7. Nuclear Theory

Electron-Positron Creation

In Chapter 4 the process by which photons transfer momentum was introduced. When a photon event occurs an electromagnetic wave is propagated and a momentum quantum h/c times the radiation frequency ν is imparted to space–time by matter releasing the photon. It is a statistical possibility that the reverse event will occur anywhere in the wave region. The likelihood of a photon being intercepted in this way probably depends on the wave amplitude and on the rate of flow of momentum locally. Another way of looking at this is to regard space as full of energy. If it contains a uniform distribution of energy, say E_0 per unit volume, and is a veritable sea of energy which is ruffled by wave disturbances, the waves may travel at the high propagation velocity c but the displacement of the energy E_0 to convey momentum will be slow. If a photon traverses a particular unit volume in unit time, the energy E_0 in this volume (of mass E_0/c^2) will be moving at a velocity $h\nu c/E_0$ to convey an energy quantum per photon of E_0 times this velocity divided by the photon velocity c. This energy quantum is, simply, $h\nu$. Hence, the energy-frequency relationship of Planck's law $E = h\nu$.

Since E_0 tends to be uniform, photons "tend" to move from their source to where they are absorbed. Energy quanta are merely exchanged with the energy content of space–time in these photon events. One can say that energy is transferred, but this transfer is indirect and energy certainly does not travel at the velocity c. If it did it would have infinite mass, which would be absurd. The wave travels at the velocity c. Momentum quanta are transferred, as is energy, via the space–time medium. However, momentum is a vector quantity and, although statistically the preservation of the uniform energy distribution in space will bring about momentum balance, it is not likely that a simple energy distribution mechanism can assure that all photons received have the same momentum vector as one emitted. Again, this leads to speculation and we will not dwell on this here.* The point

* Enough was said on page 76.

has been made that the photon mechanism involves emission and absorption of photon quanta in equal numbers if there is not to be a build-up of energy in space–time.

When we consider photon events involving creation or annihilation of electron-positron pairs there are not only the questions of energy balance and momentum balance but, in addition, the problems of what happens to the electric charges and where they come from. These actions are photon events. The photon frequency is given by $mc^2 = h\nu$, since two photons (or gamma rays) are involved in the reaction. Now, it is absurd for anyone to think that two electric charges, one positive and one negative, can possibly vanish into nothing. If this could happen there would be no physics because everything, if it ever existed, would be gone in one big bang. It is nonsense to think that the energy available could recreate charge and matter. There would be no structure, no nuclei on which to rebuild the system. Without the lasting existence of the discrete element of charge e we have no firm foundation to hold the physical universe together. Mass can vary and can come in numerous basic forms. The velocity of light varies according to the media it traverses and it even varies in free space. Planck's constant appears invariable, but would it if e varied? Physics and our existence depend upon something remaining constant and the electron charge is about all we can look to as providing this anchor. The electron and the positron might interact to become something else but their electric charges are conserved and at least one, be it the charge of the electron or the charge of the positron, must retain its discrete form.

Having declared this we have an additional constraint governing the photon events involved in electron-positron annihilation and creation. We have also the constraint introduced in Chapter 1 and discussed in detail in Chapter 6. The volume of space available to house electric charge is limiting. This tells us that if an electron and a positron change into some other particle form, by expanding, then similar particle forms elsewhere must probably contract to create an electron and positron at that other location. If these two events do not occur simultaneously, the adjustments of the structure of space–time will need extra energy to act as a buffer. The transmutations involving electrons and positrons do take place in a highly energetic environment and this buffer action can be expected. However, on balance it is to be expected that for every electron-positron annihilation there is a matching electron-positron creation elsewhere. The process is akin to the photon transfer and, via the photon actions, momentum and energy are balanced also.

With this introduction we can say that when an electron and a positron annihilate one another they meld into space–time, the negative charge of the electron becoming a particle of the E frame lattice and the positive charge of the positron melding into the uniform continuum of charge density σ. It follows that the energy needed to create an electron and a positron is not, in matter terms, $2mc^2$. It is less than this because the constituent elements from which they are created have energy themselves. However, when we think of energy transfer and momentum transfer we have to remember that the adjustment in physical size of the background constituents in space–time cause supplementary energy and momentum transfer exactly as if the $2mc^2$ energy was involved.* Thus, the frequency of the gamma radiation is exactly the frequency we would expect if there were total annihilation. This not only meets some of the perplexing philosophical aspects of this problem but, in addition, there is quantitative evidence in direct support of the theory just propounded. This will be presented below when we explain the results of Robson's experiments.

Mass of Aggregations of Electric Charge

In Chapter 4 it was noted that mass can vary according to its state of motion with the E frame of space–time. In this context the reader is reminded that the relative velocity of the space–time frames can vary slightly, adjusting the speed of light, and since energy ($E = Mc^2$) is conserved it follows that mass may vary. The E and G frames are therefore reference frames for mass quantities. The intrinsic mass energy of any particle is the same whichever of these two frames it occupies. Thus, if we take positive charge in the G frame and negative charge in the E frame and these exist at these locations in discrete particle form, we have no difficulty analysing their respective mass properties. The problem comes when we consider the mass contribution of their mutual electrostatic interaction, particularly when they come together to form a composite mass aggregation in the E frame. If we know that the zero-reference ground state is with positive charge in the G frame and with negative charge in the E frame, the change of electrostatic energy in coming together is

* See also discussion on page 204.

calculable and the net mass energy of the aggregation can be evaluated. If we take the ground state to be their separation to infinity, as is normal in physical theory, we have postulated something which is out-of-line with reality. If we wander into philosophical argument and imagine that the universe came about by all electric charge starting at infinite separation and coming together, we face enormous problems. If everything started compacted together and then separated with a bang the analysis is even worse. It seems so neat to have derived a system of space–time in which an E frame formed by practically all the negative charge is effectively displaced by a definite distance from a G frame formed by practically all the positive charge. It seems logical that at the start of things, before some of this charge got out of place to create matter, all the negative charge was effectively spaced by the same distance from all the positive charge. However, logical or not, there is experimental evidence available to demonstrate that the ground state for mass calculation of aggregations of charged particles is the condition in which opposed particle pairs are each separated by the separation distance of the E and G frames of the space–time system. This will now be presented in a more detailed analysis of the deuteron.

The Deuteron Reaction

At the end of Chapter 1 the form of the deuteron was discussed. It was shown that if it comprises electrons or positrons or both in combination with heavy fundamental particles and all have the charge quantum e then there is one favoured aggregation which could be the deuteron. This aggregation has a binding energy matching that actually measured. In this chapter this approach is taken further to develop a theory of the atomic nucleus and other basic particle systems. It is also to be noted that at the time of writing this book the author has not attempted to take the scope of this research further than that described in this chapter. The further potential of the theoretical approach being presented has, therefore, not been probed, although it does look highly promising.

Fig. 7.1 shows possible forms of the neutron and proton, as well as the deuteron. Also shown is the expression for the mass of each particle in terms of the interaction energy quantities E_1, E_2, etc.

In the case of the deuteron, E_5 has been evaluated approximately as $-4{\cdot}375\ mc^2$. This approximation is due to two factors not allowed

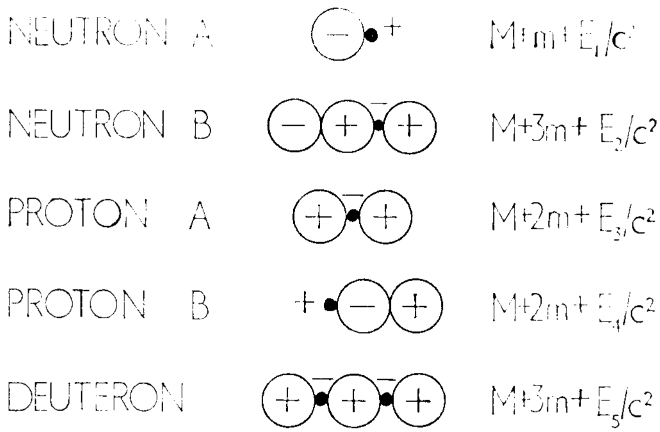

Fig. 7.1

for in the analysis. Note that mc^2 is the rest mass energy of the electron or positron. M is the mass of the fundamental heavy particle deemed to be present in these basic particle aggregations. This heavy particle is termed an H particle.

Since the mass M is about 1,836 times that of the electron, and since the radius of the H particle, being inversely proportional to mass, is 1/1,836 that of the electron, the particles forming the deuteron are spaced a little further apart than was assumed in Chapter 1. The result is that the estimated binding energy is reduced in the same ratio. The corrected value of E_5 is then $-4{\cdot}373\ mc^2$. Next, we need to consider the ground state correction. When the deuteron is broken by gamma radiation its constituent parts do not go off to infinity before recombining in another form. However, there is a fairly definite cut-off value of the gamma ray frequency which will disrupt the deuteron and this suggests that there is a fairly definite separation of the constituent particles which has to be reached before the transmutation is triggered. According to Wilson (1963), the measured binding energy of the deuteron is 2·22452 MEV. Data sources differ on the proper conversion of MEV to units of mc^2, but this measured binding energy seems to be approximately $4{\cdot}352\ mc^2$. The difference between this quantity and the theoretical value $4{\cdot}373\ mc^2$ is $0{\cdot}021\ mc^2$ and can be taken as the error in assuming separation to infinity in the theoretical calculation. We take this as experimental evidence from which to deduce the spacing of the opposed-charge pair elements in the ground state. Thus, the three positive charges will go to their ground state each pairing with a negative H particle or, for balance, an electron to form three particle pairs of interaction energy e^2/x. If we equate 0·021 mc^2 to $3e^2/x$, we find the separation distance x from the experimental data. This shows that x is close to $2r$, as expected, because $3e^2/2r$ is, from (4.1), $3amc^2$, where a is the fine structure constant. Since a is 0·007298, the $2r$ spacing would give a correction 0·022 mc^2.

This result is remarkably close, having regard to the fact that it relies upon such a small difference between the measured binding energy and the uncorrected estimate from this theory. It must be taken as giving clear support for the postulated separate E and G frames of the space–time. Further, the analysis of the mass of the deuteron has been shown to be rigorously applicable. The deuteron binding energy is predicted by the theory with extreme accuracy and this encourages the further analysis of other particle aggregations.

