Form factors of vector particles

P. Z. Volkovitskiĭ and E. P. Kaminskaya[1)]

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We consider vector and axial form factors of the transition of a vector particle into a vector particle. It is shown that in the case when the masses of the vector particles are not equal there is an additional transition axial current.

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It is not excluded that radiative and weak transitions between vector particles will be observed in the family of new stable particles, representatives of which were recently discovered. It is therefore of interest to consider the form factors of the vector particles and of transitions of one vector particle into another. The question of the form factors of particles with higher spins was discussed in the literature many times[1–3] but the formalism used was as a rule suitable for the description of all the spins (the Bargman-Wigner formalism, the bispinor formalism, etc) while the vector particle is described in most natural fashion by a transverse four-vector $e_\alpha (e_\alpha k_\alpha = 0)$.

We assume that the transitions occur between vector particles belonging to one representation of the strong-interaction group. Then the matrix element of the current of the inverse transition can be obtained from the matrix element of the currents of the direct transition by interchange of the indices of the initial and final states in all quantities. CP-invariance and hermiticity of the interaction require satisfaction of the equality

$$(J_0, \mathbf{J})^{CP} = (-J_0^+, \mathbf{J}^+). \tag{1}$$

These conditions, from among the entire aggregate of vector and axial combinations, constructed from the four vectors of the initial particle $e_\mu^{(1)}$, the final particle $e_\mu^{(2)}$, and the momenta $k_\mu^{(1)}$ and $k_\mu^{(2)}$ of these particles, leave only the following terms:

$$V_\mu^{(1)} = f_1(q^2)\,(e_\alpha^{(1)} e_\alpha^{(2)})\,(k_\mu^{(1)} + k_\mu^{(2)}),$$

$$V_\mu^{(2)} = f_2(q^2)\,[e_\mu^{(1)}(e_\alpha^{(2)} k_\alpha^{(1)}) + e_\mu^{(2)}(e_\alpha^{(1)} k_\alpha^{(2)})],$$

$$V_\mu^{(3)} = f_3(q^2)\,(e_\alpha^{(1)} k_\alpha^{(1)})\,(e_\beta^{(2)} k_\beta^{(1)})\,(k_\mu^{(1)} + k_\mu^{(2)}),$$

$$A_\mu^{(1)} = i g_1(q^2)\,\epsilon_{\mu\alpha\beta\gamma}\, e_\alpha^{(1)} e_\beta^{(2)} (k_\gamma^{(1)} + k_\gamma^{(2)}),$$

$$A_\mu^{(2)} = i g_2(q^2)\, q_\mu \epsilon_{\alpha\beta\gamma\delta}\, e_\alpha^{(1)} e_\beta^{(2)} k_\gamma^{(1)} k_\delta^{(2)},$$

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$$A_\mu^{(3)} = i g_3(q^2)\,[(e_\delta^{(1)} k_\delta^{(2)})\,\epsilon_{\mu\alpha\beta\gamma}\, e_\alpha^{(2)} k_\beta^{(1)} k_\gamma^{(2)} + (e_\delta^{(2)} k_\delta^{(1)}) \times \epsilon_{\mu\alpha\beta\gamma}\, e_\alpha^{(1)} k_\beta^{(1)} k_\gamma^{(2)}], \qquad (2)$$

where $q = k^{(2)} - k^{(1)}$. It follows from (1) that the functions $f_i(q^2)$ and $g_i(q^2)$ are real.

We note that in the case when the masses of the initial and final particles are equal we have $V_\mu^{(1)} q_\mu = 0$ and $A_\mu^{(3)} = q^2/2A_\mu^{(1)} - A_\mu^{(2)}$ (for simplicity all the $g_i(q^2)$ are assumed equal to unity). Then a vector particle has three vector CP-invariant form factors corresponding to the electric monopole and quadrupole transitions and to the magnetic dipole transition, and two axial form factors. The longitudinal part of the current A_μ corresponds in this case to a pesudoscalar transition, since the vector particle has only one CP-invariant axial-vector form factor. This is as it should be from general considerations[4].

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1)Nuclear Physics Research Institute of the Moscow State University.

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[1]V. Glaser and B. Jaksic, Nuovo. Cimento **5**, 1197 (1957).
[2]A. D. Dolgov, ZhETF Pis. Red. 2, 494 (1965) [JETP Lett. **2**, 308 (1965)].
[3]M. S. Marinov, Yad. Fiz. **4**, 379 (1966) [Sov. J. Nucl. Phys. **4**, 271 (1967)].
[4]I. Yu. Kobzarev, L. B. Okun', and M. V. Terent'ev, ZhETF Pis. Red. **2**, 466 (1965) [JETP Lett. **2**, 289 (1965)].