4. *Wave Mechanics*

Universal Time

One of the long standing problems of the Theory of Relativity is the clock paradox. Does time differ according to what happens to us and where we go as we use it? Relativity does not provide a clear, consistent and definite answer to this question. On the contrary, its application in different ways leads to conflicting results. The theory may not be wrong in its essential principles but the fact that it can be interpreted in different ways to produce conflicting results limits its immediate value in extending theoretical physics. The paradox has not been overcome during the first half century of Relativity. Experts on Relativity still come together to discuss their different views on the same problem of what happens to a clock when it goes on a journey through space. How, then, can one have confidence that Relativity is the proper foundation for the ultimate in physical theory? Is it not better to reject Relativity and start with a sound foundation providing a clear concept of time and space, building on this the pillars of a theory which is consistent with the experimental support for Relativity?

The clock paradox is avoided if we recognize that the time of a universal clock is woven into the properties of space. The principle that time is universal is a far better start for a physical theory than is the Principle of Relativity. Time has to do with change in form or position of something. It is meaningless without motion. If time is a property of space it must be related to something which moves in space. Free space is devoid of matter. Modern scientists prefer to believe that there is no aethereal medium filling space. At least, they earnestly believe that it is futile to speculate about such a medium. This is so in spite of the fact that "aether" is just a word and there is little to argue about until one becomes specific about its form. However, recognizing the prejudice against the aether, we can remain on common ground with all physicists and still refer to something capable of motion in and belonging to free space. Space contains an inertial reference frame and provides an electromagnetic reference frame. Time, as a property of space, could be quantified universally as the relative periodic motion of these two frames. This is the simple, logical proposition on which a new theory of physics can be built. It is hardly hypothesis. Time has to be defined in terms of motion. Motion is relative. Two "something" are needed to have relative motion. Only two features of space are available, the inertial and electromagnetic reference frames. To believe these frames to be one and the same is mere assumption. The reader having this belief denies himself the means for understanding Nature's means for making time universal. He is left with his problems with clocks, and even if he ever succeeds in reconciling the clock paradox and the Theory of Relativity he has then to explain why time and the fundamental constants of physics are the same for the same conditions throughout the universe.

Guided by this introduction we may now formulate the following proposition.

The electromagnetic reference frame in any part of the universe and all matter wherever located in the universe have in common a harmonious component of circular motion about an inertial reference frame.

This will be termed the "Hypothesis of Universal Time". It will be shown to unify physical theory.

The Michelson–Morley Experiment

Einstein chose to interpret this experiment as meaning that light travels at the same velocity c in all directions relative to an earthly observer. He was aware that from the standpoint of mechanics physically equivalent inertial frames of reference can exist and that an observer can expect to make observations in mechanics independent of his motion if it is uniform. The result of the Michelson–Morley experiment appeared to warrant the extension of this characteristic of mechanical laws to the more general observation that the laws of nature are in concordance for all inertial systems not in relative motion or relatively accelerated. Einstein thus formulated his Principle of Relativity. Curiously, however, he made an unwarranted assumption. He presumed that in a vacuum light is propagated with the velocity c relative to an *inertial* reference frame. It is not. Light is an electromagnetic phenomenon. It is propagated relative to an electromagnetic reference frame. This distinction is of fundamental importance. Einstein's theory has developed into a hopeless state of confusion simply because of the failure to distinguish inertial and electromagnetic frames of reference. The notion of time is implicit in the separation and relative periodic motion of the two frames. The Michelson–Morley experiment should have indicated that the light studied travelled at the same velocity c relative to an electromagnetic reference frame moving with the earth. This indication that there is a common translational motion of the electromagnetic reference frame and earthly matter is consistent with the above proposition that matter shares the intrinsic superimposed harmonious motion of the electromagnetic reference frame. We are then led immediately to the mass properties of matter and gravitation.

The Principle of Equivalence

If all elements of matter share the common circular motion of the electromagnetic reference frame (to be denoted the E frame) and move in harmony, there is centrifugal force producing an out-of-balance condition. This puts a mass-related disturbance into space. It will be proved to be the basis of gravitation in the next chapter. By its very nature, we thus see that inertial mass and gravitational mass must be identical, consistent with the Principle of Equivalence.*

The disturbance due to the out-of-balance is provided by something in space. The reader who is unwilling to believe that there is such a "something" in space is left with mere principles. His starting point to understanding gravitation is the Principle of Equivalence: a principle we have also had for half a century without understanding the nature of the force of gravity. To proceed here and retain generality, we will assume that there is something in space moving about the inertial reference frame in juxtaposition with the E frame and providing centrifugal balance. This we will term the G frame. Whatever it is, it must have a mass property used to balance the mass of any matter present in the E frame. Further, it could provide balance for any mass property of the E frame itself. At this stage, mass has been introduced in a form with which we are not familiar. The

