liquids. The angle α was deduced from the upper data of Fig. 2 using the relation $P_A/P_T = (1+0.707 \times \sin\alpha)/2$, where P_A is the power in channel A and $P_T = P_A + P_B$ is the total laser power. To compute B from α, the relation $\alpha = (10\omega^2/nc^3)P_T B$ was used. This equation was derived from (3) by assuming that the entire rotation takes place in an effective cylindrical focal volume whose length to cross-sectional area ratio is $1.2n/\lambda$, within which the beam has uniform intensity. This model is based upon the intensity distribution in the region of a diffraction-limited focus.[4] The ratio has been degraded by a factor of 3, which represents a best guess as to the effects of the observed departures from an ideal focus. Also the pulse shape was assumed square in time with duration equal to the measured half-width. The values thus deduced for B cover the same range as those obtained for similar materials from three-wave frequency-mixing experiments carried out away from a focus,[2] and third-harmonic generation experiments.[5]

In all of the liquids studied B was found to be positive. A is expected to have the same sign as B.[2] Both constants being positive implies a decrease in velocity and an increase in Rayleigh scattering with increasing intensity. In a liquid with $A \cong B \cong 10^{-14}$, changes in the refractive index of the order of $1:10^3$ will occur at an $f/10$ ideal focus of a one-megawatt laser beam. This intensity-dependent slowing should be considered in the calculation of the angles at which anti-Stokes radiation will emerge[5,6] from such a focus when Raman laser action occurs.

The high value of B for carbon disulfide arises from the two-photon absorption resonance reported by Giordmaine.[3] Its positive sign implies that 2ω is less than the resonance frequency. His value for the intensity-induced scattering cross section for plane polarized light gives $\mathrm{Im}(A + \frac{1}{2}B) = (5 \pm 4) \times 10^{-14}$ cm^3 erg^{-1}. We also have observed an intensity-dependent attenuation of 10% in carbon disulfide with $P_T = 5 \times 10^4$ watts. Using the same model for the interaction volume as in the calculation of ReB, we calculate $\mathrm{Im}(A + \frac{1}{4}B) = 2 \times 10^{-14}$ cm^3 erg^{-1}. We plan to simultaneously study the polarization dependence of the intensity-induced absorption and the intensity-induced rotation. From these data we will be able to obtain accurate relative values for ImA, ImB, and ReB.

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SLOW NEUTRON-DEUTERON CAPTURE AND THE STRUCTURE OF ^{3}H AND ^{3}He†

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Recent experiments on the elastic scattering of high-energy electrons from ^{3}H and ^{3}He show that the magnetic moment form factors for the two nuclei and the electric charge form factor for ^{3}H are all quite similar to each other, while the charge form factor for ^{3}He falls off somewhat more rapidly with increasing q^2 than do the other three.[1,2] These observations have been interpreted[2] as indicating that the like pair of nucleons (protons in ^{3}He and neutrons in ^{3}H) have a somewhat different spatial distribution than the odd nucleon; the form factors (Fourier transforms) of these probability distributions are called F_L and F_O, respectively. Since the charge in ^{3}He is carried primarily by the like pair, while the charge in ^{3}H and the moment in both nuclei are carried primarily by the odd nucleon, such a model is in at least qualitative accord with the observations.

A subsequent paper,[3] which makes use of the isotopic spin formalism, ascribes the difference between F_L and F_O mainly to interference between the dominant, fully space-symmetric $^2S_{1/2}$ state with $I = \frac{1}{2}$ (denoted by S), and a $^2S_{1/2}$ state of mixed symmetry that also has $I = \frac{1}{2}$ (denoted by S').[4]

In this way, an S'-state probability of about 4% was deduced. In the same paper, it was pointed out that an independent and quite sensitive test of the percentage of S' state is provided by the rate of capture of slow neutrons by deuterons. This process is forbidden if there is no S' state and if the exchange magnetic moment contribution is ignored.[5] The exchange moment contribution to the capture rate has been found to be of the same order of magnitude as the experimental value,[6] and our calculations, to be reported shortly,[7] confirm this. Now it is unlikely, although not impossible, that the spin and exchange moment parts of the capture matrix element will interfere destructively with each other. Except for this possibility of destructive interference, which we set aside for the present, the experimental capture rate provides an upper limit on the S'-state probability.

We find[7] that this upper limit is sensitive to the size parameter in the S'-state wave function. Calculations have been performed with the Gaussian wave function [Eq. (24) of reference 3], since explicit continuum wave functions of this form are available.[8] The size parameter α in the S function u was chosen to be in agreement with the electron scattering data and the Coulomb energy of ^{3}He, and α was replaced by α' in the S' function g. For $\alpha' = \alpha$, the case considered in reference 3, the capture rate upper limit is 0.02%, far smaller than the 3.5% inferred in reference 3 from electron scattering. The capture rate upper limit increases uniformly as α' increases, becoming equal to 2.2% when $\alpha' = 2\alpha$. At the same time the S'-state probability inferred from electron scattering decreases to a minimum of 2.5% at about $\alpha' = 1.3\alpha$, and then increases to 7.8% at $\alpha' = 2\alpha$.

