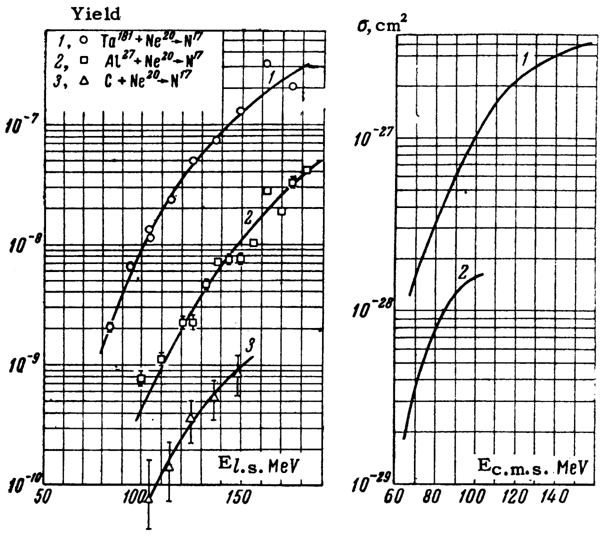

FIG. 3

of errors, with the tabulated half-life of N^{17} (4.15 sec). The background produced by the scattered ions falling on the dees was appreciable only at the lowest ion energies, and could be neglected in all other cases.

Figures 2 and 3 show the experimental data for the yield of N^{17} from thick targets (a) and for the effective reaction cross sections (b), obtained by the usual method of differentiating the yield curves. The free paths of the N^{14} and Ne^{20} ions, needed for these calculations, were taken from the paper by Northcliffe[13] or calculated from the formulas given in this paper.

The energy dependence of the cross sections is close to that obtained by Kaufmann and Wolfgang[11] for reactions involving the transfer of several nucleons. This permits us to think that the formation of N^{17} nuclei by bombardment with N^{14} ions is apparently due to the pickup of three neutrons, while in bombardment by Ne^{20} it is due to the stripping of three protons.

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OBSERVATION OF THE MÖSSBAUER EFFECT IN A TIN-CONTAINING POLYMER

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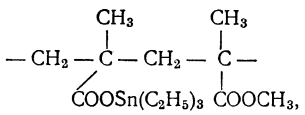
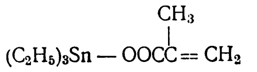
In view of the enormous possibilities for studying the structure of solids which have been opened up by the Mössbauer effect, it is a very attractive idea to try to observe the effect in a polymer. At first glance, if we use the simple pictures of the Mössbauer effect, such an effect in polymers should be extremely small because of the predominant effects of the light atoms (C, H, etc), and because of the absence of any clearly marked crystal structure in polymers. Nevertheless our attempts to observe the Mössbauer effect in tin-containing polymers have been successful.

We studied the tin-containing compound



which is a copolymer of

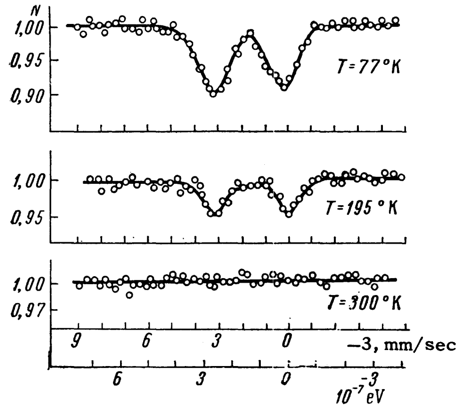


$$(C_2H_5)_3Sn-OOC\overset{CH_3}{\overset{|}{C}}=CH_2$$

with methyl methacrylate. The sample was a solid transparent substance with specific gravity 1.2 and molecular weight 2×10^6. The tin content of the sample was 30 wt %. The sample used in our work contained 110 mg/cm^2 of tin. The synthesis of the polymer is described in [1]. From data in the literature,[2] and from preliminary x-ray analysis, we can state that the polymer (obtained at a pressure of 200 atm) is a compound which is mainly in an amorphous state, with possible inclusions of crystallites which are up to a few hundred Angstroms across.

The measurements of the resonance absorption spectrum were done on the apparatus which was described earlier,[3] and also on other equipment in which the absorber was given a constant velocity relative to the source. The source of γ quanta was tin dioxide, SnO_2, containing the Sn^{119} isotope (the characteristics of the source are given in [3]).

The resonance absorption spectra which were found at three different absorber temperatures (77, 195, and 300°K) are shown in the figure (the abscissa gives the velocity of the absorber relative to the source and also the corresponding Doppler shift E_0v/c, the ordinate is the counting rate of γ quanta in relative units. The statistical error of the measurements at each point does not exceed 1.5%). We found that the resonance absorption spectrum consists of two lines, whose intensities are the same within the limits of error of the experiment. The locations of the lines correspond to 0 ± 0.2 and 3.0 ± 0.2 mm/sec. A detailed investigation of the spectrum showed that the width of the line is 0.8 mm/sec, i.e., somewhat larger than twice the natural width of the excited (23.8 keV) state of Sn^{119} (in the figure the lines have an even greater width because of the finite resolving power of the equipment with which these spectra were taken).



