^2 n^2 h^2} \sqrt{\frac{c\left(1-\beta^2\right)}{c_s}} \tag{5-24}$$

The transition energy departs the atom as a photon. Therefore, based on Albert Einstein's photon concept of light (see Postulate 4):

$$E_t = hf$$

$$f = \frac{E_t}{h} \tag{5-25}$$

Substitute equation (5-24) into (5-25)

$$f = \frac{Z^2 e_s^4 m_o}{8\varepsilon_s^2 n^2 h^3} \sqrt{\frac{c\left(1-\beta^2\right)}{c_s}} \tag{5-26}$$

The standard frequency, f_{os}, ($\beta = 0,\ c = c_s$) for the atom is calculated as:

$$f_{os} = \frac{Z^2 e_s^4 m_o}{8\varepsilon_s^2 n^2 h^3}$$

Thus:

$$\frac{f}{f_{os}} = \frac{\dfrac{Z^2 e_s^4 m_o}{8\varepsilon_s^2 n^2 h^3} \sqrt{\dfrac{c\left(1-\beta^2\right)}{c_s}}}{\dfrac{Z^2 e^4 m_o}{8\varepsilon_s^2 n^2 h^3}}$$

$$f = f_{os} \sqrt{\frac{c\left(1-\beta^2\right)}{c_s}} \tag{5-27}$$

Therefore, the natural frequency of an atom will decrease if we increase its velocity. It will also decline if we move it closer to a governing body where the speed of light is slower as indicated by equation (4-10).

We can combine equation (5-27) with (4-10) to determine the gravitational red shift of light received at the Earth from the Sun. From equation (4-10) we have:

$$c_2 = c_1 e^{\left(\frac{2MG}{c_s^2}\left(\frac{r_2 - r_1}{r_2 r_1}\right)\right)} \tag{5-28}$$

Based on equation (5-27) we can write:

$$\frac{f_1 - f_2}{f_1} = 1 - \frac{f_{os}\sqrt{\dfrac{c_2\left(1-\beta_2^2\right)}{c_s}}}{f_{os}\sqrt{\dfrac{c_1\left(1-\beta_1^2\right)}{c_s}}}$$

$$\frac{f_1 - f_2}{f_1} = 1 - \frac{\sqrt{c_2\left(1-\beta_2^2\right)}}{\sqrt{c_1\left(1-\beta_1^2\right)}} \tag{5-29}$$

Consider the Earth-Sun system: The velocity of the Earth with respect to the Sun is much less than the speed of light. The Earth's matter is also much less than that of the Sun. Hence, for this example we can assume that $\beta_1 = \beta_2 = 0$ and the influence of the Earth on the speed of light is negligible. Therefore, we can calculate the difference in the frequency of light emitted from the surface of the Sun with respect to light emitted from a similar atom on the Earth as follows:

By combining equations (5-28) and (5-29) we obtain:

$$\frac{f_1 - f_2}{f_1} = 1 - \sqrt{e^{\left(\frac{2MG}{c_s^2}\left(\frac{r_2 - r_1}{r_2 r_1}\right)\right)}} \tag{5-30}$$

If we use the following values for the Earth and Sun we can estimate the red shift of light received from the Sun as follows:

For:

r_1 = the distance of the Earth from the Sun = 150.0×10^9 m

r_2 = the radius of the Sun's surface = 6.96×10^8 m

M = the mass of the Sun = 1.99×10^{30} kg

$$\frac{f_1 - f_2}{f_1} = 1 - \sqrt{e^{\left(\frac{2\left(1.99\times10^{30}\,\mathrm{kg}\right)\left(6.6742\times10^{-11}\,\frac{\mathrm{m}^3}{\mathrm{kg\cdot s}^2}\right)}{\left(299792458.0\,\frac{\mathrm{m}}{\mathrm{s}}\right)^2}\left(\frac{6.96\times10^8\,\mathrm{m} - 150\times10^9\,\mathrm{m}}{\left(6.96\times10^8\,\mathrm{m}\right)\left(150\times10^9\,\mathrm{m}\right)}\right)\right)}}$$

$$\frac{f_1 - f_2}{f_1} = 2.11\times10^{-6}$$

This is in agreement with data for the red shift of light received from the Sun. Thus, we observe that the natural frequency of an atom is a function of position in a gravitational field. This influence causes a frequency shift between light emitted at different locations in the field. However, once emitted, the frequency of the light is constant as it moves through the field as long as the field itself is not expanding. As the light propagates, both its velocity and wavelength change so that its frequency, which is equal to the speed of light divided by wavelength, is constant.

5.5 The Mechanical Frequency Of A Spring-Mass System

Our goal here is to show that the natural frequency of a mechanical system is influenced by a change in the speed of light just like the atomic system presented in Section 5.4. If we define a spring in terms of the force required to produce a given displacement as:

$$F = kx \tag{5-31}$$

Where:

k = the spring constant.

x = the deflection of the spring from its equilibrium position.

Then, based on this equation and Definition 19, we can write the following for a spring mass system:

$$\sum F = 0 = kx + \frac{dp}{dt} \tag{5-32}$$

From equation (2-2) we have:

$$dp = \beta c_s dm + mc_s d\beta$$

If we assume that the harmonic energy is much less than mc_s^2 then we can assume that *dm* is equal to zero and:

$$\frac{dp}{dt} = \frac{mc_s d\beta}{dt} \tag{5-33}$$

By definition:

$$\beta = \frac{v}{c}$$

If we assume that *c* is constant during the oscillation of the spring then:

$$\frac{d\beta}{dt} = \frac{dv}{cdt} \tag{5-34}$$

Substitute equation (5-34) into (5-33):

$$\frac{dp}{dt} = \frac{mc_s dv}{cdt} \tag{5-35}$$

By definition:

$$v = \frac{dx}{dt}$$

$$\frac{dv}{dt} = \frac{d^2x}{dt^2} \tag{5-36}$$

Substitute equation (5-36) into (5-35):

$$\frac{dp}{dt} = \frac{mc_s d^2x}{cdt^2} \tag{5-37}$$

Substitute equation (5-37) into (5-32):

$$kx + \frac{mc_s d^2x}{cdt^2} = 0$$

$$\frac{d^2x}{dt^2} = -\frac{ck}{c_s}\frac{x}{m} \tag{5-38}$$

It can be shown that the time dependent solution for this equation results in a natural harmonic frequency of:

$$f = \frac{1}{2\pi}\sqrt{\frac{ck}{c_s m}} \tag{5-39}$$

Based on our initial definition of a spring, it is reasonable to assume that the spring constant, k, is proportional to the binding energy of an electron to the atom. If this is true then:

$$\frac{k}{k_{os}} = \frac{E_t}{E_{tos}} \tag{5-40}$$

As a reminder, k_{os} = Spring constant at the standard location for $\beta = 0$.

Based on equation (5-24) we have established:

$$E_t = \frac{Z^2 e_s^4 m_{os}}{8\varepsilon_s^2 n^2 h^2}\sqrt{\frac{c\left(1-\beta^2\right)}{c_s}}$$

For E_{tos}, $\beta = 0$, $c = c_s$, Therefore:

$$E_{tos} = \frac{Z^2 e_s^4 m_{os}}{8\varepsilon_s^2 n^2 h^2}$$

Substitute these equations into (5-40):

$$\frac{k}{k_{os}} = \frac{\dfrac{Z^2 e_s^4 m_{os}}{8\varepsilon_s n^2 h^2}\sqrt{\dfrac{c\left(1-\beta^2\right)}{c_s}}}{\dfrac{Z^2 e_s^4 m_{os}}{8\varepsilon_s n^2 h^2}}$$

$$k = k_{os}\sqrt{\frac{c\left(1-\beta^2\right)}{c_s}} \tag{5-41}$$

Therefore, if we accelerate a spring to a higher velocity or move it to a lower gravitational potential it will become less ridged.

Substitute equations (5-41) and (5-11) into equation (5-39):

$$f = \frac{1}{2\pi}\sqrt{\frac{ck_{os}\sqrt{\dfrac{c\left(1-\beta^2\right)}{c_s}}}{c_s m_{os}\sqrt{\dfrac{c}{c_s\left(1-\beta^2\right)}}}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{k_{os}}{m_{os}}}\sqrt{\frac{c\left(1-\beta^2\right)}{c_s}}$$

For f_{os}, $\beta = 0$, $c = c_s$, Therefore:

$$\frac{f}{f_{os}} = \frac{\frac{1}{2\pi}\sqrt{\frac{k_{os}}{m_{os}}}\sqrt{\frac{c\left(1-\beta^2\right)}{c_s}}}{\frac{1}{2\pi}\sqrt{\frac{k_{os}}{m_{os}}}}$$

$$f = f_{os}\sqrt{\frac{c\left(1-\beta^2\right)}{c_s}} \tag{5-42}$$

This is identical to equation (5-27) indicating that a mechanical clock will behave in the same manner as an atom. Hence, we may conclude that the natural frequency of a mechanical clock will also decrease or slow down as it is accelerated to a higher velocity and if it is moved to a lower gravitational potential (see equation (5-30)).

Hence, we have now achieved our third objective!

6 Matter And Space

By reviewing the concepts presented in Section 2.4, we recognize that time, length, and matter are all defined in terms of the wavelength of light. This observation leads to the following postulate:

Postulate 12 *Space and matter are mutually dependent upon each other. Where there is space there is matter, and where there is matter, there is space. One does not exist without the other.*

If this postulate is true, then we conclude that space is unavoidably associated with matter. There is a multitude of evidence to support this conclusion such as electromagnetic and gravitational influences. Indeed, we have never discovered any location in space that is free of these effects. This is also consistent with Definition 16, which states, "Matter is the substance of existence." Therefore, if space exists it must be composed of matter. The evidence forces us to conclude that where there is space, there is matter also.

There is evidence all around us that we can disturb the matter of space with an electromagnetic wave. We may also be able to impart motion to the matter of space that is similar to an eddy or current in a fluid. Albert Einstein's concept of General Relativity suggests this type of motion in the form of frame dragging. This is a reasonable assumption that we should investigate further with the definitions and postulates presented in this work. However, the author desires to communicate the ideas presented in this work to the public as soon as possible. Therefore, we will leave the investigation of frame dragging to a future effort and limit our current investigation to the motion of matter that does not include the influence of large-scale currents or eddies in the matter of space.

6.1 A Particle Consisting Of Electromagnetic Waves

In this section we will show that it is possible to describe the properties of a particle in terms of a standing electromagnetic wave. Based on this approach, a particle occupies a given region of space as required by Postulate 12.

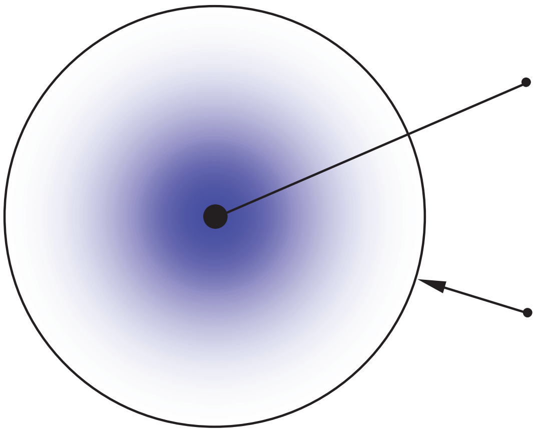


Figure 6 This figure depicts a particle with a total rest matter of m_o. It consists of electromagnetic waves confined in a spherical space in the form a standing wave with a group velocity of zero.

Let us imagine a hollow sphere at rest as presented in Figure 6. Let us also imagine that the internal surface of this sphere is a perfect mirror. Let us place inside this sphere a standing electromagnetic wave. If this sphere is at rest, then the linear momentum of the standing electromagnetic wave is equal to zero. However, the individual waves that form the standing wave inside the sphere have momentum. We shall refer to this momentum as the internal momentum (p_o) of the particle.

We can check the validity of this concept by attempting to use it to calculate the size of a proton. Let us assume that a proton is a fundamental particle composed of two waves that form a single standing wave similar to the form presented in Figure 6. Based on this concept, the diameter of the proton should be equal to 1/2 the wavelength of an electromagnetic wave that has an energy equal to 1/2 the matter of a proton. From equation (2-6) we have:

$$\lambda = \frac{ch}{mc_s^2} \qquad \text{if } c \text{ is equal to } c_s \text{ then} \qquad \lambda = \frac{h}{mc_s}$$

Let us attempt to calculate the diameter of a proton by substituting values for the constants and one half the matter of a proton into this equation:

$$\lambda = \frac{6.626\times10^{-34}\,\dfrac{\text{kg}\cdot\text{m}^2}{\text{s}}}{\dfrac{1.673\times10^{-27}\,\text{kg}}{2}\,299\,792\,458\,\dfrac{\text{m}}{\text{s}}}$$

$$\lambda = 2.64\times10^{-15}\,\text{m}$$

The diameter of a proton should be 1/2 of this wavelength:

$$d = \frac{\lambda}{2} = 1.32 \times 10^{-15}\,\mathrm{m}$$

This is about one half the experimental value obtained from scattering data for neutrons at very high energies (see Reference 5). Therefore, this concept appears to be reasonable. However, the structure of a proton may be more complex than a single standing wave. A particle consisting of two standing waves would be in closer agreement with the data.

At this point, we recognize that it is impossible to have a hollow sphere made out of nothing. However, it is conceivable that a particle is simply a group of electromagnetic waves organized as a stable standing wave. The structure of these standing waves should be dependent on the local velocity of light. The resulting concept could be investigated with wave mechanics to solve for the stable waveforms. Hopefully the scientific community will study this concept. We use the following postulate as a bridge until a more firm foundation is established.

Postulate 13 All fundamental particles are formed out of electromagnetic waves.

We shall now demonstrate that this postulate provides a remarkably simple approach to understanding why the total matter of an object is a function of velocity.

6.2 Mass And The Increase In Matter Associated With A Change In Momentum

In this section, we will derive the change in matter associated with a change in the linear momentum of a particle similar to the one presented in Figure 6. We shall first define the relationship between the linear momentum, total electromagnetic momentum, and the internal momentum of a particle as follows:

$$\vec{\mathrm{p}}_o = \hat{\mathrm{p}}_o m_o c_s = \text{Internal momentum} \tag{6-1}$$

$$\vec{\mathrm{p}}_\lambda = \hat{\mathrm{p}}_\lambda m c_s = \text{Total electromagnetic momentum} \tag{6-2}$$

$$\vec{\mathrm{p}} = m\vec{\beta} c_s = \text{Linear momentum} \tag{6-3}$$

$$\vec{\mathrm{p}}_o \bullet \vec{\mathrm{p}} = 0 \tag{6-4}$$

$$p_o = \sqrt{p_\lambda^2 - p^2} \tag{6-5}$$

Along with these definitions, we establish the following postulate of conservation:

Postulate 14 *Total electromagnetic momentum is conserved. The change in the total electromagnetic momentum of a system is equal to the electromagnetic momentum in minus the electromagnetic momentum out.*

Based on these definitions, the linear momentum of an object is orthogonal to the internal momentum of the object as presented vectorially in Figure 7.

