POLARIZATION IN p-p SCATTERING CLOSE TO 20 MeV *

G. Breit† and R. E. Seamon†

Sloane Physics Laboratory, Yale University, New Haven, Connecticut

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The p-p polarization corresponding to Y-IV fits is compared with recent Saclay measurements and values in the Saclay paper obtained from recent Livermore fits. Agreement of the Saclay measurements with Y-IV is freer of systematic deviations than in the Saclay paper with Livermore, accentuating doubts expressed by the Livermore group concerning compatibility of Berkeley polarized-target results with other scattering measurements.

In a recent note[1] Slobodrian and co-workers reported on measurements of the polarization parameter $P(\theta)$ at 9.6, 15.6, and 19.7 MeV. The absolute values of this parameter obtained by them are appreciably higher than has been believed likely from current phase-shift analyses. They conclude therefore that the spin-orbit interaction must be appreciably stronger at low energies than has been supposed heretofore. Their measurements have been made by means of a proton beam with nearly 100% polarization produced by scattering alpha particles by hydrogen. They have been discussed by MacGregor, Wright, and Arndt[2] who have considered a number of possible phase-shift sets that are consistent with (p,p) scattering data near 19.7 MeV. They conclude that the data of Ref. 1 are inconsistent with all six of the phase-shift sets tried by them. Since these phase-shift sets cover the possibilities coming under consideration rather fully, this conclusion brings out even more strongly the contradiction pointed out in Ref. 1. Since then Catillon and co-workers[3] published measurements of $P(\theta)$ at (20.2 ± 0.2)-MeV incident proton energy which are in contradiction with the data of Ref. 1. and in reasonably good agreement with the analyses in Ref. 2. Figure 2 of Ref. 3 shows in fact that the curve calculated from the phase shifts of Ref. 2 does not deviate from the new measurements by more than a standard deviation of an individual measurement. However, none of the experimental points falls above the calculated curve and in some cases they fall appreciably below it. Since the techniques used in both Ref. 1 and Ref. 3 are relatively new and not identical it was thought of interest to compare the measurements of Ref. 3 with value of $P(\theta)$ corresponding to fits[4,5] $(\text{Y-IV})_{p\text{-}p}$ and $(\text{Y-IV})_{pp+np}$. The values of P for the two fits were compared at 20.0 MeV and were found to differ by insignificant amounts, the p-p fit giving a value higher than $pp+np$ by about 0.0001 for $\theta_{\text{c.m.}}$ in the range 50°-60° and lower by a similar amount for the range 15°-25°. The remainder of the comparison is for the $pp+np$ fit at 20.2 MeV, the combined fit giving a slightly better representation of p-p data as a whole. The results are shown by the full curve in Fig. 1. The experimental points are those of Ref. 3 and the dashed curve, "Livermore," is an approximate reproduction of the curve shown in Fig. 2 of that reference. According to Catillon, Sura, and Tarrats this curve corresponds to the phase shifts of MacGregor, Wright, and Arndt in Ref. 2. Since these fits were made for 19.7 MeV, values of $P(\theta)$ for $(\text{Y-IV})_{pp+np}$ were compared at 20.2 MeV with those at 19.7 MeV. Adding the difference in these values to those of the "Livermore" curve the dotted curve "Livermore′" was obtained. This inference regarding what the fit of the Livermore group should predict at 20.2 MeV is speculative.

It is seen from Fig. 1 that the data of Catillon, Sura, and Tarrats are reproduced even better by the Yale multienergy fit than by the calculations

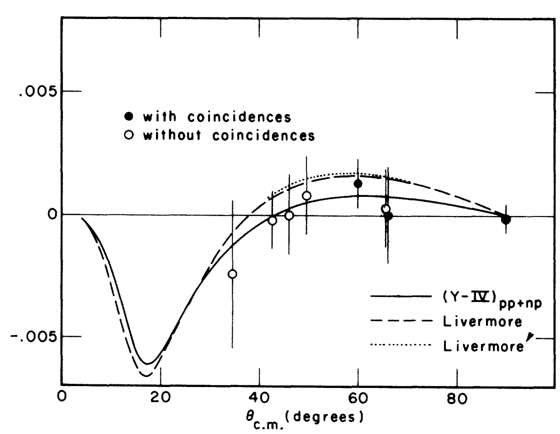

FIG. 1. Comparison of calculations with the 20.2-MeV Saclay measurements of $P(\theta)$. Dashed curve is a reproduction of curve in Fig. 2 of Ref. 3 employing 19.7-MeV analysis. Full curve is for $(\text{Y-IV})_{pp+np}$. Dotted curve contains speculatively made displacement of dashed curve allowing for measurement-analysis energy difference (20.2-19.7 MeV).

of Ref. 2 used in Ref. 3. Neither Ref. 2 nor fit $(\text{Y-IV})_{pp+np}$ has made use of the Saclay measurements.

The difference in the quality of fit between the dashed curve and the full one may be partly accidental but the fact that the Livermore curve is systematically high appears unlikely to be explicable that way. The ratio of chi-square values corresponding to the two fits is $2.85/0.76=3.7$. The normalization factor which in the Yale notation[6] is A_{δ}^{j} is 1.0036 and its effect on χ^2 is a factor $\approx 1-0.0013$. Systematic differences in the scale of the expected and observed $P(\theta)$ are thus practically absent in the case of $(\text{Y-IV})_{pp+np}$. The degree to which this is the case is doubtless accidental but the Saclay measurements indicate that the spin-orbit interaction is well represented by the last mentioned fit at 20 MeV in p-p scattering. The comparisons made above indicate the desirability of ascertaining the reason for the difference between the Berkeley[1] and the Saclay[3] experimental results.

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†Now at the State University of New York at Buffalo, Buffalo, N. Y.

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DIFFRACTED WAVE FIELDS EXPRESSIBLE BY PLANE-WAVE EXPANSIONS CONTAINING ONLY HOMOGENEOUS WAVES*

George C. Sherman

Aerospace Corporation, Los Angeles, California 90045, and
Department of Meteorology, University of California, Los Angles, California 90024

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A comprehensive study of the properties of "source-free" wave fields (i.e., diffracted wave fields expressible by plane-wave expansions containing only homogeneous waves) is summarized. The theorems proved in the study are stated. A new series mode expansion for "source-free" wave fields in included.

Although the wave fields herein called "source-free" wave fields[1] have played an important role in the theories of propagation and diffraction of monochromatic, scalar waves for nearly two decades,[2] their unique properties have not been studied in detail. Recent advances[3-12] in the diffraction theories of imaging and holography have indicated a need for improved understanding of these fields. "Source-free" wave fields are important because (1) most scalar wave fields that occur in diffraction theory can be approximated by "source-free" wave fields in regions of space far from sources, and (2) "source-free" wave fields can be treated by much simpler mathematical techniques than can other fields. In the vicinity of a source, however, it is important to distinguish between "source-free" wave fields and wave fields that are not "source-free" since the behaviors of these two types of wave fields differ greatly in the vicinity of a source. Hence, indiscriminate use of "source-free" wave fields in the study of images of sources can lead to erroneous results. The results of a recent study of the properties of "source-free" wave fields are summarized here; a comprehensive treatment, complete with rigorous proofs of the theorems, will follow.

Consider a wave field $u(x, y, z)$ expressed by the angular spectrum representation[13]

$$u(x,y,z)=\iint_{-\infty}^{\infty}F(p,q)H(p,q,x,y,z)\,dp\,dq \quad \text{for } z>0, \tag{1}$$