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THE STRUCTURE AND PROPERTIES OF MUONS AND PIONS IN THE EXPONENTIALLY DAMPED BREIT-PAULI-SCHRÖDINGER (XBPS) MODEL

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ABSTRACT

The Exponentially-damped Breit-Pauli-Schrödinger (XBPS) model of elementary particles is applied to the description of muons, pions and kaons. Based on the products of their decay processes, the compositions of these meta-stable particles are given in terms of protons, electrons, and neutrinos and their antiparticles. Claims that there is more than one flavor of neutrino are examined, including the theory of neutrino oscillations. Arguments for and against concluding that the neutrinos are massless are discussed. It is pointed out that calculations employing the XBPS model indicate that the parity of the pions is positive, contrary to the assumption of Yang and Lee which led to the belief that parity is not conserved in the weak interaction. The electroweak analogue of the Stern-Gerlach effect is shown to give a straightforward nterpretation of nuclear decay processes based on the assumption that the neutron contains an electron and antineutrino prior to its decay. On this basis the need to assume that the conservation of parity is violated in order to explain the experimental observations of Wu et al. is avoided.

KEYWORDS: *Elementary Particles, Muons, Muon Neutrinos, Neutrino Oscillations, Neutrino Rest Masses, Pions, Parity Conservation, XBPS Model, Electroweak Analogue of the Stern-Gerlach Effect*

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INTRODUCTION

The concept of the creation and annihilation of matter is such an integral part of modern theoretical physics that any attempt to modify it requires a wide-ranging survey of many types of phenomena. It is not enough to show that the hypothesis can be avoided in dealing with one group of experimental findings, only to conclude that it is nevertheless essential for a consistent interpretation of other classes of observations. In the present work we will give consideration to the properties of elementary particles observed in high-energy interactions other than those directly involved in conventional chemical and nuclear reactions.

The broad lines of the approach we shall take to this subject have already been laid down in previous work [1-3] dealing with the structure of the neutron. If one makes the counter-hypothesis that nothing appears and disappears from existence in the course of physical processes *and that an essential particle balance is always maintained as a consequence*, it becomes necessary to assume that the neutron is not an indivisible entity, but rather that it is a compound of the three elemental particles into which it decays after a relatively long lifetime. Consistency requires that the same assumption apply to the many (meta-stable) members of the lepton, meson and baryon families which have been identified since high-energy processes became accessible in laboratory investigations. At the same time, it is important to consider what relation such an approach has to existing theories on this subject, particularly those based on the quark model of elementary particles. As mentioned in Sect. 5 pf Ref. [1], the possibility that the building blocks employed in a comprehensive theory of elementary particles are themselves composed of still simpler forms of matter does not necessarily invalidate such an alternative model, particularly if useful results can be obtained from it which are either unavailable from the competing theories or can only be extracted from them with significantly more difficulty.

In the present approach, we will continue to replace the conventional assumption of the creation and destruction of particle-antiparticle pairs with that of the existence of binary systems of zero rest mass, specifically e^+e^-, p^+p^- and $\nu\bar{\nu}$ [4,5]. In one sense this substitution has already been programmed into the theory because most elementary particle processes as yet observed can be interpreted in terms of effectively balanced equations obtained by the heuristic addition or subtraction of appropriate numbers of particle-antiparticle pairs. The reactions of eqs.(i-v) and/or eqs. (i'-v') mentioned in Sect. 2 of Ref. [1] offer a simple illustration of this general procedure. In many ways it is easier to deal theoretically with particles which simply pass to and from existence, because otherwise one has to be concerned with the detailed representation of states of matter which carry neither energy nor momentum at a given stage of a reaction. The calculations of Refs. [4,5] have attempted to address this problem with the help of a Schrödinger-type formalism, but there remain many details of specific experimental processes which need to receive careful consideration in order to properly assess the viability of the mass-less binary hypothesis.

THE STRUCTURE OF MUONS AND PIONS IN THE XBPS MODEL

The lightest meta-stable elementary particle with a measurable lifetime is the muon $\mu^\pm$, a fermion of unit electric charge, existing in both particle and antiparticle forms. As before with the neutron, one can proceed on the supposition that the identity of its decay products is an important indicator of its elemental composition. There is a significant distinction, however, namely the muon's decay products are not unique, although this is nearly the case. By far the main decay mode leads to the production of three particles [6,7],$e^\pm$, ν or $\bar{\nu}$. In general, we will refrain from discussing how the identification of the decay products is established unless there is some important question regarding it. There are three other reactions for which upper limits for fractional occurrence are reported, however. Of these the most likely corresponds to the products $e^\pm$ and two photons ($\gamma\gamma$); they are thought to occur in less than 1.6 x 10^{-3}% of all muon decays. Two other even rarer sets of products (by roughly three orders of magnitude) are respectively 3e ($e^\pm$, e^+, e^-) and eγ. Under the circumstances there is really no choice in the present approach but to assume that the muon composition is $e^+\nu\bar{\nu}$ for μ^+ and$e^-\nu\bar{\nu}$ for μ^-, i.e.the major products, but it is useful to consider how the other possible products might arise.

The almost negligible occurrence of the eγ decay branch is one of the factors which led to the conclusion [8] that muon neutrinos are not identical with those occurring in nuclear β decay, as will be discussed in the fol1owing section. In the XBPS model one can at least rationalize the existence of such a possible decay branch by simply assuming that the component ν and $\bar{\nu}$ species might combine to form a mass-less $\nu\bar{\nu}$ binary which does not carry away any energy and is thus undetectable. Since the remaining electron product would violate the conservation laws of energy and momentum by taking up all the decay energy, something else would have to be involved, however. Just as with the conventional radiative processes discussed in Ref. [4]**,** it can be assumed that some energy could be carried away by a photon. Instead of the latter simply being created, however, to be consistent with the present model one must assume that an e^+e^- system which is found in the mass-less state prior to the initiation of the decay process might undergo an interaction with the muon.

In much the same way, more than one photon might conceivably become involved. At the same time, the decay energy of 104 MeV is more than sufficient to cause an e^+e^- binary to be broken into its two component elements, thereby producing yet another set of products (3e). The only point that should be emphasized at this juncture is that just because a balanced equation can be written down does not at all mean that the corresponding reaction will occur with significant probability. The potential advantage of an *ab initio* model such as the present one is that in principle it allows not only the computation of the energy and wave function of particles such as the muon, but also its relevant reaction rates and/or transition probabilities. The experimental evidence shows that each of the three minor decay modes is rarely if ever observed and one would hope that calculations can eventually be carried out to satisfactorily explain why this is the case.

For the present the immediate goal is to treat the $e^+\nu\bar{\nu}$ system with the help of the XBPS Hamiltionian in an analogous manner as for $p^+e^-\bar{\nu}$ in Refs. [2,3]. The simplest way of comparing these two systems is to replace the $0^-e^-\bar{\nu}$ complex of the neutron by the corresponding $\nu\bar{\nu}$ state and let a positron play the role of the proton relative to the earlier calculations. The resulting wave function would seemingly be consistent with the fact that the muon's magnetic moment is measured to be exactly what one would expect for an electron with a correspondingly greater rest mass (207 m_e) [9]. Any magnetic properties of ν and $\bar{\nu}$ should be expected to be effectively cancelled, but the binding of an electron to them in a resonance-type state would keep it from behaving as a free particle in the presence of an applied magnetic field. A quite similar argument has been given in Ref. [3] to rationalize the fact that the neutron's magnetic moment is only on the order of a nuclear bohr magneton, even though it is also assumed to have an electron as one of its constituents. The energy of the $e^+\nu\bar{\nu}$ system relative to its separated products can be expected to be much higher than for $p^+e^-\bar{\nu}$ because a) a positron must have much higher kinetic energy than a proton in a tight-binding state and b) even though it has a much larger q/m_o value than p, it can make little use of this advantage because of the essential neutrality of the $\nu\bar{\nu}$ component.

To investigate how the XBPS Hamiltonian would describe such an $e^+\nu\bar{\nu}$ system, calculations have been carried out by employing two different basis sets which are analogous to those discussed in Refs. [2,3] for the $p^+e^-\bar{\nu}$ complex. The same neutrino (antineutrino) $|q/m_o|$ values are assumed as before, namely 0.5733 and 0.630 a.u. for the smaller (2s,2p) and larger (3s,2p,2d) basis, respectively. It will be recalled that these values were chosen in order to fulfill the condition of obtaining the experimental neutron rest energy of +28781 hartree as the lowest eigenvalue in the corresponding full CI treatment. For consistency the previous values of the damping constant A have been employed for each basis (1.054 a.u. for 2s,2p and 1.26475 a.u. for 3s,2p,2d), these having been chosen in a similar manner to obtain the $2mc^2$ binding energies for the various particle-antiparticle binary systems.

The total energy values obtained from these calculations are shown as a function of the respective basis scale factors in Figure 1. The small basis leads to a very low minimal energy of -277630 hartree, which would indicate that the $e^+\nu\bar{\nu}$ system is actually bound with respect to the energy of the constituent particles separated to infinity. When the d functions are included the picture changes significantly, however, with the minimal energy of the system increasing to a positive value of 17954 hartree, an increase of nearly 300000 hartree (8.2 MeV) relative to the first result. By contrast, the corresponding

$p^+e^-\bar{\nu}$ minimal energies in the analogous treatments are computed (Figure 2) to be the same in both treatments (as provided for by the above choices of the respective q/m_o antineutrino values in each basis).

