5

Quantum Mechanics

Universal Time

In Chapter 3 the concept of time dilation as required by Einstein's theory was questioned. The experimental evidence supporting time dilation was challenged and this means that there is really no clear case favouring the idea that we age at different rates according to our relative state of motion. Alternative explanations for the apparent time changes are available and are consistent with the old-fashioned idea that time is universal and is shared by all in a harmonious manner. Indeed, one could say that we all sense the same time because we are part of a universal clock woven into the properties of space.

In 1932 Dirac delivered his Nobel prize lecture under the title 'The Theory of Electrons and Positrons' and made the statement:

> It is found that an electron which seems to us to be moving slowly, must actually have a very high frequency oscillatory motion of small amplitude superimposed on the regular motion which appears to us. As a result of this oscillatory motion, the velocity of the electron at any time equals the velocity of light. This is a prediction which cannot be directly verified by experiment, since the frequency is so high and its amplitude so small.

Similar proposals had been made earlier by both Einstein and Schroedinger. Einstein imagined the electron as belonging to a Galilean reference frame oscillating at a frequency determined from the electron rest mass energy and the Planck relationship, and being everywhere synchronous.

Thus, on the authority of great physicists such as Dirac, Schroedinger and Einstein, we are led, when examining the microcosmic world within the atom, to feel that matter is locked into a rhythmic motion. The quantum world of the atom is a world in which time appears to be universal.

Matter is linked by space or the so-called fields which permeate space. If time is universal then it becomes a property of space itself, owing to this role of space in providing the universal connection. Therefore, time must be connected with something which moves in space, because time without motion is meaningless. But space is devoid of matter if we consider the vacuum state. Yet there is motion in such space. The aether is then essential to provide the medium having this time-setting motion. We can avoid it by specifying formulae which reflect its properties, that is, we can avoid using the word 'aether'. This was the course followed in developing wave mechanics. Formulae, and notably the Schroedinger equation, were developed and correlated with experimental facts. The underlying physical system was not taken as a necessary foundation. It could not be firm enough, bearing in mind the failure to detect the physical aether as the absolute electromagnetic reference frame. But equations need some kind of foundation if they are to portray reality, and the aether, as a universal clock, can provide such foundation.

It needs little imagination then to realize that Dirac's words quoted above plus the ideas of Einstein lead to a model of the aether which carries matter universally in synchronous circular orbital oscillations in balance with something in space in synchronous countermotion at the relative speed of light, the frequency being $m_e c^2/h$. Here m_e is electron mass, c is the speed of light and h is Planck's constant.

Furthermore, from what has been said, space devoid of matter must also have such a state of motion. We need then to distinguish between the various elements moving in space. In Chapter 3 we spoke of the C-frame as the universal reference frame for electromagnetic action when matter was not present. Thus the C-frame becomes a primary candidate for the cyclic oscillation. The counterbalance is provided by something we will term the G-frame, which moves everywhere in the same cyclic direction as the C-frame but which, being in juxtaposition about a common inertial frame, is always moving at a fixed speed relative to the C-frame. This system is portrayed in Fig. 22.

The line grid represents the G-frame and the solid dots represent elements of the C-frame. These latter elements will later be identified as the q charges or lattice particles introduced in Chapter 2. The G-frame will be identified as the charge continuum σ, also introduced in Chapter 2 but will also comprise the gravitons introduced at the end of Chapter 2. Note then that a relative velocity of light applies for relative motion of the q charges and σ, giving u in (54) as c. Also note that at any moment all the elements of the undisturbed vacuum medium move parallel or anti-parallel.

