Table I. Molecular g factor, Λ-type doubling frequency, and hyperfine structure coupling constants of the ground $^2\Pi_{3/2}$, $J=\frac{3}{2}$ state of SH.

	Experiment			Theory
g_J	0.83792	±0.00002		0.8380 [a]
ν_Λ	111.42	±0.04	Mc/sec	114 Mc/sec [b]
$\lvert A_1\rvert$	5.61	±0.04	Mc/sec	
$\lvert A_2\rvert$	0.08	±0.04	Mc/sec	

[a]Calculated from optical data of D. H. Ramsay, J. Chem. Phys. 20, 1920 (1952).

[b]C. H. Townes, Radio Astronomy, edited by H. C. van de Hulst (Cambridge University Press, New York, 1957).

exactly the same way as for the corresponding spectrum of OH.[3] In qualitative terms, the overall location of the spectrum in magnetic field strength indicates the size of the molecular magnetic moment, while the separation of the two groups of lines is a measure of the Λ-type doubling interval. Each group contains three hyperfine structure doublets, which are separated from one another by a second-order Zeeman effect.

The major results of a detailed spectral analysis are given by Table I, which also gives comparable theoretical results calculated from optical data.

In the absence of a magnetic field, the twelve-line spectrum of Fig. 1 would condense into two strong closely spaced lines, plus two weak satellites. The complete zero-field spectrum can be calculated, with no approximations, from the data of Table I and relations found in references 2 and 3. The frequencies of the two strong ($\Delta F=0$) lines, which will serve to identify interstellar SH, are given by $\nu_\Lambda \pm 2A_2$, and are

$$\nu_1 = 111.26 \pm 0.10 \text{ Mc/sec } (F=1 \rightarrow F=1),$$

$$\nu_2 = 111.58 \pm 0.10 \text{ Mc/sec } (F=2 \rightarrow F=2),$$

with expected relative intensities of 5 for $F=1$ and 9 for $F=2$.

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MEASUREMENT OF THE DEPOLARIZATION PARAMETER FOR 50-MeV PROTON-PROTON SCATTERING AT 70° c.m.

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The phase shifts characterizing the proton-proton interaction at energies below 310 MeV are now known with reasonable precision,[1] except in the energy region between 20 and 90 MeV, where the absence of triple scattering data precludes the determination of a unique set of phase shifts. In particular, at 50 MeV, where only the differential cross section[2] and polarization[3] are known, the $^3P_0$ phase shift can vary over a range of almost 30° without appreciably altering the fit to the experimental data.[4] The depolarization parameter is very sensitive to the magnitude of this phase shift, and a single measurement of this parameter at 50 MeV would determine the $^3P_0$ phase shift to considerably higher accuracy.[5] This Letter describes such a measurement recently completed at the Rutherford Laboratory, Harwell, England.

The experimental arrangement is shown in Fig. 1. The 50-MeV vertically polarized proton beam from the linear accelerator is focused on a liquid hydrogen target (A) and protons scattered at 35° to the left and right enter polarization analyzers (B) containing high-pressure helium gas in which a second scatter can occur. Inside the analyzers, scattering angles of 60°± 15° are defined by a system of copper vanes (C), and protons are detected in plastic scintillator strips (D) viewed from one end by photomultipliers (E). Protons entering an analyzer traverse a thin counter (F) between target and analyzer, and fast coincidences between this counter and each of the counters in the analyzer are recorded.