The computed results thus indicate that the positron can easily polarize the $\nu\bar{\nu}$ system in the very small 2s,2p basis, producing significant binding, but that this process becomes rapidly less effective as polarization functions are added to the basis. The increased value of the damping constant A in the 3s,2p,2d basis greatly reduces the magnitude of the attractive r^{-3} operators in the Hamiltonian, and the corresponding reduction in the system's total kinetic energy brought about by the basis set improvement falls far short of making up for this effect, unlike the situation for its $p^+e^-\bar{\nu}$ counterpart. An analysis of the corresponding energy contributions is given in Table 1 for the larger basis, and this helps to understand the origin of the above effects. The most novel result in the table is that the usual pattern of signs of the various interactions is not adhered to for the $e^+\bar{\nu}$ pair. Normally, one finds that particles with the same sign for their q/m_o values, as in this case, have positive energy contributions for each of the spin-orbit, orbit-orbit and spin-spin interactions, but a negative value for the Darwin term. Instead, for $e^+\bar{\nu}$ one obtains negative values for the spin-other-orbit, orbit-orbit and spin-spin contributions. The spin-spin δ-function term in the latter case has an expectation value which is actually more negative than either of its $e^+\nu$ and $\nu\bar{\nu}$ counterparts.

Table 1 shows Energy contributions (in hartree) of various operators (see Table 1 of Ref. [2] for definitions) and particle combinations for the $1/2^-$ ground state of the $e^+\nu\bar{\nu}$ muon (μ^+) system obtained by employing the 3s,2p,2d basis with scale factor $\eta = 0.14$, exponential damping constant $A = 1.2648$ a.u. and antineutrino q/m_o value of 0.63 a.u. for the XBPS Hamiltonian.

Comparison with the corresponding 2s,2p results shows, however, that the absolute magnitudes of these various $e^+\bar{\nu}$ terms are only about one-half as large for the 3s,2p,2d basis, and so there seems to be a definite trend to sharply curtail their influence on the overall binding process as the level of treatment improves. It is very difficult to say anything more quantitative about what the minimal $e^+\nu\bar{\nu}$ energy is in the limit of a complete basis being employed, but it seems at least likely that a) a reasonably deep potential well should still exist and b) that the corresponding energy at this point should be much higher than indicated in the 3s,2p,2d treatment. The experimental rest mass of the muon corresponds to a total energy of 3.864×10^6hartree (105.14 Mev) relative to that of its decay products, so the calculations carried out to date are still greatly deficient in this respect. It may also be that the resonance state most properly identified with the muon at the present level of treatment actually corresponds to one of the computed excited states lying at much higher energy rather than the most stable such species whose properties are shown in Table 1 and Figure 1.

Qualitatively a rather consistent picture emerges from the computed results, however. The positron must come very close to the $\nu\bar{\nu}$ complex to overcome a large centrifugal barrier. For a narrow range of inter particle distance it might be sufficiently attracted to the neutrino (negative q/m_o value according to the $p^+e^-\bar{\nu}$ computations) to induce a polarization in the $\nu\bar{\nu}$ system. Comparison with the $p^+e^-\bar{\nu}$ results indicates that this is a relatively unstable situation, because the neutrino is more strongly attracted to e^+ than to $\bar{\nu}$ by virtue of the former's larger (positive) q/m_o value. In order to bind such light particles together it has been found in Refs. [2,3] that they should have opposite spins. In the $p^+e^-\bar{\nu}$ system the antineutrino is sufficiently more attractive for the electron than the proton that there is relatively little question about which pair of particles should bear a singlet relationship to one another. One can imagine there is a much greater competition between e^+ and $\bar{\nu}$ to form a 0^- complex with a neutrino, however, and that this eventuality shortens the lifetime of this three-particle system considerably. Experimentally the muon decays 4.17 x 10^8 times faster than the neutron. The possibility that a muon neutrino (ν_μ) is fundamentally different from ν_e is an additional source of uncertainty in the above ca1culations, as considered in detail in the next section. One could vary the q/m_o value for ν_μ so as to obtain the experimental muon binding energy, in which case it would be of interest to see how much the two charge-to-mass ratios differ in the $p^+e^-\nu_e$ and $e^+\nu_\mu\bar{\nu}_e$ ca1culations.

The above model for the structure of the muon also provides a ready explanation for the negligible probability of producing a photon in its decay processes. Since the stability of the $e\nu\bar{\nu}$ system requires the existence of a particular spin relationship between ν and $\bar{\nu}$, it seems quite likely that any bond between them is destroyed in the decay process, causing these two particles to go off in different directions rather than as a bound diatomic system. The decay energy is therefore divided up among all three component particles, with no need to involve an additional system in the neighborhood of the muon at the time of disintegration. The possibility that a muon is formed by the interaction of the same three particles, i.e. the reverse reaction, is almost never realized experimentally. Instead the most common mechanism for the formation of muons involves the decay of pions, as will be discussed below.

Since the $\pi^\pm$ mesons are observed to have a neutrino and a muon product in virtually all decay processes, it is consistent with the present model to propose that they are tetra-atomic systems, composed of an electron and three neutrinos. For π^+ it seems likely that two neutrinos are present, along with one e^+ and one $\bar{\nu}$. In this way two of the components would have positive q/m_o values ($e^+$and $\bar{\nu}$), and the two ν, negative. The μ^+ species has a positive magnetic moment, and thus would be much more likely to form a bond with a neutrino (negative q/m_o) at short range than with an antineutrino. Just as the two muons, the $\pi^\pm$ systems bear a particle-antiparticle relationship to one another, consistent with the above structure. The rest mass of the charged pions is 34 MeV or 1.25 x 10^6hartree greater than for $\mu^\pm$. Thus the increase in energy required to attach a fourth particle to the system is about the same as the energy per particle needed to form the $e^+\nu\bar{\nu}$ complex.

The XBPS model also helps to explain why pions are more likely to be formed in high-energy reactions than are muons. The latter are seen to be relatively unsaturated with respect to the addition of neutrinos, and these can be provided by mass-less $\nu\bar{\nu}$ binary systems. It is not possible to be more definite about such relationships without the benefit of quantitative calculations, but at least a picture of the muon-pion relationship emerges which is qualitatively consistent with what has been found in the treatment of proton-containing systems. The pions are known to have singlet multiplicity and as such can be distinguished from the other tetra-atomic system treated above, the $p^{+2}e^-\bar{\nu}$ deuteron analogue. The XBPS computations [5] for the e^+e^- and $\nu\bar{\nu}$ systems show that by far the lowest energy results in such light particle-antiparticle pairs for singlet multiplicity. This finding strongly suggests that the most stable states of systems composed of more than two such particles will either be singlets for an even or doublets for an odd number of constituents.

The same argument has been used in Refs. [2,3,10] to justify the well-known fact that the multiplicities of nuclei are determined solely by the nucleon spins, since electrons and antineutrinos must be expected to occur exclusively with paired spins to maintain the required stability within systems of such small radius. The relatively unsaturated nature of the charged pions also helps to explain the fact that they interact with nuclear matter much more readily than do muons. In this view, while the ingredients for muon formation, namely electrons and neutrinos of both helicities, are available in typical high-energy processes, the possibility of further reaction to form pions under the same conditions is relatively high. In cosmic rays it is found that when the translational energy drops below 100 MeV, however, the pions are much less strongly interacting, at which point their decay into muons becomes the favored process.

Five other minor decay modes are thought to occur for the charged pions, with fractions of 10^{-4}-10^{-8}. the corresponding products are eν, μνγ, π^0eν, eνγ and eνe^+e^-. All of these results can be thought of as arising from the addition or loss of a $\nu\bar{\nu}$ and/ore^+e^- binary system. In the first case, for example, it is necessary to assume that a $\nu\bar{\nu}$ species is formed but that all the decay energy is carried away by the remaining electron and neutrino of the original pion. In the second case, an additional photon is observed as well as the usual muon and neutrino products. This is always at least a theoretical possibility in the XBPS model. The π^0 species mentioned in the third minor process requires a separate discussion below, while the manner in which the eνγ products could be formed is analogous to that in the process already discussed above for muon decay involving a photon. Consequently, this is an equally (highly) improbable event, as is the related process in which the photon is replaced by its e^+ and e^- fragments.

The neutral pi meson π^0 has a rest mass only 3.4% smaller than that of $\pi^\pm$ and hence is thought to bear a close relationship to them, a feature which is of considerable importance in isospin theory. Yet the decay products are quite different for the neutral pion, and thus there is evidence that its composition is notably different than that of the charged species. In this case there are two relatively important decay modes [6,7], namely γγ and γe^+e^-, the former occurring 98.83% of the time. The assumed e^+e^- structure of the photon in the XBPS model indicates that the π^0 neutral pion contains at least one electron and positron. Even though no neutrinos have ever been observed among the decay products, it still seems probable that they are constituents of π^0 based on its close relationship to the charged pions. A conceivable structure would be $e^+e^-\nu\bar{\nu}$, for example, in which case it must be assumed that upon decomposition of the π^0 a $\nu\bar{\nu}$ binary is always formed in a mass-less state. This would suggest that the decay mechanism is significantly different than for the charged pions, which at least is consistent with the fact that π^0 has a much shorter lifetime (0.84 x 10^{-16} s vs. 2.6024 x 10^{-8} s) than the other two particles. In this case the decay would most plausibly be assumed to arise from a pairing of the ν, $\bar{\nu}$ and e^+,e^- constituents which is quite different than in the meta-stable π^0 structure itself. The energy given off in the decomposition would then have to be taken up in part by a neighboring (initially mass-less) e^+e^- system, producing two observable photons as decay products, either as bound e^+e^- species in the main branch or as one bound (γ) and one unbound electron-positron pair in the other.

