On the Elementarily of the Weak Boson-Fermion Interaction, II*

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From the results of the preceding letter\(^1\), we continue the standpoint of eliminating the universal g-int. by making the following minimum relaxation of the universal characters of f-int.

(I) "The value of the coupling constant \( f \) is unique but the coupling types are process dependent."

As regards the estimation of the absolute values of the transition probabilities, we have rather little knowledge and we cannot compare with much confidence the transition probabilities calculated for different coupling types of \( f \)-vertex. From the knowledge of \( \beta \)-decay coupling, however, we can deduce the following general arguments for the possible coupling types.

(a) \((\bar{\psi}_e O \phi_e) = S \pm T\). \((\bar{\psi}_e O \phi_e)\) contains at least \( PV \) or \( PS \).

In this case \( \pi \to e + \nu \) probabilities contain \( a^n \) compared with those of \( \pi \to \mu + \nu \) which will be useful to explain the ratio \( R \).

(b) \((\bar{\psi}_e O \phi_e) = S \mp T \pm P\). \((\bar{\psi}_e O \phi_e)\) contains at least \( PV \). This is possible only if it turns out that \( \pi \to \mu + \nu \) through \( PV \) can predominate over \( \pi \to \mu + \nu \) through \( P \).

For every vertex, however, \( \pi \to e + \nu + \gamma \) (also \( \pi \to \mu + \nu + \gamma \)) will occur through \( Gef \)-process. For the same type of \( f \)-vertex \( \pi \to e + \nu + \gamma \) will be more favoured than \( \pi \to \mu + \nu + \gamma \) by the available phase space volume. For \( (\bar{\psi}_e O \phi_e) S \mp T \) and \( V, \pi \to e + \nu + \gamma \) will be more frequent than \( \pi \to e + \nu \) because the transition probabilities contain the factor \( \alpha \) for the former cases and \( \alpha^2 \) for the latter. The situation is exactly the opposite for \( P \). Thus the experiments on the frequency ratio \( R' = W(\pi \to e + \nu + \gamma) / W(\pi \to e + \nu) \) are quite interesting. If \( R' < 1 \), (a) will be completely rejected. On the other hand, if \( R' > 1 \) (a) will be the case. For (b) it means that \( \pi \to e + \nu \) through \( P \) is less frequent than \( \pi \to e + \nu + \gamma \) through \( S \) and \( T \) which have the factor \( \alpha \) in their decay probabilities. So if \( R' \gg 1 \), (b) seems to be unacceptable. Thus the ratio \( R' \) will give an indirect test of \( \beta \)-coupling. If (i) we agree to make such a relaxation as (a) and (b) in the universal and symmetrical characters of \( f \)-int. and (ii) in addition, the values of the matrix elements \( M \) or \( M' \) in (2) or (3) of I turn out to be of the correct order, then we are in a position to be able to deduce \( \pi \to \mu + \nu \) without introducing universal g-int. If neither (i) nor (ii) is the case, the introduction of primary g-int. is the simplest and the most natural procedure. For instance, the assignment \( S \mp T \) for process independent \( f \)-int. requires the factor \( a^2 \) for \( \pi \to \mu(e) + \nu \) and it may be possible that \( Ge, \sigma \)-mechanism is not responsible for \( \pi \to \mu + \nu \).

(B) Hyperon decays

Let us proceed to other \( g \)-reactions, the Hyperon decays, assuming that \( f \)-int. have such properties as discussed above and so

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are able to lead to $\pi \to \mu + \nu$ coupled with G-int. As already pointed out we must add a new feature to $f$-int. for this purpose, namely (II) "$f$-int. must be extended into four Baryons (not neutrino processes)."

To develop the similar procedure to (A) we make the following assumption and the following approximation.

**Assumption.** "Let $f$-int. containing $(\mu, \nu)$ and $(P, \not A)$ be $(\overline{\psi}_\mu O \psi_\nu) (\overline{\psi}_a O \psi_b)$ and $(\overline{\psi}_a O \psi_b) (\overline{\psi}_\mu O \psi_{\not A})$, where $a$ and $b$ are some sets of Baryons. Among these $f$-int. there is complete symmetry between $(\mu, \nu)$ and $(P, \not A)$.

**Approximation.** "$A'$ and $P$ in these $f$-int., as $\mu$ and $\nu$, cannot interact strongly with other Baryons."

Under the above assumption and approximation $A'$-decay is realized by the processes shown in Fig. 1, which have the same diagrams as Fig. 1 of I for the intermediate states. Then completely similar arguments to (1) of I are possible.

![Diagram](https://example.com/diagram.png)

\[(\alpha) \quad (\overline{\psi}_\mu O \psi_\nu) = (\overline{\psi}_\mu O \psi_{\not A}) = S, V \text{ and } T. \text{ These are forbidden, but if we do not make the "freezing" approximation } A' \to P + \pi^- \text{ is allowed by the inclusion of } G^a\text{-correction (not } e\text{-correction).} \]

\[(\beta) \quad (\overline{\psi}_\mu O \psi_\nu) = (\overline{\psi}_1 O \psi_{\not A}) = P. \]

In place of (2) of I we have for $A' \to P + \pi^-$,

\[
M(\overline{\psi}_{\mu'} \gamma'_5 \gamma_5 \psi_{\not A}) \bar{\phi}_{\pi}. \tag{1}
\]

\[(\gamma) \quad (\overline{\psi}_\mu O \psi_\nu) = (\overline{\psi}_\mu O \psi_{\not A}) = PV. \]

In place of (3) of I we have

\[
M'(\overline{\psi}_{\mu'} \gamma'_5 \gamma_5 \psi_{\not A}) \bar{\phi}_{\pi}. \tag{2}
\]

Comparing (1) and (2) with (2) of I and (3) of I respectively, we can estimate the decay life-times of $A' \to P + \pi^-$ from that of $\pi \to \mu + \nu$ without knowing the details of $M$ and $M'$. From the results of $A$, it is shown that $O_j = 1$, $\gamma'_5 \gamma_5$ and $\bar{\gamma}_5$ can give the correct order of magnitude within the factor 2~10. The best fit is given in the case of $\bar{\gamma}_5$. This is interesting because it predicts the different space inversion parity for $A'$ and $P$. For $\sum$ and $\Xi$-decay we can have similar procedure taking their spin values to be 1/2 and can also expect the workability of $G$ and $f$-intermediation, provided that it is the case with $\pi \to \mu + \nu$. The main part of the $G$-corrections neglected due to our "freezing" approximation seems to correspond to the $G$-corrections which are also neglected in the discussion of primary $g$-int. for $A' \to P + \pi^-$. It is not certain whether such corrections may be responsible for the discrepancy of the order of 2 to 10. Analogous mechanism, of which details we do not give here, is of course considered for $K_\mu \to \mu + \nu$.

In conclusion we infer that in order to eliminate the elementary $g$-int. we must, at least, impose the more complicated structure (I) and the extension (II) to $f$-int. It is also shown that if we admit these conditions, it is possible to explain the Hyperon decays and possibly the $K_\mu \to \mu + \nu$ if we can explain $\pi \to \mu + \nu$ by $G$, $e$- and $f$-intermediation. More detailed discussions about universal interactions will soon appear in *Nuclear Physics*. We are indebted to Prof. T. Tati and Dr. S. Ogawa for their kind discussions.
Letters to the Editor

3) From the decay schemes $\pi \rightarrow \mu + \bar{\nu}$ and $A^0 \rightarrow P + \pi^-$, it may be reasonable to assume symmetry between $(\mu + \bar{\nu})$ and $(P + A^0)$ if some regularity exists for weak interactions.