CHARGE-PARITY VIOLATING ELECTROMAGNETIC INTERACTION

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Submitted 7 October 1965
JETP Pis'ma 2, 494-496 (15 November 1965).

It was noted in [1] that the electromagnetic current of particles with spin $J > 1/2$ can in principle contain both C-odd and C-even terms. (The presence of C-even terms for particles with lower spins is forbidden by current conservation.) The explicit form of the current for particles with spin 1 and 3/2 [1] shows that the contribution of C-even terms to the elastic scattering of the electron by the particle in question is proportional to q^2, the square of the momentum transfer. This signifies that the forces which do not conserve C parity are short-range. We shall show below that a similar phenomenon takes place for particles with arbitrary spin $J > 1/2$.

It is convenient to describe a particle with spin J by means of the matrix $\Psi^{\alpha_1\alpha_2\ldots\alpha_{2J}}$ (α_k = 1, 2, 3, 4), which is symmetrical in all indices and satisfies the Dirac equation [2]:

$$(\hat{p} - m)^{\beta}_{\alpha_k} \Psi^{\alpha_1\ldots\alpha_k\ldots\alpha_{2J}} = 0.$$

The general expression for the electromagnetic current is

$$j_\mu = \sum_i f_i(q^2)\, \bar{\Psi}(p_2)_{\alpha_1\ldots\alpha_{2J}} (O^i_{\mu'})^{\alpha_1\ldots\alpha_{2J}}_{\beta_1\ldots\beta_{2J}} \Psi(p_1)^{\beta_1\ldots\beta_{2J}} \cdot (g_{\mu\mu'} - \frac{q_\mu q_{\mu'}}{q^2}).$$

The sum is taken here over all the independent matrices O^i;

$$\bar{\Psi}_{\alpha_1\ldots\alpha_{2J}} = \Psi^+_{\alpha'_1\ldots\alpha'_{2J}} (\gamma_4)^{\alpha'_1}_{\alpha_1}\ldots(\gamma_4)^{\alpha'_{2J}}_{\alpha_{2J}}.$$

It is easily seen that we can choose the following matrices O^i_μ:

$$(p_1 + p_2)_\mu (\gamma_5)^{\alpha_1}_{\beta_1} \ldots (\gamma_5)^{\alpha_{2k}}_{\beta_{2k}} I^{\alpha_{2k+1}}_{\beta_{2k+1}} \ldots I^{\alpha_{2J}}_{\beta_{2J}}, \tag{1}$$

$$(\gamma_\mu)^{\alpha_1}_{\beta_1} (\gamma_5)^{\alpha_2}_{\beta_2} \ldots (\gamma_5)^{\alpha_{2k+1}}_{\beta_{2k+1}} I^{\alpha_{2k+2}}_{\beta_{2k+2}} \ldots I^{\alpha_{2J}}_{\beta_{2J}}, \tag{2}$$

$$(\gamma_\mu\gamma_5)^{\alpha_1}_{\beta_1} (\gamma_5)^{\alpha_2}_{\beta_2} \ldots (\gamma_5)^{\alpha_{2k}}_{\beta_{2k}} I^{\alpha_{2k+1}}_{\beta_{2k+1}} \ldots I^{\alpha_{2J}}_{\beta_{2J}}. \tag{3}$$

Here I is a unit matrix.

The number of independent matrices is $3J + 1$ and $3J + 1/2$ for particles with integer and half-integer spin, respectively.

We note that expressions of the type $(\gamma_\mu)^\alpha_\rho (\gamma_\mu)^\beta_\sigma$ reduce to those given above by virtue of the identity

$$(\gamma_\mu)^\alpha_\rho (\gamma_\mu)^\beta_\sigma + (\gamma_\mu)^\alpha_\sigma (\gamma_\mu)^\beta_\rho = I^\alpha_\rho I^\beta_\sigma + I^\alpha_\sigma I^\beta_\rho - (\gamma_5)^\alpha_\rho (\gamma_5)^\beta_\sigma - (\gamma_5)^\alpha_\sigma (\gamma_5)^\beta_\rho.$$

We see that expressions (1) and (2) conserve C parity, while (3) violates it.

Thus, the C-parity violating amplitudes are of the form

$$f_i(q^2)\ \bar{\Psi}\ O^i_{\mu'}\ \Psi\ (g_{\mu\mu'} - q_\mu q_{\mu'}/q^2)\ ,$$

with $q_{\mu'}\bar{\Psi}O^i_{\mu'}\Psi \neq 0$. Now to make the amplitude analytic at $q = 0$ we must have $f_i(q^2) = q^2\varphi_i(q^2)$. Our statement follows from the fact that the term proportional to q_μ makes no contribution to the elastic scattering of the electron.

We note incidentally, for reference purposes, that in the Rarita-Schwinger formalism [3] for particles with spin 3/2 the electromagnetic current contains at first glance six independent terms:

$$A_1 = \bar{\Psi}_\mu\ (p_2)\ \gamma_\sigma\ \Psi_\mu\ (p_1)\ ,$$

$$A_2 = \bar{\Psi}_\mu\ (p_2)\ \gamma_\sigma\ \Psi_\nu\ (p_1)\ p_{1\mu}\ p_{2\nu}\ ,$$

$$A_3 = \bar{\Psi}_\mu\ (p_2)\ \Psi_\nu\ (p_1)\ p_{1\mu}\ p_{2\nu}\ (p_1 + p_2)_\sigma\ ,$$

$$A_4 = \bar{\Psi}_\mu\ (p_2)\ \Psi_\mu\ (p_1)\ (p_1 + p_2)_\sigma\ ,$$

$$A_5 = \bar{\Psi}_\mu\ (p_2)\ \Psi_\sigma\ (p_1)\ p_{1\mu} + \bar{\Psi}_\sigma\ (p_2)\ \Psi_\mu\ (p_1)\ p_{2\mu}\ ,$$

$$A_6 = \bar{\Psi}_\mu\ (p_2)\ \Psi_\sigma\ (p_1)\ p_{1\mu} - \bar{\Psi}_\sigma\ (p_2)\ \Psi_\mu\ (p_1)\ p_{2\mu}\ ,$$

whereas it follows from general considerations [4] that there should be only five.

Indeed, we can verify that the quantities A_i are related by

$$\frac{1}{2}\ (p_1 + p_2)^2\ A_1 - A_2 - \frac{m}{(p_1 + p_2)^2}\ A_3 - mA_4 + mA_5 = 0.$$

The author is deeply grateful to L. B. Okun' and M. S. Marinov for interest in the work and valuable discussions.

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CONSTANTS OF INTERACTION OF VECTOR MESONS WITH NUCLEONS. PHOTOPRODUCTION OF π^0 AND η MESONS ON NUCLEONS AND ELECTROMAGNETIC FORM FACTORS OF NUCLEONS

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Submitted 7 October 1965
JETP Pis'ma 2, 497-499 (15 November 1965)

An appreciable contribution to the $\pi^0 p$ photoproduction amplitude at small angles and large γ-quantum energies is made by peripheral mechanisms corresponding to vector-meson exchange [1]. Interest in such mechanisms is due to the possibility of determining the widths