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NO8500059

INIS-mf--9760

THEORETIC PAPERS

THE BLINDERN THEORETIC RESEARCH TEAM
P.B. 1029. BLINDERN, OSLO 3, NORWAY

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Theoretic Papers 1983 Nr 5

PROPOSED INTERPRETATION OF τ-NEUTRINOS.

PREDICTED MASSES.

by

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Abstract

τ-decay is expected to produce, among other particles, also neutral leptons of mass greater then zero, according to the magnetic monopole model presented in several papers (Barricelli, 1982, 1983A, 1983B). Predicted masses, and criteria for anticipating the formation of such heavy neutral leptons in various τ-decay processes and information which may help detecting them if they are formed, are presented. Because of their long lifetimes such neutral leptons can not easily be distinguished from neutrinos, if one is not aware of their properties.

1. Introduction.

Neutral leptons designated as neutrinos are found among the decay products of published τ-decay processes (Tables of Elementary particles, 1982). It is commonly assumed that at least some of them belong to a third kind of neutrinos designated as τ-neutrinos. A determination of the masses of these neutral leptons is important for their interpretation. Recently published Tables of Elementary Particles ascribe to the τ-neutrino a mass lower than 250 MEV. There is no assurance that these neutral leptons will have a mass equal or close to zero. If so, the magnetic monopole theory presented in several earlier papers (Barricelli, 1982, 1983A, 1983B, Barricelli and Kolset, 1982) offers a possible interpretation.

2. Neutral leptons.

A series of neutral leptons, some of them experimentally not yet identified, is included in the list of leptons whose masses and other properties are predicted by the theory, and presented in table 1. Besides the two neutrinos ν^{μ} and ν^{e}, three neutral leptons μ^0, s^0, $s^{0\prime}$ with masses greater than 0, are recorded in the table. If sufficient energy is available, anyone of the three heavier neutral leptons might substitute for a neutrino in the decay of a particle. In fact, as the reader can verify by paying attention to the configurations of the D_1 and S_1 quarks (see footnote of table 1), each one of the neutral leptons is composed by the same basic monopoles, namely B_3, U^1, L^1, L^1, as the two neutrinos, possibly with the addition of a B^3B_3-pair, which can be formed or annihilated in any decay process.

The question is: how do we decide which ones of the neutral leptons (neutrinos or heavier ones) are formed in the various τ-decay processes which are listed in the literature; and in which cases, what is listed as a neutrino shall be replaced by a heavier neutral lepton, which is our version of a τ-neutrino*?

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* The suggestion that the neutral lepton s^0 could yield an interpretation of the τ-neutrino was also presented in an earlier paper (Barricelli, 1979). But at that time we did not have the additional information available today; the neutral lepton μ^0 was not included in the consideration, and the strangeness conversion phenomenon (see next section) was overseen.

Table 1

Theoretic and observed lepton properties.

Reference Number	Name	Symbol (and Mass MEV)	Theoretic Mass MEV	Configuration	Electric Charge e=1	Strangeness	Charm
1	Tau	$\tau^+(1784)$	1784.560	$(B^3(B_3L^1)OC_1)3$ or $(B^3(B_3L^1)OI_1)3$	+1	0	+1
2	Strange'	$s^{\circ\prime}$	452.123	$(B^3(B_3L^1)OS_1)2$	0	-1	0
3	Strange	s°	295.850	$(B^3(B_3L^1)OS_1)1$	0	-1	0
4	Charged Myon	$\mu^+(106)$	106.359	$(B^3(B_3L^1)OU_1)1$ or $(B_3(B^3U_1)OL^1)1$	+1	0	0
5	Neutral Myon	μ°	105.850	$(B^3(B_3L^1)OD_1)1$ or $(B_3U^1L^1L^1)1$	0	0	0
6	μ-Neutrino	$\nu^\mu(0)$	0.000	$(B_3U^1L^1L^1)0$	0	0	0
7	Electron	$e^+(0.511)$	0.511	$(U_1L^1)0$	+1	0	0
8	e-Neutrino	$\nu^e(0)$	0.000	$(D_1L^1)0$	0	0	0

Configurations of the respective anti-particles τ^-, $s_\circ'$, $s_\circ$, μ^-, $\mu_\circ$, ν_μ, e^-, ν_e are obtained by substituting upper indexes for lower indexes and conversely in the above configurations. We may also call attention to the definitions of the three quarks (used in the above configurations) D_1, S_1, C_1 in terms of the basic monopoles B,U,L, namely $D_1=(B_3U^1L^1)0$, $S_1=((B_3U^1)0L^1)1$, $C_1=((B_3S^1)2L^1)3$, $I_1=((B_3T^1)2L^1)3$.

