PHYSICS
WITHOUT EINSTEIN

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Contents

Foreword

Relativity is presently on trial. If Einstein's theory cannot be sustained there is no recognized alternative. This book provides not only an alternative but a comprehensive unification of all physics. It is based upon a straightforward confrontation with the anomalies in accepted electromagnetic theory. These undisputed inconsistencies cannot be ignored if modern science is to progress. What is offered here is not a new theory but a reconciliation of existing theories. The starting point of this work was not a lofty-minded attempt to overthrow Relativity or explain gravitation. It was a desire to understand more about the nature of ferromagnetism. However, what emerged provided physical concepts embracing fundamental magnetism from its atomic environment to the cosmos. Gravitation is explained and is supported by the derivation of G in terms of the properties of the electron. Elementary particles are explained and there is support from the exact quantitative assessment of their spin magnetic moments. Wave mechanics are explained and there is support from the quantitative evaluation of the Fine Structure Constant. Atomic structure is explained and is supported by quantitative analysis of nuclear binding energy. The evaluation of the binding energy of the deuteron is particularly revealing. It will be shown that Einstein's theory is unnecessary.

Introduction

At the end of the nineteenth century the well-tested mechanical principles of Isaac Newton were the very heart of physical theory. Electricity and magnetism still presented problems. The electron had been discovered but its charge had only just been measured. The photon light quantum and its source, the atom, attracted the attention. Electromagnetic waves had only recently been detected and their radiation pressure verified. However, Newton's principles of mechanics were firmly applied throughout physical theory. The aether was still a subject of speculation but interest in it was losing impetus. Its nature had become a great mystery, standing alongside the aged problems of the cause of gravitation and terrestrial magnetism. The great minds in physics were diverted to the atom and its quantum behaviour. Albert Einstein emerged in the midst of this diversion when, in 1905, he proposed new principles which were destined to limit the scope of application of Newton's mechanics. The already-recognized relationship between energy and mass was brought into the framework of Einstein's philosophy. A new way of looking at physics had been found. The aether had become an unnecessary integer since the mathematical structure of Einstein's theory provided the medium by which physical theory had to be linked. The Special and General Theories of Relativity became recognized aristocrats among physical theories. They have acquired and retained an undeniable elegance. However, in the past ten years, more and more voices have been raised in criticism. More is expected than the theories appear able to supply. Tests are becoming more exacting as new and better experimental techniques are developed. Relativity appears to be weakening even though it stands as a lone provider of physical understanding. There is, therefore, due cause for concern and this is an appropriate time to review physics as it could be without reliance upon Einstein's doctrines.

1. The Electron

Electron Charge

Millikan, writing about the electron in 1935, stated, "We knew that there was a smallest thing which took part in chemical reactions and we named that thing the atom, leaving its insides entirely to the future. Precisely similarly the electron was defined as the smallest quantity of electricity which ever was found to appear in electrolysis, and nothing was then said or is now said about its necessary ultimateness. Our experiments have, however, now shown that this quantity is capable of isolation, and that all the kinds of charges which we have been able to investigate are exact multiples of it."

Millikan raised the question, "Is the electron itself divisible?" and discussed the affirmative support put forward from 1914 onwards, principally by Ehrenhaft, only to conclude from an analysis of the experimental evidence that "there has then appeared up to the present time no evidence whatever for the existence of the sub-electron".

At the present time, 1969, we find that physical theories are being developed on the assumption that there are particles of sub-electronic charge. We read about the quarks,* which are hypothetical particles having charges of one third or two thirds that of the electron or positron. A neutron is then imagined to comprise an aggregation of two quarks each of charge $-e/3$ and one quark of charge $+2e/3$, whereas the proton consists of two quarks of $+2e/3$ and one of $-e/3$. Here, $-e$ is the charge of the electron. This is most interesting speculation, but the fact remains that particles with these sub-electronic charges have yet to be discovered. The quarks are purely hypothetical and Millikan's contention that the electron charge is indivisible is not yet disproved by any direct experimental evidence.

What is an Electron?

Although Millikan stated that the electron was the smallest quantity of electricity ever found to appear in electrolysis and thus characterized the electron by its quantum of charge $-e$, there are other

* Burhop, 1967. (Note that references are listed on page 217 according to author's name and year of publication.)

elementary particles possessing this unique charge. The electron is further characterized by its small rest mass m, known to be about $9{\cdot}1\ 10^{-28}$ gm. The charge e is approximately $4{\cdot}8\ 10^{-10}$ esu, expressed in cgs. units.

Having thus introduced the electron and identified it by its discrete charge $-e$ and discrete rest mass m, and shed a little uncertainty on the fundamental quantum nature of the electron charge, we are ready to consider the question, "What is an electron?" Firstly, if it is suggested to some physicists that an electron is a mere corpuscle of electric charge, this evokes a smile and a denial. An electron is not that simple. Some would present the electron as a kind of vector symbol. Others present it as a mathematical formulation. They have in mind the spin properties of the electron, or its wave characteristics, and they are not really answering the question "What is an electron?", but the question of how an electron manifests itself. Yet, its behaviour really depends upon its interaction with something else, be it only the observer! Then, we see that we might have mixed the electron up with the properties of something else. According to Heisenberg's Principle of Uncertainty, as quoted by Eddington (1929, a) "A particle may have position or it may have velocity but it cannot in any exact sense have both." Is Eddington really suggesting that a particle cannot have a position and a motion at the same time, or is he saying that our powers of observation are limited and preclude us from determining the exact position and velocity of the particle at any instant? It is submitted that the electron is not a mathematical symbol, nor is it a wave or group of waves. An electron is an elementary particle, almost by definition, and must be taken to be a corpuscle in any serious attempt to understand what it really is, meaning its size, shape and content. It can be asked why the real nature of the electron matters when physical theory need only be concerned with its behaviour as seen by an observer. The answer to this is that the electron presumably will still exist even when the observer is removed. Its properties cannot, therefore, be wholly related to the existence of the observer. The electron will still interact with other matter, and its interaction properties could well account for certain physical phenomena as yet unexplained in physical theory.

The Electron in Motion

Assuming the well known relation $E = Mc^2$ and that there is no loss of energy by radiation or otherwise when a particle of mass M is accelerated to acquire kinetic energy itself augmenting the energy E, it may be shown that the mass of a particle increases to infinity as the particle approaches the limiting velocity c. The applicable formula for the mass of the particle when moving at velocity v is given by:

$$M = M_0/\sqrt{[1-(v/c)^2]} \tag{1.1}$$

where M_0 is the mass of the particle when at rest.* The velocity c is the speed of light in vacuo.

Wilson (1946), after presenting the above result, writes "If the particle considered is an electron, M will be the mass of the electromagnetic field which it excites and which moves along with it, together with any additional mass which it may have. If the electron is merely an electric charge, it may have no additional mass, but if it has some internal energy besides its electrical energy, it will have some additional mass corresponding to this additional energy. In any case its mass should vary with its velocity in accordance with the expression found above for M, since this should hold for a particle of any kind. The experiments of Kaufmann, Bucherer and others on the variation of the mass of electrons with their velocity have shown that the mass does vary approximately in accordance with the above formula. These experiments confirm the idea that momentum is due to flux of energy, but they give no information as to the constitution of electrons."

Experiments on the increase of electron mass with velocity do, however, show that electron charge does not vary with velocity. It is mass which varies. The analysis used to derive equation (1.1) also suggests that an electron does not dissipate its energy by radiation when it is accelerated and this is a most important point to keep in mind because this is in conflict with other currently accepted theory.

X-ray Scattering by Electrons

The role of electrons in X-ray scattering has been analysed by A. H. Compton. It is found that the wave-length of the scattered rays is not the same as that of the incident rays. Compton supposed that when a photon, as an incident radiation quantum, is intercepted by an electron, a photon quantum of scattered radiation of lower frequency is produced. Then, by assuming that both energy and momentum are conserved, results in conformity with observation are obtained. Since

* The mathematical proof of this is presented in a later section of this chapter.

Compton only considers the electron's kinetic energy, this means that the energy supplied to the electron in this scattering process is wholly kinetic. Now, the electron has a charge and its velocity is changed when it absorbs momentum. Its magnetic field must therefore change and with this the magnetic field energy must change. Yet, as just stated, experiment shows that the energy form which is changed is wholly kinetic.

This result is, of course, compatible with the above theoretical explanation of the increase in mass with velocity. Magnetic energy must, presumably, be the whole or part of the kinetic energy itself. It is the implications of this which guide us to understand more about the real nature of the electron.

Magnetic Energy of the Electron

The magnetic energy of an electron in motion is easily calculated if the electron of charge $-e$ can be regarded as a sphere of radius R with the magnetic field energy wholly disposed outside the sphere. The field H distant x from a charge e moving at velocity v at an angle θ to the x distance vector is:

$$H = (ev/c)\sin\theta/x^2 \tag{1.2}$$

This can be used in the following expression for the magnetic energy.

$$E = \int_{\theta=0}^{\pi}\int_{x=0}^{\infty} (H^2/8\pi)2\pi x\sin\theta x\,dx\,d\theta \tag{1.3}$$

Upon evaluation using (1.2) and (1.3), we find:

$$E = e^2v^2/3Rc^2 \tag{1.4}$$

Nissim (1966), in reviewing the electromagnetic mass properties of this electron, writes: "Thus, by virtue of its electromagnetic field energy, an electron possesses an electromagnetic mass equivalent to $2e^2/3Rc^2$. This was held by J. J. Thomson to be in addition to the 'ordinary' mechanical mass of the electron but, as previously mentioned, Abraham and others subsequently advanced the hypothesis that the electromagnetic mass, or self-mass as it has been called, represents the total inertial mass of the electron. . . . Relativistic considerations, however, have caused physicists to abandon this idea and veer to the view that the electron possesses a certain mechanical inert mass in addition to an electromagnetic mass."

Electrostatic Rest Mass Energy of Electron

If an electron is a charged sphere and the charge is taken to be uniformly spread over its surface of radius R, the intrinsic electric field energy is $e^2/2R$, corresponding to a rest mass of $e^2/2Rc^2$, which is less than the electromagnetic mass just deduced. To resolve this difficulty, we may follow the argument of Wilson (1946) that there are binding forces restraining the electron charge from expanding and these must also represent an energy term. He calculated the binding energy for the spherical shell electron model as $e^2/6R$, which exactly balances the discrepancy between the electric and magnetic rest mass calculations.

Alternatively, if an electron is regarded as constrained to occupy a fixed volume, it will be found to adopt spherical form for minimum electric field energy and, for uniform pressure throughout this volume, its charge will be so distributed that its total electric field energy becomes $2e^2/3R$. This again leads to equality in the rest mass calculations, allowing kinetic energy to be identified with magnetic energy. A proof of this is given in Appendix I.

This may seem to be mere speculation. If an electron is a sphere of charge, it must have a certain size and therefore a certain rest energy. There must be something holding it together, whether it is spherical or not. In established physical theory these facts cannot be avoided; they are implicit in our analysis of electron behaviour. Instead of assuming a quantized charge and a quantized rest energy, which is too easy a way of avoiding the problem, we may note that, although charge does not vary with velocity, energy does vary with velocity. Then we can consider assigning a quantum volume of space to the electron. Why not quantize space rather than energy? This volume will not have to change with velocity and the fact that it is constant accounts in a single assumption for rest mass energy quantization and for the binding force action restraining charge expansion, thus simplifying the model of the electron.*

Electric Field Induction by Motion of Electric Charge

When an electric charge is in motion at a steady velocity, its electric field moves bodily with it. According to the principles of Relativity,

* The theory of quantum space has remarkable impact upon the understanding of elementary particles. See Chapter 7.

if an observer moves at this same steady velocity, he will not be able to detect any effects of the motion. If the velocity is measured relative to the observer, then the electron will induce the magnetic field just considered and, presumably, the energy of this field will account for its mass properties. However, will any electric field effect of a dynamic character also be induced? A single classical line of reasoning suggests that there is an electric dynamic field effect.

Referring to Fig. 1.1, consider a charge e located at O to be moving with a velocity v, as shown. At a point P, the strength of the field from e is e/x^2. Also at P, the electric charge e is really "seen" by an observer to be at Q because the disturbance set up by the charge in motion past P is propagated at the finite velocity c. There must,

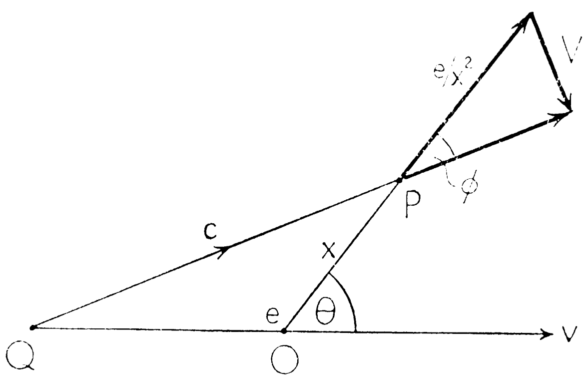

Fig. 1.1

therefore, be an electric displacement at P, denoted V. The position of Q is found from the relationship:

$$QP/QO = c/v \tag{1.5}$$

because the charge travels from Q to O in the time taken for the disturbance to travel from Q to P. When V is added vectorially to the radial field e/x^2 from O to P, the resultant vector lies along QP. Further, since the displacement field will be in the direction needed for least energy, that is minimum V, this vector V will be normal to the radial field direction QP. It follows that V is given by:

$$V = (e/x^2) \sin \varphi \tag{1.6}$$

Now, φ is the angle between QP and OP and if θ is the angle between QO and OP

$$QO \sin \theta = QP \sin \varphi \tag{1.7}$$

From (1.5), (1.6) and (1.7):

$$V = (ev/c) \sin \theta / x^2 \tag{1.8}$$

By analogy with equation (1.2), we find that the electric energy attributable to this is exactly as given by equation (1.4). Thus, the dynamic electric field energy is:

$$E = e^2 v^2 / 3Rc^2 \tag{1.9}$$

Curiously, the magnetic field energy density and electric field energy density due to the motion of the charge are identical everywhere in the field.

Now, this poses a problem. If magnetic energy is wholly identified with the kinetic energy, how can we now explain an additional component of dynamic energy which is exactly equal to the magnetic energy? This analysis draws attention to an anomaly facing the observations from the Compton Effect.

Is Magnetic Energy Negative?

It is standard in physical theory to write the magnetic energy density of a field H as $H^2/8\pi$. However, it is equally standard to put a minus sign in front of magnetic energy terms when energy balance conditions are under study. According to Bates (1951, a): "The minus sign merely indicates that we have to supply heat in order to destroy the intrinsic magnetization." Put another way, since heat is really kinetic energy, we can say that:

$$\text{Kinetic energy} - \text{magnetic energy} = 0$$

However, this does not read kinetic energy equals magnetic energy, meaning that they are identical. It reads that when we have kinetic energy and magnetic energy together in equal measure, they constitute no overall energy whatsoever.

If this applies to the electron, we see that the total of the kinetic energy and the magnetic energy is zero, but since there is also a dynamic electric energy equal to either quantity, the net dynamic energy of the electron is given by equation (1.9) alone.

It follows that we really should take the experimental evidence afforded by the Compton Effect as a clear indication that kinetic energy, magnetic energy and dynamic electric energy exist in equal measure when an electron is in motion but that since one of these, the magnetic energy, should always be considered as a negative quantity, the electron behaves as if it only possesses a normal kinetic energy related to its intrinsic electric energy.

This conclusion will now be fully supported by analysing the inertial effects of an electron when it is accelerated.

Accelerated Charge

The effect of accelerating a slow-moving charge e will now be calculated. The electric field of a charge has the property of inertia and moves with the charge. The action of acceleration, however, means that the field motion is disturbed. The electric field is distorted. For example, if an electric charge is moving at uniform velocity and then undergoes acceleration to another uniform velocity during a short period of time dt then at time t later there will be a disturbance in the field region distant ct from the charge. This assumes such low velocity that the charge is effectively still located at the centre of the radiated wave disturbance. Essentially, there is a regular radial electric field from the new position of the electric charge within the sphere of radius ct. This field is moving at the same velocity as the charge and it is therefore not distorted. Outside the radius ct the field still centres on the position the charge would have had it not been accelerated. This field is still moving with the original charge velocity. The disturbance in the field is really wholly contained in a spherical shell of radius ct and radial thickness cdt. It contains the lines of electric field flux which join the two regular field regions. The key question we face is whether the total electric field energy in this shell is different from the energy content if there were no disturbance. If the shell has extra energy, then this is energy carried off by radiation as the disturbance is propagated outwards at the propagation velocity c.

Referring now to Fig. 1.2, consider a charge e to be moving in a straight line BC at velocity v. At the point C the charge is supposed to undergo sudden acceleration causing it now to move along CD at velocity v'. CD is inclined to BC. Both v and v' are taken to be very small compared with the propagation velocity c. At time t after acceleration a field disturbance has moved to a distance ct from C. The disturbance is contained within a radial distance cdt. Now consider a point P in this disturbance region. To pass through P, a line of force will be inclined to the vector $v'-v$ at an angle θ. This is

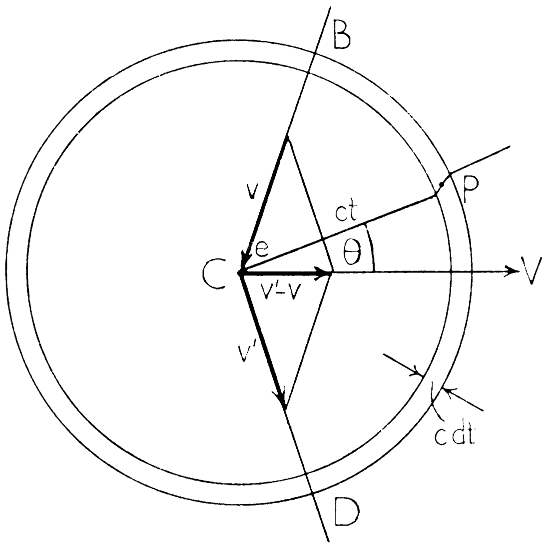

Fig. 1.2

the line of force emanating from the charge and traversing the wave region. In the region of P, however, the line of force has to undergo displacement. It is laterally displaced by the distance $(v' - v)t \sin \theta$ because, for example, if v' and v are unidirectional the field change across the wave region is an advance to a new velocity which causes a displacement in the direction of v or v' equal to the change in velocity times time. This displacement is $(v' - v)t$. At right angles to the line of motion of the charge we find the direction of this displacement to be perpendicular to the lines of force emanating from C to the field region. Directly ahead of the charge in its line of motion we find that the displacement is along the lines of force emanating from C. The resulting lateral displacement of the field lines by $(v' - v)t \sin \theta$ requires an electric field component in the disturbance at right angles to the propagation direction and in or parallel with the plane containing $v' - v$. This field component will give rise to a separate electric field energy component. The transverse field is calculated quite easily, since its ratio to the main radial field e/c^2t^2 is the above lateral displacement divided by the radial disturbance distance cdt. By putting the acceleration f as $(v' - v)t/dt$, this transverse electric field becomes $ef \sin \theta/c^3t$ Thus, the electric field energy per unit volume in the disturbance region is:

$$\frac{1}{8\pi}\left(\frac{ef \sin \theta}{c^3t}\right)^2 \tag{1.10}$$

The total electric field energy in the disturbance region, that is, the total energy carried by the disturbance, is found by integrating this expression over the volume of the shell. An elemental volume formed by an annulus through P centred around the axis $v'-v$ is $2\pi(ct)^2 \sin \theta c dt d\theta$. Performing the integration between $\theta=0$ and $\theta=\pi$, gives:

$$e^2f^2dt/3c^3$$

Since dt is the time during which the disturbance is formed and since this energy quantity is independent of the distance travelled by the disturbance, it is deduced that this energy is radiated by the charge when subjected to acceleration f and during the time dt. Should the acceleration be sustained the rate of energy radiation in the electric field form becomes $e^2f^2/3c^3$.

