the amplitude of the second resonance as a function of t was found to be

$$A(t_0+t)=A(\infty)-[A(\infty)-\lim_{t\to t_0}A(t_0+t)]\exp(-t/T_1). \quad (1)$$

T_1 was measured to be 4.0, 4.8, and 5.6 minutes, respectively, at 78°K, 4.2°K, and 1.37°K within ±15% for C_2H_2. We use the fact that $\chi_p \propto A(\infty)$ to obtain the values plotted in Fig. 1. The results are seen to be consistent with the Curie law. $\chi_p T$ at 78°K was about 25% lower than at 4.2°K and 1.37°K. This is probably accounted for by changes in circuit parameters for the spectrometer as the temperature is changed. The linewidth was constant over the entire temperature range of the experiment, but the line shape was distorted because of saturation effects.

We should add that we did not measure T_1 for H_2O and hence can make no precise statements about the temperature dependence of χ_p. However, we monitored the proton resonance signal every 15 minutes for 8 hours, 4 hours at 4.2°K and 4 hours at 1.4°K, for each sample and observed no change at constant temperature. All of the neutron scattering measurements in H_2O were performed at 4°K.[1,8]

We conclude that the neutron scattering experiments[1] in C_2H_2 cannot be interpreted in terms of spontaneous conversion from ortho to para modifications of C_2H_2. The inelastic neutron scattering experiments on an aqueous moderator[1,8] also do not seem to imply spontaneous ortho-para conversion of H_2O in ice, as suggested by Borst et al.

In any theoretical attempt to explain these results it would seem that the influence of the crystalline field on elastic and inelastic scattering cross sections and on ortho-para energy levels should be considered. For example, specific heat measurements on pure ice have shown that H_2O molecules are frozen into fixed orientations at quite high temperatures.[9] The aqueous moderator used in the scattering experiments could have quite different crystalline fields acting on the H_2O molecules than pure ice.

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NEW TERM IN THE NUCLEAR OPTICAL POTENTIAL: IMPLICATIONS FOR (p,n) MIRROR STATE REACTIONS

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The purpose of this Letter is to point out that the nuclear optical potential depends on isotopic spin, and that this has important practical consequences. If $\vec{t}, \vec{T}$ are the isotopic spins of incident nucleon and target nucleus of mass A, the dependence has the form:

$$V=V_0+A^{-1}(\vec{t}\cdot\vec{T})V_1, \quad (1)$$

where V_0, V_1 are independent of isotopic spin but depend in general on position and momentum. The term in $(\vec{t}\cdot\vec{T})$ appears straightforwardly in a calculation of V taken as a sum of two-body forces with Heisenberg components and averaged over a Fermi gas. In spite of this, it seems that it has never been written down as such.

If the potential (1) is averaged over allowed val-

ues of total isotopic spin, $\vec{T}'$ (say) $\equiv \vec{T} + \vec{t}$, with appropriate Clebsch-Gordan factors, then the mean potentials for incident proton and neutron are

$$V_p = V_0 - \tfrac{1}{4}[(N-Z)/A]V_1,$$
$$V_n = V_0 + \tfrac{1}{4}[(N-Z)/A]V_1. \quad (2)$$

This result is independent of isotopic spin mixing (as are other results below to a good approximation), so the considerations here apply to all nuclei. The dependence (2) of potential on symmetry number and the related difference between neutron and proton potentials have been noted before.[1-3]

In comparing (1) with the averaged form (2), we note that not only does (1) have the formal appeal of being charge independent, but it has two important practical implications not contained in (2):

(1) All single-particle levels for protons are split into two components corresponding to $T' = T \pm \frac{1}{2}$. Let us write the potentials and scattering amplitudes as $V_{p\pm}$ and $f_\pm(\theta)$. The difference in potentials is

$$\Delta V_p \equiv V_{p+} - V_{p-} = \tfrac{1}{2}A^{-1}(2T+1)V_1,$$

and the proton elastic scattering cross section is

$$\sigma_{pp}(\theta) = (2T+1)^{-2}|f_+(\theta) + 2Tf_-(\theta)|^2.$$

If ΔV_p is large (several Mev), this corrected form can differ appreciably from that based on a potential without isotopic spin dependence. This may mean that optical model fits of some proton elastic scattering data should be repeated.

(2) The term $(\vec{t}\cdot\vec{T})$ acting on an incident proton can convert it into a neutron, and turn the target into the corresponding isobaric state. If we ignore the facts that the neutron does not feel the Coulomb barrier and its energy is smaller, the (p,n) cross section for isobaric state excitation is

$$\sigma_{pn}(\theta) = 2T(2T+1)^{-2}|f_+(\theta) - f_-(\theta)|^2.$$

This will be valid at energies well above barrier; at lower energies, allowance must be made for Coulomb effects. Thus, we have a novel kind of process: a (p,n) reaction described by the optical model. The main correction to this expression will arise from the exchange (p,n) contribution in which a target neutron is knocked out by the incident proton. This exchange is probably small [the corresponding term in (p,p') reactions is always neglected]. Further, it does not particularly excite the isobaric state, whereas the present process does.

Finally, we have attempted to estimate V_1. In principle, V_1 is velocity dependent and so involves a number of parameters, but the items below all apply to energies at or just above the Fermi surface, so we will understand V_1 in future to be evaluated at this energy. Items relevant for fixing V_1 are:

(1) Explicit shell-model calculation of odd-parity levels in O^{16}.[4] From the centroids of the reduced widths of $T' = 0$ and $T' = 1$ levels, the splitting is 3.0, 2.5, and 3.6 Mev for $s_{1/2}$, $d_{3/2}$, and $d_{5/2}$ particles. This gives $V_1 \sim 50$ Mev.

(2) Shifts of neutron levels between Ni^{59} and Ni^{61}, and between Cu^{64} and Cu^{66} as observed from (d,p) reactions.[5] Adding, to the observed mean upward shift of 0.5 Mev, an amount 0.8 Mev from the normal downward shift, we find $V_1 \sim 120$ Mev.

(3) The nuclear symmetry energy. Unfortunately, the kinetic energy contribution to be subtracted is rather uncertain, with the result that V_1 can only be said to lie in the range 10 to 120 Mev.

At present, neither neutron and proton scattering data, nor the "proton potential anomaly,"[2] provide an estimate of V_1. In order to help fix V_1 further, it would be very useful to have data on (p,n) isobaric state excitation of the kind recently reported,[6] but preferably at higher energies.

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