The contribution of background to the observed

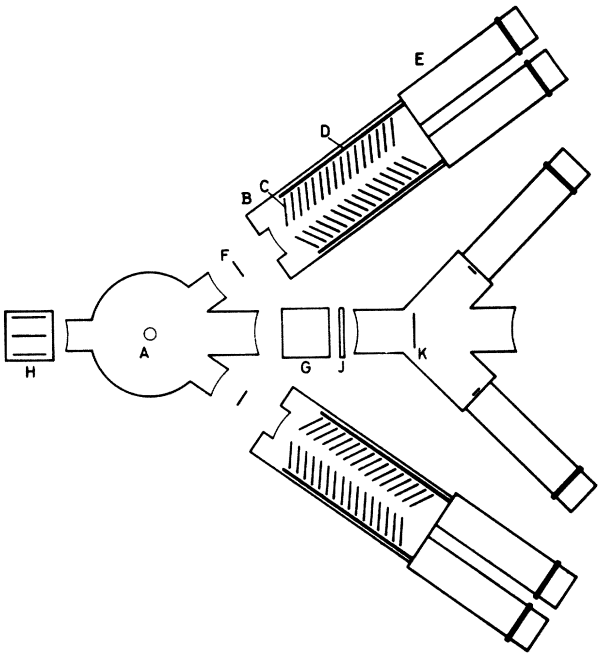

FIG. 1. Experimental layout.

counts comes from three principal sources: (a) protons scattered from the nylon appendage containing the liquid hydrogen; (b) protons scattered from the vanes in the analyzers; and (c) neutron and gamma-ray background. It was subtracted by a suitable combination of data from four runs taken under the following conditions: (i) hydrogen target full, helium pressure 30 atmospheres; (ii) hydrogen target full, helium pressure 1 atmosphere; (iii) hydrogen target empty, helium pressure 30 atmospheres; and (iv) hydrogen target empty, helium pressure 1 atmosphere. In all runs random coincidences were measured at the same time as the total counts. The beam intensity was monitored with an ion chamber (G), and a correction was made for its reduced sensitivity in the target empty runs.

The polarized ion source[6] on the linear accelerator has provision for reversing the spin direction of the proton beam, so that, by combining data from successive runs with spin "up" and "down," many sources of false asymmetry can be minimized provided no shift of position, or change of shape, of the beam is introduced. The beam position in the horizontal plane was monitored continuously throughout the experiment using a split ion chamber (H) of the type described by Metheringham and Willitts,[7] and displacements were kept well below 0.05 cm. Photographs of the beam profile taken with spins "up" and "down" showed no evidence of a change in shape.

In order to eliminate counter efficiencies, it is convenient to express the corrected counts in terms of two asymmetries e_1 and e_2 given by[8]

$$e_1=\frac{[(LLU/LLD)(RRD/RRU)]^{1/2}-1}{[(LLU/LLD)(RRD/RRU)]^{1/2}+1},$$

$$e_2=\frac{[(LRU/LRD)(RLD/RLU)]^{1/2}-1}{[(LRU/LRD)(RLD/RLU)]^{1/2}+1},$$

where, typically, LLU represents the total count in the left-hand counter of the left-hand analyzer when the incident beam spin is "up." From these asymmetries we obtain the relations

$$DP_1P_3=\tfrac{1}{2}(e_1-e_2)+\tfrac{1}{2}(e_1+e_2)P_2P_3,$$

$$P_1P_2=\tfrac{1}{2}(e_1+e_2)+\tfrac{1}{2}(e_1-e_2)P_2P_3,$$

where D is the depolarization parameter, P_1 is the incident beam polarization, P_2 is the proton-proton polarization, and P_3 is the analyzing power of the helium analyzers.

P_2 at 50 MeV and at c.m. scattering angle of 90° is accurately known,[3] and its value at 70° can be inferred and verified using the equation for P_1P_2. It is found that the term in P_2P_3 in the expression for DP_1P_3 is less than 2% of the first term and is considerably less than the statistical error.

The incident beam polarization was monitored throughout the experiment by degrading the beam traversing the hydrogen target with an aluminum absorber (J) to a mean energy of 15.7 MeV and then scattering at an angle of 45° (lab) from a carbon target (K). Using the available measurements for carbon,[9] the polarization efficiency of the polarimeter was calculated to be $-0.419^{+0.025}_{-0.016}$ giving a mean value of $P_1=0.301^{+0.015}_{-0.019}$.