We have no good criteria for deciding in which cases μ^0 or μ_0 shall be substituted for a neutrino. But recent information about the conservation of residual strangeness in C_1-decays gives a criterion for deciding in which cases one of the strange leptons s^0, s_0, $s^{0\prime}$, s_0' is likely to appear in a decay process in which a C_1 quark or its anti-quark is not conserved.

According to table 1, the τ^+ lepton is a charmed particle harbouring a C_1 quark among its constituents. Actually the mass of the τ-lepton is better interpreted by assuming that the I_1 version of the charmed quark is involved instead of C_1. But that has no consequences for the following argument. None of its decay products harbours a C_1 quark, apparently because there are no charmed particles with lower mass than τ. The C_1 quark harboured by τ must therefore decay when τ decays. The question is whether the S_1 anti-quark harboured by C_1 (see footnote of table 1) will also decay when C_1 decays.

3. Prevailing conservation of residual strangeness in C_1 decays.

In order to answer this question we may look at the decays of other charmed particles, particularly those which decay without conserving charm, since the C_1 quark does not decay in those cases in which charm is conserved. The charmed hadrons of this category are: $\Lambda_C(2282) = ((BUD)4C)1$, $D^\pm(1869) = ((BC)1(BD)1)1$, $D^0(1864) = ((BC)1(BU)1)1$, $F^\pm(2021) = ((BC)1(BT)1)1$. Like the τ lepton, all of these hadrons have about the same life time of roughly 10^{-13} sec, which seems to be the time needed for the C_1 quark to decay. All other charmed particles belong to the much faster decaying type which is known to conserve strangeness and usually also conserves charm. Apparently the strange quark needs 10^{-10} sec or longer in order to decay (see Barricelli, 1983B, section 4) and the charmed quark needs 10^{-13} sec.

If we look (tables of particle properties, 1982) at the decay products of the three charmed hadrons $\Lambda_C(2282)$, $D^\pm(1869)$ and $D^0(1864)$ we find that an overwhelming majority of decays produce strange particles mainly K and K* mesons. On the other hand the decay products of the $F^\pm(2021)$ meson, which is both charmed and strange according to its above configuration, nearly always include a strange-antistrange particle, such as $\eta(549) = (ST)1$

or $\phi(1020) = (TT)3$. The trouble is that the strange quark which appears in the decay products is not always the one included in the charmed quark of the decaying particle. For example in 9% of the cases $D^+(1864) = ((B^3C_1)1(B_3D^1)1)1$ decays into $K^{\mp}(494) = ((B^3S_1)1(B_3U^1)0)1$ and π mesons. The S_1 quark found in the decay particle K^- is not the S^1 antiquark contained in the decaying $C_1 = ((B_3S^1)2L^1)3$. The same objection can be addressed to the decays of $F^+(2021) = ((B^3C_1)1(B_3S^1)1)1$ into $\eta(549) = (ST)3$, etc. or into $\phi(1021) = (TT)3$, etc. both of which contain an S (or T) and an anti S (or T) instead of two S^1 quarks.

This may seem embarassing and could complicate the interpretation if we were not aware that the energy difference discriminating a strange quark $S_1 = ((B_3U^1)0L^1)1$ from a $D_1 = (B_3U^1L^1)0$ (representing the (L-1) and (L-0) stages of the same particle) can easily be transmitted to an antiquark $D^1 = (B^3U_1L_1)0$ converting it into a strange antiquark $S^1 = ((B^3U_1)0L_1)1$, while the original S_1 is converted into D_1 by loosing its stangeness energy (the strangeness conversion or strangeness energy exchange phenomenon). For example the meson $K^0_L(498) = ((B^3T_1)1(B_3D^1)0)1$ is repeatedly converted into its complementary configuration $((B^3D_1)0(B_3T^1)1)1$ and back to the original one by strangeness conversion forth and back between T_1 and D^1 or D_1 and T^1 (see Barricelli, 1983B, table 3B). This strangeness conversion phenomenon, if it arises during the decay of a C_1 quark may transmit the strangeness energy of its S^1 antiquark to any other D_1 quark present or created by D_1D^1 pair formation, thus converting the D_1 into an S_1 and the S^1 into a D^1.