Since e and ν have similar kinetic energies in tightly bound systems, it is reasonable to expect that a π^0 structure of this nature would also be a singlet, with about the same energy relative to its separated products as the charged pions. The larger q/m_0 values of electrons *vis-a-vis* neutrinos, plus the possibility of a favorable Coulomb interaction (with suitable polarization of the respective charge distributions) is seemingly consistent with an increase in attractive contributions to the potential energy relative to systems with only one electron and three neutrinos, and this might explain why π^0 is 2.0 x 10^5hartree more stable than $\pi^\pm$ (again compared to their respective separated products). The assumed π^0 structure also agrees with the fact that it is its own antiparticle. From this point of view an $e^+e^-e^+e^-$ composition would be equally suitable, but again consideration of characteristics of the various pion decay modes suggests that such a structure differs too greatly from that assumed for the charged pions to be consistent with the fact that all three of them have very similar rest masses. The $\pi^{\pm}$ decay to π^0 plus eν mentioned above can be made into a balanced equation by imparting a portion of the released energy to a neighboring mass-less

e^+e^- system which then promptly decomposes. The resulting electron would then effectively replace one of the charged pion's neutrinos to form π^0, while setting free the corresponding charged antiparticle. In general, once the available energy exceeds the rest masses of such meta-stable particles, there exists a certain theoretical possibility for their formation because of the relatively small binding energies of the

$\nu\bar{\nu}$ and e^+e^- binaries in their mass-less ground states and the abundance of such species which is expected based on statistical considerations [4].

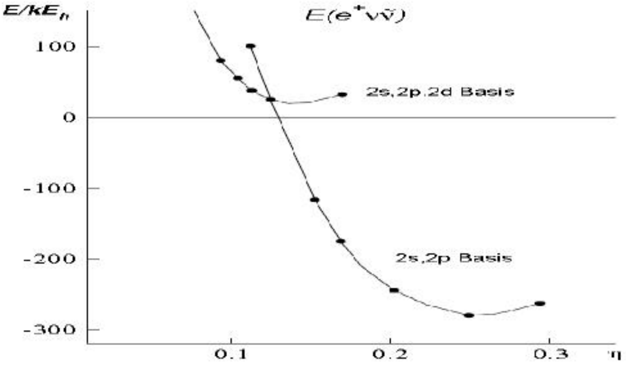

Figure 1: Comparison of the Variation of the E^+¬ $\bar{\nu}$ (μ^+)Total Energy (In Khartree) A Function of the Scaling Factor ¦ in XBPS Model Calculations Employing Two Different Basis Sets.

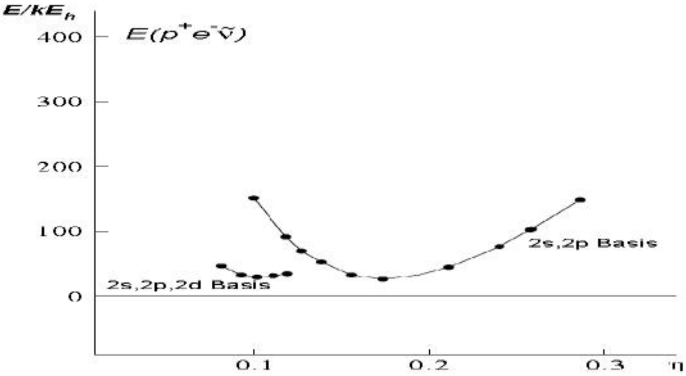

Figure 2: Comparison of the Variation of the P^+E^- $\bar{\nu}$ (N) Total Energy (In Khartree) As A Function of the Scaling Factor ¦ in XBPS Model Calculations Employing Two Different Basis Sets.

Table 1

Operator	**e^+¬**	**¬ $\bar{\nu}$**	**e+ $\bar{\nu}$**	**Total**
Kinetic Energy	914699.446 (e^+)	1246689.492 (ν)	1366978.39($\bar{\nu}$)	3528367.329
Spin-same-orbit	-186658.825	-324413.699	37375.604	-473696.920
Spin-other-orbit	-377147.037	-655810.773	-92665.363	-1125623.173
Darwin Term	144372.056	99577.870	-260521.486	-16571.560
Orbit-orbit	-385608.003	-610417.712	-164475.609	-1160501.324
Spin-spin	-157191.708	-303279.608	-24061.778	-484533.094
Spin-spin δ	-57379.559	-42673.178	-149434.600	-249487.337
Total Energy.				**17953.923**

MUON NEUTRINOS

A key consideration in the foregoing section is whether the neutrinos involved in the decay of pions and muons are different from those first encountered in (nuclear) β decay processes. In 1961 the conclusion was reached [8] that they are not the same, and it is interesting to consider the experimental evidence supporting this view. It should be recalled that the XBPS Hamiltonian leaves open the possibility that any q/m_o value for a mass-less, charge-less particle is consistent with the requirement that its particle-antiparticle binary have zero rest mass [2]. The same damping constant A leads to the desired (vanishing) energy for any q/m_o value by virtue of the scaling theorem discussed in Ref. [2], so in this sense the XBPS model would be compatible with the existence of more than one type of neutrino. It is necessary, however, to assume that the rest masses of each type of neutrino *be exactly zero* to obtain such a result in the XBPS model. Experimentally one is only able to give upper limits for the rest masses of ν_e and ν_μ but there is no proof that the true value might not be zero in both cases, so such a theoretical assumption is tenable. Originally the argument for the muon neutrino being distinct from that involved in nuclear β decay was based solely on the absence (or at least vanishingly small occurrence rate) of the decay $\mu \rightarrow e\gamma$ (see previous section). A muon quantum number L_μ was introduced[11] to explain this observation (or lack of it). As usual, this quantity is assumed to be conserved in allowed processes, and by construction this is not possible for the above photon-producing decay. Accordingly L_μ is ∓ 1 for $\mu^\pm$ but zero for e and γ. The pions are also assigned a value of $L_\mu = 0$, which means that the corresponding values for $\bar{\nu}_\mu$ and ν_μ are -1 and 1 respectively, which assignment renders pion decay into a muon and neutrino allowed (L_μ is conserved).

On the basis of L_μ conservation it can also be argued that the reaction of a muon neutrino with a neutron cannot produce an electron and a proton, since only the former particle has $L_\mu \neq 0$. The reaction would be allowed if a muon and a proton were the products, however. An experiment employing high-energy pions to produce muon neutrinos[8]was carried out to test this supposition and the results verified that muons are produced and not electrons, consistent with the L_μ conservation principle. On this basis it has generally been accepted that ν_μ and $\nu_e$are two different entities, each having its own antiparticle and presumably differing in other properties from one another. The helicities measured for ν_μ and ν_e are the same (negative and both positive for the respective antineutrinos) [12, 13].

One should be careful to note, however, that the reaction conditions under which pion neutrinos are scattered off neutrons are not the same [8] as for the corresponding processes first studied in nuclear beta decays. For example, the original Reines-Cowan experiment [14] involves antineutrinos of only 2.5 MeV energy, for which the corresponding cross section for proton-positron production is only $11 \pm 4 \times 10^{-44}$ cm^2. The Brookhaven experiments[8]by contrast employ neutrinos of much higher energies (in the GeV range), in which case muons are produced with a cross section as high as 10^{-38} cm^2, at least five orders of magnitude greater. Under the circumstances it cannot be argued with complete certainty that the distinctive reaction profiles of the two types of neutrinos prove that an intrinsic difference exists between these particles unless it can be shown that such widely different experimental conditions have no effect on the outcomes of the respective experiments. In other words it would not be the first time that different products are found to result from ostensibly the same reaction performed under widely differing experimental conditions.

If one looks at the specifics of the neutrino scattering process, it is clear that a muon can only be produced if the neutrino energy in the center-of-mass framework is in excess of 105 MeV because of the relatively large muon rest mass. This condition is not fulfilled in the Reines-Cowan experiment [14]. On the other hand, it is conceivable that when much higher energies are involved, as in the Brookhaven experiments [8], the production of electrons is suppressed to the extent that only muons are formed initially (muons decay to electrons eventually anyway). The only way to really be certain that this is not the case is to run the two types of experiments under exactly the same conditions, but this is very difficult (impossible?) to arrange in practice. If muon neutrinos are really different from electron neutrinos, it could be demonstrated by somehow accelerating the latter to energies of 1 GeV or more and seeing how many muons and electrons are produced under these circumstances. As it stands now all we know for certain is that the cross section for muon production is relatively high when the reacting neutrinos have energies in excess of 1 GeV, while that for electron production is much lower for neutrino energies of a few MeV and essentially zero for energies in the GeV range.

Especially since the longitudinal polarization experiments for the two types of neutrinos indicate no difference in their helicity properties [12,13], the availability of such experimental evidence for high-energy $\nu_e$scattering ($E \geq 500$ MeV) would seem highly desirable, if not essential, to remove any doubt that ν_μ might not in fact be identical to ν_e. Based on what has been found in calculations with the XBPS Hamiltonian for the $p^+e^-\overline{\nu}$ system, which in the present model is associated with the neutron, it is not difficult to imagine that the probability of freeing an electron by scattering neutrinos off a meta-stable nucleus is very small. With relatively little kinetic energy it is very difficult for the neutrino to overcome the substantial centrifugal barrier (Figs.1-2 of Ref. [2]), and thus come close enough to the system's electron to dislodge it. Increasing the energy to the GeV range decreases the neutrino's de Broglie radius by at least 100 times, which greatly increases the probability of decomposing the nucleus, as observed in the high-energy pion experiments[15]. At such close distances the neutrino is much more likely to make use of the short-range attractive potential needed to obtain binding in such systems according to the calculations of the XBPS model. In the process of removing an electron from the rest of the nucleus under such high-energy conditions, it therefore seems likely that the neutron's antineutrino could retain its attraction for the electron while at the same time forming a bond with the incoming neutrino. The result would be that the tri-atomic $e^-\nu\,\overline{\nu}$ complex is formed, which in the last section has been identified with the negative muon.

In other words, increasing the energy of the scattering neutrinos not only increases the probability of breaking up the nucleus but also can be expected to have a decided influence on the nature of the decay products as well. When the energy falls below the 105 MeV threshold, it is impossible to form a muon under any circumstances, so when a reaction does occur, the only possibility is for an electron to be set free. Above this energy the experiments might be indicating that the only way to free the electron from its position within the nucleus is to have it become attached to the incoming neutrino without losing its hold on an antineutrino also present in the scattered nucleus.