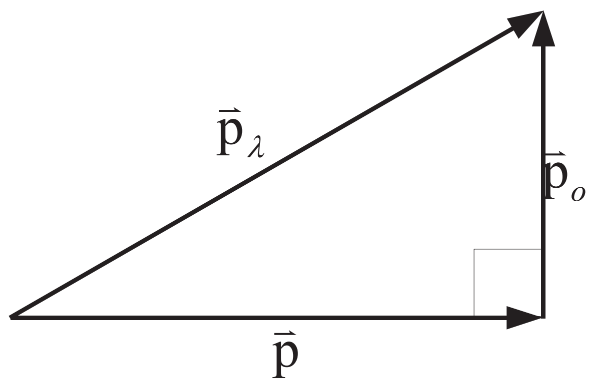


Figure 7 Relationship between internal momentum, linear momentum, and the total electromagnetic momentum of a particle or object.

In Figure 7 we see that internal momentum does not contribute to the linear momentum of a particle. Based on this concept we can define a new property that we shall refer to as mass.

Definition 24 *The **mass** of an object or particle is equal to the internal momentum of the object or particle divided by the standard velocity of light, c_s.*

$$Mass = m_o = \frac{p_o}{c_s} \tag{6-6}$$

Let us apply a force to the object presented in Figure 6 that is sufficient to impart a linear momentum of p. We recognize that the absolute velocity of the electromagnetic waves that make up the particle cannot exceed c. Therefore, with the addition of the linear momentum, p, we can substitute equations (6-1), (6-2), and (6-3) into (6-5) to obtain the following equation.

$$m_o c_s = \sqrt{(mc_s)^2 - (m\beta c_s)^2}$$

Therefore:

$$m_o = m\sqrt{1-\beta^2} \tag{6-7}$$

The simplicity of this approach combined with the accuracy of the result (compare with equation (2-13)) is remarkable. This increases our confidence in Postulate 13 confirming that all particles could be formed out of electromagnetic waves.

6.3 The Wavelength Of Interaction

We must understand how particles interact in order to calculate the result of the interaction. One important characteristic of this interaction is how one particle exchanges momentum with another. If a particle is a disturbance in space consisting of electromagnetic waves as stated in Postulate 13, then reason would indicate that these particles can also exchange momentum through electromagnetic waves as presented in Figure 8. Therefore, we establish the following postulate:

Postulate 15 Particles can interact by exchanging momentum through an electromagnetic wave.

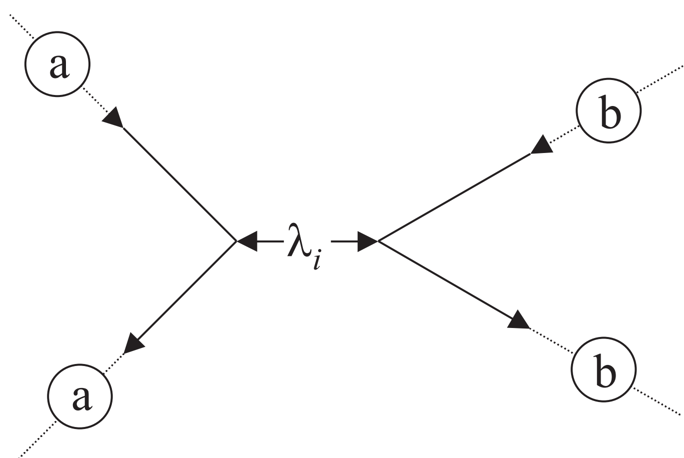


Figure 8 This represents the interaction between two particles through the influence of an electromagnetic wave. The basic concept of this example is the same as a "Feynman diagram."

It follows from Postulate 15 that the wavelength of interaction between two particles will be equal to the wavelength of the electromagnetic wave of interaction. We can derive this wavelength based on the following definition:

Definition 25 The ***Interaction Wavelength*** *(λ_i) between an electromagnetic wave and an object is the distance the wave must move through the medium of space for two maximum or minimum wave values to interact with the object.*

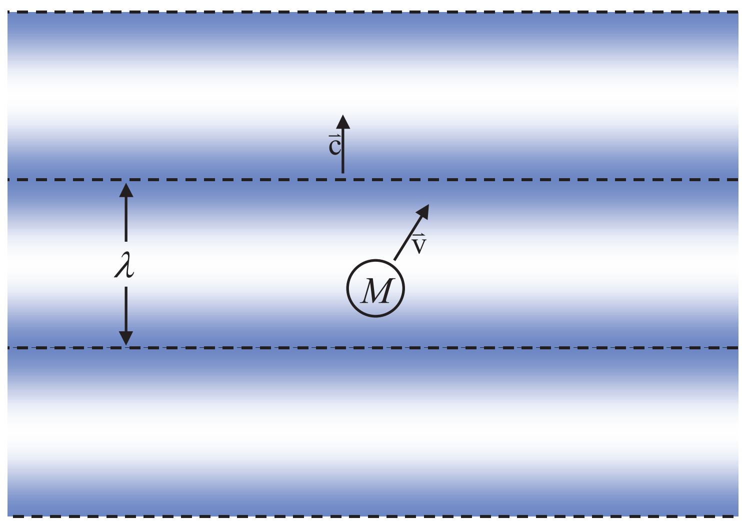


Figure 9 A wave with a velocity, $\vec{c}$, passes object, *M*, which is moving with a velocity of $\vec{v}$. The velocity of both the wave and *M* are with respect to the medium of space that supports the wave.

Let us consider the distance traveled by the wave in Figure 9 that is required for two maximum wave values to pass *M*.

Given:

$\vec{c}$ = the wave velocity through the medium of space that supports the wave. Using vector notation, $\vec{c} = c\hat{c}$ where:

c = the characteristic velocity of the wave in the medium of space.

$\hat{c}$ = a unit vector defining the direction of wave motion.

$\vec{\mathrm{v}}$ = the velocity of *M* with respect to the medium of space. Using vector notation, $\vec{\mathrm{v}} = v\hat{\mathrm{v}}$ where:

v = the velocity magnitude of *M* through the medium of space.

$\hat{\mathrm{v}}$ = a unit vector defining the direction of the change in position of *M*.

t = the amount of time required for two maximum wave values to pass *M*.

λ_i = the wavelength of interaction. This is the distance the wave must travel through the medium of space for two maximum wave values to pass *M*. Therefore:

$$\lambda_i = ct \tag{6-8}$$

λ = Distance between two maximum wave values. We can calculate this as:

$$\lambda = \left(c - \vec{\mathrm{v}} \bullet \hat{\mathrm{c}}\right)t \tag{6-9}$$

From equation (6-9) we can solve for t as:

$$t = \frac{\lambda}{c - \vec{\mathrm{v}} \bullet \hat{\mathrm{c}}}$$

By substituting this into equation (6-8) we obtain:

$$\lambda_i = c\frac{\lambda}{c - \vec{\mathrm{v}} \bullet \hat{\mathrm{c}}}$$

$$\lambda_i = \frac{\lambda}{1 - \vec{\beta} \bullet \hat{\mathrm{c}}} \tag{6-10}$$

We can calculate the wavelength of the electromagnetic wave presented in Figure 9 with equation (2-6) as:

$$\lambda = \frac{ch}{mc_s^2} \tag{6-11}$$

In this equation, m is the matter associated with the electromagnetic wave presented in Figure 9. If we substitute equation (6-11) into (6-10) we obtain the wavelength of the electromagnetic wave with respect to a moving object.

$$\lambda_i = \frac{ch}{\left(1 - \vec{\beta} \bullet \hat{\mathrm{c}}\right) mc_s^2} \tag{6-12}$$

This is the wavelength of interaction between the electromagnetic wave and the object, M.

We can calculate the momentum of interaction between the wave and *M* as:

$$p_i = \left(1 - \vec{\boldsymbol{\beta}} \bullet \hat{\mathrm{c}}\right)\, mc_s \tag{6-13}$$

This is the momentum of interaction between an electromagnetic wave and an object moving through the medium of space. It is based on the assumption that the matter associated with *M* is sufficiently large such that there is no significant change in the velocity of *M* during the interaction. By substituting equation (6-13) into equation (6-12), we see that the wavelength of interaction between an electromagnetic wave and an object can also be calculated as a function of the momentum of interaction as follows:

$$\lambda_i = \frac{ch}{p_i c_s} \tag{6-14}$$

The momentum of interaction is the primary variable in this equation. Hence, equation (6-14) is valid even if the interaction between the wave and the object, M, alters the velocity of M. We also note that the wavelength of interaction between the object and the electromagnetic wave is the same for both the wave and the object. Therefore, it follows that the wavelength of interaction between an object and the medium of space is a function of the momentum of interaction with space. Hence, we can calculate the wavelength of an object with respect to the medium of space with equation (6-14) as follows:

$$\lambda = \frac{ch}{m\beta c_s^2} \tag{6-15}$$

In this equation, *m*, is the matter associated with an object, particle, or electromagnetic wave. We recognize that for the special case where c is equal to c_s, equation (6-14) is the same as proposed by Louis de Broglie. This reinforces our confidence in Postulate 15 and Definition 25.

6.4 Length Contraction, An Inherent Property Of The Wave Characteristics Of Matter

In this section, we show that the interaction wavelength of the electromagnetic waves that form a particle is independent of orientation as stated in Postulate 16. We show that this requires a contraction of the particle in the direction of motion. In contrast, we also demonstrate that the interaction wavelength of the waves forming the particle increases with velocity. This is a key to understanding why the natural frequency of matter decreases with velocity as outlined in Section 5.

Postulate 16 *The wavelength of interaction of the electromagnetic waves that form a particle is independent of orientation.*

We derive the length contraction of an object by evaluating the influence of motion on the particle presented in Figure 10. This particle consists of two waves of equal wavelength forming a single standing wave.

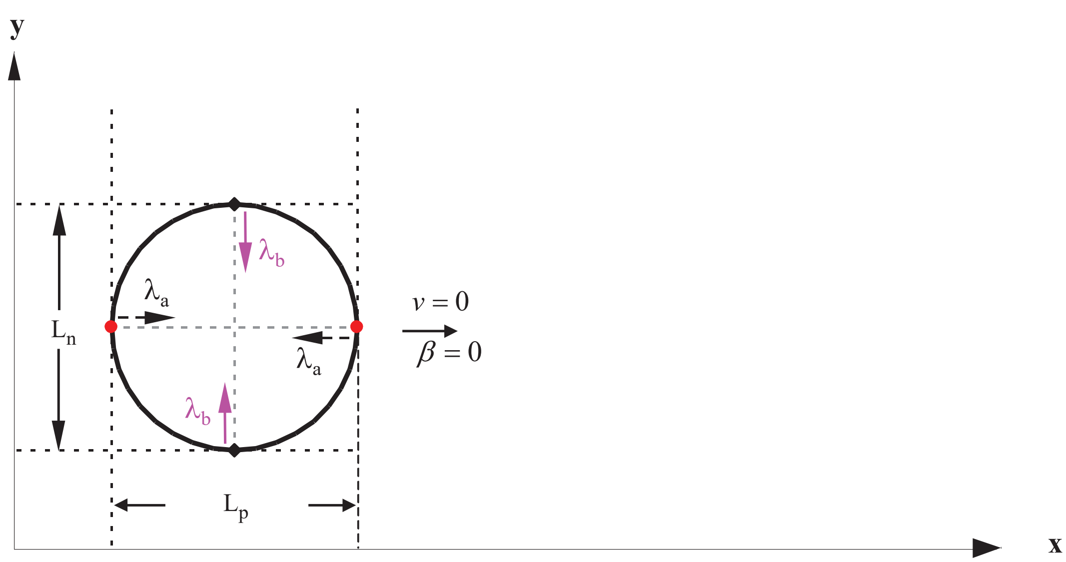


Figure 10 A particle formed out of electromagnetic waves for $\beta = 0$.

Let us now evaluate what happens if we put this particle into motion by adding to it the required momentum in the x direction as presented in Figure 11.

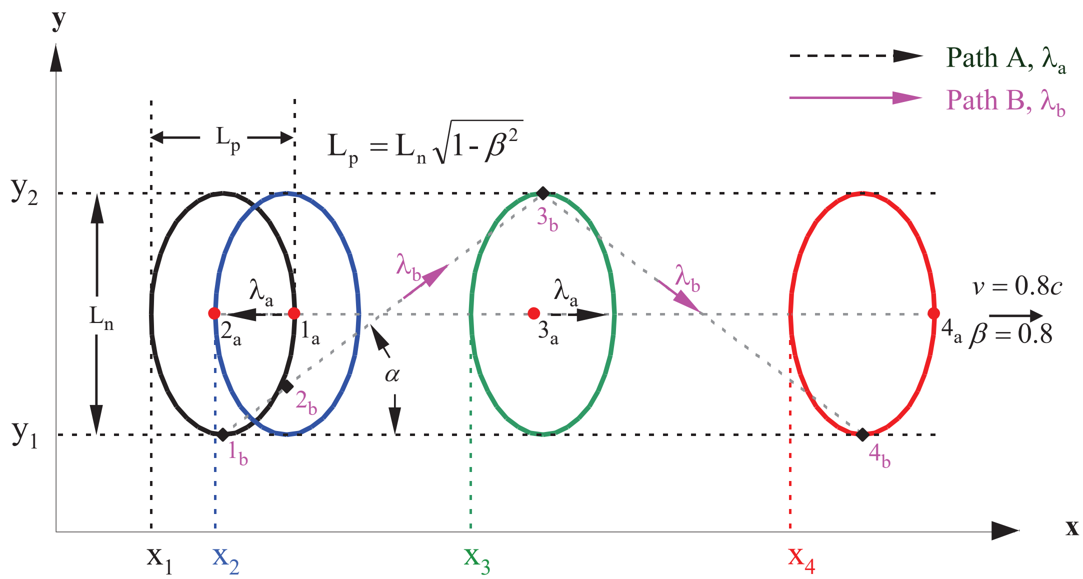


Figure 11 A particle formed out of electromagnetic waves for $\beta = 0.8$.

The waves, λ_a and λ_b, must remain in phase in order for them to form a standing wave or a particle. Therefore, at position x_4 the relationship between λ_a and λ_b is the same as at x_1. Both λ_a and λ_b move with a velocity of *c*. Therefore, the wavelength is identical for both waves as required by Postulate 16. This means that the distance of travel along path A is the same as along path B.

We will use the following convention to define the length of a particle.

L_n = the length of the particle in the normal direction which is orthogonal to the direction of motion.

L_p = the length of the particle parallel to or in the direction of motion.

Based on the nomenclature presented in Figure 11 we can calculate the following for a particle moving with a velocity of *v*.