* The mass of an element of matter can vary. Except for some unusual conditions occurring in nuclear reactions and dense stars, this mass is the sole cause of gravitational effects. Also, as later analysis will show, except under similar very exceptional conditions the Constant of Gravitation is invariant.

suggestion is that space itself has mass properties. Matter has mass properties. The inertial effects of the mass in space and the mass of matter interact so that space is disturbed by matter. The disturbance characterizes gravitation. Gravitation, as we know it, is only associated with the mass of matter as a result of this disturbance characteristic. In the absence of matter space is balanced and undisturbed. If there are forces between mass in free space these contribute to the uniformity of the system and pass undetected in our experiments with matter. It is most important to note, therefore, that though reference will be made to the mass properties of free space we are talking about a medium which is apparently weightless. Abundant evidence is available to support the proposed mass character of free space. This is reserved for Chapter 5.

Energy and Angular Momentum of Space–time

Space is really the emptiness, the void or the three-dimensional expanse in distance around us. Time is the motion of something in this space. This tangible medium which must exist in space is termed space–time. It comprises an E frame and a G frame moving about a common inertial frame in balance with one another. We now assign the symbol Ω to denote the universal angular velocity of this motion.

A system such as this, that is one capable of disturbance without change of the periodic time parameter, has the same characteristics as two masses subject to a mutually attractive force proportional to their displacement distance. An oscillatory mass having a restoring force proportional to displacement has a fixed oscillation period independent of the amplitude of displacement. Logically, therefore, if the E and G frames can be disturbed without affecting their oscillation period, their nature is likely to be such that they are subject to a mutually restoring force proportional to their separation distance.

Space–time has angular momentum. This follows from the above proposition. Now, it is a fundamental law that energy is conserved in all physical processes. It is equally fundamental that angular momentum is conserved in a mechanical system of the kind just described. If, as appears from such mechanical analogies, both energy and angular momentum in space–time are conserved, it is interesting to ask how space–time reacts with matter.

To understand this, we first note that matter lies in the E frame. Any motion of elements of matter relative to the E frame develops kinetic energy, magnetic energy, etc., and, according to the analysis in Chapters 1 and 2, adds mass properties to the matter. We can, therefore, speak simply in terms of matter moving with the E frame. This matter has motion at the angular velocity Ω in the orbit of the E frame. This adds kinetic energy, but as an energy component which appears to be devoid of mass properties since it does not arise from motion relative to the E frame. From similar reasoning it is calculable in terms of simple Newtonian mechanics. To facilitate analysis, let us assume a proposition, proved later, that the E and G frames have, when undisturbed, the same mass density ρ and rotate in the same sized orbits of radius r. The kinetic energy of unit volume of undisturbed space is then $2(\frac{1}{2}\rho v^2)$ or simply ρv^2, where v is the orbital velocity Ωr. The mass energy density of space–time is $2\rho c^2$, from the relation $E = Mc^2$. If, now, energy is added to cause the orbital radius r of both frames to expand equally, the velocity v is increased. Work is done against the restoring force between the E and G frames. This is calculated from the centrifugal force as $2\rho v^2/r$ times the increase of r. Note, however, that the angular momentum $2\rho vr$ per unit volume can be written in the form $2\rho v^2/\Omega$. If angular momentum remains constant when energy is added to space–time ρv^2 remains constant, since Ω is constant. Hence no kinetic energy can have been added although v has increased. It follows that ρ has diminished and, since the mass energy density $2\rho c^2$ of free space is likely to be conserved, it also follows that c has increased in proportion to v. The conclusion from this is that v is, in fact, a parameter of space–time related directly to the velocity of light c. Later, it will be proved that c is the relative velocity of the E and G frames, making $v = \frac{1}{2}c$. A consequence of this is that the energy added to free space all goes into doing work against the restoring force. Thus, if the velocity of light increases by δc, corresponding to an increase of r by δr equal to $\delta c/2\Omega$, the energy added per unit volume is $(2\rho v^2/r)\delta c/2\Omega$ which is $\rho v\delta c$. Since v is $\frac{1}{2}c$ this can be written as $2\rho v\delta v$, which is effectively the increase in kinetic energy if ρ were constant.

This result will be used in the next chapter to explain several phenomena associated with gravitation. The immediate objective is to understand the nature of the photon and the principles of wave mechanics. In this regard, it is noted that space–time can accept energy without changing its angular momentum. Since matter possesses an angular momentum due to its motion with the E frame, the radiation of energy by matter in a photon event must involve a process of angular momentum exchange. This is the entry point to wave mechanics.

