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ELASTIC $e^{3}H$ SCATTERING AND THE TRITIUM QUARK STRUCTURE

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It is shown that the elastic $e^{3}H$ scattering form factor can be explained within the model allowing for a six- and nine-quark admixture to the tritium wave function with the parameters obtained from the analysis of the ^{3}He form factor. In this case the interference of nucleon and multiquark channels is very important. The six- and nine-quark admixture probabilities were found to be about 15.4% and 0.54%, and the corresponding contributions to the form factor are 2% and 0.01%.

The investigation has been performed at the Laboratory of Theoretical Physics, JINR.

Упругое $e^{3}H$-рассеяние и кварковая структура трития

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Показано, что формфактор упругого $e^{3}H$-рассеяния можно объяснить в рамках модели, учитывающей шестикварковую и девятикварковую примеси в волновую функцию ядра трития с параметрами, полученными из анализа формфактора ^{3}He. При этом, также как и в случае ^{3}He, определяющую роль играет интерференция нуклонных и многокварковых каналов. Получено, что эффективный вклад шестикварковой примеси составляет примерно 2%, девятикварковой - 0,01%, а вклад соответствующих компонент в формфактор - 15,4% и 0,54%.

Работа выполнена в Лаборатории теоретической физики ОИЯИ.

Calculations of the ^{3}H factor at large transfer momenta $q^{2} > 0.5$ $(GeV/c)^{2}$ should be made by taking account of quark degress of freedom, namely six- (6q) and nine-quark (9q) systems. This follows from the corresponding calculations and comparison with experimental data for the form factors of a nucleus ^{3}He.

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The wave function of ^3H is taken like for ^3He and composed of three components: the nucleon, six- and nine-quark ones with amplitudes C_1, C_2, and C_3

$$\Psi_{^3H} = C_1\Psi_1 + C_2\Psi_2 + C_3\Psi_3 . \qquad (1)$$

Such a representation leads to a common expression for a form factor in the form

$$F_{CH}(q^2) = C_1^2F_{11} + F_{6qT} + F_{9qT} , \qquad (2)$$

where

$$F_{6qT}(q^2) = C_2^2F_{22} + 2C_1C_2F_{12} , \qquad (3)$$

$$F_{9qT}(q^2) = C_3^2F_{33} + 2C_1C_3F_{13} + 2C_2C_3F_{23} . \qquad (4)$$

Here F_{11} is the nucleon channel form factor; it has already been calculated for ^3H in the framework of the exact solution of the three-body Fadeev equation using the realistic NN potentials with and without meson exchange currents [4,5]. It was shown [4] that the contribution of the exchange currents in the case of a ^3H form factor turns out to be negligibly small.

The form factors F_{6qT} and F_{9qT} of the six- and nine-quark systems have been calculated in the relativistic oscillator model (ROM) [1-3,6,7] making use of parametrization from refs.[2,3] for the functions of relative motion of 6q and 3q clusters. The parameters were chosen the same as for ^3He. As in the case of ^3He, the important role here is played by the interference form factors. Note that just because of the interference one gets the C_2 amplitude of 6q admixture to be chosen negative and of 9q admixture of C_3 positive. Only in this case both F_{6qT} and F_{9qT} become negative and give a proper contribution to the total form factor of ^3He. Fig.1 shows the results of calculation [3] and comparison with experiment [8] of the ^3He form factor. In calculating ^3H we preserve the signs and values of the channel amplitudes the same as for ^3He: $C_1 = 1.0092$, $C_2 = -0.3297$, $C_3 = 0.0736$. As is seen from fig.2, this allows one to explain the behaviour of the ^3H form factor in the whole region of measurement [4,9] at momenta transferred up to $q^2 \approx 0.9\ (GeV/c)^2$. It is seen that the agreement with experiment is achieved in the most critical region of the second form factor maximum as well, what is hardly attainable if only nucleon degress of freedom are taken into account. The ^3H form factor $|F_{CH}|$ has a minimum at $q^2 \sim 0.5\ (GeV/c)^2$; $|F_{11}|$, at $q^2 \sim 0.6\ (GeV/c)^2$; and the second maximum $|F_{CH}|$, at $q^2 \sim 0.66\ (GeV/c)^2$.