The very frequent formation of an S^1 or an S_1 during C_1 decay can be interpreted as an indication that its S^1 antiquark is usually either conserved or replaced by an S_1 quark as a result of strangeness conversion during the C_1 decay process.

The fact that S_1 decay requires 10^{-10} sec, or longer, whereas C_1 decay requires only 10^{-13} sec, suggest that strangeness will usually be conserved, if not converted into the opposite strangeness, during the decay of a C_1 quark.*

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* Strangeness conversion may occasionally have the time to show up during the 10^{-13} seconds required for C_1-quark decay, but not during the 10^{-21} seconds required for rapid ("strong interaction") decays, which are known to conserve strangeness unaltered and unconverted.

This makes it possible to propose a criterion for deciding in which cases a neutral s_0 or s^0 lepton will arise during the decay of a τ particle, and give information which might be helpful for the experimental detection of such neutral leptons.

4. Suggested τ-decay processes.

Our aim is to suggest the substitution of heavier neutral leptons μ^0, μ_0, s^0, s_0 for supposed neutrinos in the most frequent τ-decay processes, by following the residual strangeness conservation rule as explained above. Our suggestions are presented in table 2, listing some of the most frequent τ-decay processes and a few decay processes supposedly involving heavier neutral leptons. As explained in section 2, we have no good criteria for deciding in which cases μ^0 or μ_0 shall be substituted for a neutrino. The cases in which μ^0 or μ_0 is included among τ-decay products in table 2 are only intended to indicate that their presence as a substitute for an e or μ neutrino is energetically possible, but not necessary. For this reason the % of decays listed in table 2 are, whenever μ^0 or μ_0 is one of the decay products, marked as an upper limit $\leq$ % instead of % , which is the % given in the published tables (Particle properties, 1982) for the corresponding decays. In a portion of the cases the heavy neutral lepton might have to be replaced by an e or μ neutrino or antineutrino. A heavy s^0 or s_0 neutral lepton is usually included in order to comply with the above residual strangeness conservation rules. If there is no other strange particles formed in a τ-decay process, an s^0 or s_0 neutral lepton is substituted for one of the neutrinos. Whenever consistent with a simple interpretation the substitution is made by conserving the strange S^1 antiquark harboured by C_1, without assuming strangeness conversion. Otherwise the opposite strangeness is introduced by converting a D_1 quark (produced if necessary by a D_1D^1 pair formation) into an S_1 quark. The possibility that an s^0 or s_0 neutral lepton might occasionally be replaced by a heavier $s^{0\prime}$ or $s_0^\prime$ (see table 1) in some of the decays listed in table 2, can not be ruled out if the energy available is sufficient.

Table 2

Preliminary list of decays involving heavy neutral leptons.

Decaying particles and configurations	Mean life (sec.)	Pairs formed	Rearrangements	Annihilations	Decay products	% of decays	p or p_{max} (MEV/c)	Serial Nr
$\tau^+ = (B^3(B_3L^1)0C_1)3$	5×10^{-13}	BB,UU,LL	$(B_3(B^3L_1)0S^1)1, (B^3(B_3L^1)0U_1)1, (B_3U^1L^1L^1)1$	--	s_o, μ^+, μ°	≤ 18.5	855	1
where $C_1 = ((B_3S^1)2L^1)3$		UU,LL	$(B_3(B^3L_1)0S^1)1, (U_1L^1)0, (B_3U^1L^1L^1)1$	--	s_o, e^+, μ°	≤ 16.2	864	2
		DD	$((B^3U_1)0(B_3D^1)0)1, (B^3(B_3L^1)0S_1)1, (L^1L_1)0$	LL	Π^+, s°	10.7	861	3
and $S^1 = ((B^3U_1)0L_1)1$		DD	$(((B_3D^1)1B^3)1U_1)2, (B^3(B_3L^1)0S_1)1, (L^1L_1)0$	LL	ρ^+, s°	21.6	690	4
		UU	$((B^3U_1)0(B_3T^1)1)1, (B_3U^1L^1L^1)1$	--	K^+, μ°	small	819	5
		UU	$((B^3U_1)1(B_3T^1)1)2, (B_3U^1L^1L^1)1$	--	K'^+, μ°	≤ 1.7	663	6
$\mu^\circ = (B^3(B_3L^1)0D_1)1$ or $\mu^\circ = (B_3U^1L^1L^1)1$	$\sim 10^{-6}$	UU,LL	$(B_3U^1L^1L^1)0, (U_1L^1)0, (U^1L_1)0$	--	ν^μ, e^+, e^-		53	7
$s^\circ = (B^3(B_3L^1)0S_1)1$	$\leq 10^{-8}$	--	$(B^3(B_3L^1)0D_1)1$	--	$\mu^\circ, \gamma(\gamma)$		129	8
where $S_1 = ((B_3U^1)0L^1)1$		UU	$((B_3U^1)0(B^3D_1)0)1, (U_1L^1)0$	--	Π^-, e^+		115	9
		UU,LL	$(B^3(B_3L^1)0D_1)1, (U_1L^1)0, (U^1L_1)0$	--	μ°, e^+, e^-		129	10
		UU,LL	$(B^3(B_3L^1)0U_1)1, (B_3U^1L^1L^1)0, (U^1L_1)0$	--	μ^+, μ°, e^-		103	11

