

002  $e-\nu$ -INTERACTION

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Here we treat  $e-\nu$ -interaction<sup>1)</sup> and calculate its cross section in two ways of dealing with (I) the proposed intermediate vector boson<sup>2)</sup> due to the São Paulo model<sup>3)</sup> and (II) the weak interaction. The results of these calculations will be expected to contribute  $e-\nu$ -interaction experiments of high energy physics in the near future. This paper is composed of three parts, the first is "Introduction", and "The São Paulo Model", the second is "Weak Interaction", the third is "Results and Remarks".

**I. Introduction**

In elementary particle physics the interactions are assigned four broad categories, (1) the gravitational interaction, (2) the electromagnetic interaction, (3) the strong interaction, (4) the weak interaction. (see Table 1.)

In the unified field theory it is very expected to exist a intermediate vector boson because in spite of being the disparities between the electromagnetic interaction and the weak interaction, for example, the weak

currents are heavy dependent on the electric charge of the particles. The following properties are stated about the dissimilarities and the similarities between the similarities between the two interactions.

The Dissimilarities<sup>4)</sup>:

- (1) From the point of view of current-current interactions, the weak current are always charged, on the other hand the electromagnetic currents are neutral.
- (2) The great disparity of the interaction probability between a muon or a neutrino and

**Table 1.**

	Gravitational	Electro-magnetic	Strong	Weak
Examples	Astronomical Forces	Atomic Forces	Nuclear Forces	Nuclear Beta Decay
Particles Acted Upon	Everything	Charged Particles	Hadrons	Hadrons Leftons
Particles Exchanged	Gravitons	Photons	Hadrons	?
Range	$\infty$	$\infty$	$10^{-13} \sim 10^{-14}$ cm	$\ll 10^{-14}$ cm
Strength (Natural Unit)	$G_{\text{NEWTON}} \approx 5.9 \times 10^{-39}$	$e^2 \approx \frac{1}{137}$	$g^2 \approx 1$	$G_{\text{FERMI}} \approx 1.02 \times 10^{-5}$

a hadron, and their energy relation is seen in Figure 1.

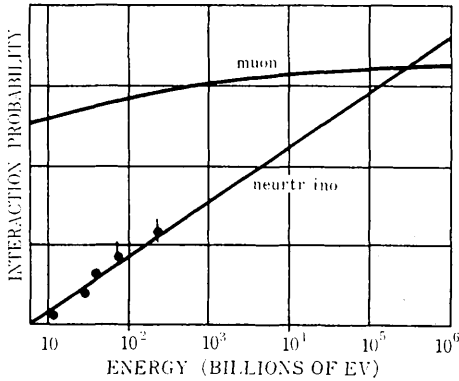


Fig. 1.

If this trend continues, namely the weak force will become same as the electromagnetic force and even greater than it, this difference of two at low energies will disappear.

(3) The parity violation occurs in the weak interaction in some cases, but does not in the electromagnetic interaction.

(4) The effective range of two interactions is quite different. The electromagnetic force is caused by a zero-mass particle, a photon. The weak force seems to act over very short distance. Then it is transmitted by the exchange of a particle, the exchanged particle is very massive.

The Similarities :

- (1) For both forces the interaction probabilities follow the same "current times current" rule.
- (2) In both interactions all particles participate, but only hadrons are affected by the nuclear force.

Summing up :

- (1) The above stated exchanged particle is called the intermediate vector boson or the W-particle.
- (2) Strangeness : In the neutral weak current the participating particles have the same degree of strangeness before the interaction

and after it. In the charged weak current, in contrast, the degree of the participating particle's strangeness may either change or stay the same.

(3) Many questions remain to be answered, such as why weak interactions violate parity<sup>5)</sup> why the range of both interactions are so different. In any case neutral weak currents will undoubtedly serve as a tool for the further discovery of many of other essential properties of elementary particles.

