# The Unification of Physics

Richard Lewis


## Abstract

The objective is to find a unified description of physical properties which applies at the small (atomic) scale and at the large (cosmological) scale. The starting point is the General Theory of Relativity. Light is described as a wave disturbance of spacetime propagating through space. The light interference experiment is discussed in detail considering light as a real physical wave passing through the apparatus and interacting with the detector so that probabilistic effects take place at the point of detection. The nature of mass and the nature of charge are explained. The concepts of force and field are shown to be dependent attributes and all properties are shown to be derived from spacetime. The nature of protons, neutrons and electrons as looped waves in spacetime is analysed with the implications for experimental observations. The unification of the four fundamental forces is achieved by recognising that the property "force" is not fundamental. The forces (gravitational, electromagnetic, strong and weak nuclear) arise as a result of differences in energy between possible positions of objects in spacetime. The forces arise in each case due to the context in which they occur. The Theory of Everything (TOE) or master theory question is resolved by showing that the core theory equations are the Einstein equations of GR with a cosmological constant of zero.

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## 1. INTRODUCTION

The objective of this paper is to propose an approach to the unification of physics by attempting to construct a physical worldview which can be used as the context for a unified physical theory. The underlying principle is that we have to construct a clear description of the physical world before we can build a unified physical theory.

The present state of physics is such that there are many theories which all differ in the descriptive context in which they operate. The theories of general relativity, quantum theory, quantum electrodynamics, string theory and the standard model of particle physics are based on differing concepts of the nature of the physical world.

The approach to unification proposed here is to first establish an appropriate physical worldview through analysis of the implications of observation and experiment. Then to identify which physical properties are fundamental and which are dependent. The fundamental physical properties will be selected to bridge the gap between the physical description and the mathematical equations. The next step is to look at the applicability of existing theories in the context of the unified physical description.

The approach to unification in the past has been to try to extend existing theories through trying to extend the mathematical models without giving sufficient consideration to the top level description of the physical world that provides the context for the mathematical equations. The approach proposed here draws on the theory of general relativity as a complete and comprehensive description of spacetime. It is intended to follow the approach used in the development of the theory of general relativity using reasoned analysis and argument to provide a valid description of the physical world for general applicability.

## 2. GENERAL RELATIVITY WORLDVIEW

The papers written by Albert Einstein reveal that he proceeded with a number of thought experiments to reach his conclusions. He worked out in special relativity that, given the experimental result of the constant speed of light this must lead to certain conclusions about space and time. The theory of general relativity was more difficult to work out and a key thought experiment was the equivalence between a uniform acceleration and gravitational effects. He realised that space coordinates could not be Euclidean and realised that Gaussian coordinates were needed to represent curved spacetime.

The theory of general relativity tells us that the effect that we experience as gravity is due to the curvature of spacetime. The presence of mass curves spacetime so that there is an energy difference between an apple hanging in a tree and an apple on the ground due to the spacetime curvature from the mass of the Earth. The same spacetime curvature due to the mass of the Earth ensures that the moon follows its orbital path.

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The theory of general relativity is a fully complete theory with a comprehensive description of spacetime, selected physical properties and equations which have been fully validated by experiment. The theory provides the basis for all our experimental measurements of the property mass including gravitational mass and inertial mass. However, general relativity does not explain how an object with mass curves spacetime.
As part of the theory of special relativity it was found that there is an equivalence between mass and energy so that conservation laws must be changed. It is mass plus energy which is conserved with the possibility of conversion between mass and energy following the equation E = mc2.
Unified Worldview

In order to construct a unified physical theory, we need to start by building up a unified physical description which encompasses the large scale realm of stars and galaxies and also the small scale realm of atoms. The general theory of relativity provides us with a comprehensive description of the large scale. We are given a concept of spacetime in which spacetime takes on the character of a 'fabric' which becomes distorted or curved in the presence of mass. At the small scale we need to have a description of the nature of light and of the constituents of the atom.

Light exhibits the properties of a wave in many experiments and the wave propagation through spacetime proceeds at the velocity of light c which is a universal constant. In our unified description it is proposed that the wave propagation is not only through spacetime but the wave motion is a moving disturbance of spacetime. It is the fabric of spacetime which is supporting a wave propagation at speed c and so we can think of spacetime as the medium for wave propagation.

The equations of general relativity have solutions which represent wave propagation of changes in spacetime curvature through space. This has been used to predict the existence of gravitational waves. The hypothesis of the Spacetime Wave Theory is that gravitational waves, radio waves, light waves, gamma rays etc are all part of the same spectrum of wave propagation in spacetime. Gravitational waves are at the lowest end of the frequency spectrum and gamma rays are at the upper end of the frequency spectrum.

The properties of light are such that although it is like a wave, it also has the property that it is always detected in discrete bundles of energy or quanta. This is because light is always emitted by an atomic electron in discrete bundles of energy. Light has zero rest mass but does have energy and momentum. We can think of these wave quanta of light (photons) as propagating as a disturbance of spacetime. All uniformly moving observers will observe the same speed of light c and physical experiments yield the same results in different uniformly moving frames of reference.

Light is emitted as a result of an atomic electron giving up some of its energy. Experiments show that electrons also have wave-like properties although they do have mass and do not travel at the speed of light. We need to construct a physical description of the electron. Since electrons emit light it is reasonable to adopt a description of the electron as a looped wave disturbance of spacetime. The looped wave is travelling within the loop at the standard velocity of wave propagation in spacetime of c. However, because the wave is looped, the electron will have a sub light speed velocity through spacetime.

This description fits well with the theory of general relativity as it shows how an electron (which comprises a looped wave of spacetime curvature) can result in a small but non-zero general change of spacetime curvature. The description provides an explanation as to how an electron curves spacetime. Protons and neutrons will curve spacetime in the same way as an electron and the theory of general relativity tells us that the gravitational effects of mass are additive.

So how can a description in which matter comprises looped waves in spacetime be reconciled with the apparently static world of our immediate environment? We could be moving at a large relative velocity to the hypothetical 'fabric' of spacetime in which the looped wave disturbances occur. The electrons in the atoms that make up our immediate physical environment seem to be stationary or move with a low relative velocity. It is a key aspect of the nature of spacetime that momentum is conserved and that the apparent forces that we observe which bind our material environment together are based on adopting the lowest possible energy state. This relationship between force and energy state is covered in more detail later.

Objects with mass moving through spacetime encounter zero resistance to uniform motion due to spacetime itself. So an object with its own internal binding forces moves in spacetime as an object seemingly independent and unconnected with the 'fabric' of space. When the object is accelerated its inertia comes into effect. Here we can see that the object is connected intimately with spacetime as it requires an external force to change its state of uniform motion.

The idea that matter comprises looped spacetime waves is given the name 'Spacetime Wave theory' in this paper. The Spacetime Wave theory provides a promising start for a physical description aimed at unification of physics because it provides a description of the very small scale using concepts arising from theories at the large scale. It is now necessary to look at the implications of this physical description with reference to established theories and experimental results.

## QUANTUM THEORY INTERPRETATION

The Copenhagen interpretation of quantum theory includes a number of descriptive principles. See Appendix 3. One principle is that of wave-particle duality. This principle states that photons and electrons have wave-like and particle-like properties but in any experiment will exhibit either wave-like properties or particle-like properties but not in the same experiment. This is termed wave-particle duality. In the context of quantum theory particle-like means that it exists in a discrete quantum of energy and exists as a single point in space with a probability distribution describing its possible location.