When the left hand boundary of the particle is at position x_1, the influence of λ_a starts moving to the left with a velocity of *c* from point 1_a, and reaches point 2_a when the particle has moved to the right with a velocity of v by a distance of x_2-x_1. Therefore, we can calculate L_p with equation (2-1) as follows:

$$L_p = (c+v)t$$

Substitute in equation (2-1) for t:

$$L_p = (c+v)\frac{(x_2 - x_1)}{v}$$

$$(x_2 - x_1) = \frac{vL_p}{(c+v)} \tag{6-16}$$

When the left hand boundary of the particle is at position x_2, the influence of λ_a starts moving from point 2_a to the right and reaches point 4_a when the particle has moved to the right by a distance of x_4-x_2. Therefore, we can also calculate L_p as:

$$L_p = (c-v)\left(\frac{x_4 - x_2}{v}\right)$$

$$(x_4 - x_2) = \frac{vL_p}{(c-v)} \tag{6-17}$$

$$(x_4 - x_1) = (x_4 - x_2) + (x_2 - x_1)$$

Substitute in equations (6-16) and (6-17):

$$(x_4 - x_1) = \frac{vL_p}{(c-v)} + \frac{vL_p}{(c+v)}$$

$$(x_4 - x_1) = \frac{vL_p(c+v)}{(c^2 - v^2)} + \frac{vL_p(c-v)}{(c^2 - v^2)}$$

$$(x_4 - x_1) = \frac{2vcL_p}{(c^2 - v^2)} \tag{6-18}$$

Now let us consider the wave moving along path B. This wave also moves in the x direction with a velocity of v. Therefore, we can calculate its velocity in the "y" or normal direction as follows:

$$v_n = \sqrt{c^2 - v^2} \tag{6-19}$$

Thus, we can calculate the length of the particle in the normal direction as follows:

$$\mathrm{L_n} = v_\mathrm{n} \frac{(x_4 - x_1)}{2v}$$

This makes it possible to calculate the relationship between $\mathrm{L_n}$ and $\mathrm{L_p}$ by substituting in equations (6-18) and (6-19):

$$\mathrm{L_n} = \frac{\sqrt{c^2 - v^2}}{2v} \left(\frac{2vc\mathrm{L_p}}{(c^2 - v^2)} \right)$$

$$\mathrm{L_n} = \frac{c\mathrm{L_p}}{\sqrt{c^2 - v^2}}$$

$$\mathrm{L_n} = \frac{\mathrm{L_p}}{\sqrt{1 - \beta^2}} \tag{6-20}$$

Hence, if the wavelength along Path A is the same as it is along Path B, then the length of the particle in the direction of motion is shorter than in the direction orthogonal to motion. It also follows that the path length of the waves that is required for them to interact as a particle increases with velocity and is calculated as:

$$\text{Path A} = \text{Path B} = \frac{2\mathrm{L_n}}{\sqrt{1 - \beta^2}} \tag{6-21}$$

This means that the wavelength of interaction between the waves also increases as:

$$\lambda_i = \frac{\lambda_{io}}{\sqrt{1-\beta^2}} \tag{6-22}$$

Where:

λ_{io} is equal to the wavelength of interaction for $\beta = 0$.

6.5 Another Look At How The Wavelength Of Interaction Increases With Velocity

Let us take another approach to evaluating the influence of length contraction. In this approach we shall model a particle consisting of two individual waves as presented in Figure 12. We shall see that this provides a good description of the momentum and the length contraction of the particle.

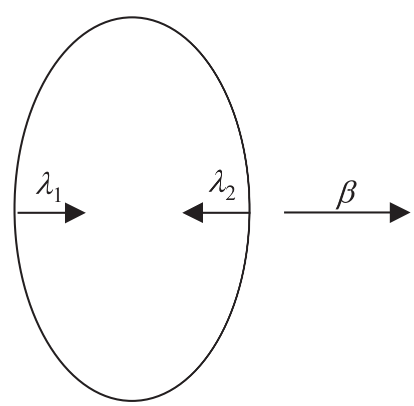


Figure 12 This figure represents a particle, that is moving to the right in the form of a standing wave consisting of waves, λ_1, and λ_2 with a group velocity corresponding to β.

As presented in Figure 12, λ_1 is traveling in the direction of motion, and λ_2 is traveling opposite to it. These waves are electromagnetic; therefore, they are both traveling with a velocity of *c*. For this example we will define the total amount of matter associated with this group of waves to be equal to *m*. Let us also assign to the first wave a matter of (1-*x*)*m* giving it a momentum of:

$$p_{\lambda 1} = (1 - x)mc_s \tag{6-23}$$

And to the second wave, a matter of *x*(*m*) with a corresponding momentum of:

$$p_{\lambda 2} = xmc_s \tag{6-24}$$

It is given that λ_2 is moving in the opposite direction of the particle's motion. Therefore, we can calculate the momentum of the particle associated with these waves by subtracting the momentum of λ_2 from the momentum of λ_1.

$$p = m\beta c_s = p_{\lambda 1} - p_{\lambda 2}$$

Substitute in equations (6-23)and (6-24):

$$m\beta c_s = (1 - x)mc_s - xmc_s$$

$$\beta = 1 - 2x$$

$$x = \frac{1-\beta}{2} \tag{6-25}$$

Substitute this back into equations (6-23) and (6-24):

$$p_{\lambda 1} = \left(\frac{1+\beta}{2}\right)mc_s \tag{6-26}$$

$$p_{\lambda 2} = \left(\frac{1-\beta}{2}\right)mc_s \tag{6-27}$$

We can use equation (6-12) to calculate the wavelength of interaction as:

$$\lambda_i = \frac{ch}{\left(1 - \vec{\beta} \bullet \hat{c}\right)\ p_\lambda c_s} \tag{6-28}$$

Therefore, we can calculate the interaction wavelength of the first wave as follows:

For λ_1, $\vec{\beta} \bullet \hat{c} = \beta$. Substitute this value and equation (6-26) into (6-28):

$$\lambda_{i_1} = \frac{ch}{(1-\beta)\left(\frac{1+\beta}{2}\right)mc_s^2}$$

$$\lambda_{i_1} = \frac{2ch}{\left(1-\beta^2\right) mc_s^2} \qquad (6\text{-}29)$$

We can also calculate the wavelength of interaction for the second wave as follows:

For λ_2, $\vec{\beta} \bullet \hat{c} = -\beta$. Substitute this value and equation (6-27) into (6-28):

$$\lambda_{i_2} = \frac{ch}{(1+\beta)\left(\frac{1-\beta}{2}\right)mc_s^2}$$

$$\lambda_{i_2} = \frac{2ch}{\left(1-\beta^2\right) mc_s^2} \qquad (6\text{-}30)$$

Comparing this with equation (6-29), we see that:

$$\lambda_{i_1} = \lambda_{i_2}$$

Therefore, although the waves λ_1 and λ_2 are not composed of the same amount of matter, they both have the same wavelength of interaction with the particle and with each other.

Now let us compare this result to that of a pair of waves with an interaction motion that is perpendicular to the direction of the particle's motion traveling along path B as illustrated in Figure 11. If the total matter associated with this group of waves is also equal to *m*, the linear momentum of each wave is given as:

$$p_\lambda = \frac{mc_s}{2} \qquad (6\text{-}31)$$

Based on Figure 11 we can calculate the following for path B:

$$\vec{\beta} \bullet \hat{c} = \beta \cos\alpha = \beta\left(\frac{v}{c}\right) = \beta^2$$

If we substitute this along with equation (6-31) into (6-28), we calculate the wavelength of interaction along path B as follows:

$$\lambda_i = \frac{2ch}{\left(1-\beta^2\right)\, mc_s^2} \tag{6-32}$$

By comparing this with equation (6-30), we see that the interaction wavelength of the waves moving along path A and B in Figure 10 is identical. We can now calculate the ratio of the interaction wavelength when the particle is moving to the wavelength when the particle is at rest.

If we substitute equation (6-7) into (6-32), we obtain:

$$\lambda_i = \frac{2ch}{\left(1-\beta^2\right)\, \dfrac{m_o c_s^2}{\sqrt{1-\beta^2}}}$$

$$\lambda_i = \frac{2ch}{m_o c_s^2 \sqrt{1-\beta^2}}$$

It follows that we can calculate the interaction wavelength of the internal momentum of the particle when at rest as:

$$\lambda_{io} = \frac{2ch}{m_o c_s^2}$$

Combining these two equations yields:

$$\lambda_i = \frac{\lambda_{io}}{\sqrt{1-\beta^2}} \tag{6-33}$$

This is identical to equation (6-22). Hence, we have demonstrated the following for a particle composed of electromagnetic waves that form a standing wave:

- The interaction wavelength of all the individual waves that form the standing wave of a particle is the same.
- The length of a particle contracts in the direction of motion. We can calculate this with equation (6-20) as:

$$\mathrm{L_p} = \mathrm{L_n}\sqrt{1-\beta^2} \tag{6-34}$$

- The interaction wavelength of the internal momentum of a particle with respect to the particle increases with velocity and can be calculated with equations (6-22) or (6-33) as:

$$\lambda_i = \frac{\lambda_{io}}{\sqrt{1-\beta^2}}$$

In Section 5.3, we derived equation (5-22) which we can use to calculate the interaction radius between an electron and the nucleus of an atom. If we substitute in the appropriate values defined by equations (5-2), (5-9), and (5-11) we obtain:

$$r_i = \left(\frac{n^2 h^2 \varepsilon_s}{Z e_s^2 \pi m_{os}}\right)\sqrt{\frac{c}{c_s\left(1-\beta^2\right)}} \tag{6-35}$$

Therefore:

$$\frac{r_i}{r_{ios}} = \sqrt{\frac{c}{c_s\left(1-\beta^2\right)}} \tag{6-36}$$

This shows that the radius of interaction increases with velocity. The radius of interaction is also a scalar function of the wavelength of interaction between the electron and the atomic nucleus as demonstrated by a comparison between equations (6-33) and (6-36). We recognize that although the radius of interaction increases with velocity, there is no change in the length of the atom in the normal direction to motion. However, the length of the atom in the direction of motion decreases in accordance with equation (6-34). Last of all, we observe that the physical size of an atom is a function of the square root of the speed of light.

6.6 The Density Of Rest Matter Is Inversely Proportional To The Speed Of Light

In this section we derive the relationship between the speed of light and the density of rest matter. We proceed by calculating the ratio between the density of an atom at the standard location and a similar atom in a "*c*" environment. From equations (5-10) and (6-36) we have:

$$m_o = m_{os}\sqrt{\frac{c}{c_s}} \qquad \text{and} \qquad \frac{r_o}{r_{os}} = \sqrt{\frac{c}{c_s}}$$

We can calculate the average density of a sphere as:

$$\rho_o = \frac{3m_o}{4\pi r_o^3}$$

Combining these equations, we obtain:

$$\rho_o = \frac{3m_{os}c_s}{4\pi r_{os}^3 c}$$

It follows that:

$$\frac{\rho_o}{\rho_{os}} = \frac{c_s}{c}$$

Therefore, we see that the density of rest matter is inversely proportional to the speed of light. This also means that the density of rest matter increases as you move closer to a governing body. In other words, we would expect the density of an atom at rest on the Sun to be greater than a similar atom at rest on the Earth.

It is the author's opinion that the density of space is also inversely proportional to the speed of light. However, this idea has yet to be supported by a mathematical derivation.

7 Motion In Space Is Governed By Wave Propagation

In Section 1 we demonstrated that wave propagation could be used to calculate the path of motion for the type of objects that we deal with everyday. We will now investigate this in more detail to obtain a general solution for all objects similar to photons, baseballs, or planets based on the concepts we have established in this book. In the process of doing this we will explain what gravity is.

We will derive an equation by which we can calculate the curvature of the path that a wave follows in space under the following conditions:

1. The matter associated with the wave is constant.
2. The speed of light is a function of position.

We will demonstrate that the curvature of the path that an object follows as it moves through space is a function of its wavelength and the gradient of the speed of light in space.

It is a well understood principle that a wave traveling through a medium in which its characteristic length is a function of position follows a curved path as illustrated in Figure 13. Drivers who see a mirage in the distance on a hot roadway observe this type of influence frequently in desert locations. The hot air above the road causes a gradient in the speed of light in the air that in turn causes light to bend. This can cause the driver to see an image that looks like a reflection of the horizon off a wet roadway.

Note: In this example we refer to how the hot air above a roadway can cause a gradient in the speed of light. This pertains only to how light propagates through the air and not in a vacuum. As a rule (in this book), when we speak of a gradient in the speed of light we are referring to conditions in a vacuum.

We will extend this concept of wave propagation to all objects by establishing the following postulate.

Postulate 17 *If the wavelength of an object is a function of position, and there is no other influence, the motion of the object is a pure function of wave propagation.*

Hence, based on this postulate an object follows a curved path in a space where its wavelength is a function of position unless its path is parallel to the gradient of the speed of light.

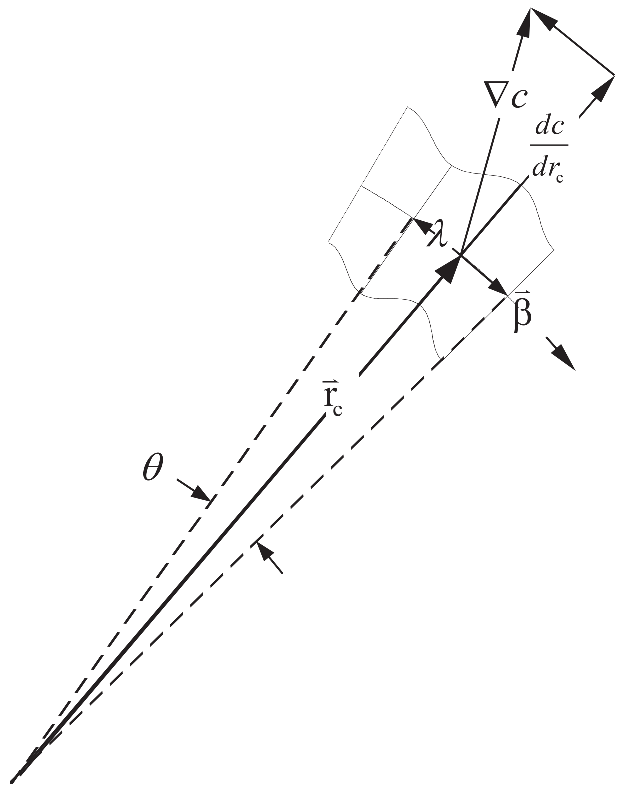


Figure 13 This figure presents the curvature of a particle's path defined in terms of its wavelength as $r_c = \frac{\lambda}{\theta}$.