This result is that classically obtained by applying Maxwell's equations to the problem of radiation by accelerated charge. It has to be doubled to follow the usual wave propagation theories, according to which electric and magnetic field energies are equal for wave propagation through a vacuum. Classically, magnetic field energy has to be added to the expression deduced in order to evaluate the total rate of energy radiation.

Now, this feature of energy radiation by accelerated charge, particularly electrons, is relied upon in many accepted physical theories. It has been accepted quite readily because energy transfer by electromagnetic wave propagation is fundamental. Yet, the energy quanta are supposed to come along as photons according to other physical theory and factual observation. There is nothing of a quantum nature about the derivation of the energy radiation presented above, or about the classical derivation using Maxwell's equations. Hence, there is a problem. It is part of an accepted mystery in physics. Acceptance emerges from the reconciliation by the physicist in believing that there can be two ways of looking at the same thing. The duality of wave and photon principles of energy transfer is no longer treated as an absurdity. It is an accepted and fascinating feature of Nature. Yet, if one dares to ask the question of how an electron can radiate energy and still stay an electron, or how the energy radiated is fed to the electron, one is asking too much from physical theory. We should look, instead, at the broader energy balance and make our analysis by reference to the field equations. How is it that the physicist has given in to this problem? Surely, we will never understand the real nature of the electron if we tolerate two conflicting explanations for the same phenomenon and stop asking the questions about the source of the electron's energy radiation.

One simple fact is evident. If electromagnetic wave propagation had not been discovered, energy radiation merely due to electron acceleration would be highly questionable. The physicist would retrace his theoretical steps, even revise his theory, before building his further theories on the notion that an electron can radiate energy. This should be even more a matter for concern in the light of the quantum features of energy transfer. Had the discovery of the photon preceded the theory of electromagnetic wave radiation, the conflict of the dual existence of wave and quantum theory could hardly have become a tolerable situation. At this stage, the author puts before the reader the clear proposition that *an accelerated charge does not radiate energy*. We will re-examine the above analysis to find out where it went wrong.

We do not have to look very far. It was postulated that the acceleration of the charge e was f. From the time of Newton it has been known that acceleration cannot be assumed. It results from a force. To apply a force to an electric charge demands a field acting on the charge. No such field was incorporated in the analysis. Our object was to calculate energy and energy is a quadratic expression and cannot be calculated if fields present are ignored. Here, then, is the source of the error. Now, it seems absurd to suggest that such a mistake could have gone without notice for so many years. Perhaps this can be understood if we argue that the wave disturbance set up by accelerated charge must eventually pass well outside the region of any local accelerating field. Then the analysis must be valid. If energy is carried along by the disturbance it must come from somewhere. It comes from the direction of the accelerated charge. Presumably it comes out of the field at the source. It does not have to come from the electron itself. It is just that the acceleration of the electron is a necessary adjunct to whatever it is that causes energy to be radiated. This is an argument, but it does not eliminate the duality problem and it does involve an all-important assumption that energy is in fact carried by an electromagnetic wave. This is an assumption having no analogy in other physics. Waves on water involve local interchanges between kinetic and potential energies and no forward migration of water or energy at the wave velocity. It seems a better assumption to propose non-radiation of energy by the accelerated charge, non-transfer of energy by electromagnetic waves, and leave the physicist free to accept the quantum mechanism of energy transfer without ambiguity. At least, it is worth the effort of re-analysing the mechanism of wave propagation by an electron, allowing for the accelerating field. The method of analysis being used by reference to Fig. 1.2, incidentally, is a textbook method which is attributed to J. J. Thomson. It is only the following introduction of the accelerating field which is new.

An electric field V is applied in the direction of acceleration of the charge depicted in Fig. 1.2. This field V may be resolved at P into two components, one radial from C augmenting the regular field of e, and the other in opposition to the transverse field component from which the radiated energy is derived. Thus, expression (1.10) for the energy density in the disturbance region can be expressed as:

$$\frac{1}{8\pi}\left(\frac{ef\sin\theta}{c^3t} - V\sin\theta\right)^2 \tag{1.11}$$

Although it is tempting to choose V so that this is zero for all θ, we cannot do this because the square of the last term in the expression is an energy component belonging to the field V and it cannot be assumed to move with the disturbance. The rest of the expression, including the interaction term found when the expression is expanded, does denote energy moving with the disturbance. The energy density which can move with the disturbance is different from that previously calculated by the reducing amount:

$$\frac{1}{8\pi}(2V\sin\theta ef\sin\theta/c^3t) \tag{1.12}$$

Upon integration, as before, this is $2Veftdt/3$. Thus, the total energy carried by the disturbance is:

$$e^2f^2dt/3c^3 - 2Veftdt/3 \tag{1.13}$$

Now, in considering the mass acted upon in charge acceleration, we must equate this mass to that of the electric field remaining to be accelerated. This is a function of ct. Expression (1.13) has to be zero on the basis of our assumption that the charge does not radiate energy. This means that:

$$Ve/f = e^2/2c^3t \tag{1.14}$$

This expresses the ratio of force Ve to acceleration f, and is a measure of the effective mass of the electric field remaining to be accelerated. The energy of the electric field outside the disturbance region is $e^2/2ct$. Denoting this as E, we have from (1.14):

$$E = Mc^2 \tag{1.15}$$

where M is the mass involved.

It follows that the assumption that an electric charge does not radiate energy leads to the conclusion that an electric field energy has mass according to the relation $E = Mc^2$. If this latter relationship is not valid, then there should be radiation of energy by accelerated charge and we are led back into the duality problem confronting physics. The duality problem is avoided if we accept that $E = Mc^2$ is a valid relation. Now, this latter expression is an accepted result in modern physics. It has been verified in its application to atomic reactions and electron-positron annihilation. Since it must be true, an accelerated charge cannot radiate energy. Therefore, if an electromagnetic wave carries energy with it, it must acquire this energy as it passes out of the field causing the charge acceleration. If it does this, we come back to the duality problem. Also, imagine two electric charges mutually attracted and accelerated towards one another. If both radiate energy generated somehow in their fields, they must lose some of their fields and so their charge. Note that they need not, theoretically, have much velocity but may have a high acceleration. In short, while it is not proved that there is no energy radiation from the field, it is certainly likely to present some peculiar problems to assume that the wave gets a supply of energy at some position remote from its source. If this assumption is avoided and we accept the validity of Maxwell's equations we are left with but one conclusion. The assumption made in applying the Poynting vector to deduce energy propagation by an electromagnetic wave is wrong. This assumption is that the energy of the wave is carried by the wave. In fact, the energy might come from a source in the medium through which the wave is propagated. It might come from the aether. Or it might not exist at all. If, in applying Maxwell's equations, we assume that because electric field and magnetic field are equal in a plane wave, we have an equal contribution of electric field energy and magnetic field energy *but only if both of these energy quantities are positive.* If magnetic energy is negative, the equality of field strengths predicted from Maxwell's theory corresponds to zero energy carriage by the waves and we have a wholly consistent approach to our understanding of the electron and its behaviour when accelerated.

A word should be said about the assumption in the above analysis that the electric charge had a velocity which was small compared with the velocity of light c. It is submitted that if we can prove that there is no radiation of energy from the accelerated charge at a low velocity we should not expect a different situation at higher velocity. Rigorous analysis to cater for high velocity charge motion is not necessarily worth while. The author has not attempted it, mainly because it is necessary to claim that the velocity of light is relative to something. If it is measured relative to an observer and the charge moves at high velocity relative to this observer and is accelerated, one will possibly get energy radiation. If it is measured relative to a different observer, one will get a different energy radiation. This seems ridiculous. If it is measured relative to the charge e, one can forget the idea of the electric charge moving at high velocity. It is effectively at rest in the frame of reference which matters. Put another way, an electric charge might know that it is accelerated but it has no way of knowing that it is moving at any particular velocity. Its energy radiation cannot, therefore, depend upon its velocity. Since it is zero at low velocity from the above analysis, it must be zero at any velocity.

The argument that it cannot tell whether it has uniform velocity follows from Newtonian principles. The talk about observers follows from Einstein's approach to Relativity. If anything, therefore, the non-radiation of energy by accelerated charge is an indication that some arguments available from Einstein's Theory of Relativity cannot be relied upon, although there is the inevitable result that zero-energy radiation for all velocities is consistent with the Principle of Relativity.

It is noted that the mutual requirement for $E=Mc^2$ and non-radiation of energy by accelerated charge was the subject of a contribution by the author to the discussion of a paper by P. Hammond, relating to the Poynting Vector (Aspden, 1958, a) see also Aspden (1966, a), where the author drew attention to this result in view of controversy about the proper formulation of electromagnetic radiation.

Superconductivity

It has been concluded that an accelerated electron develops electromagnetic waves but need not radiate energy by these waves. This explains why electrons can move about in atoms without radiating energy and why electrons can travel through a superconductor without developing heat. We need not have recourse to arbitrary quantum assumptions to explain these basic facts of physical science. It is true that the motion of electrons through materials at normal temperatures results in heat generation. There are collisions between the electrons and the atoms. The electrons have kinetic energy and may transfer some of the atoms. Then, the atoms could be the source of the heat and not the electrons. Atoms do radiate energy in quanta. They are the source of photon radiation and, as we shall see later, an electron has a role to play anyway in the photon action. However, to emit photons one has to have enough energy to form a quantum. Thus, when an atom is part of a cold substance it has a small amount of kinetic energy. No doubt this energy varies about a mean value and as long as it is at least occasionally above the threshold needed to excite the photon emission there will be radiation. Meanwhile, the general interaction between the atoms and the exchange of kinetic energy will assure the manifestation of a temperature, even without such radiation. Electron flow merely adds to this kinetic energy exchange process and by its collisions will trigger off more photon emissions. If this electron flow and its collision action does not lift the energy level of the atom up to the threshold for radiation, assuming the material is at a really low temperature, no photons will be emitted. The collisions will occur without energy loss. Since they will be between electrons, either those carrying the current or those surrounding the atomic nucleus, they will be between particles of equal mass. Elastic collisions of this kind result in an exchange of velocities. Momentum is conserved. The result is that electrons can move without any apparent restraint through a loss free medium. The current will be sustained because the momentum is sustained by the electrons.

The above theory for superconductivity is merely suggested as the possible explanation. If it is valid, one would expect that if two superconductors composed of different isotopes of the same element are compared the heavier isotope will remain superconductive to a higher temperature than the other. The reason for this is that at the same temperature the heavier isotope has possibly a vibration condition of its atoms at a lower maximum velocity. Being heavier these atoms do not have to move so fast to keep the temperature balance with an interface at a reference temperature. It follows that their electrons are less likely to have the more highly energetic collisions with the conduction electrons. As a result, photons will be produced in such collisions at a lower temperature in the lighter isotope. This is mentioned because this is exactly what is found and because the recent discovery of this fact has disproved the conventional theory of superconductivity, which predicted the inverse. This was reported by Fowler *et al.* (1967), who found that uranium 235 becomes superconductive at 2·1°K and uranium 238 becomes superconductive at 2·2°K.

The Velocity-dependence of Mass

The expression $E = Mc^2$ applies to electric field energy. It follows that when we consider an electric charge in motion as having a kinetic energy, a magnetic energy and a dynamic electric field energy, as we did in explaining the problem with the Compton Effect, we are fortunate that one of these items, the magnetic energy, is negative and cancels one of the others. This really means that the dynamic electric field energy alone can be regarded as the motion energy of the charge. Since $E = Mc^2$ applies to such energy, the problem we now face is that mass must increase as the electric charge increases velocity relative to the electromagnetic reference frame. Here, it is necessary to talk about motion relative to the electromagnetic reference frame because it is in this frame that the magnetic field is induced and with it the dynamic electric field. It remains to be seen in our later discussions what physical form is to be attached to the means sustaining the magnetic field. Whatever these means are, we must assume that they have a co-operative influence in determining both the dynamic electric field and the magnetic field. It may be that very close to the electron itself there is nothing to support the magnetic field. But this does not matter as far as the analysis of the energy radiation is concerned. Nor does it matter in the earlier calculations of magnetic energy and dynamic electric field energy, because these latter quantities cancel. It does matter in calculating the mass effect of the dynamic electric field, in view of the assumed equality of the dynamic electric field energy and kinetic energy. To proceed, it is assumed that, at least over a period of time, the statistical mean value of the dynamic electric field energy is equal to the kinetic energy so that the latter can be regarded as offset by the magnetic energy, leaving the electric field energy as the only mass-containing quantity.

On this basis, from $E = Mc^2$ we can say that a mass M moving at velocity v has momentum $Mv = Ev/c^2$. Force is the rate of change of momentum and when this is multiplied by v we have rate of change of energy. Thus:

$$v \frac{d}{dt} (Ev/c^2) = \frac{dE}{dt} \tag{1.16}$$

When solved, this gives:

$$E = E_o/\sqrt{[1-(v/c)^2]} \tag{1.17}$$

The corresponding mass relationship is:

$$M = M_o/\sqrt{[1-(v/c)^2]} \tag{1.18}$$

This result shows that mass increases with velocity in the electromagnetic reference frame. It shows that there is a limiting velocity at which mass will become infinite. This is when v becomes equal to c, the speed of light. The increase of mass with velocity is well known from experiment, as already mentioned earlier in this chapter.

Fast Electron Collision

A direct experimental support for the non-radiation of energy by an accelerated electron is also afforded by collisions between fast electrons and electrons at rest. Using a Wilson cloud chamber, Champion (1932) has shown that when an electron moving at high velocity (of the order of 90% of the speed of light) collides with an electron at rest the resulting motion of the electron satisfies the formula in (1.18). On simple Newtonian mechanics the angle between the electron tracks after collision should be 90°. Using the above relation between mass and velocity and specifying *no loss of energy by radiation*, the conservation of momentum in the collision process leads to the formula:

$$\cos(\varphi + \theta) = \frac{(m/m_o - 1)\sin\theta\cos\theta}{[(m/m_o + 1)^2 \sin^2\theta + 4\cos^2\theta]^{\frac{1}{2}}} \tag{1.19}$$

where m is the mass of the incident electron as given in terms of its rest mass m_o using (1.18), and θ and φ are the angles between the electron tracks after collision and the direction of motion of the incident electron.

By measuring the velocity of the electron before collision and these two angles, Champion was able to verify equation (1.19) as taken in conjunction with (1.18). Now, although in such experiments one would expect quite significant radiation of energy by accelerated electrons using the classical formula discussed above, Champion was able to conclude as follows: "Considering the total number of collisions measured it would appear that, if any considerable amount of energy is lost by collisions during close encounters, the number of such inelastic collisions is not greater than a few per cent of the total number."

Electrons and Positrons as Nuclear Components

So far, the electron has been the topic of interest. Presently, following this chapter, we will enquire into some of the field interaction properties of the electron and its electrodynamic behaviour as a current element. Thereafter, we will study its role inside the atom and later its role in the atomic nucleus itself. However, it is appropriate at this stage to outline briefly the potential which the electron, as portrayed in this chapter, has in nuclear theory. This will be done without recourse to quantum electrodynamics or even wave mechanics. An omission, to be rectified in a later chapter, is the analysis of the spin properties of the electron and its anomalous magnetic moment. An explanation of spin is important, if only as a check on the theory offered to account for any elementary particle. For the moment, spin is ignored.

As mentioned earlier in this chapter, quark theory invites us to believe that the proton consists of three elementary particles in close aggregation. This quark theory is untenable with the theory presented in this work. Here, there is complete reliance upon the indivisibility of the charge quantum e, so far as it appears in matter. It will, however, be a contention of this theory in Chapter 7 that the proton does comprise three elementary particles as required by quark theory, but these are the electron, the positron and a heavy elementary nucleon of positive charge e. The positron was discovered in 1932. It appeared in cosmic rays and is, of course, merely a particle exactly like the electron but with a positive charge e. Positrons are ejected from radioactive substances, which suggests their existence in the atomic nucleus. It has been found that a proton can lose a positive electron, or positron, and become a neutron. Also, a neutron can lose a negative electron and become a proton. This suggests that the proton and neutron must each contain an electron and a positron. Both must contain the heavy nucleon just mentioned, and the neutron must have one electron in addition. Now, all this supposes that there are no interchanges of polarity or energy exchanges in these various transmutations. This is unlikely. Indeed, if we go on to consider the combination of the neutron and the proton, it has been suggested that they might be bound together by what is called an "exchange force" arising because they are rapidly changing their identity. The suggestion is that they are exchanging the electrons and positrons as described above, so that, according to a proposal by Fermi, the neutron and proton are really different quantum states of the same fundamental particle. Now, this may be true, but we should not blind ourselves to the other possibilities. If we know that these elementary particles are aggregations of electrons, positrons and some heavy particles, and we know the physical size of these particles, as explained earlier in this chapter, it is worth while examining what follows from this knowledge. The result contains a double surprise, and is all the more gratifying because of its simplicity.

