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ИЗВЕСТИЯ АКАДЕМИИ НАУК ЭСТОНСКОЙ ССР. ТОМ 31
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I. OTS

ON LEPTON DECAYS INVOLVING SPIN 3/2 AND SPIN 1/2 NEUTRINOS

I. OTS. LEPTONI LAGUNEMISEST 3/2- JA 1/2-SPINNIGA NEUTRIINODE KORRAL

И. ОТС. О РАСПАДЕ ЛЕПТОНА ПРИ НЕЙТРИНО СО СПИНАМИ 3/2 И 1/2

(Presented by H. Keres)

The study of spin 3/2 fields is of current interest for the reason that in the supergravity models a spin 3/2 field plays an important role. But besides the spin 3/2 gravitino there may exist other spin 3/2 leptons in nature. One may ask what happens if the gravitino projection operator [1]

$$P^{3/2}_{\mu\nu}(q) = \gamma_\nu \hat{q} \gamma_\mu / 2 \tag{1}$$

is used in usual weak processes for spin 3/2 neutrinos.

There is no condition

$$\gamma_\mu u^\mu(q) = 0 \tag{2}$$

in the class of gauges used in supergravity and all four possible helicity states of a massless fermion are taken into account in the operator (1)*.

The aim of this note is to show that when using operator (1) for spin 3/2 neutrinos in certain types of currents, these particles may behave like ordinary spin 1/2 ones.

Indeed, let us consider the weak leptonic decay of an oriented heavy lepton

$$L^- \to l^- + \tilde{\nu}_l + \nu_L, \tag{3}$$

where both neutrinos are taken to be massless particles with spins 1/2 or 3/2.

For convenience, we denote the currents only by the spin values of their particles. So the light lepton current can be written as $[S_l, S_{\tilde{\nu}_l}]$, and the heavy lepton current as $[S_L, S_{\nu_L}]$. Then reaction (3) may be given by its symbolic matrix element

$$[S_l, S_{\tilde{\nu}_l}]\,[S_L, S_{\nu_L}]^+.$$

Let us take first the massive leptons L and l to be spin 1/2 particles. In that case we consider the decay process (3) with two spin assignments of neutrinos. First we take $S_{\nu_L} = 3/2$, $S_{\tilde{\nu}_l} = 1/2$ and, secondly, $S_{\nu_L} = 3/2$, $S_{\tilde{\nu}_l} = 3/2$. These processes are denoted, accordingly, by symbols $[1/2, 1/2]\,[1/2, 3/2]^+$ and $[1/2, 3/2]\,[1/2, 3/2]^+$. For the $[1/2, 1/2]$ current the ordinary V-A type is used and the $[1/2, 3/2]$ current may be given as

* The possibility of non-maximal helicity 1/2 states was also recently suggested by D. H. Miller [2].

$$[1/2, 3/2] = u(1+a\gamma_5)u^{\mu}, \qquad (4)$$

where u^{μ} denotes the Rarita-Schwinger vector spinor.

Now, one can easily find that up to the numerical factor, the squared matrix element of the reaction $[1/2, 3/2][1/2, 3/2]^+$ with $a=1$ is equal to that of the ordinary reaction $[1/2, 1/2][1/2, 1/2]^+$. Hence, these reactions have the same distribution of final particles. Similarly, one can find that the final distribution of the reaction $[1/2, 1/2][1/2, 3/2]^+$ with $a=-1$ is the same as the distribution in L^+ decay of $[1/2, 1/2][1/2, 1/2]^+$ reaction.

So, for the reactions considered above one can write the familiar distributions

$$dw \sim x^2[3-4x \pm \vec{k}\vec{\eta}(1-4x)], \qquad (5)$$

where the upper sign belongs to the reaction $[1/2, 3/2][1/2, 3/2]^+$ and the lower sign to $[1/2, 1/2,][1/2, 3/2]^+$ and $x=E_l/M_L$. These familiar spectra must be analyzed taking into account the new spin values of neutrinos. Let us investigate these distributions near the energy maximum of the final l lepton. If the direction of final lepton momentum is taken to be the axis of quantization, one can see from (5) that in the reaction $[1/2, 3/2][1/2, 3/2]^+$ L lepton can decay only in the state $m_L=-1/2$ and in the $[1/2, 1/2][1/2, 3/2]^+$ reaction only in the state $m_L=+1/2$.

