SPIN FLIP PROBABILITIES IN ^{208}Pb MEASURED WITH 200 MeV PROTONS

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Using 200 MeV protons, spin–flip data for ^{208}Pb covering an excitation energy of approximately 2 to 24 MeV were obtained in E333 and reported in the last annual report.[1] In this contribution, we present new distorted and plane wave calculations by Unkelbach and Wambach using RPA wavefunctions for ^{208}Pb.

In Fig. 1 we compare these calculations to our data binned with a 1 MeV width to improve statistical precision. This theory is based on 1p–1h RPA including 2p–2h damping in the continuum.[3] The same single–particle basis and residual interaction as in ref. 3 have

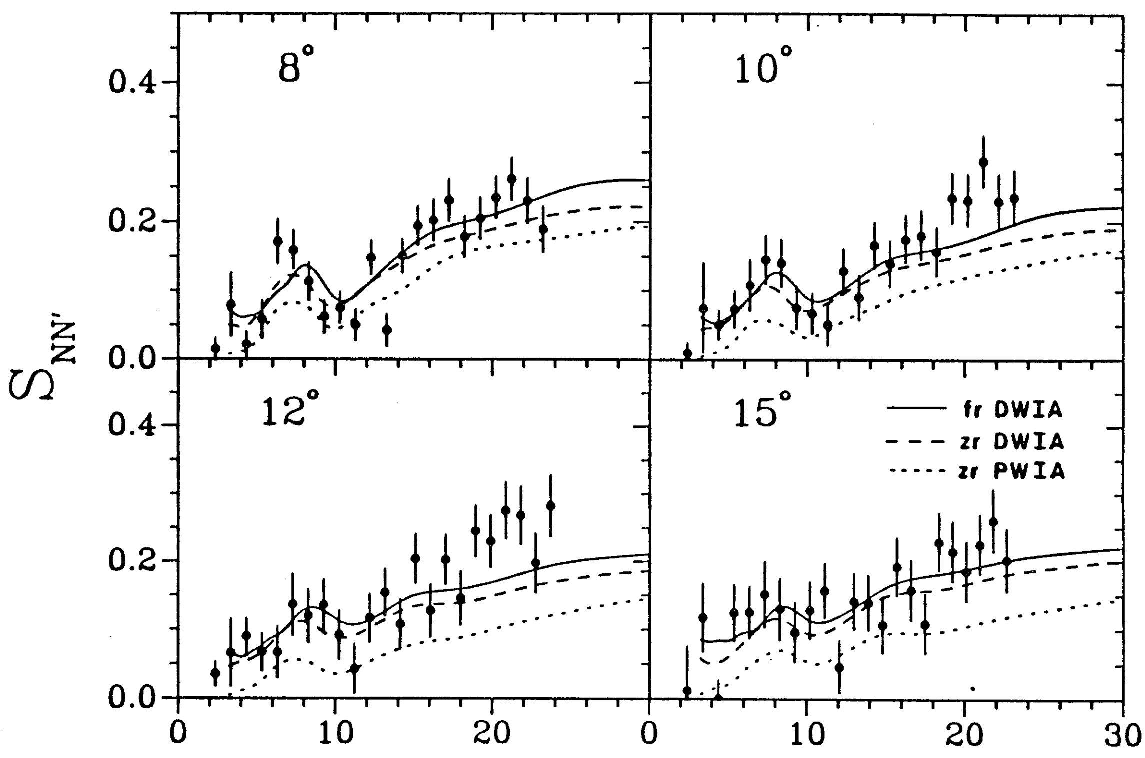


Figure 1. Data obtained in E333 compared to DWIA and PWIA calculations. The solid (long–dashed) curves are the result of distorted wave impulse approximation calculations using the finite–range (zero–range) residual interaction. The short–dashed curves correspond to plane wave calculations with the zero–range force.