Experiment shows that when the deuteron is disintegrated a proton and a neutron are produced. This leads us to understand the composite nature of these particles. A step to be taken at this stage is to realize that for any stable nucleon to change its form, except transiently, there has to be a fundamental change in character of at least two of the constituent particles. The change we contemplate is one in which the energies of two particles of different mass are exchanged. This will be termed particle inversion.

Particle Inversion

Particle inversion is depicted in Fig. 7.2. Here, a positive H particle and an electron interchange energies to form a positron and

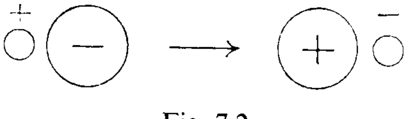

Fig. 7.2

a negative H particle. This can only occur in a highly energetic environment, but when it has occurred the individual particles have adopted a stable form. Overall, there is no total energy change or change in volume of space occupied. Charge is conserved. The physical process has involved some other particle in the environment becoming compacted as it stores energy supplied. This makes a volume of space available which allows the H particle to expand and so release some of its energy. The electron can take a little of this energy and be compacted a little in this process. The form to which this system will revert when balance is restored will probably depend upon which of the two particles, the H particle or the electron, is physically the larger when the reversion process begins. This action is, of course, highly unstable and it has to be remembered that there is no freedom for the various particles to adopt any mass value by appropriate sharing of space and energy. Fundamental particles have discrete forms and, although interchange between these discrete forms is possible, there are a limited number of such forms which can be adopted by a stable particle. We exclude unstable systems and mere particle aggregations in considering this limited number of particle forms, because, as is well known, there seem to be numerous varieties of elementary, though unstable, particles and there are many isotope nuclei. The important point under review is that unless there is particle inversion the disintegrated elements of a particle aggregation will come together again to form the same unit.

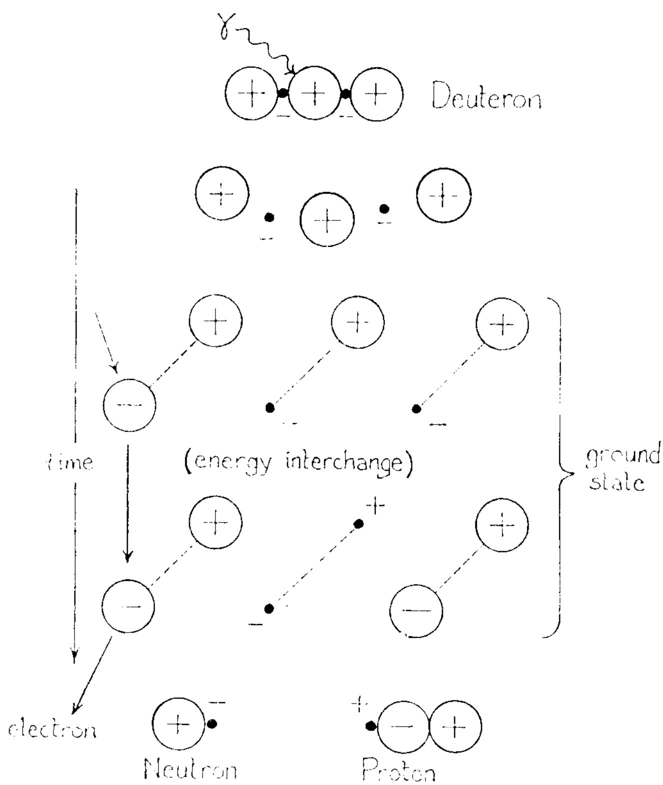

Fig. 7.3

This leads us to the sequence of events depicted in Fig. 7.3. A gamma ray γ acting on the deuteron results in kinetic energy being added to the deuteron. At a certain stage in the process energy inversion occurs, as noted, and this results in there being two heavy H particles of opposite polarity. This is facilitated if it occurs in the ground state, as depicted, because there can be balance, at least transiently, in a dynamic sense if there is a heavy H particle in each of the E and G frames. When this particle system reverts to a normal state we find that the product is a proton and a neutron. We are, therefore, able to investigate the forms of these newly-formed particles.

The Proton

The H particle cannot exist alone for very long. The reason is that an electron or positron, whichever has opposite polarity, will combine with it to form an aggregation having even less energy than the H particle itself. The binding energy exceeds in magnitude the rest mass energy of the electron. Such a neutral system must eventually come into collision with another charged particle. Then, further combination will occur because the total energy of the aggregation can be less than that of its constituent parts.

Referring to Fig. 7.1, for neutron A we can calculate E_1 as approximately $-1{\cdot}5\ mc^2$. This follows because the electrostatic energy of the electron is $2e^2/3a$, where a is its radius, and the electrostatic energy of the coupling between the electron and a point charge e at its surface is $-e^2/a$. This makes E_1 1·5 times the rest-mass energy of the electron. For proton A, E_3 is $-3\ mc^2$, doubling the above because there are two positrons involved, plus the interaction energy between the two positrons of $0{\cdot}75\ mc^2$, because they are at a spacing of $2a$. Thus, E_3 is $-2{\cdot}25\ mc^2$. Similarly, for proton B, E_4 is $-1{\cdot}75\ mc^2$.

Since the binding energy of proton A is greater than that of proton B, proton A is more stable. However, there is a much higher probability of forming proton B. This is because in an environment of H particles a combination of such a particle with an electron-positron pair is far more likely than a combination with two electrons or two positrons. Also, there are less positrons than electrons available in free form. When we discuss the origin of the H particle we will see that it is formed by pairing with an electron or positron of opposite polarity. More electrons implies a greater likelihood of forming the positive H particle initially. Then, we have the increased likelihood of combination with the easily induced electron-positron pair. A less likely event is the combination of the positive H particle with two electrons to form an anti-proton of form A. Least likely, is the formation of proton A.

Following this line of reasoning, we have presented in Fig. 7.2 a proton form B as the product of the deuteron reaction. Therefore, the negative H particle formed by inversion has gone into the neutron product. Before discussing the neutron and neutron decay, it is to be noted that we have deduced a relationship between the mass of the H particle and the mass of the regular proton. Since E_4 is $-1{\cdot}75\ mc^2$, the proton mass, from Fig. 7.1, is $M + 0{\cdot}25\ m$. Thus, the mass of the H particle is less than that of the proton by 0·25 electron mass units. Since, later, we will deduce the mass of the H particle from the teachings of this theory, we have thereby explained the mass of the proton. Note that spin is something which depends upon what is happening to a particle. When the proton is in an atom it has spin properties because of its interplay with the photon units and electrons in the atom. When the proton is isolated, spin cannot be precluded because it might depend upon what the proton brings with it from wherever it has been. Proton spin will be dealt with in detail later in this chapter.

The Neutron

It has just been stated that the positive H particle is the more fundamental. It is the most likely one to be formed. The fact that the deuteron models shown in Fig. 1.3 of Chapter 1 all comprise positive H particles with the exception of model C may seem inconsistent. In discussing the proton we argue in favour of the one having the least binding energy on the grounds that the H particle in positive form has abundance and ease of combination. Why are things different for the deuteron? Why did we not choose between models A, B and D and ignore C, the one with the negative H particles. The reason is clear, now that H particle inversion has been explained. H particles are the origin of matter. They are as fundamental as electrons and positrons. Preponderantly, they are produced in positive form. They first form neutrons by aggregation with electrons or protons by aggregation with electron-positron pairs. Indeed, as will be shown, H particles can, in fact, be actually created in their association with an electron-positron pair. If anything, one would expect the proton really to be formed in much greater abundance than the neutron. It is easier to develop an electron-positron pair if there is an inflow of energy creating matter. Electrons are not produced in isolation. So far as they do exist they can combine with the positive H particle to form a neutral aggregation and then this will join another electron to form an anti-proton because this anti-proton has the least total energy compared with the neutron or the normal proton and has also the strongest binding energy.

The result of this is that the process of matter creation has to be explained in terms of the creation of an abundance of protons of form B with a few anti-protons of form A. In an energetic environment some of these protons and anti-protons will undergo inversion and then combine to form the deuteron as illustrated in Fig. 7.4. Some protons will couple with an electron to form a hydrogen atom or go into the nucleus of a heavy atom. Some protons will undergo inversion and then aggregate with an electron to form a neutron of the form B, shown in Fig. 7.1. Then these will probably go into the formation of heavier atoms or decay back again by ejection of an electron. The anti-protons are possibly preserved until they invert, whereupon they are captured by inverted protons to form deuterons. If the protons and anti-protons aggregate before inversion of the latter they form something less stable than the deuteron and the process of disruption and regeneration can be expected to occur. In the basic matter creation process, the main product is the proton B, the neutron B and the deuteron according to model C in Fig. 1.3 or as shown in Fig. 7.1. Fig. 7.4 shows how a proton and an anti-proton may invert and combine to form the deuteron, ejecting an electron. Then, with the input of a gamma ray, it is shown how this deuteron disrupts to form proton A and a neutron. The neutron may invert and couple with an electron-positron pair in view of the energy available and then may eject an electron, decaying into a proton B. Similarly, the proton A may invert to develop proton B. If the reaction does not go in the way outlined in Fig. 7.4, what are the alternatives? Firstly, could the proton combine with the anti-proton? It might form a particle aggregate, electrically neutral overall, and of the order of mass of the deuteron. Now, it will be contended* that any particle aggregate which has a mass of the order of three or more times that of the proton and which is highly compacted cannot be

* See page 203.