We may assume that such a spectrum shape is caused by the quadrupole interaction of the Sn^{119} nucleus in the excited state with the inhomogeneous electric field at the locations of the tin nuclei in the molecules of the polymer. From the experimental data, the quadrupole coupling $eQ\partial^2V/\partial z^2$ (where Q is the nuclear quadrupole moment and $\partial^2V/\partial z^2$ is the electric field gradient) is 4.8×10^{-7} eV. We note that this value for the quadrupole coupling is approximately twice as large as that observed earlier in inorganic compounds of tin.[3,4] Possibly, however, there is another explanation of the splitting—the occurrence of two states for the tin in the molecules of the polymer, which have different densities of the electronic wave functions at the position of the nucleus. According to preliminary data of our later experiments, a splitting like the one described, which is absent in tin-organic compounds of the type SnR_4, appears when we go to molecules of the type SnR_iX_{4-i} ($i = 1, 2, 3$).

The probability, f′, for recoilless resonance absorption of γ quanta was determined from the size of the observed effect, the known sample thickness, and source characteristics. This probability was 0.04 at 77°K and about 0.017 at 195°K. A quantitative comparison of the values of f′ with any sort of theoretical estimates is hardly possible at present. The various methods of calculating in the Debye approximation give a much sharper drop in the magnitude of the effect with increasing temperature than is observed experimentally. A similar temperature dependence of the effect was observed earlier for the compounds SnO_2[3] and Dy_2O_3.[5] The possibility of having a sizable Mössbauer effect on heavy nuclei contained in a light lattice, and at the same time having a weak dependence of the effect on temperature, was first noted by Kagan,[6] who called attention to the special role of the optical branches of the phonon spectrum of solids in the Mössbauer effect.

As was recently shown theoretically,[7] the Mössbauer effect can be observed not only in regular structures containing Mössbauer nuclei, but also when these nuclei are an impurity in a host matrix of light atoms. In this connection it is extremely interesting to observe the Mössbauer effect in tin compounds which are contained in polymers, not in the polymer chains, but as components of solid solutions. It would be particularly desirable to see whether the Mössbauer effect is sensitive to the composition and state of the solvent.

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WIDTH OF CYCLOTRON RESONANCE LINE IN SEMIMETALS AND DETERMINATION OF THE CORRELATION FUNCTION FOR BISMUTH

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THE width of a resonance line is usually defined in terms of the corresponding relaxation time. However, for cyclotron resonance, the Fermi-liquid interaction exerts an appreciable influence on the width of the line. It is evident from previously derived formulas[1] that when $\omega \sim \omega_1$, i.e., when $r \sim \delta_0$, we have $\omega\tau_{\text{eff}} \sim g$ (where $\omega_1 \sim v\omega_0/c$, r —Larmor radius of the electrons, $\delta_0 \sim c/\omega_0$, ω_0 —plasma frequency of the electrons, v —velocity, $g \sim \int G\,dS/v$, $G(\mathbf{p}, \mathbf{p}')$ —correlation function); for $g \sim 1$, resonance is in fact nonexistent. Since Aubrey and Chambers[2] observed in experiments on bismuth (where, $\delta/r \sim 2$ and $\omega\tau \sim 370$ for "holes") that the width of the resonance curve was of the order of unity (and not 10^{-2} which it should have been from $\omega\tau$) then, evidently, appreciable interaction takes place in bismuth, with $g \sim 1$. As far as we know, this is the first instance in which it has been possible to evaluate the order of the Fermi-liquid interaction in metals. It stands to reason that more detailed research would permit the function $G(\mathbf{p}, \mathbf{p}')$ to be clarified in greater detail.[1]

In this connection, it is of interest to determine how the Fermi-liquid interaction manifests itself during resonance over the entire frequency range. Since resonance calls for $\omega\tau \gg 1$, the depth of the skin-layer is $\delta \sim \delta_0 \sim c/\omega_0$ and does not depend on $\omega\tau$ and $r \sim v/\omega$. Consequently, two cases are possible: 1) sufficiently low frequencies, $\omega \ll \omega_1$, where cyclotron resonance[1] takes place (this range may not be attainable for semimetals and semiconductors because of the small ω_1, which corresponds to $\omega_1\tau \ll 1$); 2) sufficiently high frequencies, $\omega \gg \omega_1$, which is the range of diamagnetic resonance.

Let us set down, without derivation, the results in both these frequency ranges. In the cyclotron resonance range[1] we have:

$$\nu_{\text{eff}} \sim \frac{1}{\tau_{\text{eff}}} \sim \begin{cases} \omega_1(\omega/\omega_1)^2 & \text{(quadratic dispersion)} \\ \omega_1(\omega/\omega_1)^3 & \text{(non-quadratic dispersion)} \end{cases},$$

and in the diamagnetic resonance range:

$$\nu_{\text{eff}} \sim \frac{1}{\tau_{\text{eff}}} \sim \begin{cases} \omega_1 & \text{(quadratic dispersion)} \\ \omega_1(\omega_1/\omega) & \text{(non-quadratic dispersion)} \end{cases}.$$

It is clear from the above that the relative resonance width $1/\omega\tau_{\text{eff}}$, due to the Fermi-liquid interaction, has a maximum at $\omega \sim \omega_1$.

Let us explain the cause of the Fermi-liquid suppression of resonance, which has no connection with any real attenuation, and its smallness in almost all cases despite the fact that the interaction itself is not at all small. The point is that the Fermi-liquid interaction leads to an additional spatial dispersion $\omega = \omega(k)$ as compared to a Fermi-gas, where, it is easily seen, $\omega = k\bar{v}_z + q\Omega$ (it is essential to notice that the level spacing $\Delta\Omega$ does not depend on k), where $\bar{v}_z$ —average velocity of electrons within the metal, Ω —Larmor frequency.

The averaging over k, which takes place in the impedance with account of the anomalous skin-effect, leads to a suppression of the resonance. However, the "broadening" of the resonance is