The deuteron, the nucleus of heavy hydrogen, is the particle form to be expected when a proton and a neutron are bound together. We will assume that this deuteron, which has a mass of the order of two protons and a charge e which is positive, comprises two identical heavy particles and some electrons or positrons or a mixture of both. Then there are a number of possible configurations having electrostatic stability. For one of these the energy has a minimum value. This configuration is deemed to be that of the deuteron. Its electrostatic interaction energy is a measure of the nuclear binding energy. It is the energy needed to separate the nuclear components well apart from one another. How far apart is critical to the analysis if we wish to be exact, but for the initial study in this chapter we assume separation to infinity. The binding energy of the deuteron is known from measurements. Hence, the theory can be checked.

In Fig. 1.3 different models of possible deuteron configurations are shown. Model A depicts two heavy positively-charged particles of mass M. They have a very small radius because for a discrete charge e the electrostatic energy is inversely proportional to radius, as shown in Appendix I. In model A there is one electron located between the two heavy particles, or H particles as they will be denoted. Since the charges act from their particle centres, the radius a of the electron becomes the only significant dimension in the analysis. Then, the energy of deuteron model A is $2M+1$ electron units plus the interaction energy. It is convenient to evaluate mass quantities in terms of the electron mass as a unit. The interaction energy comprises three components. Between one H particle and the electron there is an energy $-e^2/a$. Between the other H particle and the electron there is the same energy $-e^2/a$, and between the two H particles there is the positive energy $e^2/2a$. The total interaction energy is $-1{\cdot}5e^2/a$. Now, we will put:

$$ke^2/a = mc^2 \tag{1.20}$$

where k is a constant and m is the mass of the electron. Then, in the units of mass for which m is unity we can express the total energy of model A as $2M+1-1{\cdot}5/k$.

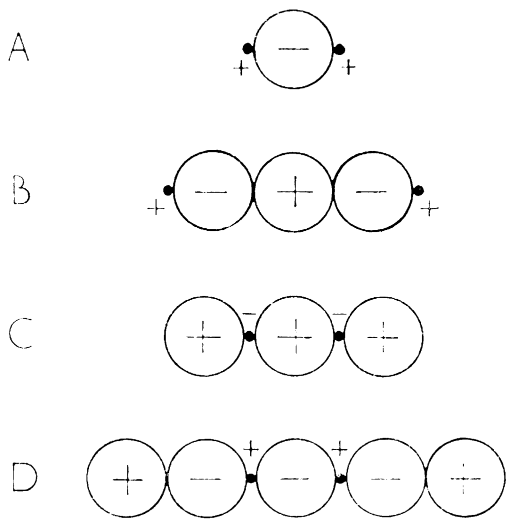

Fig. 1.3

In similar manner the other models of the deuteron presented in Fig. 1.3 can be analysed. An energy evaluation for each model shown results in the following masses:

A $2M+1-1{\cdot}5/k$
B $2M+3-2{\cdot}317/k$
C $2M+3-2{\cdot}917/k$
D $2M+5-3{\cdot}558/k$

For different values of k the deuteron could be different, since the deuteron will be the one of smallest total mass. Even so, the term involving k is the binding energy of the deuteron, and it is known from experiment that this binding energy is about 2·22 MEV or 4·35 electron mass units. Thus, proceeding from this we can derive k. Firstly, if model A is the minimum mass model, k has to be about 0·35 to assure that $1{\cdot}5/k$ is 4·35. Then we can see that model C has lower energy still, which makes us rule out model A. Model B is ruled out on direct comparison with model C. If model C is chosen, then k will be about 0·67. This gives model C slightly less overall energy than model A. It has also less energy than the other models, as may be verified by continuing this exercise. It will be found that model C is the only one able to explain the measured binding energy of the deuteron. Thus, if this theory is correct k should be 0·67, which is verification of the 2/3 factor already deduced earlier in this chapter by reference to Appendix I.

If we pause to comment on this verification that k is 2/3, we note that there are now available the following mutually-supporting points. Firstly, the magnetic field energy induced around a spherical electron of radius a in motion has a mass equivalence, if equated to kinetic energy, which puts k as 2/3. Secondly, if we assume that the constraint or binding action at the surface of the electron is such that the repulsive forces within the electron develop a uniform pressure throughout its volume, k is 2/3. This is proved in Appendix I. Thirdly, if we assume that the electric charge e of the electron is distributed throughout the body of the electron to cause the electric field or energy density to be uniform, k is 2/3. This is mentioned in Appendix I. Fourthly, it so happens that if k is 2/3 the deuteron binding energy is explained and the deuteron is identified with the model C in Fig. 1.3. It follows that there is little scope for doubt about the real nature of the electron. There have, indeed, been two surprises from this analysis. The first is that the deuteron energy is calculable on such a simple model, one which happens to be the least mass form. The second is that although the form of the electron had been deduced by separate analysis, we were able to find an empirical approach using experimental data to verify that the energy of the electron is $2e^2/3$ divided by its radius.

It is noted that a value of k of 2/3 used in connection with model C results in a binding energy of 4·375 electron units, or about 2·24 MEV. In Chapter 7 it will be shown that we can take this further to find the exact value of the deuteron binding energy. As it is, it suffices that the theoretical figure is within 1% of that measured.

Summary

In this chapter the reader has been shown that there is purpose and merit in regarding the electron as a spherical ball of charge. The quantitative analysis has drawn attention to the need to regard magnetic energy as a negative quantity, a feature which is compatible with other physical theory, and this has led to an understanding of the mass properties of the electron. In previous textbooks the dynamic component of the electric field energy has not be considered. Another omission in the past has been an inclusion of the field needed to accelerate the electron when studying its radiation effects. By rectifying these omissions, a new insight into physics has become available, with consequent benefits. It is incredible to the author that the classical formula for the energy radiated by the accelerated electron could have been accepted when it has no dependence upon the mass or size of the electron, but, be that as it may, it has been proved that non-radiation leads us to understand the nature of mass and the derivation of the relation $E=Mc^2$. The increase in mass with velocity follows from this relation, as is well known. Accordingly, although the law $E=Mc^2$ and the velocity dependence of mass are regularly ascribed to Einstein's theory, their existence in no way makes Einstein's theory an essential part of physics. They do not depend upon Einstein's Principle of Relativity. The chapter has been concluded by showing that the deuteron binding energy can be calculated to provide a result highly compatible with the model of the electron presented. This demonstrates one of the potential applications of this theory of the electron. The analysis of the atomic nucleus is an important subject in this work, as will be seen later in Chapter 7. Meanwhile, it is hoped that the reader may be beginning to realize that Nature is not quite as complicated in the realm of truly fundamental physics as might appear from modern mathematical treatments.

2. Mutual Interaction Effects

Reaction Effects

It has been shown in the previous chapter that an electric charge in motion has three dynamic energy components. These are its kinetic energy, its dynamic electric field energy and its magnetic energy. Further, these are all equal in magnitude for observations in the electromagnetic reference frame and when the velocity is small relative to the velocity of electromagnetic wave propagation. Also, and most important, the magnetic energy is a negative quantity because it is energy supplied *from* the field medium. Thus, the total self-dynamic energy of an electric charge in motion under the conditions just specified is, for normal observations, simply its kinetic energy.

The same principles apply to any reacting charge in motion in the magnetic field set up by the above charge, but when additional charges are present there are mutual interaction effects to consider. It is of importance to consider the mutual interaction energy components present when a group of interacting electric charges is in a dynamic state. The basic principles of magnetism are founded in the physical understanding of these interactions.

By way of definition, it will be assumed that a discrete charge in the sense to be used in this study of mutual interaction effects is a unit which, if not spinning in the inertial reference frame, has all its constituents moving together at the same velocity. Such a charge might comprise a close-compacted aggregate of charged particles of both polarities. For example, if a proton consists of three quarks as already mentioned, we still regard this as a single unit of charge. The physical reason for this distinction will become evident below.

Discrete units of charge in a general interacting system may be classified as primary or reacting. By this is meant that any charge which forms part of the system and has a controlled motion is termed primary charge. Other charge present is merely disturbed and reacts to the motion of the primary charge so that it may be termed reacting charge. An example of this is the flow of current in a circuit. The electrons carrying the circuit current comprise the primary charges. Electrons in any surrounding conducting medium comprise a reacting system. Even though the circuit current is steady, the conduction electrons in adjacent conductive media provide a system of charge capable of reacting in the sense intended here.

The three dynamic energy components will be denoted K, E and H respectively applying to kinetic energy, electric energy and magnetic energy. Also, a suffix P, R or M will denote primary charge, reacting charge and mutual interaction between charge, respectively. Thus, the total dynamic energy of the system under study is given by:

$$K_P + E_P + H_P + K_R + E_R + H_R + K_M + E_M + H_M \tag{2.1}$$

Now, we have already established that the self-electric and magnetic energies of the charges are equal. Further, the magnetic energy quantity is negative. Thus E_P and H_P in (2.1) sum to zero and E_R and H_R sum to zero. Physically, this is because the disturbance of the field medium which we term magnetism involves a redeployment of energy in the field itself. In fact, the terms in (2.1) are energy changes and the requirement that E_P and H_P sum to zero is merely a mathematical account of a situation in which the phenomenon of magnetism causes energy to be released from one form in the field medium and used to generate the dynamic electric field present where this energy is released. The mutual interaction between the charge causes a magnetic interaction energy term H_M which also must combine with E_M to sum to zero. The result is that the energy given by (2.1) can be simplified as:

$$K_P + K_R + K_M \tag{2.2}$$

The term K_M has been introduced for generality and denotes what we could term mutual kinetic energy. It is of interest to examine what is meant by mutual kinetic energy.

Mutual Kinetic Energy

Kinetic energy can be said to be the intrinsic energy of motion which we associate with a particle. It has been shown in the previous chapter that the mass property of a particle is related to its intrinsic electric field energy. The law $E = Mc^2$ was derived. The rest mass of the particle is found by dividing the electric field energy of the particle by c^2. In the sense of (2.1) we have precluded consideration of effects internal to composite charge aggregations. These have self-balancing mutual dynamic interactions and the kinetic energy is that of the composite mass of the aggregations. We need only consider the mass effect of the mutual electric interactions in our open system. This has to take account of the implications in the analysis that mutual magnetic interaction involves field energy redeployment to produce dynamic mutual electric energy states. However, such energy can give no mass property to the system since the mutual dynamic *field* energy (electric and magnetic) sums to zero anyway. There are mutual non-dynamic electrostatic interaction energy components not included in (2.1) and these could be said to give rise to a mutual kinetic energy effect for a system in motion. However, in analysing interaction effects in a complete system, which is just what we are doing, effects are being analysed relative to the common inertial frame of the system. The total momentum of the system relative to its own inertial reference frame cannot vary if we consider only the effects of interaction and the self-action effects of the system itself. This is a well accepted fundamental rule of physics. Thus, if the electrostatic interaction energy is taken to be at rest in the inertial reference frame under study, simply because it is taken to define this frame by its very position, we cannot attribute kinetic energy to the motion of the interaction electrostatic energy with the system as a whole. In other words, we expect that there is no such thing as mutual kinetic energy in the context used above.

To relate this to the orthodox teachings in physics, consider two electric charges of opposite polarity but identical mass moving towards one another at equal speeds, the motions being in a common straight line. By accepted principles there are no magnetic forces between these two charges because there is no field along this line. This leaves us to accept that the mutual electrostatic attraction between the charges causes electrostatic energy to decrease as it is converted into the kinetic energy added by the accelerated motions of the charges. The analysis is simple and the reasoning quite straightforward. However, let us ask where the mutual electrostatic energy is located. Surely, it is in the field, that is, it is spread over the space surrounding the charges. As the charges come closer together, this field energy is released and converted to kinetic energy. Where is this kinetic energy located? As the charges come closer together, the mutual electrostatic field energy which is not yet released and converted to kinetic energy has nevertheless been compacted into a region closer to the charges. The energy distributed in the field has moved to new positions. Does this involve any kinetic energy effects itself? Accepted physics does not answer these questions. They are not formulated so bluntly. Yet, the questions must be asked and answered if our understanding of physics is to develop.

Let us try to formulate some rules. Every fundamental electric particle has an associated electric field and an intrinsic electric field energy. This gives the particle a rest mass, found by dividing the energy by c^2. Kinetic energy is then the energy of motion of this intrinsic electric field energy. The velocity of such motion has to be measured in an inertial reference frame which we take to be a non-rotating frame in which the "centre of gravity" of the mutual electrostatic energy of the complete system of electric charge including the particle is at rest. There is no such thing as mutual kinetic energy on this definition. Mutual electrostatic energy can be redeployed in its distribution in space without involving any additional dynamic energy effects not summing to zero. Mutual electrostatic energy can be released to augment the kinetic energy of the charges in the system.

These rules cater for the simple example of the two approaching oppositely charged particles. They do not cater for the increase in mass of an electric charge as its speed increases. The rules will therefore be extended as follows. The intrinsic electric field energy of the particle moves with the particle. This energy accounts for the mass of the particle. In the field surrounding the particle there is a dynamic disturbance of the electric field which involves an increase in electric field energy. This added field energy moves with the particle and augments its mass. There is a deficit in the intrinsic energy of the field medium termed magnetic energy and there is kinetic energy in equal measure. Both of these move with the particle but they compensate one another and have no mass effect. The dynamic electric field energy remains to add increased mass to the system. Since it could be replaced in analysis by the equal valued kinetic energy, we may then speak as if kinetic energy is the sole dynamic energy quantity.

It is a conclusion at this stage that there is no such thing as mutual kinetic energy. Thus, K_M in (2.2) is zero. This leaves us with the interesting result that the total energy in any system of electric charge in motion, apart from the rest electrostatic energy, is the kinetic energy of the charges. In particular, we can ignore magnetic energy which is somehow cancelled out by the properties of the system.

The Nature of Induced EMF

Consistent with the above analysis we can say that (2.1) and (2.2) can be written as:

$$K_P + K_R + E_M + H_M \tag{2.3}$$

where:

$$E_M + H_M = 0 \tag{2.4}$$

To give a physical interpretation of this expression as applied to an electric current in a solenoid, we can say that the energy K_P is the energy needed to establish current flow merely to get the electrons moving to form the current circuit. In such a case, this energy is small compared with the mutual energy components. The energy E_M is the energy needed to overcome the back EMF, the induced electromotive force in the system. It is energy supplied and stored in the mutual interaction of the dynamic electric states of the system. It remains available to return energy when the current is stopped. This energy is known to equal the conventional magnetic field energy supplied to the system. It is numerically equal, but that is all. In fact, magnetic energy is not supplied to the solenoid when it is magnetized. The energy E_M is supplied and by this action the negative energy H_M of equal numerical magnitude is made available in the field to provide energy K_R. The energy supplied to the solenoid is thus merely:

$$K_P + E_M \tag{2.5}$$

and we find that:

$$K_R + H_M = 0 \tag{2.6}$$

The result arrived at now means that we can extend the rules we have formulated still further. Although for a discrete electric charge in motion we could say that the magnetic energy released in the field was deployed to provide the dynamic electric energy component in the field, we now find that where significant mutual interactions between charges occur, the release of mutual magnetic energy is applied to augment the kinetic energy of the reacting system of electric charge present. In other words, we find that when a solenoid is magnetized, the core of the solenoid as the seat of the reacting charge should be heated to acquire a thermal energy exactly equal to the magnetic energy associated with the magnetization. This means that thermal energy is available to be radiated away from the core once it is magnetized, so that if the magnetic field is switched off after it is cooled down, we expect the solenoid energy to come from the term E_M right away, whilst the kinetic energy of the reacting charge in the system has to struggle to return the magnetic energy H_M to the field. The result should be a cooling of the solenoid core when it is demagnetized.

Magnetocaloric Effects

It has been deduced that the process of magnetization and demagnetization must be associated with thermal effects in such a way that magnetization develops heat whereas demagnetization produces cooling. This is, of course, found to be supported by experiment. If a paramagnetic material is magnetized it is found that its temperature increases. The phenomenon is used in the process of cooling by adiabatic demagnetization. When magnetized, it seems that energy has been added to the conduction electrons in kinetic form which is shared with the kinetic energy of the atoms to increase the temperature of the body. When a ferromagnetic is magnetized, the intrinsic magnetic state of domains in the substance is being brought into alignment. This does not cause thermal change related to the apparent magnetic energy involved. However, the thermal effects are manifested in the change in specific heat near the Curie Point. Due to intrinsic magnetism being destroyed as the temperature is increased, the specific heat of a ferromagnetic is greater than that which would be exhibited by a normal metal under the same physical conditions. These are well known phenomena. Less known, perhaps, is what happens even to a ferromagnetic material when it is suddenly magnetized to a very high field strength which far outweighs its intrinsic ferromagnetic field. H. P. Furth (1961) has described a test procedure attributed to F. C. Ford in which a number of $\frac{3}{4}$-inch diameter rods were transiently subjected to fields of the order of 600 kilogauss. Some test samples showed signs of thermal damage as if they had melted and solidified again. Others were ruptured as if they had been broken in a tensile testing machine and also showed signs of thermal damage. Furth demonstrates how these effects can be explained by relating the melting temperature in ergs per cc. with the energy density $B_m^2/8\pi$ and the tensile stress in dynes per square cm. with the energy density $B_s^2/8\pi$. For hard copper, for example, he found B_m to be 500 kilogauss and B_s to be 300 kilogauss. Appropriately, the copper sample showed both mechanical deformation and surface melting in the 600 kilogauss field. For hard steel, with B_s and B_m both 700 kilogauss there is no damage at all in the 600 kilogauss field. For mild steel which has a lower B_s there is some deformation. Thus, the magnetocaloric effect imposes a limit on the fields which can be developed at least transiently in any material. There is ample evidence to show that when a magnetic field is produced in any substance, a thermal effect of energy equal to the change of magnetic field energy is developed. Since magnetic energy cannot be simply identified as thermal energy owing to the dispersal property of thermal energy not being contained like magnetic energy by the inducing current, we must recognize that magnetic energy and the related thermal energy are of separate character. If we do this we are forced to answer the problem posed by the mysterious source of the thermal energy. If we still have the magnetic energy in the inductive storage of the magnetized system, where has the thermal energy come from? The answer to this problem has been presented above. It is not a hypothesis. It is an inevitable conclusion to be drawn from the facts of experiment.

