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4.11 $D_{NN}(0°)$ Measurement for the $^{58}Ni(\vec{p},\vec{n})^{58}Cu$ Reaction at 80 MeV

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One of reasons the spin-isospin excitation mode in nuclei has attracted interest is the phenomenon of quenching, particularly in the Gamow-Teller strength. It is obviously desirable to map spin-flip strength as directly as possible by experiment. The spin-transfer coefficient D_{NN} may provide such a tool. We report values of $D_{NN}(0°)$ for the $^{58}Ni(p,n)^{58}Cu$ reaction at 80 MeV. It has been pointed out by Moss[1] that D_{NN} depends strongly on the transferred spin (ΔL) angular momentum, but at small angle (small q) depends rather weakly on distortions and on details of nuclear structure.

This experiment used on 80-MeV polarized proton beam from the AVF cyclotron at the Research Center for Nuclear Physics, Osaka University. The neutron polarimeter is described elsewhere[2]. The neutron flight path was 6 m. Overall time resolution was about 0.8 ns. The target was a self-supported metallic foil (99% ^{58}Ni, 209 mg/cm^2 thick). The short flight path and rather thick target led to a reasonable counting rate, but also to some sacrifice in the energy resolution ($\Delta E \simeq 2.8$ MeV for $E_n = 60$ MeV). The effective analyzing power of the polarimeter was determined by means of neutrons of known polarization from the reaction $^6Li(\vec{p},\vec{n})$, at 60 MeV and referring to the D_{NN} values for the $D(\vec{p},\vec{n})2p$ reactions at 50 and 70 MeV[3]. Obtained D_{NN} value has a normalization uncertainty of about 15%.

Fig. 1 shows (top) the observed neutron energy spectrum and (bottom) the extracted values of $D_{NN}(0°)$ with 1-MeV energy bins and without any background subtraction. The observed energy spectrum is consistent with that found by Rapaport et al.[4] at a similar momentum transfer, but at 120 MeV and with ∿300 keV resolution.

The GTGR was observed as a peak at around $E_x = 9$ MeV in ^{58}Cu. The observed value is

$$D_{NN}(0°) = -0.36 \pm 0.07,$$

for the GTGR region ($\Delta E = 3$ MeV)[5]. This value is extracted without any background subtraction. DWBA calculations were performed for the GTGR T=0, 1 and 2 states by using the shell model wave functions of Muto[6] with the M3Y effective interaction. All calculated results have values on $D_{NN}(0°)$ between -0.35 and -0.45. These values are very close to the observed values. Thus our $D_{NN}(0°)$ data for the GTGR region seem to indicate that the most of the yield beneath the apparent GTGR peak is also due to transitions with $\Delta S=1$.

A rather broad bump was observed in the energy spectrum at around $E_x = 18$ MeV. The peak energy corresponds to that of the giant dipole resonance ($\Delta L=1$, $\Delta S=0$). It is expected that a spin-flip dipole resonance ($\Delta L=1$, $\Delta S=1$) exists at about the same energy. Our data shows that $D_{NN}(0°)$ changes smoothly from negative values at the GTGR to values of +0.1 to +0.2 at the $E_x = 18$ MeV bump.

Now let us estimate the strength of the spinflip dipole resonance by using the observed D_{NN} values (0.1 - 0.2) and assuming the PWIA. In the PWIA D_{NN}=1 for the non-spinflip dipole and $D_{NN} = -1/3$ for the spinflip dipole after weighting the D_{NN} coefficients by the $d\sigma/d\Omega$ for the possible spins $J=0^-$, 1^- and 2^-, respectively. Then we get,

$$\frac{\sigma(\text{non-SF})\cdot 1 + \sigma(\text{SF})\cdot(-1/3)}{\sigma(\text{non-SF}) + \sigma(\text{SF})} = 0.1 - 0.2 \;;$$

therefore

$$\sigma(\text{SF}) = (1.5\text{-}2.1)\cdot\sigma(\text{nonSF}).$$

Thus in the broad bump at around E_x = 18 MeV the spinflip dipole strength seems to be about 1.5-2.1 times stronger than the non-spinflip dipole strength. A more accurate estimate of the relative strength would require a more complete understanding of background contributions to $D_{NN}(0°)$.

In summary the transverse spin-transfer coefficient $D_{NN}(0°)$ was obtained for the $^{58}Ni(\vec{p},\vec{n})^{58}Cu$ reaction at 80 MeV. $D_{NN}(0°)$ = -0.36 for the GTGR. The spinflip dipole strength seems to be about 1.5-2.1 times stronger than the non-spinflip dipole strength.

References

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5) Slightly smaller value has been reported to the Telluride Conference 1985, because of the erronious neutron polarimeter efficiency calibration.
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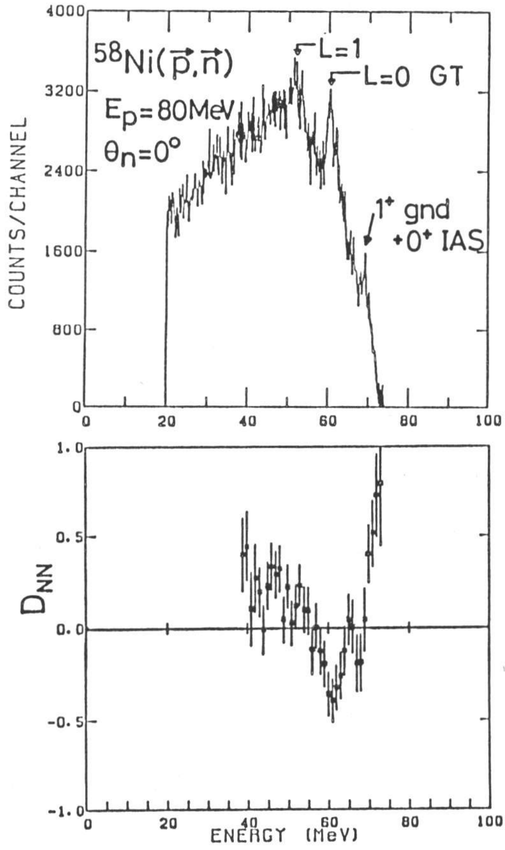

Fig. 1. Energy spectrum (top) and $D_{NN}(0°)$ (bottom) for the $^{58}Ni(p,n)^{58}Cu$ reaction at 80 MeV and θ=0°.