The discussion about whether there are two kinds of neutrinos became even more complicated when it was reported that a third flavor, the tau neutrino, had been found [16]. The tau particle itself is 20 times heavier than the muon. The arguments given above for the possible fallacious assignment of the muon neutrino also apply in the case of the tau neutrino. It is also worth noting that there was a parallel attempt to investigate whether the proton is subject to decay, as predicted by the Grand Unified Theories [17,18] of elementary particles, but in the meantime it is taken as a virtual certainty that this is not the case. A perfectly stable proton is completely consistent with the XBPX model. The related work involved new experiments dealing with atmospheric neutrinos, however. This led to the theory of neutrino oscillations [16].

When an atmospheric neutrino interaction occurs inside water, secondary particles are produced, and some of them travel faster than the speed of light in water. In this case Cherenkov radiation is observed…The signature of an electron is much different than for a muon [16]. A prediction of the numbers of e-like and μ-like events [19] was not verified to a satisfactory extent, and this led to an explanation in terms of neutrino oscillations./

This theoretical result is still controversial, as indicated, for example, by the fact that there was a period of 3.5 years between the initial submission of Kajita's paper [16] and its eventual publication. One of the questions this work raises is whether the muon neutrino actually exists as such or whether instead that it is constantly changing from one type to another

Without the benefit of quantitatively reliable calculations it is difficult to either prove or disprove the validity of such a model. If the neutrino q/m_o value required for the present XBPS Hamiltonian (retaining the original e^+e^- damping constant A) to yield the experimentally measured rest mass of the muon as the minimal energy for a (meta-stably) bound $e\nu\overline{\nu}$ system is the same as needed to obtain the neutron's rest mass for the $p^+ e^- \overline{\nu}$ system, such evidence would seemingly favor the conclusion that $\nu_\mu$and ν_e are actually identical, as suggested by the arguments given above. If instead, one looks at such reactions as involving annihilation of incoming particles and creation of outgoing species in their place, it is reasonable to overlook such possibilities and simply conclude that at least two fundamentally different types (or flavors) of neutrinos must exist in order to explain the results of the Brookhaven high-energy pion experiments [8]. Once it is assumed that particles cannot be created and destroyed, however, it is necessary to consider the mechanism of the neutrino attachment process in more detail, and it becomes less obvious that such a conclusion is justified.

One of the most remarkable claims of the theory of neutrino oscillations is that it requires that there be a non-zero rest mass of the neutrino [16]. Pauli's argument for the existence of the neutrino in β decay [20] was based on his belief that the laws of energy and momentum conversation mustbe satisfied in sucha process. Moreover, this fact could only be explained by the existence of a third particle,in addition to the daughter nucleus and an electron, in the products of the decay. The distribution in the energy of the electrons emitted in the decay of ^{12}B is shown in Fig. 9-20 of Ref. [21], for example. It shows first and foremost that there is a wide range of kinetic energies, in agreement with Pauli's conclusion than a two-particle decay is ruled out by these results. Careful attention to detail shows, however, that the maximum in kinetic energy is exactly what one would expect for a strictly two-particle decay. The simplest explanation of the latter finding is that the third particle possesses a vanishing rest mass. During his lifetime, Pauli complained [22] that the upper limit for this rest mass was set too high. Contrast this statement to the remark made by Kajita [16]: "If the mass of the neutrino is heavy, one naively expects that the maximum energy of the observed electron is lower than that in the case of a massless neutrino."Comparison of these two views emphasizes the need for renewed effort to minimize the discrepancy between the observed maximum kinetic energy of the decay electrons and the theoretical value indicated on the basis of assuming a vanishing rest mass for the neutrino. Such investigations are at least relatively straightforward in comparison to the extremely complex attempts to verify neutrino oscillations. Until a definitive result can be obtained from such experiments, the possibility continues to exist that the assumption of both the Grand Unified Theories and the XBPS model of a massless neutrino is completely justified.

One of the main differences in the properties of massless vs. massive neutrinos concerns their maximum speed. According to Einstein's relativity theory [23], it is impossible for an object with rest mass $m_0>0$ to ever reach a speed of $v=c$ since this would mean that its relativistic mass/energy would attain an infinite value. As discussed in previous work [24], however, a massless particle not only can travel with $v=c$ but also with speed in excess of c. Sommerfeld [25]disputed this point, but he based his conclusion on the Lorentz transformation (LT), which has since been shown to be invalid. This is because it leads to the conclusion of remote non-simultaneity, as illustrated in his popular example of lightning strikes on a moving train [26]. The Newton-Voigt transformation (NVT [27]) corrects this error, and shows that super-luminal speeds can be attained by light passing through a medium with $n_g<1$. If neutrinos have zero rest mass, the same argument might be used to predict v>c speeds for neutrinos, but this seems highly unlikely because of the absence of a comparable medium with which they might interact. There is nonetheless a strong likelihood that neutrinos always move with speed v=c in free space because of their vanishing rest mass,

CHARGED KAON COMPOSITION AND DECAYS: SYSTEMATIC NOTATION

Since a general procedure has been developed in the previous sections to describe the compositions of elementary particles, it becomes convenient to define some simplified notation which will help to make the subsequent presentation more compact. Especially after the discussion of the preceding section, it is at least tempting to restrict the class of *Aufbau* particles to include only the proton, electron and neutrino plus their respective antiparticles. It is helpful then to define a *composition vector* which contains an ordered set of occupation numbers for these particles in the order p^-, e^+, $\bar{\nu}$ .p^+, e^-, ν, i.e. antiparticle occupations before the decimal point, and corresponding particle values after it. For example, a proton is 100 (omitting the decimal when no antiparticles are involved), an electron is 10 (omitting left-hand zeroes where possible), and a neutrino is simply 1 (without a decimal point). The corresponding antiparticles then are 100, 10. and 1. respectively, suppressing right-hand zeroes when only antiparticles are present. The corresponding three particle-antiparticle binaries are then denoted by 100.100, 10.10 and 1.1 respectively, i.e.zeroes are only used as placeholders when absolutely necessary to avoid any ambiguities regarding which particles are present in a given system.

With the help of this notation a number of the most frequently occurring particles are analyzed in terms of their known decay products in Table 2. Since the thesis put forth in the above discussion is that different groups of decay products can only differ from the corresponding meta-stable particle's composition by an integral number of particle-antiparticle binaries, however, a further simplification can be introduced. Instead of listing the composition vectors for each collection of decay products, the numbers of such (differentiating) particle-antiparticle binaries is listed in the order: p^+p^-, $e^+e^-$and $\nu\bar{\nu}$. Net losses of such species are indicated with a bar over the corresponding number. As an example, consider the muon and its various decay products. Since its composition has been assumed above to include one electron (μ^-), one antineutrino and one neutrino, the corresponding vector is 1.11 (or 11.1 for μ^+). Since the major decay products are $e^-\nu\bar{\nu}$, no change in the corresponding composition vector is needed to represent this branch, as indicated by a zero in the right-hand part of Table 2.

The next set of decay products considered is eγγ, which can be obtained relative to the original 1.11 composition by the addition of two e^+e^- binaries and the corresponding loss of one of $\nu\bar{\nu}$ type. Hence this decay is listed as $2\bar{1}$ (again left-hand zero occupations are suppressed in the notation, in this case indicating the lack of involvement of p^+p^- binaries). Note that the corresponding μ^+ decay also involves the $2\bar{1}$ differential occupation of binary systems, this time relative to a 11.1 composition. Charge conjugation is represented in the composition vector notation by interchanging parts of the vector lying on opposite sides of the decimal point, but no corresponding change in the net gain or loss of particle-antiparticle binaries is ever needed. The other two decays discussed in Sect. II involve a $1\bar{1}$ change in binary systems in both cases, i.e. producing respectively three electrons ($e^{\pm}e^+e^-$) or $e^{\pm}\gamma$. In general no distinction is made between γ and e^+e^- in this notational scheme, consistent with the discussion in Refs. [4,5] in which the photon is assigned an electron-positron composition. The various conventions may be conveniently checked using the example of the pions and their decays, also as discussed in Sect. II.

Table 2 shows Classification of elementary particles by means of composition vectors as discussed in the text (rest masses in units of MeV /c^2). The composition vector is an ordered set of six occupation numbers abc.def, whereby. a, b and c are respectively the number of constituent antiprotons, positrons and; antineutrinos, and d, e and f are the corresponding numbers of protons, electrons and neutrinos. Left-hand zeroes are suppressed and the decimal point is given explicitly only when antiparticles are present. Also listed are the known (or in some cases, assumed) decay products of each particle and the fraction of each type of decay (see Refs. [6-7]). The number of particle-antiparticle binary systems needed to balance the corresponding decay reactive equation (binary increment BI) according to the present model are listed in the last column by means of the ordered set of numbers ghi, where g, h and i are respectively the number of additional p^+p^-, e^+e^- and $\nu\overline{\nu}$ species required (a bar over any of the latter quantities indicates that the binary systems must be included as products rather than reactants to achieve elemental balance; 0 denotes that no change in the corresponding number of binaries is needed relative to the reactants and decay fragments as written).

The next most massive mesons are the charged kaons $K^{\pm}$. Their decay energy is 3-4 times larger than for the muons and pions, and as a result it comes as no surprise that the number and variety of corresponding decay products grows accordingly. No less than six branches are observed with fractions in excess of 1%. In addition, many other less probable reactions are thought to occur. The first problem that arises as a result is that it is now less clear what elemental composition should be assigned to these particles prior to their decay. It is interesting to compare this situation with that faced by chemists when they are confronted with a previously unknown system which is found to participate in several different reactions under similar conditions.