One question which inevitably emerges from the above analysis is whether the field medium can be caused to supply energy for practical application. For example, imagine a solenoid containing a movable non-ferromagnetic core to be magnetized. The core receives heat energy. The field medium releases magnetic energy. The induced EMF action requires retention of energy in the inductive system. What if we then withdraw the core before demagnetizing the solenoid? Do we not then find that we have a surplus of heat energy in the core and can get back the inductive energy put into the solenoid, leaving the vacuous field medium itself in a cooler state (whatever that means)? The answer to this is that as the core is withdrawn from the field it will cool down, thus thwarting the attempt to get energy from nowhere. Then one might say, why not wait for the thermal energy to be conducted away from or radiated by the core. Then, using this energy to perform a useful function, we can later demagnetize the solenoid to end up with a process in which temperature can be cycled to do useful work without the expenditure of energy save to sustain copper loss in the solenoid. This should be possible. It is analogous to the heat pump in which energy comes from the ambient thermal source. What then if we add more thermal energy to the core in this cycle than is needed to cool the specimen down to absolute zero of temperature in the reverse process? If the core is at room temperature and then magnetized to a very high field which will raise its temperature to 500°C, say, what will happen if we then allow it to cool in this field back to room temperature and then demagnetize it? This is a most interesting question which experiment will one day answer. The best answer the author can give is that the field medium itself will be cooled down, meaning our energy balance problem can then show experimentally that there is an aether medium which acts as a source as well as a store of energy.

Evidence of Magnetic Reaction Effects

As just explained, there is abundant evidence to support the expression in (2.6), the equality of kinetic energy in the reacting system and the negative measure of the magnetic field energy due to mutual interaction effects. However, it is of interest to enquire into the other evidence which should be available to demonstrate that there are kinetic properties linked with mass in motion and associated with the magnetic field. To proceed, imagine a magnetic field H to exist in the reacting system under study. We are, for example, considering the state of uniform magnetization within a ferromagnetic domain. Consider then each element of reacting charge as, for example, a conduction element in a ferromagnetic. Let its charge be q in electromagnetic units, and denote its mass M and its velocity v. In the field H it will move to provide maximum opposition to the field. Then, balancing centrifugal force against magnetic force:

$$Hqv = Mv^2/r$$

where r is the radius of the charge orbit. Now, $qvr/2$ is, on classical theory, the magnetic moment of the reacting charge. Thus, the total reaction magnetic moment per unit volume becomes, from the above equation, the total kinetic energy of the reacting charge system per unit volume divided by H. Since this reaction field is not observed in experiment, it follows that the primary charge is really developing the field H plus a component to cancel this reaction effect. If the primary action develops the field kH, where k is a mere numerical factor, we note that $4\pi k$ becomes the factor relating the current moment to the induced field. Thus, we deduce:

$$H = kH - 4\pi k(K_R)/H \tag{2.7}$$

For maximum reaction kinetic energy, that is, the maximum energy transfer induced by the primary charge system, it may be shown by differentiating (2.7) with the primary field constant that k is 2. When k is 2, K_R becomes $H^2/8\pi$. Then, from (2.6), we find that:

$$H_M = -H^2/8\pi \tag{2.8}$$

This is a wholly consistent result. We have arrived at the usual expression for magnetic energy density. The magnetic energy has had to be taken as a negative quantity as we have predicted. Further, we have deduced that the magnetic field induced by any charge in motion is really invariably double that expected on conventional theory. However, as has been shown, reaction effects invariably halve this field to leave us with the value found in experiments.

For maximum reaction kinetic effect, reacting charges of larger mass will be favoured as those to provide the energy term K_R. Thus, when a magnetic field is induced in a metal, the heavier of any free electric charges will move to set up K_R. If there is free charge in the aether medium in quantum units of the electron charge e, then, whether or not these react, or the conduction electrons in the metal react, will depend upon which have the greater mass. If the conduction electrons have the greater mass they will provide the energy K_R. Then, the angular momentum of the reacting charge will manifest itself in magnetization changes. It follows that an experiment which can respond to the relation between magnetic moment and angular momentum of both the primary charge and the reacting charge will allow a direct measurement of the factor k. On the other hand, if there is *free* charge in the aether medium which *may* fill the voids between the atomic substance in the magnetized material and this charge has greater mass than electrons, this medium will itself provide the reaction effects and, although the magnetic field will be attenuated as the theory requires, the mechanical effects will not occur and the observation that k is 2 cannot be expected. This assumes the well known fact that the elusive aether does not provide any mechanical resistance to the motion of matter and so cannot communicate any angular momentum.*

* There are interesting exceptions to this rule discussed in Chapters 4 and 5.

In the latter event it will be difficult to explain how the magnetocaloric effects can occur. If the reaction kinetic energy is not provided by matter, it must occur in the aether medium and it cannot then cause thermal effects in matter. It must, therefore, be expected that if the aether has migrant charge free to move to react to magnetic fields, these charges must be of smaller mass than the electron. Further, the experimental derivation of the factor k from observation on magnetomechanical effects must then be possible.*

Before discussing the evidence supporting this proposal, we note that the energy K_R has to be sustained in a steady magnetic field because (2.7) is applicable to the steady state. Thus the physical meaning of the equation is that K_R has to be maintained by the reacting electric charge system. This is assured if the thermal energy of the conduction electrons is adequate, that is, if the temperature is sufficiently high. If the temperature is too low because there has been cooling after magnetization occurred, it may well be that free charge in the aether takes over the role of K_R in (2.7). This means that at magnetic fields and temperatures low enough to permit the superconductive state in materials exhibiting this property, it could be that the charge in the aether takes over the role of reacting to cancel half of the magnetic field. Thus the magnetomechanical ratio should not be anomalous under these circumstances. Kikoin and Goobar (1938) have measured the gyromagnetic ratio, as it is called, for superconducting lead. They found k to be unity. In referring to this result, Bates (1951, b) said, "We conclude that the large diamagnetism of superconductors is due to electrons moving in orbits in the crystal lattice as if they were free in the sense of having ordinary values of e and m." However, as will now be explained, k is greater than unity under normal circumstances.

The Gyromagnetic Ratio

Richardson (1908) suggested that when the magnetism in a pivotally mounted ferromagnetic rod is reversed, the rod should sustain an angular momentum change. It was predicted that the gyromagnetic ratio, the ratio of the change of angular momentum to the change of magnetic moment, should be $2mc/e$, the quantity applicable to the electron in free orbital motion, where e is the electron charge, m is its mass and c is the velocity of light. Einstein and Haas (1915) first

* The analysis was presented also by the author in ref. Aspden (1966, b).

observed the effect. Sucksmith and Bates (1923) then found that the effect was only one half of that predicted. The gyromagnetic ratio was only slightly greater than mc/e. Meanwhile, Compton (1921) had suggested that the electron possesses an intrinsic angular momentum or spin and a magnetic moment. Uhlenbeck and Goudsmit (1925) proposed an angular momentum of $h/4\pi$, and a magnetic moment of $eh/4\pi mc$, corresponding to the gyromagnetic ratio of mc/e. This spin property of the electron was found to help resolve problems in spectral theory, and the use of this concept is now firmly established in atomic theory. Later, Sucksmith (1930) took the experimental observations on ferromagnetic specimens as an indication that ferromagnetism is, in the main, due to electrons spinning on their own diameters. This conjecture has, however, not really been substantiated and is likely to be in error, while the spin concept remains to define a primary property of elementary particles having no clear physical interpretation.*

When the direction of magnetism is reversed in a ferromagnetic rod, the electrons generating the magnetic flux undergo a change in angular momentum. However, the magnetic flux traverses the ferromagnetic medium and this contains free electrons in a state of agitation. Similarly, magnetic flux in vacuo may also traverse an aether medium in which (for all we know) there could be free electric charge in a state of agitation. Free conduction electrons satisfying Fermi–Dirac statistics are so numerous in a ferromagnetic conductive material that, as a little analysis shows, they should react to cancel any magnetic flux traversing the substance. The magnetic field deflects the electrons into orbital motion between collisions and, regardless of their velocity or direction, the arcuate motion invariably develops a reaction field component and a reaction angular momentum.

The field attenuation problem thus predicted does not show itself in our experiments and its absence, or apparent absence, requires explanation. In the above analysis it was shown that the magnetic field to be expected from orbital electrons in motion in a ferromagnetic is really double that normally predicted. There is then an attenuation in that reaction effects due to conduction electrons halve the field. Curiously, the analysis points to this halving effect as a

* In a textbook on magnetism, Professor W. F. Brown (1962) wrote: "If later theoretical research succeeds in reinterpreting the 'spinning electron' as an actual system of spinning charge or as a system of poles, this . . ." His book was written without reliance on either interpretation, clearly having in mind the uncertainty surrounding the subject.

universal effect but leaves scope for variations in the magnetomechanical ratios involved in different circumstances. However, the analysis does show that the parameter k must be 2 and this means a gyromagnetic ratio of mc/e and not $2mc/e$. The predictions of the previous analysis are clearly supported by the gyromagnetic ratio. Also, it is then possible to say that ferromagnetism is due to the orbital motions of electrons in atoms and not to the mysterious spin property which is so much in dispute. What remains a mystery is the way in which the electron reaction effect in metals subject to magnetization has been overlooked in the researches on the subject. It is true that there is a magnetic anomaly facing researchers who try to compare theoretical eddy currents and those observed. This anomaly, termed the "eddy current anomaly" involves the study of reaction currents when there is changing magnetic flux. Its explanation is bound up with the behaviour of magnetic domains, as the author has demonstrated experimentally (1956). The mystery we are concerned with is how electrons can move about in a metal to set up a reaction effect without this having been recognized. The simple answer, given by the informed physicist, is that it has been recognized, but a correct analysis shows that the reaction sums to zero. However, it should be noted that such analysis was performed when it was expected that the result should sum to zero. It was later that the gyromagnetic anomaly was observed. If we examine how one can obtain the zero reaction result we find that the argument is somewhat equivalent to what is portrayed in Fig. 2.1. In this figure electrons are shown describing circular paths to develop the magnetic reaction effect opposing an applied magnetic field. Electrons at the boundaries are caused by collision with the boundaries to migrate around the whole magnetized region and so develop an opposite magnetic effect. They

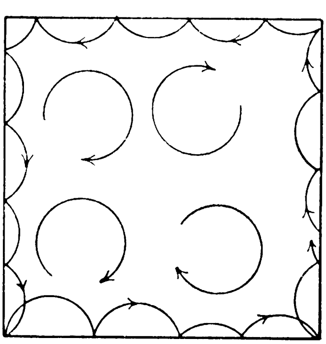

Fig. 2.1

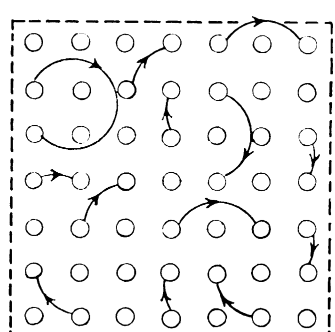

Fig. 2.2

migrate, as can be seen, in the opposite sense to the orbital reaction motion of the electrons in the body of the magnetized material. Of course, collisions are occurring between electrons and atoms and there is no clear boundary as indicated, but the effect is the same. Mathematical analysis shows that there is complete cancellation. It is a matter of statistics. Now, if we accept this explanation we have to dismiss the gyromagnetic explanation offered in the previous pages. But if we accept the explanation of this reaction cancellation we must accept that electrons bounce like billiard balls in their collisions with atoms. Furthermore, there is no boundary at the surface of any real substance. All there is to keep the electrons from going into space or into another material is an electric field or perhaps a magnetic field which deflects the electron back again. It suffices, then, to talk of collisions with atoms. Do electrons bounce back like billiard balls, recoiling from the heavy atoms as the billiard ball recoils from the edge of a billiard table? Alternatively, do electrons strike the electrons in an atom and transfer their momentum to these electrons just like a billiard ball exchanges momentum with another billiard ball in its collisions on the table? When superconductivity was discussed in Chapter 1, it was this latter argument that was followed. If electrons merely transfer momentum to other electrons and there is continuous electron exchange between atoms we get the situation depicted in Fig. 2.2.* There is no countermotion of electrons to develop the cancelling effect. Is not this an important question? It is simply a question of whether, when an electron collides with an atom, it collides with a rigid body having the mass of the whole atom or collides with an electron having a mass like itself. In one case we have no field reaction effects and in the other we have those offered to explain the gyromagnetic ratio. The reader has his choice. On the conventional path he is led to the intricacies of quantum electrodynamics to seek his answers to the problems posed. On the other path, the one which assumes that an electron certainly must collide with one of the electrons acting as outer guard in the atom, he is led with the author along a virgin and unconventional path. However, this is a path well worth exploration, particularly in view of some of the uncertainties which now beset physical theory.

* Clarricoats (1961) in discussing loss mechanisms in ferrites states. "In ferrite materials which contain iron in two valence states, certain electrons can move quite readily through the crystal lattice." The fact that the gyromagnetic ratio is still 2 in such non-conductive materials does not invalidate the argument that the gyromagnetic anomaly is due to electron exchange between atoms.

In this quest it has to be assumed that the magnetic field produced by any electric charge in motion relative to the electromagnetic frame will be exactly double that measured in experiment but that, invariably, there is something which reacts to halve the true field, whether in free space or in matter. This assumption is in line with the finding that magnetic field energy is a deficit of energy equivalent to the kinetic energy of reacting charge. There has to be a reacting charge in free space and it has to have a priming of energy to be able to assert a reaction. Having said this, the reader must understand that the double magnetic field can be ignored in further analysis. The gyromagnetic factor of 2 has to be used in certain magnetomechanical analyses but this is in line with normal physics. Furthermore, when we come to explain the anomalous magnetic moment of the electron, the gyromagnetic factor is merely assumed on the strength of the above explanation and the anomaly is explained by regular analysis.

The Aether

Before going on to show how the above principles have immediate application to the derivation of the true law of electrodynamic force between charges in motion, it is appropriate to comment on the concept of the aether. It is usual to ignore this medium in modern physics. This is more a matter of convenience than anything else. Its existence is a matter for intuition. Electromagnetic waves travel through free space at a certain finite velocity. There must be a medium to sustain such waves. Hence, from time immemorial when the aether was a matter of philosophical hypothesis to today when it is more a question of logic, the aether has been ever present. To recognize its existence in any specific form causes the difficulties. If we have preconceived notions about the aether as a medium which provides an absolute frame of reference for light propagation, then the physicist rightly will reject such aether. There is experimental evidence to the contrary, notably the famous Michelson–Morley experiment. However, we do not intend to make such assumptions. The aether under review in this work is the one indicated by experiment, not an imaginary one conceived by hypothesis. The aether is the medium permeating space and having the property that it can store a magnetic field. Seemingly, from the foregoing analysis, it contains free electric charge in motion and able to react to the action of electric charge in matter. If we are not then to be led immediately into the trap of thinking that this reacting charge determines the frame of reference for electromagnetic wave propagation, we must think in terms of wave *disturbance*. Something is disturbed. There must be something other than the reacting charge. Without the reacting charge the aether can be said to be unable to sustain a magnetic field, but it may still contain electric charge provided this can be regarded as primary in the sense used above. Such charge would have a *controlled* motion. With no reacting charge K_R in (2.3) is zero, and then from (2.4) it is seen that the only energy in the aether is K_P, the kinetic energy of its controlled primary charge. Adding what must be a relatively small energy in the form of the reacting system gives an energy priming of ψ, say, equal to the kinetic energy K_R of the reacting system. Then, since ψ fixes the limit on the energy which can be stored by a magnetic field we have to expect there to be a limit on the maximum magnetic field which can exist in space. In addition it can be said that since ψ is much less than K_P we have to think in terms of the probability that the intrinsic energy density of the aether is significant.

Is there any evidence of a limit of magnetic field strength? Already in this chapter there has been reference to fields of 700 kilogauss used in practice. Probably the highest magnetic fields are produced in thermonuclear reactor experiments in which a self-pinching electric discharge is used to focus the magnetic energy of an electric current. The object is to develop very high temperatures in an almost infinitesimal volume disposed along the current filament. Evidence of a limit on the temperature which can be obtained in practice would be evidence of a limit on magnetic field. However, the problem confronting such research is that of keeping the discharge stable during the collapse. Yet, even if the discharge can ever be stabilized sufficiently, there might be a limit on the maximum temperature which can ever be reached and this limit might be set by a *saturation effect in the aether*. This is speculation, it is true, but it might be worthwhile speculation in view of the cost of thermonuclear research. Later, in Chapter 6, it will be shown how evidence is forthcoming indirectly from the theory and experiment to indicate that there might well be such a limiting effect and to afford an estimate of the magnitude of ψ.

Thermonuclear Reactor Problems

The research into the development of the thermonuclear reactor gave prominence to plasma physics. Electric and magnetic phenomena in a plasma of ions and electrons need thorough analysis to study the behaviour of the processes being applied to induce high temperatures by thermonuclear reaction. As mentioned above, a strong current arc contracts under its self-pinch action to produce high temperatures. With a high energy concentration around atoms of heavy hydrogen, having the deuteron as nucleus, it is sought to produce a temperature of the order of 300,000,000°K for long enough to cause fusion into tritium and helium. Nuclear energy will then be released in excess of the energy supplied to stimulate this action.

As was announced in 1958, trouble was being encountered in stabilizing the electric arcs, with the result that they snaked around within the reaction chamber and were destroyed by contact with the walls. Using the accepted teachings of electrodynamics it was possible to devise systems which could, at least theoretically, overcome the stability problem. One simple proposal offered by the author (1958, b) was to induce the arc along the central axis of a hollow primary conductor, the arc being, in effect, the secondary circuit of a transformer. However, what has seemed a theoretical possibility has remained a practical impossibility. The attempts to stabilize the discharge have gone on without success, or at least without sufficient success to induce the high temperatures expected. It is not difficult to begin to wonder whether the laws of electrodynamics applied with such success in other fields have their limitations in this area. One is dealing with a closed electric arc which is not held in place by a conductor of solid material. The rigidity of the usual current conductor is not present. Further, there is scope for the arc to act on itself. Electrodynamic theory is usually applied to actions between currents where, invariably, one current is a closed circuit. Our simple formulations in electrodynamics depend upon this assumption. However, it does not apply if we can have one part of a current circuit acting on another and we have nothing to restrain the interaction. This introduces the next topic in this work, the law of electrodynamic force between two isolated charged particles in motion. It is an academic problem of classical importance. The practical motivation could be the problems of the thermonuclear reactor discharge. The encouragement available is the foregoing new approach to magnetic theory and a desire to see how far we can proceed without invoking Einstein's theory as a pillar in the analysis. Again, we will come to a seemingly heretical suggestion. It will be suggested that there was failure to realize the full implications of the

Trouton–Noble experiment. The result of the experiment was not surprising in the light of Einstein's theory. However, had there been no Einstein's theory the result of the experiment might have been used to provide the missing piece in the jigsaw posed by the electrodynamic problem.