Thus application of the test proposed in reference 3 suggests that there is probably not enough S' state present to account for the observed difference between F_L and F_O. It is, of course, possible that destructive interference between spin and exchange moment capture will lead to a different conclusion, and this is now being investigated.[7]

In the meantime, other interpretations of the electron scattering data must be considered. One such interpretation assumes that there is no S' state, that $F_L = F_O$, and that the difference between the electric charge form factors of ^{3}H and ^{3}He arises from the neutron charge distribution.[9] This leads to neutron electric form factors that are appreciably larger than those inferred from experiments on electron-deuteron scattering.

Another interpretation[10] ascribes the difference between F_L and F_O to the D states believed to be present in the lowest energy eigenfunction of the three-nucleon system.[11] There are three such $^4D_{1/2}$ states with $I = \frac{1}{2}$; they cannot contribute to the charge form factors through interference with the S state, but can contribute by themselves. It seems more convenient in the present situation to describe them with the formalism of Sachs[12] than with that of Derrick and Blatt.[4] These three D functions (Nos. 6, 7, and 8 in Sachs's notation) are not orthogonal as they stand, but can be made so by replacing No. 6 with a linear combination of Nos. 6 and 7. Now the difference form factor $F_2 = F_O - F_L$ is zero at $q^2 = 0$, since F_L and F_O are normalized to unity there. It is sufficient for our present purpose to consider only the coefficient of the leading q^2 term in F_2, and it turns out that this arises entirely from interference between D states Nos. 7 and 8; there is no contribution from any one of the three states by itself, nor from the interference between the new combination that replaces No. 6 and either No. 7 or No. 8. Further, these states do not contribute significantly to the slow-neutron capture rate in deuterium.[6]

The observations[2] indicate that $F_2 \cong +0.05q^2$ for small q^2. This can be accounted for, if the neutron electric form factor is neglected, as a D-state interference effect of the type just described. We use the Irving[3,13] form for the radial dependence of the D functions, and choose a linear combination of Nos. 7 and 8 that maximizes the contribution to F_2. Agreement is then obtained if the radial size parameter α_D and the total D state probability P_D are related by $\alpha_D^2 \cong 14P_D$. Thus if P_D is assumed to be 4%, α_D is found to be 0.75 inverse fermi. This seems to be a reasonable value in comparison with the corresponding S-state size parameter, which was found[3] to be about 1.27 F^{-1} for the Irving function. The details of this calculation, and the contribution of SD interference to the moment form factors (mentioned in reference 3), will be reported later.[10]

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EFFECT OF STRONG ABSORPTION IN PARTICLE EXCHANGE REACTIONS

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It has been suggested[1] that certain high-energy reactions are dominated by the one-particle exchange mechanism. This type of mechanism has also been applied[2] successfully to the so-called "direct nuclear reactions." In the case of direct nuclear reactions the exchanged particle is a nucleon or a cluster of nucleons, while for high-energy reactions it may be an elementary particle or a "Regge pole."[3] For both high-energy and direct nuclear reactions it appears that the distortion effects due to interactions in the incident and outgoing channels lead to a reduction in the contribution to the reaction of the partial waves of low angular momentum.

It has been suggested[4] that a dispersion-theoretic analysis can be used to describe the effect of elastic distortion on the one-particle exchange amplitude. Such an approach uses the unitarity and time-reversal symmetry of the S matrix together with certain assumptions about the analytic behavior of the transition amplitude. In this analysis it is customary to neglect certain terms in the unitarity relation. In this note we wish to point out that the neglect of these terms leads directly to very interesting consequences.

If $T_{\beta\alpha}$ is the scattering amplitude for the reaction $\alpha \to \beta$ where α and β represent equal- (positive-) energy channels, then unitarity and symmetry of the S matrix imply

$$\mathrm{Im}T_{\beta\alpha} = \tfrac{1}{2}(2\pi)^4\{\textstyle\sum_{\beta'} T_{\beta\beta'} T^{\dagger}_{\beta'\alpha} + \sum_{\alpha'} T_{\beta\alpha'} T^{\dagger}_{\alpha'\alpha} + \sum_{\nu} T_{\beta\nu} T^{\dagger}_{\nu\alpha}\}\delta^4(P_\alpha - P_\beta), \quad (1)$$

where $T_{\beta\beta'}$ is the amplitude for elastic scattering. It is customary to assume that the third sum on the right of Eq. (1), which comprises all intermediate states ν which cannot be reached by elastic scattering in the initial or final channel, can be neglected. The justification of this step rests on the observation that since the nonelastic amplitudes are small compared to the elastic amplitudes, the terms in the third sum on the right of Eq. (1) are small compared to the terms in the first two sums. The fact that the various terms of these sums have different phases makes it unlikely that the sum will be of a different order of magnitude than its individual terms. Then rewriting Eq. (1) in the angular momentum representation gives

$$\mathrm{Im}T_l^{(\beta\alpha)} = u_l^{(\alpha)} T_l^{(\beta\alpha)*} + u_l^{(\beta)*} T_l^{(\beta\alpha)}, \quad (2)$$

where

$$u_l^{(\alpha)} = \exp(i\delta_l\alpha)\sin\delta_l\alpha \quad (3)$$

and δ_l is the elastic phase shift.

We note that Eq. (2) is, in fact, two linear homogeneous algebraic equations for the real and imaginary parts of $T_l^{(\beta\alpha)}$. Thus we have three possibilities: (a) $T_l^{(\alpha\beta)} = 0$, (b) $u_l^{(\alpha)} = u_l^{(\beta)} = 0$ and $T_l^{(\alpha\beta)}$ is real, or (c) the determinant of the system of equations must vanish. The third alternative results in the following re-