A direct experimental determination of P_3 is difficult because of the large angular and energy spread of the protons entering the analyzers. Since, however, the geometry of the system is well defined and there is adequate information on cross section and polarization in proton-helium scattering at energies below 30 MeV, a Monte Carlo calculation of P_3 can be reliably effected.[10] This method gives a value $P_3=-0.476\pm0.020$.

Combining these results with the observed asymmetries leads to a value of $D=-0.249\pm0.075$.

This result is in agreement with the predictions of Breit et al.[11] and of Noyes.[12] The inclusion of this result in preliminary phase-shift analysis of the 50-MeV data appears to improve the fit to the $^3P_0$ phase shift considerably,[4] but more de-

tailed work is needed to confirm this impression.

It is a pleasure to thank the many members of the staff of the Rutherford Laboratory who helped with this experiment. In particular, we wish to thank P. D. Wroath for his invaluable assistance in all stages of the experiment.

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REMARKS ON THE MULTIPLET STRUCTURE OF STRONG INTERACTION SYMMETRY*

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In the usual group-theoretic discussion of strong interaction symmetry, one starts with a given symmetry group and then proceeds to examine what kinds of supermultiplets are predicted by the group under consideration. For instance, in the so-called "eightfold way,"[1] we start with the group SU(3) together with the requirement $|p-q| = 0, 3, 6, \cdots$, where p and q refer to the numbers of the upper and lower indices of an irreducible tensorial representation; we then obtain the result that the strongly interacting states must be grouped into supermultiplets of dimensionalities 1, 8, 10, 27, etc., with definite isospin and hypercharge contents. Since what we directly observe in our laboratory are not the structure constants of a Lie algebra but rather the supermultiplets themselves, it is of some interest to examine the converse problem of inferring the correct symmetry group once the patterns of supermultiplets are given. The purpose of this Letter is to show how this problem may be solved in some simple cases using specific illustrative examples. We also comment on the recent work of Capps[2] who claims to have derived the SU(3) symmetry from dispersion-theoretic considerations.

First, for orientation purposes, let us consider the very trivial and familiar case of the Yukawa-type coupling of the (π^+, π^-, π^0) triplet to the (p,n) doublet. We do assume electric charge conservation and baryon number (or nucleon number) conservation, but let us pretend that we are ignorant of the $\vec{\tau}\cdot\vec{\pi}$ structure of the interaction or of the rule for adding angular momenta. Before we switch on the pion-nucleon interaction, the charged and the neutral pions as well as the p and n are assumed to be degenerate. It is of interest to note that we can actually "derive" the consequences of charge independence of the $\bar{N}N\pi$ vertex merely by demanding that the degeneracies persist in the presence of the pion-nucleon interaction. To see this, we just require that the self-energies of the p and the n (the $\pi^\pm$ and the π^0) be equal; by considering second-order graphs, we have

$$\delta m_p = \delta m_n \Rightarrow G^2(\pi^+\bar{p}n) + G^2(\pi^0\bar{p}p) = G^2(\pi^0\bar{n}n) + G^2(\pi^+\bar{p}n),$$

$$\delta m_{\pi^+}{}^2 = \delta m_{\pi^0}{}^2 \Rightarrow G^2(\pi^+\bar{p}p) = G^2(\pi^0\bar{p}p) + G^2(\pi^0\bar{n}n),$$

and hence the famous relation

$$G^2(\pi^+\bar{p}n) = 2G^2(\pi^0\bar{p}p) = 2G^2(\pi^0\bar{n}n).$$

Similar considerations based on fourth-order graphs lead to one additional condition,

$$G(\pi^0\bar{p}p) = -G(\pi^0\bar{n}n).$$

In other words, the very existence of the degenerate pion multiplet and the degenerate nucleon multiplet in the presence of their mutual interactions demands that the $\bar{N}N\pi$ vertex satisfy the usual requirements that follow from the charge-independent $\vec{\tau}\cdot\vec{\pi}$ interaction.