where the $\chi(\vec{q})$'s denote the Fourier coefficients in the expansion of χ, assuming the usual boundary conditions. The sum over $\vec{r}_i$ gives zero unless $\vec{q}$ is zero or one of the reciprocal lattice vectors $\vec{K}$. Thus the magnetization is

$$\chi(0)+\sum_{\vec{K}}\chi(\vec{K})e^{i\vec{r}\cdot\vec{K}}.$$

The leading term is, of course, the magnetization due to a spatially uniform field of unit strength. Assuming that χ is simply the Ruderman-Kittel susceptibility, $\chi(\vec{q})$ decreases from $\chi(0)$ to zero at $q=2k_f$. Therefore, unless $2k_f$ is comparable with one of the $\vec{K}$'s the sum will be negligible, and Eq. (3) is justified. The internal consistency of the data suggests that no such special conditions prevail.

Only for a naive model would one expect a detailed agreement between $\mathcal{J}_{sf}$ as derived from the NMR and EPR experiments since the former gives the polarization at the Al site while the latter that at the Gd site. The fact that both measurements show a negative polarization is strong evidence for assuming $\mathcal{J}_{sf}<0$.

To our knowledge this is the first determination of the sign of conduction electron polarization in a magnetic metal.[10]

We are particularly indebted to H. J. Williams and R. C. Sherwood for the measurements of the susceptibilities, to A. M. Clogston for many critical discussions, and to Mrs. V. B. Compton for x-ray analyses.

[1]The cubic Laves structure AB_2 belongs to the space group $O_h{}^7=Fd3m$; the point symmetry for the A site is $\bar{4}3m$ and the B site $\bar{3}m$. An axial quadrupole interaction is possible for the B site. All NMR measurements were made above the Curie point.

[2]The compounds were prepared by induction heating of stoichiometric amounts of the pure metals in silica or alumina crucibles in an argon atmosphere. J. H. Wernick and S. Geller, Trans. Am. Inst. Mining, Met. Petrol. Engrs. (to be published). S. E. Haszko, Trans. Am. Inst. Mining, Met. Petrol. Engrs. (to be published). For the NMR and EPR experiments, the samples were pulverized and sieved (400 mesh).

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[10]J. Owen, M. E. Browne, V. Arp, and A. F. Kip, J. Phys. Chem. Solids 2, 85 (1957), have found no shift for the EPR of Mn^{++} in copper but have detected a broadening of the Cu NMR.

OPTICAL OBSERVATION OF SPIN-ORBIT INTERACTION IN GERMANIUM

Jan Tauc and Emil Antončík
Institute of Technical Physics, Czechoslovak Academy of Sciences, Praha, Czechoslovakia
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Philipp and Taft[1] have recently determined the optical constants of germanium from the measurement of reflectivity in a broad wavelength range. In the reflection spectrum they observed near 2 ev a characteristic peak which Phillips[2] from an analysis of the absorption curve ascribed to the transition $L_{3'}\rightarrow L_1$ (see also Roth and Lax[3]). Our measurements of the reflection spectrum on etched single crystals of germanium have shown that this peak is split into two peaks, a at 2.1 ev and b at 2.3 ev (see Fig. 1). Using the optical constants as determined by Philipp and Taft[1] and considering the splitting $a-b$ as a small perturbation of the reflectivity reproduced in reference 1, it is possible to show that in the absorption

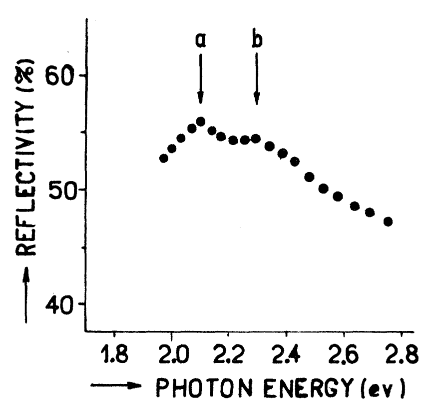

FIG. 1. Reflection spectrum of germanium (at 300°K) near 2 ev.

spectrum a similar splitting appears (naturally with the peaks somewhat shifted).[4]

The double peak may be explained by the splitting of the state $L_{3'}$ by spin-orbit interaction. The observed value of about 0.2 ev agrees well with the theoretical estimate by Roth and Lax.[3]

The correctness of this interpretation is supported by measurements on Ge - Si alloys: the splitting diminishes with increasing content of Si (e.g., in an alloy with 22% atomic percent of Si the energy interval of the peaks a, b in the reflection curve is only 0.15 ev; in Si it was not observable at all).[5] Similar double peaks were also found[5] in the reflection spectra of GaAs (the peak a is at 2.94, b at 3.20 ev), GaSb (2.00; 2.48), InAs (2.53; 2.82), InSb (1.82; 2.38); the general features of our interpretation are here in good accord with theoretical expectations as was kindly pointed to us by Phillips.[6]

It may be expected that the corresponding spin-orbit splitting in the Γ point should also be observable optically; however, in the absorption spectrum of Ge determined by Dash and Newman[7] this is not apparent. This point deserves further experimental investigations.

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[4]At our suggestion F. Lukeš from the University of Brno determined the absorption index k of germanium by the method of D. G. Avery [Proc. Phys. Soc. (London) B65, 425 (1952)]; his preliminary results confirm our observations. He found the peaks in the k curve at about 2.11 and 2.32 ev (private communication).

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PROTON HELICITY FROM Λ DECAY

Robert W. Birge and William B. Fowler*
Lawrence Radiation Laboratory, University of California, Berkeley, California
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When Λ hyperons are produced with K^0 mesons in $\pi^- - p$ reactions there is a large up-down asymmetry of the decay products with respect to the production plane.[1] The angular distribution of the decay pion from a completely polarized hyperon at rest can be written as[2]

$$dN = (1/4\pi)(1 + \alpha \cos\chi)d\Omega,$$

where $d\Omega$ is the solid angle of the pion momentum vector $\vec{P}_\pi$, and χ the angle between $\vec{P}_\pi$ and the spin of the hyperon. The constant α is given by

$$\alpha = 2 \,\mathrm{Re}(A^*B)/(|A|^2 + |B|^2),$$

and characterizes the degree of mixing of parities in the decay. A and B are the amplitudes for decay into $s_{1/2}$ and $p_{1/2}$ final states of the pion-nucleon system. The quantity $\alpha\overline{P}$, which has the possible values $0 \leq |\alpha\overline{P}| \leq 1$, is a measure of the up-down asymmetry and has been experimentally shown[3] to be $\geq 0.73 \pm 0.14$. This large asymmetry can exist only if the Λ's are highly polarized in the production process and if there is nonconservation of both parity and charge conjugation in the decay process.

Another necessary consequence of parity nonconservation in the decay process is a longitudinal polarization of the decay proton from unpolarized Λ's decaying at rest. It can be shown that this longitudinal polarization equals $-\alpha$.[4]

Fortunately, this longitudinal polarization of the proton, referred to the center of mass of the Λ, appears as a partial transverse polarization in the laboratory system when a Λ decays in flight and, hence, can be measured by a suitable scattering experiment. In this way the helicity of the proton can be obtained, whereas in the $\alpha\overline{P}$ experiments only the lower limit to the magnitude can be determined. The sign of α was determined in an experiment of Boldt et al.,[5] who found $\alpha = +0.85^{+0.15}_{-0.21}$, based on 54 selected events from a total of 257 in a multiplate cloud chamber.

In the course of an experiment designed to produce Ξ particles[6] from a high-momentum (1.1-Bev/c) K^- beam[7] impinging on the Berkeley