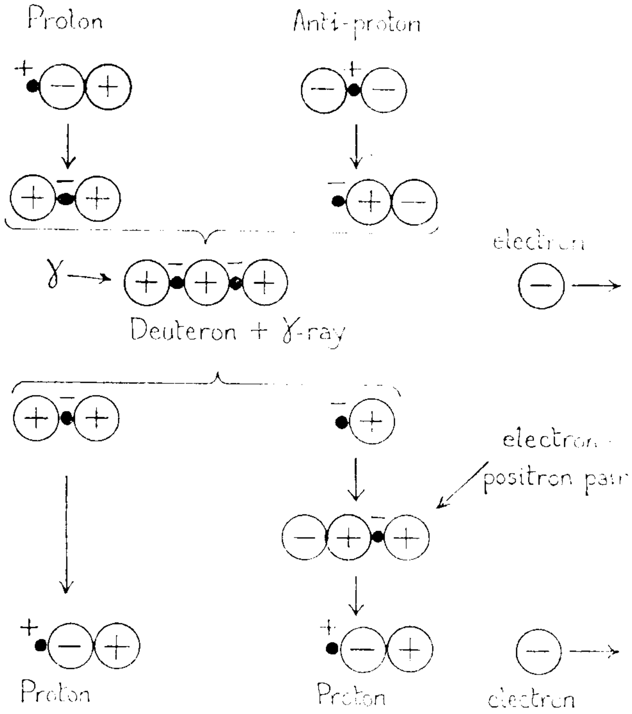

Fig. 7.4

effectively balanced by the interaction of gravitons in the G frame. Two gravitons separated by the lattice dimension d of space–time might share in the balance of a double-proton sized particle, but it is unlikely that three could co-operate in this way. Thus, since we shall later see that one graviton is needed per proton mass unit, we have to preclude aggregations of three or more H particles of the same polarity. We allow but one, the most stable, aggregation of two such particles. At this level the most stable is the deuteron according to model C in Fig. 1.3. To keep the analysis general, but at the level of mass of the deuteron, we can show that model C is favoured even if we involve H particles of opposite polarity in the selection. The mass level requirement is dealt with by allowing the H particles to be no closer than the diameter of an electron. In Fig. 7.5 several possible combinations including two H particles are shown and the total mass value applicable to each is given. None has as low a mass as the deuteron according to model C.

If the proton and anti-proton of Fig. 7.4 combine directly we expect the aggregation shown in Fig. 7.5(b). If the proton inverts its form and combines with the anti-proton the model shown in Fig. 7.5(c) results. If the anti-proton inverts and combines with the proton another model not shown is produced, but all have greater total mass than that depicted in Fig. 7.5(e), which is the model C deuteron. It is a similar story when we consider the possibility of combinations of the products of the deuteron when disrupted by gamma radiation. If anything forms having a mass approximately that of the deuteron it must decay into a deuteron. Effectively, the gamma radiation is dispersed without an end product. If there is an end product we would expect protons and neutrons (in form B) because these are the product of the basic matter creation reaction. These emerge from nuclear processes. Neutrons of the form B have transient stability. They decay via inversion into proton B and an electron.

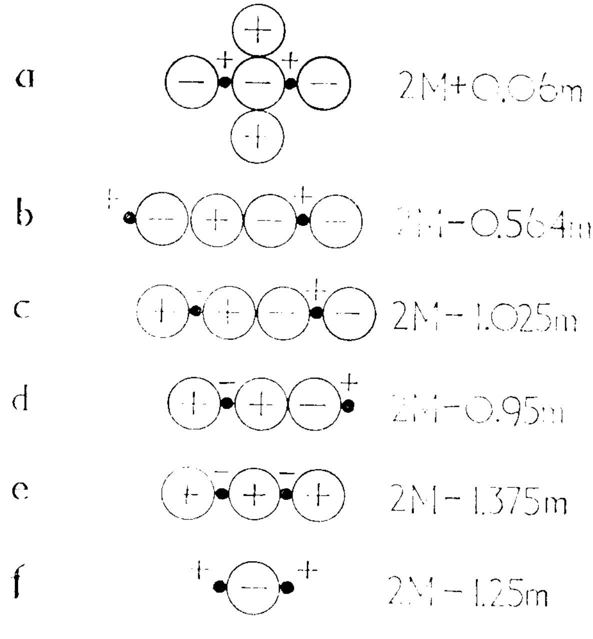

Fig. 7.5

An interesting speculation is whether the deuteron with all polarities reversed, the anti-deuteron, could form from two anti-protons or from some products of the reaction. Let us assume that the answer is affirmative. It is unlikely to happen because the anti-protons are scarce, but it can happen. The result could be an atom with a negative nucleus and a satellite positron. Such an atom would be a misfit in the system of matter we know. Probably such an atom would interact with a normal atom, with the electrons and positrons around their nuclei wiping one another out to develop energy which would stir up more reactions and work the "anti-bodies" out of the system. In the end, only one form of atom can win and that is apparently the one we have assigned a positive nucleus.

The deuteron mass augmented by gamma radiation which puts it into the ground state is simply $2M + 3m$. Then, from the known reaction:

$$D \rightarrow P + N$$

which indicates that the deuteron D converts to a proton P and a neutron N, we can deduce the mass of the neutron. We note that the mass of the proton is $M + 0{\cdot}25m$, as already shown, but subject to a small correction. The mass of the deuteron is really $2M + 3m - 4{\cdot}373m + 3\alpha m$, the latter term being the ground state correction due to the triple pair of charge elements. Similarly, the mass of the proton B is $M + 2m - 1{\cdot}75m + 2\alpha m$, because the ground state correction arises from interaction between two positive charges in the G frame and two negative charges, if we include the transient electron. in the E frame. It follows that the mass $2M + 3\ m$ available can go to create a proton and will leave mass $M + 2{\cdot}75\ m - 2am$ as the mass we can associate with the neutron. Compared with the proton, we find that the neutron is heavier by $2{\cdot}5\ m - 4\alpha m$, or $2{\cdot}4708\ m$. This is, of course, pure theory. An exact check with experiment is not possible because the absolute masses of these two quantities are not known to sufficient accuracy. Roughly, however, the predicted value seems correct. For example, if the proton-electron mass ratio is, say, 1,836·2, the neutron-mass ratio should be 1,838·67. These figures are fairly representative on existing data sources.

If we consider neutron decay, there is a check on the analysis. The neutron can produce a proton and eject an electron, as mentioned above. However, as Fig. 7.4 shows, it has to create and absorb an electron-positron pair. This returns us to the rather complex problem of the energy features of space–time. It was stated early in this chapter that the energy needed to create an electron and a positron is not, in matter terms, $2mc^2$. It is less because the constituent elements from which they are created have energy themselves. We have to digress a little to analyse this.

Firstly, the origin of the electron-positron pair is the lattice particle and a unit volume of continuum in space–time. As was explained in Chapter 6, there is a difference between mass balance and energy balance when we think of these elements. Energy in the form of lattice particles has its proper measure of mass but these particles move in a medium which itself has mass. There is a certain buoyancy effect, the result of which is that dynamic balance in free space comes about from energy in the *G* frame which is only half that in the *E* frame, as far as the relatively large lattice particles only are concerned. Hence, if we take four units of energy from the lattice particle system we take two from the *G* frame system, and we can deploy these six units of energy to create matter and an equal energy balance in the *G* frame. Hence, for each lattice particle and its related *G* frame continuum substance deployed to create the electron and the positron there is available from space–time the energy of 1·5 lattice particles, half of which goes into matter form. That is, the energy of 0·75 lattice particles or $0{\cdot}75(2e^2/3b)$, where b is the radius of the lattice particle, is released to matter in the electron-positron creation process. From the equation (6.39) this is $1{\cdot}5\ m_0c^2$, where m_0 has the value of 0·0408 m, as already shown.

Thus, the energy needed to generate an electron-positron pair corresponds to a mass of $2m - 0{\cdot}0612\ m$ or 1·9388 m. From the neutron we have 2·4708 m. If 1·9388 m of this is used to create an electron and a positron, and we allow for the fact that the mass m of the positron has been included already in the mass assigned to the proton, we must subtract 0·9388 m from 2·4708 m to obtain the mass of the surplus energy. The surplus energy is, therefore, $1{\cdot}532\ mc^2$ and this is released alongside the electron and the proton as a decay product of the neutron.

This energy quantity is 0·782 MEV, and this happens to be *exactly* the value measured by Robson (1951) from end point measurements in the beta spectrum derived from neutron decay. This result shows that the theoretical approach we are following has substantial experimental support. The minor ground state correction needed to understand the exact binding energy of the deuteron, and the energy corrections needed to understand the role of electron-positron creation in neutron decay, both give direct verification of the space–time system on which this whole theory is founded. These exact quantitative results are to be followed by many more in this chapter. Next, we will calculate from basic theory the mass of the particle H. Knowing this mass, we have, from the above analysis, the mass of the deuteron, the proton and the neutron.

The Origin of the Basic Nucleons

To explain the formation of matter as we know it, it is necessary to explain the origin of the basic nucleons, the H particles of the above analysis. The quantization of angular momentum is basic to atomic systems. With this in mind, it can be assumed that in a highly energetic reaction in space–time where nuclear actions are in process almost any energy quantum between that of the graviton and that of the lattice particle can be formed. However, even transient stability requirements pose the need for appropriate disposition of quanta of angular momentum. Owing to angular momentum criteria, certain energy quantized systems are favoured and from these certain stable particle forms can develop. Both the neutron and the deuteron featured in the above analysis contain a negative H particle. To be formed from space–time, the H particle is likely to come from the energy released by an expanding graviton. The graviton provides the gravitational property of the space–time lattice, even in the absence of matter. This is necessary in view of the argument leading to equation (5.6) in Chapter 5. The E frame has gravitational effects according to its mass density. Thus, when the graviton expands, and so loses energy and mass, it is less able to balance mass in the space–time lattice. Graviton expansion must, therefore, accompany some break-up of the lattice. Now, all that this means is that the translational motion of a space–time system and graviton expansion both require lattice particles to be freed from their orbital motion with the E frame. Graviton expansion implies release of energy. This implies the formation of matter. Hence, translational motion of space–time has some fundamental association with the existence of matter. To provide dynamic balance and gravitational effects in an undisturbed space–time, the graviton must, before expansion, be effectively compacted through a definite volume from a gravity-free reference state. The compaction of the graviton through a certain volume produces a related electrodynamic effect causing gravitation. If the graviton provides a basic gravitational effect according to the mass density of the space–time lattice, it must already be compacted through the related volume. Since G is, apparently, the same for gravitation between space–time and matter, the volume compaction of the graviton from its zero-gravitation state to its normal condition must have a ratio to the graviton mass equal to its incremental rate of volume compaction to mass ratio. From simple analysis based on equation (5.10), it can be shown that the total volume compaction of the graviton is three times its final and normal volume. In other words, the action of balancing the space–time lattice causes each graviton to be a compacted version of its gravity-free form and to occupy only one-quarter of its gravity-free volume. The corresponding energy and mass states of the graviton are in the ratio of the cube root of one quarter to unity. Thus, if the mass of the graviton is $5{,}063m$ in the normal gravitating state, it is $3{,}189\ m$ in the non-gravitating state, that is, $1{,}874\ m$ less.