Heisenberg's Principle of Uncertainty

In order to extend the theory we need to evaluate Ω or r. This can be done in a preliminary way by considering an electron moving with the E frame. Because of this motion it has a position which changes constantly. It is never at rest in the inertial frame. Its position is uncertain by an amount equal to the diameter of the orbit of motion $2r$. Its momentum is uncertain since its motion at velocity $\frac{1}{2}c$ constantly reverses. The uncertainty of momentum is twice its instantaneous momentum $\frac{1}{2}mc$. Here, m denotes the mass of the electron. Thus, the product of uncertainty of position and uncertainty of momentum is $2mcr$. Now, according to Heisenberg's Principle of Uncertainty, the product of these two parameters is $h/2\pi$, where h is Planck's constant. This is an accepted postulate in quantum mechanics. It is used here merely to estimate r and Ω. Since Ω is $c/2r$, we can deduce from the data just given that:

$$r = h/4\pi mc \tag{4.1}$$

and

$$\Omega = 2\pi mc^2/h \tag{4.2}$$

As already noted on page 2, Heisenberg's Principle of Uncertainty has been expressed by Eddington in the words: "A particle may have position or it may have velocity but it cannot in any exact sense have both." In the sense of our analysis, a particle at rest in the electromagnetic reference frame does have velocity in the inertial frame. In an exact sense it has velocity and position, but we must not think it is at rest when it is always moving and we cannot, nor do we ever need to, say exactly where it is in its motion about the inertial frame because all matter shares the same motion. The basis of the uncertainty is eliminated by recognizing the separate existence of the electromagnetic reference frame and the inertial frame.

Our analysis so far does tell us that an electron has an intrinsic motion when at rest in the electromagnetic reference frame. Its own angular momentum is $mcr/2$ but there is an equal associated angular momentum due to the balance afforded by the G frame. Thus, the total angular momentum intrinsic to the electron and due to motion with the space–time system is mcr, which is $h/4\pi$, from (4.1). This is of importance when we come to discuss the nature of electron spin.

It is appropriate to mention here that something quite close to this theory of space–time is implicit in a physical interpretation of de Broglie waves once presented by Einstein (1925). The electron in the atom was deemed to be at rest with respect to a Galilean system oscillating at a frequency mc^2/h which is everywhere synchronous. This corresponds exactly with the result given in (4.2).

Space–time Spin Vector

The universal motion at the angular velocity Ω defines a fixed direction in space. There is not really any evidence of a fixed direction having preferred properties in space. Space is not deemed to be anisotropic. However, in Chapter 8 we will see that at least from this theory we can expect the axes about which space–time spins to be approximately normal to the plane in which the planets move about the sun. The evaluation of the earth's magnetic moment provides the evidence of this. It is probable from this that the spin motion at angular velocity Ω, though the same throughout all space in magnitude, may be directed in different directions in the environment of different and widely spaced stellar bodies. When the nature of gravitation is explained it will be seen that this implies that widely spaced stars do not mutually gravitate in strict accordance with Newton's universal law. Gravitation exists everywhere and between all matter, but two elements of matter separated by several light years may not be mutually attracted in strict accordance with Newton's Law.

For the analysis in this chapter the direction of Ω is of little significance. No angular momentum is added to this motion in the photon processes under study. Though reference will be made to angular momentum in connection with the space–time system, the reader should not restrict his thoughts of this angular momentum to an association with Ω and consequently a fixed direction in space.

Planck's Radiation Law

An electromagnetic wave is a propagated disturbance of the E frame. The E frame can be disturbed if a discrete non-spherical unit of it rotates and so sets up a radial pulsation. This is depicted in Fig. 4.1. The E frame is shown in lattice form and a cubic unit is

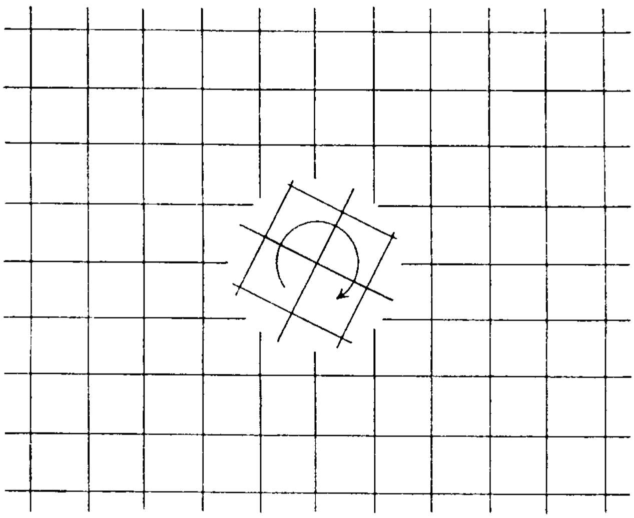

Fig. 4.1

deemed to be in rotation. Any axis of rotation through the centre of the cubic unit can be chosen. The E frame will be disturbed at a frequency proportional to the speed of rotation of the unit. We presume that the cubic unit of space–time is such that it has the same moment of inertia about any axis through its centre. Therefore, the propagated disturbance frequency ν will be directly related to the angular momentum of the unit and independent of the direction of this angular momentum vector. The conditions just assumed will be proved to be applicable in Chapter 6, where it will also be shown that the unit has discrete unique form. Below, it is termed a photon unit.