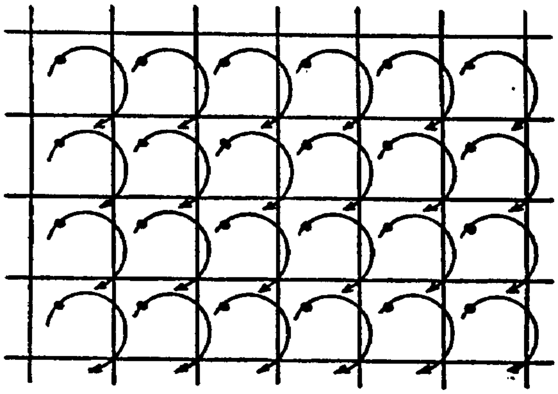

Fig. 22

When we come to consider the presence of matter, sharing the motion of the C-frame, then we will see justification for having a dynamic balance between the mass-energy of the gravitons and that of the matter plus the q charge system. The inertial mass of matter present thus becomes connected with the additional graviton mass, in exactly the manner required to explain the electrodynamic disturbance giving rise to gravitational effects. The equivalence of inertial mass and gravitational mass is inherent to such a model. Also, the mutually parallel motion of the gravitons and the continuum satisfies the requirement of the law of electrodynamics for direct mutual attraction along the line joining two electrodynamic disturbances. This gives the key connection with a gravitational law of force. It depends upon the interaction being insensitive to the high frequency of the oscillations. This is assured in the theory presented because the Neumann potential is proportional to $(\mathbf{v}.\mathbf{v}')$ and if $\mathbf{v}$ and $\mathbf{v}'$ are always parallel and equal then their product is a constant scalar quantity having no time dependence. The energy distribution throughout space as represented by the Neumann potential is then independent of the space oscillation frequency, provided the amplitudes of $\mathbf{v}$ and $\mathbf{v}'$ are constant. Thus the same forces are to be expected whether the frequency is very high or as small as we choose to make it. The gravitational potential must therefore be unaffected by the frequency and apply as if there is true instantaneous action at a distance. There is energy deployment when two gravitational disturbances, that is two particles of matter, move *relative* to the C-frame. Then we do have retardation effects as if gravitation is subject to a finite speed of propagation, but the key point is that the rapid cyclic motion portrayed in Fig. 22 has no retarding effect upon gravitational action. Nor, indeed, does it affect the electrical actions between the charges because the spatial energy deployment of the direct electric interaction fields remains constant relative to the C-frame. The circular motion of the q charges nevertheless is subject to the self-field action which gives the charges a mass property. However, it is a different mass property from that we associate with isolated charge in motion. The q charges are all constrained in the system depicted in Fig. 22 to stay in synchronism. This constraint comes from their electric interactions. It gives rise to extraneous fields which resist any distortion of this synchronous state. Radial distortions and lateral distortions can occur but not this frequency distortion. Therefore the q charges have only two degrees of freedom. This affects the mass property by causing any addition to the self-energy which we would normally associate with the kinetic energy of the charge to be dispersed throughout the q charge lattice. It is shared to the extent that any additional mass is distributed throughout the whole lattice. As a result there can be no relativistic increase in mass of a q charge. Its mass is effectively constant. Now this is very important, firstly because it facilitates analysis, but secondly because it assures that the system behaves as a linear oscillator and this is a key requirement to our understanding of wave mechanics. We can therefore use Newtonian mechanics to calculate the behaviour of the space medium, in spite of the fact that the relative velocity of the C-frame and G-frame is the speed of light.

Planck's Law

In Chapter 2 it was shown that the q charges when displaced in the continuum of charge density σ were subject to restoring forces proportional to the displacement. This can be set in balance with the centrifugal forces of the q charges, allowing us to write:

$$4\pi\sigma qx = m\Omega^2 r \tag{86}$$

from (37). Here r is the radius of the orbits of the q charges and Ω is the angular frequency of space. m is the mass of the q charges.

x denotes the separation distance between the σ continuum and the q charge system. Thus $(x-r)$ is the orbital radius of the cyclic motion of the graviton and σ continuum system. The σ continuum and the gravitons are best regarded as an integral system statistically smeared into a uniform whole as far as interaction with the q system is concerned. Thus, since the gravitons are deemed to be relatively massive, they need only have a sparse population compared with the lattice particles having the q charge. Let m' denote the mass of the continuum-graviton system per lattice particle. Then:

$$m\Omega^2 r = m'\Omega^2(x-r) \tag{87}$$

The kinetic energy density of these C and G frame constituents of space is proportional to:

$$mr^2 + m'(x-r)^2 \tag{88}$$

because the space frequency is constant. We may then expect the electric potential energy of such a system to have minimized, so determining x, and the rest mass energy of m and m' to have been deployed between m and m' to maximize (88), inasmuch as kinetic energy is drawn from a source of potential energy and, with energy conservation, minimization of the latter means maximization of the former.