What this tells us is that, when a part of the lattice is displaced to the inertial frame to form free particles accompanying translational motion of the lattice, there is dynamic out-of-balance allowing graviton expansion to release energy in quanta of $1{,}874\ mc^2$. The value of G has to be the same throughout such transitions, otherwise there would be problems explaining loss of gravitational potential. Hence, a quantum condition is imposed upon energy release.

Remember that in deriving equation (4.4) it was assumed that any angular momentum of the G frame was part of the zero angular momentum balance of a particle in the E frame. When this part comes out of its E frame orbit it deploys the corresponding orbital angular momentum from the G frame graviton to cancel its spin. This applies to the electron, as was shown in Chapter 4. It may also apply to the lattice particles. Hence, the release of the energy by the graviton in the manner just described does not release any angular momentum so as to cause a surplus. The graviton itself has no spin. Furthermore, since the graviton has no spin and since the freed lattice particles or electrons, in the sense of Chapter 4, have no spin either, the basic formation of matter occurs under zero-spin conditions.

Now, without elaborating further on the reasons, let us assume that a package of energy of up to $1{,}874\ mc^2$ is nucleated by a positive charge e and that an orbital electron having the basic angular momentum $h/2\pi$ goes into orbit around it. Note that the energy need not be wholly associated with the positive charge. It could develop electron-positron pairs by its catalytic action in promoting such events in space–time. We may assume that most of the energy does find itself stored by the positive nucleating charge.* Then, we have a

* In Chapter 9 we will discuss the source of this positive charge. As will be explained, it is a positron. The source of the positron can be better understood when certain cosmic properties have been analysed.

simple problem. The nucleus thus formed needs to have some angular momentum itself. How does it get it? A dynamic system has been formed. There has to be balance. Space–time is not reacting in this case to provide the balance. The lack of angular momentum is the root of the problem anyway. Does it share some of the angular momentum with the electron. If so, how? It is not as if the electron originated from the central nucleus and developed the reaction. If interaction does operate to cause the angular momentum to be shared, which is the normal assumption, then the electron will not have the exact quantum $h/2\pi$.

The next problem with this system is that it will radiate electromagnetic waves because of the electron motion unless we can provide a photon unit to compensate. This is not feasible because such units are located in the E frame and the electron is moving in the inertial frame, in the strictly relative sense. Therefore, the only answer to turn to is that the electron is moving at an angular frequency exactly equal to the universal angular frequency Ω. Then there should be no radiation problem.

This then raises other problems. There is motion relative to the E frame. This means that there are magnetic effects to consider. Curiously, however, it is possible for us to analyse the system without considering the magnetic force between the charges. There is, instead, a radiated wave of *angular field momentum*. This has its reaction in the system and this will be analysed. The proposition is that the electron retains its quantum angular momentum $h/2\pi$ and that exactly the angular momentum needed by the nucleus is that in balance with the field angular momentum radiated. There is a mass-dependence in the analysis. This condition is only met for a definite nuclear mass quantity. It is this quantity which leads us to the mass of the H particle, and Nature happens to make this quantity just a little less than the energy quantum of 1,874 m available for its creation.

In Fig. 7.6 a charge e carried by a particle of mass M is depicted in a dynamically balanced state with an electron of charge $-e$ and mass m. The motion of the electron in the inertial frame is circular and has velocity v in an orbit of radius x. From the above introduction:

$$mvx = h/2\pi \tag{7.1}$$

The angular momentum of the particle of mass M will, therefore, be m/M times $h/2\pi$, from simple dynamic considerations. It is to be noted that Newtonian dynamics are deemed to be strictly applicable because we are not dealing with a translational motion through the electromagnetic reference frame. There is the cyclic motion at the

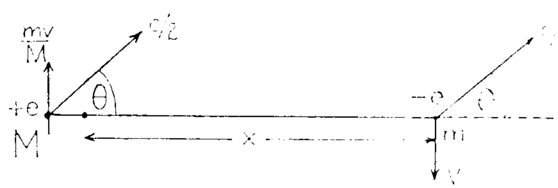

Fig. 7.6

frequency of space–time to consider. In fact, in some direction, say at angle θ to the line joining M and m, we must add the velocity vector $c/2$ to relate the motion in the inertial frame with one relative to the electromagnetic frame. The angle θ does not change during the successive cycles of the E frame since the motion of the E frame and that of the dynamic system under study are both at the angular velocity Ω. Note that the nature of the forces holding the two charges in this mutual orbital condition are not to be discussed. One must presume some kind of electric field interaction with space–time as we did in considering the physical basis of the Schrödinger Equation. There is some distinct similarity because the orbital radius can be shown to be $2r$ from the data just presented and this is the same radius as that of the orbit of the non-transit electron discussed in developing the explanation of wave mechanics.

It is shown in Appendix II that where there are two interacting current vectors in the same plane there must be a radiated field angular momentum equal to the product of the two vectors multiplied by:

$$\frac{1}{c}\left(\frac{\pi}{12}-\frac{1}{9}\right)\sin\theta_o \qquad (7.2)$$

where θ_o is the angle between the vectors. The two current vectors have, of course, to be developed by separate charges. Since a current vector is charge times velocity divided by c, the quantity of interest from Fig. 7.6 is:

$$-\left(\frac{\pi}{12}-\frac{1}{9}\right)\frac{e^2}{c^3}\left(1+\frac{m}{M}\right)\frac{vc}{2}\sin\left(\theta-\frac{\pi}{2}\right) \qquad (7.3)$$

Note that v is the velocity of the electron and that the field angular momentum has two components because there are two pairs of interacting current vectors.

For maximum angular momentum reaction consistent with a minimum energy deployment to form the mass M, the angle θ must be zero. This gives the total field angular momentum as:

$$-\left(\frac{\pi}{12}-\frac{1}{9}\right)\left(1+\frac{m}{M}\right)\frac{e^2 v}{2c^2} \qquad (7.4)$$

On the principles introduced this quantity should compensate the angular momentum of M itself. That is, it should balance $(m/M)h/2\pi$. Since v/x is Ω or $c/2r$, (4.1) and (7.1) show that v is, simply, c. Thus, putting this in (7.4) and balancing with the angular momentum of M, we have a relation which can be rearranged as:

$$\frac{M}{m}=\frac{hc}{2\pi e^2}\,\frac{2}{\left(\frac{\pi}{12}-\frac{1}{9}\right)}-1 \qquad (7.5)$$

Upon evaluation, simplified by the fact that $2\pi e^2/hc$ is the dimensionless fine structure constant (approximately 1/137), we find that M/m is 1,817·8.

Later in this chapter it will be shown that particles having this mass of 1,817·8 m have an important role to play in the nuclei of heavy atoms. Such particles, being of extremely small radius, can readily combine with other particles, mesons, electrons, positrons, etc. For the moment, our interest must turn to the event in which an electron-positron pair, developed as the particle is actually formed, participates in the angular momentum reaction in the field. The proton is the prime system under study, so we will analyse the system presented in Fig. 7.7.

In Fig. 7.7 an electron-positron pair is shown to be in the near

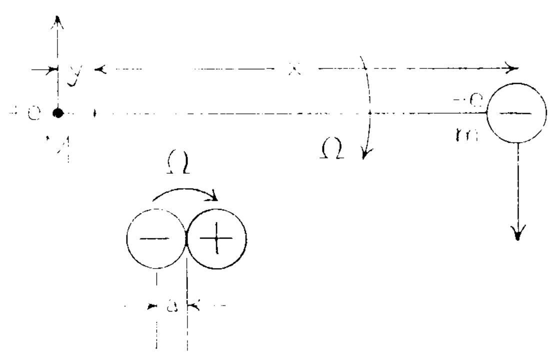

Fig. 7.7

vicinity of the heavy particle and the electron. This heavy particle, termed the H particle, moves in balance with the electron as described already by reference to Fig. 7.6. The electron-positron pair forms its own dynamic balance system and also rotates about its own centre of inertia at the angular frequency Ω. These motions are about parallel axes and are synchronous in the sense that the velocity vectors of the particles in the two systems are at all times mutually parallel or anti-parallel, but in such relative direction as to assure the maximum combined angular momentum reaction in the field.

The purpose of this analysis is really to determine the mass of the heavy particle formed in the event of its creation being in close association with an electron-positron pair. The previous analysis led us to the mass of such a particle when created in isolation. Also, before proceeding too far, it is as well to realize that later we will be confronted with the problem of how, once the heavy particle is formed, it ever gets into the E frame to become normal matter. It will need angular momentum then in much larger quantities than can be induced by reaction with the field radiation. This problem will be discussed in Chapter 9.

Now, referring to Fig. 7.7, it is necessary to calculate the angular momentum of the field radiation due to the mutual interaction of the four particles. Any particle will react with the compounded $c/2$ current vectors of the other three. The result is four terms in the angular momentum expression:

$$-\left(\frac{\pi}{12}-\frac{1}{9}\right)(y-a-a+x)\left(\frac{c}{2}\right)\frac{\Omega e^2}{c^3} \qquad (7.6)$$

It is noted that the paired electron has a radius a, and therefore a velocity vector $-a\Omega$, whereas the positron has a velocity vector $a\Omega$. Since they have opposite polarity charge they combine to provide unidirectional current vectors.