5. Information which may be helpful for the detection of heavy neutral leptons.

In the published tables of particle properties of April 1982 a particle designated as τ-neutrino (ν_τ) is ascribed a mass < 250 MEV. We do not know which one of the many listed τ-decay processes are used for that measurement.

We may suggest that not only one, but at least two neutral leptons, μ^0 and s^0 of mass greater than zero can be formed in various τ-decay processes. The first one μ^0 has a mass of about 105 MEV, the second one s^0 has a mass of about 296 MEV (see table 1). Information which may be helpful for the detection of these neutral leptons is presented in table 2. The τ-decays listed in table 2 are obtained by modifying some of the most frequent τ-decay processes listed in the tables of particle properties of April 1982, according to the criteria presented above in section 3.

In the lower part of the table predicted decay properties of the μ^0 and s^0 neutral leptons are presented. For each decay the calculated impuls moment p (or p_{max}) of the decay products is presented in order to help identifying the masses of the neutral leptons. The reader can compare the calculated p-values listed in table 2 with the p-values for the corresponding decays (given in the 1982 particle property tables), which are calculated on the assumption that all neutral leptons have a mass equal to zero. These values are listed in table 3. If some p-measurements can be made with sufficient accuracy to discriminate between the two, that may help deciding whether neutral leptons formed by τ-decay have a mass close to zero or different masses approaching those of the μ^0 and s^0 leptons.

If it were possible to observe the decays of some μ^0 and s^0 leptons that would be a more direct way of measuring their masses. The lower part of table 2 gives some information which may help evaluating this problem. The mean life time of μ^0 is expected to be comparable to that of $\mu^\pm$, or roughly 10^{-6} sec and that of s^0 is expected to be comparable to that of most strange stable hadrons probably 10^{-8} to 10^{-10} sec, since it can only decay without conserving its strangeness, and the S_1 quark needs 10^{-8} to 10^{-10} sec in order to decay.

Table 3

Tau decays according to "Particle Properties 1982".

Decaying particle	Mean life (sec.)	Mass (MEV)	Decay products	% of decays	p or p_{max} (MEV/c)	Serial Nr
τ^+	5×10^{-13}	1784.2	$\mu^+,\bar{\nu},\nu$	18.5	889	1
			$e^+,\bar{\nu},\nu$	16.2	892	2
			Π^+,ν	10.7	887	3
			ρ^+,ν	21.6	726	4
			K^+neutrals	small		5
			K'^+,ν	1.7	669	6

Such relatively long life times may make it difficult to distinguish these neutral leptons from neutrinos. But if some of the decays described in the lower part of table 2 can be observed, the impuls moment given in table 2 for each decay may help identify them. Only decays which may have interest for the identification are listed. Possible decays which would produce no charged particles and no photons are not included. Likewise possible decays which would include only neutrinos and photons are not included since the p (or p_{max}) of the photons would obviously be 106/2 = 53 for μ^0 decays and 296/2 = 148 for s^0 decays, and does not have to be listed in the table.

We have no reliable way of anticipating the frequencies of the μ^0 and s^0 decays listed in table 2. But there is a good possibility that some of them may have sufficiently high frequency to be detectable if a method of detecting neutral lepton decays is found.

Finally we shall call attention to the fact that the calculated masses of s^0 and $s^{0\prime}$ listed in table 1 are obtained on the assumption that the S_1 quark included in both of these strange neutral leptons is not split. If the split T_1 quark is used instead of S_1, their masses calculated by the machine are respectively 268.722 MEV and 425.05 MEV. As usual the probability that the quark could be split is much greater for the higher energy particle $s^{0\prime}$ than for the lighter s^0.

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