A little consideration will show that if the unit rotates at an angular velocity $\Omega/4$ it will develop an electromagnetic pulsation at the frequency of the universal motion of space–time. Under these conditions there is no electromagnetic wave propagation since a little local adjustment of the E frame can contain the disturbance. A photon unit rotating at the angular velocity $\Omega/4$ will be termed a standard photon unit. If the unit rotates at an angular velocity differing from $\Omega/4$ there will be electromagnetic wave propagation at a frequency corresponding to four times this difference quantity. Thus:

$$\nu = 4\omega/2\pi \tag{4.3}$$

where ω is the amount by which the angular velocity of the photon unit differs from $\Omega/4$, denoted ω_0 below.

Having specified the existence of a standard photon unit we will now speculate about the possible existence of a unique particle form in association with this unit. Firstly, the angular momentum of the unit may have some exchange relationship with such a particle. Angular momentum cannot be absorbed by space–time for the reasons already given. Therefore, if the angular velocity of the unit is to change we must have angular momentum drawn from some other source. Secondly, we now presume that this particle form can exist in either of two states. In one state it has its association with a photon unit. In the other state it is transferring from association with one photon unit to association with another somewhere else in the E frame. We take a simple case in which this transfer is linear and presume that during such linear transfers the particle has lost its motion with the E frame. When moving with the E frame the particle of mass m' has an angular momentum of $\frac{1}{2}m'cr$ plus any intrinsic spin s plus the associated component $\frac{1}{2}m'cr$ linked by the balance action of the G frame. This is taken to be zero on the assumption that angular momentum is conserved and is zero for the linear motion. This gives the condition:

$$s = -m'cr \tag{4.4}$$

The kinetic energy associated with the motion with the E and G frames is released when the particle is in transit to its new location. This energy is $\frac{1}{2}m'(\frac{1}{2}c)^2$ for each frame or a total of $\frac{1}{4}m'c^2$. Since the transit of the particle from one part of the E frame to another is an observable phenomenon, the energy of the particle in transit is drawn from "observable" sources. The particle will not move without the reason causing movement and the energy source associated with it. Thus, the energy $\frac{1}{4}m'c^2$ is surplus for the very short transit state of the particle.

Essentially, the particle, once it has left its association with a photon unit, is looking for another one. The proposition we now have is that the energy just freed is used to produce two counter-rotating standard photon units along the trajectory of the particle. Thus, when the particle reaches the outermost of these photon units it has the opportunity to revert to its state of motion with such a unit by virtue of the collapse of the remaining pair of photon units. The energy is redeployed as if the process is reversible. This is illustrated in Fig. 4.2. Note that the particle can move in any direction in space. The spin s has a set direction in space but the photon unit spins, though all parallel or anti-parallel, can be in any orientation. If I denotes the moment of inertia of the standard photon unit, the kinetic energy of the two created units is twice $\frac{1}{2}I\omega_o^2$. Thus:

$$\tfrac{1}{4}m'c^2 = I\omega_o^2 \tag{4.5}$$

From the fact that ω_o is $\Omega/4$ we can use (4.2) and (4.5) to show that:

$$I\omega_o = (m'/m)h/2\pi \tag{4.6}$$

From (4.1) and (4.4):

$$s = -(m'/m)h/4\pi \tag{4.7}$$

Unless we recognize fractional units of the fundamental spin angular momentum quantum $h/4\pi$ we must, therefore, take m' to be equal to m or a multiple of it. The logical conclusion is that the photon-related particle is the electron, of mass m.

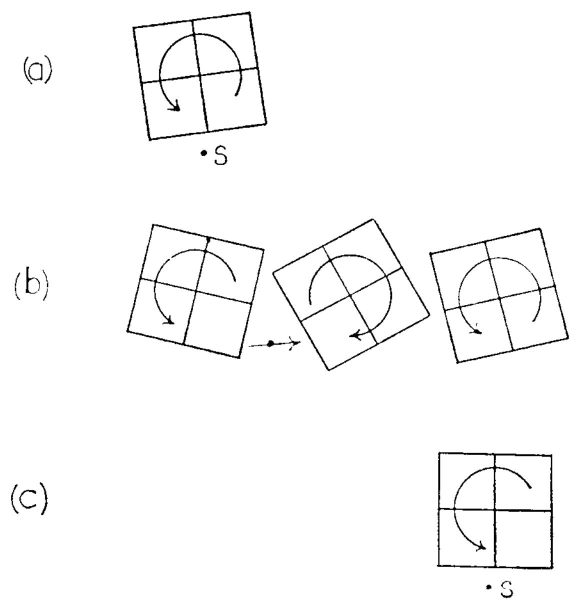

Fig. 4.2

This gives us the angular momentum of the standard photon unit. It is $h/2\pi$. An electron is, presumably, normally associated with a photon unit of spin $h/2\pi$. As it moves linearly through the E frame it induces counter-rotating photon units in its path which collapse behind it as it transfers between its pauses in a successively-new, but ever present, standard photon unit. This has been shown in Fig. 4.2 where at (a) the electron has its spin s and is associated with the single photon unit. At (b) it has lost its spin and is moving in a path in which two new counter-rotating photon units have been formed. At (c) the electron has reached the outermost photon unit, reassumed its spin, and the units left behind have been eliminated. Note that the electron can only settle with a photon unit having a rotation in a specific sense.

