cannot be explained by a longer relaxation time in these fields. (With $\mu_2=0.5\ \mu_1$ the maximum discrepancy could be 15 percent instead of the observed factor 3.) The small increase in μ_1 below 6.25 oersteds could be entirely due to magnetization by rotation of the spin directions. We therefore conclude that *at* 200 mc *magnetization by the displacement of domain boundary walls is greatly reduced and is almost wholly out of phase with the magnetizing field, and that magnetization by rotation is the dominant effect.*

This investigation is being extended to other materials and to other wave-lengths.

[1] Abstracts L4 and L5, Bull. Am. Phys. Soc., Jan. 30, 1947.
[2] We are indebted to Mr. R. A. Chegwidden of the Bell Telephone Laboratories for samples of several magnetic materials.
[3] In practice the frequency is held constant and the resonant wave-length of the cavity altered linearly by displacing a dielectric bead.
[4] We are much indebted to Mr. E. A. Gaugler of the Naval Ordnance Laboratory for the preliminary measurements of d.c. incremental permeability shown in Fig. 2.

A Defense of the Cauchy Relations

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EPSTEIN[1] has recently presented a theoretical analysis of the Cauchy relations between the coefficients of elasticity. From this analysis he concludes that the assumption of central forces does not necessarily lead to relations of the Cauchy type, and implies that the failure of the Cauchy relations in particular lattices has no theoretical significance. The purpose of the present letter is to point out that the Cauchy relations do follow when in addition to the assumption of central forces we assume that each atom is at a center of symmetry of the lattice. Since many metals and salts satisfy this symmetry condition, namely simple cubic, face centered cubic, and body centered cubic crystal structures, a failure of the Cauchy relation between their coefficients of elasticity is of theoretical significance, namely this failure implies that all the forces are not of the central type acting along lines joining lattice points.

The proof that the Cauchy relation follows from the above two assumptions has been given by Love.[2] An alternative proof is in fact furnished by Epstein's own analysis. Epstein shows that the correct relations are identical with the Cauchy relations save for the presence of certain expression of the type

$$v_{jk}=\Sigma_{\mu\nu}A_{\mu\nu}a_{\mu\nu j}a_{\mu\nu k},$$

where the symbols in the right member are defined in reference 1. The above expression may be written in the more familiar form

$$v_{jk}=\tfrac{1}{2}\Sigma_{\mu\nu}l_{\mu\nu}m_{\mu\nu}a_{\mu\nu}\phi'(a_{\mu\nu}),$$

where $l_{\mu\nu}$ and $m_{\mu\nu}$ are the direction cosines of the vector passing from the lattice point μ to the lattice point ν, referred to the j and k axes, respectively. Love[2] has given a very simple interpretation to this second expression for v_{jk} in the case of central forces when each atom is at a center of symmetry; namely, he has shown that aside from a multiplicative constant, v_{jk} is simply jk, the stress acting across a plane normal to the j axis in the direction of the k axis. Under these two conditions the Cauchy relations are therefore valid, provided the specimen is under no initial stress.

[1] Paul S. Epstein, Phys. Rev. **70**, 915 (1946).
[2] A. E. H. Love, *Mathematical Theory of Elasticity* (Cambridge University Press, 1906), second edition, p. 535.

The Upper Energy Limit of the K^{40} Beta-Ray Spectrum

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KONOPINSKI[1] has discussed the disintegration on K^{40} in terms of the selection rules, which are assumed to hold during the beta-decay. The nuclear transition involved is a highly forbidden one, and therefore interesting from the theoretical point of view. However, no decision could be made between the Gamow-Teller and Fermi selection rules because of the conflicting experimental values for the upper limit of the spectrum. For this reason it is felt that a fuller account of my measurements[2] of the upper limit may be of interest.

The measurements were made by the absorption method wherein the absorption of the K^{40} beta-rays in copper was compared with the absorption of radium E and uranium X_2 beta-rays under the same experimental conditions. Since the activity of potassium is very small, a large solid angle and a sensitive detector are required. A cylindrical Geiger-Müller counter of diameter 1.7 cm and length 5 cm of Dow-metal wall, of 0.0354 g/cm^2 was surrounded by a cylinder of KCl, of inner diameter 3.2 cm and 2.3 cm thick. In this arrangement the initial count, with only the counter walls absorbing, was 500 per minute. The absorption curve obtained by dropping copper tubes over the counter is shown in Fig. 1. After the beta-rays have been stopped at a range of 0.375 g/cm^2 of copper, there remains a constant background due to the gamma-radiation of energy 2.0×10^6 volts emitted[3] by potassium, with an intensity of 3 quanta per 100 disintegrating potassium atoms.