We can calculate the curvature, r_c, at any point along this path as follows:

Let $\lambda = r_c\theta$ as presented in Figure 13.

$$\theta = \frac{\lambda}{r_c}$$

For constant θ:

$$\frac{d\lambda}{dr_c} = \theta$$

Substitute in the value for θ:

$$\frac{d\lambda}{dr_c} = \frac{\lambda}{r_c}$$

$$r_c = \frac{\lambda}{d\lambda} dr_c \tag{7-1}$$

We can use equation (6-15) to calculate the wavelength of an object with respect to the medium of space as:

$$\lambda = \frac{ch}{m\beta c_s^2} \tag{7-2}$$

$$\lambda = chm^{-1}\beta^{-1}c_s^{-2}$$

For this task the values of *h, m,* and c_s are constant, Therefore:

$$d\lambda = dc\left(hm^{-1}\beta^{-1}c_s^{-2}\right) - chm^{-1}c_s^{-2}\beta^{-2}d\beta$$

$$d\lambda = \frac{hdc}{m\beta c_s^2} - \frac{chd\beta}{m\beta^2 c_s^2} \tag{7-3}$$

We can combine equations (7-2) and (7-3) to obtain:

$$\frac{d\lambda}{\lambda} = \frac{\frac{hdc}{m\beta c_s^2}}{\frac{ch}{m\beta c_s^2}} - \frac{\frac{chd\beta}{m\beta^2 c_s^2}}{\frac{ch}{m\beta c_s^2}}$$

$$\frac{d\lambda}{\lambda} = \frac{dc}{c} - \frac{d\beta}{\beta} \tag{7-4}$$

From equation (6-7):

$$\frac{m_o^2}{m^2} = 1 - \beta^2 \tag{7-5}$$

For this problem, m is constant and m_o is a variable that is a function of the speed of light. Therefore:

$$\frac{2m_o dm_o}{m^2} = -2\beta d\beta$$

$$\beta d\beta = -\frac{m_o dm_o}{m^2}$$

Substitute in equation (4-7) for dm_o:

$$\beta d\beta = -\frac{m_o \dfrac{m_o dc}{2c}}{m^2}$$

$$\beta d\beta = -\left(\frac{m_o^2}{m^2}\right)\left(\frac{dc}{2c}\right)$$

Substitute in equation (7-5):

$$\beta d\beta = \left(\beta^2 - 1\right)\left(\frac{dc}{2c}\right)$$

$$\frac{d\beta}{\beta} = \frac{\left(\beta^2 - 1\right)dc}{2\beta^2 c} \tag{7-6}$$

Substitute equation (7-6) into (7-4):

$$\frac{d\lambda}{\lambda} = \frac{dc}{c} - \frac{\left(\beta^2 - 1\right)dc}{2\beta^2 c}$$

$$\frac{d\lambda}{\lambda} = \frac{2\beta^2 dc - \left(\beta^2 - 1\right)dc}{2\beta^2 c}$$

$$\frac{d\lambda}{\lambda} = \frac{\left(\beta^2 + 1\right)dc}{2\beta^2 c}$$

$$\frac{\lambda}{d\lambda} = \frac{2c}{\left(1 + \frac{1}{\beta^2}\right) dc} \tag{7-7}$$

Substitute equation (7-7) into (7-1):

$$r_{\mathrm{c}} = \frac{2c}{\left(1 + \frac{1}{\beta^2}\right) \frac{dc}{dr_{\mathrm{c}}}} \tag{7-8}$$

Based on the nomenclature presented in Figure 13 we can calculate the change in the speed of light with respect to the radius of curvature as:

$$\frac{dc}{dr_{\mathrm{c}}} = \nabla c \bullet \hat{\mathrm{r}}_{\mathrm{c}}$$

Therefore:

$$r_{\mathrm{c}} = \frac{2c}{\left(1 + \frac{1}{\beta^2}\right) \nabla c \bullet \hat{r}_{\mathrm{c}}} \tag{7-9}$$

The gradient of the speed of light, ∇c, is defined as follows:

$$\nabla c = \frac{\partial c}{\partial x} \vec{\mathrm{i}} + \frac{\partial c}{\partial y} \vec{\mathrm{j}} + \frac{\partial c}{\partial y} \vec{\mathrm{k}} \tag{7-10}$$

For a governing body we can calculate this with equation (4-8) as:

$$\nabla c = \frac{dc}{dr} \hat{\mathrm{r}} = \frac{2cMG}{c_s^2 r^2} \hat{\mathrm{r}} \tag{7-11}$$

Hence, based on Figure 13 and equation (7-11) we have:

$$\frac{dc}{dr_{\mathrm{c}}} = \frac{2cMG}{c_s^2 r^2} \hat{\mathrm{r}} \bullet \hat{\mathrm{r}}_{\mathrm{c}}$$

Where:

$\hat{\mathrm{r}} =$ the unit vector defining the direction of the object's position with respect to a single governing body.

$\hat{\mathrm{r}}_{\mathrm{c}} =$ the unit vector defining the direction of the radius of curvature.

Substituting this into equation (7-9) we obtain:

$$r_{\mathrm{c}} = \frac{c_s^2 r^2}{\left(1 + \dfrac{1}{\beta^2}\right) MG\left(\hat{\mathrm{r}} \bullet \hat{\mathrm{r}}_{\mathrm{c}}\right)} \tag{7-12}$$

Equation (7-8) provides a simple method to calculate the radius of curvature for the path of any object including a wave of light. For a single governing body system we can express this in the form of equation (7-12). We have derived this equation based on the concept that all objects similar to photons, baseballs, and planets move as a wave.

From equation (7-8) we see that the primary influence governing the wave motion of matter is the gradient of the speed of light where the object is located. Thus we see that the properties of space govern the motion of matter in contrast to the "force at distance" concept of classical Newtonian mechanics.

Hence, we have now achieved our fourth and final objective. We have explained what gravity is by showing that we can interpret gravity as the refraction of a wave through the medium of space. We have also developed a method providing us with equation (7-8) for predicting the motion of matter or, in other words, the path of a photon, baseball, or planet. We will demonstrate the accuracy of this method through comparisons with data in Section 8.

8 Experimental Verification Of The Wave Propagation Method

In this section we present a few comparisons between experimental data and predicted results using the wave propagation method outlined in Section 7. The four types of motion that we will investigate are:

1. Low velocity trajectory motion
2. Planetary orbital motion
3. The orbital precession of Mercury, Venus, Earth, and Mars
4. The bending of light past the Sun

By these comparisons we demonstrate our ability to use wave propagation to model the motion of objects as stated in Postulate 17. We use the PATH Fortran program presented in Appendix A to calculate the results (the output files are included in Appendix B). In this program we use equation (4-12) in the form (4-14) to calculate a change in the speed of light as a function of a change in position. We integrate the overall path by breaking it up into small arcs, calculating the radius of curvature with equation (7-12), and then adding up the individual arc lengths.

8.1 Wave Propagation Is Indistinguishable From Newtonian Mechanics At Low Velocities

In this example we use the PATH program (see Appendix A) using equation (7-12) to calculate the path of motion for an object moving at only 0.14 m/s. Table 1 presents the initial conditions for this calculation. We see that the result presented in Figure 14 is indistinguishable from what we obtain with well established classical Newtonian mechanics. This is something new and fantastic to understand! We have proven our ability to predict the path of an everyday object such as a baseball with wave propagation. This provides convincing evidence that just like small particles (electrons, protons, etc.), the large objects we deal with on a day to day basis also move as a wave!

Table 1 Initial conditions for the trajectory presented in Figure 14.

Property	Value	Units	Description
M	5.9723E+24	kg	Mass of the Earth
G	6.6742E-11	$m^3/(kg\ s^2)$	Universal gravitation constant
R	6.3675E+06	m	Radius from the center of M
g	-9.83	m/s^2	Classical Newtonian acceleration
v_x	0.10	m/s	Horizontal velocity
v_y	0.10	m/s	Vertical velocity
Note: 100 iterations at 1.25^o per iteration were used to obtain the wave propagation solution			

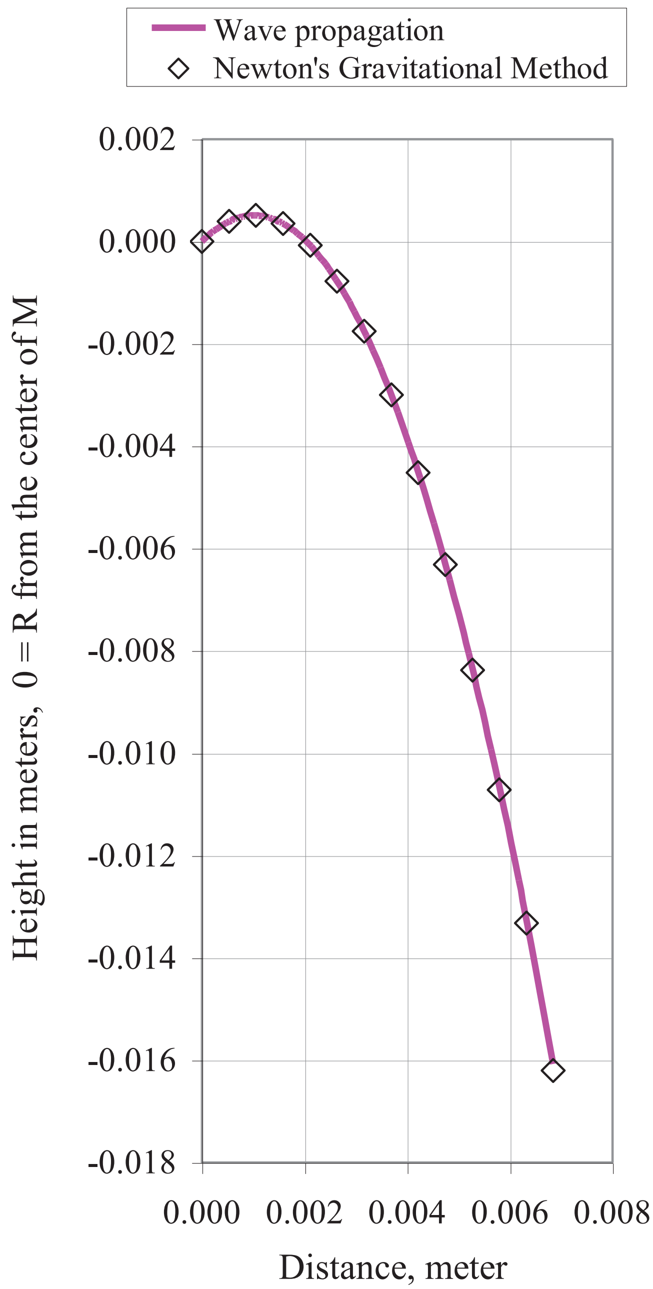


Figure 14 If we use wave propagation to calculate the path of motion for objects that we deal with everyday, the result is indistinguishable from classical Newtonian mechanics. Note: 100 iterations at 1.25° per iteration were used to obtain the wave propagation solution. The constants presented in Table 1 were used to calculate the classical Newtonian solution.

8.2 Wave Propagation Accurately Predicts Planetary Orbits

We can also use the PATH program to calculate the orbits of planets in our Solar System. All we need to know is the mass of the Sun, the initial velocity and position of the planets, and the speed of light at a given position from the Sun. We calculate the speed of light at a given distance from the Sun away from the influence of the earth in the region of its orbit about the Sun by using equation (4-11).

For this example, let us assume the radius of the "standard location" is equal to the average of the Earth's polar and equatorial radii. Combining this with the value of MG for the earth as published in Reference 7 we calculate the speed of light away from the influence of the earth as follows:

$$c_\infty = 299\,792\,458\,\frac{\text{m}}{\text{s}}\,e^{\left(\frac{2\left(3.986\times10^{14}\frac{\text{m}^3}{\text{s}^2}\right)}{\left(299\,792\,458\frac{\text{m}}{\text{s}}\right)^2 6\,367\,450.0\,\text{m}}\right)}$$

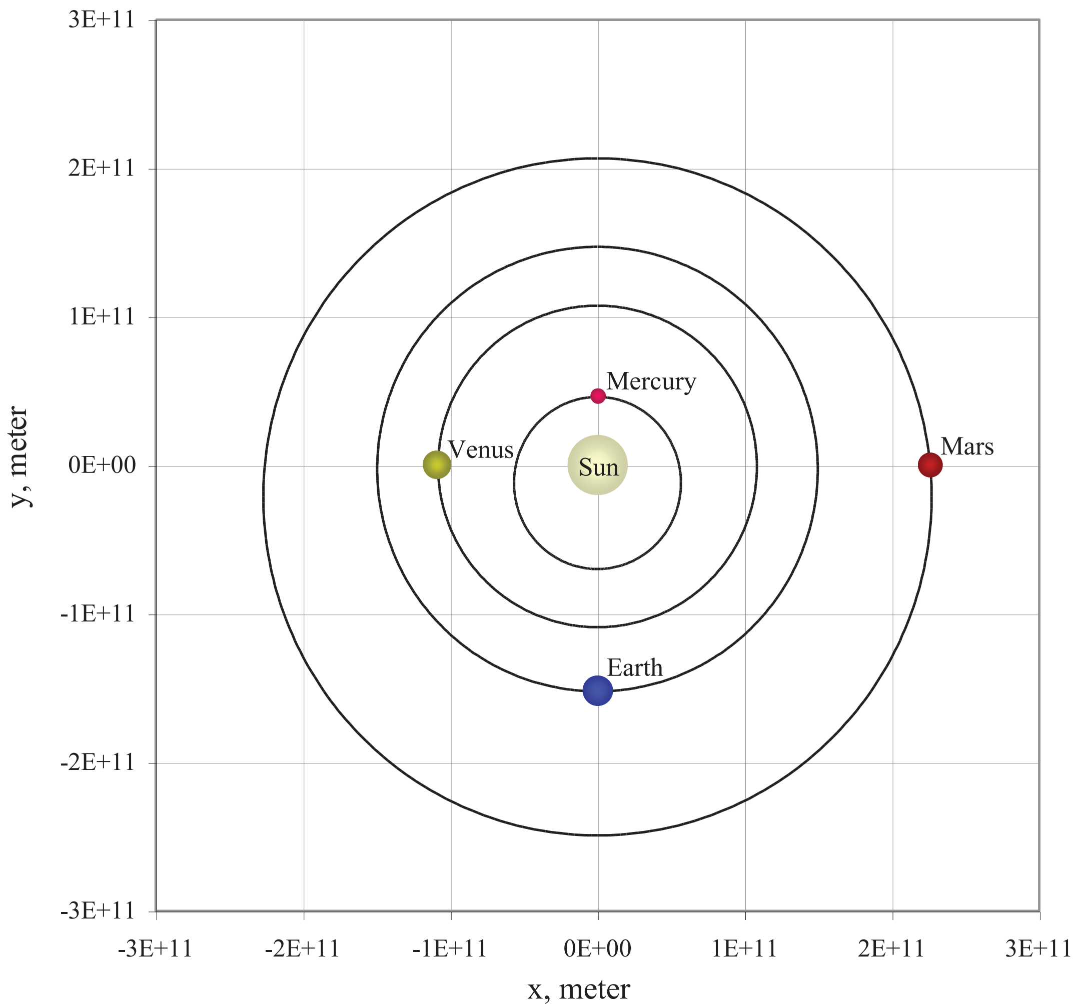
$$c_\infty = 299\,792\,458.418\,\frac{\text{m}}{\text{s}}$$

This is the speed of light away from the influence of the earth at a distance of the Earth's orbit from the Sun, which we will assume for this example to be the semi-major orbital axis of the Earth.

We can now use the PATH program to calculate the mass of the Sun by combining this information with the Earth's perihelion, maximum orbital velocity, and orbital period as contained in Reference 7. This is done by an iterative process of adjusting the mass of the Sun in the PATH program input file until the calculated orbital period of the earth agrees with the value published in Reference 7. Completing this process yields a mass for the Sun of 1.988 618 4 E+30 kg.

When we use this information with the PATH program to calculate the orbital parameters of the inner planets of our Solar System, we see that the results agree very well with the published values presented in Figure 15.

Therefore, we have proven our ability to calculate the orbit of a planet based on its wave characteristics!



Orbital parameters	Mercury		Venus		Earth		Mars	
	PATH[1]	Data[2]	PATH[1]	Data[2]	PATH[1]	Data[2]	PATH[1]	Data[2]
Sidereal period (days)	87.963	87.969	224.712	224.701	365.256	365.256	686.608	686.980
[3]Perihelion (10^6 km)	46.00	46.00	107.48	107.48	147.09	147.09	206.62	206.62
Aphelion (10^6 km)	69.82	69.82	108.95	108.94	152.11	152.10	249.11	249.23
[3]Max velocity (km/s)	58.98	58.98	35.26	35.26	30.29	30.29	26.50	26.50
Min velocity (km/s)	38.86	38.86	34.78	34.79	29.29	29.29	21.98	21.97
Eccentricity	0.2056	0.2056	0.0068	0.0067	0.0168	0.0167	0.0932	0.0935

[1]As calculated with the PATH program for a velocity rotation of 360°.
[2]See Reference 7. [3]Initial condition for the PATH program calculation.

Figure 15 Wave propagation accurately predicts orbital motion. The input values used with the PATH program to calculate these results are included in Appendix B. In this example we have ignored the mass of the planets and their influence on each other.

8.3 Wave Propagation Accurately Predicts The Precession Of Orbits

When we use wave propagation to evaluate the orbit of a planet, we find that the orbital path rotates in the direction of the planet's rotation about the governing body as presented in Figure 16. We present this example as an extreme case to illustrate the effect.