At this stage it should be said that the atom is the home for photon units having this special affinity for settled electrons. When the electron is in its settled state in association with a photon unit it complies with wave mechanical criteria. When the electron is in transit to another photon unit it complies with Bohr's analysis of the atom. Wave mechanics determine the probable position of the electron when it is in its settled or pause state. Full analysis requires a substantial insight into the mechanisms within the atom and leads to the explanation of the photon itself and Planck's radiation law. As a preliminary we will explore the state in which the theory of the Bohr atom is applicable.

The Bohr Atom

If an electron in an atom can move almost anywhere within reasonable limits about the nucleus according to a probability condition set by a wave mechanical formula, we have to accept that it is not moving in a simple orbit with fixed angular momentum. However, the effect of the nuclear charge will cause its successive transits from one photon unit to the next to be small arcs of different, but nevertheless simple, orbits. Where does this angular momentum come from? The answer to this is that in the atom it may be that when the electron moves out of spin and goes into transit the energy released is deployed into forming two photon units which spin in the same direction. Then, there will be a reaction angular momentum of twice $h/2\pi$ imparted to the mass energy. This mass energy comprises the energy mc^2 of the electron, or multiples of this in a many-electron atom. The angular momentum will really come in quanta of $h/2\pi$, even though made available in pairs in the transition phases of an atom or molecule. Note the existence of the single photon unit state implicit in (a) of Fig. 4.2. By this mechanism we expect that an electron can move about around the atomic nucleus sporadically complying in its motion with successive sections of Bohr orbits.

In a multi-electron atom or in a single electron atom in an energetic environment primed by free electrons, there is the possibility that some electrons in transit between rest positions may move linearly even though their surplus energy has gone to form a pair of photon units having the same direction of rotation. The surplus angular momentum is then available in units of $h/2\pi$ to be added to the angular momentum of another electron in orbital transit. The result is that integral quantization of angular momentum in multiples of $h/2\pi$, as assumed in Bohr's theory, is to be expected.

According to Bohr's theory of the atom, an electron describing a circular orbit around a nucleus of charge Ze moves so that its centrifugal force mv^2/R is in balance with the electrostatic force of attraction Ze^2/R^2. Here, R is the distance of the electron from the nucleus and v is the electron velocity. By assuming that the angular momentum of the electron is quantized in units of $h/2\pi$ it is then possible from simple algebra to deduce that the kinetic energy of the electron is given by:

$$\text{K.E.} = \tfrac{1}{2}mv^2 = \frac{2\pi^2}{n^2h^2} Z^2e^4m \tag{4.8}$$

where n is the number of units of the angular momentum quantum.

This kinetic energy quantity is the energy possessed by the electron during its transit between photon unit positions. When it reaches such a position and is put into its wave mechanical state this energy is deployed to prime the electron with a different motion. The electron loses its quantum of angular momentum but, as will be seen below, it has interplay with the photon unit. Angular momentum is exchanged. There is interaction with the nucleus and the properties of the atom and its nucleus can be explained.

The applicability of Bohr theory intermittently in the successive transits of the electron shows that the argument used in Chapter 3 to account for ferromagnetism has good basis in atomic theory and, as will emerge, is not inconsistent with wave mechanical treatments of the atom.

Electron-Positron Annihilation

It may be asked whether the two counter-rotating photon units shown in Fig. 4.2 can split. As long as they are so close together they are ready to mutually cancel. In Fig. 4.3 it is shown how an electron and a positron which pass through the transit state together may form photon unit pairs and then mutually annihilate one another. The

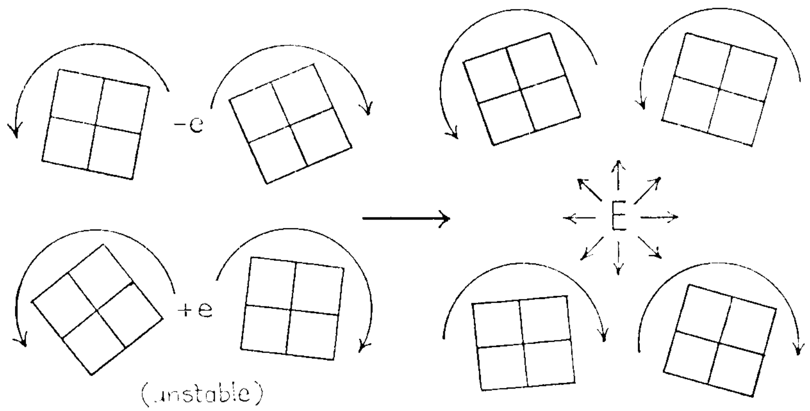

Fig. 4.3

reaction is deemed to divide the photon units into pairs having the same spin direction. As the energy E released by the mutual cancellation of the electron and positron is dispersed the pairs of standard photon units are left with their angular momenta. They are available for capture by atoms. It is a matter for speculation to ask whether an atom could contain photon units having stable spin states in opposite directions. Already, we have seen that the angular momentum priming of the Bohr atom can involve standard photon units with spins in the same direction. At least here we have the storage medium for paired photon units with the same spin direction. This is possibly the source of the photon units needed for the reverse process of electron-positron creation.