## II. The São Paulo Model

Next we assume a vector boson, according to the São Paulo model, and its initial and final states.

Writing down the Hamiltonian and their Feynman diagrams, we calculate cross sections on the proper cases.

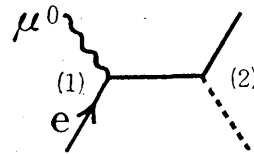
Assumed to be a composite particle of the electron and the muon, substituting  $\mu^+$  for  $e^+$  in  $\gamma = (e^-, e^+)$

$$\mu^0 = (e^-, \mu^+), \quad \bar{\mu}^0 = (e^+, \mu^-) :$$

$$m_{\mu^0} < m_\mu + m_e$$

where  $\mu^0$  is a boson with a rest mass  $m_{\mu^0}$

We are considering now the second order weak interaction because  $S_{w,a}^{(1)}$  is not used for the cross section calculation of our purpose.



$$S_{w,a}^{(2)} = (-i)^2 \int dx_1 dx_2 P(H_w(x_1) H_a(x_2))$$

At the point of (1) it is called the weak interaction

$$H_I = H_w + H_a$$

$$H_a = a \bar{e} \mu \cdot \chi + a^* \mu \cdot e \chi^+$$

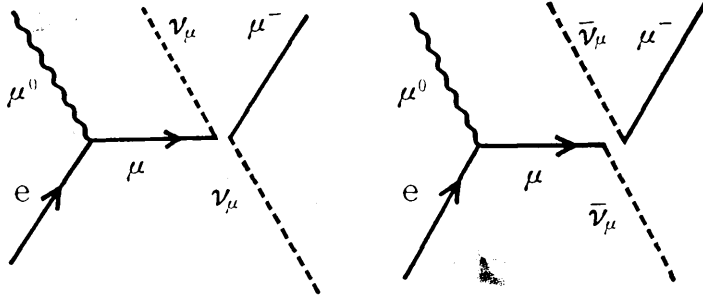
$\chi$  : complex vector,  $e = 0$

$a, a^*$  : coupling constant

$$P[N(\mu \nu_\mu \nu_\mu + \mu \nu_\mu \nu_e e + \bar{e} \nu_\mu \mu + \bar{e} \nu_e \nu_e e) \\ N(\mu e \chi + \bar{e} \mu \chi^+)]$$

Every term is below written and its Feynman diagram.

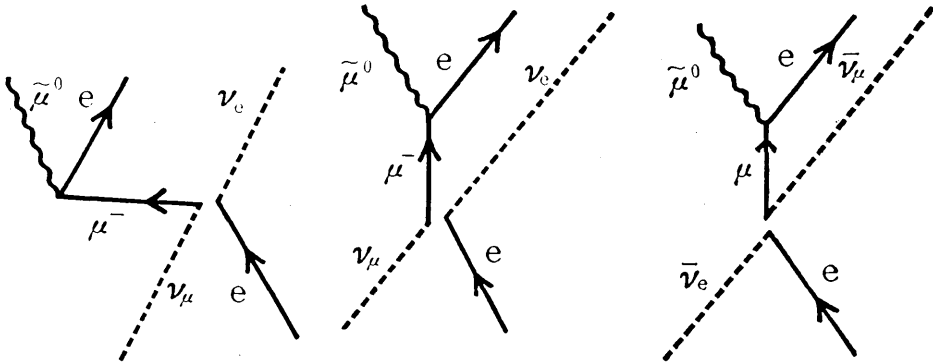
1)  $P[N(\mu\nu_\mu\nu_\mu\mu)N(\mu e\chi)]$