As before, the value of x is $2r$, and y is $(m/M)2r$, where M is now the mass of the H particle. From (6.60), (6.69) and (6.70), the electron radius a is $4/3(ar)$, or $r/103$. Ω is $c/2r$. Thus (7.6) is simply:

$$-\left(\frac{\pi}{12}-\frac{1}{9}\right)\left(1+\frac{m}{M}-\frac{1}{103}\right)\frac{e^2}{2c} \qquad (7.7)$$

As before, we equate this in magnitude to $(m/M)h/2\pi$ and find that M/m is 103/102 times the value given by (7.5). It is thus deduced that M is 1,835·6 m. The mass of the H particle we seek is about 0·25 m

less than the mass of the proton. The mass of the proton is about 1,836·2 *m*, so the *H* particle mass should be about 1,835·9 *m*, say. This is near enough to exact agreement with the theoretical value, so it can be said that very probably this analysis is well founded. The mass of the H particle has been derived from fundamental principles and it has been shown that there are two such heavy particle forms. They both are likely to have positive charge *e*. The heaviest is formed in close association with an electron-positron pair and has a mass a little less than 1,836 *m*. The lightest is formed in isolation and has a mass of about 1,818 *m*. This happens in the presence of an available energy quantum of about 1,874 *m* released from the graviton, which, possibly, provides the nucleus for the formation of these heavy particles. As might be expected, the electron-positron pair can join with the H particle once formed to create the proton form B, already deduced as being the most prevalent in the process of matter creation.

Atomic Nuclei

Before studying the spin properties of the proton, neutron and deuteron and providing further verification of the theoretical approach so far followed, it is convenient to pause here to explain the nature of the binding forces in heavier atomic nuclei.

The atomic nucleus comprises an aggregation of elementary particles. Principally, the nucleus is composed of protons and neutrons. We believe this because all atomic nuclei have masses which increment by approximately the same amount relative to their neighbours in the atomic mass scale. This mass increment is approximately the mass of the neutron or proton. Mass incrementation by the addition of a proton increases the electric charge of the nucleus by the unit *e*. It follows that if a nucleus has charge Ze it is most likely composed of Z protons. If its atomic mass is approximately X times that of the proton (after adding a little to account for binding energy) it is most likely composed also of $X-Z$ neutrons.

Our problem is to determine how the mutually repulsive charges are held together and to examine what other elementary particles are in the nuclear composition. This problem is readily answered by this theory and is supported by the appropriate quantitative and qualitative findings.

The analysis of the deuteron has shown how nuclei might be formed from elementary particles. There is, however, a problem in suggesting that heavy nucleons can become closely compacted. This is the problem of gravitational balance. It was shown in Chapter 6 that the gravitons in the G frame provide the gravitational mass balance in space–time. These particles have a mass which is about 2·7 times that of the proton. Further, these gravitons, being mutually repulsive, cannot compact without losing their space–time character. The statistical probability of the proximity of a graviton to any element of matter is related to the mass of that element so that the balance condition is assured. The gravitons are effectively melded with the distributed charge of the continuum element of space–time. They have a distribution which makes the mass density of this continuum G frame system uniform save where mass of matter present requires some concentration. The gravitons are, therefore, spaced apart on some statistical basis. However, the closest spacing where balance is needed within a well-compacted atomic nucleus is deemed to be the metric spacing d, the spacing of the lattice forming space–time. This will be discussed further in Chapter 9, since it involves possibilities which are a little speculative but, suffice it to say, we will assume that the proper spacing of gravitons in a nucleus has a lattice form with spacing d. The gravitons can move about in their statistical pattern but favour certain relatively spaced discrete positions matching the spacing of the space–time system. On this basis, we will also preclude more than two heavy nucleons from forming a compacted nucleus. The gravitons cannot balance three nucleons in a closely compact state. Further, in atomic nuclei containing more than two heavy nucleons, it seems more logical for them to have the regular spacing introduced above. In short, our hypothesis is that a loosely compacted nucleus can be formed of many nucleons provided it has a dynamic affinity with a graviton spacing matching the lattice spacing of the particles forming the E frame of space–time. This allows the nucleons to occur singly (or perhaps in pairs as well) in an atomic nuclear lattice also of cubic form and of spacing d of $6{\cdot}37\ 10^{-11}$ cm.

We may then portray an atomic nucleus as in Fig. 7.8, where the bonds between the nucleons are all of length d and are aligned with the fixed directions of the space–time lattice. This means that an atomic nucleus lattice cannot spin, even though the individual nucleons may spin about their own diameters and the whole nucleus can move linearly or in an orbit relative to the E frame lattice. The nucleus lattice retains its fixed spatial orientation.

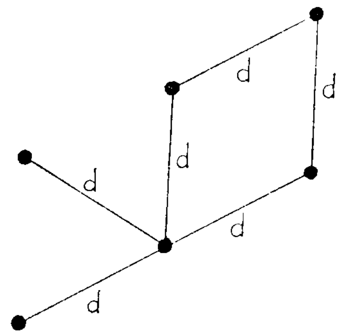

Fig. 7.8

Nuclear Bonds

What is the form of the nuclear bonds? Each of the six nucleons in Fig. 7.8, three protons, say, and three neutrons, identified by the full bodied circles, has a bond of its own providing one of the links. These bonds are the real mystery of the atomic nucleus. We will assume that their most logical form is merely a chain of electrons and positrons arranged alternately in a straight line. The reason for the assumption is that electron-positron pairs are readily formed in conjunction with matter, and we have seen how an in-line configuration of alternate positive and negative particles has proved so helpful in understanding the deuteron. Stability has to be explained. Firstly, the chain is held together by the mutually attractive forces between touching electrons and positrons. Secondly, it will be stable if the ends of the chain are held in fixed relationship. This is assured by the location of the nucleons which these bonds interconnect. In Fig. 7.9 it is shown how the bonds connect with the basic particles. In the examples shown, the nucleons are positioned with a chain on either side and are deemed to be spinning about the axis of the chain. Intrinsic spin of the chain elements will not be considered. It cancels as far as observation is concerned because each electron in the chain is balanced by a positron. In Fig. 7.10 it is shown how, for the neutron, for example, the spin can be in a direction different from that of the chain. Also, it is shown how another chain may couple at right angles with this one including the neutron. Note, that the end electron or positron of the chain does not need to link exactly with the nucleon. Therefore, it need not interfere with the spin.

We will now calculate the energy of a chain of electrons and positrons. For the purpose of the analysis we will define a standard

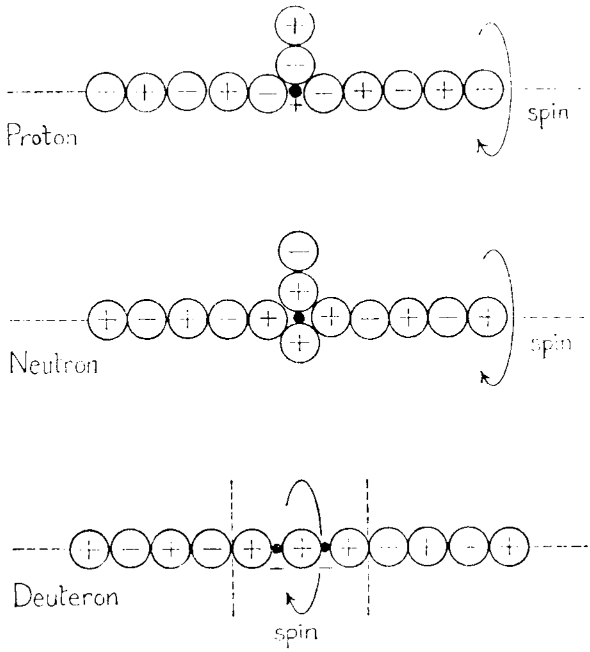

Fig. 7.9

energy unit as $e^2/2a$. This is the conventional electrostatic energy of interaction between two electric charges e of radius a and in contact. Since $2e^2/3a$ is mc^2, as applied to the electron, this energy unit is 0·75 mc^2. On this basis, a chain of two particles has a binding energy of -1 unit. If there are three particles the binding energy is the sum of -1, $\frac{1}{2}$ and -1, since the two outermost particles are of opposite polarity and their centres are at a spacing of $4a$ and not $2a$.

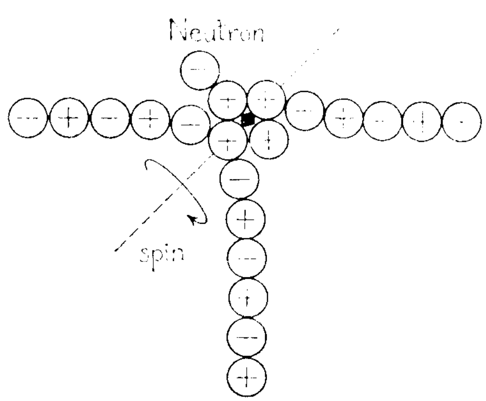

Fig. 7.10

For N particles, with N even, the total interaction energy is:

$$-(N-1)+\frac{(N-2)}{2}-\frac{(N-3)}{3}+\ldots\frac{2}{(N-2)}-\frac{1}{(N-1)}$$

which is $-N \log 2$, if N is large. If N is odd, the last term in the above series is positive and the summation, for N large, is $1-N \log 2$. To find N we need to know how many particles are needed for the chain to span a distance d. d can be related to m by eliminating r from (4.1) and (6.60). Then $d/2a$ is found using $2e^2/3a=mc^2$. It is 54π, so N may be, say, 169, 170 or possibly 168, particularly if N has to be even and there has to be space for any nucleons. For our analysis we will calculate the binding energy of the chain and the actual total energy of the chain for all three of these values of N. The data are summarized in the following table.

N	168	169	170
$-N \log 2$	−116·45	−117·14	−117·83
Binding Energy (units)	−116·45	−116·14	−117·83
Binding Energy (mc^2)	−87·34	−87·11	−88·38
Add Self Energy (mc^2)	168	169	170
Total Chain Energy	80·66	81·89	81·62
Ground State Correction	0·61	0·62	0·62
Corrected Energy (mc^2)	81·27	82·51	82·24

In the above table the binding energy has been set against the self energy of the basic particles and a correction has been applied of amc^2 per pair of particles to adjust for the fact that mass is not referenced on separation to infinity, as was discussed earlier in this chapter. The total mass energy of the chain is seen to be about 81 or 82 electron mass energy units, depending upon its exact length.

This shows that while the electron-positron chain proposed will provide a real bond between nucleons linked together to form an atomic nucleus, it will nevertheless add a mass of some 81 m per nucleon. This seems far too high to apply to the measured binding energies. Furthermore, it is positive and the nature of binding energy is that it must be negative. This can be explained by introducing the π meson or pion, as it is otherwise termed.