It is, perhaps, appropriate here to note that in the transit state of the electron or positron depicted in Fig. 4.3 the energy mc^2 will transform according to Planck's law (Energy $= h\nu$) into radiation at a frequency corresponding to the angular velocity Ω. This follows from (4.2). The electron and the positron have this intimate physical connection with the properties of the space–time system which determine Planck's constant.

The Schrödinger Equation

This equation is the basic formula of wave mechanics. It will now be shown how it results from the physical theory presented above. In simple terms, the atom captures a pair of standard photon units, having the same direction of spin, for each electron position. These units are divided. One is located with the electron. The other is located in the nucleus.

Referring to Fig. 4.4, consider a photon unit rotating at an angular velocity different from ω_0 and at a distance from the nucleus of an atom. Assume that an electron moves about the centre of this unit and that, provided it moves to compensate the electric field disturbance of the unit normally associated with wave propagation, the

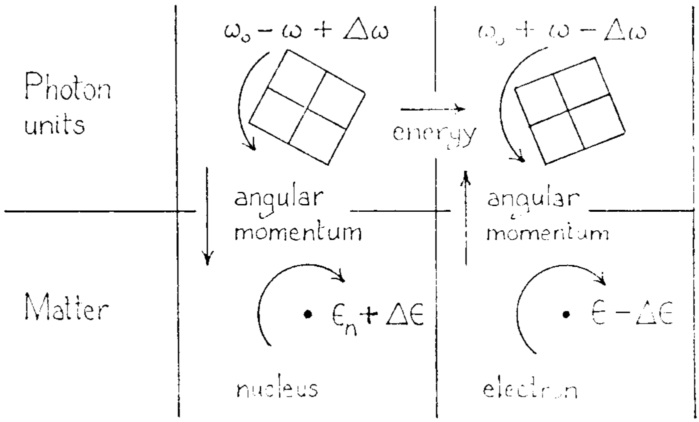

Fig. 4.4

system will not be radiating uncompensated electromagnetic waves and so may be stable. There is also a second photon unit which is positioned with the nucleus. This second unit also rotates at an angular velocity different from ω_0 but is complementary with the other unit in the sense that it generates a pulsating disturbance at exactly the same frequency. It does this by rotating slower than ω_0 by the amount by which the other unit rotates faster. The electron is thus able to compensate the propagation tendencies of both photon units. This action will occur because the priming of the two photon units by their high velocity rotation in the same direction allows this complementary change in angular velocity by mere energy transfer between the units. Angular momentum is conserved between the photon units and their respective particles, the electron or the nucleus.

Our problem is to analyse the motion of the electron. This comprises the regular motion to compensate the rotation of the photon units and leads to the derivation of the Schrödinger Equation. It also comprises a migratory motion about the nucleus as determined statistically by the solution of this equation. Even so, as has been explained, this migration is by way of a transit between photon units on trajectories determined according to Bohr's theory of the atom. This, then, is the physical picture of what is happening inside a stable atom. Stability prevails until some quantum event happens to prevent the electron from affording the compensation. Then, since the photon units are not rotating at the non-disturbance frequency ω_0, there is wave propagation. The quantum event will be discussed later in connection with photon emission.

When the stable state is merely perturbed, as by the electron rotating at a lower frequency about its photon unit centre, we find that there is still no radiation. The photon unit changes its rotation speed by exchanging angular momentum with the electron. They are both rotating about the same centre. Any change of kinetic energy by the electron involves interchange of energy with other matter forms. The mass energy of the system is conserved. Thus, the energy change of the photon unit is accommodated by energy transfer between the two photon units. The result of this is the change in angular velocity of the photon unit in the nucleus and the related angular momentum exchange between it and the nucleus. On balance, therefore, both energy and angular momentum are conserved in the matter of the atom, but we have a process of transfer of angular momentum indirectly between the nucleus and the electron.