In the first case both the maximal and the non-maximal helicity states of $\tilde{\nu}_l$ and ν_L are allowed. Indeed, at the maximal possible energy of the final lepton both $\tilde{\nu}_l$ and ν_L are emitted in the opposite direction to the l lepton and their spin components add up to zero (if both have only maximal or only non-maximal helicities). Then the final spin state of reaction (3) is determined only by the spin state of the final l lepton. If $a=1$, l lepton is left-handed, and L lepton can indeed decay only in the state $m_L=-1/2$. In the reaction $[1/2, 1/2][1/2, 3/2]^+$ the helicities of l and $\tilde{\nu}_l$ add up to unity (opposite to l momentum direction) and the reaction is allowed only when L neutrino is in the maximal helicity state. If $a=-1$, L neutrino is left-handed and, indeed, L lepton can decay only in the state $m_L=1/2$. If the massive leptons in reaction (3) may also be spin 3/2 particles, one can find similarities between the behaviour of currents $[3/2, 3/2]$ and $[3/2, 1/2]$ as well. One can build here two simple $[3/2, 3/2]$ currents — the usual one

$$[3/2, 3/2] = u_{\sigma}\gamma_{\mu}(1+a\gamma_5)u^{\sigma}_{\nu_L} \qquad (6)$$

and a new, an unusual one

$$[3/2, 3/2] = u_{\mu}\gamma_{\sigma}(1+a\gamma_5)u^{\sigma}_{\nu_L}. \qquad (7)$$

In reaction $[1/2, 1/2][3/2, 3/2]^+$ the last current gives the same distribution as the current

$$[3/2, 1/2] = u_{\mu}(1+a\gamma_5)u_{\nu_L} \qquad (8)$$

in reaction $[1/2, 1/2][3/2, 1/2]^+$. This distribution is given in [3]. Near the energy maximum this distribution can be interpreted if only non-maximal helicities contribute to it.

Current (6) does not behave effectively like current (8). For the reaction $[1/2, 1/2][3/2, 3/2]^+$ it gives a new, unknown distribution. We do not give this distribution in this note but we say only that near the maximal energy this distribution can be interpreted only if in the case of

$a=-1$ the L neutrino has maximal helicity and in the case of $a=+1$, non-maximal helicity.

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П. АДАМСОН

РАСПРЕДЕЛЕНИЕ ПОТОКА МОЩНОСТИ НАПРАВЛЯЕМЫХ МОД АСИММЕТРИЧНОГО ПЛОСКОГО ДИЭЛЕКТРИЧЕСКОГО ВОЛНОВОДА

P. ADAMSON. TASAPINNALISE ASÜMMEETRILISE DIELEKTRILISE LAINEJUHI SUUNATUD MOODIDE VÕIMSUSVOO JAOTUS

P. ADAMSON. POWER DISTRIBUTION OF THE GUIDED MODES OF AN ASYMMETRIC DIELECTRIC SLAB WAVEGUIDE

(Представил К. К. Ребане)

Плоские диэлектрические волноводы (ПДВ) интенсивно исследуются в настоящее время в связи с широкими возможностями применения их в интегрально-оптических системах передачи и обработки информации [1,2]. Модель ПДВ является основой и для анализа волноводных свойств резонатора полупроводникового гетеролазера [3,4]. Цель данного сообщения — анализ распределения потока мощности в асимметричном ПДВ в зависимости от степени его асимметрии. Представлена также аппроксимационная формула для расчета фактора оптического ограничения (ФОО) ТЕ-мод, показывающая, какая доля полного потока мощности распространяется в среднем слое ПДВ.

Рассмотрим асимметричный трехслойный бесконечнопротяженный в двух измерениях ПДВ со скачкообразными изменениями диэлектрических проницаемостей на границах. Степень асимметрии ПДВ характеризуется фактором $\eta=(\varepsilon_1-\varepsilon_2)(\varepsilon_1-\varepsilon_3)^{-1}$, где ε_1 — диэлектрическая проницаемость среднего слоя ПДВ, а ε_2 и ε_3 — диэлектрические проницаемости крайних слоев ($\varepsilon_1>\varepsilon_{2,3}$, $\varepsilon_3\geqslant\varepsilon_2$). В дальнейшем индекс 1 проставляется у всех величин, характеризующих средний слой с ε_1, а индексы 2, 3 — у величин, относящихся к крайним слоям с ε_2 и ε_3 соответственно.

Распределение потока мощности моды ПДВ определяется ФОО моды Γ_1 и факторами делокализации моды $\Gamma_{2,3}$ — относительные доли