The Pion

When an electron becomes attached to a small but heavy particle of charge e, the interaction energy is very nearly $-e^2/a$ or 1·5 times the energy unit mc^2. This means that the mass of the heavy particle is effectively *reduced* when an electron attaches itself to it and becomes integral with it. If we go further and seek to find the smallest particle which can attach itself to a heavy nucleon to provide enough surplus energy to form one of the above-mentioned electron-positron chains, we can see how this nucleon plus this particle plus this chain can have an aggregate mass little different from that of the initial nucleon. This can reconcile our difficulties. The fact that an electron can release the equivalent of about half its own mass indicates that to form the chain of mass 81 m we will need a meson-sized particle of the order of mass of the muon or pion. To calculate the exact requirement we restate the inverse relationship between the mass m of a particle of charge e and its radius a:

$$2e^2/3a = mc^2 \tag{7.8}$$

This applies to the electron, but it can also be used for other particles such as the meson and the H particle.

It may then be shown that if two particles of opposite polarity charge e are in contact, their binding energy, e^2 divided by the sum of their radii, is $3c^2/2$ times the product of their masses divided by the sum of their masses. Let M_o be the mass of the meson involved and M be the mass of the H particle. The following table then shows the value of the surplus energy:

$$\frac{3M_oMc^2}{2(M_o+M)} - M_oc^2 \tag{7.9}$$

in terms of units of mc^2, for different values of M_o/m and the two values of M of 1,818 m and 1,836 m.

M_o/m	$M = 1{,}818\ m$	$M = 1{,}836\ m$
230	76·1	76·4
240	78·0	78·3
250	79·7	80·0
260	81·2	81·5
270	82·6	83·0
280	84·0	84·5

This shows that the energy of the formation of the meson will be adequate to form the chain if the meson is in the mass range of M_o/m between 260 and 270. The only meson available in this range is the neutral π meson of mass $264{\cdot}6 \pm 3{\cdot}2\ m$, according to Marshak (1952). However, this is a neutral meson. The best available meson, that is the one of lowest mass and having a charge but yet sufficient to form a chain of energy 82 mc^2, is the charged π meson which has a measured mass of about 276 m. According to the above table, this affords an energy of slightly less than 84 mc^2, which is sufficient to form a chain while providing a surplus of one or two electron mass units. This means that the combination of such a meson, a nucleon and a chain has a total mass which differs from that of the nucleon itself by only one or two electron mass units. The total mass will be less by this amount so that this really is a measure of the binding energy involved.

This gives us an approach to calculating the mass of an atomic nucleus. The nucleus can be regarded as an aggregation of some protons containing H particles of mass 1,818 m or 1,836 m or a mixture of both, some neutrons which may also comprise either H particle, and as many π mesons and chains as there are nucleons (except for the deuteron and the hydrogen nucleus). There is the clear indication that the π meson has an important role to play in nuclear physics. In fact, it has been believed for some years that it is involved in the binding mechanism of the atomic nucleus, and this theoretical finding is, therefore, by no means unexpected.

It is of interest to speculate about the electron-positron chain coming free from the nucleus. With an even value of N the chain would be a neutral entity having a mass of 81·27 or 82·24 times that of the electron. If this latter energy is deployed to remove a meson attached to an H particle of mass 1,836 m, the above table shows that it could develop a meson of mass 265 m. If the meson came from the lighter H particle, it would be 267 m. It is possible, therefore, that the nuclear chain could be created by the formation of a charged π meson of mass 276 m, as the latter comes into aggregation with the H particle. Energy of some one or two electron mass units is surplus from this reaction. However, in the reverse direction, it might happen that the π meson can, in nuclear reactions, expand to lose some of its energy and, then, just as it reaches the stage where a chain can collapse to provide the energy needed to drive the meson away from the H particle, it is released. At this stage its mass would be about

265 m or 267 m. Although it would still have a charge, it could be that this process has some relation with the formation of the neutral π mesons. These do have this lower mass value.

This is, of course, mere speculation. It is open to criticism because it is not clear how a long series of electrons and positrons can just vanish and release all their mass energy. If they meld into space-time, as with the annihilation of the electron-positron pairs, there is still about 3% of the energy of mc^2 of each electron and positron needed to sustain the charge in its new form (see page 138). Thus, about $5mc^2$ is to be subtracted from the energy released by the chain. Also, if we examine Fig. 7.9 closely and ask how a meson is attached to the heavy H particle in each of the systems shown, we see that it is easy in the case of the proton but in the case of the neutron or deuteron an oppositely-charged particle would make it difficult to have the particle configuration shown. Even in the case of the proton, the presence of a negative meson attached to the positive H particle opposite the electron-positron pair, would alter the polarity sequence of the chain ends.

These are not problems which invalidate the theory. They are indications that we cannot expect to have the atomic structure fit together easily to provide simple and convincing results. It is possible that we should not be thinking in terms of protons and neutrons when we analyse heavy atoms. Perhaps we should consider only H particles connected by chains and having the mesons attached to them, possibly in the chain. The answers can probably best be found by indirect analysis. For example, the spin properties of the proton and neutron can be studied under different conditions. This type of approach seems more appropriate at the present stage of development of the theory.

Proton Spin

The nuclear theory presented so far in this chapter might seem to be elaborate in certain respects. However, it has been supported by the following quantitative results:

(a) The derivation of the observed binding energy of the deuteron,
(b) The derivation of the observed energy of the electron ejected in neutron to proton decay,
(c) The derivation of the observed mass of the π meson, in the

approximate sense and on the assumption that the π meson serves a prime role in nuclear binding,

(d) The derivation of the mass of the H particle from first principles, this quantity being then available to obtain from this theory the masses of the neutron, proton and deuteron, all stated as a ratio in terms of the mass of the electron.

The question now faced is whether these same principles guide us to the magnetic moments and spin angular momenta of these nuclear particles.

Consider the spin condition of the proton shown in Fig. 7.11. The spin condition is deemed to be that in which a particle rotates about a centre within the particle. Thus a single sphere of charge rotating about a diameter is said to *spin*. An aggregation of such charge spheres rotating about the common centre of mass can be said to spin also. *Intrinsic spin* will be used to represent the sum of the spins of the individual spheres of charge in such a particle aggregation. Thus, in Fig. 7.11 we denote the spin angular velocity about the

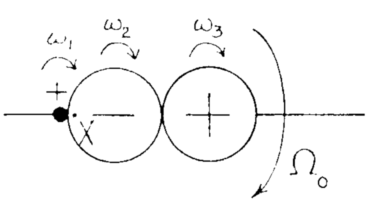

Fig. 7.11

point X as Ω_o. X is the centre of mass of the proton and is distant approximately two H particle radii from the centre of the H particle. The particles in the proton are deemed to be in rolling contact. Let $\omega_1, \omega_2, \omega_3$ denote the angular velocities of the H particle, the electron and the positron in the inertial frame. Then, relative to the line of centres which rotates at Ω_o, the angular velocities become $\omega_1-\Omega_o$, $\omega_2-\Omega_o$, $\omega_3-\Omega_o$ respectively. For rolling contact, taking radii as r_1, r_2, r_3 respectively:

$$(\omega_1-\Omega_o)r_1 = -(\omega_2-\Omega_o)r_2 = (\omega_3-\Omega_o)r_3 \tag{7.10}$$

The spin angular momentum of each component particle is proportional to its mass, angular velocity and radius squared. Since mass is inversely proportional to radius, spin angular momentum is proportional to $\omega_1 r_1, \omega_2 r_2, \omega_3 r_3$ for the three particles respectively. The intrinsic spin angular momentum of the proton is thus proportional to the sum of these quantities. This spin angular momentum is assumed to be zero, as will be discussed later. Accordingly:

$$\omega_1 r_1 + \omega_2 r_2 + \omega_3 r_3 = 0 \tag{7.11}$$

Now, r_2 and r_3 are respectively the radius of the electron and positron, both denoted a elsewhere in this book. r_1 is the radius of the H particle and is $(m/M)a$, where m/M is the mass ratio of the electron and H particle. Since M is about 1,836 m, r_1 can be assumed negligible for a first analysis, making ω_1 very high and allowing $(\omega_1 - \Omega_o)r_1$ in (7.10) to be replaced by $\omega_1 r_1$. From (7.10) and (7.11) it is then simple algebra to show that ω_1, ω_2, ω_3 are respectively $-2\Omega_o(M/m)$, $3\Omega_o$, $-\Omega_o$.

We can now consider the magnetic moment of the proton. From Appendix I the spin contribution of each component particle is $e/6c$ times angular velocity and radius squared. For orbital motion $e/6c$ has to be replaced by $e/2c$, as is well known. Also, it must be remembered from Chapter 2 that, strictly, these quantities may have to be increased by a factor to explain certain anomalous behaviour.