In the Spacetime Wave Theory we are trying to build a single description so the idea of dual characteristics is to be avoided. We would like to find a single universal physical description. So a light wave is described as having wave-like properties and the energy in a light beam is composed of quanta of light. In the light interference experiment using two slits, the wave quantum passes through both slits in the experiment and the wave quantum (photon) interferes to create the characteristic pattern on the detection screen

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The detection screen plays an important active role in the outcome of the experiment. The screen is designed to interact with the incoming photons in such a way as to reveal their existence and location. However, prior to detection the wave entity was dispersed in space with an intensity corresponding to the pattern on the screen. Once an atom on the detecting screen interacts with an incoming photon the entire quantum of energy is instantaneously absorbed and no other atom on the screen can detect this photon.

This description emphasises the active role of the detector in the experiment. Rather than thinking of the incoming photon collapsing to a point and hitting the screen, instead think of a specific atom of the detector screen collecting the dispersed wave of the photon and absorbing the quantum of energy.

The Spacetime Wave theory asserts the existence of an observer independent reality in the form of the spacetime wave of the photon. The Spacetime Wave theory is non-local meaning that effects can occur over a distance instantaneously as in the case of a detection occurring at a specific atom of the detection screen resulting in no detection at any other atom of the detection screen.
So in the Spacetime Wave theory, the photon is considered to be a real physical wave dispersed in space whereas in the Copenhagen interpretation it is a wavefunction representing a probability distribution of the location of the photon which has passed through the interference apparatus. Furthermore in quantum theory it is assumed that between the emission and absorption or detection of a particle that the particle does not exist. Entities only exist at the point of observation.

The existence of a real physical wave in the case of the photon and the electron is fundamental to the Spacetime Wave theory. When using the term particle in the context of the Spacetime Wave theory it is used as a collective term for particles such as the electron, proton or neutron. It is not used to denote particle-like properties.

The Copenhagen interpretation of quantum theory includes Heisenberg's uncertainty principle. The uncertainty principle asserts that 'It is not possible to measure simultaneously certain pairs of observables - such as position and momentum, energy and time - with a degree of accuracy which exceeds a limit expressed in terms of Planck constant h.'

This is not intended to reflect a failure of experimental accuracy, rather it is a fundamental physical limitation. Applied to the electron as an example, it means that if you measure accurately the position of the electron, then there are limits to the accuracy with which you can measure its momentum and precise limits are placed on the combined accuracy of these measurements.

In the Spacetime Wave theory, the electron is considered to be a looped spacetime wave and is dispersed in space meaning that the wave energy does not have a precise position. The equations of quantum theory give a method of calculating the probability of finding an electron in a specific small local region of space. This can be used to calculate the energy distribution of the electron spacetime wave. A higher probability of finding an electron corresponds to a higher proportion of the total wave energy being located there. In the Spacetime Wave theory the uncertainty principle is seen as a direct result of the spacetime wave nature of particles.

## 3. SELECTING FUNDAMENTAL PROPERTIES

We are approaching the problem of unification with a concept fundamentally based on the nature of spacetime. The geometric properties of spacetime define three space dimensions and one time dimension which together comprise a four dimensional spacetime. Spacetime is curved in the presence of mass. Furthermore objects within spacetime are comprised of atoms which in turn are comprised of particles (protons, neutrons, electrons) which are described as wave disturbances of spacetime.

The Spacetime Wave theory at the descriptive level will reference the fundamental properties of space, time, energy and momentum. Starting from these properties we aim to be able to specify other properties such as mass, force, field and charge. Once we have a good description of how all these properties are defined, we can proceed to look at the equations which can be used for analysis in the context of the Spacetime Wave theory.

## 4. THE NATURE OF MASS

We experience mass in two ways in our everyday experience. The weight of an object otherwise known as its gravitational mass is a direct result of the spacetime curvature induced by the Earth and explained and quantified by the theory of General Relativity. The other case is the inertial mass of an object which can be thought of as a resistance to acceleration. In the theory of General Relativity (GR), gravitational mass and inertial mass are shown to be equivalent. An object under gravitational influence is equivalent to the same object under acceleration.

To obtain a complete picture of the property mass we need to understand how objects with mass curve spacetime. GR asserts that objects with mass curve spacetime (and provides equations relating a distribution of mass to spacetime curvature) without describing how mass curves spacetime. In the Spacetime Wave theory we have a description of electrons, protons and neutrons as looped disturbances of spacetime. GR tells us that the effect of spacetime curvature due to mass is additive so that the greater the mass, the greater the spacetime curvature and apparent gravitational forces. Down at the particle level, the electron is a fluctuating change in local spacetime curvature and it can therefore be seen that this local fluctuation will produce a small general change in spacetime curvature at a distance from the electron. The same holds true for the proton and neutron so that atoms, molecules and complete objects create a change in spacetime curvature according to the total mass.

Now consider the effect of a curved spacetime environment on an individual particle such as a proton, neutron or an electron. The looped wave in spacetime is affected by the curved spacetime environment and that would tend to make the looped wave move to a lower energy position which is the equivalent of being accelerated in the gravitational field.

## 5. THE NATURE OF FORCE

Let's start by considering what we refer to as the gravitational force. General Relativity tells us that this force arises as a result of spacetime curvature which in turn results in energy differences between possible configurations of objects in spacetime. So for example an apple suspended in the tree has a higher energy level than the apple on the ground. This gravitational potential energy underlines the concept that a force will be present when there exists a difference in energy between possible configurations of objects in spacetime.

There are considered to be four fundamental forces namely gravitational, strong nuclear, weak nuclear and electromagnetic. It is proposed that all these forces are related by the common theme that it is the geometry of spacetime and its variation which is the cause of all the four fundamental forces. The forces appear as differences in energy between possible configurations of curved spacetime entities.

In the case of the strong nuclear force we are considering the binding force of the atom which bonds together protons and neutrons in the nucleus. Thinking of protons and neutrons as looped spacetime waves, it is found experimentally that the nucleus of an atom has a mass which is less than the total mass of all the protons and neutrons. This means that the state in which the protons and neutrons are in close proximity is a lower energy state than the same particles widely separated. This experimental result is known as the mass defect. Since mass and energy are related through the equation E = mc2 we can regard the mass defect as an energy difference and this energy difference can be considered to be the cause of the hypothetical strong nuclear force binding the nucleus together.

The weak nuclear force is associated with beta decay in which a neutron decays into a proton and an electron with the emission of an antineutrino. Again we can consider the energy difference between the state before and after the beta decay. This again leads to an understanding of the weak nuclear force as arising from an energy difference between possible configurations.

In considering the electromagnetic force we shall first look at electrostatic forces and magnetic forces individually. An electrostatic force can be measured experimentally. Two electrons will try to move away from close proximity. This is because the electron has a property called 'charge' which will be described later and this property results in a situation where the electrons in close proximity have a higher energy state than one of greater separation. So the electrons will try to move to a lower energy configuration resulting in the electrostatic force. Similarly an electron and a proton will be in a lower energy state in close proximity as they have opposite charge.
The magnetic force is derived by moving electric charge. This moving electric charge may be in a metallic wire or at the level of the atom in the case of magnetised materials. In both cases the magnetic force arises when the configuration is such that a lower energy state would be achieved by moving in the direction of the apparent magnetic force.

So all fundamental forces are explained in the Spacetime Wave theory as a difference in energy between possible configurations. The fact that there are four fundamental forces is simply a result of the context in which each force occurs.

## 6. THE NATURE OF FIELD

The concept of a field can be illustrated by considering an electrostatic field a magnetic field or a gravitational field. In each case we can measure the force associated with the field at any point in space and this force also has a direction vector. We can consider a field to be a three dimensional map of the directional forces. So the property 'field' is dependent on 'force' which is dependent on energy difference.

