UNIVERSITY OF CALIFORNIA

DEPARTMENT OF PHYSICS
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Dear Dr. Jürsey.

Many thanks for your letter of Feb. 23, which arrived yesterday and which I studied with great interest. I am in favour of your idea, to make the neutrino rather than the vacuum responsible for the strangeness. Independent of this other difficulties connected with the spinor-model, which I discuss first.

1. γ_5-invariance and reflexions.

I say, the theory is invariant with respect to some operation, if both the Lagrangian and the commutation relations have this invariance.

Suppose now the theory is invariant with respect to the operation $\psi' = \gamma_5 \psi$ (or $\psi' = i\gamma_5 \psi$).

If then a particle with spin 1/2 - which is obtained from the vacuum by an odd number ψ-operator factors ~~and not vanishing~~ obeys a Dirac-equation

$$\left(\gamma^\nu \frac{\partial}{\partial x^\nu} + m\right)\psi = 0 \quad \text{with } m \neq 0$$

there should, due to the γ_5-invariance also exists a "double" of this particle, obeying the Dirac-equation

$$\left(\gamma^\nu \frac{\partial}{\partial x^\nu} - m\right)\psi = 0.$$

This can be applied for instance to the electron, but also to an isotriplet like Λ_0. (The latter has been proposed by Källén).

As there is so much 'complexity' in nature, one could indeed find, that Lagrangian and commutation rules can not be both γ_5-invariant.

This seems to agree with your conclusion on p. 2 of your letter, particularly regarding the terms $\frac{1-\gamma_5}{3}\frac{1+\sigma_3}{2}$. - (In any case Lagrangian and commutation rules can not have the same symmetry. To which of them one gives the higher symmetry is an open question.)

But here seems to me a difficulty: If the γ_5-invariance is destroyed - either in the Lagrangian or in the commutation relations - what is then the justification for your statement, that f and n (hence N and Λ) are good quantum-numbers?

In the moment I don't know any good answer. I would like to hear your opinion about it.

Källén seems to think, that this is a definite <u>dis</u>proval of the spinor-model. But I am not yet convinced of such a far reaching conclusion. What do you think of it?

2.) <u>Eigenvalue-problem.</u> Nobody knows any good method to determine the invariant functions ($F(s)$, $G(s)$, $G_1(s)$) occurring in the vacuum-expectation-values (V.E.) (*) (therefore also in the anticommutators).

Heisenberg therefore applies the Tamm-Dancoff-method. I personally don't trust at all this method, therefore I abstain from collaboration in this part of the work done in Göttingen (at present by Heisenberg and Mitter). – Moreover, if one already introduces an indefinite metric in Hilbert-space, I believe, one should claim complete regularity (on the light cone) of all V.E., and <u>not</u> admit any logarithmic singularity.

This are the more fundamental difficulties. (One an objection, the other an essential lack of a good method – in spite of the existence of so many experts).

Now – more specific – to your interesting

(*) There must be some (probably indirect) mathematical connections of them with the Lagrangian.

proposal of an asymmetric neutrino.
First: there are some slight mistakes on your p. 2
below: One should read $\frac{l}{2} = \frac{N - L + S}{2}$ (instead of
$\frac{l}{2} = Q + \frac{N - L + S}{2}$], as $I_3 + l/2 = Q$. This is also in
agreement with your other formulas on p. 2 and 3.
If the μ^+ is considered to be the "mirror" of
ε^-, then in Table I one has to correct $t_3 = 3/2$ and
$\frac{Y}{2} = -\frac{3}{2}$ [instead of $t_3 = \frac{1}{2}$ for μ_+ and $\frac{Y}{2} = -\frac{5}{2}$].
Bad luck, that Schwinger's idea to consider
$\mu^\pm$ as the mirror particles of $\varepsilon^\mp$ is not possible.
The mirror particles of $\varepsilon^\mp$ must be something
(perhaps something unstable)
not yet observed and the μ-particle must be some-
thing else. The decay $\mu \to e + \nu + \bar{\nu}$ being certain.
I want to maintain the two component theory of
the neutrino.) I leave it to you, to make proposals
for the μ-particle in your scheme. One possibility
is $S(\mu^+) = +1$; $\left(\frac{Y}{2}\right)_{\mu_+} = 3/2$.

So far physics for today.

Personal. I have good news from Zürich, that I get some money to invite Oberlehrer to Zürich, probably already this autumn. The definite decision will be by end of March. Of course, I would like very much to have you in Zürich. Other winter-term starts middle of October and last till 1st of March. The summer term starts end of April and lasts till about 18th July.

I also wrote to Oppenheimer on behalf of you. Possibly you will have to decide whether you prefer to be in Princeton or in Zürich next winter. In the first case you could come to Zürich in the spring- and summer-terms '59 (then the Princeton-Institute is empty).

In any case I would like to know the amount of money which you would need either for half a year or for one year in Zürich. I understand that you have also a stipend from your Government. One can not simply compute the cost of living in Switzerland from those in the State here with the official course of $: Even then. With this measure, I believe, that the cost of living

in Switzerland are less. But the details are of the operation complicated.

So, please, think it over. There are many Swiss physicists in the States (Frauenfelder, Scherrer, E. Baker, Macdox etc.). You can also ask one of them.

All good wishes

Sincerely Yours

W. Pauli