the electronic specific heat coefficient, it should be possible to trace the shape of the partially filled d-band, i.e., the density of states as a function of the electron concentration, by determining experimentally the electronic specific heat coefficient γ for a series of solid solution alloys of a given crystal structure.

In the present work, low-temperature specific heats were determined for body-centered cubic binary solid solutions in the Cr-Fe and the Cr-Mn systems. Specific heats were measured in the temperature range of 1.6° to 4.2°K to an estimated accuracy of ±2% for most alloys. For a few alloys, where the specific heat depends very sensitively on the alloy composition, the accuracy may have been as low as ±5%. The alloy specimens were prepared by induction melting from electrolytically refined metals, and homogenized by annealing for at least three days at 1170°C in a purified 92% He + 8% H_2 gas mixture and quenched to room temperature.

The low-temperature specific heats were analyzed by means of the usual C_v/T vs T^2 extrapolation to $T=0$, to obtain the coefficient γ of the temperature-linear term. These γ values are plotted in Fig. 1 as a function of the electron concentration. The γ for Fe was measured and found to be in excellent agreement with the value reported by Keesom and Kurrelmeyer.[1] The γ for $Cr_{0.44}Fe_{0.56}$, as determined by Hoare and Matthews,[2] was plotted in Fig. 1, and it fits the curve for the Cr-Fe alloys very well. A large peak occurs at $Cr_{0.81}Fe_{0.19}$, with a γ value more than ten times that for Cr.[3] The fact that similarly high γ values were found also for specimens in the Cr-Mn alloy series at corresponding electron concentrations suggests that the observed effect may be related to characteristic values of the electron concentration. However, it is as yet uncertain whether or not the γ-peak should be interpreted simply in terms of density of states. The work on the low-temperature specific heat and on other physical properties of these alloys is continuing, and it should eventually make possible proper interpretation.

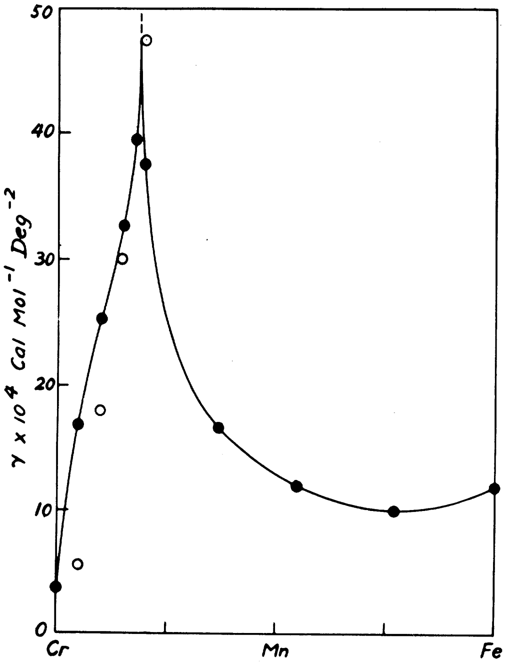

FIG. 1. Coefficient of term linear in temperature in the expression for the low-temperature specific heat, vs electron concentration. Cr-Fe alloys ●, Cr-Mn alloys ○.

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VALLEY-ORBIT SPLITTING OF ARSENIC DONOR GROUND STATE IN GERMANIUM

Gabriel Weinreich, W. S. Boyle,
Harry G. White, and K. F. Rodgers
Bell Telephone Laboratories,
Murray Hill, New Jersey
(Received January 15, 1959)

A comparison of the density-of-states effective mass obtained from low-temperature Hall measurements on n-type germanium[1] with the effective-mass tensor yielded by cyclotron resonance experiments[2] suggests that, of the two states into which the donor ground state is split by the valley-orbit interaction,[3] the triplet is the lower one.[4] It has further been pointed out[5] that the differences in binding energies among the various donors is not inconsistent with such an assignment. By investigating the far-infrared excitation spectrum of bound electrons[6] in an elastically strained sample, we have now verified that for the arsenic donor the triplet is, in fact, the lowest lying state.

The splitting of the singlet, triplet, and a typical p-state under an applied strain can be calculated.[7] One assumes for this purpose that if the wave function is expanded in conduction band Bloch waves only k-values very near the energy minima appear, so that the energy shift of each component is equal to the energy shift of the minimum near which it lies.

Since, for the p-state, the valley-orbit splitting is negligible, the quantization can be made simply by valleys. Such is not the case for the s-state, and as a result the frequencies of the s-p transitions are split. The intensities of the various components can be calculated from the selection rule that intervalley transitions by photon absorption are forbidden.