Write M as $m+m'$ to obtain from (87):

$$x-r=(m/M)x \text{ and } r=(m'/M)x \tag{89}$$

Put these in (88) to obtain:

$$(mM^2 - Mm^2)x^2/M^2 \tag{90}$$

Since M and x are constant, we may now differentiate this energy expression with respect to m to find its maximum by equating the differential to zero. This gives:

$$1-2m/M=0 \tag{91}$$

from which we deduce that $m=m'$ and, from (89), that $x=2r$.

The C-frame and the G-frame describe orbits of equal radius r. As their relative velocity is c, they move at a speed $\frac{1}{2}c$ in orbit. As the space frequency is $m_e c^2/h$, the value of Ω is given by:

$$\Omega = 2\pi m_e c^2/h \tag{92}$$

The radius r is then known, because Ωr is $\frac{1}{2}c$. Thus:

$$r = h/4\pi m_e c \qquad (93)$$

At this stage it is interesting to show the link with a basic principle of wave mechanics, Heisenberg's Principle of Uncertainty. An electron located in the C-frame is never at rest in the inertial frame. Its position is uncertain by an amount $2r$ and its momentum is uncertain owing to the constant reversal of its motion at speed $\frac{1}{2}c$. The uncertainty of momentum is twice its instantaneous momentum $\frac{1}{2}m_e c$. Thus the product of uncertainty of momentum and uncertainty of position is $2m_e cr$, which, according to the Heisenberg Principle, is $h/2\pi$. This is confirmed by (93).

Eddington* wrote in 1929 about the Heisenberg uncertainty principle and said:

> 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 of free space 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, 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 and is *relatively* at rest in this respect.

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 $m_e cr/2$ but there is a connected angular momentum due to the balance afforded by the G-frame. Thus the total angular momentum intrinsic to the electron and due to the motion of the space medium is $m_e cr$, which, from (93) is $h/4\pi$. This is the well-known value associated with electron spin.

The universal motion at the angular velocity Ω defines a fixed direction in space. A direction anisotropy in the properties of space is not in evidence in experiments so far, though the space medium is interacting with high energy particles and upsetting the parities which apply theoretically. When we come to study the rotation of the space medium with the Earth, it will then be seen that the earth's magnetic moment indicates that the axes appropriate to Ω are approximately normal to the plane in which the planets move about the sun. It is

* A. S. Eddington, *The Nature of the Physical World*, Cambridge University Press, p. 220, 1929.

probable from this that the space motion at the 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. There may be space domains measured in dimensions of many light years and within which Ω is unidirectional. Its direction may change from one domain to the next, affecting gravitational interaction between bodies located in separate domains. These are cosmological questions to be addressed in Chapter 8. Suffice it to say here that the direction of Ω is of no significance to the analysis in this and the next chapter. Space behaves as an isotropic medium in its quantum mechanical interactions with the atom.

An electromagnetic wave is a propagated disturbance of the lattice structure formed by the q charges. The lattice can be disturbed if a discrete non-spherical unit of it rotates and so sets up a radial pulsation. This is depicted in Fig. 23. A cubic unit is shown rotating about

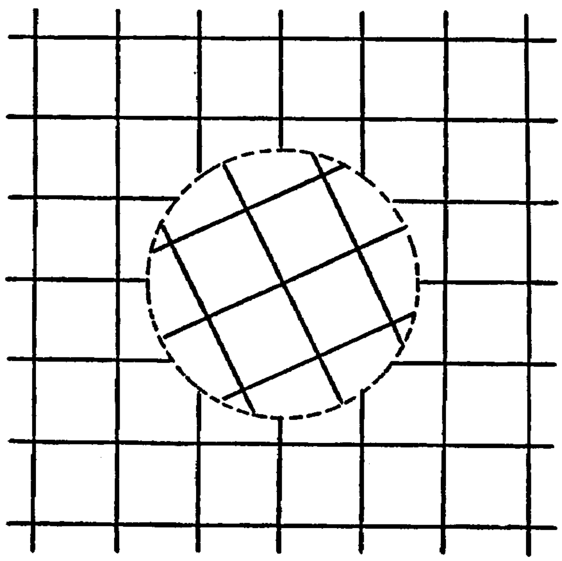

Fig. 23

a central axis. Any axis through the centre of the cubic unit can be chosen. The direction does not have to be parallel either with the direction of the Ω motion or a recognized direction of the lattice. The rotation will disturb the lattice at a frequency proportional to the speed of rotation of the unit. The three-dimensional symmetry assures that the unit has the same moment of inertia about any axis through its centre. The axis can be inclined to the lattice forming the unit. Therefore, the propagated disturbance frequency ν will be directly related to the angular momentum of the unit and independent of the angular momentum vector. Our object is to show that this has meaning in relation to Planck's radiation law:

$$E = h\nu \qquad (94)$$

and the rotating cubic lattice will henceforth be termed the photon unit. Before showing how (94) is supported by this theoretical enquiry, a proof will be given for the above-asserted inertial properties.