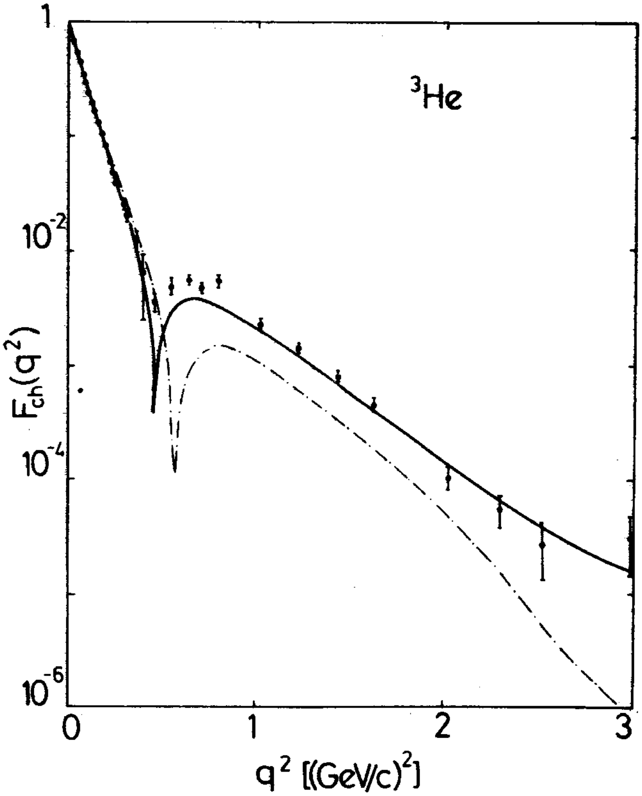

Fig.1. Form factor of ^3He: the solid line is the calculation taking account of 6q and 9q admixtures; the dashed, the impulse approximation for the three-nucleon channel /5/; *the experimental data are taken from ref.* /8/.

Fig.3 shows the contribution to the ^3H form factor of individual terms $|F_{11}|, |F_{6qT}|, |F_{9qT}|$. At chosen values and signs of C_2 and C_3, the form factor F_{6qT} turns out to be negative at $q^2 < 2.4$ $(GeV/c)^2$; and at large q^2, positive; $F_{9qT} < 0$ at all $q^2 < 3$ $(GeV/c)^2$. The dominating contribution at $q^2 < 0.5$ $(GeV/c)^2$ comes from the nucleon channel form factor F_{11} and at $0.5 < q^2 < 1.5$ $(GeV/c)^2$ the dominating is F_{6qT}; whereas at $q^2 > 1.7$ $(GeV/c)^2$, the form factor F_{9qT}. Note that the contribution of $|F_{6qT}|$ and $|F_{9qT}|$ at $q^2 = 0$ is approximately 2% and 0.01% respectively, though the values of $C_2^2 \approx 15,4\%$ and $C_3^2 = 0.54\%$. This is due to the fact that the interference terms F_{12} and F_{23} in (3) and (4) are of opposite sign ($C_2 < 0$!) so that the different terms in F_{6qT} and F_{9qT} partially compensate each other.