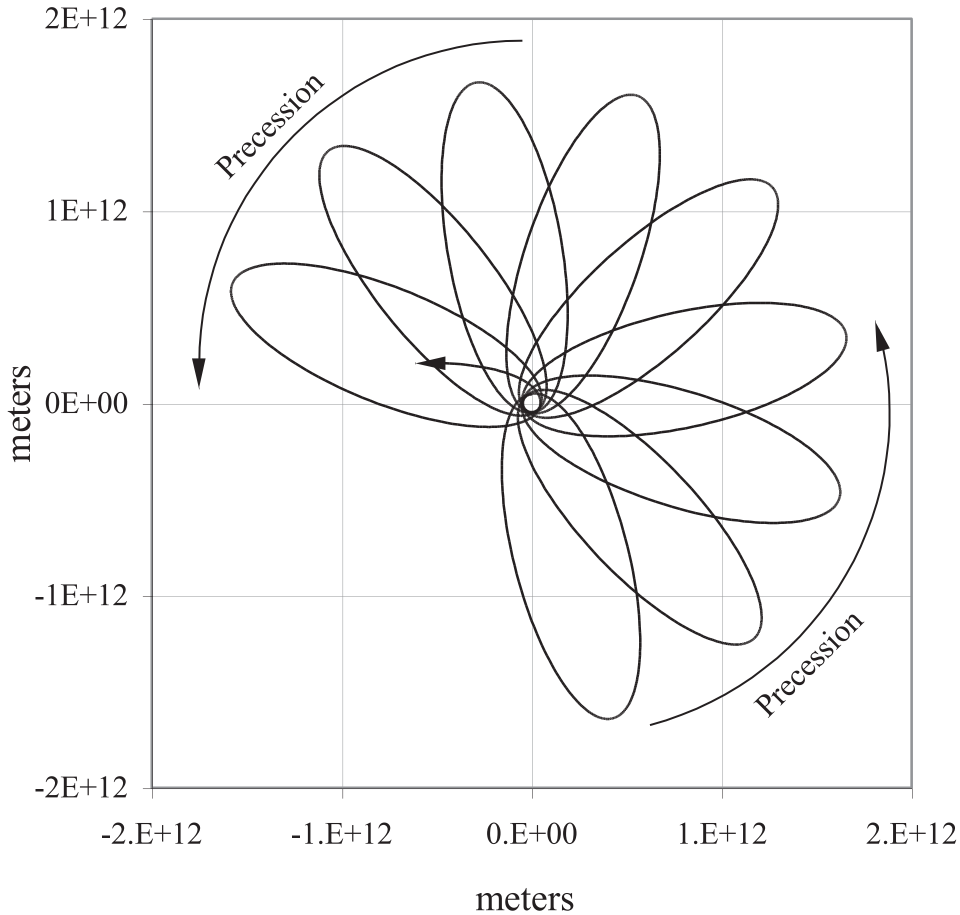


Figure 16 Here we have an extreme case of orbital precession as calculated with wave propagation. This demonstrates how the elliptical form of an orbit rotates in the direction of orbital motion. Appendix B provides the input values that were used with the PATH program to create this example.

When we use the PATH program to calculate the orbital precession of planets in our Solar System, the results are in excellent agreement with data as presented in Table 2 and Figure 17.

Table 2 These results, calculated with the PATH program, are in close agreement with measured data for orbital precession in our Solar System. These values represent converged solutions as illustrated in Figure 17.

Planet	Orbital Precession arcseconds / century	
	Calculated[1]	Observed[2]
Mercury	42.987	42.56 ± 0.94
Venus	8.625	8.4 ± 4.8
Earth	3.839	4.6 + 2.7
Mars	1.351	1.5 + 0.04

[1]Calculated with the PATH program using 256000 iterations.
[2]See Reference 8.

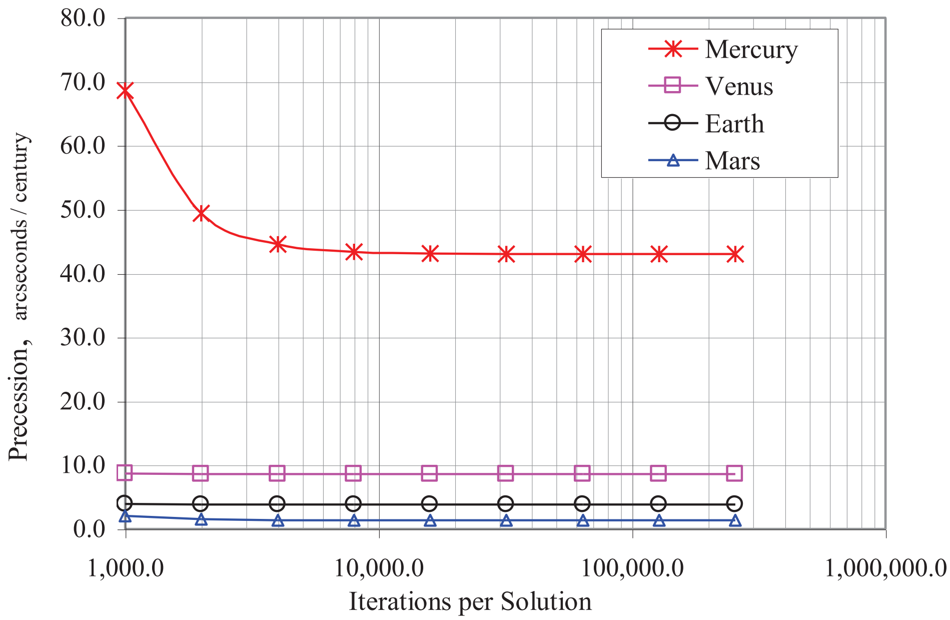


Figure 17 This plot of numerical results, from the PATH program for the orbital precession of planets in our Solar System, demonstrates that the values presented in Table 2 represent converged solutions.

We have now demonstrated that we can model the motion of a photon, baseball, or planet as pure wave propagation. This reinforces our confidence in the definitions and postulates we have established to arrive at this conclusion. It also gives us greater appreciation for the wave nature of matter.

8.4 Wave Propagation Accurately Predicts The Bending Of Light Past The Sun

In this example we use the PATH program to calculate the path of a light wave moving from a distant star just past the surface of the Sun on its journey to Earth. In this program, we use numerical integration to calculate the result. Therefore, in concept the accuracy of the solution should converge to a constant value as we increase the number of iterations used for the calculation. This is precisely what happens. As we increase the number of iterations past 1000, the answer converges to a solution of about 1.75 arcseconds as presented in Figure 18. This agrees well with the answer published in various collage textbooks. Figure 19 presents the calculated path of the light wave as it passes the Sun demonstrating its curved motion.

This is amazing! We can use the same equation that we used in our previous examples to predict the path of a light wave! This is further confirmation that all objects move as a wave.

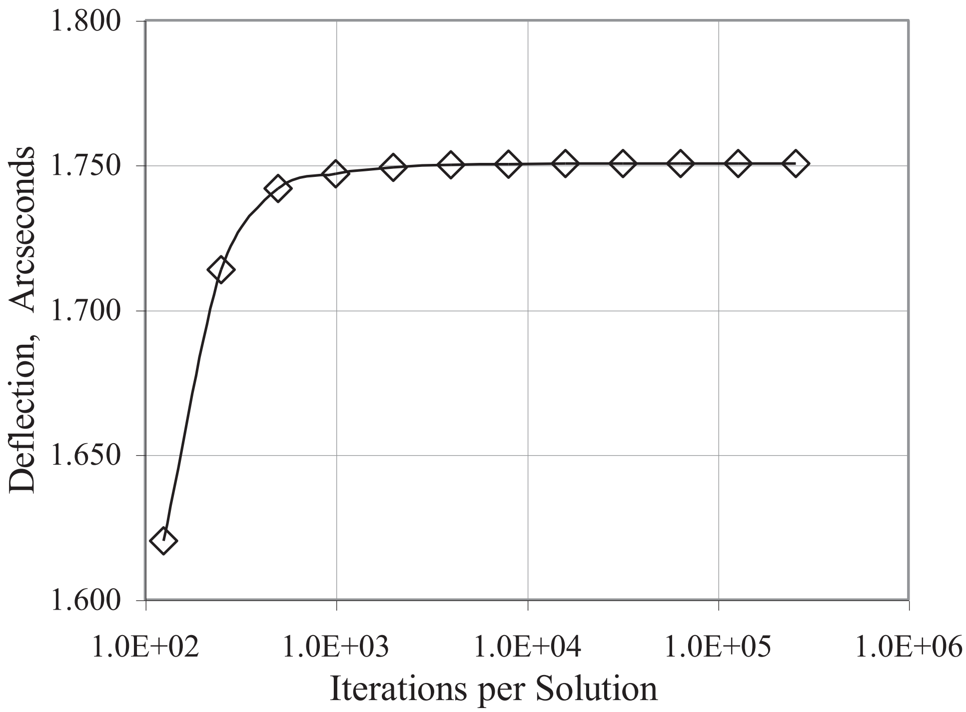


Figure 18 This presents numerical results from the PATH program for calculating the bending of light past the Sun, demonstrating that the solution converges to a value of 1.75 arcseconds in agreement with published data.

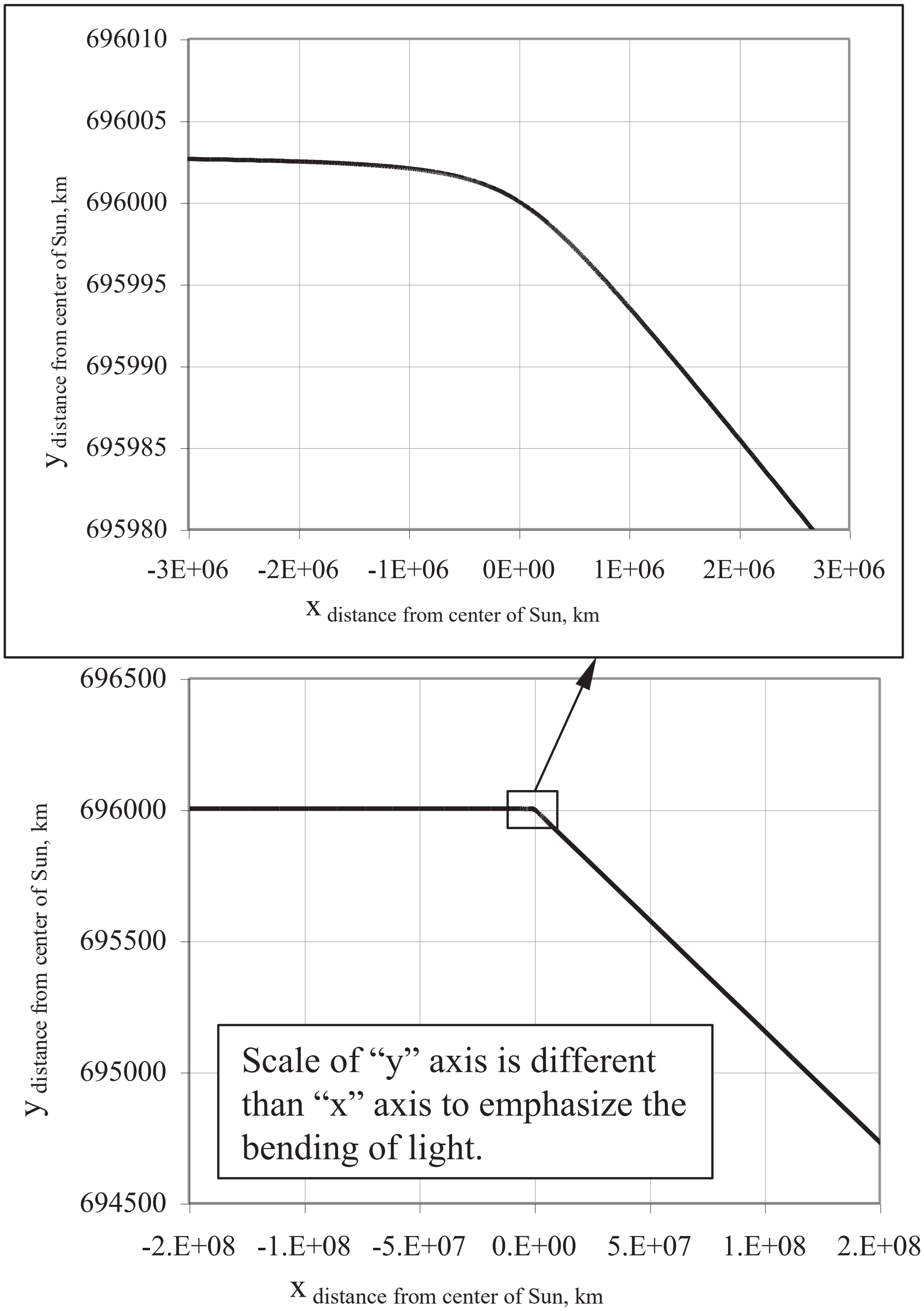


Figure 19 This presents the calculated path for a light wave as it grazes the surface of the Sun from a distant star on its way to the Earth. The scales of the "y" and "x" axis are different to emphasize the bending of light.

9 Verification Of The Need To Modify Newton's Law Of Gravity

We demonstrated in Section 4 that we must modify Newton's law of gravity into the form of corrected gravity as defined in Postulate 6 to be consistent with our definitions of momentum and energy. Table 3 presents a comparison of the resulting equations with similar equations we would have obtained with Newton's original law.

In reviewing Table 3 we see that corrected gravity yields a speed of light as a function of position that is in the form of a natural logarithm. It is interesting to note that this equation is not singular for a radius of zero. In contrast, the equation we obtain for the speed of light based on Newton's original law is singular for a radius of zero.

The information presented in Table 4 also demonstrates that corrected gravity is in better agreement with data than Newton's original law.

Table 3 This table presents a comparison between the equations we derived in Section 4 with similar ones we would have obtained without modifying Newton's law of gravity for a single governing body system.

Value	Based on Newton's Law of Gravity	Based on Corrected Gravity
Force	$F = \frac{mMG}{r^2}$	$F = \frac{m_o MG}{r^2}\frac{c}{c_s}$
c	$c_2 = c_1 - \frac{2MG}{c_s}\left(\frac{r_1 - r_2}{r_1 r_2}\right)$	$c_2 = c_1\, e^{\frac{2MG}{c_s^2}\left(\frac{r_2 - r_1}{r_1 r_2}\right)}$
∇c	$\nabla c = \frac{2MG}{c_s r^2}\hat{\mathrm{r}}$	$\nabla c = \frac{2cMG}{c_s^2 r^2}\hat{\mathrm{r}}$
r_c	$r_c = \frac{c c_s r^2}{\left(1 + \frac{1}{\beta^2}\right) MG(\hat{\mathrm{r}} \bullet \hat{\mathrm{r}}_c)}$	$r_c = \frac{c_s^2 r^2}{\left(1 + \frac{1}{\beta^2}\right) MG(\hat{\mathrm{r}} \bullet \hat{\mathrm{r}}_c)}$

Table 4 This table presents a comparison of predicted values along with some data for the two sets of equations presented in Table 3

Effect	Based on			Units
	Newton's Law of Gravity	Corrected Gravity	Observation	
Deflection of light past the Sun	1.751	1.751	≅ 1.75	arcseconds
Precession of Mercury's orbit	57.315	42.987	≅ 43	$\frac{\text{arcseconds}}{\text{century}}$
Red shift of light from the Sun	2.11E-06	2.11E-06	≅ 2E-06	
(c - c_s) at the surface of the Sun	-1265.850	-1265.847	N/A	m/s
Gradient of c at the surface of the Sun	1.827854E-06	1.827846E-06	N/A	1/s

This table indicates that corrected gravity as defined in Postulate 6 is correct, since without it the results do not all agree with observation. Figure 20 indicates that corrected gravity also provides a more reasonable prediction near a very large governing body than Newton's original law.