The photon unit is considered as an array of lattice particles locked in fixed relative positions. Take co-ordinates referenced on the centre of the unit. Imagine a particle with co-ordinates x, y, z distant p from the origin. Take spin about the x axis. The moment of the particle about this axis is $y^2 + z^2$. This is $p^2 - x^2$. Now take spin about an axis inclined at an angle θ with the x axis. The moment about this new axis is $p^2\sin^2\theta$, or $p^2 - p^2\cos^2\theta$. Let l, m, n denote the direction cosines of this new axis of spin, relative to the x, y, z axes. Then the moment about the new axis found from the direction cosine formula for $\cos\theta$ is:

$$p^2 - (lx + my + nz)^2 \qquad (95)$$

If now we apply this to a group of particles having three-dimensional symmetry, there is a particle with co-ordinate $-x$ for every one with co-ordinate $+x$. Similarly for y and z. Thus cross-multiples of x, y and z cancel. The expression (95) then becomes a summation:

$$\sum p^2 - (l^2\sum x^2 + m^2\sum y^2 + n^2\sum z^2) \qquad (96)$$

Cubic symmetry means that it does not matter if x, y and z are interchanged. Consequently their summations must be equal. Then, since the sum of the squares of direction cosines is unity, we find the expression in (96) becomes the summation of $p^2 - x^2$ for all particles in the group. This is independent of the direction of spin.

A little consideration will show that if the photon unit depicted in Fig. 23 rotates at an angular speed $\Omega/4$ it will develop an electromagnetic pulsation at the frequency of the universal motion of the space medium. Under these conditions there is no electromagnetic wave propagation since a little local adjustment of the surrounding lattice can contain the disturbance. A photon unit rotating at the angular speed $\Omega/4$ will be termed a standard photon unit. It is a quantum of angular momentum which is characteristic of the space medium.

Now when an energy quantum E is added to the dynamic state of the space medium it will, as with any linear oscillator, be shared equally between the potential energy and the kinetic energy. With the constant angular frequency Ω, this means that $\frac{1}{2}E$ is added to the kinetic energy. That is:

$$\tfrac{1}{2}E = \tfrac{1}{2}H\Omega \tag{97}$$

where H is the corresponding quantum of angular momentum. Thus, even though the energy E may become dispersed throughout the medium, it carries with it a related angular momentum given by:

$$H = E/\Omega \tag{98}$$

The space medium is known to react critically to certain energy quanta related to the mass of the electron or positron at rest. It somehow permits the creation of electrons and positrons at these exact energy levels, as if there is some kind of resonance at the characteristic frequency of the space medium. It seems essential to connect this phenomenon with the standard photon unit, especially so in view of the clear connection evident from (92). The standard photon unit must be associated with this energy quantum $m_e c^2$. Thus, from (98), H is $m_e c^2/\Omega$, which, from (92), is:

$$H = h/2\pi \tag{99}$$

The moment of inertia I of the photon unit is given by:

$$H = I(\Omega/4) \tag{100}$$

which, from (99), gives:

$$I = 2h/\pi\Omega \tag{101}$$

Taking now a photon unit rotating at a much lower angular speed ω, this is related to the frequency ν radiated by:

$$4\omega = 2\pi\nu \tag{102}$$

The angular momentum of this unit is $I\omega$, which (101) and (102) show to be:

$$I\omega = h\nu/\Omega \tag{103}$$

Then, from (98), since $I\omega$ is H:

$$E = h\nu \tag{104}$$

which is Planck's radiation law.

Note that the kinetic energy of the photon units caused by their rotation has been ignored. This is because the lattice particles forming such units are still locked into their synchronous motion with the lattice generally. Their masses are held constant and the energy which would have constituted their kinetic energy due to the photon rotation is dispersed.

