ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ

Дубна

E2 - 3559

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MESON FORM-FACTORS

ЛАБОРАТОРИЯ ТЕОРЕТИЧЕСКОЙ ФИЗИКИ

1967.

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The algebra of currents saturated by single particle intermediate states leads to form factors equal to zero or unity [1]. Nontrivial solutions for nucleon form-factors have been obtained [2] when was taken into account only the subalgebra of the colinear momentum transfers.

In the present paper we consider those commutation relations of the current algebra which in the approximation of single particle intermediate state lead to nontrivial form factors for pseudoscalar mesons.

We restrict ourselves to the algebra generated by isospin current

$$[j_0^{\alpha}(x)\, j_0^{\beta}(y)]\, \delta(x_0 - y_0) = i\, \epsilon_{\alpha\beta\gamma}\, j_0^{\gamma}(x)\, \delta(x-y) \qquad (1)$$

which for the Fourrier components

$$V^{\alpha}(\vec{q}) = \int j_0^{\alpha}(x)\, e^{i\vec{q}\vec{x}}\, d^3x \qquad (2)$$

gives the following commutation relations

$$[V^{\alpha}(\vec{q})\, V^{\beta}(\vec{q}\,')] = i\, \epsilon_{\alpha\beta\gamma}\, V^{\gamma}((\vec{q} + \vec{q}\,')) . \qquad (3)$$

We take the expectation value of eq. (3) for meson states with momentum $\vec{p} \to \infty$. In this limit, if $\vec{q}$ is perpendicular to $\vec{p}$, the matrix elements of $V^{\alpha}(\vec{q})$ are dependent only on $\vec{q}$. Keeping only pseudoscalar meson intermediate state and choosing $\vec{q}$ and $\vec{q}'$ perpendicular to $\vec{p}$ the following substitution holds in eq. (3)

$$V^{\alpha}(\vec{q}) = f(q^2)\, t^{\alpha}\,, \tag{4}$$

where $f(q^2)$ is the electric form-factors of the meson and t^{α} are matrices of the irreducible representation of the isospin group.

From eq. (3) and substitution (4) the following equation is obtained for the form-factor

$$f(q^2)\, f(q'^2) = f((\vec{q} + \vec{q}')^2)\,. \tag{5}$$

If $\vec{q}$ and $\vec{q}'$ are parallel the solution of eq. (5) is the trivial one

$$f(q^2) = 1\,. \tag{6}$$

If $\vec{q}$ and $\vec{q}'$ are perpendicular the solution of eq. (5) is

$$f(q^2) = e^{-cq^2}. \tag{7}$$

The constant c may be put equal to the inverse of the square of the mass of the rho-meson if we want to have the same mean square radius as that obtained when the vector current is dominated by the rho-meson.

Going further to the SU(3) symmetry the following changes are necessary: in eq.(1) and (3) the antisymmetric tensor $i\epsilon_{\alpha\beta\gamma}$ is replaced by the structure constants $f_{\alpha\beta\gamma}$ of the SU(3) group and the substitution (4) becomes

$$V^{\alpha}(\vec{q}) = f(q^2)\, F^{\alpha} + d(q^2)\, D^{\alpha}\,, \tag{8}$$

where F and D are eight dimensional matrices of the antisymmetric and symmetric representation of the SU(3) group.

These give the following equations:

$$\begin{aligned} f(q^2)\, f(q'^2) + d(q^2)\, d(q'^2) &= f((\vec{q} + \vec{q}')^2) \\ f(q^2)\, d(q'^2) + f(q'^2)\, d(q^2) &= d((\vec{q} + \vec{q}')^2) \end{aligned} \tag{9}$$

which have the solutions:

$$f(q^2) = 1\,, \quad d(q^2) = 0 \tag{10}$$

for $\vec{q}$ parallel to $\vec{q}'$, and

$$f(q^2) = e^{-cq^2}, \; d(q^2) = 0 \tag{11}$$

for $\vec{q}$ perpendicular to $\vec{q}'$.

The expressions (7) and (11) show that the commutation relations (3) having $\vec{q}$ perpendicular to $\vec{q}'$ do not determine completely the form factors,. Their solutions contain an arbitrary constant which is determined by the mean square radius of the considered meson.

The contribution from higher intermediate states seems to be small. For example the vector meson intermediate state gives a vanishing contribution.

References:

1. G.Veneziano. Nuovo Cimento, 44, 295 (1966).
2. K.J.Barnes and E.Kazes. Phys.Rev.Letters., 17, 978 (1966).

Received by Publishing Department
on October 20, 1967.