been used. This interaction is a zero–range Landau–Migdal force. To look for finite–range effects, a calculation with a $\pi + \rho$–exchange force has also been performed. The ρ–coupling constant was increased by a factor of 1.25 in order to properly describe the energy of the Gamow–Teller and M1 resonances. An additional delta–force in the electric channels had to be added to describe the electric resonances. The reaction model is based on the impulse approximation using either plane or distorted waves. The Love–Franey effective interaction[4] is used for the residual projectile–target interaction. No Coulomb excitation is included. The distortions are described by phenomenological optical potentials of Woods–Saxon type from ref. 5. In Fig. 1 the solid (long–dashed) curves are the distorted wave calculations using the finite–range (zero–range) residual interaction. The dotted curves correspond to the plane wave calculations with the zero–range force.

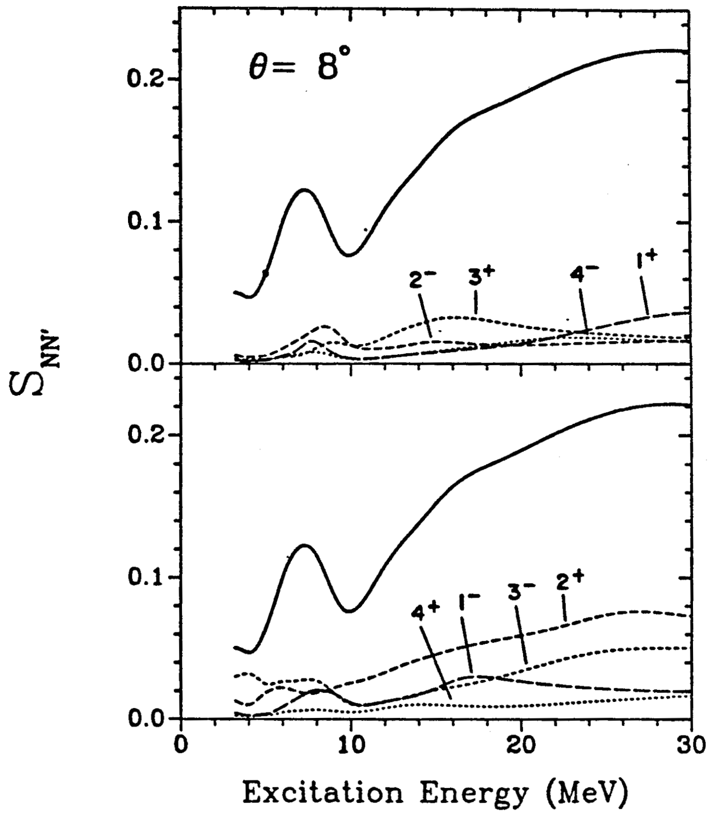
The first result apparent from Fig. 1 is the sensitivity to distortions as illustrated by the difference between the PWIA and the DWIA calculations. This effect is due mainly to the spin–orbit terms in the nuclear distortions. The PWIA results are always lower in magnitude than the DWIA. This difference increases with angle until at 15° the PWIA is approximately 2/3 of the DWIA results. At higher momentum transfers the LS-distortions become more important. This distortion dependence can lead to ambiguities in extracting spin–flip strength for the various multipoles if the distortions are not included properly. In order to search for a dependence on the type of distortion employed, $S_{NN'}$ was calculated using two different optical model parameter sets from ref. 5 (both of which equally well described the elastic scattering data). One set was based on a best fit to only 200 MeV elastic cross section and analyzing power data on ^{208}Pb;[6] the other set was obtained from a global fit of 200 to 500 MeV cross section and analyzing power data on ^{208}Pb.[6] The difference between the two distorted wave $S_{NN'}$ calculations was about 5%, much less than the errors in the present set of measurements and much smaller than the differences between the PWIA and DWIA calculations.

The difference between the finite– and zero–range distorted wave calculations in Fig. 1 is a measure of the dependence of $S_{NN'}$ on the residual interaction. This difference arises from the tensor–exchange part of the interaction, which acts strongly in the isoscalar $\Delta S=1$ channel.

