

There is some anti-symmetry in the η 's.

$$P' = P e^{i\alpha B + i\beta L + i\gamma Q}$$

is as conserved as P .

By choosing $\alpha \neq 0$, we may fix $\eta_p = \eta_n = \eta_e = 1$.

But η for π^0 is unique — carries no conserved quantum numbers.

P^2 is (like) an internal symmetry

$$P^2 4 \frac{t}{\alpha} = \eta_{n_1}^2 \eta_{n_2}^2 \eta_{n_3}^2 \dots 4 \frac{t}{\alpha}$$

$\stackrel{i \vec{\alpha} \cdot \vec{Q}}{\longrightarrow}$

If we can set $\eta_\alpha^2 = e$

with $[Q, H] = 0$, then we can say

$$P^2 = e^{-i\vec{\alpha} \cdot \vec{Q}/2}$$

and $P' = P e^{i\alpha B + i\beta L + i\gamma Q}$

satisfies

$$P'^2 = P^2 P^{-2} = I.$$

Call P' parity and have

$$P'^2 = I,$$

and so $\eta_\alpha = \pm 1$.

But such an $\alpha \cdot Q$ may not be available. If v is Majorana, $B_v = L_v = 0$, then $\eta_v = \pm i$ is possible.

Noir (3.3.42) says

$$S_{\alpha\beta} = \gamma_\alpha^* \gamma_\beta S_{\rho\alpha\rho\beta} .$$

So if $\eta_\alpha = \pm \eta_\beta$, then

$$S_{\alpha\beta} = \pm S_{\rho\alpha\rho\beta}$$

or S is even in the $\vec{p}'s$.

$$1951 \quad (\pi^- d) \rightarrow n n$$

$$\begin{array}{ll} l=0 & l=1 \\ j=1 & s=1 \end{array}$$

$$S_{\alpha\beta} = - S_{\rho\alpha\rho\beta}$$

$$S_{\alpha\beta} = - \eta_\alpha \eta_\beta = -1$$

$$d \rightarrow l=0 \quad \eta_p = \eta_n \quad \text{so} \quad \eta_d = 1$$

$$\eta_{\pi^-} = -1 .$$

pseudoscalar ($\pi^\frac{0}{0}$ all have $\eta_{\pi^-} = -1$)

If $X \rightarrow \pi \pi \pi$,

then in next frame $\overrightarrow{p_1 + p_2 + p_3} = \vec{0}$

being rotationally invariant

So S_n just depends on $p_1 \cdot p_2$ etc $p_2 \cdot p_3$.

The only available scalars made from p_i

that are rotationally invariant. So

$$S_{\pi\pi\pi X} = (\gamma_\pi^*)^3 \gamma_X S_{P(\pi\pi X)}$$

$$= -\gamma_X S_{\pi\pi\pi X}$$

So

$$\gamma_X = -1.$$

And if $\gamma \rightarrow \pi \pi$, then $\gamma_\pi = +1$.

T, θ puzzle late 1940's

same names and lifetimes. $T, \theta \rightarrow \pi \pi \pi$

Lee-Yang 1956 : $\not\models P$ in weak int's.

Rate $\alpha \rightarrow \beta \propto |S_{\alpha\beta}|^2$
 factors are just E's.
 invariant under P.

If α, β have fixed #s of particles, the γ 's
 are irrelevant in the rates

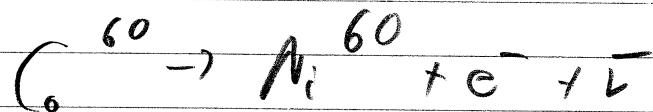
$$\text{So } P \Rightarrow S_{\beta\alpha} = \gamma_\beta^* \gamma_\alpha S_{\beta\alpha} \theta_{\beta\alpha}$$

$$\text{Rate } (\alpha \rightarrow \beta) = \text{Rate } (\beta \rightarrow \alpha)$$

rates invariant under reversal of all

3-momenta $\overset{\rightarrow}{P_i}$

Lee, Yang, Wu

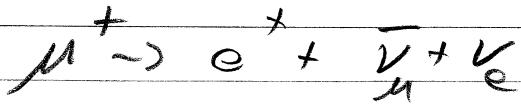


found e^- 's came out more
 in direction opposite $\vec{\nu}$ of ${}^{60}_Co$.

Also seen in



(polarized)



But in vector gauge theories parity
is conserved. (12.5) as long as
 $e_L = e_R$ in QED e.g.

from

Time Reversal

$$T \Psi_{p_1, \sigma_1, n_1, p_2, \sigma_2, n_2}^{\pm} = \prod_{n_1}^{j_1 - \sigma_1} (-1)^{j_1 - \sigma_1} \prod_{n_2}^{j_2 - \sigma_2} (-1)^{j_2 - \sigma_2} \\ 4^{\mp} (p_1, -\sigma_1, n_1; p_2, -\sigma_2, n_2)$$

in $n > 0$ case,

$$T 4_{\alpha}^{\pm} = 4_{\bar{\alpha}}^{\mp} \quad (3.3, 4.4) \\ \text{includes phases!}$$

$$T \text{ is anti unitary} = (4_{\alpha}^+, 4_{\beta}^-)^* \quad (2.2, 4) \\ S_{\beta\alpha} = (4_{\bar{\beta}}, 4_{\alpha}^+) = (T 4_{\alpha}^+, T 4_{\beta}^-) \\ = (4_{\bar{\alpha}}^-, 4_{\bar{\beta}}^+) = S_{\bar{\alpha}\bar{\beta}}$$

$$S_{p_1' \sigma_1' n_1'} \dots p_1 \sigma_1 n_1 \dots \\ = \prod_{n_1'} (-1)^{j_1' - \sigma_1'} \dots \prod_{n_1}^* (-1)^{j_1 - \sigma_1} \dots$$

$$S_{p_1' \sigma_1' n_1'} \dots p_1 \sigma_1 n_1 \dots$$

$$\text{If } T_0 \phi_\alpha = \phi_{\tilde{\alpha}}$$

$$\text{and } T_0^{-1} H_0 T_0 = H_0$$

$$\text{If also } T_0^{-1} V T_0 = V$$

$$\text{Then } T_0^{-1} H T_0 = H \text{ and}$$

we take $T = T_0$ and get by (3.1.17)

$$\begin{aligned} T \psi_\alpha^\pm &= T \mathcal{L}(\pm\infty) \phi_\alpha \\ &= T e^{\mp i H T_B} e^{\pm i H_0 T_B} \phi_\alpha \\ &= e^{\pm i H T_B} e^{\mp i H_0 T_B} T \phi_\alpha \\ &= \mathcal{L}(\pm\infty) \phi_{\tilde{\alpha}} = \psi_{\tilde{\alpha}}^\pm \end{aligned}$$

which is (3.3.44) and which implies the covariance

of the S-matrix under time reversal, i.e., the behavior of the S-matrix in a theory that has time-reversal symmetry.

One may also use (3.1.16) and (3.3.48-50). In either case

$$S_{\beta,\alpha} = S_{\tilde{\alpha},\tilde{\beta}}$$

$$\text{i.e. rate } R(\alpha \rightarrow \beta) = R(\tilde{\beta} \rightarrow \tilde{\alpha}).$$