Also note that the photon unit need not be a rigid structure when rotating. When near positions in which it is in register with the surrounding lattice it will have the same basic structure and this will determine I. $I\omega$ will be constant throughout the rotation, but neither I or ω need stay constant at the intermediate positions.

The Schroedinger Equation

A photon unit rotates and so propagates disturbances at the frequency given by (102). If an electron is constrained by such a photon unit to describe orbits at this same frequency and can deploy itself in the field as a whole between such orbital phases, it could, collectively with other electrons, screen the photon radiation. Such an electron would have a kinetic energy W given by:

$$W=(\alpha H)\tfrac{1}{2}(2\pi\nu) \qquad (105)$$

where αH denotes the orbital angular momentum of the electron.

This orbital angular momentum is the minor orbital quantity associated with the photon unit screening action. It is taken to be equal and opposite to that of the photon unit, as part of this conservative role. Putting αH equal to $I\omega$, we have from (103) and (105):

$$W=\pi h\nu^2/\Omega \qquad (106)$$

From (92) this is:

$$W=\tfrac{1}{2}h^2\nu^2/m_ec^2 \qquad (107)$$

The electron will need to deploy into successive positions throughout the photon unit field in order to effectively screen the wave radiation caused by the rotation of the photon unit. Let p be a measure of the probability of finding the electron within a unit volume at radius x from the centre of radiation. Then a spherical shell of thickness dx at this radius x will, on average, contain $4\pi x^2pdx$ of the electron charge. The radiation field of an electromagnetic disturbance diminishes in inverse linear proportion with x. Therefore, to screen such a field the local motion of the screening electron has not only to conform with the frequency but has to be matched in magnitude by the charge effect. This means that the expression:

$$(1/x^2)\int_0^x 4\pi x^2 p\,dx \qquad (108)$$

has to be inversely proportional to x. This is a requirement that p is proportional to $1/x^2$, which means that it is proportional to A^2, where A is the wave amplitude at x.

The position of the electron in the photon unit field will then be governed by a wave equation and A^2 will give the probability of finding the electron at any position in the wave field.

The standard wave equation of frequency ν is:

$$\Delta A + (4\pi^2\nu^2/c^2)A = 0 \qquad (109)$$

Eliminating ν from (109) using (107) gives:

$$\Delta A + (8\pi^2 m_e/h^2)(E - V)A = 0 \qquad (110)$$

if W is written as $E-V$, denoting the difference between the total energy E assigned to the electron and its potential energy V. This difference is the kinetic energy W.

Equation (110) is the Schroedinger equation. This 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 the electron structure of the atom by taking the Schroedinger equation as a starting point. However, particularly in respect of the quantitative priming of the energies of the discrete energy levels of the electrons, the classical Bohr theory of the atom has to be used in conjunction with wave mechanics for a complete understanding of the atom.

The weakness of the Bohr theory arose from the assumption that the orbital electrons had angular momentum in units of the quantum $h/2\pi$. It is, therefore, interesting to see that this quantum emerges as the angular momentum of the standard photon unit in the above theory. It is the natural angular momentum quantum arising from electron or positron annihilation. It may then seem reasonable to expect multiples of this angular momentum quantum to be characteristic of possible motion states of the electron when freed from its minor orbital motion with the slow photon unit. On such an assumption the Bohr theory could apply to the electron as it is in transit between different field positions at which it halts to react with such a photon unit.

In such a transit the kinetic energy of the electron will be as determined by Bohr theory. The electric field interaction energy applicable between the electron and the nucleus of the atom will apply as in Bohr theory but throughout the transits and the photon unit interactions. However, the kinetic energy as formulated from Bohr theory and that given by (105) apply to different states of motion. The energy must be the same throughout. This gives us a connection between (105) and the normal parameters of the atom.