The Law of Electrodynamics

A summary of the early development of the law of electrodynamic action between current elements has been presented by Tricker (1965). He recites the basic paper of Ampère on this subject, and the criticisms sustained by Ampère's law and alternative formulations by Biot and Savart and by Grassmann. Also mentioned is the general empirical formulation by Whittaker (1951, a) in which he proposes a simplified new law based upon new assumptions. The common problem is that none of these laws is fully consistent with Newton's Third Law when applied to interactions between individual elements of current. Yet, all the formulations appear to give the correct answers when used in integrated form to apply to interactions involving a closed circuit. Tricker then reaches the seemingly inevitable conclusion that an isolated element of steady current is a contradiction in terms, and thus he leaves open the question of how two electrons in motion really react owing to their electrodynamic interaction. This question is important in any attempt to understand the physical behaviour of electric charge on a fundamental basis. Electrical measurements are based upon electric current flow in solid conductors. Forces can possibly be absorbed by such conductors. As explained above, there is unusual behaviour in the case of electrical discharges which are not constrained by a solid conducting path. Hence, it is the basic action between isolated charges in motion which has to be understood if the true physics of electrodynamic phenomena are to be discovered. It may well be that when we consider the interaction between two isolated current elements, the proper application of Newton's Third Law requires us to consider a complete system. Then, if the facts of experiment do not match the results of applying this law to the two current elements, the inevitable conclusion is that the system is incomplete. In other words, perhaps the field or the aether medium has to be brought into the analysis. Here, it is proposed to apply Newtonian principles to the problem of two interacting electrical particles. From very simple considerations a formulation of the law of interaction is deduced which is fully consistent with the empirically derived general formula of electrodynamics. It has a specific form which is identical with that which can be derived empirically if we introduce the experimental result afforded by the experiment of Trouton and Noble (1903). Curiously this latter experiment does not appear to have been applied in previous analyses of this problem. The specific law of electrodynamics deduced is different from the laws deduced, by assumption, by Ampère, Biot and Savart, Grassmann, and Whittaker. The new law of electrodynamics has a most valuable feature. It indicates that there should be an inverse square law of attraction operative between like current vectors, the force acting directly along the line joining the currents. This feature is not shared by the other laws and it is exactly such a feature which is needed to contemplate the eventual explanation of gravitation in terms of electromagnetic effects. Apart from this, the law has another very significant feature when applied to the study of interaction effects between electric particles of different charge-mass ratios. This may have value in explaining certain hitherto unexplained anomalies in electric discharge phenomena.

Four basic empirical facts were relied upon by Ampère in deriving his law:

(a) The effect of a current is reversed when the direction of the current is reversed.
(b) The effect of a current flowing in a circuit twisted into small sinuosities is the same as if the current were smoothed out.
(c) The force exerted by a closed circuit on an element of another circuit is at right angles to the latter.
(d) The force between two elements of circuits is unaffected when all linear dimensions are increased proportionately, the current strengths remaining unaltered.

Ampère combined with the above the assumption that the force between two current elements acts along the line joining them, and thus he obtained his law:*

$$F = kii' \left\{ \frac{3(ds.r)\,(ds'.r)}{r^5} - \frac{2(ds.ds')}{r^3} \right\} r \tag{2.9}$$

In the equation F denotes the force acting upon an element ds' of a circuit of current strength i' and due to a current i in an element ds.

* Note that expressions in r are vectors, whereas r^3, r^5 etc. are scalar.

The line from ds to ds' is the vector distance r; k is arbitrary and depends upon the limits chosen, although its polarity may be determined by using the law to verify the observation:

(e) Two extended parallel circuit elements in close proximity mutually repel one another when carrying current in opposite directions, or attract when carrying current in the same direction.

From the analysis by Whittaker, disregarding Ampère's assumption, the general formulation consistent with observations (a) to (d) is found to be:

$$F = kii' \left\{ \frac{3(ds\,.\,r)(ds'\,.\,r)r}{r^5} - \frac{2(ds\,.\,ds')r}{r^3} + \frac{A(ds\,.\,r)ds'}{r^3} - \right.$$
$$\left. \frac{B(ds'\,.\,r)ds}{r^3} - \frac{B(ds\,.\,ds')r}{r^3} + \frac{3B(ds\,.\,r)(ds'\,.\,r)r}{r^5} \right\} \qquad (2.10)$$

Here, A and B denote arbitrary constants. Whittaker then assumed linear force balance as represented by symmetry in ds and ds'. This involves equating A and $-B$. In its simplest form, with k and A both equal to unity, the law becomes:

$$F = \frac{ii'}{r^3}\{(ds\,.\,r)ds' + (ds'\,.\,r)ds - (ds\,.\,ds')r\} \qquad (2.11)$$

Inspection shows that this formulation satisfies observation (e). However, Whittaker made no mention of the all-important experimental discovery of Trouton and Noble. Their experiment demonstrated that separated charges in a capacitor do not cause the capacitor to turn when in uniform linear motion transverse to its suspension. Put another way:

(f) There is no out-of-balance interaction torque between anti-parallel current elements.

This balance of torque action is not assured by the simple formulation of Whittaker in (2.11). To satisfy observation (f), terms other than those in r must cancel when ds is equal to $-ds'$. This applies to the general formulation when $A = B$. Using the general formulation (2.10) and putting $A = B = -1$, and $k = 1$ to obtain the simplest version using all the empirical data, we find:

$$F = \frac{ii'}{r^3}\{(ds'.r)ds - (ds.r)ds' - (ds.ds')r\} \tag{2.12}$$

According to this law, when $ds = ds'$, meaning that the current elements are mutually parallel, the last term only remains to indicate a mutual force of attraction, inversely proportional to the square of the separation distance, and directed along the line joining the two elements. Now, it will be shown how this can be explained from Newtonian principles without knowledge of any electromagnetic phenomena, but assuming that there is a fully-balanced interaction force of some kind acting directly along the line joining the elements. This force will then be explained in terms of magnetic field theory, so combining with the Newtonian argument to provide a truly basic explanation of the empirical law in (2.12).

Consider two particles of mass m and m'. They are separated by the distance vector r. The centre of inertia of this two-particle system is taken to be distant x and y respectively from m and m'. Then,

$$m'y = mx \tag{2.13}$$

Let v, the velocity of m, tend to change, decreasing by dv. This must arise from a force $-m(dv/dt)$ acting on m in the direction v. Let v', the velocity of m', tend to change, decreasing by dv'. This must arise from a force $-m(dv'/dt)$ acting on m′ in the direction v'.

These two forces on m and m' will, in the general case, produce a turning moment in the system. Since there is no evidence that any system can begin to turn merely by its own internal interactions, the forces in the system must be such as to prevent out-of-balance couple from asserting itself. Accordingly, there are restrictions on the proper relationship between the two forces just specified. These restrictions can be allowed for analytically by adding force components to the two particles to compensate, as it were, for any turning effects. On m we add the force:

$$-m'\frac{dv'}{dt}\frac{y}{x} = -m\frac{dv'}{dt}$$

from (2.13). On m' we add the force:

$$-m\frac{dv}{dt}\frac{x}{y} = -m'\frac{dv}{dt}$$

The total force on m' now becomes:

$$-m' \frac{dv'}{dt} \text{ in } v' \text{ direction,}$$

$$-m' \frac{dv}{dt} \text{ in } r \text{ direction,}$$

$$-F' \text{ in } r \text{ direction,}$$

where $-F'$ is the force we now assume to act directly on m' as a result of its electromagnetic field interaction with m. This force is a fully balanced interaction force. It will be discussed in detail later. In summary, we now have three force components acting on each particle. One is the prime direct electromagnetic force which induces acceleration in a particle and therefore inertial reaction. The other two are components of force representing this inertial reaction, but, notwithstanding initial generally-directed motion of the particles, subject to the condition that the system cannot develop any out-of-balance couple about its centre of inertia.

Consider the rate of energy change at m', that is:

$$-m'\left(\frac{dv'}{dt}.v'\right)-m'\left(\frac{dv}{dt}.v'\right)-\frac{F'}{r}(r.v') \tag{2.14}$$

We then remove the kinetic energy term and equate the remainder to zero. Thus,

$$m'\frac{dv}{dt}=-\frac{F'}{r}\frac{(v'.r)v}{(v.v')} \tag{2.15}$$

Similarly for m,

$$m\frac{dv'}{dt}=\frac{F'}{r}\frac{(v.r)v'}{(v.v')} \tag{2.16}$$

We can now evaluate the resultant force acting on each particle. For the particle of mass m', equations (2.15) and (2.16) may be used to derive the general force expression:

$$F=\frac{F'}{(v.v')r}\left\{(v'.r)v-\frac{m'}{m}(v.r)v'-(v.v')r\right\} \tag{2.17}$$

If it is now assumed that the particles are electrons, the masses m and m' become equal, and since the effective current elements ev and ev' may be written ids and ids', respectively, where e denotes the electron charge in the appropriate units, (2.17) becomes:

$$F = \frac{F'}{(ds \,.\, ds')r}\{(ds' \,.\, r)ds - (ds \,.\, r)ds' - (ds \,.\, ds')r\} \tag{2.18}$$

Comparison with (2.12) shows this to be of the same form as that found empirically. It is identical if:

$$F' = \frac{kii'(ds \,.\, ds')}{r^2} \tag{2.19}$$

From observation (*e*), with $ds = ds'$, (2.18) shows that k in (2.19) is positive and unity with the right choice of dimensions. Of interest then, is the fact that the force given by (2.19) is exactly the force deduced theoretically by evaluating the interaction component of the integrated magnetic field energy due to the two current elements.

Whittaker (1951, b) explains how Neumann published in 1845 a memoir showing how the laws of induction of currents were deduced by the help of Ampère's analysis. Neumann proposed to take a potential function as the foundation of his theory, the nature of which was expressed by Whittaker in the form:

$$ii'\iint\frac{(ds \,.\, ds')}{r} \tag{2.20}$$

where the integrations are performed over closed current circuits. This expression represents the amount of mechanical work which must be performed against the electrodynamic ponderomotive force in order to separate the two circuits to an infinite distance apart, when the current strengths are maintained unaltered. It therefore accounts for the force *component* between current elements, as presented in (2.19). Then, later in his book at page 233, Whittaker refers to a series of memoirs published between 1870 and 1874 by Helmholtz and refers to Helmholtz's observations that for two current elements ds, ds', carrying currents i, i', the electrodynamic energy is:

$$\frac{ii'(ds \,.\, ds')}{r} \tag{2.21}$$

according to Neumann, but different according to other writers, as, for example, Weber. Again, it is noted that all formulations meriting attention give the same result when applied to entire circuits. The failing seems to be that, although it was recognized long ago by Neumann that the true electrodynamic effect is that given by (2.19), the mechanical effects of inertial reactions in discrete charge systems have not been appreciated. It is wrong to assume that current strength remains constant when we talk of discrete charges in motion and subject to forces. There has been heavy reliance upon hypothetical formulations, without true appreciation of the simple mechanical implications of the problem.*

One of these implications, the key difference between the Whittaker formulation in (2.11) and the author's formulation in (2.12), is that Whittaker forbids out-of-balance linear force. The author forbids out-of-balance torque, with experimental backing, but allows out-of-balance linear force. This is seen by the lack of symmetry in ds and ds' in (2.12). Interchanging ds and ds' gives different results for the total force. Then the force on m does not balance the force on m'. Now, this does not mean that we have argued against Newton's Third Law. Action and reaction still have to balance in a complete system. It merely means that the system of two particles is incomplete unless, perchance, they move mutually parallel or anti-parallel, a circumstance which does eliminate the first two terms in (2.12) and thereby leaves the equation symmetrical. This tells us that the field medium itself, or space–time, has to be regarded as a part of the system separate from the particles under study. It also tells us that, if space–time contains electrical particles in motion, then, being collectively a complete system, they must have a motion which is always mutually parallel or anti-parallel as, for example, a harmonious circular motion.

The thought that space–time can exert an out-of-balance linear force is feasible. It is well known that photons convey linear momentum. Photons are disturbances of space–time and they exert linear forces on matter in their creation and absorption. The thought that space–time cannot exert out-of-balance torque is feasible. If space–time has the force transmission characteristic similar to that of a solid body it can be understood how a part of it can be caused to turn within the whole without steady restraint, once the slip action is developed and the inertial action overcome. This does not mean that we are precluded from acknowledging that space–time can accept some angular momentum. This is needed to sustain inertial action.

This type of argument may seem to be fanciful, but, be that as it may, a law of electrodynamic force applicable to actions between

* Note that (2.14) declares that a free electric charge can only store its own kinetic energy, as shown on page 26.

isolated charges in relatively steady motion has been developed and has empirical support. It remains for us to use the law to prove its value. It has already been indicated that the law may have value in gravitational theory. This is deferred until Chapter 5. It will be shown in Chapter 3 that the law has application to the understanding of the nature of ferromagnetism. To conclude this chapter, since it has been suggested that the law might have value in understanding electrical discharges, it is appropriate to draw attention to the significance of the middle term in (2.17). This middle term represents a force component along the direction of current flow, and we may predict that in a discharge circuit, where electrons carry current in a cathode and positive ions contribute to the current to the cathode, there will be an electrodynamic force manifested along the discharge. Similarly, some manifestation of the predicted anomalous forces should appear in plasma work.

Many authors have found anomalous cathode reaction forces in discharge studies. For example, Kobel (1930) found an anomalous cathode reaction force of 250 dynes at 16 amps and 1,400 dynes at 35 amps. This is of the order of $100i^2$, where i is the current in absolute units. This quadrature current phenomenon has defied explanation. Mere reaction momentum considerations lead to a relatively small cathode reaction force which is linearly dependent upon current. Even using equation (2.9), for example, any element of current in a continuous filament is subjected to balancing forces from the filament current on either side. There is no force action along the filament. This also applies to the classical formulations of the electrodynamic law. However, bearing in mind that in a discharge at least some of the current at the electrodes suddenly is transported by ions and not electrons, the m'/m factor to be used with the middle term of equation (2.12) assumes importance. On one side of this current junction, at the cathode, electrons act upon ions in the discharge, and on the other side ions act on ions. It works out that there is an out-of-balance force productive of a cathode reaction by impact from the ions. This force is the product of the constituent ion current component squared and the ratio of the ion mass to the electron mass. Forces of the order of $100i^2$, as found by Kobel, are therefore readily explained.

It may be concluded that the resolution of this long-standing problem of the true nature of this basic electrodynamic law is not a mere academic topic. Some deeper understanding of the law will have practical consequences in discharge and plasma control. For comment on this see Aspden (1965). Also note that the law was first suggested by the author some years previously (Aspden, 1960) in connection with gravitational theory. The analysis in this chapter is substantially the same as that in a paper published by the *Journal of the Franklin Institute* (Aspden, 1969).

Summary

In this chapter the principles developed in Chapter 1 have been extended to a study of mutual interaction effects rather than effects only concerned with isolated charge. It has been shown that the idea that there are three separate energy components to consider in field calculations is wholly compatible with more general phenomena. The concept that magnetic energy is a deficit of an energy level throughout space is, no doubt, a step which the conservative physicist will hesitate to take. Even so, there are rewards in accepting this and there are many avenues opened for further advances. The gyromagnetic ratio ceases to be a problem needing specialist treatment in the analysis of the spinning electron. The electron has a spin property but it need not have this property to account for the factor of 2 found in gyromagnetic ratio measurements. Spin will be discussed later in Chapter 7. Also, the law of electrodynamic force between two isolated charges has been formulated from empirical experimental data and verified by separate analysis using the theory thus developed. The law is simple but different from previous proposals. It has features which may have practical importance and its form is such that it gives new hope for explaining gravitation by an electrodynamic approach, our quest in Chapter 5. The inevitable conclusion, however, is that attention has to be paid to the aether medium. It would be folly to continue efforts to try to cancel it out of our theoretical studies, because, though many would say that it has cancelled itself out, the fact remains that there are four basic discoveries in the last two chapters which owe their origin to the fact that omissions in existing theory have eliminated the need to recognize the aether. This is a reference to the omission of the accelerating field in calculating the energy radiated by an electron, the failure to recognize the existence of a dynamic electric field induced by charge in motion, the failure to give weight to the potential reaction effect of free electrons in a magnetized substance, and even the alleged misinterpretation of the Trouton–Noble experiment.

3. *The Nature of Ferromagnetism*

Heisenberg's Theory

Heisenberg's theory of ferromagnetism attributes the ferromagnetic state to an alignment of electron spins in atoms due to exchange forces. In wave-mechanical terms, the probability that an electron in one atom will change places with an electron in an adjacent atom is given by an exchange integral which is positive or negative according to the ratio of the radius of the relevant electron shell r and the atomic spacing d. In general, this integral is negative since the attractions between the atomic nuclei and the electrons are greater than the repulsions between the nuclei and between the electrons. It is positive when there exists a certain ratio d/r of the distance between the adjacent atoms of the crystal and the radius of the electron shells containing the uncompensated electron spin. Slater (1930) presents the data:

Metal	Fe	Co	Ni	Cr	Mn	Gd
d/r	3·26	3·64	3·94	2·60	2·94	3·10

The conclusion drawn from this is the empirical presumption that, for ferromagnetism to exist, d/r must be greater than 3·0 but not much greater.*

As Bates (1951, c) points out, in Heisenberg's theory the exchange forces depend upon the alignment of the electron spins but the forces between the spins themselves are not responsible for the ferromagnetic state. Ferromagnetism is presumed to be due to interaction forces between the atoms because these forces apparently have a common feature if the ratio d/r has an approximately common value, evidently greater than 3·0 but not much greater. However, is this a

* In this chapter the symbols r and d are used to denote dimensions in an atomic lattice, whereas in the remainder of this book they are used consistently to denote dimensions of the space–time lattice. The coincidental feature that the ratio d/r is slightly more than 3 in the space–time lattice is deemed to be fortuitous.

sufficient explanation of the ferromagnetic state? Also, accepting that the exchange forces do have values coming within certain limits which are conducive to the ferromagnetic state in the ferromagnetic substances, what really is the link between these forces and the intrinsic magnetism? How do the electron spins get aligned and why is it that so few electrons in each atom have their spins set by action of the exchange forces? Why is Heisenberg's theory so vague in its quantitative account of the ferromagnetic state? Also, since in Chapter 2 it has been argued that ferromagnetism is not primarily associated with electron spin, as is popularly believed, but is in fact due to the orbital motion of electrons, how is this to be related to Heisenberg's theory?

