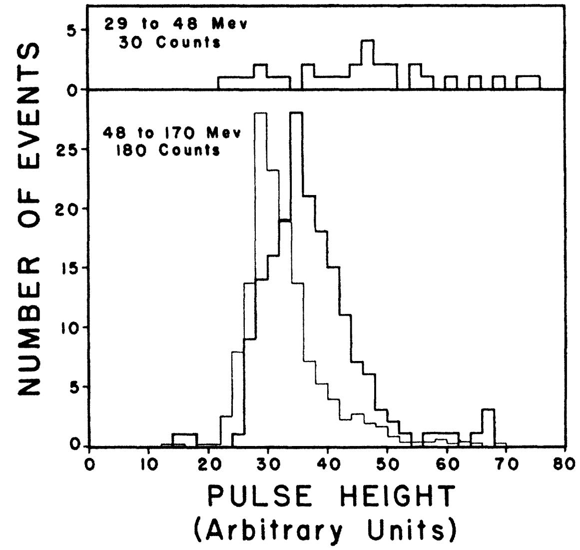

FIG. 2. Upper histogram: the distribution of pulse heights for μ-mesons of energies between 29 and 48 Mev [range (a)]. Lower histogram: the heavy curve shows the distribution of pulse heights for meson energies between 48 and 170 Mev [range (b)]. The light curve is the distribution of Fig. 1A, which is shown for comparison.

the one of Fig. 1A. This is a consequence of the continuous increase in energy loss throughout each energy range.

On the basis of the Bethe-Bloch ionization curve the mean increase in energy loss for μ-mesons (relative to the loss at minimum ionization) should be 20.5 percent for range (b) and 61 percent for range (a). As shown in Fig. 2, the experimental mean values are 22.8±2 percent and 54±7.5 percent above the experimental mean value for minimum ionization, for ranges (b) and (a), respectively. The corresponding shift of the distribution histograms in Fig. 2 to higher values of pulse height is clearly visible.

Knock-on electrons, accompanying μ-mesons and triggering the counter telescope, are necessarily in the range of minimum ionization energy. The pulses of minimum ionization, as shown in the top histogram of Fig. 2, are obviously due to such knock-ons.

In view of these results and by considering the energy range (b) as the most reliable one, proportionality between energy and pulse height within a limit of less than 5 percent seems to be strongly indicated for μ-mesons up to 170 Mev. This further indicates that for other particles one should also expect proportionality up to the respective energies of minimum ionization.

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The Effect of Electron-Neutron Interaction on Spectral Isotope Shifts

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HAVENS, Rainwater, and Rabi[1] have reported an electron-neutron interaction potential $V=5300\pm1000$ ev, assuming a square well of radius $r_0=2.8\times10^{-13}$ cm. This interaction may be expected to contribute to the isotopic displacement of spectral lines, particularly among the heavier atoms where the large nuclear charge results in a considerable electron density for s electrons at the nucleus.

The relativistic density for s electrons near a point charge Ze is given by[2,3]

$$P(r)=\frac{2(1+\rho)\psi^2(0)}{[\Gamma(2\rho+1)]^2}\left(\frac{2Zr}{a_0}\right)^{2\rho-2}=Ar^{2\rho-2},$$

where

$$\rho=(1-Z^2\alpha^2)^{\frac{1}{2}}$$
$$\alpha=e^2/\hbar c$$
$$a_0=\hbar^2/mc^2$$

and $\psi(0)$ is the nonrelativistic Schroedinger wave function for the electron at $r=0$. If one assumes that the additional neutrons of a heavier isotope are to be found primarily near the edge of the nucleus, then the contribution to the isotopic displacement for an s electron is

$$\epsilon=4\pi nAR^{2\rho-2}r_0{}^3V,$$

where R is the nuclear radius and n is the difference in atomic weight.