The electron is deemed to have an angular momentum ε, which is deployed in a motion to compensate the photon unit rotation. Let ε decrease by $\Delta\varepsilon$ as angular momentum is transferred to the photon unit of the electron. This unit has the standard angular velocity ω_0, corresponding to an angular momentum $h/2\pi$, and an additional angular velocity ω which complements the motion of the electron. In this sense it is to be noted that the standard angular momentum $h/2\pi$ has to be changed to provide the electron with any angular momentum in its compensating state. The photon spin is taken to be opposite to that of the electron because energy transfer to a limited degree is needed between the matter and the photon units due to the second order energy considerations, and this is more likely to occur in the electron environment. To understand this, note that energy terms in ω^2 need to be added to the photon units. In the nucleus this energy can be drawn from the reduction in angular velocity of the standard photon unit as the electron is adopted by the outer photon unit. In this latter position, energy is needed in addition to the surplus from the nuclear photon unit. It is available from the motion of the electron. However, this situation requires the opposed motions of the electron and its associated photon unit. Returning to our analysis of the perturbed state, the transfer of $\Delta\varepsilon$ to the photon unit of the electron slows it down by a small amount of angular velocity $\Delta\omega$. Neglecting second order terms, for energy conservation and wave compensation, we find that the nuclear photon unit will then spin at the angular velocity $\omega_0 - \omega + \Delta\omega$. It will interact with the nucleus to give it the angular momentum $\Delta\varepsilon$. This is added to its intrinsic angular momentum ε_n which probably will be some basic quantum as adjusted by an initial priming as the electron entered the condition under analysis.

The process described provides some remarkable results when we come to evaluate quantitatively the magnetic moments and spin properties of atomic nuclei. This subject is treated in Chapter 7.

To provide compensation in its non-transit state the electron describes a circular orbit at a frequency ν which matches the angular velocity ω of the photon unit. Thus, from (4.3) we have a relation between ν and ω. From (4.6), with $m = m'$ and $\omega_0 = \Omega/4$, we have a value of the moment of inertia I of the photon unit. Thus:

$$I\omega = h\nu/\Omega \tag{4.9}$$

The kinetic energy W of the electron can be expressed in terms of its angular momentum in its orbit. Thus:

$$W = \pi\nu\varepsilon \tag{4.10}$$

Since the angular momentum ε is equal and in balance with $I\omega$, these equations give:

$$W = \pi h\nu^2/\Omega \tag{4.11}$$

The electron moves to compensate a wave disturbance which would be developed by the photon units and which would have the frequency ν but for the action of the electron. To make this compensation complete for both photon units, the position of the electron must move about the nucleus so that there is effective compliance of position with the amplitude of a wave tending to be developed at the frequency ν. It is noted that in Chapter 1 it has been explained that an electromagnetic wave does not need to convey energy. It is a disturbance in which energy is exchanged between different states without being propagated. The wave is propagated, if not compensated, but the energy involved in the wave disturbance is not carried away at the wave velocity. Thus, so long as the electron can wander around the nucleus by its transits between photon units and satisfies the conditions of circular orbital motion as specified by equation (4.10), there is no sustained unbalance of radiation. The statistical position of the electron is governed by its need to comply with the form of the wave amplitude.

The standard wave equation of frequency ν is:

$$\Delta A + (4\pi^2\nu^2/c^2)A = 0 \tag{4.12}$$

where A is wave amplitude. Eliminating ν from (4.11):

$$\Delta A + (4\pi\Omega/hc^2)WA = 0 \tag{4.13}$$

This becomes the well-known Schrödinger Equation:

$$\Delta A + (8\pi^2 m/h^2)(E - V)A = 0 \tag{4.14}$$

when, consistent with (4.2):

$$\Omega = 2\pi mc^2/h \tag{4.15}$$

$E - V$ denotes the kinetic energy W as the difference between the total energy E assigned to the electron in the atom and the potential energy V.

Physically, instead of the electron moving in an orbit about the nucleus to balance centrifugal force against the electric field of the nucleus, as in the Bohr state, it is moving under the influence of the induced electric fields in the wave field. Its total energy is conserved but it has exchanged its angular momentum with photon units, as already explained.

The Schrödinger Equation is the basic equation of wave mechanics and much of the success of physical theory which may be termed "non-classical" has resulted from the valid application of the equation. As is well known by students of quantum theory, it is possible to develop the theory of electron structure of the atom by using the Schrödinger Equation. However, particularly in respect of the quantitative priming of the energies of the discrete energy levels of the electrons, the Bohr theory has to be used in conjunction with wave mechanics for a complete understanding of the atom.

Photon Momentum

We will now consider those events in which there is an unbalanced state, where the electron is somehow jolted in its successive transits between photon units so that it might move to another energy level and fail to provide full compensation for wave propagation. In short, we consider the mechanism of the photon.

From (4.10) and (4.11):

$$\varepsilon = hv/\Omega \tag{4.16}$$

Since ε is $2\pi v$, the angular velocity, times the moment of inertia of the electron, mx^2, about the centre of its orbit of radius x:

$$\varepsilon = 2\pi v m x^2 \tag{4.17}$$

These two equations and the fact that Ω is $c/2r$ give:

$$x = 2r \tag{4.18}$$

When the electron is in transit from one photon unit to another its kinetic energy corresponds to its velocity and momentum. However, these quantities are very much contained by the atom if it is not radiating. Momentum has direction and as the electron moves about in the atom this will somehow be exchanged, absorbed and balanced by other motions. This sort of momentum is lost from the atom when the electron goes out of the atom as well. It is not radiated.

