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POLARIZATION TRANSFER MEASUREMENTS FOR THE (d,pX) REACTION AT Ed=65 MeV AND THE REACTION MECHANISM FOR THE PROTONS IN THE CONTINUUM

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Résumé

Nous avons mesuré la section efficace doublement différentielle, le pouvoir d'analyse, la polarisation et le coefficient de transfert de polarisation pour la réaction (d,pX) sur le ^{12}C à 14° et le ^{58}Ni à 7.0 , 14.0 , 20.5 et 40.0° à $E_d=65$ MeV. Les données expérimentales ont été analysées dans la forme "post" de la DWBA, bien appropriée ici, et dans le modèle d'excitons en pré-équilibre avec mode d'évaporation. Les distributions angulaires expérimentales sont bien expliquées en prenant en compte ces processus sur toute la gamme d'énergie.

Abstract - The double-differential cross section, analyzing power, polarization and polarization transfer coefficient were measured for the (d,pX) reaction with 65 MeV deuterons for ^{12}C at 14.0° and for ^{58}Ni at 7.0° , 14.0° , 20.5° and 40.0° . The experimental data were analyzed within the framework of the post form DWBA appropriate for the "spectator breakup", and the preequilibrium exciton model together with the evaporation mode. The experimental angular distributions are well explained by taking into account for these processes over the whole proton energy region observed.

1 - INTRODUCTION

The energy spectra of protons emitted in deuteron induced nuclear reactions at incident energies below 100 MeV have a characteristic feature common to various target nuclei /1/ which can be distinguished as follows. At the high energy end the spectra show discrete peaks, whereas the contribution of equilibrium emission is present at the low energy end. A large continuum region exists between the above extremes. For loosely bound projectiles such as the deuteron, the spectra show a prominent bump at forward angles whose peak position corresponds to near the incident projectile velocity. Many experimental as well as theoretical approaches have been developed to interpret the underlying reaction mechanism in this continuum region for the (d,pX) reaction /2/.

It is the purpose of this paper to get a better understanding of the underlying reaction mechanism for the continuum protons in the (d,pX) reaction. Spin observables in addition to standard inclusive energy spectra have been measured with a higher accuracy and a more broad energy range than the existent measurements /3/.

2 - EXPERIMENTAL METHOD AND RESULTS

The experiment was performed using a vector polarized deuteron beam of 65 MeV from the 230 cm AVF cyclotron at the Research Center for Nuclear Physics (RCNP), Osaka University. The use of the recently developed spectrograph DUMAS /4/ and polarimeter MUSASHI /5/ has enabled us to perform this experiment. The data were taken at angles ranging from forward angles, where the direct process dominates, to backward angles, where the preequilibrium process cannot be neglected. The double differential cross section $d^2\sigma/d\Omega dE$, analyzing power A_y , polarization P_y , and polarization transfer coefficient $K_{y'}$ were measured for the proton continuum spectra for ^{12}C at 14.0° and for ^{58}Ni at 7.0° , 14.0° , 20.5° and 40.0° .

The spectra $d^2\sigma/d\Omega dE$ (fig. 1-(a)) show a prominent bump located near half the incident deuteron energy at 7.0° and its height decreases as the measured angle increases. At 40° , the tail of the cross section on the low proton energy side decreases more slowly than that on the high side, which might be understood in terms of the contribution of the preequilibrium process. The angular dependence and the width of a bump around the energy corresponding to the beam velocity is roughly understood by a participant spectator breakup model /2/.

The A_y and P_y values (fig. 1-(b) and (c)) are almost zero around the breakup region at all angles measured. This is consistent with the prediction of the models such as the plane wave limit of the participant-spectator model or the statistical model with no spin dependence. From the data of A_y and P_y only, this reaction is thought to be