Research into the nature of light has shown that it can be represented as an electromagnetic wave. Maxwell's equations model the interaction of electric and magnetic fields and it is tempting to think of the electromagnetic field as something real which permeates space and supports wave propagation. In the Spacetime Wave theory, a field is not a physical entity capable of supporting wave propagation. The medium for the propagation of light waves is spacetime.

## 7. THE NATURE OF CHARGE

In some theories, electric charge is regarded as a fundamental property of elementary particles without having any underlying cause. In the Spacetime Wave theory, charge is viewed as being a property of some particles due to the spacetime wave nature of the particles. The electrostatic force between two electrons is viewed as an energy difference. The cause of the energy difference is due to the nature of the looped spacetime wave that is the electron.

Remember that the wave is actually a fluctuation in the geometry of space and time and it is the wave fluctuation in the time dimension which is the underlying cause of the property 'charge'. Imagine a sine wave variation in space curvature propagating in a closed loop. Within each cycle of the sine wave, space is expanding and compressing. Now imagine a wave variation in the time dimension at the same frequency which can be in phase or 180 degrees out of phase with the space wave. In this wave variation in the time dimension, time speeds up or slows down following the rules of general relativity. If the time wave is in phase with the space wave, there will be a net expansion of space. If the time wave is out of phase with the space wave there will be a net compression of space.

Now consider an electron and a positron in proximity. One particle is creating an environment in which space is expanded and the other particle is creating an environment in which space is compressed. Move these particles closer together and the energy of the system is decreased resulting in an electrostatic force of attraction. Similarly, moving two electrons closer together will increase the energy of the system resulting in an electrostatic force of repulsion.

A derivation of the Spacetime Wave model of charge is provided in Appendix 1. This shows that the magnitude of the charge of the electron is the same as the magnitude of the charge of the proton but with opposite sign.

## 8. LOOPED SPACETIME WAVES

To develop a clearer picture of the nature of the looped spacetime waves that comprise the electron, neutron, proton and other particles we need to consider the experimental evidence. These particles behave like waves with a frequency given by $E = hf$. So we can think of an electron as a closed spacetime wave loop with a level of dispersion meaning that the wave has an existence over a region of space with decreasing wave energy the further from the average position of the particle. The speed of the wave in the loop is the standard speed of wave propagation in space c.

Why is the closed loop stable? One might imagine that the wave would dissipate or that the loop would open. In the case of electrons bound to the atom, the smaller the radius, the lower the energy so an electron moving to an excited state will move to a larger radius. The energy of the spacetime wave in a closed loop represents a lower energy state which is therefore stable. Furthermore, the spacetime wave must be in phase with itself on completion of the loop so that there must be a whole number of wavelengths within the loop. This constraint means that an electron can only gain or lose energy in discrete quanta of energy and this energy is in the form of spacetime wave energy that is not looped i.e. a photon.

Any time we attempt to make a measurement of the position or momentum of an electron, we do so by causing an interaction with some device which itself is comprised of atoms and particles which are looped spacetime waves. The outcome of any measurement may not be predetermined because of the nature of the particle and the nature of the detector.

How do these particles interact in proximity? We can imagine two electrons that are bound to a helium nucleus occupying the spherical region around the nucleus as two dispersed spacetime waves. There will be an electrostatic attraction to the nucleus tending to keep the electrons from leaving the atom. There will be an electrostatic repulsion between the electrons meaning that the electrons will occupy positions of least energy.

The Pauli exclusion principle operates in such a way that only a certain number of electrons may exist within each shell. When this limit is reached the shell becomes full. How does the Pauli Exclusion Principle operate when considering looped spacetime waves?

A different approach is taken considering that the looped spacetime waves occupy some volume of the space around the nucleus so that collectively the space becomes fully occupied when the shell is full. (see Appendix 5)

## 9. THE STRUCTURE OF THE ATOM

The model of the atom with a nucleus of protons and neutrons and shells of electrons applies with the additional concept that these particles are looped spacetime waves. The stability of the nucleus depends on the mass defect which is equivalent to an energy difference between the energy of the nucleus and the energy of the constituent particles. This energy difference of the nucleus does not follow a simple formula and depends on the number of neutrons and protons in each atomic element or isotope.

Considering the mass defect associated with a proton - neutron combination it can be seen that the looped spacetime waves will have a lower energy in close proximity. The analysis in Appendix 4 shows that the proton and neutron have similar frequencies so it is expected that a neutron and proton in close proximity as spacetime waves will have a lower combined energy.
The interaction of protons and neutrons in the nucleus depends on the adoption of a lowest energy configuration of interacting spacetime waves. The neutrons and protons have lower energy in close proximity and there is an energy interaction between protons associated with the electrostatic repulsion.

The model of the electrons as looped spacetime waves around the nucleus fits well with experimental evidence, particularly the emission of photons when an electron changes state. The example of the hydrogen atom is analysed in Appendix 2. The grouping of the electrons into electron shells is discussed in Appendix 5.

## 10. ELECTROMAGNETIC WAVES

The representation of light as an electromagnetic wave is established and modelled using Maxwell's equations in free space. The electromagnetic wave is modelled as an interacting electric and magnetic field. The Spacetime Wave theory models light as a moving wave disturbance of spacetime. How do we reconcile these two descriptions? Let's look at another form of electromagnetic wave namely radio waves. Radio waves are transmitted when a radio antenna has an applied alternating current. Electrons are moving within the antenna and waves in the radio frequency portion of the spectrum are emitted.

In the Spacetime Wave theory we would note that the looped spacetime waves that are the electrons have emitted non-looped spacetime waves which then propagate at the standard wave speed in space of c.

The electromagnetic field view of the emission of radio waves would note that the varying current in the antenna induced a varying electromagnetic field in space and this interacting electric and magnetic field is self propagating through space. This electromagnetic wave once emitted is free and independent of the source and propagates by means of the interplay between the electric and magnetic field vectors.

The crucial question is whether the electromagnetic field provides a physical medium for wave propagation. In the Spacetime Wave theory, fields are considered to be a dependent (not fundamental) property and it is spacetime itself that provides the medium for wave propagation.
Spacetime Wave Theory Equations

The Spacetime Wave theory has been developed at the descriptive level and the description is complete in the sense that the description does not depend on any undefined fundamental entity. The description uses purely the concept of spacetime as being fundamental.

Let us look at equations already established and proven relating to other properties.

For mass we have E = mc2 which relates mass to the equivalent energy. We can also use the relationship between energy and the frequency of the wave E = hf. This relationship E = hf applies to non-looped wave quanta (photons) and looped waves (electrons, protons and neutrons)
The wavelength associated with a wave moving at velocity c is given by $f\lambda = c$.
For a looped wave, the wave must be in phase with itself on completion of the loop so that the number of wavelengths in the loop (X) must be an integer.

The path length of the loop (s) is given by the equation $s = X\lambda$.

Ultimately the detailed analysis of waves in spacetime must make use of the equations of general relativity which provide a calculation for spacetime curvature resulting from an energy distribution.

## 11. Review of Experimental Results

All experiments where light behaves as a wave are consistent with the Spacetime Wave theory. For experiments claiming to reveal the 'particle' nature of entities (e.g. the photoelectric effect), these are explained in the Spacetime Wave theory as due to the quantum nature of the entities.
The experiments devised and implemented by Michelson and Moreley were aimed at detecting the existence of the aether. They found that the speed of light within their apparatus was unaffected by the orientation of the apparatus with reference to the movement of the Earth. This experiment shows that the speed of light is a constant but it does not rule out the possibility of a medium for light wave propagation.

