COEFFICIENT OF SPIN CORRELATION IN pp SCATTERING AT 310 Mev AND 90° IN THE C.M.S.

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A phase shift analysis has been made of the data obtained in Berkeley from the complete set of experiments on elastic interaction of 310-Mev protons, which did not include investigations of the spin correlation of the scattered protons. We know that this analysis[1] has led to an ambiguous result. It was possible to separate from the possible solutions, five independent phase-shift sets, satisfactorily describing the experimental data. The solutions obtained led to different values of the coefficient $C_{nn}(90°)$, which determines the correlation between the spin components normal to the scattering plane. Thus, for the phase-shift sets numbered 1, 2, 3, 4, and 6, the values of $C_{nn}(90°)$ obtained were 0.158, 0.711, 0.300, 0.490, and 0.425, respectively.[2] In this connection, an experimental investigation of the spin correlation of the scattered protons at 310 Mev has become very important. However, the ambiguity of the analysis was subsequently greatly reduced through further extension and improvement of the nucleon-nucleon scattering phase-shift analysis itself.[3] The first analysis included 14 phase shifts, belonging to states up to H waves inclusive. In the new analysis[3] additional account was taken of states with higher orbital momenta, on the basis of the one-meson approximation developed by Chew[4] and by Okun' and Pomeranchuk.[5] This additional contribution was calculated in first approximation by perturbation theory, and added to the analysis merely one additional parameter, the pion-nucleon coupling constant g^2. The modified analysis made it possible to establish that only the first and second sets of phase shifts describe satisfactorily the experimental data for $g^2 \sim 14$. The value of the coefficient $C_{nn}(90°)$ becomes, in accordance with the new values of the phase-shift of the separated sets, equal to 0.38 for the first set and 0.61 for the second set.

The first experiments on the determination of $C_{nn}(90°)$, carried out in Liverpool at proton energies of 320 Mev and in Dubna at 315 Mev, favor the second phase-shift set.[6] Thus, the Liverpool group found the coefficient of spin correlation to be $C_{nn}(90°) = 0.75 \pm 0.11$. Our own measurements, in which the preliminary data of the calibration experiment on the determination of the polarizing ability of graphite analyzers were used, have yielded $C_{nn}(90°) = 0.7 \pm 0.3$.

We have now completed an experiment on the determination of the analyzing ability of the scatterers. The calibration experiment was carried out with a proton beam of energy approximately 160 Mev, the polarization of which was found to be 0.667 ± 0.027. The polarizing ability of the analyzers used in the measurements of the correlation asymmetry was found to be 0.28 ± 0.02. Considering that the coefficient C_{nn} cannot exceed unity, we obtained

$$C_{nn}(90°) = 0.84^{+0.10}_{-0.22}$$

We have thus obtained experimentally for the coefficient C_{nn} a large value, which is difficult to reconcile with the value predicted on the basis of the first phase-shift set.

From earlier experimental data for elastic pp scattering at 310 Mev, estimates have been made of the contribution of the singlet interaction b^2 and the contributions of the triplet interaction of the spin-orbit (c^2) and the tensor (h^2) types. Thus, Wolfenstein[7] found $15\% < b^2 < 60\%$, $35\% < c^2 < 70\%$, and $2\% < h^2 < 20\%$. According to Nurushev's[8] estimates, $b^2 \approx 25\%$, $c^2 \approx 62\%$, and $h^2 \approx 13\%$.

From the relations

$$b^2 = \frac{1}{2}(1 - C_{nn}), \quad c^2 = \frac{1}{4}(1 + C_{nn} + 2D),$$

$$h^2 = \frac{1}{4}(1 + C_{nn} - 2D)$$

and from the value obtained for $C_{nn}(90°)$ and $D(90°) = 0.42$ (obtained by extrapolating the data of Chamberlain et al.[2]), the corresponding contributions are found to be $b^2 \approx 8\%$, $c^2 \approx 67\%$, and $h^2 \approx 25\%$.

The situation with respect to the separation of the phase shift sets that describe the elastic pp scattering at 310 Mev has been recently changed somewhat by a modified phase-shift analysis of the earlier experimental data.[9] The change in the analysis consisted of reducing the number of phase-shifts taken into account and extending the single-meson approximation to states with correspondingly lower orbital momenta. The analysis performed, which included 5, 7, and 9 phase shifts, has shown that if nine phase shifts are taken into account instead of the previous 14, and if the pion-nucleon coupling constant g^2 is also taken into account, a fully satisfactory description of the same experimental data is obtained in the case of the second phase-shift set and even more so in the case of the first. At the same time, the coefficient $C_{nn}(90°)$, calculated from the new phase shifts, was found to be approximately 0.41 for either set. In this connection, MacGregor et al.[9] believe that to solve the problem of the two phase-shift sets it is necessary to measure the value of C_{kp} at 45°, which determines the correlation between the spin components in the plane of the main scattering.

However, the new analysis with the nine phase shifts and with the constant g^2 has led not only to the disappearance of the difference between the coefficients $C_{nn}(90°)$ corresponding to the first and second sets, but also to a value that contradicts the available experimental data. In our opinion, this discrepancy should be considered as an indication that nine phase shifts are not enough. If the analysis were to include the experimental values of $C_{nn}(90°)$ in the procedure with the nine phase shifts, then an excessive value would be obtained for the parameter χ^2 for both sets, similar to what takes place in the analysis of the experimental data in which the quantity C_{nn} is not included and only seven phase-shifts are taken into account.

While analyses with seven and nine phase shifts give preference to the first set of phase shifts over the second,[9] the inclusion of the larger experimentally-obtained value of the coefficient $C_{nn}(90°)$, with account of 14 phase shifts and the constant g^2, makes the two phase-shift sets equally probable, as indicated by Allaby et al.[10] For an unambiguous determination of the phase shift it is obviously necessary to carry out more exact measurements of several of the quantities included in the analysis.

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159

ON THE USE OF THE MÖSSBAUER EFFECT FOR STUDYING LOCALIZED OSCILLATIONS OF ATOMS IN SOLIDS

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THE Mössbauer effect consists in the emission (or resonant absorption) by a nucleus in a solid of a γ quantum with an energy which is precisely equal to the energy of the transition, because of the fact that the recoil momentum is transferred to the crystal as a whole.

Usually the nucleus which radiates the γ quantum is formed by the decay of some other nucleus. As a result of this process, the nucleus can with a very high probability leave its place in the lattice and get stuck somewhere at an interstitial position. But, even if the nucleus does not move about, if it should change its atomic number as a result of the decay the forces holding it in the lattice will change. Thus the nucleus emitting the Mössbauer quantum must be a lattice defect.

On the other hand it is well known (cf. reference 1) that the spectrum of oscillations of a defect atom in a lattice consists of a continuous spectrum, coinciding with the spectrum of oscillations of the ideal lattice, and of discrete frequencies which do not coincide with any of the frequencies of normal vibrations of the atoms of the ideal lattice. Vibrations with such frequencies (localized oscillations) cannot propagate through the lattice over any sizeable distance.

At the same time there is a finite probability that in the emission of a γ quantum there is simultaneously emitted or absorbed (the latter, naturally, only for sufficiently high temperatures, $T \gtrsim \hbar\omega_L$, where ω_L is the frequency of the local-