The Cause of Ferromagnetism

In considering the nature of ferromagnetism, the idea that magnetic energy is a negative quantity, presented in the previous chapter, has immediate significance. Magnetism may have a tendency to become the preferred state and ferromagnetism will result if the other forms of energy which go with this magnetic state can be fully sustained by the source of magnetic energy itself. This is simple physics without recourse to exchange integrals defining probabilities of electron interchanges between atoms.

On this point of negative magnetic energy, it is appropriate to note that it is included as a negative term in magnetic domain theory where the equilibrium states of magnetic domain formation are evaluated (see Kittel, 1949). "The minus sign merely indicates that we have to supply heat in order to destroy the intrinsic magnetization."*

To say that energy has to be supplied to *destroy* intrinsic magnetism is to say that energy is needed to restore the undisturbed state of the field medium (the aether) since the disturbance, which is magnetism, has yielded energy and needs it back to be restored to normal. If ferromagnetism, meaning an alignment of the magnetic moments of adjacent atoms in a crystal, needs other energy to sustain it, such as strain energy, this other form of energy can participate in the return to the demagnetized state. But the question of whether a substance is or is not ferromagnetic must depend upon the ratio of the available energy from the magnetic source and the sustaining

* See page 7.

energy needed, as by the strain. If this ratio is greater than unity, there is ferromagnetism. Otherwise there is no ferromagnetism.

Why is iron ferromagnetic to the exclusion of so many other elements? The answer to this question is that it so happens that in the atomic scale iron is positioned to have properties for low interaction forces between atoms, with a significant alignment of certain electron states. In addition, iron is strong enough to withstand the effects of these forces, which are many tons per square inch and do approach the normal breaking stresses of metallic crystals. Further, iron, as well as nickel and cobalt, does happen to have a rather high modulus of elasticity so that the energy needed to sustain the strain is relatively low.

Why does the ferromagnetic property disappear as temperature is increased through the Curie point? There are the conventional explanations for this in the standard works on magnetism (such as that of Smart, 1966). A simple alternative answer which appeals to the writer is that, since the modulus of elasticity does decrease rather rapidly with increase in temperature, by the right amount, the strain energy needed to sustain magnetism increases to cross the threshold set by the ratio mentioned above. This threshold is at the Curie point.

If ferromagnetism is so closely related with internal strain, and if this internal strain is high, and if at high strain the modulus of elasticity becomes non-linear, all of which are logical, then, at least in some ferromagnetic substances, there should be significant changes in the modulus of elasticity at the Curie point. This is found to be the case. The phenomenon has been discussed by Döring (1938).

It is shown below how the elements of a theory of ferromagnetism can be based on the above argument. The analysis is simplified by the expedient of regarding the Bohr theory of the atom as applicable. This merely serves to allow easy calculation of the stresses mentioned.

Stress Energy Analysis due to Orbit-Orbit Interactions in a Ferromagnetic Crystal Lattice

In view of the different account of the gyromagnetic ratio given above, the ferromagnetic state can be regarded as due to electrons in an orbital motion, rather than a mixture of spin and orbit actions. The electron in orbit traversing a circular loop at a steady speed will be taken seriously, notwithstanding the wave-mechanical aspects and the accepted improbability of such steady motion in an atom. The purpose of this is to facilitate the approximate calculations presented here. Offset against this also, one can argue that the Principle of Uncertainty, as used in wave mechanics, may well only have meaning when viewing events in atoms on a statistical basis. This principle is no warranty that, in some atoms, those of certain size, arranged in certain crystal configurations and under certain energy conditions, just one electron could not defy the principle, *as viewed by an electron in an adjacent atom*, and actually be in a harmonious state of motion with such electrons in adjacent atoms. The motion of electrons in atoms is not random. Statistically, wave mechanics helps us to understand the systematic behaviour of atomic electrons, but they are a mere mathematical tool used for this purpose and not a set of laws which a particular electron has to obey. If, energetically, it suits the electron to move steadily in an orderly orbit, it will do so. Such is the premise on which the model to be studied is based, and with it the Bohr theory of the atom will be used.

Imagine two adjacent atoms arranged in a crystal lattice with their electron orbits aligned along the crystal direction linking the particles. This is illustrated in Fig. 3.1. Only one electron per atom is taken to be in this state. The atoms are spaced apart by a distance

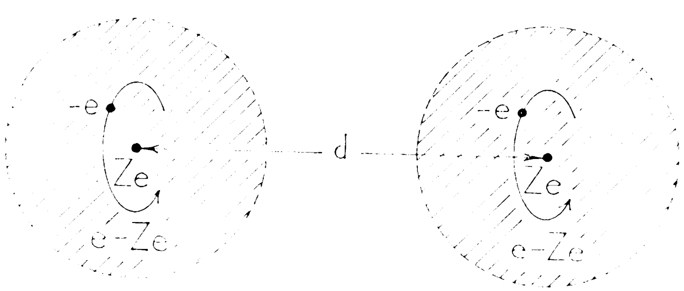

Fig. 3.1

d. Each atom has a nuclear charge Ze, an electron system depicted as a cloud, shown shaded, of charge $e-Ze$, and a single electron of charge $-e$ describing a circular orbit of radius r and velocity v. In effect, it is assumed that one electron in each atom has adopted a motion in strict accordance with Bohr's theory, whereas the other electrons form, statistically, a charge centred on the nucleus, but not screening the orbital charge from the electric field set up by the nucleus.

The orbital electrons are taken to move in synchronism in view of their mutual repulsion. Then the following components of interaction force between the two atoms may be evaluated in terms of the radius r of the electron orbits and the velocity v of the electrons.

(a) Between the orbital electrons: e^2/d^2 repulsive,
(b) Between the orbital electrons: $(ev/c)^2/d^2$ attractive,
(c) Between the remaining atoms: e^2/d^2 repulsive,
(d) Between the orbital electrons and the atoms: $2e^2d/(r^2+d^2)^{3/2}$ attractive.

These force components are, simply, the electrostatic and electrodynamic interaction forces between the two electrical systems defined. If the last term is expanded, then, neglecting high order terms in r/d, since r is less than d for all cases and very much less for most, it becomes $2e^2/d^2 - 3e^2r^2/d^4$ . . . Combining the force components, the total force between the two atoms becomes, approximately, $(v/c)^2 - 3(r/d)^2$ times e^2/d^2, as an attractive force.

On Bohr theory:

$$v/c = \alpha Z/n \tag{3.1}$$

where α is the Fine Structure Constant $7{\cdot}298\ 10^{-3}$, and n is the quantum number of the electron level in the atom. Also:

$$r = n^2 r_H/Z \tag{3.2}$$

where r_H is $5{\cdot}29\ 10^{-9}$ cm.

It follows that as Z increases, the attractive force component diminishes and the repulsive force component increases. The zero force state occurs when:

$$Z^4/n^6 = 3r_H{}^2/\alpha^2 d^2 \simeq 4{,}000$$

if d is $2\ 10^{-8}$ cm. This gives, for $n=2$, $Z=23$. For iron, $Z=26$, and it so happens that the measured value of the effective value of n is $2{\cdot}2$. This represents the number of Bohr Magnetons per atom applicable to iron in its state of intrinsic magnetization.

The above calculation is merely to demonstrate that the approach being pursued may prove profitable.

To develop the theory on more realistic, though still approximate, terms, the transverse forces have to be taken into account in stress energy considerations. The force in the lateral sense between two atoms in the crystal lattice will be effectively all electrodynamic. The electrostatic action of the orbital electron of one atom will, on average, tend to act from a point close to the nucleus when its action on the other atomic nucleus is considered. It follows from the law of electrodynamics developed in Chapter 2, that the force $(ev/c)^2/d^2$ will act in the lateral sense. This will create components of stress energy precluding the total stress energy from passing through zero as Z increases. This will make the ferromagnetic state less likely to occur and very much will depend upon the value of the related magnetic field energy and stress energy.

To proceed, the stress in the substance will be taken to be of the order of $1/d^2$ times the elemental force just deduced. This is taking into account only forces between adjacent atoms in a cubic lattice. The actual force will be greater than this, perhaps by a factor of two or three. Although there are many atoms interacting, when the spacing doubles the forces are reduced in inverse square proportion. Further, the harmonious nature of the electron motions may not be seen as such for interactions over large distances. In travelling a distance d of $2\ 10^{-8}$ cm at velocity c of $3\ 10^{-10}$ cm/sec, the electrodynamic action, for example, involves a transmission time of $0{\cdot}67\ 10^{-18}$ seconds. In this time, for $Z=23$ and $n=2$, equation (3.1) shows that the electron may move $1{\cdot}7\ 10^{-9}$ cm. This is slightly more than one quarter of a revolution. This really means that this approach to explaining ferromagnetism requires a redefinition of the synchronous state assumed in Fig. 3.1. In fact, since energy considerations are involved, the mutual repulsion forces between the electrons in orbit urge maximum separation, subject to the propagation velocity. This velocity may be different from c, but this does not matter. We take it that synchronism exists as viewed by each individual atom. This means that electrons in adjacent atoms are out-of-phase in their motion as viewed from remote positions. It also means that atoms not adjacent to the one under study will be seen by that atom to have orbital electrons also out-of-phase. There is an exception for successive atoms along the magnetization direction and transverse to it along the crystal axis, because the effective value of d increases in integral steps. From considerations such as this, it may be shown that the prime term is the energy due to interaction with atoms adjacent in the crystal lattice directions. The energy will be greater than this only provided the surrounding atoms are seen to be in synchronism and make a significant contribution to the energy required. If these atoms are out of synchronism, they may add to, or subtract from, the energy, but, overall, should have little effect.

Along the direction of magnetization, there will be a stress F_x given by:

$$F_x = (e^2/d^4)[(v/c)^2 - 3(r/d)^2] \tag{3.3}$$

In the orthogonal directions, there will be forces F_y and F_z, both given by:

$$F_y = F_z = (e^2/d^4)(v/c)^2 \tag{3.4}$$

From (3.3) and (3.4):

$$F_x = F_y - F_o \tag{3.5}$$

where:

$$F_o = 3(e^2/d^4)(r/d)^2 \tag{3.6}$$

In terms of Young's Modulus Y and Poisson's Ratio σ, the strain energy density is:

$$E = \frac{1}{2Y}[F_x^2 + F_y^2 + F_z^2 - 2\sigma F_x F_y - 2\sigma F_y F_z - 2\sigma F_x F_z]$$

and, if σ is approximated as 1/3, from (3.4), (3.5) and (3.6):

$$E = \frac{1}{2Y}[F_y^2 - \tfrac{2}{3}F_o F_y + F_o^2] \tag{3.7}$$

From equations (3.1), (3.2), (3.4), (3.6) and (3.7), it is possible to evaluate $2YE/e^4$ as a function of Z for different values of n, provided d is known. The value of d depends upon the nature of the crystal, the atomic weight and the density of the substance. Consistent with the degree of approximation involved in deriving (3.7), it seems feasible to assume that d changes linearly with increasing Z. It will be taken as the cube root of the atomic weight divided by the density, and referred to two substances, say, iron and lead, for which Z is 26 and 82 respectively. The crystal lattice will be taken to be simple cubic, even though iron is body-centred, with lattice dimension $2{\cdot}8\ 10^{-8}$ cm. The value of d, derived as indicated, is given by:

$$d = (1{\cdot}93 + 0{\cdot}0143Z)\,10^{-8} \tag{3.8}$$

The plot of $2YE/e^4$ is shown in Fig. 3.2 for $n = 1$, 2, 3 and 4. In the same figure, along the abscissa, the short lines indicate those atoms for which the atomic susceptibility has been found to exceed 10^{-4}. The broken lines indicate the values of $2YE_{mag}/e^4$, plotted for different values of n and on a base value of Y of 2 10^{12} cgs units. E_{mag} is the magnetic energy density, evaluated as $2\pi n^2/d^6$ times the value of the Bohr Magneton (in cgs units) squared. The Bohr Magneton is 9·274 10^{-21}.

The pattern of the high susceptibility atoms has a grouping matching the minima of the strain energy curves. This encourages the strain analysis approach to explaining ferromagnetism. The minima of the strain energy curves corresponds to the increased likelihood of ferromagnetism, though this latter state can only occur if the magnetic energy (being negative) exceeds in magnitude the strain energy. Of importance here is the fact that the strain energy density and the magnetic energy density are of the same order of magnitude, thus making select states of ferromagnetism feasible in some materials but not in others. The strain energies of the order of 10^7 ergs per cc, correspond to stresses of tens of tons per square inch. This means that selectivity for the ferromagnetic state may also depend on the rupture strengths of the materials; ferromagnetism clearly being more likely in strong materials of high Young's Modulus.

Discussion of New Theory

Theoretically, ignoring the error factor in the under-estimation of the strain energy, the curves show that a simple cubic crystal of oxygen ($Z=8$), if it could exist and if its Young's Modulus was 2 10^{12} or higher, would be ferromagnetic. For $n=1$, the prospect of a ferromagnetic state has to be ruled out for other atoms, except possibly carbon. Diamond has an extremely high Young's Modulus, some five times that assumed for the comparison curve. However, with $Z=6$, carbon, to be ferromagnetic, would have to sustain very high internal stresses and these probably preclude ferromagnetism. For $n=2$, iron, nickel and cobalt have to be given favoured consideration. They all have a relatively high Young's Modulus, some 50% higher than for copper, for example. They are all strong enough to sustain stresses accompanying the ferromagnetic state. Note that for Fe, Co, Ni and Cu, Z is 26, 27, 28 and 29 respectively. The broken curve in Fig. 3.2 has to be placed 20% or so higher for Fe, Ni and Co and the same amount lower for Cu. Fig. 3.2, therefore, explains why iron is ferromagnetic and copper non-ferromagnetic. Of course, in applying the curves in Fig. 3.2, it should be noted that

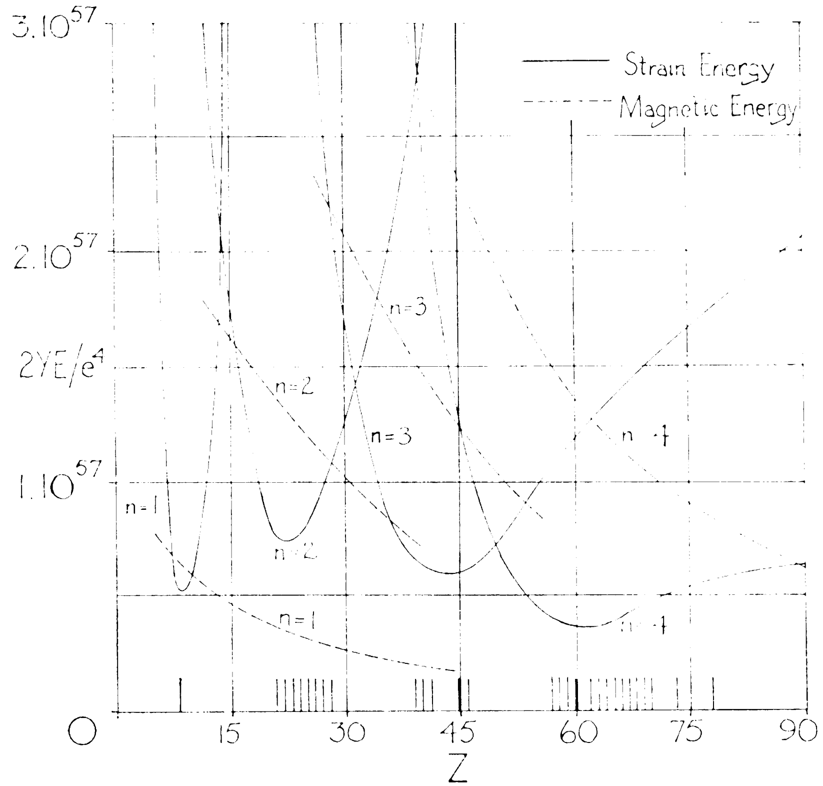

Fig. 3.2

the analysis has only been approximate. Perhaps, also, it was wrong to ignore the screening action of some of the electrons in inner shells or perhaps this, and an accurate evaluation of the strain energy allowing for surrounding atomic interaction, will shift the minima of the curves very slightly to the right. This would better relate the minima to the susceptibility data and permit a higher error factor in the strain energy evaluation. Note that if the strain energy is underestimated by much in Fig. 3.2, nickel is only marginally ferromagnetic. With $n=3$ and 4, the screening action of electrons will assume more importance and the evident prediction of a theoretical state of ferromagnetism in several substances shows some qualification of the actions to be necessary. It is significant that Gd with Z of 64, located near the minimum of the $n=4$ curve, is ferromagnetic. It may well be that the higher n and the higher Z, the more electrons there are in the shell which can be ferromagnetic. Then, the less likely it is for the synchronous action to remain as a preferred energy state. The interference from the effects of other electrons could well suppress this condition in the larger atoms.*

The understanding of ferromagnetism by its relation to stress properties may prove of interest in that it may be that under the very high pressures prevailing inside the earth, even materials which are not ferromagnetic at the surface may become ferromagnetic. Young's Modulus may then be of no importance and a compression modulus may be the factor which is deciding the state of balance between stress energy and magnetic energy.