When the electron, in its normal migration around the atomic nucleus, goes out of transit and moves into association with a photon unit it acquires angular momentum ε in an orbit of radius $2r$. Consequently there is a sudden change of the linear momentum of the electron equal to $\varepsilon/2r$. This linear momentum arises from direct interaction with space–time. It is not a reaction with other matter. From (4.16) this momentum is $hv/2r\Omega$, or since Ω is $c/2r$, hv/c. It follows that each time the electron goes in and out of transit there is a momentum exchange with space–time. In a stable atom these exchanges occur alternately with alternate compensations of momentum. However, if the atom is disturbed to become radiating, and some of this momentum is lost by the electron, it cannot assume a compensating state. There will be a difference in the frequencies of the electron motion and the photon units giving rise to a propagated wave disturbance. The frequency of the radiated wave will be related to the lost momentum. The lost momentum will be simply h/c times the radiation frequency. This is the simple mechanism of the photon. A photon is an event in which momentum is exchanged between matter and space–time. An exchange in one location results in the emission of a wave radiation throughout space. This primes space at the disturbance frequency and encourages atomic systems elsewhere to restore balance and compensate the radiation by inverting the process and exchanging, in the opposite sense, the same momentum quantum with space–time. The overall result, of course, is that it appears that a photon is a corpuscle which moves with momentum h/c times the radiation frequency. In fact, the momentum has been imparted to space–time. Probably the E frame is given a push which on balance tends to be cancelled by successive actions in the opposite sense. On this theme, it would be interesting to know whether this momentum of space–time can be deployed to generate photons of different frequencies not in the same proportion as those imparting the momentum. Experiments seem to be restricted to the study of a radiation momentum in relation to energy absorbed or a single emission frequency. However, this is mere speculation and is beyond the scope of the present work. Suffice it to say, the analysis of the atom discussed above is wholly consistent with the momentum properties of the photon.

Anomalous Electron Behaviour

Before leaving this chapter, it is worth noting that an uncertainty jittering of the electron at the Compton wavelength related to the angular velocity Ω has been proposed as a basis for explaining the anomalous spin moment of the electron (Harnwell, 1966). Precise measurement of the ratio of the magnetic moment and spin angular momentum of the electron shows that it differs slightly from the mere ratio of $eh/4\pi mc$ to $h/4\pi$, or e/mc, as previously expected. The quantum-mechanical explanation is rather complicated and is not wholly accepted, but it appears to predict that the ratio is greater by the factor $1+a/2\pi$, where a is the fine structure constant. The physical basis of the explanation is that the electron may be thought of classically as exchanging radiant energy with its surroundings. This makes the electron mass appear different for its linear accelerated motion and its spin.

The above account, however, is hardly acceptable from the theory presented in this work. This, therefore, sets us the task of finding the reason for the anomalous magnetic moment of the electron. It is a challenge which can be met, and, indeed, the explanation is really quite simple. However, since its quantitative aspects require some further analysis of the parameters of space–time, it is reserved for Chapter 7. Even so, it is appropriate here to evaluate some data of later use in this exercise. This is the angular momentum component of the photon unit due to the balance of the electron angular momentum in the non-transit state. Put another way, we will evaluate ε.

From (4.9) and (4.11):

$$I\omega = \sqrt{(Wh/\pi\Omega)} \tag{4.19}$$

Since the kinetic energy W is given by (4.8) we then have:

$$I\omega = (Ze^2/nc)\sqrt{(2\pi mc^2/h\Omega)} \tag{4.20}$$

Simplifying this from (4.2) and putting $Z = 1$ and $n = 1$, we have:

$$I\omega = 2a(h/4\pi) \tag{4.21}$$

where a is the fine structure constant $2\pi e^2/hc$.

Summary

To summarize, in this chapter we have developed a notion of space–time which lends itself to the linking of gravitation and wave mechanics. A common feature of space–time has provided the clues to the Principle of Equivalence, the disturbance in dependence upon mass of matter, and, most important, the basic motions and spin relationships operative in wave mechanics. The analysis has led to the Schrödinger Equation and supported it by a clear physical picture of the structure of the atom. The mechanism of photon momentum has emerged from the analysis. A key feature has been the development of the space–time properties by which energy can be added to space–time without augmenting its angular momentum. This makes the theory ready for extensive development in the next chapters. Energy added to space–time has the effect of increasing the velocity of light. This is our starting point in Chapter 5. It is feasible to regard space–time as primed by a small amount of such energy. Though not discussed in this chapter, this priming energy, briefly introduced already in Chapter 2, will be later seen to be of fundamental importance. It will be termed space polarization energy and denoted ψ. It is small compared with the intrinsic mass energy of space–time but its depletion from its normal value is, seemingly, the state of magnetism and also the indirect source of gravitational force.