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

$$W = \tfrac{1}{2}mv^2 = 2\pi^2 Z^2 e^4 m_e / n^2 h^2 \tag{111}$$

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

For the hydrogen atom with $Z=1$ and $n=1$, (111) becomes:

$$W = (2\pi e^2/hc)^2 m_e c^2/2 \tag{112}$$

Let us now calculate the angular momentum of the electron in its minor orbits when balancing a photon unit. This is αH from (105) or $I\omega$ from (103). Eliminating ν from these two expressions gives us the angular momentum of:

$$(Wh/\pi\Omega)^{\frac{1}{2}} \tag{113}$$

From (92) this is:

$$(Wh^2/2\pi^2 m_e c^2)^{\frac{1}{2}} \tag{114}$$

From (112) this is:

$$(2\pi e^2/hc)(h/2\pi) \tag{115}$$

Since this is αH and H is $h/2\pi$, from (99), we find that α is given by:

$$\alpha = 2\pi e^2/hc \tag{116}$$

This quantity is known as the fine structure constant. It is a very important dimensionless constant. Its numerical derivation from a rigorous analysis of the structured lattice of the space medium is basic to the theory in this work. The discovery in the latter part of

1955 that this quantity could be derived from the geometry of the synchronous lattice system of Fig. 22 was the starting point for the research into the derivation of a whole series of fundamental constants, which are considered in the pages ahead. It will be shown how α is derived in the next chapter. First, however, since the calculation of the anomalous magnetic moment of the electron is generally regarded as the major example of numerical verification of theory and this depends closely upon α, it is appropriate to discuss this in relation to the author's methods.

The Electron g-factor

The theory of quantum electrodynamics by which the anomalous angular momentum properties of the electron in spin has been explained is a very complex theory, albeit one which has also proved very successful. Its methods differ from the more direct approach which will here be adopted. Our object is to show that a simple approach may well be as good and possibly better. Research into fundamental physics may not necessarily depend upon the use of relativistic or quantum electrodynamic techniques based on abstract concepts. There is considerable scope for simplifying quantum electrodynamics, having an eye upon the synchronous lattice model of the space medium shown in Fig. 22.

When an electron is in the confined state of motion we refer to as 'spin' it exhibits a magnetic moment which is not strictly $e/m_e c$ times its angular momentum. The discrepancy is termed the g-factor. The ratio of magnetic moment to angular momentum is then g times $e/m_e c$. For the electron the experimental value of g is 1·00115965. The measurement of g is really by comparison with $e/m_e c$ as it applies to an electron not in a state of spin. An electron in an atom may be in a state of spin in contrast with an electron moving freely.

One cannot really be sure whether the anomaly arises because there is something special about the spin motion or something special about the motion of an electron in a less-confined orbit. Nor, indeed can one be sure that it is the magnetic moment that is anomalous rather than the mass in one of the electron's two states.

To proceed, however, we will opt in favour of the mass property being anomalous. Thus imagine the electron charge as a seat of radial oscillations in its electric field. Suppose these oscillations occur at the speed c and at the natural frequency $m_e c^2/h$ of the space medium.

There will be a radius from the electron at which a resonance can occur as these oscillations traverse the resonant radius in both directions in the period of one cycle of the natural frequency. The resonant radius distance will then simply be half of the Compton wavelength, or $h/2m_ec$. Beyond this radius, for a point charge electron, the electric field energy is $\frac{1}{2}e^2$ divided by the radius, or:

$$\delta E = e^2 m_e c/h \tag{117}$$

This tells us that the electron has a mass energy δE beyond a radius defining a resonance zone. From the $E = Mc^2$ formula this then means that it has a mass component δm_e outside this resonance zone, where:

$$\delta = e^2/hc \tag{118}$$

It needs little imagination to look to this mass to justify the anomaly. It is decoupled from the electron by virtue of the resonance boundary, at least notionally. If the electron moves along a path which is substantially linear compared with the scale set by the Compton wavelength then the mass δm_e must move with the electron. However, if the electron has a very restricted motion, confined well within the Compton range, as it has in sharing the motion in the space medium, an orbit of radius r given by (93), then one might expect its mass to exclude δm_e.

The consequence is that in the latter state, which we associate with spin, the value of e/m_ec will be increased approximately by the factor δ. Note then that from (116) and (118) δ is $\alpha/2\pi$, and, as α is known to be 0·007297, this gives g as 1·00116. This seems to be a promising approach, having regard to the experimental value of g mentioned above.

Of course, it is a little difficult to imagine that the energy in the electron field can package itself into two separate segments in this way, but it may be that the mathematics tell us rather more than the physical picture on which the analysis is based. Some statistical processes are undoubtedly at work and give better basis for the mathematics than does the steady state model of the electron field.