Overall, the DWIA calculations describe the $S_{NN'}$ data well, particularly in the vicinity of the structure near 7 MeV. However, the calculations do not describe the structures observed near 10 and 12 MeV (which are apparent in our more finely binned data presented in ref. 1). At the higher excitation energies the calculations are somewhat smaller than the data, especially at 10° and 12°.

Figure 2 presents the DWIA calculations for $S_{NN'}$ at 8° (solid line) along with the predictions of various multipoles that contribute to $S_{NN'}$. The upper portion of the figure presents the contributions for the unnatural parity excitations, while the lower portion presents those for the natural parity excitations. The largest contribution to $S_{NN'}$ is from the spin flip strength of the natural parity excitations, with the 2^+ contributing the most followed by the 3^-. The strongest unnatural parity excitation is the 3^+ spin quadrupole between 10 and 20 MeV. Except for the region around 7 MeV there are no observed localizations of strength. In general, the spin–flip probability rises at higher excitation

Figure 2. Multipole decomposition of the 8° DWIA calculation (finite–range) for $S_{NN'}$. The top portion is for unnatural parity transitions while the bottom portion is for natural parity transitions.



energies as has been observed in other experiments.[7,8] This trend has been attributed to the depletion of most of the $\Delta S=0$ strength at the lower excitation energies, so that only $\Delta S=1$ strength remains at the higher excitation energies.

As is observed in Fig. 2, the broad structure centered around 7 MeV is a superposition of many spins and parities, as would be suggested from the levels reported in the Nuclear Data Tables.[9] One of the largest contributors to this structure is 3^- strength. This may be further evidence for the low energy octupole resonance in ^{208}Pb as observed by Fujita *et al.*[10] with 65 MeV proton inelastic scattering and as calculated by Unkelbach, Speth and Wambach.[11]

In summary, we have obtained high statistics measurements of $D_{NN'}$ for ^{208}Pb, covering an excitation energy range from 2 to 24 MeV and a momentum transfer range from 0.45 to 0.84 fm^{-1}. This is the heaviest nucleus for which the continuum spin–flip probability $S_{NN'}$ has been measured to date. Our data are described well by a recent DWIA, RPA calculation. This calculation, when compared to PWIA results, shows the importance of including distortions on the shape and magnitude of the calculations of $S_{NN'}$. At a momentum transfer of 0.84 fm^{-1} the PWIA calculations are approximately 2/3 of the DWIA results. We observe a structure centered near 7 MeV with a width of 2.5 to 3 MeV. The RPA calculations suggest that this structure contains a large variety of spins and parities. In the continuum region the major contributors to the observed spin–flip strength are the natural parity excitations with no localization of strength for any spin and parity.

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MODIFICATIONS OF THE EFFECTIVE ISOVECTOR INTERACTION FROM STUDIES OF $(\vec{p},\vec{p}')$ POLARIZATION TRANSFER

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As a result of cyclotron experiments E245 and E306, a complete set of polarization transfer coefficients (D_{ij}), as well as differential cross section, analyzing power (A_y), and induced polarization (P), are now available[1,2] for the 4^- "stretched" $T = 0$ and $T = 1$ transitions in $^{16}O(\vec{p},\vec{p}')^{16}O$ at $E_p = 200$ MeV. These transitions at 17.79 and 19.80 MeV ($T = 0$) and at 18.98 MeV ($T = 1$) can be described within the framework of the distorted wave impulse approximation, which models the transition with an effective t-matrix based on NN scattering. The spin transfer ($\Delta S = 1$) required by the dominant $1p_{3/2}^{-1}1d_{5/2}$ character of these transitions emphasizes their sensitivity to the spin-orbit and tensor parts of the t-matrix. Various interactions[3,4] based on free NN scattering (phase shifts or potentials) often agree with each other but not with the measurements, giving several systematic discrepancies[1,2] with the polarization transfer observables. Because the "stretched" transitions occur predominantly in the low density of the nuclear surface, interactions[4] that correct for Pauli blocking in the nuclear medium have little effect on these calculations.[2]