Experiments have been conducted (EPR) to show that photons and electrons can be 'entangled' in such a way that the system of particles must be considered as a single entangled system even though the particles may be separated in space. It appears that cause and effect in these experiments travels instantaneously through space so that a measurement of one particle instantaneously affects the outcome of the measurement of the entangled particle. This does imply that space acts as the medium for these instantaneous effects.

Where experiments are conducted using beam splitters and detectors to show the existence or absence of wave interference it is important to note that the role of the detector in such experiments is an active role. The detectors are not merely watching to see which route the 'particle' has taken.

Instead in the Spacetime Wave theory description, the spacetime wave takes a portion of its energy on all possible paths through the apparatus. Only when a detector absorbs or detects the 'particle' is the entire quantum of energy located at that detector and other possible outcomes are ruled out by this detection.

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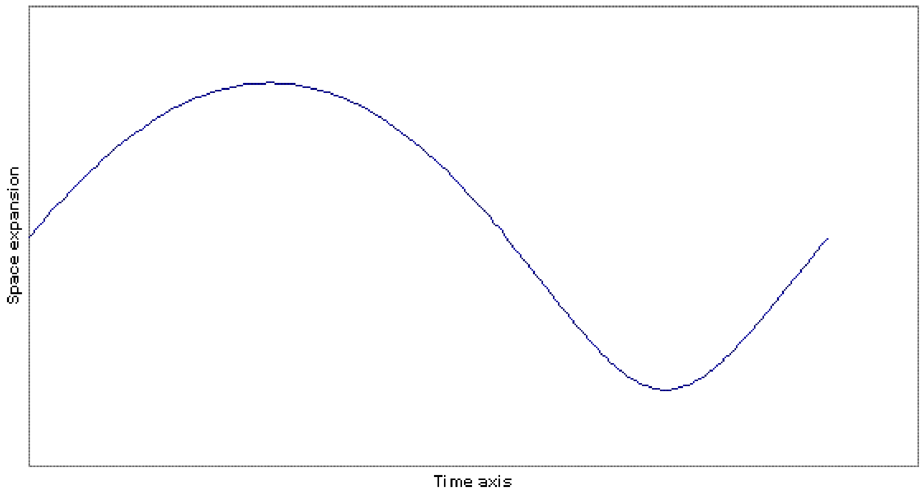
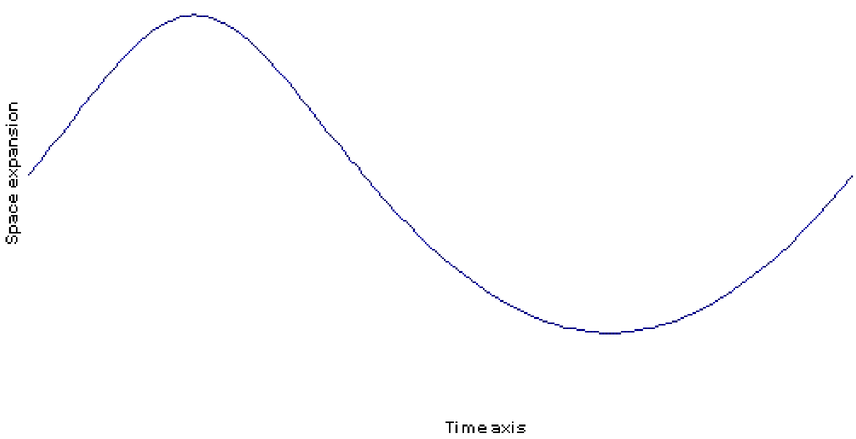
## Appendix 1

### Electric Charge

Case 1: Space and Time expansion in phase




Case 2: Space and Time expansion out of phase



The analysis is based on the idea that an electron and other particles with mass comprise looped waves in the medium of space-time. One wavelength of the looped wave is shown in the diagrams above. General Relativity encourages the idea of four dimensional space-time. Suppose that we had not only fluctuations in the space dimensions (like a gravitational wave) but also fluctuations in the time dimension synchronised with the fluctuations in the space dimensions. The curves then show that during the cycle of the wave as illustrated, the sine curve one would normally expect for a wavelike disturbance is distorted by the time variation in the wave. The curves shown above represent the variation in the expansion of space over one cycle of the wave. If we take S as the expansion of space, then S is proportional to A sin(w).

Let the constant of proportionality be D so S = D A sin (w).
A is the energy in one wave cycle and w is the phase angle. If there were no wave variation in the time dimension then both Case 1 and Case 2 would be a sine curve. In this case the time T would be proportional to the phase angle w. The relationship between T and w is obtained by recognising that the time for one cycle is equal to 1/f where f is the frequency of the wave. So in the case where there is no time dimension fluctuation:

$$T = w/2\pi f$$

Now in the case where there is fluctuation in the time dimension we have:

$$dT/dw = (1 + B \sin(w))/2\pi f$$

This means that during the wave cycle there is a variation in the rate of passage of time which is synchronised with the phase angle. The constant B takes some value from 0 to 1. Integrating the equation for dT/dw we obtain:

$$T = (w + B(1-\cos(w))/2\pi f$$

Now if we wish to establish the area under the curve for the Case 1 curve this will provide us with a measure of the net expansion of space over the cycle. We need to integrate S dT from T = 0 to T = 1/f. This is the same as integrating the expression:

$D A \sin(w) (1 + B \sin(w))/2\pi f$ from w = 0 to $2\pi$
Integrating D A sin(w) from 0 to $2\pi$ gives 0.
Integrating DAB $\sin^2(w)/2\pi f$ from w =0 to $2\pi$ gives DAB/2f.

Now if we consider the looped wave as having X wavelengths we have the total net expansion as XDAB/2f. By the definition of A we have energy E = XA so that the total net expansion is EDB/2f. But we know that E = hf where h is Planck constant so that the net expansion is DBh/2. For Case 2 the time fluctuation is 180 degrees out of phase with the space fluctuation so that:

$$dT/dw = (1 + B \sin(w + \pi))/2\pi f$$

which is the same as:

$$dT/dw = (1 - B \sin(w))/2\pi f$$

So the net expansion for Case 2 is -DBh/2 which is a net compression.

Notice that these values are independent of the energy or the frequency and have two possible values one positive the other negative and depend on the value of the constant B which describes the magnitude of the fluctuation in the time dimension during the wave cycle and the constant D which describes the magnitude of the expansion of space for a given quantity of energy.

The proposal presented here is that the fluctuation in the time dimension is the cause of electric charge. Two looped waves, one having a net expansion of space and one having a net compression of space will find a lower energy level when the distance is closer. One of the looped waves represents the electron and the other a positron which will experience a 'force' of attraction due to the lower energy level when these particles are moved closer together. This is the underlying cause of the electrostatic 'force'.

The analysis explains why the positive charge of the proton is the same in magnitude as the negative charge of the electron since the value of the constants B and D are the same in both cases. It also provides the possibility of determining the value of the basic unit of charge from the characteristics of spacetime.

The effect of the electric charge is spread uniformly throughout the looped wave so that there is no longer a concept of a point charge. This approach to the electrostatic force leads to a description of the decay of a single neutron into a proton, electron and anti-neutrino. The neutron is a neutral particle and there is no wave variation in the time dimension.

It is also important to note that within a single wavelength there is an expansion and compression of spacetime so that for the electron we can consider each wavelength as having a negative charge followed by a positive charge where the magnitude of the negative charge is greater than the magnitude of the positive charge by an amount DAB/2f.

We can analyse this further by integrating DAsin(w) (1+B sin(w))/2πf from w = 0 to π, and then again from π to 2π.