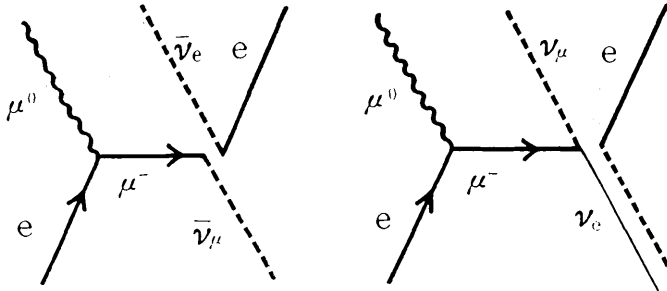
2)  $P[N(\mu\nu_\mu\nu_\mu\mu)N(\bar{e}\mu\chi^+)]$  non-existence

3)  $P[N(\mu\nu_\mu\nu_e e)N(\mu e\chi)]$  non-existence

4)  $P[N(\mu\nu_\mu\nu_e e)N(\bar{e}\mu\chi^+)]$

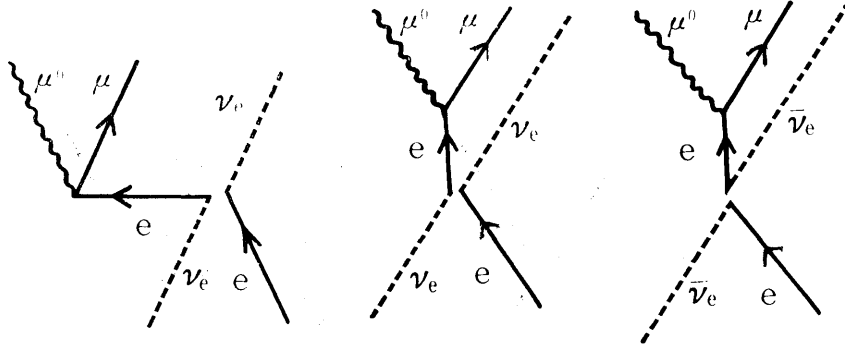


5)  $P[N(\bar{e}\nu_e\nu_\mu\mu)N(\mu e\chi)]$



6)  $P[N(\bar{e}\nu_e\nu_\mu\mu)N(\bar{e}\mu\chi^+)]$  : non-existence

7)  $P[N(\bar{e}\nu_e\nu_e e)N(\mu e\chi)]$



8)  $P[N(\bar{e}\nu_e\nu_e e)N(\bar{e}\mu\chi)]$  non-existence

Then we suppose the process of  $(e\nu_\mu)(\mu^0\mu^-)$ , we can pick up the case 1).

The calculation of this process is in the following stated.

$$P[N(\mu\nu_\mu\nu_\mu\mu)N(\mu e\chi)]$$

$$L = \bar{u}(\mu^-) \gamma_\alpha (1-i\gamma_5) u(\nu_\mu) \bar{u}(\nu_\mu) \gamma_\alpha (1-i\gamma_5) (\mu-m_\mu)^{-1} u(e) \chi^+$$

$$L^* = \bar{u}(\nu_\mu) \gamma_\beta (1-i\gamma_5) u(\mu^-) \bar{u}(e) \gamma_\beta (1-i\gamma_5) (\mu-m_\mu)^{-1} u(\nu_\mu) \chi$$

The Casimir Operators are

$$\Lambda_+(\mu^-) = \bar{u}(\mu^-) u(\mu^-)$$

$$\Lambda_-(e) = u(e) \bar{u}(e)$$

$$\Lambda_+(\nu_\mu) = \bar{u}(\nu_\mu) u(\nu_\mu)$$

$$\Lambda_-(\nu_\mu) = u(\nu_\mu) \bar{u}(\nu_\mu)$$

In order to get this cross section, we must have its trace.

$$LL^* = \text{Tr}[\Lambda_+(\mu^-) \gamma_\alpha (1-i\gamma_5) \Lambda_-(\nu_\mu)] \times \text{Tr}[\Lambda_+(\nu_\mu) \gamma_\alpha (1-i\gamma_5) \Lambda_-(e) \gamma_\beta (1-i\gamma_5) \gamma_\beta (1-i\gamma_5) \frac{P+m}{2m}] \chi^+ \chi$$

: continued

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