The new ingredient in the puzzle which clearly complicates matters in the present case, however, is that there is no way to be absolutely certain how many particle-antiparticle binaries are either consumed or generated during the course of high-energy elementary particle decays. Under the circumstances one can never really claim that an absolute determination of the structure of a given particle has been made. There is naturally certain logic in choosing a composition which requires a minimal addition or loss of various particle-antiparticle binaries to achieve elemental balance in the totality of all decay modes for the system, and this approach has generally been taken in constructing the entries of Table 2. In the future it can be hoped that calculations of the particle's rest mass along the lines discussed in Sect. II and earlier in this study will help to verify whether a given assignment is realistic. Even if that situation comes to pass, it is still necessary to face up to the fact that there can never be any definitive means of proving that a particle's elementary composition has been correctly determined. The impossibility of observing the mass-less particle-antiparticle binaries which might be involved in a given decay reaction precludes this possibility.

With these preliminary remarks let us consider what composition can be assigned to the charged kaons based on the present model. One possible choice for the composition vector of K^- is 2.11, i.e.the same as for π^-. The possibility that two different elementary particles might have the same composition in terms of numbers of electrons and neutrinos cannot be ruled out because their different properties may simply arise because of the way the constituent particles are bonded together in each system. Again, in terms of conventional phenomena known in chemistry and molecular physics, one can speak of either different isomers or different excited states of the same collection of atomic building blocks (elements). It is at least conceivable that a collection of one electron and three neutrinos can be bound together in ways that are sufficiently different to produce distinct meta-stable states differing from one another by a large amount of energy (rest mass). On the basis of the calculations already discussed, for example, it is clear that rearranging the respective spin orientations of the various pairs of constituent particles can have a profound effect on the resulting total energy of the state formed.

The principle of requiring a minimal number of particle-antiparticle binaries to account for the observed decay modes of a given system nevertheless suggests a different assignment for the K^- structure, namely 13.22. Such a choice keeps the number of e^+e^- and $\nu\bar{\nu}$ binaries to an average of essentially one each in the six most important K^- decay modes. The entries in Table 2 are thus determined on this basis. The fact that this assignment puts the number of constituent particles at eight, which is double that for each of the pions, whereas the corresponding $K^\pm/\pi^\pm$ rest mass ratios are on the order of three to one, would therefore suggest that the kinetic energy of each electron and neutrino must be significantly greater for the charged kaons than for the muon and pion systems first considered. Since it is expected that the electron constituents must travel with nearly the speed of light, i.e.only slightly more slowly than the neutrinos, because of the very small dimensions involved, it follows that the total kinetic energy increases nearly linearly with the reciprocal of the inter-particle separation for both kaons and pions. Thus the 13.22 assignment for the K^- composition in Table 2 suggests that the radius of this system is somewhat smaller than that of the pions.

The main decay branch (63.52%) for $K^\pm$ leads to the formation of a neutrino and a muon of like charge. With an eight-particle assignment for the charged kaons it follows that both a $\nu\bar{\nu}$ and an e^+e^- mass-less binary must be formed in this decay and go undetected by virtue of their total lack of energy. Historically, the other major decays involving pion products have received the lion's share of interest, particularly since events producing both two and three such particles are observed. Because of this observation Yang and Lee were led to postulate[28] that parity is not conserved in these decays (τ-Θ puzzle), since each pion is assigned a negative parity and the appearance of both even and odd numbers of them had raised questions about how a single system can produce different sets of decay products of opposite parity. Further discussion of this point will be reserved until the next section in which the neutral kaons are discussed. In the present context it is better to pursue the question of how balanced reactions can be written down which cover both sets of pion products.

As shown in Table 2, no differential binary systems are needed in the present assignment to allow for the formation of $\pi^\pm$ and π^0 from $K^\pm$, while two additional $\nu\bar{\nu}$ species are needed to produce

$\pi^+\pi^-\pi^+$products (a binary increment of 2 in the table). In the latter case, the large amount of decay energy released by the charged kaons must cause the decomposition of these neighboring particle-antiparticle systems, with subsequent rearrangement to give the various multiple-pion products. The other three relatively frequently occurring decay modes for this system require the addition of an e^+e^- and $\nu\bar{\nu}$ binary, no change, and the loss of a single $\nu\bar{\nu}$ species, respectively. Thus, in both the $\mu^-\bar{\nu}$ and $e^-\pi^0\bar{\nu}$ branches it is assumed that mass-less particle-antiparticle binary systems are formed in the decay of the negative kaon.

In this connection it is well to recall that the discussion of the quantum characteristics of photons in Ref. [4] has led to the general conclusion that whenever a particle and its antiparticle form a tight-binding state of zero rest mass, the product should have no translational energy relative to the center of mass of the initial reactants. Any other state of translation for a product of vanishing rest mass must correspond to motion at the speed of light, which makes a transition to it from a stationary set of reactants highly improbable. By the same argument, whenever a photon with non-zero energy is observed as a decay product, it should correspond to an initially mass-less e^+e^- system which has simply gained energy as a result of the decay, rather than to one which has been formed from the elements of the original meta-stable species.

This situation implies that the possibility of any such binary system being formed in its mass-less state (and thus going undetected) must be left open on a general basis, i.e. just as for the various e^+e^- and $\nu\bar{\nu}$ species which are indicated in Table 2 to be present after a given reaction (as denoted by means of a bar over the appropriate entry for the number of differential binaries in each case). At the same time, it will be assumed throughout that $\nu\bar{\nu}$ and p^+p^- mass-less systems are much less likely to absorb a portion of the decay energy in such processes than their e^+e^- counterparts because of the latter's larger radius (see Sects. 3.6 and 3.7 of Ref. [5] and Sect. 2 of Ref. [2]) and greater affinity to participate in both long- and short-range interactions. It is clear that the *inability* of observing mass-less particle-antiparticle species is a key assumption in the XBPS model, because it ultimately allows one to forgo the creation-annihilation hypothesis in interpreting the results of elementary particle decays.

Table 2

Particle	**Symbol**	**Rest Mass**	**Composition**		**Decay**	**Fraction**		**BI**
		(Lifetime)	Vector		Products			
proton	p^+	938.2592±0.0052		100	stable			
electron	e^-	0.5110041±0.0000016		10	stable			
neutrino	ν p- e+ $\bar{\nu}$ p^+p^-	0.0		1	s table			
antiproton		938.2592±0.0052	100.		stable			
positron		0.5110041±0.000001.6	10.		Stable			
antineutrino		0.0	1.		Stable			
prophoton		0.0	100.100		Stable			
photon	$e^+e^-(\gamma)$	0.0	10.10		Stable			
photrino	$\nu\bar{\nu}$	0.0	1.1		Stable			
muon	μ^-	105.659±0.0003	1.11		$e^-\nu\bar{\nu}$	1.00		0
		(τ=2.1994 x 10^{-6}s)			$e^-\gamma\gamma$	< 1.6 x 10^{-5} <6 x 10^{-9} < 2.2 x 10^{-8} 1.00 1.24 x 10-4 1.24 x 10-4 1.02 x 10-8 3.0 x 10-8 < 3.4 x 10-8		$2\,\bar{1}$
					3 e			$1\,\bar{1}$
					$e^-\gamma$			$1\,\bar{1}$
charged pion	π^-	139.5688±0.0064	2.11		$\mu^-\bar{\nu}$			0
		(τ = 2.6024 x 10^{-8}s)			$e^-\bar{\nu}$			$\bar{1}$
					$\mu^-\bar{\nu}\gamma$			10
					$\pi^0e^-\bar{\nu}$			10
					$e^-\bar{\nu}\gamma$			$1\,\bar{1}$
					$e^-\bar{\nu}e^+e^-$			$1\,\bar{1}$
neutral pion	π^0	134.9645 ± 0.007 4	11.11		$\gamma\gamma$	0.9883		$1\,\bar{1}$
		(τ=8.4x10^{-17}s}			γe^+e^-	0.0117		$1\,\bar{1}$
					$\gamma\gamma\gamma$	<5.0 x 10^{-6}		$2\,\bar{1}$
					$e^+e^-e^+e^-$	3.47 x 10^{-5}		$1\,\bar{1}$
charged kaon K^-		493.715±0.037	13.22		$\mu^-\bar{\nu}$	0.6352		$1\,\bar{1}$
		(τ= 1.2371 x 10^{-8}s)			$\pi^-\pi^0$	0.2106		0
					$\pi^-\pi^-\pi^+$	0.0559		2
					$\pi^-\pi^0\pi^0$	0.0173		11
					$\mu^-\pi^0\bar{\nu}$	0.0324		0
					$e^-\pi^0\nu$	0.0485		$\bar{1}$
					$e^-\pi^0\pi^0\nu$	1.8 x 10^{-5}		10
					$\pi^-\pi^\mp e^\pm\nu$	3.7 x 10^{-5}		1