With the ordinary radioactive bodies, where the intensity is much greater, it is customary to use some empirical relation[4,5] to calculate the upper energy limit from the range or the absorption coefficient. Such a procedure is not permissible in the case of potassium because of the low initial activity, and the range 0.375 g/cm^2 must be corrected by comparison with other radioactive bodies where the energy distribution is known. The measurements were therefore repeated using identical sized sources of radium E and U_3O_8 mixed with NaCl as filler to make up the same mass per unit area as the KCl source. In each case the strength was adjusted so that the initial intensity was approximately the same as the KCl—i.e., 500 counts per minute. The radium E and uranium X_2 curves are included in Fig. 1. From these absorption curves the apparent ranges of the radium E and uranium X_2 beta-rays are 0.310 g/cm^2 and 0.865 g/cm^2, respectively. The correct ranges of the beta-rays from these bodies are very well known,[6-8] and are 0.475 g/cm^2 and 1.10 g/cm^2. It is apparent that the ranges measured with low intensity sources are too small, and the usual relations cannot be used to find the upper limit. From the discrepancy between the observed ranges and the true ranges for radium E and uranium X_2, we can estimate that the correct range for the potassium beta-rays is 0.55 g/cm². This value, by the use of Feather's[5] range energy equation $R=0.543\times E-.160$, gives 1.3×10^6 volts as the upper limit of the K^{40} beta-ray spectrum.

No claims of exactness can be made for this value, but it is clear from the curves that K^{40} emits beta-particles of higher energy than does radium E, where the upper limit is known[9–11] to be 1.15×10^6 volts. Another estimate may be made from the absorption coefficients since the absorption curves are exponential over a large part of their length. The absorption coefficients of radium E and uranium X_2, and data from other bodies where the upper limits and absorption coefficients are known give a rough μ/ρ *vs.* upper limit curve. From this curve the $\mu/\rho=12.8$ for potassium yields an upper limit of 1.4×10^6 volts. The last estimate is valid only if the shape of the potassium spectrum is sensibly the same as that of the other bodies. That the K^{40} spectrum is not highly complex is indicated by the low intensity of the gamma-rays emitted. It is felt that the value derived from the corrected range is more reliable and that the best value is 1.3×10^6 volts with an estimated error of 0.15×10^6 volts.

The former lower values of about 700 kilovolts for the upper limit of K^{40}, derived largely from absorption data, are due in part to the fact that corrections were not made for the low activity of the source. Libby and Lee[12] have investigated the K^{40} spectrum with a concentric arrangement of source and counter, and an axial magnetic field, and give a value of 725 kilovolts, but state that no effort was made to obtain an accurate value. This type of measurement with a more elaborate system of counters, has been repeated recently by Dzelepow, Kopjave, and Vorobjov,[13] who find a value of 1.35×10^6 volts.

These measurements were done some years ago at Queen's University, Kingston, Canada, and I wish to thank Dr. J. A. Gray, F.R.S., for the use of the equipment, and radioactive sources used in the experiment.

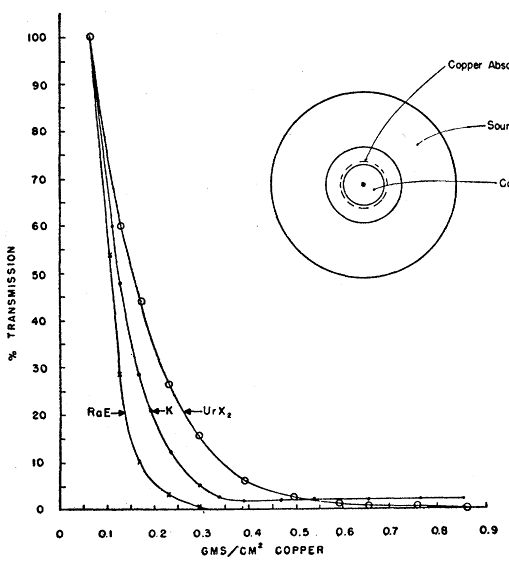

FIG. 1.

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Coincidence Experiments on Ga^{72}

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A PRELIMINARY investigation has been made, with coincidence methods, of the radiations from the 14.0-hour radioactive Ga^{72}. A sample of gallium was activated by exposure to slow neutrons from the cyclotron. The short period activity (20 min.) of Ga^{70} was allowed to die out and the longer period activity investigated. The radiation consists of both gamma- and beta-rays.

The most energetic gamma-ray was found by measuring the energy of Compton recoil electrons ejected from an aluminum radiator. The recoil electrons were made to pass through two thin-walled counters connected in a coincidence circuit. Thin sheets of aluminum were placed between the counters until the number of coincidences dropped to a small, constant background. The range of the recoil electrons was found to be 1.22 g/cm² (including counter wall thickness). From the curve of Curran, Dee, and Petrzilka[1] for the energy of the gamma-ray in terms of the range of the Compton electrons ejected from aluminum, the energy of the most energetic gamma-ray is found to be 2.4±Mev. An absorption curve of the gamma-rays in lead shows, in addition to the hard component, a soft component whose absorption coefficient corresponds to that of a gamma-ray of about 0.82 Mev energy.

The beta-ray endpoint was determined by absorption in aluminum and was found to be 2.3 Mev.

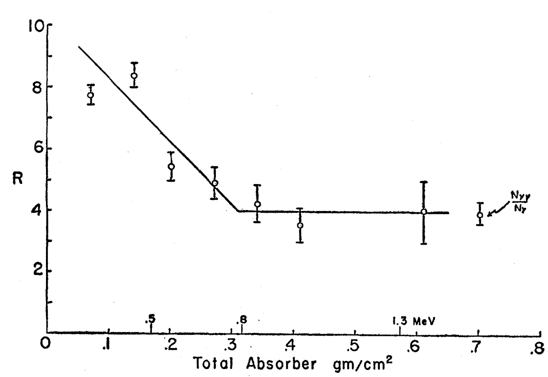

FIG. 1.