From 0 to π we obtain: (2DA +DABπ/2)/2πf (always positive)
From π to 2π we obtain: (-2DA +DABπ/2)2πf (always negative since B < 1)

This gives an indication that when a looped wave follows a path around a nucleus there will be a strong tendency for the wavelength positions to align with half a wavelength displacement in the direction of the wave.

## Appendix 2

### Energy Levels in the Hydrogen Atom

When an electron changes state and emits a photon of a particular frequency, this reveals the energy difference between the states before and after the emission of the photon.

If we take $E_{gs}$ as the ground state energy of the electron then for integer values of n the energy of a particular state $E_n$ is given by the equation:

$$\mathbf{E_n = E_T - E_{gs}/n^2}$$

Note that this equation is derived experimentally as a result of the measurement of the frequency of the emitted photon.

In this equation $E_T$ is the total energy of the electron as measured by its mass. In the spacetime wave theory, all of the energy of the electron is wave energy (E = hf). There is no particle of mass m to consider in the energy equation.

Now if we consider the energy state change from an excited state $E_m$ to the state $E_n$ we have:

$$\textbf{Energy of emitted photon} = E_{gs}/n^2 - E_{gs}/m^2$$

For the emitted photon E = hf and λf = c where:

h is Planck constant.
f is the frequency of the photon.
λ is the wavelength of the photon.
c is the speed of light.
The Wavelength of the emitted photon is given by λ = ch/E:
$\boldsymbol{\lambda = c\, h\, n^2\, m^2/E_{gs}(m^2 - n^2)}$

This is the formula found by Balmer: $\lambda = b[m^2/(m^2 - n^2)]$

If we take the values m = 3, n = 2, the measured wavelength is 656.210 nm.

$\boldsymbol{E_{gs} = 36hc/5\lambda}$
$\boldsymbol{E_{gs} = 13.603\ \text{eV}}$

The Spacetime Wave theory asserts that the electron is a looped wave in spacetime but the path of that wave should not be thought of a circle in the case of an electron bound to an atom. Instead think of the wave as a closed loop in which the electron charge is evenly distributed throughout the loop. Each part of the loop is attracted towards the opposite charge of the proton. The closed loop is constrained by wanting to be as close as possible to the nucleus and at the same time experiencing a force of repulsion from other parts of the electron looped wave.

The looped wave of the electron follows a path around the nucleus which matches the observations of the charge distribution of the electron around the nucleus. If an experiment is conducted to observe the electron by using a high powered laser, then the electron will appear to be a particle at a particular position and many repeats of this experiment will reveal the possible positions of the electron.

The observation that the electron appears to be a point particle in this experiment is an inevitable result of the detection mechanism. The interaction of the laser pulse causes the electron to leave the nucleus, a detector then observes the electron and the measurement of the electron determines the apparent location of the electron.

The interaction of the laser pulse with the looped wave of the electron occurs in a dispersed way due to the spread out nature of the waves but the set up of the experiment and the detector necessarily results in a specific point being the apparent position of the electron. This point is just the centre of the interaction of the wave of the laser pulse and the wave of the electron.

With this model in mind we can complete some analysis of the path length of the wave loop and the number of wavelengths.

**Definitions:**

$E_n$ The energy of the electron in state n.
$f_n$ The corresponding frequency of the electron ($E = hf$)
$\lambda_n$ The corresponding (Compton) wavelength of the electron ($f\lambda = c$)
$X_n$ The number of wavelengths in the looped wave.
$s_n$ The path length of the looped wave such that $s_n = X_n \lambda_n$

We have the following relationships:

$$\mathbf{E_n = hc/\lambda_n = X_n\, hc/s_n}$$
$$\mathbf{E_n = E_T - E_{gs}/n^2}$$

Therefore:
$$\mathbf{X_n = s_n(E_T - E_{gs}/n^2)/hc}$$

The condition that $X_n$ is an integer for all values of n means that $s_n$ must take the form $s_n = s_1 n^2$
Therefore:

$$\mathbf{X_n = s_1(E_T n^2 - E_{gs})/hc}$$

The condition that $X_n$ is an integer for all values of n means that:

$s_1E_T/hc$ is an integer and$s_1E_{gs}/hc$ is an integer

Let us assign an integer value K to $s_1E_{gs}/hc$

$$\mathbf{s_1E_{gs}/hc = K}$$

$E_T / E_{gs}$ is a known value:

Using the value of $E_T$ as 0.510998 MeV = 510998 eV we have $E_T / E_{gs} = 37565.09593$

Within the accuracy of the measurement of $E_T$ and $E_{gs}$ the integer value may be 37565 +- 1 or 2. Assuming the value 37565, our formula the number of wavelengths in the loop is:

$$\mathbf{X_n = s_1(E_T n^2 - E_{gs})/hc}$$
$$\mathbf{X_n = s_1E_{gs}/hc\ (E_T/E_{gs}\ n^2 - 1)}$$
$$\mathbf{X_n = K\ (37565\ n^2 - 1)}$$

If we take K = 1, using the above formulae we can determine what happens when the electron goes from energy level 2 to 3.

The frequency goes from $1.2355797 \times 10^{20}$ to $1.2355842 \times 10^{20}$
The wavelength goes from $2.4236268 \times 10^{-12}$ to $2.4236178 \times 10^{-12}$
The path length goes from 365.5504 nm to 820.2384 nm
The number of wavelengths in the loop goes from 150259 to 338084

From the formula $s_n = X_n \lambda_n$ it can be seen that it is possible to double the path length and number of wavelengths in the loop (K=2) without affecting the frequency and therefore the energy of the electron.

The path of the electron looped wave in spacetime is pulled towards the positive charge of the proton. The negative charge of the looped wave at all points in its looped path has the effect of repelling other parts of the looped wave to create a variety of smooth three dimensional shapes.
In this model of the electron, we can think of the electron looped wave as occupying a certain volume. Starting with the electron in its ground state we have:

$$\mathbf{E_1 = E_T - E_{gs}} = 510998 - 13.6 = 510984.4 \text{ eV}$$

The corresponding frequency given by E = hf with h = 4.135 667 662 x $10^{-15}$ eV s is 1.2355547925 x $10^{20}$ $s^{-1}$. The corresponding wavelength is 2.4263793 x $10^{-12}$ m.

The number of wavelengths in the loop assuming K to be 1 is 37564 wavelengths.

The volume occupied by this electron depends on the minimum distance of separation of the segments of the looped wave of the electron. We can then think of the looped wave as a narrow cylinder. The parameter d represents the number of wavelengths corresponding to the distance of separation and need not be an integer.

So in this example the volume occupied by the electron is: $\pi\ (dw/2)^2$ 37564 w which is: 29502 $d^2$ $w^3$ . If we take the initial assumption that d = 2 (i.e. the radius of the cylinder of the looped wave is one wavelength) then the volume of the electron is 1685768 x $10^{-36}$ $m^3$

This corresponds to a sphere of radius 7.383 x $10^{-11}$ m. Considering a circumference corresponding to this radius the path length of one circumference is approximately 191 wavelengths which suggests that the path of the looped wave orbits the nucleus 37564 / 191 times which is approximately 197 times.

The charge e is spread out equally to all wavelengths of the loop so each wavelength carries a net charge of e / 37564 but by the nature of the expansion and compression of the spacetime wave (see Appendix 1), each wavelength is a small positive charge followed by a slightly greater negative charge. This will cause successive loops to be positioned half a wavelength displaced in the direction of the wave.

This model is a departure from the Pauli Exclusion Principle for explaining the structure of the atom. Instead, this spacetime wave model assumes that each electron occupies a certain volume and the placement of electrons in shells arises due to the fact that there is a certain physical volume available in each electron shell.