Table 2 Contd.,

				$\pi^-\pi^\pm e^\mp\nu$	<5.0 x 10^{-7}	1
				$\pi^-\pi^-\mu^+\nu$	0.9 x 10^{-5}	2
				$\pi^-\pi^+\mu^-\bar{\nu}$	<3 x 10^{-6}	2
				$e^-\bar{\nu}$	1.38 x 10^{-5}	$\bar{1}\ \bar{2}$
				$e^-\bar{\nu}\gamma$	<7 x 10^{-5}	$\bar{2}$
				$\pi^-\pi^0\gamma$	2.66 x 10^{-4}	10
				$\pi^-\pi^+\pi^-\gamma$	1 x 10^{-4}	12
				$\pi^0e^-\bar{\nu}\gamma$	3.7 x 10^{-4}	$1\bar{1}$
				$\pi^-e^+e^-$	< 4.0 x 10^{-7}	$\bar{1}$
				πee	< 1.5 x 10^{-5}	$\bar{1}$
				$\pi^-\mu^+\mu^-$	< 2.4 x 10^{-6}	1
				$\pi^-\gamma\gamma$	< 3.5 x 10^{-5}	$1\bar{1}$
				$\pi^-\gamma\gamma\gamma$	<3 x 10^{-4}	$2\bar{1}$
				$\pi^-\nu\bar{\nu}$	<1.4 x 10^{-6}	$\bar{1}\ 0$
				$\pi^-\gamma$	<4 x 10^{-6}	$\bar{1}$
				$\pi^-e^+\mu^-$	< 3 x 10^{-8}	0
				$\pi^-e^-\mu^+$	< 1.4 x 10^{-8}	0
				$\mu^-\nu\bar{\nu}\ \bar{\nu}$	<7 x 10^{-6}	$\bar{1}\ 0$
neutral kaon K_S^0		497.71 ± 0.13	13.13	$\pi^+\pi^-$	0.6881	0
(short-lived)		(τ=8.82 x 10^{-11}s)		$\pi^0\pi^0$	0.3119	$1\bar{1}$
				$\mu^+\mu^-$	< 7.0 x 10^{-6}	$\bar{1}$
				E^+e^-	< 3.5 x 10^{-4}	$\bar{3}$
				$\pi^+\pi^-\gamma$	2.3 x 10^{-3}	10
				$\gamma\gamma$	< 7.0 x 10^{-4}	$1\bar{3}$
Neutral kaon	K_L^0	497.71±0.13	13.13	$\pi^0\pi^0\pi^0$	0.215	20
(long-lived)		(τ=5.181 x 10^{-8}s)		$\pi^+\pi^-\pi^0$	0.126	11
				$\pi^+\mu^-\bar{\nu}$	0.269	0
				$\pi^+e^-\bar{\nu}$	0.388	$\bar{1}$
				$\pi^+e^-\bar{\nu}\gamma$	0.0013	$1\bar{1}$
				$\pi^+\pi^-$	1.57 x 10^{-3}	0
				$\pi^0\pi^0$	9.4 x 10^{-4}	$1\bar{1}$
				$\pi^+\pi^-\gamma$	<4.0 x 10^{-4}	10
				$\pi^0\gamma\gamma$	<2.4 x 10^{-4}	$2\bar{2}$
				$\gamma\gamma$	4.9 x 10^{-4}	$1\bar{3}$
				$e^\pm\mu^\mp$	< 1.6 x 10^{-9}	$\bar{2}$
				$\mu^+\mu^-$	< 1.9 x 10^{-9}	$\bar{1}$
				e^+e^-	< 1.6 x 10^{-9}	$\bar{3}$
Eta	η	548.8±0.6	22.22	$\gamma\gamma$	0.380	$\bar{2}$
		(τ=2.50 x 10^{-19}s)		$\pi^0\gamma\gamma$	0.031	$1\bar{1}$
				$3\pi^0$	0.300	11
				$\pi^+\pi^-\pi^0$	0.239	2
				$\pi^+\pi^-\gamma$	0.050	1
				$\pi^0e^+e^-$	<4.0 x 10^{-4}	$\bar{1}$
				$\pi^+\pi^-e^+e^-$	1.0 x 10^{-3}	1
				$\pi^+\pi^-\pi^0\gamma$	<2.0 x 10^{-3}	12
				$\pi^+\pi^-\gamma\gamma$	<2.0 x 10^{-3}	11
				$\mu^+\mu^-$	2.2 x 10^{-5}	$\bar{1}\ 0$
				$\mu^+\mu^-\pi^0$	<5 x 10^{-4}	1

NEUTRAL KAONS AND MORE ABOUT PARITY CONSERVATION

The next heaviest elementary particles are the neutral kaons. Just as the charged kaons, they have played an important role in the development of the theory of this branch of theoretical physics, particularly in the parity non-conservation analysis. It is now believed that there are two distinct such particles [6,7], a short-lived K_S^0 and a relatively long-lived K_L^0. The K_S^0 species decays predominantly into two pions ($\tau=0.882 \times 10^{-10}$ s), while K_L^0decay generally produces three pions ($\tau=0.5181 \times 10^{-7}$ s). The rest masses of the two particles are nearly identical, but they are believed to differ by 2×10^{-5} eV. The K_L^0 species also undergoes a small fraction of two-pion decays [29], however, whose discovery led to some consternation about the then existing theoretical interpretation of such processes. Specifically, up to that time (1964) it was held that the product of the charge conjugation and parity operations CP is conserved in all interactions, but the two-pion decays of K_L^0were taken as an unexplained violation of this rule. Since there is general agreement that the product TCP commutes with any conceivable Hamiltonian [30-32], this development could also be taken as proof that the time-reversal operation also is not conserved.

In Ref, [33] it has been argued that the creation-annihilation hypothesis is crucial to the logical argumentation which has led to the conclusion that parity is not conserved in the weak interaction. Once one insists that electrons and neutrinos which are observed to exhibit longitudinal polarization [34-37]*existed as components of meta-stable particles prior* to *their decay*, however, it is no longer possible to justify such a thesis unambiguously on the basis of such findings. When Yang and Lee proposed that parity might not be conserved [28], their main concern was to explain how the same particle $K^{\pm}$ (or τ - Θ in their notation) could decay both into two and three pions in different channels. This argument is based on the assumption that the pions all have negative parity, from which it follows that it is impossible for both decays to be allowed according to selection rules based on the conservation of this quantity. Since the three-component model of a neutron ($p^+e^-\overline{\nu}$) suggested by the XBPS model offers a way of explaining the longitudinal polarization phenomenon while still retaining the possibility that parity does commute with the corresponding Hamiltonian, it is well to review the whole question of parity conservation from the time it was first called into question by Lee and Yang.

To do this we start at the point at which the parity concept for particles is usually introduced into the theory of elementary particles, namely to interpret the results of low energy π^- capture by deuterons [38]. This process leads to the production of two neutrons with or without an additional photon. Because a corresponding set of products $nn\pi^0$ is never observed, it has been argued that this process must be forbidden, from which the supposition follows that some selection rule must be violated in this case which is satisfied in both of the first two reactions [39]. In search of a suitable selection rule one was drawn to the consideration of parity. Since a deuteron is known to be a triplet while πhas zero angular momentum, it can be safely concluded on the basis of conservation of angular momentum that the reaction products must form a triplet. In this connection it is important to note that it is also assumed that the pion has come to rest relative to the deuteron, and thus that there is no additional orbital angular momentum (or translation) to be taken into account in the present analysis.

It is by no means straightforward to deduce the total parity eigenvalue for this system, however, because there is no way to measure this quantity directly [39]. Moreover, it is not even clear that each particle must have a definite parity. An electron is not assigned a parity value, for example, nor is the neutrino. It only becomes obvious that a given system should be characterized by a definite parity when it can be described in terms of a many-particle wave-function, such as is the case for hydrogenic atom states in the most well-known example. Such an assumption is then implicit for each of the particles involved in the $d\pi^-$ interaction. With this background the argument can proceed as follows. Since the deuteron is known to correspond to a bound proton-neutron state, the parity of the overall reactants is assumed to be the product of the individual parities of the three particles, p, n, and π^-. At this stage of the argumentation one has no way of assigning a definite parity to any of these particles individually, nor is the value of the product of these quantities known. If parity is conserved, however, as one assumes for this process, the combined parity of the product system nn must be equal to the corresponding value for the $d\pi^-$ reactants.

Since the two neutrons are indistinguishable fermions, their total wave-function must be anti-symmetric with respect to their exchange. This anti-symmetry can be looked upon as deriving from two factors, the spatial and spin parts of the two-neutron wave-function, in analogy to the treatment of the two-electron He atom which ultimately led to the anti-symmetry principle for fermions [40]. On this basis it is argued that if the spin state of the neutron pair is a singlet, and therefore anti-symmetric with respect to such a permutation, the corresponding spatial state must be symmetric. Then it is asserted that a symmetric spatial state is only consistent with an even value of the total angular quantum number L of the system. If $S = 0$ this implies that $J = L + S$ is also even, which is inconsistent with the $J=1$ value of the initial system $d\pi^-$. Consequently the value of S must be unity and the spin state must be symmetric, the spatial state anti-symmetric. Therefore, by the same logic, the spatial state must be of odd L, specifically $L = 1$, and the parity of the products as a whole must be negative.

It should be noted, however, that the purported connection between the permutation symmetry of the spatial part of the two-neutron wave function and the value of its associated orbital angular momentum quantum number is by no means certain once when one allows for the possibility that the neutron is not an elemental system, i.e.without internal structure. If the nn system contains pairs of protons, electrons and antineutrinos (making it a six-particle system), it is not possible to properly describe it in terms of a single set of internal coordinates r_{12}. This being the ease, one cannot be certain that the angular characteristics of the two-neutron state can be represented exclusively by spherical harmonic functions whose parity is always given by $(-1)^L$. In the helium atom, for example, states of S (L=O) and P (L=1) type are known for both triplets and singlets, and all of them satisfy the Pauli anti-symmetry principle [41].

Keeping this qualification in mind, we may follow the argument further. Assuming that $L = 1$ implies odd parity and that this quantity is conserved in the present reaction leads one to conclude that the parity of $d\pi^-$ must also be negative. If the parity of the proton is defined to be positive, *which amounts to an additional assumption in the argument*, it therefore follows that the combined parity of the $n\pi^-$ system is also negative, which means the neutron and pion must have opposite values for this quantity. Even if one accepts this conclusion, however, it is still not possible to say with certainty which of the latter two particles has negative parity, because a straightforward theoretical argument[39]shows that it is impossible to settle the matter by experimental means. A way out of this impasse can only be found with recourse to yet another theoretical assumption, as discussed below.