Figure 1 shows the splitting of any $(1s)$-(np) transition under a (111) uniaxial compression for the two cases in which the s-state is (a) a singlet or, (b) a triplet, taking into account the fact that the deformation potential Ξ_u is positive.[8] Relative intensities are indicated with each component. The undisplaced line in the triplet case arises from a nonzero electron population in substates other than the lowest one and is therefore temperature-sensitive. Except for this undisplaced line, the two patterns are mirror images of each other, with the intense line displaced toward high or low wavelength if the ground state is, respectively, the triplet or the singlet. The quantity Q, which governs the magnitude of the shifts, is given by

$$Q = \Xi_u t/9c_{44}, \tag{1}$$

where t is the applied stress and c_{44} the usual elastic constant.

We have studied the splitting of some $(1s)$-(np) absorption lines by such a uniaxial strain in a 1-mm thick sample containing about 3×10^{15} arsenic donors per cubic centimeter at a temperature of about 1.5°K. Figure 2 shows the observed absorption as a function of wavelength in the region of the $(1s)\rightarrow(2p, m=\pm1)$ transition, for the strained and unstrained case, after subtract-

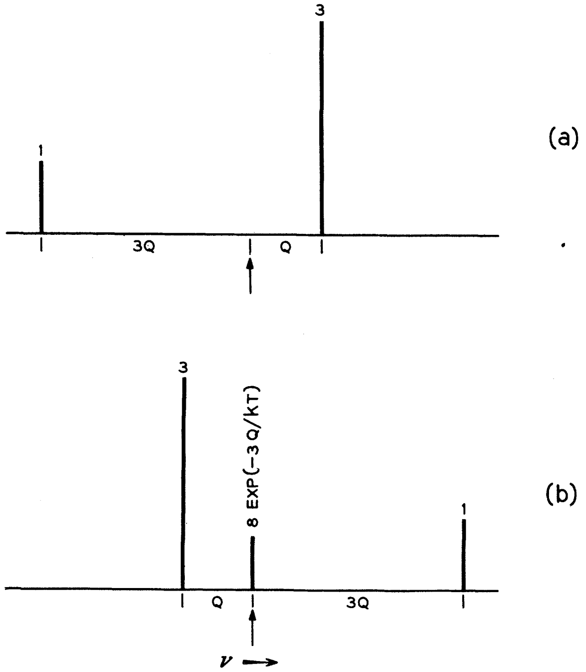

FIG. 1. Splitting of a $(1s\rightarrow np)$ line under a ⟨111⟩ compression. Case (a): singlet s-state. Case (b): triplet s-state.

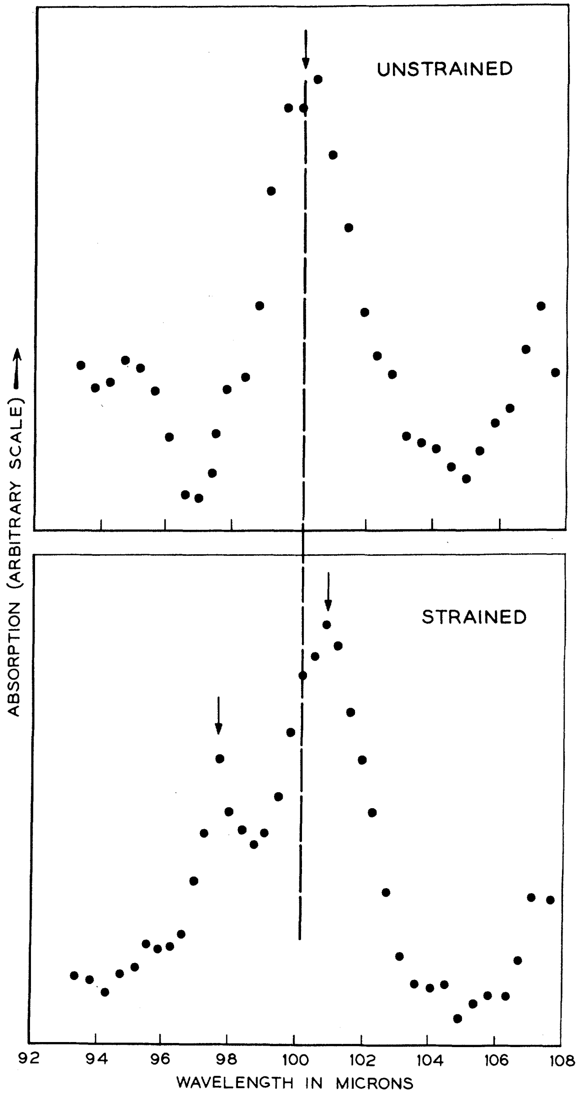

FIG. 2. Behavior of $(1s\rightarrow 2p, \pm1)$ line under ⟨111⟩ compression; sloping background absorption subtracted out.