It is interesting to observe (see Table 4) that at the surface of the Sun the difference in the calculated speed of light between these two methods is only 0.003 m/s. The difference in the gradient of the speed of light is also very small at only 0.0004%. However, these very small values cause a huge difference of 33% in the calculated precession of Mercury's orbit. This shows that ignoring higher order influences can cause a very large error when attempting to calculate the precession of an orbit.

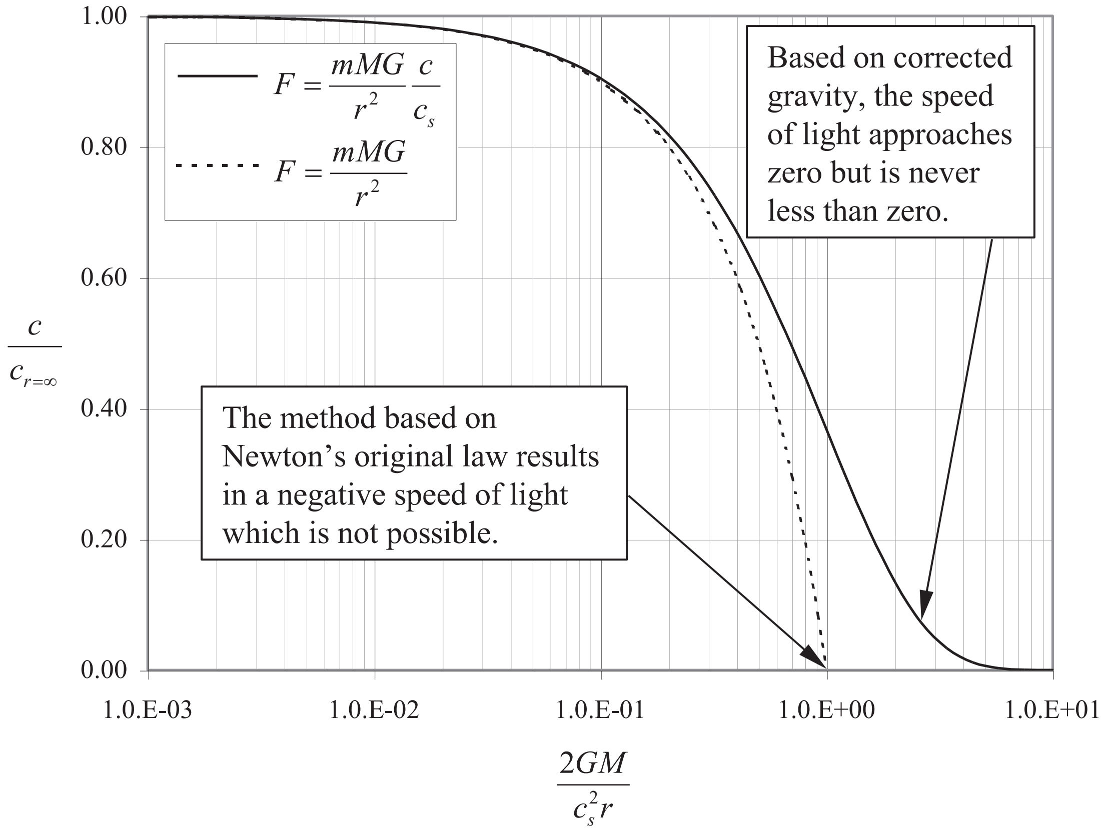


Figure 20 The speed of light based on corrected gravity, as defined in Postulate 6, can approach zero but it can never become less than zero. However, equations based on Newton's original law of gravity can result in a negative or imaginary value for the speed of light.

In Figure 20 we observe that the speed of light as calculated with Newton's law of gravity can become negative near a very large governing body. This is not possible. For motion, the magnitude of velocity must always be positive. Hence, we conclude that there is something wrong with this approach. However, when we modify Newton's law of gravity into the form of corrected gravity (see Postulate 6) we see that the velocity of light is always positive, which is a much more reasonable result. Combining this observation with the comparisons presented in Table 4 reinforces our confidence in Postulate 6.

Based on Postulate 6, observational data of a very large governing body could be interpreted as a "black hole" by cosmologists. However, Postulate 6 does not satisfy the traditional concept of a black hole. Instead, we have a concept indicating that as a governing body becomes very large; it loses the ability to absorb matter. This is because as it captures a particle it converts most of the matter to light and emits this back into space as radiation, much of which could be in the form of long wavelength electromagnetic energy. The result is a body that may be black in "visible radiation" but bright in terms of long wavelength radiation depending on the amount of particular matter it captures from space. The scientific community should study the validity of this concept.

10 Future Considerations

This section provides a short list of some topics that we should investigate with the definitions and postulate we have developed. There is still a lot more to learn!

10.1 The Influence Of Acceleration On Natural Frequency

We have not investigated the influence of acceleration on the wavelength of interaction between two objects. However, it should be possible to solve for this relationship by including acceleration in the derivation presented in Section 6.3. The result should be a further increase (over what is associated with velocity only) in the wavelength of interaction and a further reduction in natural frequency.

10.2 Frame Dragging As Caused By A Governing Body Imparting Rotation To The Matter Of Space

The concept of "Frame Dragging" is reasonable as outlined in Section 6 and deserves further investigation in light of the definitions and postulates presented in this work.

10.3 The Speed Of Gravity Waves

By nature of the method presented in this work, the characteristic velocity of gravity waves is equal to the speed of light. This is because a gravity wave would be a disturbance in the matter of space, which would move with the characteristic velocity of space or the speed of light.

10.4 The Density Of Space

Based on Postulate 12, space is a form of matter. Therefore, it must have density. It is the author's opinion that the density of space is inversely proportional to the speed of light in the same way that rest matter is (see Section 6.6). We should investigate this concept further to determine if it is possible to calculate the density of space.

10.5 Gravitational Force Between Galaxies

If we know the gradient of the speed of light, we can predict the path of motion. We have derived this for a single governing body system based on the properties of matter in our solar system. In the regions between galaxies the type of matter and the properties thereof may be different. Therefore, equation (7-12) may not be valid in the space between galaxies. However, equation (7-9) should still give the correct results.

11 Conclusion

We have accomplished our first two objectives by defining the meaning and characteristics of time and by defining a standard unit of matter in terms of light (see section 2.5).

We have achieved our third objective by explaining why motion and gravity influence the natural frequency of matter. We have also shown that this explanation is in agreement with experimental evidence (see Section 5).

Finally we have achieved our fourth objective by explaining what gravity is and developing a method for predicting the motion of matter as presented in Section 7.

In summary, we have presented a concept of time, matter, and gravity that is useful in understanding how things work. Specifically we have demonstrated that:

- The foundation of definitions and postulates presented in this work provides an effective framework for explaining the laws of nature.
- The Position Definition of Time provides a sound basis for understanding the behavior of matter.
- The units of time, length, and matter can be defined in terms of light.
- We can model the influence of a governing body on its surroundings as a distortion in space that causes the speed of light to be a function of position.
- Mass, charge, and natural frequency are proportional to the square root of the speed of light.
- We can model the wavelength of interaction as a function of the momentum of interaction.
- A particle can be modeled as a standing electromagnetic wave.
- The force of gravity and the motion of matter in the form of photons, baseballs, and planets can be described in terms of wave propagation.

12 References

1 Peter J. Mohr and Barry N. Taylor, CODATA Recommended Values of the Fundamental Physical Constants: 2002, To be Published. This information was obtained from http://physics.nist.gov/constants on 3/3/2004.

2 Newton, Isaac "The Principia" Translated by Andrew Motte, Published 1995 by Prometheus Books in the "Great Minds Series" page 14

3 Webster's New Encyclopedic Dictionary; Copyright 1993

4 Quote from Loren R. Anderson provided during a review of this book in 1995

5 Kaplan, Irving; Nuclear Physics pages 386-387 Copyright 1955

6 Shigley, Joseph Edward (1969) Kinematic Analysis of Mechanisms Second Edition pages 15-17

7 This information was obtained from the following web address on 3/23/2004. http://nssdc.gsfc.nasa.gov/planetary/factsheet/sunfact.html

8 V. M. Blanco and S. W. McCuskey (1961) Basic Physics Of The Solar System page 217

Appendix A PATH Fortran Program For Calculating The Path Of Motion

This program makes it possible for us to calculate an object's path of motion with numerical methods. It is only valid for an object of constant matter along the path of motion and for a single governing body system. As such, we ignore the matter of the object in calculating the gradient of the speed of light.

We use Vectors in a Cartesian coordinate system to keep track of the math. We use equation (4-12) in the form of equation (4-14) to calculate the speed of light as a function of position. We integrate the overall path numerically by dividing the total path into small arcs, calculating the radius of curvature for these arcs with equation (7-12) and add up the individual arc lengths.

Figure 21 presents a particle that is moving through space along a curved path. If we know the direction and curvature of motion at point 1, we can estimate the direction of motion at point 2 by rotating the curvature vector, r_{c1}, through an angle of α. The radius of curvature at point 2 can then be calculated and compared to r_{c1}. If there is a significant difference, we use an average value and re-calculate the location of point 2. After we have determined the location of point 2, we can repeat the process and calculate the next position along the path. This is a simplified explanation of the process we use in our program to calculate the path of motion.

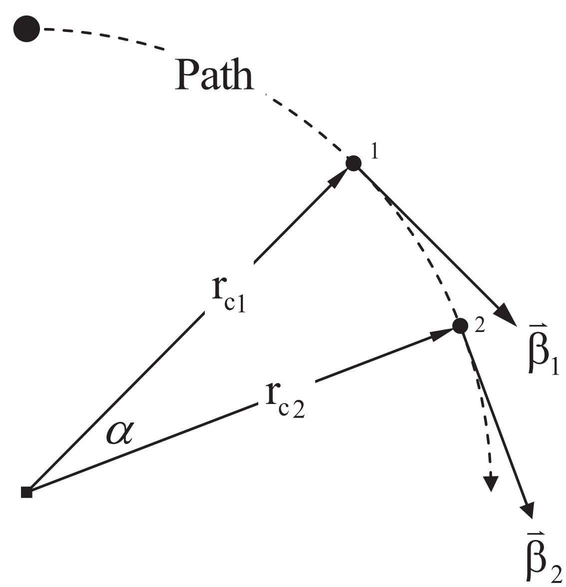


Figure 21 The radius of curvature, based on equation (7-12), is used to integrate the path of motion.

The input file setup is described in the PATH program with comment statements. Appendix B presents example output files from the program. These can also be used by the reader as sample input files to verify that the program is working correctly.

In using the PATH program to calculate the precession of an orbit, the essential points to remember are:

1. The initial conditions should represent the nearest approach to the governing body. As such, the initial velocity should be normal or perpendicular to the position vector that originates at the center of the governing body.
2. Enter a total rotation angle of 360° to calculate the precession associated with one orbit.
3. The program will calculate the actual rotation that is required for the object to return to a condition where the velocity vector and the position vector are again normal to each other. This is determined in the program mathematically as the point were the dot product of the velocity vector and the position vector is equal to zero.

We use the same general input setup with the PATH program to calculate the trajectory of a ball or light wave. However, the user may set up the initial conditions as desired and there is no check on the dot product at the end of the path. The program simply stops after rotating the path through the required angle. The user can limit the maximum path length for an individual calculation step. This ability is very useful when calculating the path that a light wave follows through space near a star. This is because the radius of curvature quickly approaches a very large value as it leaves the vicinity of the star.

PATH Fortran Program Listing

This program in its current form will not work for an initial velocity of zero. However, if the initial velocity is zero, the motion will be parallel to the gradient in the speed of light. Therefore, the reader could create a simple spreadsheet program with the equations presented in the book to solve these types of problems.