In Sect. III of Ref. [42] the theory of isospin was reviewed. The key assumption in this development is that the proton and neutron form an isospin doublet. Although a careful parallel is drawn between the properties of isospin [43-45] and those of spatial angular momentum, no provision had been made for an associated parity operation. Since each component of a multiplet of a given angular momentum has the same parity value in conventional space, there is seemingly good reason to assume that the same relationship holds true for the members of an isospin multiplet. On this basis it was ultimately decided that the neutron’s parity is the same as that of the proton, i.e.positive, and by implication that the pion’s parity must be negative. In making the above assignment of parities of different components of the same isospin multiplet, however, one overlooks the possibility that the spatial parity operation may not be identical to the one used in the isospin justification. After all, the same physical system can have different values of the total angular momentum and isospin quantum numbers, the deuteron being the most familiar such example. Why can it not be that there are two different parities as well, one operating in conventional space, the other in isospin space? If that is the case it is no longer certain that the corresponding two parity eigen values are the same for every component of a given isospin multiplet. Moreover, even if the respective parities of the proton and neutron are equal, there is no more reason to assume that the corresponding value is positive than there is that it be negative, as already mentioned.

In summary, there are no less than three separate, experimentally un-provable, assumptions which must be made in order to arrive at the conclusion which has proven to have such dramatic consequences in the development of theoretical physics in the last 65 years, namely that the parity of the pion is negative. If the opposite conclusion is made, there is no violation of a parity selection rule required to explain why K_L^0can decay into either two or three pions because both sets of products then have the same (positive) parity. Similarly there is no need to conclude that CP (or T) is not conserved on the basis of the neutral kaon’s decay characteristics [46]. The prediction and observation of longitudinal polarization in β decay has always been assumed[29] to be inconsistent with a positive value for the pion’s parity, but as has been shown in Refs [33], recognition of the possibility that electrons and antineutrinos might enjoy continuous existence both before and after the onset of the corresponding nuclear transition invalidates any such conclusion. The question that must be asked under the circumstances is *whether one or the other of the logical uncertainties connected with the derivation of the pion's negative parity might actually be incorrect.* Is there perhaps another way to explain all these seemingly baffling observations that requires somewhat less dramatic theoretical developments?

The calculations of the various particle-antiparticle binaries and other systems discussed earlier lead to some definite conclusions about symmetry themselves. The Hamiltonian on which they are based commutes with T, C and P, as well as with the total angular momentum. The results of these calculations indicate that the neutron’s wavefunction has $1/2^-$ symmetry, while each of those for the e^+e^-, p^+p^- and $\nu\overline{\nu}$ systems is 0^-, at least in their respective lowest-energy (translation-less) states. The deuteron in this(XBPS) model possesses a $p^{+2}e^-\overline{\nu}$ structure, whose ground state is computed to have 1^-symmetry [10,42]. The π^-parity is less certain based on what we know thus far from XBPS calculations, but the most likely choice for its symmetry is 0^+, i.e.positive parity. This is because it has consistently been found that pairs of light fermions of opposite q/m_o values prefer 0^- states. As indicated in Table 2, the negative pion appears to be composed of an electron, a neutrino and two antineutrinos and thus consists of two such pairs (Sect. II). Moreover, considerations of particle balance in the $d\pi^-\rightarrow nn$ equation require that a $\nu\overline{\nu}$ product result as well, which again according to the calculations should have 0^- symmetry, i.e. negative parity.

The best inference from the above calculations is therefore: a) the parities of both d and n are negative, b) the parities of $\pi^\pm$ (and π^0) are positive, and c) the overall parity of the above reaction is negative. The last point follows because although nn is found to have positive parity, the equation of interest is only balanced with the addition of a single $0^-\nu\overline{\nu}$ state. In this way the reaction is found to conserve parity, and thus to be an allowed process, in agreement with observation:

$$d(1^-) + \pi^-(0^+) \rightarrow n(1/2^-) + n(1/2^-) + \nu\overline{\nu}\ (0^-)$$

Hence no contradiction arises when the pions are assigned positive parity in this reaction. The calculations indicate that the parities of the proton and neutron are not the same, although this relationship depends on the orbitals occupied by the individual proton components within a given nucleus. As mentioned above, there is no conflict between this finding and the assumption that these two particles are different components of the same isospin doublet[43] because the isospin analogue of the parity operator need not be identical to that acting in physical space. *With these assignments all* of *the arguments based on parity violation in the* ^{2}-n *puzzle* or *the two- and three-pion decays of* K_L^0*lose their validity*. If the intrinsic parity of a pion is positive, then nothing stands in the way of an odd or even number of such particles being produced from the same starting point. On this basis one is led to look for a different explanation for the longitudinal polarization phenomenon, one of which has already been formulated in terms of the XBPS model in the Ref. [33].

The details of the $d\pi^-$reaction given above are also consistent with other characteristics of this process. First of all, it is clear that total angular momentum can be conserved, but only if J=1. The same conclusion was mentioned in the discussion of parity conservation given above, but the indication now is that the two-neutron state has ^3S symmetry, i.e.L=0, in contrast to what is usually assumed. With two proton $s_{1/2}$ spin orbitals involved, we have a concrete verification of the assertion that anti-symmetric spatial states can possess even L values. With the help of Table 2, we can describe the reaction in terms of a transfer of an electron and an antineutrino from the negative pion to the proton of the deuteron. The parallel spins of the proton constituents in the original nucleus are not affected by this transfer, so that a triplet two-neutron state must result. The $\nu\bar{\nu}$ fragment of the pion is then expected to be emitted in its 0^-massless state. In all this, both parity and total angular momentum must be conserved in the model because the Hamiltonian governing the transition commutes with both types of operators.

What about the reaction in which two neutrons and a photon are produced from $d\pi^-$? In this case one must only assume that the parity of the emitted photon is negative, i.e. the same as for the massless system from which it is formed. In a dipole-allowed radiative transition it is known that the perturbing field has 1^- symmetry, from which one must conclude that the non-massless, energetic photon resulting from excitation of the latter system has $0^- \otimes 1^- = 1^+$ symmetry. This does not mean at all that every photon with energy different from zero has 1+ symmetry, however, rather only that one resulting from a dipole-allowed process relative to a massless photon must have this value. Other states of e^+e^- have different values of J and P. Indeed, it is no longer clear that the evenness or oddness of J dictates a definite parity in the case of a photon. It is a relativistic particle, always moving with speed c when it possesses non-zero mass, and in that case the conventional idea of a wavefunction consisting of a product of an internal and a purely translational factor does not necessarily apply.

The last of the three reactions suggested for $d\pi^-$ would yield $nn\pi^0$, but it is never observed. The above assignments indicate that parity is also conserved in this process, however. Does this prove that the present parity assignments are wrong? Not at all, because not every reaction allowed by symmetry must occur in nature. Other factors can be involved, most prominently the availability of conditions for formation of one or the other of the products. In the XBPS model an additional e^+e^- binary is required on the reactant side to balance the above equation because π^0 is assigned the composition $e^+e^-\nu\bar{\nu}$ (Table 2). Since this massless binary system has negative parity, it cancels the deuteron's negative parity to give the same (positive) result on both sides of the equation.

But is there any driving force to involve such an e^+e^- massless binary? In the XBPS model, what must happen is that the electron and one antineutrino attach themselves to the deuteron's proton, inducing dissociation into two neutrons. There is a $\nu\overline{\nu}$ system left over from π^- as a result, but it apparently prefers to assume its massless state, as indicated in the above equation. The alternative of attaching the $\nu\overline{\nu}$ product to a neighboring e^+e^- massless binary to form a π^0 with 135 MeV rest mass is perhaps conceivable, but who can say it is not preferable that the $\nu\overline{\nu}$ species remain inert and instead have all the decay energy go to the departing neutrons? Or to give a part of the energy to a massless e^+e^- system so that it appears as a photon at the end of the reaction? In the future it may be possible to carry out calculations which compare these three reaction probabilities in a quantitative manner, but for now it should at least be clear that such an explanation for the presence or absence of these various reactions is a definite possibility. At the very least, it is in no way ruled out by anything one could possibly infer from symmetry arguments alone.

The composition vectors listed in Table 2 for K_S^0 and K_L^0 are suggested on the basis of the type and frequency of their respective decay modes. As before with the charged kaons, there is some justification for assuming that more than the four particles of a pion are contained in K_S^0 and K_L^0 because of their larger rest masses (3-4 times larger than $\pi^\pm$, π^0). Because the rest masses of the neutral kaons are so similar to those of the charged $K^\pm$ species, it is natural to assume that the compositions of all these particles must be very similar, particularly with regard to the number and type of constituent electrons and neutrinos. The choice in Table 2 of a 13.13 composition for both K_S^0 and K_L^0 is tantamount to assuming that the two neutral kaons correspond to very closely-lying states of the same system. The (assumed) energy difference between them (0.5×10^{-5} eV) is so small that it would be all but impossible to compute it in any *ab initio* model.

The most interesting feature of the decay of the neutral kaons is the fact that sets of both two and three pions are observed. In the present model, in which all the pions are suggested to have positive parity, one can expect that even though both types of decay fragments are allowed by symmetry, the amount of phase space available in the two cases definitely favors the two-pion decays, as observed [6,7]. The K_S^0 system with a lifetime of 0.882×10^{-10} s exhibits only two-pion decays, while the K_L^0 species has a sixty-fold greater lifetime and produces $\pi^0\pi^0\pi^0$ and $\pi^+\pi^-\pi^0$ fragments in a total of 34.1% of its decays. At first, it was thought on the basis of theoretical arguments involving CP conservation that K_L^0 would not exhibit any two-pion decays, but in 1964 Christenson *et al.* and Abashian*et al.* showed that this is not the case [29]. The latter work found that 0.2% of all K_L^0 modes are two-pion decays ($\pi^+\pi^-$). It is worth noting, however, that in 65.7% of all decays, the observed products are $\pi\mu\nu$ and $\pi e\nu$which in turn are the known products of $\pi^+\pi^-$decay, i.e.with one pion remaining intact and the other decomposing into a muon and a neutrino (or to an electron and neutrino after further decomposition of the muon). These types of decays do not normally enter into the discussion of parity values, however, for the simple reason that the electron, neutrino and muon are not assigned a definite parity.