One problem we need to address is the finite size of the electron on the basis of the J. J. Thomson formula. A point charge would have infinite energy on classical foundations. Yet, in the quantum world of space, it is difficult to be sure of any of our basic physical ideas. Some writers have speculated about the nature of space as a world of the sub-quantum, invoking the idea that neutrinos travel in all directions at high speed. We need not indulge in such speculation, except in suggesting that the sub-quantum world may in some respects be like a gas, setting the propagation speed for electric disturbances at the value c and providing the medium which asserts the resonant cavity properties we have just introduced.

In this it helps to think of corpuscles bombarding the electron and bouncing back to be reflected again by the cavity surface at the resonant radius. If these corpuscles are themselves electrical in character their path is likely to be ordered along radii from the electron rather than random, at least in the near vicinity of the electron. Beyond a critical radius from the charge surface their ordering will be random as in any gas. There is thus a probable transition between the random region with its three degrees of freedom and a region in the near vicinity of charge with one degree of freedom. This transition radius will correspond to an area three times larger than the area of the surface of the electron charge, in order that the pressure on the charge surface should equal one third that in the gas outside this transition radius.

The transition radius is therefore $3^{\frac{1}{2}}$ that of the electron charge radius a. The resonance occurs beyond this radius $3^{\frac{1}{2}}a$, so that we add half the Compton wavelength to the transition radius to obtain the radius of the resonant cavity as:

$$h/2m_e c + 3^{\frac{1}{2}}a \tag{119}$$

This gives us a small correction term to allow for the finite size of the electron. The value of a is determined from the J. J. Thomson formula:

$$m_e c^2 = 2e^2/3a \tag{120}$$

From (116) and (120), (119) becomes:

$$(1 + 2\alpha/3^{\frac{1}{2}}\pi)h/2m_e c \tag{121}$$

The value of δ is then seen to be reduced by this factor $(1 + 2\alpha/3^{\frac{1}{2}}\pi)$ to become:

$$\delta = (\alpha/2\pi)/(1 + 2\alpha/3^{\frac{1}{2}}\pi) \tag{122}$$

The g-factor for the spinning electron then becomes $1/(1-\delta)$ or $1 + \delta + \delta^2 + \delta^3 \ldots.$ From (122) this is:

$$g = 1 + (\alpha/2\pi) + (\tfrac{1}{4} - 3^{-\frac{1}{2}})(\alpha/\pi)^2 + (\tfrac{2}{3} - 3^{-\frac{1}{2}} + \tfrac{1}{8})(\alpha/\pi)^3 \ldots. \tag{123}$$

or

$$g = 1 + (\alpha/2\pi) - 0{\cdot}32735(\alpha/\pi)^2 + 0{\cdot}21(\alpha/\pi)^3 \ldots. \tag{124}$$

This compares with the quantum electrodynamic derivation of Sommerfield:*

$$g = 1 + (\alpha/2\pi) - 0{\cdot}328(\alpha/\pi)^2 \ldots . \quad (125)$$

The formulae differ by a few parts in 10^9. Hence we see that there is scope for matching the results of quantum electrodynamics by considering electrons as charges of spherical form and complying with J. J. Thomson's classical formula.

Later, when we consider the creation of the muon, we will also address the muon g-factor and show that similar results are obtained.

Meanwhile, however, and before leaving the problem of the electron g-factor, it is appropriate to anticipate a result we will come to in Chapter 9. It will be suggested that a particle of mass m will, even in what we regard as its rest state, store a dynamic energy equal to φm, where φ is the local gravitational potential, due principally to the masses of the Earth and Sun. This energy, as a kind of kinetic energy, may be stored by the transient creation of electron-positron pairs, in which case the energy will be part of the system beyond the resonant radius of the cavity. Thus φm will be energy of mass $\varphi m/c^2$ adding to the linear mass of the electron but not the spin mass. Thus g is increased by φ/c^2.

At the Earth's surface φ/c^2 is $1{\cdot}06\ 10^{-8}$, which adds $0{\cdot}84(\alpha/\pi)^3$ to the g-factor of (124). Upon evaluation, using a recent evaluation† of α^{-1} of 137·035963(15), (124) becomes, with this modification:

$$g = 1{\cdot}001159657 \quad (126)$$

This compares with the measured value‡ of:

$$g = 1{\cdot}0011596567(35) \quad (127)$$

* C. M. Sommerfield, *Physical Review*, **107**, 328 (1957).
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