**Appendix 3 Reinterpretation of Quantum Theory**

The objective is to use the physical description of the Spacetime Wave theory and show that this description of reality explains the results of experiments.The Spacetime Wave theory describes light as a wave disturbance of spacetime and electrons, protons and neutrons as looped wave disturbances of spacetime.

When considering an experiment such as the dual slit light interference experiment, the light is considered to be a real physical wave dispersed in space. It is only when a detection is made at the detector screen that the wave is absorbed by a single atom so that the energy from the dispersed wave becomes localised to an electron of the detecting atom.

If we think about the model of an electron as a moving point particle and an associated probability distribution and then compare this with a model in which the electron is a wave which corresponds to the track of the point particle then it can be seen that these two descriptions are equivalent from the point of view of the position and momentum of the electron.

It follows then that the wave functions and wave equations of quantum theory apply equally well to the spacetime wave model of the electron. Then it becomes clear that the underlying physical description of the electron as a wave in spacetime is the real fundamental nature of the electron and the wavefunction is a description of the position and propagation of this electron wave.
There is no collapse of the wavefunction. There is a physical interaction between an electron and a detector which means that the wavefunction describing the electron before the interaction with the detector ceases to apply after the detection. This then solves the measurement problem and removes the need for an hypothesis such as 'Many Worlds'.

**Waves vs. Particles**

The Copenhagen interpretation of quantum theory considers the electron to be a point particle with an associated wavefunction which provides a means of determining the probability of finding the particle at a particular point in space. In the Spacetime Wave theory, the description of the electron is as a real physical wave.

The probability of detection of the wave at a certain point in space is determined from the quantum wavefunction. Even though the detection outcome appears to indicate a particle at a precise position, we know that before the detection the wave was more spread out in space.
In the Spacetime Wave theory any observation of the looped wave in spacetime (which is the electron) will cause the electron to move from its previous state so that our observation seems to be of a point particle.

Ultimately the objective will be to use the equations of general relativity to model the fundamental particles (electron, neutron and proton). These GR equations have already been used to model gravitational waves and need to be extended to model non-looped waves (photons) and looped waves (electrons, neutrons and protons) in spacetime.

**The Uncertainty Principle**

Heisenberg: It is not possible to measure simultaneously certain pairs of observables - such as position and momentum, energy and time - with a degree of accuracy which exceeds a limit expressed in terms of Planck constant h.

The relationship $\Delta p \Delta q >= h/2\pi$ limits the accuracy with which the momentum p and the position q of a particle can be measured. In the Wave description the looped disturbance in space-time does not have a precise location in space. Any measurement will result in uncertainty in the outcome of the measurement because of the inherent lack of precision in the location of a wave entity.

The uncertainty principle is necessary in a particle based model but in a wave based model it is not needed because the real physical waves are actually dispersed in space.

**Wave – Particle Duality**

The objects described by quantum theory (photons, electrons etc) have particle like and wave like properties. In the Copenhagen interpretation the idea of complementarity was introduced. This was a principle that the wave and particle aspects of light and matter are complementary but exclusive. An experiment can be devised to reveal either the wave properties of light or its particle nature, but not both at the same time.

This is an unsatisfactory position to be in and leaves confusion about whether the true nature of the entity is a wave or particle. In the Spacetime Wave theory we are always dealing with wave quanta – a wave in spacetime which comprises a specific quantum of energy.

Light is emitted when an atomic bound electron changes energy levels and the quantum of light energy emitted is determined by the energy levels of the initial and final state of the electron. Light is quantised because that is the way it is emitted, not through some inherent property of light. The looped waves always have a quantum of energy given by $E = hf$.

Considering the photoelectric effect it is the relationship $E = hf$ for the incoming light quantum (photon) which determines if there is sufficient energy to free an electron from the metallic surface. In the Spacetime Wave theory the photon is always considered to be a wave quantum which matches the experimental results of the photoelectric experiment.

Note that the quantisation is of objects in spacetime, not that spacetime itself is quantised or granular. By adopting a wave based description of reality, all physical properties are viewed as continuous. Quantised effects are due to the way in which wave quanta are emitted or the way in which they exist as looped waves. Spacetime is continuous and not discrete.

**Virtual particles**

The concept of virtual particles arises in the perturbation theory of quantum field theory, an approximation scheme in which interactions (in essence, forces) between actual particles are calculated in terms of exchanges of virtual particles. In the Spacetime Wave theory, forces arise when there is an energy difference between possible configurations of objects in spacetime and there is no requirement for virtual particles.

**Empty space**

Taking the Spacetime Wave theory and the General Theory of relativity together there are no longer inconsistencies between explanations which apply at a large (cosmological) scale and a small (atomic) scale. The ideas of quantum gravity try to extend quantum theory to include gravity. Instead, in the Spacetime Wave theory, the equations of General Relativity are extended to include effects at the atomic scale.

In the Spacetime Wave theory the equations of General Relativity operate down to the smallest scales. The equations of general relativity show that in the absence of matter and energy, spacetime is flat.

**The Evolution of Systems**

A system of objects in spacetime evolve over time and at any point in time the system is considered to be in a single state. The idea that a particle can be in two places at the same time is replaced by the idea that a system which consists of a wave dispersed in space may result in a particle detection at a number of possible places.

A particle cannot be simultaneously in two places at the same time. Also a system cannot be simultaneously in two states superposed. A system evolves over time moving to different states.

The whole process of superposition which is used in quantum theory is set aside as not representative of reality.

Quantum superposition as an analytical method is to be avoided. For example in the case of electron spin, the outer electron of a silver atom will be free to align in a magnetic field and starting from a random orientation will adopt one of two possible alignments up or down with reference to the applied field. This is a better explanation than thinking of the electron as being in a superposition of 'up' and 'down'.

When considering the quantum entanglement of two particles, the system of two entangled particles is one system which is spread out in space. A measurement of one particle instantaneously changes the state of the whole system placing constraints on the possible outcome of the measurement of the other particle. This non-local effect is a real phenomena which only occurs at the point of measurement. The effect is the result of a spacetime wave entity extending over a significant distance resulting in the instantaneous change of the whole system during the measurement of one local part.

**Electricity and Magnetism**

In quantum theory the property of electric charge is considered as a fundamental property of a particle such as the electron. In the Spacetime Wave theory, electric charge is a dependent property of a looped spacetime wave which arises due to the wave variation in the time dimension. The charge is a part of the wave and is dispersed in space following the position of the wave of the electron or proton.

In the Spacetime Wave theory, magnetic effects always arise as a result of a moving electric charge. As a result, when magnetic effects are present, there will always be a magnetic dipole.

**Appendix 4**

**Wave Description of the Proton and Neutron**

**Proton**

Considering the proton as a loop wave in space-time, calculate the number of wavelengths in the loop.

The mass of the proton is: 938.272046 MeV ($9.38272046 \times 10^{8}$ eV)

Using E = hf where:

E The energy equivalent of the proton.

h Planck constant. ($4.135667662 \times 10^{-15}$ eV-s)
f The corresponding frequency of the proton
$f = E/h = 2.268731 \times 10^{23}$ which is in the gamma ray part of the spectrum.

Using $\lambda f = c$ where:

$\lambda$ is the wavelength.
c is the speed of light. ($2.99792458 \times 10^{8}\ ms^{-1}$)
$\lambda = c/f = 1.321409 \times 10^{-15}$ m

The effective radius r can be thought of as the radial midpoint of the energy distribution of the wave. Its value is defined as the radius at which $X\lambda = 2\pi r$ where X is the integer number of wavelengths in the loop.