The spin contribution just mentioned is one-third that of the related orbital contribution simply because the charge within the sphere is distributed over its volume. Accordingly it cannot be regarded as all being at the specified radius, as it can in the case of orbital motion. In evaluating the spin magnetic moment of the composite particle shown in Fig. 7.11, we find that there is a component due to the intrinsic spin and a component due to the spin about the point X. This latter component is evaluated from the above mentioned orbital formulation. Thus, it consists approximately of only two major elements, $e/2c$ times $9a^2\Omega_o$ for the positron and $-e/2c$ times $a^2\Omega_o$ for the electron. Note that $r_2 + 2r_3$ is $3a$. The H particle makes a very small contribution to magnetic moment and it can be ignored. Due to intrinsic spin, there are also two major elements, $e/6c$ times $a^2\omega_3$ for the positron and $-e/6c$ times $a^2\omega_2$ for the electron. Again, the H particle can be ignored. Since ω_2 is $3\Omega_o$ and ω_3 is $-\Omega_o$ the total contribution due to intrinsic spin is $-4(e/6c)a^2\Omega_o$. Collecting the components due to motion about X gives $8(e/2c)a^2\Omega_o$. Thus the total magnetic moment should be $20(e/6c)a^2\Omega_o$ times the appropriate anomalous factor. Putting this as γ we have a proton magnetic moment of:

$$20\gamma(e/6c)a^2\Omega_o \tag{7.12}$$

In connection with Fig. 4.4 it was explained how the nucleus of an atom has an angular momentum exchange relationship with a nuclear photon unit. Applying this to the proton, it is to be expected that the rotation about the point X will be synchronous with the rotation of the photon unit. The reason is that the proton has a non-symmetrical distribution of its charge. A small electric disturbance developed by the rotation of the proton can probably be compensated by an appropriate but very small perturbation of the motion of the associated electron. This tells us that:

$$\Omega_0 = 4(\omega_0 - \omega) \tag{7.13}$$

where ω now has the meaning given in Fig. 4.4. The sense of "synchronous", as just used, therefore means that the rotation frequency of the proton about its centre of mass is exactly *four* times that of the photon unit. The reason is that the photon unit generates four pulsations every revolution. For the standard photon unit, ω_0 is $\Omega/4$ and $I\omega_0$ is $h/2\pi$. For the simple electron-proton system, (4.21) shows that $I\omega$ is $ah/2\pi$. This shows that (7.13) becomes:

$$\Omega_0 = (1 - a)\Omega \tag{7.14}$$

The magnetic moment of the proton is evaluated from (7.12) and (7.14). To test this analysis it has to be noted that the measured magnetic moment involves a pre-knowledge of the proton spin angular momentum. This angular momentum is finite, even though we have assumed a total intrinsic spin component to be zero. There is a basic angular momentum quantum of $h/4\pi$. In interpreting proton magnetic moment measurements this quantum is assumed to apply. However, remembering the mechanism presented in Fig. 4.4, we have to note that an angular momentum ε is transferred between the electron and the proton. This quantity ε is $I\omega$ in (4.21). Thus, it is to be expected that the proton angular momentum is really $(1+2a)h/4\pi$ and the electron angular momentum $(1-2a)h/4\pi$ in this particular system. The magnetic moment of the proton is measured by a resonance technique in which the ratio of the *actual* magnetic moment and the *actual* angular momentum is observed. If the angular momentum has been underestimated then the measured magnetic moment will be too high. To facilitate comparison with reported measurements based upon the assumed half-spin quantum, the proton magnetic moment given by (7.12) and (7.14) should be adjusted by multiplying it by $(1+2a)$. Thus, the proton magnetic moment can be written as:

$$20\gamma(e/6c)a^2(1-a)(1+2a)\Omega \qquad (7.15)$$

At this stage, we pause to introduce a result derived in Appendix III. The value of γ is 9·6, a quantity much higher than the factor of 2 derived for the large-scale orbital motions in Chapter 2. It seems that in order to generate the kinetic reaction effects in the field medium the spins of elementary particles have to be higher than one would expect from normal theory. This result is deduced from the analysis of the balance conditions of magnetic field and angular momentum in the space–time system. It can be put to immediate test in applying (7.15).

Putting γ as 9·6 in (7.15) and noting that a/r is $4a/3$, Ω is $c/2r$ and a is $1/137$, the expression for the measured proton magnetic moment becomes:

$$\frac{256}{9}a^2(1-a)(1+2a)er$$

where er is the Bohr Magneton. When evaluated this gives:

$$1{\cdot}525\ 10^{-3}$$

Bohr Magnetons, which is very close to the measured value of $1{\cdot}521\ 10^{-3}$. The fact that the H particle has been taken to be of negligible size may account for the slight difference in these results. Certainly, it seems that there is evidence to support the proton form presented, besides affording verification of the theoretical evaluation of γ.

Neutron Spin

To calculate the spin properties of the neutron we have to know the form assumed by the neutron in the experimental environment of nuclear resonance. If another electron is added to the proton system in Fig. 7.11 on the left-hand side of the H particle and the proton spins are retained, we can easily calculate the neutron magnetic moment. In the case of the proton magnetic moment the electron contributed -6 units to the parameter 20. Thus, for the neutron just developed the parameter 20 in (7.12) becomes 14. The ratio of the neutron magnetic moment to that of the proton should therefore be about 14/20 or 0·7. In fact, from experiment it is −0·6850. The minus sign means that we should have inverted all the polarities in the neutron model just proposed. It must comprise a negative H particle, two positrons and one electron. It has the form used in Fig. 7.4 and as depicted as form B in Fig. 7.1.

It is possible that when the ratio of the magnetic moments of the proton and neutron is measured they are so close together that the proton is not bound by the photon unit coupled with the electron action but the neutron is. The neutron does not really qualify for pairing with an electron, and thereby being detected, since it has no resultant charge. However, it can assert an association with an electron if it is paired with a proton and if it takes over the electron associated with the proton. The affinity between the neutron and the electron may be favoured from their magnetic interaction. This means that the proton will have the half spin quantum $h/4\pi$ whereas the neutron will take the angular momentum $(1+2a)h/4\pi$ and rotate with a photon unit to comply with (7.14). We then expect the measured ratio of neutron and proton magnetic moments to be −0·7 times $(1-a)/(1+2a)$ or −0·6849. This seems close enough to the measured value of −0·6850 to give adequate satisfaction. It is further gratifying because in evaluating a ratio we avoid dependence upon the parameter γ.

We now turn attention to Figs. 7.9 and 7.10. The neutron is there shown in its bound state in the atomic nucleus coupled to the electron-positron chains by attachment to the positron terminations of the chains. These illustrations were merely diagrammatic. The coupling needs to be considered more closely. In Fig. 7.12 an electron and a positron are shown attached to the neutron along the spin axis. They are ready to form the connections with any chains in the nucleus. It may be shown that a pair of electrons or a pair of positrons cannot

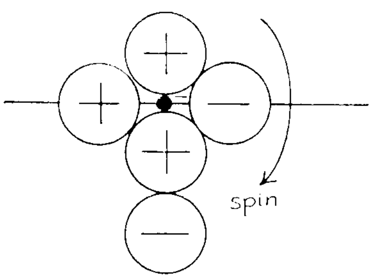

Fig. 7.12

replace the added electron-positron pair and yet form an arrangement in which the forces between the component particles will hold things together. We must assume, therefore, that a neutron can capture an electron-positron pair to form the system shown in Fig. 7.12 or, at least, that it joins to nuclear bonds through an electron on one side and a positron on the other. If the neutron spins there will be rolling contact with these end particles. For no slip they must rotate and so become a feature of the neutron spin. This is the other reason why they should have opposite polarity. Their magnetic moments will cancel and so not affect the above analysis.

Neglecting the finite size of the H particle, and remembering that the adjacent particles have spin at $3\Omega_o$ besides rotating about the neutron spin axis at Ω_o, we see that the contact with the end particles causes them to spin on the neutron spin axis at $-2\Omega_o$. The point about this is that for electrons or positrons on a spin axis an angular velocity of $2\Omega_o$ is to be expected.

Deuteron Spin

The deuteron has symmetry and is therefore not involved in a spin governed by photon units. The problem, therefore, is to decide how to determine any spin of the three positron constituents in its composition. From the foregoing comments one could guess that each positron may have a spin of $2\Omega_o$ where Ω_o is put equal to Ω. The parameter of magnetic moment is then 6 units compared with 20 for the proton and -14 for the neutron. Alternatively, since the deuteron is little different from a proton and a neutron combined we can possibly combine 20 and -14 to obtain the same parameter 6.

To apply this to experiment we note that in terms of a measured separate proton resonance for which the proton magnetic moment parameter is slightly less than 20 and its spin angular momentum slightly more than $h/4\pi$, the deuteron magnetic moment is:

$$\frac{6}{20}(1+2a)/(1-a) \qquad (7.16)$$

Upon evaluation, this is 0·3066, which compares with a measured value of 0·3070. Again, allowing for the fact that the dimensions of the H particle are ignored, this result is excellent.

The difficulty with the deuteron is to understand how it contributes to the magnetic resonance experiment. Are we even certain that the deuteron which performs in such experiments is quite the same as the one which undergoes transmutation in nuclear processes? May it not be that a proton and a neutron have become locked together in a state of spin? Going back to the basic deuteron model, let us examine what has to happen to a neutron and a proton for the compacted deuteron to form. In Fig. 7.13 the neutron and the proton are shown

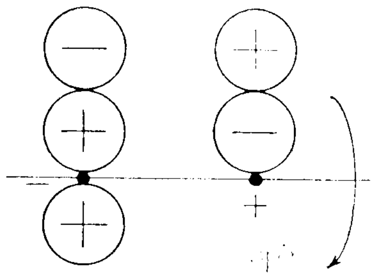

Fig. 7.13

side by side spinning about the same axis. Note that the spin motions of the outer electron in the neutron and the outer positron in the proton are identical from the foregoing analysis. Since these two particles have opposite polarity they effectively cancel one another's magnetic moment. Now, if the neutron and the proton become locked together in a spin motion state, the combined magnetic moment is independent of the presence of the electron and positron just mentioned. If the neutron and proton fuse together and eject the electron and the positron we have the inverse process to that shown in Fig. 7.4. There, the deuteron absorbed an electron and a positron to form a neutron and a proton. Here, once the electron and positron are removed, we are left with the same total magnetic moment. Also, by the inversion of the positive H particle and its electron, we can expect aggregation to form the deuteron comprising two negative H particles and three positrons. If each positron adopts a 2Ω spin, or thereabouts, sharing the magnetic moment of the neutron and proton, the magnetic moment of the deuteron is still as given by (7.16) in comparison with that measured for the free proton. It follows that it is possible to explain spin magnetic properties of the deuteron in terms of the same model as was used to calculate the binding energy. This affords a double check on the nature of the deuteron and its constituent nucleons.

Electron Spin

Before leaving this chapter we must consider the rather complicated problem of electron spin.

In the analysis in Chapter 4 it was found appropriate to assume that the total angular momentum of a basic particle (the lattice particle or the electron) is zero. This meant that there was a spin component and an orbital component compensating each other, as formulated in equation (4.4). It will also be found in Appendix III that we will apply this concept of total angular momentum being zero for the lattice particle when we analyse the residual spin frequency of the particle. Quite apart from angular momentum balance, we will there use the particle spin to explain the source of a magnetic moment balancing the magnetic moment of the continuum charge in space–time. The latter moves cyclically relative to the electromagnetic reference frame set by the lattice particles. Now, the balance conditions just mentioned are subject to small residual effects. In the main these can be ignored in the analysis. However, to explain certain phenomena and discrepancies in quantitative analysis we do have to pay attention to them.

