THE POLARIZATION EFFECTS OF THE n-^{9}Be NEUTRON ELASTIC SCATTERING

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The differential cross-section of the n-^{9}Be neutron scattering and polarization effects is calculated in the framework of the eikonal approximation theory. In this paper by taking explicitly into account the composite quark structure of nucleons exchange effects we eliminate some discrepancies between the theory and the data that were recently pointed out.

1. Introduction

The reactions with neutron have been used to study several topics in nuclear structure and fundamental symmetries. Cross-section for these reactions is of applied interest in areas such as the embrittlement of reactor containment vessels.

The specific feature of this kind of reaction is that the transition amplitude is in general a sum of several nucleon contributions, each with its own phase and amplitude. The available experimental data point to the absence of the energy interval of scattering. This makes a basis for the hypothesis about the existence of a non-zero polarization research on the future accelerators will provide information about the structure of the nucleon interaction at large distances.

In this paper we regard the quark cluster model results for the polarization effects of n-^{9}Be scattering. Early, it was shown [1] that in the framework of the hypothesis concerning the existence of quark bag in nuclei we managed to describes the behaviour of the formfactors of nuclei at large q and structure functions of nuclei.

2. The model formalism

A nucleus in the quark cluster model is described as a system of many clusters- completely antisymmetrized with respect to the quark variables [2]. Each cluster consists of three quarks and the nucleon quantum number, namely it has symmetry for spin-isospin SU(4),symmetry for colour SU(3), and SU(3) symmetry for the radial part. The parameters of quark distribution in the bag at $k>>k_0$ (the parameter k_0 may in principle be different for different bags) extracted from the data on formfactors and on deep inelastic scattering of nucleons on nuclei proved to be very close.

In the eikonal approximation [3],which is usually sufficient for practical purposes, the scattering amplitude is

$$f(q)=\frac{ik}{2\pi}\int exp(iqb)\langle\Psi|\Gamma(b)|\Psi\rangle db, \qquad (1)$$

$$\Gamma(b)=1-\prod_{j=1}^{A}\left[1-\gamma_j(b-s_j)\right]. \qquad (2)$$

Here q is the momentum transfer, k is the value of the wave vector of the neutron, b is the impact-parameter vector, $\Psi(r_1,r_2,...,r_A)$ is the ground state wave function of the nuclei, $\Gamma(b)$ is the total neutron–nuclei interaction profile function, $\gamma_j(b)$ is the profile function for the neutron-nucleon interaction, brackets $\langle||\rangle$ mean interactions over the nucleon coordinates.

Non-antisymmetrized wave function for the ^{9}Be in the oscillator-cluster model can be written as

$$\Psi_{^9Be}=\phi_{N1}(r_1,r_2,r_3)\cdots\phi_{N9}(r_{25},r_{26},r_{27})x \\ \chi(R_1,R_2,...,R_9), \qquad (3)$$

where the nucleus is pictured as a bag with radius R_h, located at R_A enclosing A nucleons. Using the relations

$$R=\frac{r_{3i-2}+r_{3i-1}+r_{3i}}{3}, \quad i=1,2,\ldots,9 \qquad (4)$$

and

$$\phi(r)=(\sqrt{\pi}R_h^2)exp(-r^2/R_h^2), \qquad (5)$$

we can write (3) in a factorised form

$$\Psi_{^9Be}=\prod_{j=1}^{9}exp[\frac{r_{3j-2}^2+r_{3j-1}^2+r_{3j}^2}{R_h}-2i\left(\frac{1}{R_A^2}-\frac{1}{R_h^2}\right)x \\ (s_{3j-2}+s_{3j-1}+s_{3j})]P_n(r_j)Y_{lm}(\vartheta,\varphi) \qquad (6)$$

Then scattering amplitude (1) may be written in the form

$$f(q)=(ik/2\pi)\int db\,exp(iqb)(\delta_{mn}\delta_{MN})- \\ Det\left|\delta_{mn}\delta_{MN}-\left\langle M|\prod_{i=1}^{3}\prod_{j=1}^{3}(1-\gamma(b-s_i+r_j))|N\right\rangle\right|$$

The matrix element of the profile function between the single particle states described by the quantum numbers M and N.