Numerical precision is very important in calculating the precession of orbits in our Solar System. Therefore, in order to duplicate the results presented in this book, it is recommended that this program be compiled in double precision on a system with similar or better capability than an IBM type 9112-265 workstation.

```
Program PATH
c-----------------------------------------------------------------------
c
c     Author:  Morris G. Anderson
c
c     This program can be used to calculate the path of an orbit,
c     the precession of an orbit, and the path of a trajectory.
c
c               Created on  August 28, 2002
c               Last update March 30, 2004
c
c   This program was written to run on an IBM Type 9112-265 workstation
c
c         Compile this program as follows:
c
c         xlf -qautodbl=dblpad -o path path_aix_march_30_2004.f
c
c     program files:
c
c             in  = input file
c             out = output file containing the input file information
c                   along with the calculated orbital precession
c                   information if applicable.
c             xy  = output file containing calculated results along
c                   the objects path.
c
c-----------------------------------------------------------------------
c
c     Definitions
c
c     a   = angle of change for the vector rc per iteration
c     am  = maximum angle for calculation
c     b   = motion vector. 1 = i, 2 = j, 3 = k, 4 = magnitude of v / c
c     c   = speed of light at a given point
c     cr  = the reference speed of light at a distance of rr from m
c     cs  = standard speed of light
c     g   = gravitational constant
c     m   = mass of gravitational body
c     ni  = number of increments for path calculation
c     pi  = 3.14159265359
c     r   = position vector. 1 = i, 2 = j, 3 = k, 4 = magnitude of r
c     rc  = curvature vector. 1 = i, 2 = j, 3 = k, 4 = magnitude of rc
c     rr  = radius from center of m corresponding to cr
c     sm  = maximum path length per calculation, if = 0.0 then
c           there is no constraint
c     v   = velocity
c     vt  = temporary vector used in calculations
c     w   = rotation vector
c-----------------------------------------------------------------------
      Integer dn
      parameter ( dn = 500000 )

      Real * 16  a, ab, am, cr, cs, f0, f1,  g, m, pi, rr, s, si, sm,
     +           t, tol, v, vx, vy, vz,  x, x0, x1, y, z

      Real * 16  b (dn,4), c (dn), r (dn,4), rc (dn,4), w (4)

      Character * 90 title
      Character * 4  title7, beta

      beta = 'beta'

      open (  5, file = 'in'     )
      open (  6, file = 'out'    )
      open (  7, file = 'xy'     )
```



```
c     Read input file data

c     Read in program option.  1 = Orbital Precession, 2 = Trajectory

      Read (5, '( a90 )' ) title
      Read (5, *) option
      Write (6, '( a90, /f2.0  )' ) title, option

c     Read in the standard speed of light,cs, in m/s

      Read (5, '( /a90 )' ) title
      Read (5,*) cs
      Write (6, '( /a90, /e21.15  )' ) title, cs

c     Read in pi, the ratio of circumference to diameter of a circle

      Read (5, '( /a90 )' ) title
      Read (5,*) pi
      Write (6, '( /a90, /e21.15  )' ) title, pi


c     Read in the reference speed of light in m/s

      Read (5, '( /a90 )' ) title
      Read (5,*) cr
      Write (6, '( /a90, /e21.15  )' ) title, cr

c     Read in the radius from m for cr in meters.

      Read (5, '( /a90 )' ) title
      Read (5,*) rr
      Write (6, '( /a90, /e21.15  )' ) title, rr

c     Read in g, universal gravitational constant. Units = m^3/(kg s)

      Read (5, '( /a90 )' ) title
      Read (5,*) g
      Write (6, '( /a90, /e21.15  )' ) title, g

c     Read in m, This is the mass of the governing body in kilograms

      Read (5, '( /a90 )' ) title
      Read (5,*) m
      Write (6, '( /a90, /e21.15  )' ) title, m

c     Read in x, y, z,  Initial location coordinates with respect to
c     the center of mass of the governing body, m, in meters.

      Read (5, '( /a90 )' ) title
      Read (5,*) x, y, z
      Write (6, '( /a90, /3e21.15  )' ) title, x, y, z

c     Read in vx, vy, vz, Initial velocity in m/s.  If the first part
c     of the title is input as "beta", then these values are treated
c     as vx/c, vy/c, vz,c

      Read (5, '( /a4, a90 )' ) title7, title
      Read (5,*) vx, vy, vz
      Write (6, '( /a4, a90, /3e21.15  )' ) title7, title, vx, vy, vz

c     Read in number of rotation steps (ni), maximum rotation in
c     degrees (am), and the maximum path length of rotation (sm).
c     If sm is set to 0.0, then there is no limit applied to path
c     length of each step.

      Read (5, '( /a90 )' ) title
```



```
      Read (5,*) ni, am, sm
      Write (6, '( /a90, /i10, 2e16.9  )' ) title, ni, am, sm

      am = am * pi / 180.0
      a   = am / ni


c-----------------------------------------------------------------------
c     Calculate initial values for starting point
c-----------------------------------------------------------------------

      r (1,4) = sqrt (  x*x +  y*y + z*z  )
      r (1,1) = x  /  r(1,4)
      r (1,2) = y  /  r(1,4)
      r (1,3) = z  /  r(1,4)

      c(1) = cr *exp( (2*m*g/cs/cs ) * ( ( r(1,4)-rr ) / (rr*r(1,4))) )


      If ( title7 .eq. beta ) Then

       b ( 1, 4 ) = sqrt(  vx * vx + vy * vy + vz * vz )

       b ( 1, 1 ) = vx /  b ( 1,4 )
       b ( 1, 2 ) = vy / b ( 1,4 )
       b ( 1, 3 ) = vz / b ( 1,4 )

      Else

       v  = sqrt(  vx * vx + vy * vy + vz * vz )

       b ( 1, 4 ) = v  /  c ( 1 )

       b ( 1, 1 ) = (  vx  /  c ( 1 )  )  /  b ( 1,4 )
       b ( 1, 2 ) = (  vy  /  c ( 1 )  )  /  b ( 1,4 )
       b ( 1, 3 ) = (  vz  /  c ( 1 )  )  /  b ( 1,4 )

      Endif

c     Calculate direction of rotation vector - use cross product.  This
c     is a unit vector that is perpendicular to the plane of rotation.

      w(1) =  r(1,2) * b(1,3)  -  r(1,3) * b(1,2)
      w(2) =  r(1,3) * b(1,1)  -  r(1,1) * b(1,3)
      w(3) =  r(1,1) * b(1,2)  -  r(1,2) * b(1,1)

      w(4) = SQRT( w(1)**2 + w(2)**2 + w(3)**2 )

      w(1) = w(1) / w(4)
      w(2) = w(2) / w(4)
      w(3) = w(3) / w(4)
      w(4) = 1

c     Calculate the direction of the curvature vector at the starting
c     point.  This is done with a cross product.

      rc(1,1) =  b(1,2) * w(3)  -  b(1,3) * w(2)
      rc(1,2) =  b(1,3) * w(1)  -  b(1,1) * w(3)
      rc(1,3) =  b(1,1) * w(2)  -  b(1,2) * w(1)

c ----------------------------------------------------------------------
c     option = 1.  The program calculates the precession of an orbit.
c                  If the max angle (am) is input as 360 this is done
c                  for one revolution.  If it is put in as 2 * 360 this
c                  is done for two revolutions. and so forth.
c ----------------------------------------------------------------------
```

```
      If ( option .ne. 1 ) Go to 100


      nmax   = 50

      icount = 1

      tol   = 1e-20

      x0 = am
      f0 = curve ( a, b, c, cs, g, m, ni, r, rc, sm, w )

      am  = am + 0.01
      a   = am / ni

      x1 = am
      f1 = curve ( a, b, c, cs, g, m, ni, r, rc, sm, w )



      Do 10 j = 1, nmax


       x = x1 - f1 * ( x1 - x0 ) / ( f1 - f0 )

       If ( abs (( x - x1 )/x1) .lt. tol ) Go to 20

       x0 = x1
       x1 = x
       f0 = f1

       am = x1
       a   = am / ni


       f1 = curve ( a, b, c, cs, g, m, ni, r, rc, sm, w )

       icount = icount + 1

       Write ( 6,'(''iteration'', i5)') icount

10    Continue

20    Continue

      If ( icount .ge. nmax ) Then

       Write ( 6, '( '' solution failed to converge for option 1'')')

      Endif

      ab = b(ni+1,1)*b(1,1) + b(ni+1,2)*b(1,2) + b(ni+1,3)*b(1,3)

      ab = acos(ab)*180.0/pi

      Write(6, '(/''Rotation   = '',1e21.15,'' degree'' )' )am*180.0/pi
      Write(6, '( ''Precession = '',1e21.15,'' degree'' )' ) ab

      Go to 200

100   Continue
c ---------------------------------------------------------------------
c     option = 2.  This option calculates the trajectory of motion.
c                  For example:  if the max angle is input as 35 this
```

```
c                  is done for a total change in the path direction of
c                  35 degrees.
c ---------------------------------------------------------------------

      If ( option .ne. 2 ) Go to 200

      f1 = curve ( a, b, c, cs, g, m, ni, r, rc, sm, w )

      t = 0

      Write(7,'(10x,''x'',19x,''y'',19x,''z'',18x,''rc'',15x,''c'',
     +          15x,''b'',15x,''v'',15x,''t'')')


      Do 110 j = 1, ni+1

      Write(7, '( 3e21.15, 1e15.5, 4e16.9   )' )
     +                          r(j,1) * r(j, 4),
     +                          r(j,2) * r(j, 4),
     +                          r(j,3) * r(j, 4),
     +                         rc(j,4),  c(j   ),
     +                          b(j,4),
     +                          b(j,4) * c(j),
     +                          t

c     Calculate angle between position vectors in the solution.  This
c     is used to calculate the individual path lengths so that the
c     corresponding time intervals can be calculated.

      ab = rc(j,1)*rc(j+1,1) + rc(j,2)*rc(j+1,2) + rc(j,3)*rc(j+1,3)

c     Numerical errors can cause ab to be greater than 1.0.  Therefore,
c     check value.  If greater than 1.0 set equal to 1.0

      if (ab .gt. 1.0 ) ab = 1.0

      ab = acos(ab)

      s = ab * ( rc(j,4) + rc(j+1,4) ) / 2.0

      t = t + s / ( ( b(j,4) * c(j) + b(j+1,4) * c(j+1) ) / 2.0 )

110   Continue

c
c     Calculate the total angle of rotation
c
      ab = b(ni+1,1)*b(1,1) + b(ni+1,2)*b(1,2) + b(ni+1,3)*b(1,3)

      ab = acos(ab)*180/pi

      Write(6,'(/''Angle between start and end in deg. ='',1e21.15)')ab

200   Continue


      t = 0
      s = 0

      jrmin = 1
      jrmax = 1

      Do 250 j = 1, ni+1


c     Calculate the time required from start to finish.
```



```
      si = a * ( rc(j,4) + rc(j+1,4) ) / 2.0

      t = t + si / ( ( b(j,4) * c(j) + b(j+1,4) * c(j+1) ) / 2.0 )

      s = s + si

c     Check for min and max radius

      if ( r(j,4) .lt. r(jrmin,4) ) jrmin = j
      if ( r(j,4) .gt. r(jrmax,4) ) jrmax = j


250    Continue

      Write(6, '(/''Rotation time        = '', 1e21.15,'' s'' )' ) t

      Write(6, '(''Total path length    = '', 1e21.15,'' m'' )' ) s

      Write(6, '(''End position "x y z" = '', 3e21.15, '' m'' )' )
     +             r(ni+1,1) * r(ni+1, 4),
     +             r(ni+1,2) * r(ni+1, 4),
     +             r(ni+1,3) * r(ni+1, 4)

      Write(6, '(/''At Max radius    = '', 1e21.15,'' m'' )')r(jrmax,4)
      Write(6,'(13x,''v/c = '', 1e21.15,''    '')') b(jrmax,4)
      Write(6,'(13x,''v   = '', 1e21.15,'' m/s'')') b(jrmax,4)*c(jrmax)
      Write(6,'(13x,''c   = '', 1e21.15,'' m/s'')') c(jrmax)

      Write(6, '(/''At Min radius    = '', 1e21.15,'' m'' )')r(jrmin,4)
      Write(6,'(13x,''v/c = '', 1e21.15,''    '')') b(jrmin,4)
      Write(6,'(13x,''v   = '', 1e21.15,'' m/s'')') b(jrmin,4)*c(jrmin)
      Write(6,'(13x,''c   = '', 1e21.15,'' m/s'')') c(jrmin)

      Stop
      End

c-----------------------------------------------------------------------
c
c                  Function curve
c
c     This function calculates the average radius of curvature for a
c     given amount of orbital rotation and the end point conditions.
c-----------------------------------------------------------------------
      Function curve( a, b, c, cs, g, m, ni, r, rc, sm, w )

      Integer dn

      Parameter ( dn = 500000 )

      Real * 16  a, ai, cs, dc, g, m, rca, rcheck, sm, tol

      Real * 16  g1, g2, g3, g4, g5, g6, g7, g8,r2, x2, y2, z2

      Real * 16  b (dn,4), c (dn), r (dn,4), rc (dn,4), vt (4), w (4)


      Do 30 n = 1, ni

c     Calculate path radius of curvature at point n

      rc(n, 4) =    (  r(n,4) * r(n,4) * cs**2  )     /
     +           (  ( 1 + 1 / b(n,4)**2 ) * m * g  )  /
     +  (  r(n,1) * rc(n,1) + r(n,2) * rc(n,2) + r(n,3) * rc(n,3)  )
```

```
      rca = rc(n, 4)

c     Calculate direction of curvature vector for n+1

      ai = a

c     Check on limit of path length for iteration

      IF ( sm .GT. 0.0 ) Then
       IF ( (rca * ai) .gt. sm ) ai = sm / rca
      ENDIF

       vt(1) = rc ( n, 1 ) + b (n,1)  *  abs (  tan ( ai )  )
       vt(2) = rc ( n, 2 ) + b (n,2)  *  abs (  tan ( ai )  )
       vt(3) = rc ( n, 3 ) + b (n,3)  *  abs (  tan ( ai )  )

       vt(4) = sqrt( vt(1)*vt(1) + vt(2)*vt(2) + vt(3)*vt(3) )

       rc ( n+1, 1 ) = vt(1) / vt(4)
       rc ( n+1, 2 ) = vt(2) / vt(4)
       rc ( n+1, 3 ) = vt(3) / vt(4)


      x2 = r(n,1) * r(n,4)  + rca * ( rc(n+1,1) - rc(n,1) )
      y2 = r(n,2) * r(n,4)  + rca * ( rc(n+1,2) - rc(n,2) )
      z2 = r(n,3) * r(n,4)  + rca * ( rc(n+1,3) - rc(n,3) )

      r2 = sqrt ( x2 * x2  +  y2 * y2  +  z2 * z2 )

c     c2 = c(1) * exp((2*m*g/cs/cs ) * (  (r2-r(1,4)) / (r(1,4)*r2 )) )
c     dc = c(1) - c2

c     ----------------------------------
c     Calculate conditions for point n+1.
c     ----------------------------------

c     Calculate speed of light at point n+1.

      g1 = ((2*m*g/cs/cs ) * (  (r2-r(1,4)) / (r(1,4)*r2 )) )
      g2 = g1 * g1
      g3 = g2 * g1
      g4 = g3 * g1
      g5 = g4 * g1
      g6 = g5 * g1
      g7 = g6 * g1
      g8 = g7 * g1

      dc = c(1)*(-g1 -g2/2. -g3/6. -g4/24. -g5/120.0
     +            -g6/720. -g7/5040. -g8/40320)

      c (n+1) = c(1) - dc

c     Calculate direction of motion at point n+1

      b(n+1,1) =  w(2) * rc(n+1,3)  -  w(3) * rc(n+1,2)
      b(n+1,2) =  w(3) * rc(n+1,1)  -  w(1) * rc(n+1,3)
      b(n+1,3) =  w(1) * rc(n+1,2)  -  w(2) * rc(n+1,1)

c     Calculate beta at point n+1

      b(n+1, 4) = sqrt (  (  dc + b(1,4)*b(1,4) * c(n+1)  ) / c(1)  )

c     Calculate position vector at point n+1

      r ( n+1 , 1 ) = x2 / r2
      r ( n+1 , 2 ) = y2 / r2
```

```
      r ( n+1 , 3 ) = z2 / r2
      r ( n+1 , 4 ) = r2


      j = 0

10    Continue

      j = j + 1

      If ( j .gt. 1000) Then
       Write(6, '( ''solution failed to converge for rc at n ='',I6)')n
       Go to 20
      Endif

c     Calculate path radius of curvature at point n+1

      rc(n+1, 4) =    (  r(n+1,4) * r(n+1,4) * cs**2  )     /
     +            (  ( 1 + 1 / b(n+1,4)**2 ) * m * g  )  /
     +  (  r(n+1,1) * rc(n+1,1) + r(n+1,2) * rc(n+1,2) +
     +                                r(n+1,3) * rc(n+1,3)  )

c     Check on difference in curvature used to calculate point n+1.  If
c     greater than tolerance, calculate point n+1 based on the average
c     radius of curvature between point n and n+1.

       rcheck = (  rc(n,4) + rc(n+1,4)  ) / 2

       If ( ABS ( 1 - (rca / rcheck) ) .lt. 1e-20 ) Then
        Go to 20
        Else
        rca = rcheck
       Endif

c     Check on limit of path length for iteration and re-calculate
c     direction of curvature vector for n+1 if required.

      IF ( sm .GT. 0.0 ) Then
       IF ( ( rca * ai ) .gt. sm ) ai = sm / rca

       vt(1) = rc ( n, 1 ) + b (n,1)  *  abs (  tan ( ai )  )
       vt(2) = rc ( n, 2 ) + b (n,2)  *  abs (  tan ( ai )  )
       vt(3) = rc ( n, 3 ) + b (n,3)  *  abs (  tan ( ai )  )

       vt(4) = sqrt( vt(1)*vt(1) + vt(2)*vt(2) + vt(3)*vt(3) )

       rc ( n+1, 1 ) = vt(1) / vt(4)
       rc ( n+1, 2 ) = vt(2) / vt(4)
       rc ( n+1, 3 ) = vt(3) / vt(4)

      ENDIF


      x2 = r(n,1) * r(n,4)  + rca * ( rc(n+1,1) - rc(n,1) )
      y2 = r(n,2) * r(n,4)  + rca * ( rc(n+1,2) - rc(n,2) )
      z2 = r(n,3) * r(n,4)  + rca * ( rc(n+1,3) - rc(n,3) )

      r2 = sqrt ( x2 * x2  +  y2 * y2  +  z2 * z2 )

c     c2 = c(1) * exp((2*m*g/cs/cs ) * (  (r2-r(1,4)) / (r(1,4)*r2 )) )
c     dc = c(1) - c2

c     -----------------------------------
c     Calculate conditions for point n+1.
c     -----------------------------------
```

```
c     Calculate speed of light at point n+1.

      g1 = ((2*m*g/cs/cs ) * (  (r2-r(1,4)) / (r(1,4)*r2 )) )
      g2 = g1 * g1
      g3 = g2 * g1
      g4 = g3 * g1
      g5 = g4 * g1
      g6 = g5 * g1
      g7 = g6 * g1
      g8 = g7 * g1

      dc = c(1)*(-g1 -g2/2. -g3/6. -g4/24. -g5/120.0
     +            -g6/720. -g7/5040. -g8/40320)

      c (n+1) = c(1) - dc

c     Calculate direction of motion at point n+1

      b(n+1,1) =  w(2) * rc(n+1,3)  -  w(3) * rc(n+1,2)
      b(n+1,2) =  w(3) * rc(n+1,1)  -  w(1) * rc(n+1,3)
      b(n+1,3) =  w(1) * rc(n+1,2)  -  w(2) * rc(n+1,1)

c     Calculate beta at point n+1

      b(n+1, 4) = sqrt (  (  dc + b(1,4)*b(1,4) * c(n+1)  ) / c(1)  )

c     Calculate position vector at point n+1

      r ( n+1 , 1 ) = x2 / r2
      r ( n+1 , 2 ) = y2 / r2
      r ( n+1 , 3 ) = z2 / r2
      r ( n+1 , 4 ) = r2

      Go to 10

20    Continue

c     Calculate dot product between position unit vector and direction
c     unit vector at point n+1.

      curve = b(n+1,1)*r(n+1,1) + b(n+1,2)*r(n+1,2) + b(n+1,3)*r(n+1,3)

30    Continue

      Return
      End
```


Appendix B PATH Fortran Program Output Files

A few of the output files that were used to create the charts presented in Section 8 are included in the following sections. These files can also serve as input files for the program as a check to see if it reproduces correct results when compiled.

