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Physics

On the Deuteron Relativistic Wave Function

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ABSTRACT. Light front form of the relativization of the deuteron wave function is considered. Parameters of the wave function are extracted comparing theoretical results with experimental data. Experimental data are obtained on the two-metre propane bubble chamber of JINR (Dubna) bombarded by the deuteron beam with momentum of 4.2 GeV/c/nucleon. *© 2011 Bull. Georg. Natl. Acad. Sci.*

Key words: *nucleon, nucleus, stripping protons, relativization, light front.*

From the very beginnig of the development of relativistic nuclear physics the problem of relativization of nuclear wave functions has been posed. The problem is twofold: relativization of the intrinsic motion of nucleons in nuclei and the relativization of the movement of the nucleus as a whole [1].

In the present note relativization of the deuteron wave function is considered. From the experimental point of view the most convenient is the study of stripping proton distribution in the bubble chamber (the incoming nucleus is deuteron), since the deuteron relativistic wave function enters this distribution as a multiplier.

Consider the relativistic deuteron break up on the carbon target, when stripping protons are detected in the final state. In the impulse approximation the cross section of this process looks as follows [2]:

$$E^{st}\frac{d}{d\vec{p}} \sim \frac{{}^{1/2}(s_{NN},m^2,m^2)}{{}^{1/2}(s,m^2,m_d^2)}\ {}_{tot}(s_{NN})\,|\frac{(x,\overrightarrow{p\ \ })}{1\quad x}|^2 \quad (1)$$

Here s is the usual Mandelstam variable,

$$s_{NN}\quad s(1\quad x^{st})\quad m^2\quad \frac{\overline{p^{st^2}}}{x^{st}}\quad \frac{m^2}{x^{st}}, \qquad (2)$$

${}_{tot}(\ {}_{NN})$ is nucleon-nucleon total cross section, m is the nucleon mass, m_d is the deuteron mass.

$$(x,y,z)\quad (x\quad y\quad z)^2\quad 4yz. \qquad (3)$$

The variable x^{st} in the laboratory frame is defined as follows:

$$x^{st}\quad \frac{E^{st}\quad p^{st}}{(E_d\quad p_d)\quad m}. \qquad (4)$$

$(x,\overrightarrow{p\ \ })$ is the deuteron relativistic wave function. Its arguments are related to the observable quantities as follows:

$$x\quad 1\quad (1\quad \frac{m}{E_d\quad p_d})x^{st} \qquad (5)$$

$$\overrightarrow{p}\qquad \overrightarrow{p}^{st} \qquad (6)$$

We choose the deuteron relativistic wave function as a generalization of the well-known Hulthen wave function:

$$(x,\overrightarrow{p\ \ }) \sim \frac{1}{[\frac{\overrightarrow{p}^2\quad m^2}{x(1\quad x)}\quad {}_R][\frac{\overrightarrow{p}^2\quad m^2}{x(1\quad x)}\quad {}_R]}, \quad (7)$$

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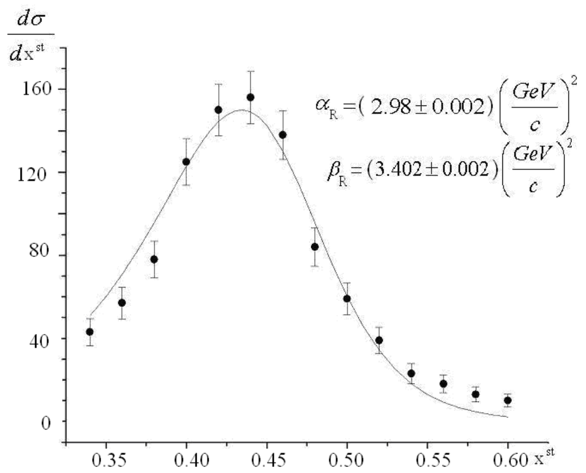

Fig. 1. $\frac{d}{dx^{st}}$ distribution of stripping protons from the reaction dC p^{st}

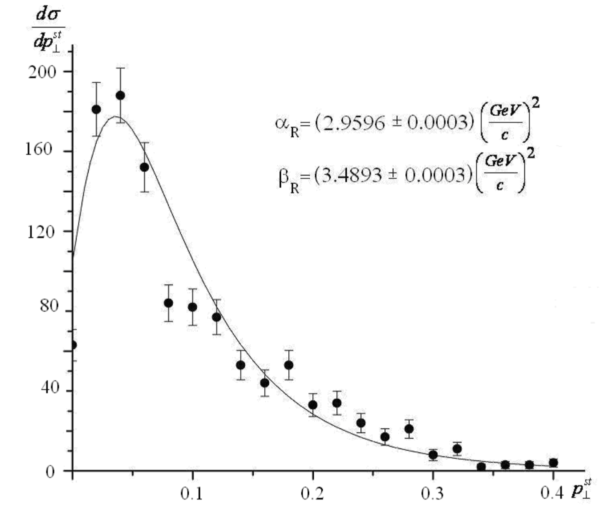

Fig. 2. $\frac{d}{dp^{st}}$ distribution of stripping protons from the reaction dC p^{st}

$_R$ and $_R$ are adjustable relativistic parameters, which are extracted from the experimental data.

From (1) one-dimensional distributions $\frac{d}{dx^{st}}$ and $\frac{d}{dp^{st}}$ are obtained:

$$\frac{d}{dx^{st}} \quad {}_{0}^{P^{st}_{\max}} \frac{d^2}{dx^{st}dp^{st}}dp^{st}, \qquad (8)$$

$$\frac{d}{dp^{st}} \quad {}_{x^{st}_{\min}}^{x^{st}_{\max}} \frac{d^2}{dx^{st}dp^{st}}dx^{st}. \qquad (9)$$

Characteristic feature of the x^{st} distribution is the existence of maximum at the point:

$$x^{st} \quad \frac{1}{2(1 \quad \frac{m}{E_d \quad p_d})}. \qquad (10)$$

Experimental data are obtained on the 2 metre propane bubble chamber *PBC-500* in the Laboratory of High Energies of the Joint Institute of Nuclear Research (Dubna). The chamber was bombarded by deuteron beam with momentum of 4.2 GeV/c per nucleon. Methodological problems of the experiment are given in Refs [3-8]. Proton is said to be stripping if its momentum is bigger than 3 GeV/c and emission angle less than 4^0.

In Fig. 1 $\frac{d}{dx^{st}}$ distribution of stripping protons is compared with corresponding experimental data and parameters $_R$ and $_R$ are extracted.

In Fig. 2 the same procedure is performed for $\frac{d}{dp^{st}}$ distribution.

Numerical values of the parameters $_R$ and $_R$ are in a good agreement with the results obtained by other methods [2] ($_R$ $(3.522 \quad 0.006)(GeV/c)^2$ and $_R$ $3.383 \quad 0.033)(GeV/c)^2$).

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ფიზიკა

დეიტერიუმის რელატივისტური ტალღური ფუნქციის შესახებ

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ი. ჯავახიშვილის სახ. თბილისის სახელმწიფო უნივერსიტეტის მაღალი ენერგიების ფიზიკის ინსტიტუტი

(წარმოდგენილია აკადემიის წევრის ა. ხელაშვილის მიერ)

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