Summary

In this chapter, it has been shown how the nature of ferromagnetism can be explained without recourse to wave mechanics. The law of electrodynamics developed in Chapter 2 and the principles of negative magnetic energy are applied successfully in the analysis. In the next chapter we will explain how the theory is reconciled with wave-mechanics. It will be shown that an electron can spend some time in a Bohr orbit and some time in its wave mechanical state. Thus, a factor has to be applied to lower the magnetic energy curves in Fig. 3.2, so limiting the elements in the ferromagnetic state still further.

* In *Physical Review Letters*, v. 22, p. 1260, June 1969, E. Bucher *et al.* report the discovery that Pr and Nd, of atomic numbers $Z = 59$ and 60, respectively, are ferromagnetic in their face centred cubic phases.

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

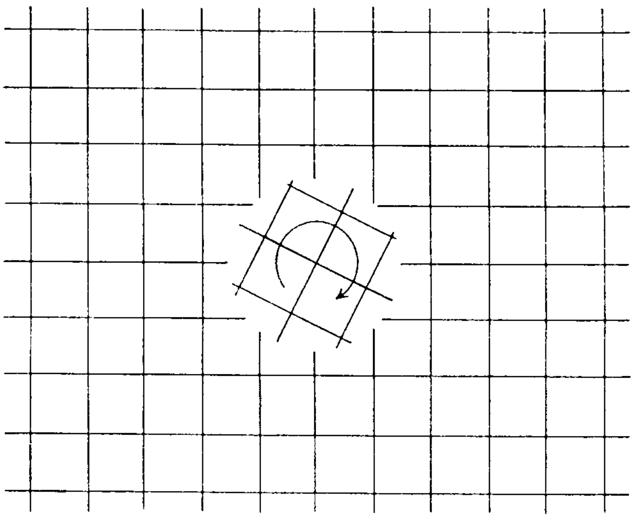

Fig. 4.1

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.

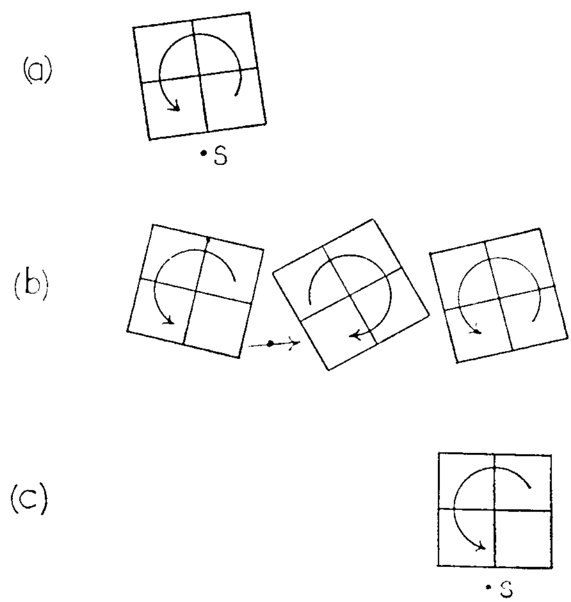

Fig. 4.2

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

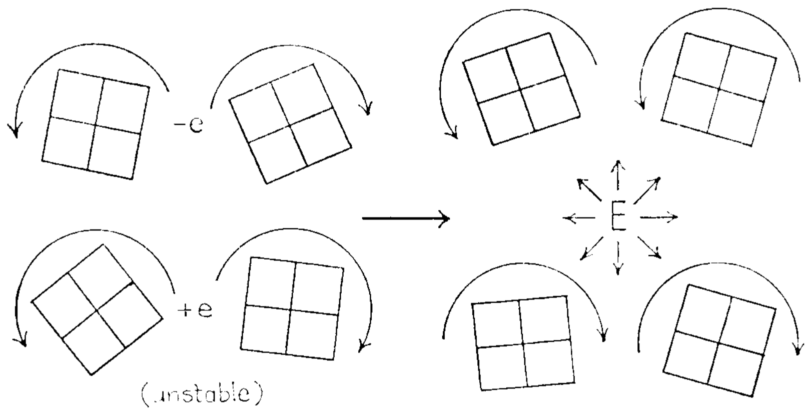

Fig. 4.3

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

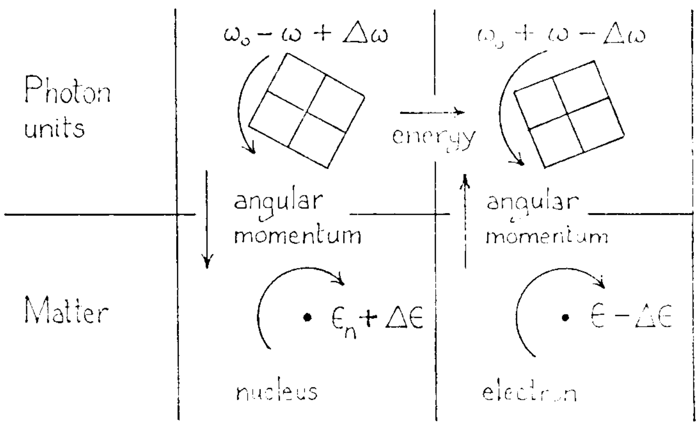

Fig. 4.4

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):

$$\varepsilon = h\nu/\Omega \tag{4.16}$$

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

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

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 $h\nu/2r\Omega$, or since Ω is $c/2r$, $h\nu/c$. 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 $1+\alpha/2\pi$, where α 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.

5. Gravitation

The Nature of Space–time

It has been said by Hoyle (1964) that "there is no such thing as gravitation apart from geometry . . . the geometrical relationship between different localities is the phenomenon of gravitation". If we fall down it is because we are involved in geometry. It seems absurd to say this, but it makes sense according to Einstein. Gravitation is deemed to be a phenomenon due to the interplay between matter and space–time. Matter distorts the space–time metric. In Einstein's theory this distortion finds a way of expression which, in effect, makes gravitation a geometrical property of a mathematical formulation of space–time. Below, it is sought to portray the metric of what we call space–time in a truly physical form with a view to explaining gravitation in more meaningful terms.

It is convenient, by way of introduction, to imagine space as if it is a three-dimensional lattice of physical substance. Any physical portrayal of space with an added time dimension must still be three-dimensional even though mathematical space can be multi-dimensional. As already suggested in Chapter 4, a simple way of introducing time is to assume that the lattice has a rhythmic harmonious motion such as a regular cyclic motion. Since space–time is, almost by definition, the frame of reference for light propagation and the famous Michelson–Morley experiment shows that an observer at rest in the earth frame shares the motion of the light reference frame, the lattice of our space–time moves with the earth. However, there is no evidence that space–time has linear momentum. Therefore, it is probably true to say that the centre of mass of any substance forming space–time can be deemed to be at rest in an absolute frame of reference. Now, how can this be possible while we have motion of the space–time lattice in a linear sense with the earthly observer? This is a most basic question in physics.

The answer is equally basic and quite logical. If the lattice moves but the centre of mass is at rest, something associated with the lattice must be moving in the opposite direction. One of the earliest observations connected with gravity was that the water on the earth always moves downwards towards the earth's centre. Yet, the levels of the seas tend to remain constant as if their centres of mass remain a fixed distance from the centre of the earth. As is well known, there is something associated with the water moving upwards and this is water vapour. Whatever it is that forms the propagation velocity determining lattice of space–time may move but there may be a counter-motion of it in different form which does not affect the propagation properties. It can be said that with the earth's water we need the sun's heat to sustain the circulation. This implies energy and resistance in the space–time analogy. However, in reply it can be argued that the lattice has its rhythmic motion and that if parts of the lattice come loose these parts could deploy their motion to speed them in the reverse direction so fast that they hardly disturb the properties of the lattice as a whole. This is depicted in Figs. 5.1 and 5.2. Fig. 5.1 shows a lattice which may be regarded in the rest state.

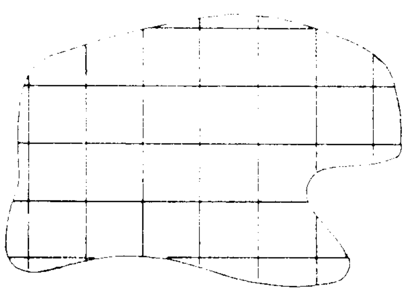

Fig. 5.1

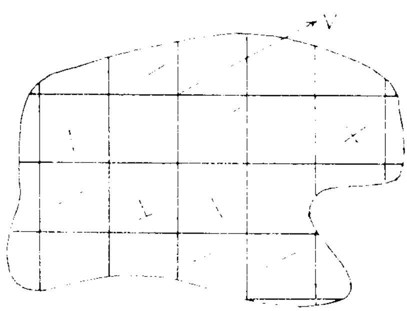

Fig. 5.2

It has a cyclic circular motion, not shown, which is like a vibration and which does not affect this argument. The lattice is the E frame of Chapter 4. The boundary is an arbitrary boundary enclosing any volume of space. Now, if we imagine that somehow this lattice moves with a velocity v, say, as shown in Fig. 5.2, it may shed some of its substance, expanding a little, and thereby allowing linear momentum to be balanced by the reverse motion of such substance. This reverse-moving substance is shown by the dotted elements in the figure. They are not held in a regular lattice pattern and have lost their vibration state. Thus, they may use their kinetic energy to sustain their high velocity motion in the inertial frame in the direction opposite to v. In the same volume of space such lattice motion could occur indefinitely because this substance could reform into lattice structure at the rear boundary of the lattice and yet constantly hold the centre of mass of space–time fixed in the inertial frame (vibration being ignored).

It is thus seen that in any volume of space we *can* have motion of the light reference frame without motion of the centre of mass of the carrier medium. The above account is not hypothesis. It is the only feasible physical answer to a basic problem in physics. We cannot be too rigid about what we mean by "lattice", and the question of its physical nature will be kept open until, later in this chapter, we adduce support for the above proposal. For the moment, it suffices to say that as long as one is prepared to use the words "space–time" we must be prepared to recognize that something termed "space–time" exists, as otherwise we would not need to refer to it. It is elusive. Though it apparently has mass properties it does not reveal itself in linear momentum interchange. It offers no resistance, inertial or frictional. We know that it does provide the carrier medium for light waves and that its frame of reference moves with the earthly observer. We suspect that its distortion by matter is the cause of gravitation. Furthermore, in the previous chapter it was shown that it had its own harmonious motion, two frames being, in effect, in dynamic balance. It was shown to have angular momentum yet could store energy without addition of angular momentum. It was suggested that it could have discrete units of its lattice structure in rotation to cause electromagnetic disturbance. These are our starting points in an effort to apply a physical interpretation of space–time to the explanation of what appear to be gravitational properties.

Tests of Einstein's General Theory

Einstein's General Theory of Relativity is supported by four quantitative tests. These are:

(a) The solar red shift;
(b) The deflection of stellar light by the sun's gravitational field;
(c) The slowing down of radar waves when subject to the sun's gravitational field; and
(d) The account of the anomalous component of the perihelion motion of the planet Mercury.

Tests (a), (b) and (c) have never really been supported by measurements accurate enough to be conclusive. Recently, measurements reported by Gwynne (1968) according to test (c), however, do look like affording fairly good evidence in favour of Einstein's results. Test (d) is the most important. It has really carried Einstein's General Theory for many years, though, as will be explained later, it has been challenged with some success in the last few years.

Now, in fact, tests (a), (b) and (c) are all closely related because they all stem from a common aspect of Einstein's theory which requires the velocity of light to be smaller in a gravitational field. As Fock (1964) interprets the equation:

$$n = 1 + 2GM_s/Rc^2 \tag{5.1}$$

"The fictitious medium of refractive index n is optically more dense in the vicinity of the sun than it is far away from it. Therefore, light waves will bend around the sun. . . ." In the equation, M_s denotes the mass of the sun and R is distance from its centre of gravity. G is the constant of gravitation.

It follows that if we can now derive the equation without using Einstein's Theory, any evidence supporting tests (a), (b) and (c) equally supports this new theoretical analysis. We have an entry to the problem because early in Chapter 4 it was shown that the velocity of light depended upon the energy density of space–time. Test (d) concerning the planetary motion is more challenging. However, we have our entry here, too, because, although space–time has no linear momentum property, it would seem that the lattice in Fig. 5.1 could rotate about a central axis without having to shed any of its substance and while keeping its centre of mass at the same point in the inertial frame. In the study of planetary motion we are dealing with angular momentum. Perhaps the angular momentum of the space–time in a planet cannot be ignored. If we allow for it, perhaps we can explain the problem with Mercury's perihelion.

Before proceeding, it should be mentioned why the red shift test is embraced by (5.1). A photon has conserved momentum $h\nu/c$ and the fundamental quantum of a photon is really momentum. It is not energy. This has been explained near the end of the previous chapter. With Planck's constant h invariant, the value of ν for a particular quantum will be set in proportion to c at the source. Thus ν, the radiation frequency, which must be constant throughout transit (ignoring any doppler effects), will be determined for any characteristic spectral emission according to the way c is determined *at the source*. In a strong gravitational field, according to (5.1), c will be reduced because n is increased, making ν lower also. It follows that light spectra emitted by the sun, which has a gravitational field at its surface much stronger than that on earth, will have lower frequency than spectra of earthly origin. This phenomenon is termed "red shift" because it corresponds to a displacement of spectral lines towards the red end of the spectrum.

In Chapter 2 it has been suggested that gravitation is a magnetic phenomenon. This is our basic assumption. We take gravitational energy to be magnetic energy. In Chapter 2 it was argued that magnetic energy was a condition of depletion of the primed energy level of the aether or space–time, as it is termed here. Magnetic energy is a *deficit* of kinetic energy in space–time, that is, a reduction of the space–time kinetic energy from its normal level. This kinetic energy is, of course, the energy of the harmonious rhythmic motion of the space–time lattice. Thus, following the analysis in Chapter 4, we may calculate the kinetic energy density of space–time as:

$$\tfrac{1}{2}(2\rho)(c/2)^2 \tag{5.2}$$

since the E and G frame each have the same mass density ρ and each move at velocity $c/2$. A reduction in this energy density by φ corresponds to a reduction of c by δc, where:

$$\varphi = \tfrac{1}{2}\rho c\delta c \tag{5.3}$$

In such a region the refractive index n of the space–time medium, normally deemed to be unity, may be expressed as:

$$n = c/(c - \delta c) \tag{5.4}$$

From (5.3) and (5.4):

$$n = 1 + 2\varphi/\rho c^2 \tag{5.5}$$

On the above argument about the relationship of kinetic energy change and magnetic or gravitational energy, φ may be equated to the gravitational potential energy per unit volume. This can be expressed by:

$$\varphi = GM\rho/R \tag{5.6}$$

where M is a mass developing the gravitational field and R is the distance between M and the region of the E frame under study. It is to be noted that only mass in the E frame has gravitational properties. This follows from the discussion of the Principle of Equivalence in Chapter 4. For this reason the mass density ρ of only the E frame is used in the above equation. From (5.5) and (5.6) the equation (5.1) is obtained, showing that this theory leads directly to the same result as Einstein's without recourse to the geometry of a four-dimensional or multi-dimensional space–time medium.

To digress a little, it is important to bear in mind that this analysis has been pursued by reference to kinetic energy changes, even though it was shown in the analysis of space–time energy in Chapter 4 that it is really potential energy and not kinetic energy which is stored by doing work against the restoring forces between the frames of the space–time metric. It was there explained how it was equivalent to work from the kinetic energy analysis. This aspect of the theory will be further considered when the derivation of the fine structure constant is discussed in Chapter 6.

We turn next to the fourth test of Einstein's General Theory to see what alternative can be offered by the straightforward physical approach being pursued in this work.

Mercury's Perihelion

The mainstay of Einstein's theory is the explanation for the small anomaly in the motion of the planet Mercury about the sun. Newton's laws fail to provide the exact estimation of the perihelion motion of Mercury due to the perturbations of other planets. They fail if the assumption of conserved angular momentum is correct as applied to the matter constituting the solar system. The measured anomalous value of the perihelion advance for Mercury is 42·56 seconds of arc per century. Einstein's theory, which is inflexible in its estimation, gives a theoretical value of 43·03 seconds of arc per century. This is a most remarkable result. However, the measured value is really the difference between the measured motion of the planet and predictions of its motion as perturbed by the masses of other planets. Some of these masses have been of questionable accuracy. Least certain, in the past, has been Mercury's mass but this has had no effect on the calculation of its own perturbation, though it has made estimates for Venus's perihelion anomaly uncertain. Strangely, however, the calculations of the measured anomaly for Mercury have failed to cater for the possibility that the sun itself may not be oblate. Being such a massive body even a small degree of oblateness can cause a small perturbation affecting the anomaly. The problem of solar oblateness has caused Einstein's theory to come under attack in recent years. Dicke (1965) has argued that if the sun is oblate by as little as 0·005%, then the numerical estimate afforded by Einstein will be in error by 10%. Dicke said: "It must be emphasized that Einstein's General Relativity is without a single definitive quantitative test until the possibility of non-negligible solar oblateness is excluded." Then Dicke (1967) reported measurements of solar oblateness which point to a discrepancy of 8% in Einstein's result. The sun must, of course, be oblate because it is rotating and is gaseous. Centrifugal forces at its equator will, of necessity, develop the oblate form. Furthermore, the expected oblateness on this account is of the order measured by Dicke. Indeed, if the sun were not oblate we would be confronted with a problem of more significance than that presented by the perihelion anomaly.

It is submitted that, since three of the four tests of Einstein's theory have ready alternative explanation and since the theory fails to retain its validity in respect of the fourth test (and if invalid for one it is invalid for all), we must of necessity reject the General Theory of Relativity. The perihelion anomaly has to be re-examined and perhaps the best approach is along new fundamental lines. It seems unlikely that one can modify Einstein's ideas in some way, when after fifty years of effort to expand his theory to unify physics little of value has emerged. From the fundamental point of view it is important to ask whether we are concerned with an anomaly in gravitation or an anomaly in mechanics. Attention is diverted to the question of the conservation of angular momentum in the planetary system, bearing space–time in mind.

Rotating space–time has angular momentum whereas it does not have linear momentum. The reason is that the lattice system shown in Fig. 5.1 can rotate about a central axis without disturbing the lattice structure of any surrounding space–time lattice. It cannot move linearly without causing such disturbance unless it crumbles away at the interface and some of its substance travels in the reverse direction to reform behind the moving lattice. Alternatively, the lattice of the space–time system in the path of the moving lattice may crumble and be deployed in the same way. The result is the space–time property of no linear momentum but possible angular momentum.

