Since the effect of shear on the phonon energies at the point L in the BZ is zero for stress along [001], the energy shifts measured with stress along this direction are caused by an equivalent hydrostatic pressure $P = X/3$. Hence, using Eq. (2) and a value[9] $K = 1.31 \times 10^{-12}$ cm^2/dyne, the individual phonon Grüneisen constants $\gamma_b(L)$ can be calculated. These are listed in column 4 of Table I.

Bienenstock[6] has carried out a semiempirical calculation of the $\gamma_b(q)$ for germanium using the acoustic $\gamma_b(q)$, a nonrigid shell model with an adjustable parameter, and treating the optic modes in an Einstein approximation where $\gamma_{\mathrm{TO}} = \gamma_{\mathrm{LO}} = 1.29$ for all the points in the BZ. His results for the $\gamma_b(L)$ are given in column 6 of Table I. With the exception of the $\gamma_{\mathrm{LA}}(L)$ the agreement with experiment is as good as can be expected.

By subtracting the pressure-induced shifts as obtained from stress measurements along [001] from the energy shifts measured with stress along [110] one obtains the energy shifts caused by the shear part of the stress tensor alone. Following the notation of deformation potential theory[10] the energy shifts ΔE of the phonons at L for an arbitrary stress can be expressed in terms of the deformation potentials E_1 and E_2 for pure dilatation and pure shear, respectively, as

$$\Delta E^{(i)} = \vec{n}^{(i)} \cdot \{E_1 \mathrm{Tr}(u) I + E_2[u - \tfrac{1}{3}\mathrm{Tr}(u) I]\} \cdot \vec{n}^{(i)}. \quad (3)$$

Here u is the strain tensor and $\vec{n}^{(i)}$ is the unit vector pointing to the ith point L in the BZ. The values of E_1 and E_2 for the four phonons at L are listed in Table II.

While it is still to be shown that the line shapes are adequately understood to relate completely the peak voltage with the phonon energy, it is believed that these effects will only slightly change the magnitude of the stress-induced energy shifts and the phonon energies. If this is the case the presence of a negative $\gamma_{\mathrm{TA}}(L)$ is sufficient to explain qualitatively the anomalous temperature dependence of α.

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β DECAY AND THE STRUCTURE OF H^3 AND He^3

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Recent measurements[1,2] of the electromagnetic form factors of H^3 and He^3 have directed attention to the detailed forms of the H^3 and He^3 wave functions. In particular, arguments have been presented[3,4] for and against the inclusion of a $^2S_{1/2}$ state (S') of mixed spatial symmetry, in addition to the dominant space-symmetric $^2S_{1/2}$ state (S) and the usual $^4D_{1/2}$ states (D). It is the purpose of this Letter to point out that the β decay of H^3 to He^3 serves as a sensitive test of the presence or otherwise of the state S' and, incidentally, of other states which might be proposed.

A comparison of the ft values for the β decay of H^3 and the neutron gives

$$\frac{(ft)_n}{(ft)_{H^3}} = \frac{G_V^2 + |M_A|^2 G_A^2}{G_V^2 + 3G_A^2} \quad (1)$$

where M_A is the axial vector matrix element for the decay $H^3 \rightarrow He^3 + e^- + \bar{\nu}$ and conserved vector current theory has been assumed. G_V and G_A are the usual polar- and axial-vector coupling constants. Taking[5-7] $(ft)_n = 1180 \pm 35$, $(ft)_{H^3} = 1137 \pm 20$, and $(G_A/G_V)^2 = 1.4 \pm 0.1$ gives $|M_A|^2 = 3.14^{+0.19}_{-0.18}$.

Now $|M_A|^2$ is given by the following expression[8]:

$$
\begin{aligned}
|M_A|^2 = 3\{&p(\mathrm{I}\,^2S) - \tfrac{1}{3}p(\mathrm{I}\,^2P) - \tfrac{1}{3}p(\mathrm{II}\,^2S) \\
&+ \tfrac{1}{9}[p(\mathrm{II}\,^2P) - 5p(\mathrm{II}\,^4P) - 6\alpha(\mathrm{II}\,^2P)\alpha(\mathrm{II}\,^4P)] \\
&+ \tfrac{1}{3}p(\mathrm{II}\,^4D) - \tfrac{5}{3}p(\mathrm{III}\,^2S) + \tfrac{5}{9}p(\mathrm{II}\,^2P)\}^2
\end{aligned}
\qquad (2)
$$

where p is the probability and α the amplitude with which a particular state occurs in the H^3 or He^3 wave function. The symbols I, II, III refer to states which are spatially symmetric, of mixed symmetry, or antisymmetric, respectively.

If the S' (i.e., $\mathrm{II}\,^2S_{1/2}$) state probability is taken to be 4%, as suggested by Schiff,[3] then, with an additional 4% D-state probability (this is probably an underestimate; see, e.g., Blatt, Derrick, and Lyness[9] and Blatt and Delves[10]), $|M_A|^2$ is calculated to have the value 2.54, in violent contradiction with the value deduced above from experiment. The discrepancy in $|M_A|^2$ is $24^{+7}_{-8}\%$ which is even further enhanced by relativistic effects in the H^3 beta-decay. These have been estimated[7] to be of the order 4% leading to a total discrepancy $\approx 28^{+7}_{-8}\%$.

An alternative interpretation of the H^3 and He^3 form factors assumes zero S' state probability, and a 4% admixture of D state. In this case $|M_A|^2 = 2.84$, still in disagreement with experiment, but not so violently. Including relativistic effects, the discrepancy then amounts to $\approx 15 \pm 7\%$.

Both discrepancies may well be underestimated since the D-state percentage could be appreciably higher than 4%. But in principle they can be resolved if it is assumed that there are substantial mesonic exchange corrections[11] to M_A. However, estimates[11] of these effects indicate that they are at most about 8%, and so could only hope to reconcile theory and experiment in the latter case. The indications are, therefore, that, in agreement with the evidence from the capture rate of slow neutrons by deuterons and also with theoretical estimates,[9] the S' state probability is small.

It is to be noted that the form of (2) is such that $|M_A|^2$ is always less than 3, provided that the space-symmetric S state dominates, and that its value can drop substantially below 3 for quite small admixtures of other states. The measured ft value for H^3 decay in comparison with the ft value for neutron decay can, therefore, set quite severe limits on the structure of the H^3 and He^3 wave functions. More accurate experimental values for these two decays would serve to make these limits more precise.

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