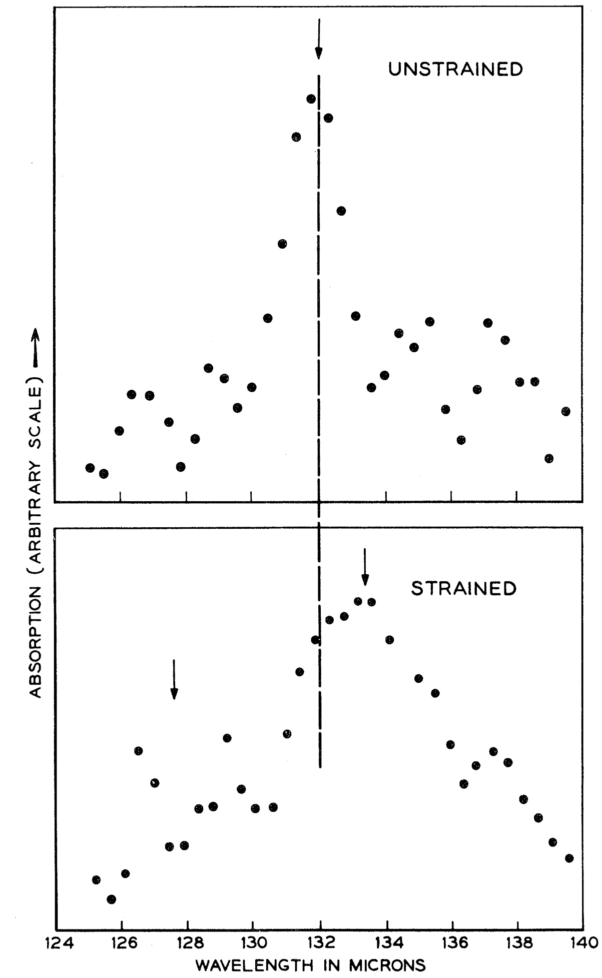

FIG. 3. Behavior of $(1s\rightarrow 2p,\ 0)$ line under $\langle 111\rangle$ compression.

ing out the slowly varying absorption on which the line is superimposed. Figure 3 gives the corresponding data for the $(1s)\rightarrow(2p, m=0)$ transition (in this case there is no slowly varying background).

It is quite clear in both Figs. 2 and 3 that the intense component is shifted toward longer wavelength, thus identifying the ground state as the triplet. In Fig. 2 the weak component, which is shifted in the short-wavelength direction by triple the amount, is also apparent. This component is not, however, discernible in the 135μ region, Fig. 3, where it is masked by an oscillating background which we believe to be of instrumental origin. Since the $m=0$ transition has half the strength of the $m=\pm 1$ transition and is furthermore in a region where the power from the monochromator is smaller, it is not surprising that its weak component is more difficult to detect; we hope to improve this situation in future work. The undisplaced component, being quite weak at this temperature, cannot be definitely resolved in either set of data.

The arrows in Figs. 2 and 3 indicate a theoretical fit to the data. We treated the value of Q as an adjustable parameter and found it to be $0.85\ \text{cm}^{-1}$. (Of course, the same Q must apply to both the $m=0$ and $m=\pm 1$ transitions.) On the basis of Eq. (1), we would have predicted Q to be a little over $1\ \text{cm}^{-1}$. We do not at present consider this discrepancy significant, since our method of measuring the applied stress is quite crude.

We hope by extending the experiment to higher applied stress to make the strain-induced energy shift comparable to the triplet-singlet energy difference $\Delta\nu$; the results could then be interpreted to yield the value of $\Delta\nu$, whereas we have so far only determined its sign. We are also planning to repeat these measurements on donors other than arsenic.

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TIME-REVERSAL INVARIANCE AND PARITY CONSERVATION IN STRONG INTERACTIONS

L. Rosen and J. E. Brolley, Jr.*
Los Alamos Scientific Laboratory,
University of California,
Los Alamos, New Mexico
(Received December 15, 1958)

In view of the failure of parity conservation in weak interactions,[1] it is appropriate to investigate, under diverse situations, the degree to which strong interactions are invariant under the