Now, consider the motion of a spherical volume of space–time about a remote axis. If this space–time is rotating at a steady velocity within its own spherical bounds there is a steady angular momentum due to this. Also, however, we have to consider what happens to the displaced lattice substance in the reverse motion. This moves about the remote axis in an arc, whereas the centre of mass of the lattice is effectively a point in which the lattice mass in motion is concentrated. In effect, the lattice moves in one direction with its angular momentum about the remote axis given by $MX^2\omega$, whereas the lattice substance in reverse motion has an angular momentum in opposition of $M'(X^2+2R^2/5)\omega'$, where $M\omega=M'\omega'$. Here, M is the mass of the lattice and ω its angular velocity about the remote axis distant X from M. M' is the mass of the displaced substance and ω' its angular velocity in the reverse direction. This has involved the use of the parallel axes theorem. It is like having a compound pendulum having a spherical bob of radius R fixed to the arm of the pendulum in counter motion with a simple pendulum having a pivotal spherical bob rotating at a steady speed. Assuming the bobs are the same size, the total angular momentum per unit mass is evidently:

$$2\omega R^2/5 \tag{5.7}$$

If this argument is applied to the space–time contained within a planet rotating about the sun it becomes clear that (5.7) is a measure of the angular momentum of space–time due to such motion. If the orbit of the planet is truly circular, meaning that ω is constant, then the space–time angular momentum is constant, as is the component due to the rotation of the planet about its own axis. Then it would pass unnoticed. On the other hand, if the planet moves in an elliptical orbit so that ω varies we must expect space–time to make a contribution to the balance of angular momentum in the matter system itself. It is easy to calculate the effect of this contribution.

The Newtonian equation representing the motion of a planet around the sun, neglecting perturbation by other planets, is given in polar co-ordinates by:

$$\frac{d^2}{d\theta^2}\left(\frac{1}{X}\right)+\frac{1}{X}=GM_s/H^2 \tag{5.8}$$

M_s denotes the mass of the sun, taken as a point mass much larger than that of the planet, G is the constant of gravitation and X, θ are the polar co-ordinates. H is the moment of velocity of the planet in its orbit. If H is constant as applied to the planet only, (5.8) represents an ellipse with the sun at one focus. If, however, angular momentum is constant as applied to the system of matter *and* space–time, $H - \Delta H$ is constant, where ΔH is the expression in (5.7). Then (5.8) represents an ellipse which advances progressively in the plane of the orbit as the planet describes successive orbits. There is an advance of perihelion. The advance, measured in radians per revolution, may be evaluated as:

$$\frac{8\pi}{5} \frac{M}{P} \frac{R^2}{X^2} \tag{5.9}$$

where P is the mass of the planet. R has become the radius of the space–time lattice of the planet and X is distance from the sun.

An anomalous advance of perihelion must, of course, follow if we ignore the effect of space–time. There is, therefore, nothing surprising about the perihelion motion of Mercury. Indeed, the fact that the discrepancy between the measured and theoretical value neglecting space–time is detected is a clear indication that (5.7) is not neglible. The mass of the space–time lattice can be deduced from observation. Attempting this, we note that it is unlikely that the space–time volume of the planet will be simply co-extensive with its physical form. It will be somewhat larger. The ionosphere limits of the earth suggest a location for the boundary. Let us guess that for the planet Mercury the space–time lattice has a radius 10% larger than that of the planet. Mercury has a radius of 1,500 miles, so this assumption puts the boundary 150 miles above its surface, about the same height as the ionosphere above the earth. Then, available data enable the mass density of the space–time lattice to be calculated. The mass P of Mercury is $3{\cdot}27\ 10^{26}$ gm. X is $5{\cdot}7\ 10^{12}$ cm. The radius of Mercury is $2{\cdot}495\ 10^8$ cm. The orbital period is 88 days. The anomalous perihelion advance measured, allowing for the solar oblateness, is 38 seconds of arc per century. From (5.9) it may then be shown that the mass density of the space–time lattice is about 150 gm/cc.

This is not conclusive until it is shown that the space–time lattice has a mass density of this order calculable from physical observation *in the laboratory*. Atomic physics affords all the data needed to evaluate the mass density of space–time, as will be shown in the next chapter. For the moment, it is worthy of note that the above explanation can be applied satisfactorily to the earth's perihelion motion and that of other planets, including Venus. But, more than this, we can take what seems to be an absurd result, this very high density of space–time, and make sense out of it in two immediate respects.

Firstly, common sense must tell us that, if the explanation of the Principle of Equivalence in Chapter 4 has merit, then the presence of ordinary matter in space–time is a mere disturbance in a heavier medium. The substance of the *G* frame has to balance the extra disturbance of matter which, as we know from observation, can have densities up to about 10 or 15 gm/cc. Space–time must be more dense, appreciably more dense, than this. 150 gm/cc is highly reasonable. Secondly, on the basis that the sun has a density of about 1·4 gm/cc and an angular momentum which is only 1% that of the planets in their orbits, we see that to add the angular momentum of the rotating space–time will make the sun have about the same angular momentum as the total of that of the planets. More will be said about this in Chapter 8. In the meantime, the reader should not underestimate the importance of the really great anomaly which has confronted us since the time of Newton. Angular momentum is supposed to be conserved in a complete system. If the solar system has been a complete system since the birth of the planets and before, how is it that the sun has so little of the angular momentum now belonging to the solar system? There is no problem if we recognize the role of space–time. Not only will it solve the anomalous perihelion difficulty, but we can see a sensible basis for explaining the creation of the solar system.

Another point which may have occurred to the reader is that this theory might preclude the existence of very high densities of matter. The reader who can visualize gravitational collapse of stars and contraction of matter to almost infinite mass densities should remember that he is assuming that *G*, the constant of gravitation, remains constant under such conditions. It is a convenient assumption encouraged by the inflexibility of Einstein's theory, but if gravitation has its origins in a real physical disturbance of space–time, as we believe, it may well not cater for some of the mathematical fantasies of the astrophysicist. After all, the physicist does not understand what gravity is, so he is being rather bold to assert that its action has no dependence upon the concentration of the substance exhibiting gravitation. All the author can offer ahead is an argument explaining *why G* cannot be constant when we consider really dense matter, and the encouragement that gravitation is explained and *G* is *evaluated* from atomic data.

Already, it has been shown that Einstein's General Theory of Relativity has no advantages over the present theory. All four of its quantitative tests have been derived by other means. The tests provide equal support for the theory under review and the theory under review has very many more advantages. Already, it has been shown that this theory has application to atomic theory. We have the link with wave mechanics and with field theory. We are ready also to turn attention now to the serious analysis in this work, leading us to the derivation of G in terms of the properties of the electron. This, of necessity, involves us in an explanation of the nature of gravitational force.

The Nature of Gravity

If space–time is not something real, then it is simply imaginary and serves as a mere exercise for the imagination. If it is real we cannot dispose of it, as Einstein does, by mere mathematics. If has, therefore, to be portrayed in physical terms. Above, the lattice of space–time has been deemed to become crumbled at its forward boundaries when in motion. What does this mean physically? The simple answer is that the lattice is probably an array of electrically charged particles. At the boundary, particles come out of their lattice positions and travel through the lattice. This can be fully supported by a rigorous analysis of an electrical space–time system. Imagine the lattice to comprise identical particles of electric charge permeating a uniform electric continuum of opposite charge. The particles mutually repel. For zero electrostatic interaction energy, these particles form into a simple cubic array. Their arrangement is different for minimum electrostatic energy, the normal assumption in physics. However, we are dealing here with space–time. In laboratory experiments, where electric charge can be separated to store energy and provide a system which tends to be restored to its original state by tending to minimum energy, we deal only with relative quantities. Negative energy in a relative sense is possible in such analysis. On an absolute basis, in space–time, negative energy is beyond imagination. We are not dealing in relative terms. The system is absolute. This is the key to the analysis, because it means that the stable state of space–time is not one of rest. The zero energy condition is not the one of zero restoring force. Electrostatic forces will occur in the system of electric particles and continuum described above and will be finite for zero electrostatic interaction energy. Such forces are balanced by the centrifugal forces of an orbital motion, the harmonious motion of space–time already introduced. The time dimension comes into space–time because the rest condition of space–time would have minimum energy which is *negative*. The fundamental energy condition applies everywhere in space. The interaction energy cannot be negative in some parts and positive in others. Each lattice particle in the E frame of space–time must satisfy the same energy condition. This assures a kind of symmetry and causes the particles to be arranged in a simple cubic array.

When the lattice is in linear motion, some particles must exist in a free state. They are the lattice "substance" displaced by the motion. They do not form part of the lattice array (see Fig. 5.3), but because they are present the lattice will have expanded. This follows from electrostatic charge balance considerations. Space is electrically neutral on a macroscopic scale. This will be further analysed in Chapter 8. The freed particles can deploy their kinetic energy to travel at speed in the direction opposite to the linear motion of the lattice, as shown by the arrows in Fig. 5.3.

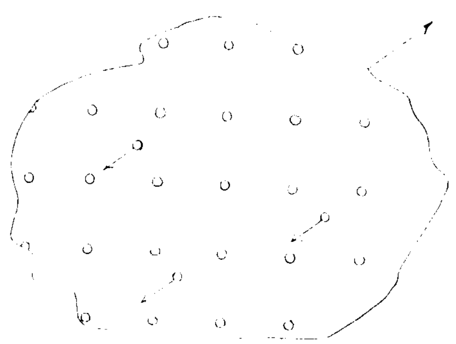

Fig. 5.3

Ignoring the existence of free particles, which, because of their rapid transit through the lattice, tend to meld statistically into the background charge of the electric continuum, we can now illustrate the harmonic motion of the E frame. Firstly, note that each electric particle in this frame is attracted to a neutral rest position in the continuum. Each particle is held displaced by a state of motion. The whole particle lattice forming the E frame moves in a circular orbit so that each particle is subjected to the same centrifugal action and can retain its position against the electric forces urging it to the rest position in the continuum. As is evident from the analysis already presented, this continuum is part of the G frame which provides the counter-balance to the motion of the E frame. Indeed, both the E frame and the G frame move in counter-balance in the same circular orbit relative to the inertial reference frame. In Fig. 5.4 the broken

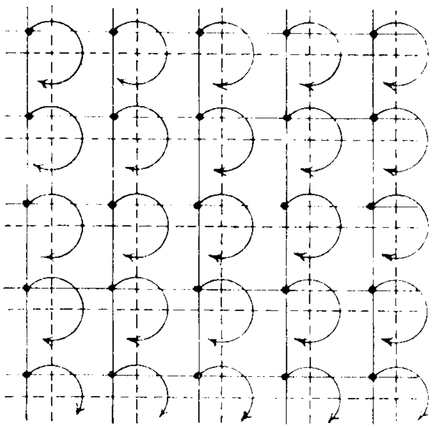

Fig. 5.4

lines show the position of the inertial frame and the full lines show the position of the E frame. The electric particles forming this frame are depicted each in circular motion with the frame. Fig. 5.5 shows the way in which the orbits of the E frame particles are diminished around a gravitating system of matter not illustrated but deemed to be centrally located in the system shown. Gravitation involves magnetic forces, and these affect the balance between the centrifugal

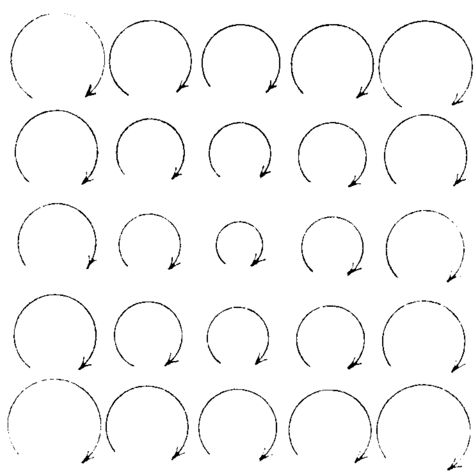

Fig. 5.5

force and electrostatic force on each E frame particle. Said another way, in the light of the argument in Chapter 2, the diminution of the kinetic energy or, more correctly, the diminution of the electrostatic energy is the magnetic effect corresponding with gravitation. Remember that in Chapter 2 it was suggested that there was a small priming energy in space–time which set the condition from which a reduction of energy corresponding to magnetism was possible. This is consistent with the zero electrostatic interaction energy condition discussed above. This is the lower limit of energy reduction, or the upper limit of magnetization or gravitation. It will be better understood when Planck's constant is evaluated in Chapter 6.

Since the E frame is the electromagnetic reference frame, there can be no direct magnetic force between these particles forming the lattice. In contrast, since the charge of the continuum in the G frame is moving at velocity c relative to the E frame it has its own mutual magnetic interaction which exactly cancels its mutual electrostatic action. This follows using the law of electrodynamics presented in Chapter 2. At any instant the charge is in parallel motion. Exact cancellation of the mutual forces in the continuum explains why it can form into a continuum. It is unlike the behaviour of charge in a particle subject principally to self-repulsion.

We are now ready to explain gravitation, subject to two minor comments. Firstly, note that there is no question of propagation delays in the magnetic interaction forces between G frame substance. Motions are mutually parallel but constantly changing direction. Yet, field energy between interacting charge is the same even though the directions of the current vectors are changing. Hence, unless the sources of these vectors move in the electromagnetic reference frame, either by coming together or separating further apart, there is no reason for a propagation phenomenon. It can be said that gravitation, as a magnetic force, is propagated at the velocity c, but this requires motion of the gravitating bodies and is not related to the universal motion of space–time. Secondly, note that, if the G frame comprises the same magnitude of charge as that of the lattice particles in the E frame, it is difficult to understand how the G frame can have the same mass density and so have the same orbital radius. These are requirements of the balance condition under study. The only answer available is to assume that the G frame has some rather heavy elementary particles of charge e (positive polarity), sparsely populating the G frame, but providing the mass needed for balance. These particles are termed "gravitons". Their existence is supported by abundant evidence to be presented. They are the seat of the reaction which causes gravitation.

Now consider a particle of matter at rest in the E frame. In Fig. 5.6, this particle denoted P is shown with the continuum of positive charge streaming past it at velocity c relative to P. Note that we take the lattice particles to be negative. The approach velocity of the continuum relative to P is c and the recession velocity is c, but to maintain continuity the continuum has to speed up a little in passing

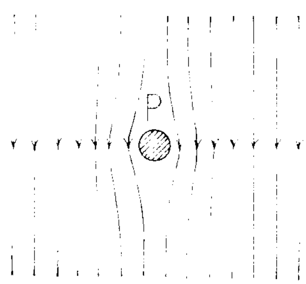

Fig. 5.6

the particle owing to its effect as an obstruction. This means that the integral of the current vector quantity or charge-velocity parameter applicable to the continuum is *independent* of the physical size of the particle P. It is like saying that the quantity of gas passing through a pipe in unit time can be measured at either end of the pipe without worrying about the nature of any partial obstructions *en route* within the pipe. The charge-velocity parameter or current vector is what gives rise to electrodynamic action. It therefore follows that there is no direct electrodynamic action seated in a particle of matter at rest in the electrodynamic reference frame. However, there is an indirect effect. Since P is at rest in the E frame it moves with the space–time universal motion about the inertial frame. It needs to be balanced. It is balanced by something in the G frame. As already indicated, the mass of the G frame is attributed to "gravitons". These are all that is available to accept disturbance due to P and provide balance. Their disturbance consists in their contraction slightly to become a little heavier. Mass is inversely proportional to radius. As is shown in Appendix I, electric energy is inversely proportional to radius, for any charged particle. Since $E = Mc^2$ applies to such energy, mass is an inverse function of the physical radius of a charged particle. Now, if the particle of matter P causes a nearby graviton in the G frame to alter slightly in size, we do have an electrodynamic effect. A current vector parallel with all current vectors associated with all other elements of matter is developed. The current vector is directly determined by the mass of the matter causing it. Consequently, there is a mutual force of electrodynamic attraction between regions of space–time containing matter. Effectively, there is a mutual force of attraction between all elements of matter. This is the force of gravitation.

The test of this theory is the evaluation of the constant of gravitation. To proceed in this direction, let dE denote the rest mass energy of a particle of matter causing the graviton disturbance. To balance this, the graviton has to increase its energy by dE also. From equation (6) in Appendix I, the energy of a graviton charge e can be expressed as:

$$E = 2e^2/3x \tag{5.10}$$

where x is the radius of the graviton. If E increases by dE, x is reduced and there will be a continuum charge increase by the elemental volume change $4\pi x^2 dx$ times the continuum charge density σ. The electrodynamic current vector developed by dE is then:

$$(6\pi x^4 \sigma / e^2) dE \tag{5.11}$$

as is found by differentiating (5.10) and substituting dx. Note that, since the charge moves at c relative to the electromagnetic reference frame, though in its small space–time orbit which does not give rise to relativistic mass considerations, the electrostatic charge is equal in magnitude to the electrodynamic current vector.

Using the electrodynamic law developed in Chapter 2, it follows that the force of attraction between two spaced mass energy quantities like dE is the product of two quantities such as (5.11) divided by the square of the separation distance. By analogy with Newton's gravitational force, we find that the constant of gravitation G is, simply:

$$G = (6\pi x^4 \sigma c^2 / e^2)^2 \tag{5.12}$$

c has been introduced to convert energy into mass, using $E = Mc^2$.

This equation shows that in order to evaluate the constant of gravitation it is necessary to determine the mass of the graviton, and so x, as well as the lattice spacing of the E frame, and so σ. In short,

G becomes a simple property related to the parameters of the system comprising space–time. It is important to note that the gravitons have not merely been invented to provide this explanation of gravitation. They are the energy source for the creation of matter, and much of the analysis in the following pages is concerned with their role in creating elementary particles. The mass of the graviton is calculable in terms of the mass of the electron. It depends upon the *geometry* of space–time, curiously enough. It gives the *exact* value of G when used in (5.12). Further, there is experimental evidence indicating the existence of this unusual particle.

Summary

The concepts on which wave mechanics were explained in Chapter 4 have been presented in a manner more dependent upon the physical form of space–time. It has been shown that all four quantitative tests of the General Theory of Relativity can be explained by this new space–time theory. The potential of this new theory in explaining the nature of gravitation and evaluating the constant of gravitation has been outlined. It remains to analyse space–time rigorously now, in order to deduce theoretical values of the fundamental physical constants.