This may be compared with the isotope shift due to the change in nuclear radius.[2–4] If one assumes a uniform charge distribution throughout the nucleus, this shift is given by

$$\delta\Delta W=\frac{12\pi AZe^2}{(2\rho+1)(2\rho+3)}R^{2\rho-1}\delta R.$$

Upon inserting the values for r_0 and V, and using the empirical formula for the nuclear radius $R=1.5\times10^{-13}A^{\frac{1}{3}}$ cm, the ratio between the two contributions to the shifts is given by

$$\epsilon/(\delta\Delta W)\approx0.0122(2\rho+1)(2\rho+3)A^{\frac{1}{3}}/Z\ \mathrm{cm}^{-1}.$$

For zinc ($A=64$, $Z=30$) this ratio is about 0.024; it decreases with increasing atomic number. In deuterium, the $2S$ level would be shifted by 0.36 Mc due to the interaction.

The above calculations have not considered the distortion of the wave function due to the departure of the potential from a coulomb field. This effect has been treated in the case of the displacements due to the change in nuclear radius,[3,5] and has been found to reduce the shifts by a factor possibly as small as 0.5. A similar correction factor would be expected in the case of the electron-neutron interaction.

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Magnetic Resonance Absorption in Antiferromagnetic Materials

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THE microwave resonance absorption technique at 3.2-cm wavelength has been used to study the magnetic resonance absorption in MnS, MnO, and MnSe, which have Curie points at −75°C, −151°C, and −123°C,[1] respectively.

In the present experiment the specimen, in a form of a thin disk, was mounted at the bottom of a rectangular resonant cavity, which forms one arm of the microwave bridge and is made of transparent quartz plate, whose inside surface is coated with silvered thin copper plate. The relative magnetic absorption was obtained by observing the Q-value of the cavity, changing the dc magnetic field which was applied orthogonally to the rf magnetic field by an electromagnet.

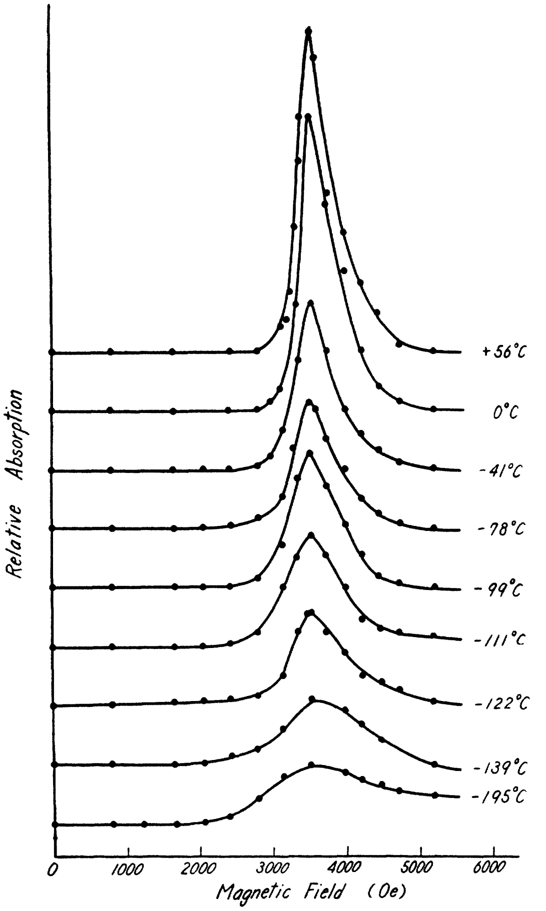

FIG. 1. The curve of resonance absorption *versus* dc magnetic field for MnS at various temperatures.