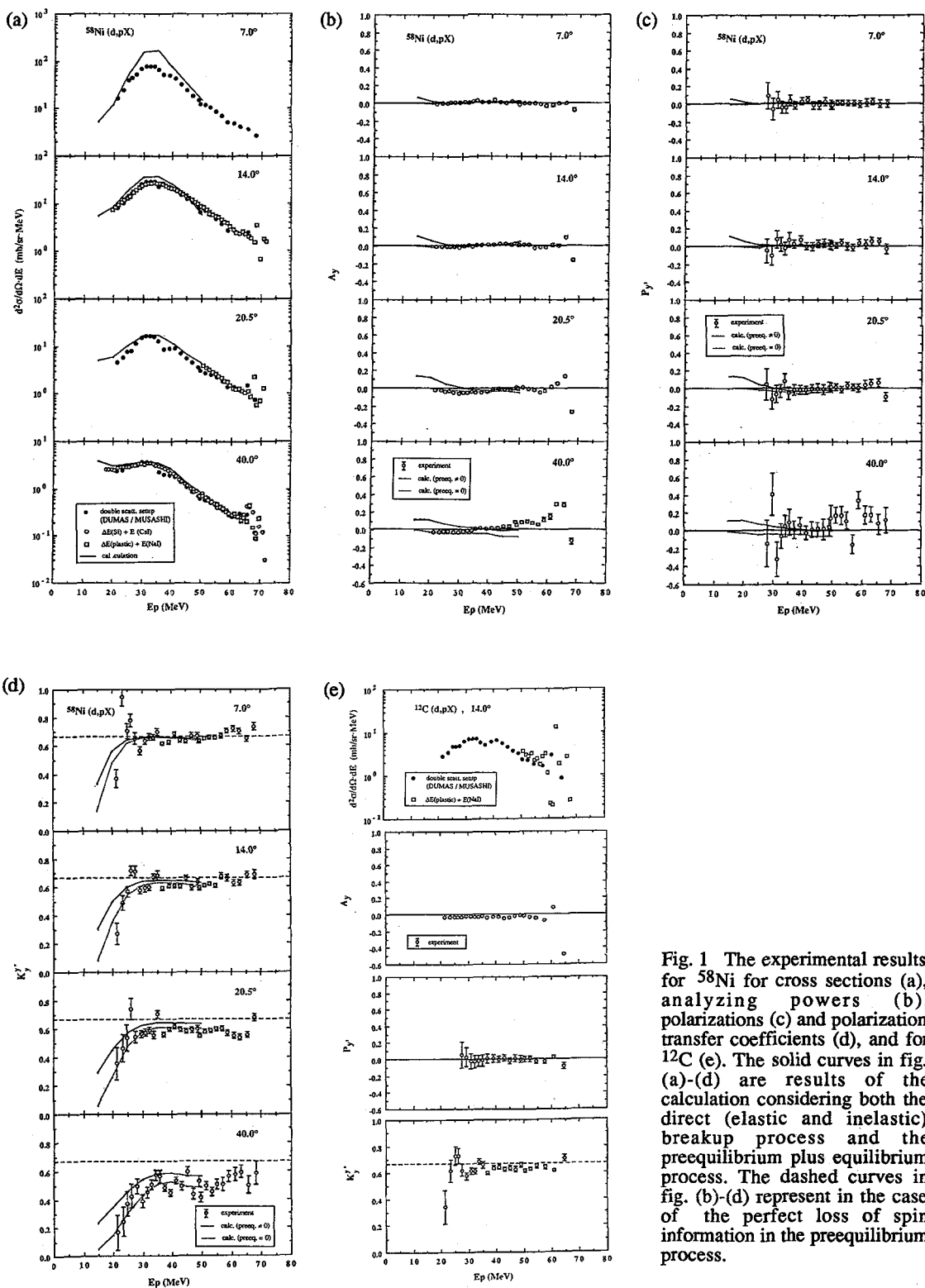


Fig. 1 The experimental results for ^{58}Ni for cross sections (a), analyzing powers (b), polarizations (c) and polarization transfer coefficients (d), and for ^{12}C (e). The solid curves in fig. (a)-(d) are results of the calculation considering both the direct (elastic and inelastic) breakup process and the preequilibrium plus equilibrium process. The dashed curves in fig. (b)-(d) represent in the case of the perfect loss of spin information in the preequilibrium process.