The assignments in Table 2 also leave open the possibility that both K_S^0 and K_L^0 are their own antiparticles, just as is generally accepted for π^0. Originally, theoreticians spoke of a single neutral kaon K^0, whose antiparticle is $\overline{K}^0$. The work of Gell-Mann and Pais [46] led to the designation of two separate particles K_1^0 and K_2^0 of different lifetimes. Subsequent experiments[29] ruled out the straightforward assignments of definite and opposite parities to these two species, however, contrary to what had been suggested in the above theoretical work. With 13.13 assignments for both K_S and K_L, it can be seen that their most common decay products can all be reached with the addition of a small number of massless e^+e^- and $\nu\overline{\nu}$ binaries as reactants, sometimes with the assumption that such systems go undetected as products as well. Accurate calculations seem to be the only way of obtaining more confidence in any of these assignments, but at least it is clear how they might have to be changed when more information becomes available, namely by suitable addition (or subtraction) of e^+e^- and $\nu\bar{\nu}$ binaries to the structures given in Table 2.

The composition vector for the η resonance is more difficult to specify than for any of the lighter mesons. Its lifetime is relatively short (2.5 x 10^{-19} s, corresponding to a linewidth of 1.316keV). The most common decay products are groups of two or three pions or several photons, with or without pion accompaniment. The two-photon decay occurs in 38.0% of all cases, compared to 30.0% for $3\pi^0$ and 23.9% for $\pi^+\pi^-\pi^0$ decays. As usual all these products can be related by the gain or loss of an integral number of e^+e^- and $\nu\bar{\nu}$ binaries. The mass difference relative to the neutral kaons is relatively small (ca. 50 MeV), so that the composition of the η particle is likely to also be fairly similar, such as the 22.22 designation given in Table 2. The only point which should be stressed in this assignment is that the hypothesized availability of massless binaries at this site and all other particle decays can be used to explain all of the observed products. There are a number of other heavier mesons which have not been listed in Table 2, including the η', $\rho^{\pm}$, ρ^0, ω^0, φ^0, K^{*0} and $K^{*\pm}$ particles. These resonances play a key role in the quark model of elementary particles.

CONCLUSIONS

The indication in the XBPS model is that the neutron is composed of the very particles it is seen to emit upon decay. Consistency requires that a similar conclusion is reached for the composition of other unstable elementary particles such as pions, muons and kaons. A complicating factor is that the decay products are not unique for any of the latter particles. Nonetheless, the main decay modes lead to the production of the same two light particles believed to be the constituents of the neutron, namely $e^{\pm}$, νor

$\bar{\nu}$, so the most obvious choice for the muon μ^+ composition is $e^+\nu\bar{\nu}$ and $e^-\nu\bar{\nu}$for μ^-. Each muon has the observed value of the electric charge of +/-1 and its magnetic moment can be looked upon as that of a heavy electron with a mass of 207 m_e. The other (minor) decay modes are obtained in the XBPS model by adding or subtracting massless e^+e^- and $\nu\bar{\nu}$ binaries,

The 0^- $e^-\bar{\nu}$ complex found to be present in the neutron also fits in well with the above muon composition. In this way, one expects in the XBPS model that the angular momentum value of the particle is determined exclusively by that of the electron/positron. Calculations have been carried out for the $e^+\nu\bar{\nu}$ system in two different basis sets. They show that the positron can only polarize the $\nu\bar{\nu}$ massless binary in a small basis (Fig. 1), whereas the proton can polarize the $e^-\bar{\nu}$ complex in large basis sets as well as small (Fig. 2). An even larger basis is required to obtain a value for the muon's energy which is consistent with experiment.

The XBPS model helps to explain why a photon is never produced in muon decays. A particular spin relationship between ν and $\bar{\nu}$ is required to produce a stable muon according to the calculations. It therefore seems likely that any bond between them is destroyed in the decay process. This causes the two neutrinos to depart in opposite directions rather than as a bound diatomic system. It therefore seems highly unlikely that a muon is formed in the reverse reaction, consistent with observation.

Pions almost always have a muon and a neutrino as decay products. Therefore the XBPS model indicates that they are tetratomic systems composed of an electron and three neutrinos. The energy required to attach a fourth particle to the muon is about the same as the energy per particle needed to form the $e\nu\bar{\nu}$ composition assumed for the muon. Pions are relatively unsaturated with respect to the addition of neutrinos and these can be provided by massless binaries. They are known to have singlet multiplicity, and as such can be distinguished from the deuteron, another four-particle system, with its triplet multiplicity.

The neutral π^0 meson has a smaller rest mass than the charged pions. The assumed e^+e^- structure assumed for the photon indicates that π^0contains at least one electron and positron. Even though they are never observed as π^0decay products, it still seems likely that neutrinos are constituents based on the close relationship between the charged pions and π^0, for example, $e^+e^-\nu\bar{\nu}$. Based on the above arguments, the composition vectors of a large number of metastable particles are given in Table 2.

The original argument for muon neutrinos as being distinct from electron neutrinos that are emitted in the β decay of nucleons was the experimental finding of the *absence* of a $\mu \rightarrow e\gamma$ branch. An experiment employing high-energy pions to produce muon neutrinos was carried out. It verified that muons are produced and not electrons. It should be noticed, however, that the experimental conditions for scattering pion neutrinos off neutrons are fundamentally different than in the key antineutrino absorption processes first carried out by Reines and Cowan in 1956 in which electrons (positrons) are produced. In other words, the different experimental results might simply be attributable to the distinction in the energies of the scattered neutrinos. This uncertainty can only be removed by subjecting electron neutrinos to the GeV energy range used in the Brookhaven experiments for the neutrinos that produced muons, something that is impossible in practice. The same arguments are also relevant for the tau neutrino that was later reported as being distinct from both ν_e and ν_{μ}.

Neutrino oscillations were then introduced into the theoretical discussion. The indication from this theory is that the individual neutrinos are constantly changing their flavor as they move through different environments. It requires that the rest masses of the neutrinos be non-zero for the oscillations to occur.

Both the Grand Unified Theories and the XBPS model stand in opposition to this view.

It should be emphasized that there is a straightforward experimental test to determine if the neutrino rest mass is zero, namely to measure the maximum kinetic energy of the electrons that are emitted in the β decay of nucleons. If this value is exactly equal to that of the recoil of the nucleus, as if only a two-particle decay were involved, the conclusion would be clearly that the rest mass of the third particle in the decay is zero.To date no experiment has been precise enough to rule out this possibility, thereby leaving open the distinct possibility that the neutrino is massless, as assumed in the XBPS model.

A major consequence of the massless character of the neutrino is that its speed through free space must be equal to c. In this connection, it needs to be pointed out that there is unimpeachable experimental evidence that photons can travel with $v>c$ in regions of media with $n_g<1$. In view of the extreme penetrability of neutrinos, it seems highly unlikely that such a possibility is available to them.

The cardinal assumption in the XBPS model is that all matter is composed of three elementary stable particles, the proton electron and neutrino and their three antiparticles. A notation is developed on this basis in which the composition of each particle is expressed in terms of six integers which give the respective occupation of each of the fundamental particles. A number of the most frequently occurring particles are characterized in Table 2 using this notation. Different sets of decay products are noted in each case. In accord with the XBPS model, they differ in each case by an integral number of the three massless binaries: p^+p^-,$e^+e^-$and $\nu\bar{\nu}$.

The next most massive particles after the muon and pions are the kaons, both with and without charge.

Their decay energies are generally 3-4 times larger than the former. It is impossible to fix their composition because of the uncertainty in the number of massless binaries that may be involved. In the table it is assumed that each kaon has eight fundamental particles, twice as much as for the pions, although one might just as well limit this number to only four fundamental particles as is done for the pions.

The neutral kaons have played a special role in the development of the overall theory of particle physics. The analysis of their decay products led Yang and Lee to conclude that parity is not conserved for these processes. Experiments carried out by Wu et al. added support to this hypothesis. It has recently been shown, however, that all such experiments can be understood by assuming, in agreement with explicit calculations with the XBPSmodel, that electrons and antineutrinos are present in such unstable nuclei *prior to decay.*One can understand the experimental data by assuming that there is an electroweak analogue to the Stern-Gerlach effect which is active in each case. It is argued on this basis that the field gradient is positive (in the direction of the field) at the onset of the decay, which means that the magnetic moment of the emitted particle must be parallel to the force applied to it. As a consequence, neutrinos are predicted to behave as left-handedscrews in the decays, while antineutrinos are predicted to be right-handed. The experimental data are perfectly consistent with these conclusions.This allows one to explain all such details without claiming that the law of parity conservation is violated in the weak interaction.

Moreover, consideration of the arguments that led Yang and Leeto their conclusion of non-conservation of parity shows that they are based on the unproven assumption that pions have negative parity. The basis for this assumption goes back to consideration of the $d\pi^-$ reaction, which upon balancing, i.e. removing an $e^-\bar{\nu}$ complex from the pion (see Table 2), leads to $nn\nu\bar{\nu}$ as products. The best inference from the XBPS calculations is that the parities of both d and n are negative because of the 0^- symmetry of the $e^-\bar{\nu}$ complex contained in each of them. As a result, the parity of π^- is deduced to be *positive* because both d and $\nu\bar{\nu}$ have negative parity. With this assignment all of the arguments based on the supposed parity violation in the τ-Θ puzzle lose their validity. It also is necessary to assume that the parity of the photon is negative, which again agrees with the results of the XBPS model which indicate that the photon has an e^+e^- composition with 0^- symmetry.

The most interesting feature of the decays of neutral kaons is that both two and three pions are observed as products. The two-pion decays can be expected to be more probable because the respective amounts of phase space definitely favor them over their three-pion counterparts. The assignments in Table 2 indicate that K_S^0 and $K_L^0$are their own antiparticles. With a 13.13 assignment (Table 2) for both K_S^0 and K_L^0, the most common decay products of both can be reached with the addition of a small number of massless binaries.

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