The anomalous spin properties of the electron *may* be due to this cause. For the orbital electron we have seen in Chapter 2 that an angular momentum of $h/2\pi$ can develop a magnetic effect equivalent to that of two Bohr Magnetons. The magneto-mechanical ratio is e/mc and this leads to a magnetic moment based on $h/2\pi$ of twice $eh/4\pi mc$, the Bohr Magneton. It was there shown that reaction effects cancelled half the field, thus making the *apparent* magnetic moment of an orbital electron of angular momentum $h/2\pi$ seem to be that of the Bohr Magneton. When we turn to the problem of spin we find evidence of half-spin quanta of angular momentum $h/4\pi$ and the measured magneto-mechanical ratio of the electron appears still to be e/mc, though only approximately. Indeed, the anomaly factor of 2 becomes, when measured, slightly higher than 2 by the factor $1{\cdot}001146 \pm 0{\cdot}000012$ or $1{\cdot}001165 \pm 0{\cdot}000011$. Sommerfield (1957) has presented the experimental data and mentions these two conflicting measurements. The anomalous component in this factor is assumed to be in the magnetic moment and not in the angular momentum. Also, Farley *et al.* (1966) have measured the same anomaly for the negative muon and found the anomalous component to be $0{\cdot}0011653 \pm 0{\cdot}0000024$.

There is, therefore, a fundamental problem to answer. It is associated with spin, and yet spin seems to be some property merely attributed to the half-quantum $h/4\pi$, whereas the main anomalous effect is associated with the mysterious doubling of the magneto-mechanical ratio. The anomalous properties of the electron may still be seated in what can just as well be termed orbital motion.

Quantum electrodynamics already provides an answer for the anomaly. By a rather complex treatment, which has not been wholly accepted by the physicist, quantum electrodynamics gives a value of $a/2\pi$ or 0·001161, subject to slight upward revision to allow for higher order terms in the calculations. As before, a is the fine structure constant. It is therefore not really necessary to challenge this explanation in this work. Quantum theory is linked to the concepts newly introduced in the previous pages. Thus the anomalous magnetic moment of the electron and the not-unrelated phenomenon known as the Lamb Shift which already have explanation in physics need not strictly be pursued here. However, the author has relied upon the space–time reaction as offering explanation for the anomalous factor of 2 in electron magneto-mechanical studies. Also, the quantum electrodynamic explanation presents some doubts. Therefore, the reader may be interested in a little speculative enquiry into the anomalous electron spin properties.

In the analysis of the formation of the H particle it was found that some field angular momentum due to radiation would be developed. Thus, there can be change in angular momentum according to the different states of transmutation of the system of particles involved. A basic angular momentum quantum due to field radiation is that given by (7.4). Ignoring the small component m/M and introducing the value of r, this expression gives the angular momentum quantum:

$$\left(\frac{\pi}{12}-\frac{1}{9}\right)\frac{e^2}{2c} \qquad (7.17)$$

This angular momentum quantum has some association with the existence of the H particle. Now, consider an H particle and an electron as shown in Fig. 7.14 spinning in rolling contact and turning at the universal angular velocity Ω about their common centre of mass. Neglecting terms in m/M, the mass ratio of the electron and H particle, the angular momentum of the system is $ma^2\Omega$ or $\frac{1}{2}mcr(a/r)^2$, which is $\frac{1}{2}(h/4\pi)(4a/3)^2$.

We thus have, as it were, a need for these small angular momentum

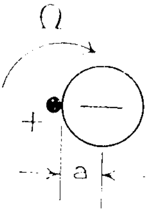

Fig. 7.14

quantities when we think of the transmutation of particles involving heavy nucleons, the H particles, in motion at the angular velocity Ω. The motion states considered involve balance with an electron. Consequently, it may be that these angular momenta have some residual association with the electron even when it has transferred to perform other roles. Guided by the quantitative implications, we will evaluate the two angular momentum quantities just derived. That just presented is simply 8/9 divided by 137 squared in units of $h/4\pi$. This is:

$$0{\cdot}000049$$

(7.17) is simply evaluated since $e^2/2c$ is $a(h/4\pi)$. It is:

$$0{\cdot}001100$$

Together, the angular momenta total 0·001149 half-spin units which could possibly be an anomalous angular momentum component of the electron. Furthermore, as already discussed, the electron participating in balance in magnetic nuclear resonance measurements can have an angular momentum of $(1-2a)h/4\pi$ owing to transfer action with the nucleus. This is mentioned in deriving (7.15). On this basis it is possible that in some situations the anomalous parameter 0·001149 is referenced on $1-2a$ instead of unity. This would increase its effect, as a ratio, to 0·001166.

This is mere speculation. No attempt is made to explain the physical processes by which the electron acquires its residual spin properties. Further, no attempt is made to explain the true nature of the magnetic moment of the electron. There are problems remaining. Suffice it to say that we need not be surprised that the electron behaves anomalously. It may be coincidence that the analysis just presented leads to anomalous factors of 0·001149 and 0·001166 according to the two possible states of the electron in its nuclear balance role. The fact that two conflicting measurements of 0·001146 and 0·001165 have emerged in practice is certainly of interest. Although, as yet, the argument presented is not conclusive, it is possibly sufficient to show the reader that the success of the quantum electrodynamic approach may not be the last word on the subject. What is offered here may lead to a better explanation.

The outcome of this review is that residual spin properties are a feature of the electron produced in transmutations. Apart from this, the zero total angular momentum condition is retained and can be applied both to the space–time lattice particles and, at least to close approximation, to the electron moving with the E frame. The half-spin quantum $h/4\pi$ remains standard either as the basic approximate quantum of electron spin or as the balancing orbital effect due to E frame motion and G frame balance. The proton in the E frame has zero intrinsic spin. Other heavy composite particles, the neutron and the deuteron, for example, appear to have a small intrinsic spin. Thus, it appears that, apart from any intrinsic spin, heavy particles containing nucleons have a total spin property not merely set by their mass and not merely in balance with the E and G frame motion components. These particles somehow get primed with spin angular momentum in multiples of $h/4\pi$. The proton has a spin angular momentum of $h/4\pi$ in spite of its zero intrinsic spin. The neutron has the same spin angular momentum with non-zero intrinsic spin. The deuteron has a spin angular momentum of $h/2\pi$. This topic will be discussed further in Chapter 9. The quantum nature of the spins of heavy particles has been assumed in the above analysis of spin magnetic moments. There were minor modifications of the spin quantization to allow for transfers of angular momentum. These involved the fine structure constant α. Accordingly, though it is claimed that an adequate account of magnetic moment of the spin states of nuclear particles has been developed, there is no explanation given for the angular momentum quantization. Also, the heavy particles containing nucleons do have angular momentum from their motion with all matter in the E frame. It is not true to say that their angular momentum sums to zero. Thus an out-of-balance of the angular momentum is a feature of the presence of matter in space–time. It is not surprising, therefore, to find astronomical bodies turning without there being any apparent balance of angular momentum amongst matter.

The problem of the spin magnetic moment of the electron has not been analysed directly. It will be shown in Appendix III that a lattice particle develops, by spin, a magnetic moment equal to two Bohr Magnetons. Perhaps the electron does the same for the same reason when it is set in the E frame. Perhaps, however, since this magnetic moment is locked in a fixed direction in space and is acting to cancel that developed by other electric charge in space–time, this property passes undetected. We do not need to speculate about it further. Little is likely to emerge. It is true that spin magnetic moment of the electron has been explained on established theory as being due to two separate components of charge differently distributed over the electron. One is deemed to rotate while the other remains at rest. This is bold assumption, indeed. It is analysed by Page and Adams (1965). It is demonstrative of the difficulties which the physicist has given himself by refusing to have anything to do with a real space–time medium and retaining inflexible electrodynamic principles.

Summary

The ideas developed in Chapter 4 on the wave mechanical model of the atom have been melded with the thoughts on the electron and deuteron presented in Chapter 1. The object has been to provide an insight into the structure of the atomic nucleus. The nature, mass and magnetic moment of the proton, neutron and deuteron have been explained. It is to be expected that the properties of atomic nuclei, as aggregations of protons and neutrons, should become explicable on this theory. Though this remains to be explained, progress has been made in finding the bonds between such nucleons. These bonds appear to be electron-positron chains and this is evidenced by the essential role played by the pion in their formation. The pion latches on to a heavy basic particle, a nucleon, and so releases a binding energy which is enough to account for the self-energy of the pion and provide a surplus needed to create the chain. The result is that the mass effect of the binding energy, being negative, just over-compensates the mass of the pion itself and that of the related chain forming one of the bonds between the protons and neutrons. The result, of course, is that any atomic nucleus appears from its mass relation with other atoms to be a mere aggregation of neutrons and protons and little else. The fact that pions, which have significant mass, can appear to come from nuclei is, therefore, no longer perplexing. This problem has been overcome, with the most encouraging result that the length of the electron-positron chains forming the bonds has to equal the lattice spacing of space–time for the pion binding energy to a nucleon to provide the right answers.

The calculation of the energy released in neutron to proton decay has been an important feature of this chapter. The prediction of the existence of a fundamental particle, the so-called H particle, is important. The indication that it can have two forms, one slightly less massive than the other, can have important bearing upon the explanation of the packing fraction curve in further development of this account.

Electron spin has been discussed. Anomalous properties of the electron are consistent with the ideas presented in the analysis of the magnetic moments of the proton, neutron and deuteron. Also, the argument was linked with the explanation of the gyromagnetic ratio presented in Chapter 2. This in turn involved further support for the basic features of space–time as outlined in Chapter 6, since the analysis in Appendix III has a basic dependence upon these features.

We must next turn attention to the magnetic properties of much larger bodies. Terrestrial magnetism can be explained without difficulty from the same principles as used above. This is pursued in the next chapter. It shows that gravitation is not the sole link in the application of this new concept of space–time to both the atom and the cosmos.