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HAL Id: jpa-00230908
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Submitted on 1 Jan 1990

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MEASUREMENTS OF INPLANE POLARIZATION TRANSFER COEFFICIENT IN $^{24}\text{Mg}(p,p')$
REACTION AT $E_p=65$ MeV

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Abstract

Elastic and inelastic spin rotation parameters $K_{p-p'}$ of protons scattered from $^{24}\text{Mg}$ were measured for incident energies of 65 MeV by the $^{24}\text{Mg}$. L'analyse en
phénoménologie de Dirac s'avère satisfaissante aussi à cette énergie en et en
diffusion inélastique. La valeur du moment $Q_2$ du potentiel de Dirac est
différente de celle du potentiel de Schrödinger.

1. INTRODUCTION

Dirac phenomenology have succeeded in reproducing the spin rotation parameters in proton-nucleus elastic scattering/1/. Theoretically,a momentum space calculation pointed out that the incorporation of the virtual pair effects in the Dirac approach is the essential reason for the difference between the relativistic and the non relativistic approaches/2/. How is it in the case of inelastic scattering? For inelastic scattering, the validity of a Dirac treatment is less obvious than in elastic scattering. And only a few Dirac calculations have
been made for deformed nuclei where multistep processes are important and therefore require proper coupled
channel calculations/3/. With this motivation, we have measured spin rotation parameter of $^{24}\text{Mg}$ at 65MeV ,and performed the Dirac coupled channel analysis and compared it with the Schroedinger coupled channel analysis.

2. EXPERIMENTAL METHODS

The experiment was performed at RCNP using 65MeV polarized proton beam. With the use of a superconducting solenoid, the polarization axis of the beam is precessed by 90 deg from the vertical direction to the horizontal direction. The beam polarization are monitored by this polarimeter placed just after the superconducting solenoid. These transverse-horizontally polarized protons were scattered by the $^{24}\text{Mg}$ metal
foil of 100mg/cm$^2$ thickness. The momenta of scattered particles were analyzed at the first focal plane(FP1) of the polarization spectrograph DUMAS/4/ and tagged by MWPC placed at FP1. The scattered particles are again focused achromatically at the second focal point(FP2) where the polarimeter MUSASHI/5/ are placed. The polarimeter MUSASHI can measure the transverse-horizontal components of the polarization of the scattered particle at the exit of DUMAS, using the large asymmetry of p-$^{12}\text{C}$ elastic scattering.

The second scattering targets consist of 7 carbon sheets. By ray tracing the MWPC data,we obtain the position and angle of the scattering. Only the elastic scattering from the second scattering target was used for the analysis by using the energy signal from the plastic scintillators at the side walls.

Article published online by EDP Sciences and available at http://dx.doi.org/10.1051/jphyscol:1990641
Dirac coupled channel analysis and Schrödinger coupled channel analysis were performed for the \(0^+\) and \(2^+\) states of \(^{24}\text{Mg}\) using the code ECIS79 and ECIS88 of RAYNAL/G. The Dirac optical model consists of a Lorentz scalar potential and the time-like component of a Lorentz vector potential:

\[
\{\alpha \cdot p + \beta (m + U_s) + (U_0 + V_s)\} \Psi = E \Psi
\]  

(1)

The deformed optical potential parameters of each model were searched to fit the differential cross sections and the analyzing powers for the \(0^+\) and \(2^+\) states. For the analysis, we adopted a macroscopic collective model, assuming that \(0^+\) and \(2^+\) states of \(^{24}\text{Mg}\) are the members of ground state rotational band. \(0^+, 2^+\) and \(4^+\) states are coupled in the coupled channel calculations. The deformation parameters were set equal for each parts of the potential.

The fitting results are shown in Fig.1. The \(\chi^2\) values of each approach are in the same order. It seems that both approaches can reproduce the experimental data equally well. The spin rotation parameter \(K_r = \gamma\) was also calculated with this best fit potential, and we compared Dirac coupled channel analysis (D.C.C) with Schrödinger coupled channel analysis (S.C.C). The results of the calculation by D.C.C and S.C.C are shown with experimental data in Fig.2. The error bars of experimental data are statistical errors only. Both approaches reproduce the experimental data equally well. It seems that Dirac phenomenology succeeds at 65 MeV, and explains also the inelastic scattering.

**DISCUSSION**

Dirac real scalar potential has a large negative potential, and Dirac real vector potential has a large positive potential. In Fig.3 we show the shapes of Schrödinger equivalent and Schrödinger potential. The shapes of each potential part are very similar. So, the mean square radius of Schrödinger equivalent potential and Schrödinger potential are similar.
Fig. 2. Spin rotation parameter ($K_{xX'}$). The left figure is that of elastic scattering and the right is that of inelastic scattering. The solid curves are results of Dirac coupled channel calculations. The dashed curves represent the Schrödinger coupled channel calculations.

Fig. 3. The shapes of each parts of Schrödinger equivalent and Schrödinger potentials. The solid curves are the Schrödinger equivalent potentials and the dashed curves are the Schrödinger potentials.

The mean square radius of $^{24}$Mg and other various nuclei are shown in Fig.4. The value for other nuclei were taken from our elastic scattering data/7/. The mean square radius of Dirac scalar and vector potentials are very similar. The deformed nuclei have a little larger mean square radii than spherical nuclei. We notice that the difference between the mean square radius of Dirac potential and that of charge density becomes larger as the target mass number increases. This means that the Dirac potential also has some kind of density dependence due to Pauli blocking.

Furthermore, $Q_2$ moment of Dirac potential and Schrödinger potential were compared with that of charge distribution obtained by electron scattering. $Q_2$ moment of Schrödinger potential is about 10% larger than that of charge densities. A folding model calculation shows that the main part of this difference is attributed to the density dependence of the effective interaction/8/. On the other hand, $Q_2$ moment of Dirac real potential is a little smaller than that of the charge densities. In order to confirm these results, we have performed the Dirac coupled channel analysis for our old cross section and analyzing power data for 4 typical rare earth nuclei. The result is shown in Fig.4. The same tendency is found in all these rare earth nuclei. Namely, $Q_2$ moments of Dirac potential of $^{166}$Er, $^{168}$Er, $^{174}$Yb, $^{176}$Yb are also a little smaller than those of the charge distributions for these nuclei, and $Q_2$ moments of Schrödinger potential are larger than those of the charge distributions. If we assume the folding model, this means that the effective interaction in the Dirac formalism has almost no density dependence. But this result is different from the result deduced from the discussion on the mean
square radius. In order to investigate this difference, we are now performing the moment scaling search under the condition that multipole moments for each part of the potential are set to be the same.

Fig. 4. The left figure shows the mean square radius. The right figure shows $Q_2$ moment of various nuclei.

5 - SUMMARY

We have measured the spin rotation parameter $K_{1/2}$ in $^{24}$Mg (p,p') reaction at 65 MeV. It is found that Dirac coupled channel method can reproduce the experimental data at lower energy and also explain the inelastic scattering. Dirac approach and Schrödinger approach can reproduce the experimental data equally well, but there is a difference between the value of $Q_2$ moment of Dirac potential and that of Schrödinger potential; $Q_2$ moment of Dirac potential is a little smaller than that of the charge distribution, and $Q_2$ moment of Schrödinger potential is larger than that of the charge distribution.

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