Use of the spin-non-flip amplitude of the n-^{9}Be reaction, obtained from the formulae (7) permits us to calculate the correct picture of polarisation scattering neutron. We consider the case where spin-flip is neglected. It is important to emphasise that the case of the nucleon-nuclei scattering the leading asymptotic terms of the spiral amplitudes is also determined by the contribution of the quark cluster with the evident replacement of $f(q)$ by the pion-nucleon scattering amplitudes.

3. Comparison with the experimental data.

Fig. 1 compares the results of the calculation based on formulae (7), with the experimental data for n-^{9}Be scattering [4]. The solid line corresponds to the cross section calculated equation (7). The sign corresponds to the experimental data. Fig. 1 shows that the composite nucleon model yields better agreement.

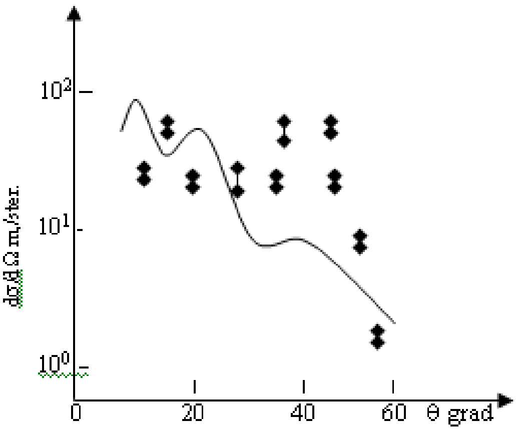

Fig. 1. The differential cross sections of the *n*-^{9}Be reaction

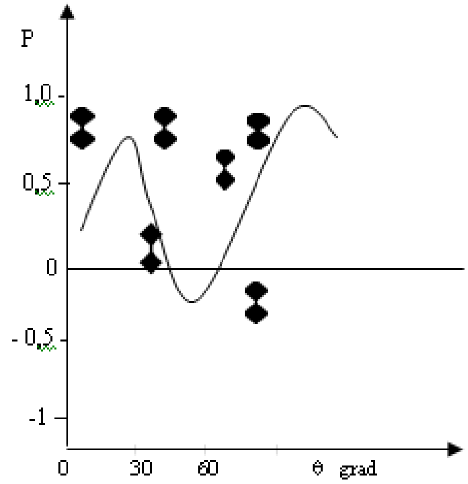

Fig. 2. The polarization of the neutron in *n*-^{9}Be scattering

However, taking into account the exchange terms improved the agreement between theory and experiment. A detailed comparison with the most recent and precise data on elastic scattering however, seems to display a small but definite discrepancy between the data and some characteristic features of the model, in particular the position of the first diffraction dip, the forward slope of the cross section and the relative height of the cross section of the optical point and after the dip.

The model prediction for the polarisation of elastic n-^{9}Be scattering, corresponding to the experimental data is shown in fig.2. Note that the model predicts a large polarisation at high energies in the range of the diffraction peak. The analysis shows that when the preasymptotic corrections are absent, we have the zero polarisations.

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NEYTRONUN *n*-^{9}Be ELASTİKİ SƏPİLMƏSİNDƏ POLYARİZASİYA EFFEKTLƏRİ

Eykonal yaxınlaşma nəzəriyyəsində neytronun *n*-^{9}Be səpilməsinin effektiv kəsiyi və polyarizasiya effektləri tədqiq edilir. Nuklonların kvark quruluşunu nəzərə alaraq nəzəriyyə ilə təcrübi faktlar arasında müəyyən uyğunlaşmalar müşahidə edilmişdir.

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ПОЛЯРИЗАЦИОННЫЕ ЭФФЕКТЫ В ЭЛАСТИЧНОМ *n*-^{9}Be РАССЕЯНИИ НЕЙТРОНОВ

В приближении эйкональной теории исследуются эффективное сечение и поляризационные эффекты в рассеянии *n*-^{9}Be. С учетом кварковых структур нуклонов получилось удовлетворительное согласие теоретических данных с экспериментальными.

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