The effective radius of the proton must be less than the charge radius which describes the extent of the proton wave and has the value: $0.8751 \times 10^{-15}$ m

If we used the charge radius to obtain a first approximation for X we obtain:

$X = 2\pi r/\lambda = 4.16102$

There must be a whole number of wavelengths in the loop and the definition of the effective radius suggests that it must be less than the charge radius.

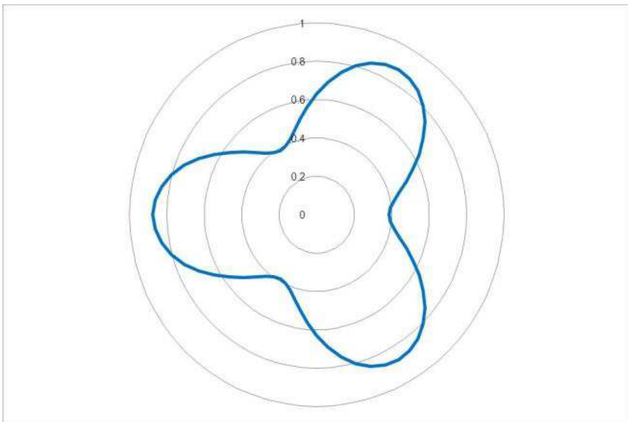
X = 4 or X = 3 are the most likely values.

For X = 4 the effective radius is calculated using $r = X\lambda/2\pi$

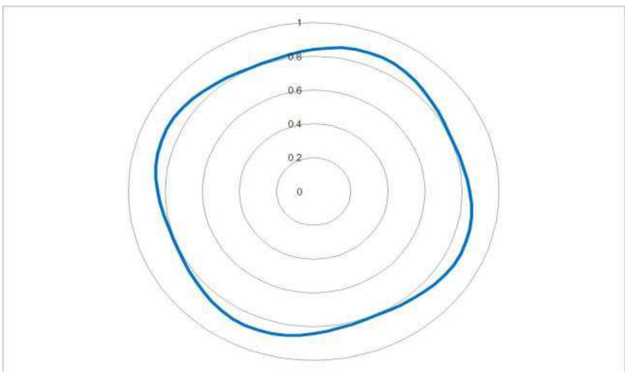
Effective radius $r = 4\lambda/2\pi = 0.841235 \times 10^{-15}$ m

For X = 3 the effective radius $r = 3\lambda/2\pi = 0.630929 \times 10^{-15}$ m

The value X = 3 is chosen as it represents a lower energy state than the proton model with X = 4.




**Proton or Neutron as a looped wave of three wavelengths**



**Proton or Neutron as a looped wave of four wavelengths**

**Neutron**

The neutron is neutral in charge with a mass slightly greater than the proton. The neutron can be modelled as a looped wave in space-time in which there is no associated electric charge.

The calculation is similar to that for the proton:

The mass of the neutron is: 939.565378 MeV ($9.39565378 \times 10^8$ eV)
Using E = hf where:
E The energy equivalent of the neutron.
h Planck constant. ($4.135667662 \times 10^{-15}$ eV-s)
f The corresponding frequency of the neutron
$f = E/h = 2.271859 \times 10^{23}$ which is in the gamma ray part of the spectrum.

Using $\lambda f = c$ where:

$\lambda$ is the wavelength.
c is the speed of light. ($2.99792458 \times 10^8$ $ms^{-1}$)
$\lambda = c/f = 1.319590 \times 10^{-15}$ m

The effective radius of the neutron is estimated from the proton charge radius which is: $0.8751 \times 10^{-15}$ m

If we used the proton charge radius to obtain a first approximation for X we obtain:

$X = 2\pi r/\lambda = 4.16676$

There must be a whole number of wavelengths in the loop.

We could take X = 4 or X = 3 as the most likely values.

For X = 4 the effective radius is calculated using $r = X\lambda/2\pi$
Effective radius $r = 4\lambda/2\pi = 0.840077 \times 10^{-15}$ m
For X = 3 the effective radius $r = 3\lambda/2\pi = 0.630058 \times 10^{-15}$ m
The value X = 3 is chosen as it represents a lower energy state than the neutron model with X = 4.

**Observations**

This model of the proton and the neutron as a looped wave in spacetime has some useful benefits when it comes to the interpretation of experimental results.

The charge radius of the proton can be affected by the charge environment within which it is located. For example when an electron is replaced by a muon in a hydrogen atom we have muonic hydrogen. The muon has a greater mass than the electron and the same electric charge. The mass difference will affect the location of the looped wave that is the muon and the charge radius of the proton will be different from the charge radius of a proton in a normal hydrogen atom since the looped wave of the proton is affected by its environment.

The effective radius of the proton is the middle position of the energy of the looped wave and the charge radius lies outside this effective radius by a greater or lesser amount depending on the charge environment.

Visualising the spin of a proton and how it is distributed if the proton comprises sub particles is a difficult problem. With the proton described as a looped wave in spacetime, the property spin arises as a natural feature for the entire proton.

The effective radius of the neutron 0.630058 x $10^{-15}$ m is difficult to measure experimentally. However, in the analysis of neutron stars the radius of the neutron is an important factor. There is a specific size at which a neutron star forms an event horizon at the surface of the neutron star and becomes a black hole. This size is approximately 3.4 solar masses. This is consistent with observations of neutron stars and black holes. The smallest black hole is greater than 3.4 solar masses. The largest observed neutron star is less than 3.4 solar masses.

Although this observation is not sufficient to allow a precise measurement of the effective radius of the neutron, it is sufficient to rule out the case X = 4 with an effective radius of 0.840077 x $10^{-15}$ m.

**Dark matter**

Thinking of the neutron as a looped wave in spacetime of three wavelengths, each of the three wavelengths of the loop comprise a positive charge followed by an equal negative charge.
Then if two neutrons with the same axis of rotation are in close proximity the two neutrons will attract each other and bond with a displacement of half a wavelength. This bonding of two neutrons will form a stable structure and is proposed as the dark matter which is observed through its gravitational effect.

When measuring neutron decay using the two standard methods (bottle and beam) it is proposed that the difference in results is because, in the case of the bottle method, approximately 1% of the neutrons bond to form dineutrons (pairs of bonded neutrons) which are the dark matter particle.

**Appendix 5 Electron shells and bonds**

The objective is to understand the electron shells in the context of the Spacetime Wave theory in which electrons are looped waves in spacetime. For each of the elements of the periodic table, the atom has an equal number of electrons and protons. The protons and neutrons comprise the nucleus and create a positive charge environment for the electron looped waves.

The looped waves of the electron will try to find the lowest energy position which means getting as close as possible to the nucleus. However, for the hydrogen atom the single electron in its lowest energy state has a wavelength 1836 times greater than that of the proton. In the analysis of the hydrogen atom the minimum number of wavelengths in the lowest energy state was calculated to be 37564 wavelengths. In order to find a position as close as possible to the nucleus, the looped wave will make many passes looped around the nucleus.

The looped wave of the electron has momentum and the tendency of the wave will be to travel in a straight line but this is overcome by the electrostatic forces. The result is a curved path for the looped wave. Each electron carries the same total electric charge and the longer the path of the looped wave, the less is the amount of charge in each wavelength.

There is a limit to the proximity of the segments of the looped wave to each other. Each wavelength of the looped wave carries the same negative charge and so will repel every other part of the electron wave loop with a greater or lesser amount depending on distance. This creates a minimum possible separation of segments of the looped wave so we can think of the looped wave as having a cross sectional area. This together with the path length of the looped wave means that we can think of the electron as occupying a certain volume.

