Calculation of the complete set of spin transfer coefficients for ^{40}Ca(p, nx) at 346 MeV including up to two-step process

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The semiclassical distorted wave model, hereafter referred to as the SCDW model, has been succeeded in reproducing the experimental data of double differential inclusive cross sections (DDXs) at intermediate energies[1, 2, 3], except at forward angles and with large energy transfer ω. This success seems to justify the application of the SCDW model to the investigation of spin degrees of freedom to clarify the reaction mechanism in more detail. One can expect in particular that studies of the complete set of spin transfer coefficients give important information on the effective nucleon-nucleon (NN) interaction in the nuclear medium. In the present work, we make an analysis of the D_{ij} measured at RCNP in Osaka University[4], quantitatively evaluating the two-step contribution and aim to extract a piece of information on effective interactions in the nuclear medium. For this purpose, the SCDW model is extended to calculate the complete set of spin transfer coefficients, making use of in-medium NN effective interactions in coordinate representation. In the formulation, relativistic modification of the kinematics is made.

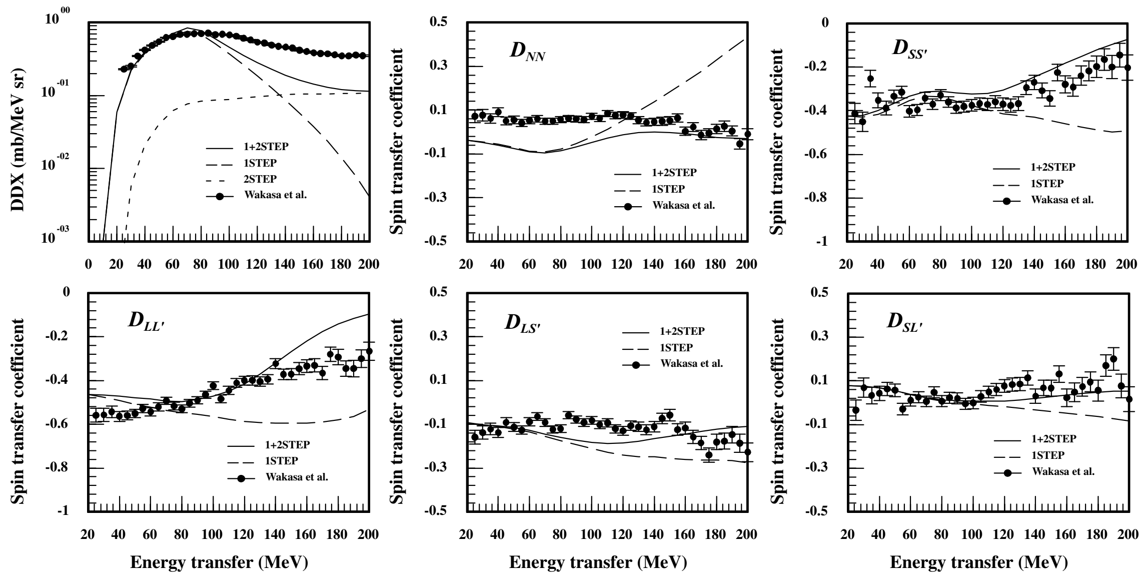

Figure 1: The calculated and measured[4, 5] DDX and D_{ij} for ^{40}Ca(p, nx) at $E_p = 346$ MeV and $\theta_n = 22°$ as functions of the energy transfer ω.

The results for the DDX and D_{ij} of the SCDW model for ^{40}Ca(p, nx) at E=346 MeV and $\theta_n = 22°$ are shown in Fig. 1. The dashed and solid lines correspond to the one-step process and one- plus two-step processes, respectively. The dotted line in the panel for the DDX is the contribution of the two-step process. The calculated DDX well reproduces the experimental data[4, 5] around the quasi-free peak. In contrast, calculation much underestimates the data in large ω regions. Since the shape of the one-step DDX around the quasi-free peak is dictated by the Fermi motion of the nucleon in the target nucleus, a reason of the underestimation might be in the inadequate treatment of the nuclear states. The theoretical and experimental results for D_{ij} are in overall good agreement, except considerable disagreement in D_{NN} at small ω. One sees from Fig. 1 the importance of two-step processes for D_{ij} in this region, just as for DDX at large ω.

The disagreement in the DDX at large ω makes the agreement in the D_{ij} look fortuitous. However, since each D_{ij} is a ratio of the expectation values of two quadratic forms of the T-matrix elements, it is possible that the calculated D_{ij} comes out right even if the individual expectation values, including the DDX, do not. The fact that all components of the D_{ij} agree with the experimental data at large ω strongly suggests that this is indeed the case.

We also investigated the dependence of the calculated DDX and the D_{ij} on the choice of the bare NN forces on which the effective interactions are based, on the method of calculating the G matrix, and on the effect of the in-medium modification of the effective interaction. The dependence of the DDX on them turns out to be quite small. In contrast the D_{ij} are found to be sensitive to all the factors mentioned. In particular, the in-medium modification of effective interactions is necessary to reproduce the experimental data. It is also found that only a few components of the effective interaction contribute to the individual D_{ij}. The analysis of the D_{ij} in terms of the number of steps of the reaction process and the kind of effective interactions is very important for understanding the reaction mechanism and the effective interaction in the nuclear medium.

References

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