Figure 1 shows the curve of resonance absorption *versus* dc magnetic field for MnS at various temperatures ranging from −195°C to 60°C. The height of the resonance absorption decreases and the absorption line becomes broader with decreasing temperature, especially below the Curie temperature. The position of the maximum was found to be at a constant magnetic field of 3510 oe throughout this temperature range. The half-width of the absorption line and the height of the absorption peak for MnS, MnO, and MnSe were obtained as functions of the temperature, as illustrated in Figs. 2 and 3, respectively. These temperature dependences are quite contrary to those of the ferromagnetic materials—namely, nickel, supermalloy,[2] and ferromagnetic ferrites;[3] and it seems to suggest the existence of strong local magnetic fields in antiferromagnetic materials.[4,5] The maximum resonance field of 3510 oersted was found for all samples at the frequency of 9311 Mc.

These results may be compared with other studies of magnetic resonance in antiferromagnetic materials. Trounson and his coworkers[4] reported the result of a resonance experiment for Cr_2O_3. They found a second peak appearing at a lower magnetic field below the Curie temperature, and the position of the second peak was found to change with varying temperatures. However, we have not found such phenomena for MnS, MnO, and MnSe. On the contrary, a broadening which might be ascribed to a second peak seems to appear at low temperatures on the higher magnetic field side of the main peak.

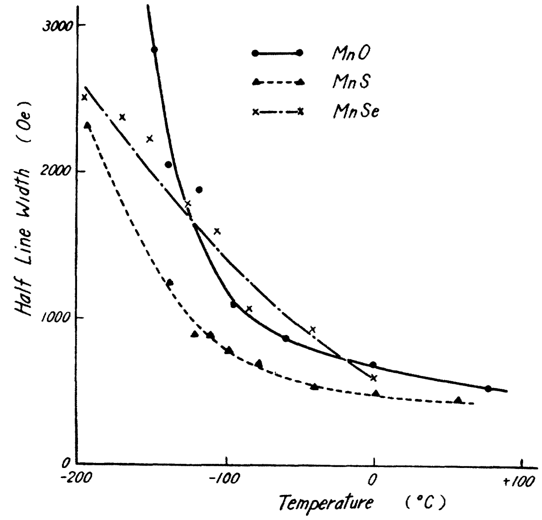

FIG. 2. The half-width of the absorption line as a function of temperature for MnO, MnS, and MnSe.

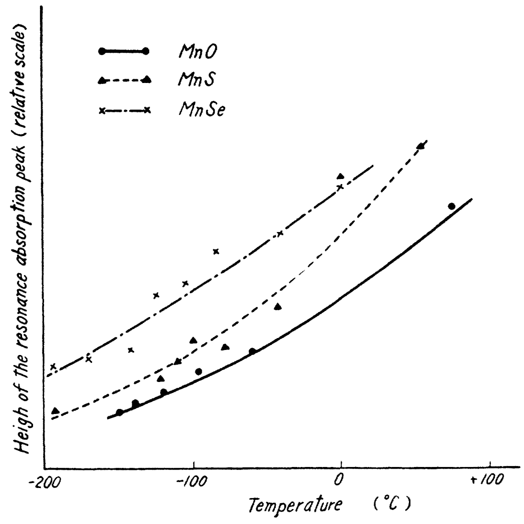

FIG. 3. The height of the absorption peak as a function of temperature for MnO, MnS, and MnSe.

A resonance condition for antiferromagnetic materials was given by S. Nakajima and S. Simizu[6] using a model proposed by Van Vleck;[7] they find that when $T<T_c$, the resonance frequency ω_l is given by

$$\omega_l=\gamma\left[1-\frac{2T_c}{T_c+(1-4S_0^2)^{-1}T}\right]H_0,$$

where S_0 is the mean component of an atom's spin in the direction of the antiferromagnetic spontaneous field. If we assume ω_l to be constant in this formula, the resonance field in this formula becomes infinite at $T=T_c$, and the resonance condition at $T=0$°K becomes $\omega_l=\gamma H_0$, the usual expression for paramagnetic resonance. Although it is difficult to explain the aforementioned results by this formula, we intend to examine the resonance absorption at higher magnetic fields.

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