Output File - The Trajectory Example Presented In Figure 14

```
Trajectory:  Program option.  1 = Orbital Precession, 2 = Trajectory
2.

cs,  The speed of light at the standard location in m/s
 .299792458000000E+09

pi,  Ratio of the circumference to diameter of a circle
 .314159265358979E+01

cr, The Speed of light in a vacuum at a radius of rr from m in m/s
 .299792458000000E+09

rr, The radius from m for cr.            This value is the Semimajor axis of Earth
 .636745000000000E+07

g,  Gravitational constant in m^3/(kg s)
 .667420000000000E-10

M,  Mass of governing body in kilograms.   This is the mass of the Earth
 .597230000000000E+25

X, Y, Z,  Initial coordinates in meters.   Average radius of Earth
 .000000000000000E+00 .636745000000000E+07 .000000000000000E+00

Vx, Vy, Vz   Initial velocity in m/s.      This is a slow moving particle
 .100000000000000E+00 .100000000000000E+00 .000000000000000E+00

Number of Rotation Steps, Maximum degree of rotation, No limit on sm
       100  .125000000E+03  .000000000E+00

Angle between start and end in deg. = .125000000000000E+03

Rotation time        =  .756884028478068E-01 s
Total path length    =  .214046437883099E-01 m
End position "x y z" =  .684750483931437E-02 .636744998391984E+07 .000000000000000E+00 m

At Max radius    =  .636745000050866E+07 m
             v/c =  .333539742408863E-09
             v   =  .999926992174400E-01 m/s
             c   =  .299792458000000E+09 m/s

At Min radius    =  .636744998391984E+07 m
             v/c =  .193403005732213E-08
             v   =  .579807624730484E+00 m/s
             c   =  .299792458000000E+09 m/s
```

Output File - The Precession Example Presented In Figure 16

This file is for a single orbit. However, the information presented in Figure 16 was calculated for a total rotation of 3600 degrees using only 3600 iterations.

```
Precession:  Program option.  1 = Orbital Precession, 2 = Trajectory
1.

cs,  The speed of light at the standard location in m/s
 .299792458000000E+09

pi,  Ratio of the circumference to diameter of a circle
 .314159265358979E+01

cr, The Speed of light in a vacuum at a radius of rr from m in m/s
 .299792464336000E+09

rr, The radius from m for cr.              Very far away from m
 .100000000000000E+21

g,  Gravitational constant in m^3/(kg s)
 .667420000000000E-10

m,  Mass of governing body in kilograms.   A very massive Sun
 .300000000000000E+37

x, y, z,  Initial coordinates in meters.
 .000000000000000E+00 .460000000000000E+11 .000000000000000E+00

beta, bx, by, bz  Initial velocity in m/s. A very fast moving planet
-.300000000000000E+00 .000000000000000E+00 .000000000000000E+00

Number of Rotation Steps, Maximum degree of rotation, No limit on sm
    256000  .360000000E+03  .000000000E+00
iteration    2
iteration    3
iteration    4
iteration    5
iteration    6

Rotation   =  .389264114766054E+03 degree
Precession =  .292641147660537E+02 degree

Rotation time        =  .364568288769602E+06 s
Total path length    =  .392643780381442E+13 m
End position "x y z" = -.224864636042492E+11 .401292780220973E+11 .000000000000000E+00 m

At Max radius    =  .169350783080706E+13 m
             v/c =  .895397061033541E-02
             v   =  .267727970135183E+07 m/s
             c   =  .299004745253630E+09 m/s

At Min radius    =  .460000000000000E+11 m
             v/c =  .300000000000000E+00
             v   =  .816348404124408E+08 m/s
             c   =  .272116134708136E+09 m/s
```

Output File - Orbital Precession Of Mercury - See Figure 17

This file can also be used with the PATH program to calculate the results presented in Figure 15 by changing the program option to “2” for Trajectory. This will limit the calculation to a total rotation of only 360°. However, this makes very little difference in the answer because for this case the precession of the orbit is extremely small.

```
Mercury:  Program option.  1 = Orbital Precession, 2 = Trajectory
1.

cs,  The speed of light at the standard location in m/s
 .299792458000000E+09

pi,  Ratio of the circumference to diameter of a circle
 .314159265358979E+01

cr, The Speed of light in a vacuum at a radius of rr from m in m/s
 .299792458418000E+09

rr, The radius from m for cr.             This value is the Semimajor axis of Earth
 .149600000000000E+12

g,  Gravitational constant in m^3/(kg s)
 .667420000000000E-10

m,  Mass of governing body in kilograms.   This is the mass of the Sun
 .198861840000000E+31

x, y, z,  Initial coordinates in meters.   This is the perihelion of mercury
 .000000000000000E+00 .460000000000000E+11 .000000000000000E+00

vx, vy, vz   Initial velocity in m/s.      This is the max orbital velocity of mercury
 .589800000000000E+05 .000000000000000E+00 .000000000000000E+00

Number of Rotation Steps, Maximum degree of rotation, No limit on sm
    256000  .360000000E+03  .000000000E+00
iteration    2
iteration    3
iteration    4

Rotation   =  .360000028758250E+03 degree
Precession =  .287582493034713E-04 degree

Rotation time        =  .760001598041246E+07 s
Total path length    =  .359970302925385E+12 m
End position "x y z" =  .230886023229263E+05 .459999999999942E+11 .000000000000000E+00 m

At Max radius    =  .698161358463281E+11 m
             v/c =  .129624208391160E-03
             v   =  .388603592273270E+05 m/s
             c   =  .299792451654249E+09 m/s

At Min radius    =  .460000000000000E+11 m
             v/c =  .196736111821257E-03
             v   =  .589800000000000E+05 m/s
             c   =  .299792445087996E+09 m/s
```


Output File - Orbital Precession Of Venus - See Figure 17

This file can also be used with the PATH program to calculate the results presented in **Figure 15** by changing the program option to “2” for Trajectory. This will limit the calculation to a total rotation of only 360°. However, this makes very little difference in the answer because for this case the precession of the orbit is extremely small.

```
Venus:  Program option.  1 = Orbital Precession, 2 = Trajectory
1.

cs,  The speed of light at the standard location in m/s
 .299792458000000E+09

pi,  Ratio of the circumference to diameter of a circle
 .314159265358979E+01

cr, The Speed of light in a vacuum at a radius of rr from m in m/s
 .299792458418000E+09

rr, The radius from m for cr.            This value is the Semimajor axis of Earth
 .149600000000000E+12

g,  Gravitational constant in m^3/(kg s)
 .667420000000000E-10

m,  Mass of governing body in kilograms.   This is the mass of the Sun
 .198861840000000E+31

x, y, z,  Initial coordinates in meters.   This is the perihelion of Venus
 .000000000000000E+00 .107480000000000E+12 .000000000000000E+00

vx, vy, vz   Initial velocity in m/s.      This is the max orbital velocity of Venus
 .352600000000000E+05 .000000000000000E+00 .000000000000000E+00

Number of Rotation Steps, Maximum degree of rotation, No limit on sm
    256000  .360000000E+03  .000000000E+00
iteration    2
iteration    3
iteration    4

Rotation   =  .360000014738857E+03 degree
Precession =  .147388565020435E-04 degree

Rotation time        =  .194151261948626E+08 s
Total path length    =  .679931310492281E+12 m
End position "x y z" =  .276483243670315E+05 .107479999999996E+12 .000000000000000E+00 m

At Max radius    =  .108950925726159E+12 m
             v/c =  .116026807051464E-03
             v   =  .347839614721332E+05 m/s
             c   =  .299792456209751E+09 m/s

At Min radius    =  .107480000000000E+12 m
             v/c =  .117614700712855E-03
             v   =  .352600000000000E+05 m/s
             c   =  .299792456098528E+09 m/s
```

Output File - Orbital Precession Of Earth - See Figure 17

This file can also be used with the PATH program to calculate the results presented in **Figure 15** by changing the program option to “2” for Trajectory. This will limit the calculation to a total rotation of only 360°. However, this makes very little difference in the answer because for this case the precession of the orbit is extremely small.

```
Earth:  Program option.  1 = Orbital Precession, 2 = Trajectory
1.

cs,  The speed of light at the standard location in m/s
 .299792458000000E+09

pi,  Ratio of the circumference to diameter of a circle
 .314159265358979E+01

cr, The Speed of light in a vacuum at a radius of rr from m in m/s
 .299792458418000E+09

rr, The radius from m for cr.            This value is the Semimajor axis of Earth
 .149600000000000E+12

g,  Gravitational constant in m^3/(kg s)
 .667420000000000E-10

m,  Mass of governing body in kilograms.   This is the mass of the Sun
 .198861840000000E+31

x, y, z,  Initial coordinates in meters.   This is the perihelion of Earth
 .000000000000000E+00 .147090000000000E+12 .000000000000000E+00

vx, vy, vz   Initial velocity in m/s.      This is the max orbital velocity of Earth
 .302900000000000E+05 .000000000000000E+00 .000000000000000E+00

Number of Rotation Steps, Maximum degree of rotation, No limit on sm
    256000  .360000000E+03  .000000000E+00
iteration    2
iteration    3
iteration    4

Rotation   =  .360000010663971E+03 degree
Precession =  .106639707781258E-04 degree

Rotation time        =  .315581197522683E+08 s
Total path length    =  .939910988833635E+12 m
End position "x y z" =  .273765969340963E+05 .147089999999997E+12 .000000000000000E+00 m

At Max radius    =  .152113453133911E+12 m
             v/c =  .976998940644517E-04
             v   =  .292896914383150E+05 m/s
             c   =  .299792458515798E+09 m/s

At Min radius    =  .147090000000000E+12 m
             v/c =  .101036564328684E-03
             v   =  .302900000000000E+05 m/s
             c   =  .299792458317001E+09 m/s
```

Output File - Orbital Precession Of Mars - See Figure 17

This file can also be used with the PATH program to calculate the results presented in **Figure 15** by changing the program option to "2" for Trajectory. This will limit the calculation to a total rotation of only 360°. However, this makes very little difference in the answer because for this case the precession of the orbit is extremely small.

```
Mars:  Program option.  1 = Orbital Precession, 2 = Trajectory
1.

cs,  The speed of light at the standard location in m/s
 .299792458000000E+09

pi,  Ratio of the circumference to diameter of a circle
 .314159265358979E+01

cr, The Speed of light in a vacuum at a radius of rr from m in m/s
 .299792458418000E+09

rr, The radius from m for cr.             This value is the Semimajor axis of Earth
 .149600000000000E+12

g,  Gravitational constant in m^3/(kg s)
 .667420000000000E-10

m,  Mass of governing body in kilograms.   This is the mass of the Sun
 .198861840000000E+31

x, y, z,  Initial coordinates in meters.   This is the perihelion of Mars
 .000000000000000E+00 .206620000000000E+12 .000000000000000E+00

vx, vy, vz   Initial velocity in m/s.      This is the max orbital velocity of Mars
 .265000000000000E+05 .000000000000000E+00 .000000000000000E+00

Number of Rotation Steps, Maximum degree of rotation, No limit on sm
    256000  .360000000E+03  .000000000E+00
iteration    2
iteration    3
iteration    4

Rotation   =  .360000007060750E+03 degree
Precession =  .706074953400820E-05 degree

Rotation time        =  .593228900505534E+08 s
Total path length    =  .142860390685851E+13 m
End position "x y z" =  .254624700303390E+05 .206619999999998E+12 .000000000000000E+00 m

At Max radius    =  .249109858656912E+12 m
             v/c =  .733173249575083E-04
             v   =  .219799812669874E+05 m/s
             c   =  .299792460782305E+09 m/s

At Min radius    =  .206620000000000E+12 m
             v/c =  .883944846226607E-04
             v   =  .265000000000000E+05 m/s
             c   =  .299792460051365E+09 m/s
```

Output File - The Bending Of Light Past The Sun - See Figure 18

```
Light bend past the sun:  Program option.  1 = Orbital Precession, 2 = Trajectory
2.

cs,  The speed of light at the standard location in m/s
 .299792458000000E+09

pi,  Ratio of the circumference to diameter of a circle
 .314159265358979E+01

cr, The Speed of light in a vacuum at a radius of rr from m in m/s
 .299792458418000E+09

rr, The radius from m for cr.             This value is the Semimajor axis of Earth
 .149600000000000E+12

g,  Gravitational constant in m^3/(kg s)
 .667420000000000E-10

m,  Mass of governing body in kilograms.   This is the mass of the Sun
 .198861840000000E+31

x, y, z,  Initial coordinates in meters.   This is the radius of the sun
-.149600000000000E+12 .696002939520000E+09 .000000000000000E+00

beta,  This is to calculate the bending of light past the sun
 .100000000000000E+01 .000000000000000E+00 .000000000000000E+00

Number of Rotation Steps, Maximum degree of rotation, Limit on sm
    256000  .500000000E-03  .149600000E+11

Angle between start and end in deg. = .486273807757701E-03

Rotation time        =  .113480737062477E+15 s
Total path length    =  .340110037470111E+23 m
End position "x y z" =  .105246491903273E+15-.197232339309414E+09 .000000000000000E+00 m

At Max radius    =  .105246491903458E+15 m
             v/c =  .100000000000000E+01
             v   =  .299792464328315E+09 m/s
             c   =  .299792464328315E+09 m/s

At Min radius    =  .696000000000324E+09 m
             v/c =  .100000000000000E+01
             v   =  .299791192153074E+09 m/s
             c   =  .299791192153074E+09 m/s
```