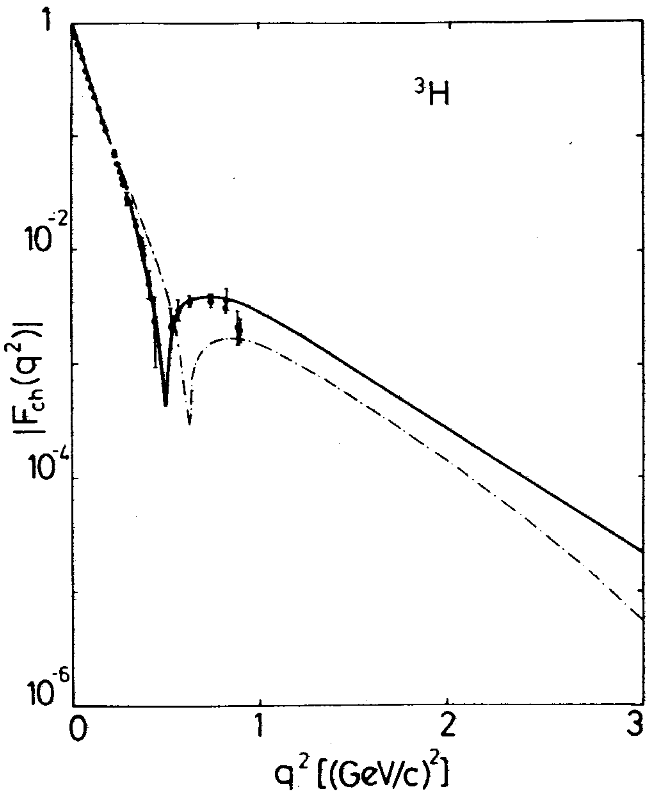

Fig.2. Form factor of ^3H. The notation is the same as in Fig.1. The experimental data are taken from refs. /4,9/.

From the above analysis we can make the following conclusions:

1) Inclusion of multiquark admixtures in ^{3}H is necessary.

2) Amplitudes of C_2 and C_3 for ^{3}H are evidently similar to those obtained for the nucleus ^{3}He.

3) Interference of multiquark and nucleon channels plays an important role in analysing experiment.

4) Calculations have shown that the contributions of nucleon, six- and nine-quark channels are divided along the momentum transferred. Therefore, to estimate the role of nine-quark admixtures, the form factor of the nucleus ^{3}H should be measured at $q^2 > 1$ (GeV/c)^2.

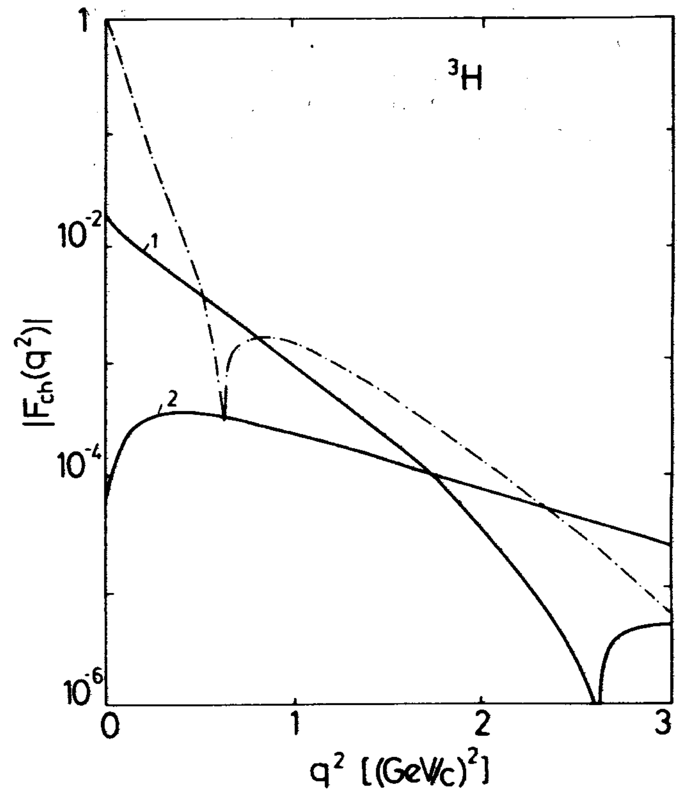

Fig.3. Form factor of ^3H: 1 - is the contribution of **6q** *channel* $|F_{6qT}|$, *2 - is the contribution of the* **9q** *channel* $|F_{9qT}|$, *the dashed line is the* ^3H *form factor impulse approximation for the three-nucleon problem* /15/.

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