independent of the spin interaction. However, polarization transfer coefficients $K_y y'$ (fig. 1-(d)) are almost $2/3$ at 7.0° and gradually fall off over the whole energy region of emitted protons as the measured angle increases. At 40.0° , the $K_y y'$ values are apparently smaller than $2/3$ around the breakup region. This behavior of $K_y y'$ is not described by the participant-spectator model even if the deuteron D-state is considered [3]. The different reaction mechanism with other spin dependence might play an important role in this observable. The results for ^{12}C are shown in fig. 1-(e). There are no remarkable difference compared with ^{58}Ni

3 - ANALYSIS AND SUMMARY

To investigate the underlying reaction mechanism, the experimental data were analyzed considering the contribution of some possible processes as follows. (a) Direct process : The incident deuteron breaks up in the field of the target nucleus into its constituents. The proton behaves as a spectator throughout the nuclear reaction. (b) Statistical process : The proton and/or neutron in the incident deuteron impinge on the target nucleus, and the system leads to the preequilibrium and proton emission in the continuum. For the direct breakup process (a), the post-form DWBA with the surface approximation was used to describe inelastic breakup mode as well as elastic breakup mode [6] (Fig. 2). For the statistical process (b), we applied the hybrid and the geometrical dependent hybrid model [7] for the nucleon in the incident deuteron. That is, the proton and the neutron with energies corresponding to the momentum distribution in the incident deuteron impinge on the target nucleus, and these nucleons give rise to successive NN scattering in the target nucleus as a Fermi gas. Spin observables of the NN scattering are estimated using the values estimated from the phase shift analysis. The program used are the codes DWBA2 and UBFF1 of M. Igarashi et al. for the direct breakup process, the code ALICE85 of M. Blann et al. for the statistical process and the code SAID of R. A. Arndt for the evaluation of NN spin observables.

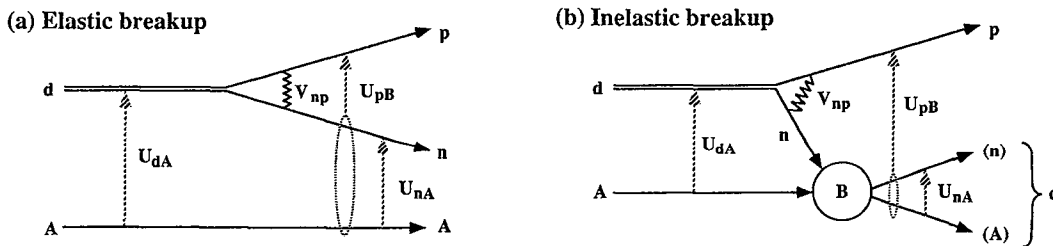


Fig. 2 Diagrams for the elastic breakup mode (a) and for the inelastic breakup mode (b) within the framework of the post-form DWBA. V_{np} is the residual interaction in the final state. The dotted arrows (U) represent the distorting potential for each particle.

The calculated results for the $^{58}\text{Ni}(d,pX)$ reaction using the above models are also shown in figs. 1 (a)-(d). We have also performed another trial calculation by assuming that the information on spin is fully lost even in the preequilibrium process. The results of this assumption are shown by dotted curves in figs. 1 (b)-(d).

The observables $d^2\sigma/d\Omega dE$, A_y , P_y and $K_y y'$ in the energy spectra at measured angles were compared simultaneously for the first time with the calculation not only of the direct breakup process but including the preequilibrium process. The experimental results are explained well taking account for all the above processes. The preequilibrium process is taken into account for the angular distribution in the present work, so that the spectral shape and the magnitude of the cross sections can be well reproduced over the whole energy range of protons observed up to 40° . Our calculation for the preequilibrium process using a hybrid model provides a good estimation for the preequilibrium contribution to the outgoing proton spectra in the (d,pX) reaction and also it gives support to the direct breakup calculation of Baur et al. As for spin observables, the results under the assumption of loss of information on spin in the preequilibrium process seem to give a better account of the data than the solid curves as a whole [8]. To investigate the spin observables more quantitatively, it is interesting to measure the $K_y y'$ for the $(p,p'X)$ reaction changing the proton/neutron ratio of the target nucleus to clarify the mechanism of the loss of spin memory.

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