Now when considering the electron shells, the hydrogen atom contains just one electron and we know that when we have helium with two electrons the first electron shell is full. Why does the second electron not just form its own shell outside the first electron? It must be that the constraints on path volume, number of wavelengths and the positive charge of the nucleus mean that the configuration with two electrons in a shell is the lowest energy configuration.
Each completed electron shell will be approximately spherical in shape because this represents the position in which the electrons collectively are as close as possible to the nucleus. The first shell is full with two electrons (helium) and the second shell is full with eight electrons for a total of ten electrons (Neon). It is again a volume constraint which limits the second shell to eight electrons. Elements with a full outer shell are unreactive or inert to chemical reactions.

The third shell can have up to 18 electrons and starting with potassium, the fourth shell starts to be occupied after 8 electrons have filled the third shell. This effect is again a result of the electrons finding the lowest energy position for each element.

The element silver (atomic number 47) has a shell configuration which is 2, 8, 18, 18, 1. This element has a single electron in the fifth shell which is surrounding a spherical fourth shell. This makes it a useful element for experiments studying magnetic effects of the electron looped wave.
The idea of an electron occupying a certain volume when bound to an atom is investigated by considering the inert gases helium, Neon, Argon and Krypton. These gases are inert because the electron shell is full in each case.

| **Table 1** | **Helium** | **Neon** | **Argon** | **Krypton** |
|---|---|---|---|---|
| Number of electrons | 2 | 10 | 18 | 36 |
| Van de Waals radius ($10^{-12}$ m) | 140 | 154 | 188 | 202 |
| Van de Waals volume ($10^{-30}$ $m^3$) | 11.494 | 15.298 | 27.833 | 34.525 |
| Average volume per electron ($10^{-30}$ $m^3$) | 5.474 | 1.529 | 1.546 | 0.959 |

The Van de Waals radius of an atom is the radius of an imaginary hard sphere representing the distance of closest approach of another atom. This radius is used to obtain an estimate of the radius of the outer shell of electrons. From this we can obtain an estimate of the average volume per electron for each of the inert gases in Table 1.

If we take neon we have an average volume per electron of $1.529 \times 10^{-30}$ $m^3$. Now if we think of this volume as being the electron as a looped wave of path length s and cross sectional area A we can analyse the possible path of the looped wave in general terms.

Suppose the cross sectional area of the wave is equivalent to a circle of radius one electron wavelength (2.4236 x $10^{-12}$ m). This would give a cross sectional area of 18.4532 x $10^{-24}$ $m^2$. From the estimated volume and cross sectional area we obtain a path length of 82904.673 x $10^{-12}$ m which is 34207 electron wavelengths.

A single circular path around the radius of the neon atom would be 967.61 x $10^{-12}$ m which is 399 electron wavelengths. So under the above assumptions the looped wave will make approximately 85 passes around the atom before the loop is closed.

The above calculation is intended to illustrate the idea of the model rather than to give definite numerical results. The path length depends greatly on the assumptions about the cross sectional area. The calculation does show that the wave model is consistent with the idea of the looped wave making many passes around the nucleus which opens the possibility of tracing out the three dimensional shapes actually observed in experimental observations of atoms such as the hydrogen atom.

The fact that it takes two electrons to fill the first shell as in the case of helium means that in the case of hydrogen the looped wave which is the electron has considerable freedom to position itself in accordance with the lowest possible energy state. Imagine bringing two hydrogen atoms into close proximity. What would happen is that the force of repulsion between the two electrons would result in the electrons tending to move away from each other into the hemisphere remote from the other atom. In this state there is an optimum position which is the lowest energy state. This creates the bond to form the hydrogen atom. The atoms are not sharing their atomic electrons. It is just that the electrons have the freedom to move away from the other atom. This is why hydrogen atoms form a bond to create a molecule and helium atoms do not form such a bond.

**Appendix 6 Electron Spin**

The explanation for the effect of the Stern-Gerlach experiment changes completely from the quantum theory interpretation based on quantised spin.

In the Stern-Gerlach experiment, silver atoms are sent through a spatially varying magnetic field which deflects them before they strike a detector screen. The screen reveals discrete points of accumulation rather than a continuous distribution.

The experiment is explained in the context of the Spacetime Wave theory by considering the effect of the experimental apparatus on the single electron in the outer shell of the silver atom. This single electron is a looped wave in spacetime which can readily change its orientation in response to an externally applied magnetic field.

The silver atoms before entering the magnetic field can be in any orientation but after entering the magnetic field will adopt one of two possible orientations being clockwise or counter clockwise with reference to the magnetic field (which is referenced as the z-axis). The choice will depend on the random orientation of the electron before entering the magnetic field.

The looped wave of the electron is a moving electric charge and creates a magnetic dipole which can be thought of having a North/South orientation either up or down with reference to the magnetic field. The magnetic field then acts on this magnetic dipole resulting in the two points of accumulation on the detector screen in the up or down direction.

After measuring the orientation of the electron in the z direction, any measurement in the x or y direction will have an equal probability of the outcome since we know that the original orientation was in the z direction.

**Appendix 7 Quantisation of Angular Momentum**

In our model of the electron as a looped wave in spacetime as described for the hydrogen atom (see Appendix 2) it was explained that the looped wave passes many times around the nucleus before the loop is closed.

Let us take the total number of wavelengths in the loop as X and the number of times the loop passes around the nucleus as L. Also the radius of the position of the loop around the nucleus is r. Then we can see that the total path length $X\lambda = 2\pi r L$

The total angular momentum for the entire looped wave is equal to $pr = hr/\lambda$

Using the value of the wavelength lambda from the first equation we obtain:
Angular momentum = $hrX/2\pi r L = (h/2\pi)(X/L)$

Now X/L is the number of wavelengths in a single loop around the nucleus and this must be an integer with a half wavelength displacement to adjust to the optimum alignment of adjacent loops of the wave.

**Appendix 8 The Core Theory**

In the search for a single equation of physics, the unification of physics described in this paper suggests an approach to the resolution of this problem. Given that the neutron is a looped wave in spacetime of three wavelengths it is entirely appropriate to attempt to use the equations describing curved spacetime to try to model this particle.

$$R_{\mu\nu} - \tfrac{1}{2} g_{\mu\nu} R = (8\pi G/c4) T_{\mu\nu}$$

Einstein Field Equations (cosmological term omitted)

This equations describes the relationship between a distribution of mass / energy /momentum and curved spacetime. How can we use this equation to model a looped wave in spacetime of three wavelengths that is the neutron? It is unlikely that we would be able to find a complete solution to the Einstein equations for this case but we could proceed along the lines used to model the merger of two neutron stars to result in gravitational waves.

Such an approach would take a hypothetical form of the wave and apply the Einstein equations to determine the incremental change in the wave after an incremental time interval. To complete the analysis would require a trial and error approach to determining the form of the wave which would most likely have a wave component in the direction of travel around the loop thus resulting in the compression and expansion of space so the that neutron appears to comprise a loop of 3 positive and 3 negative charges in a closed ring. This is the reason why neutrons will only bond when their axis of rotation (spin) is in alignment as in the case where two neutrons bond to form a neutron group (dark matter).

The question arises that the Einstein equation does not contain Planck's constant and we would expect the basic equation of physics to yield the result $E = hf$. We can put this equation in the form Energy x Wavelength = hc and we will know that we have the correct model for the neutron when the only stable result that we find has a numerical result that the energy times the wavelength is equal to hc.

This approach to the core theory to resolve the conflict between quantum theory and general relativity starts from the equations that apply to spacetime on the large scale. The derivation of the curved spacetime element in these equations does not reference any scale or size and so we should expect these equations to apply right down to the scale of the atom.