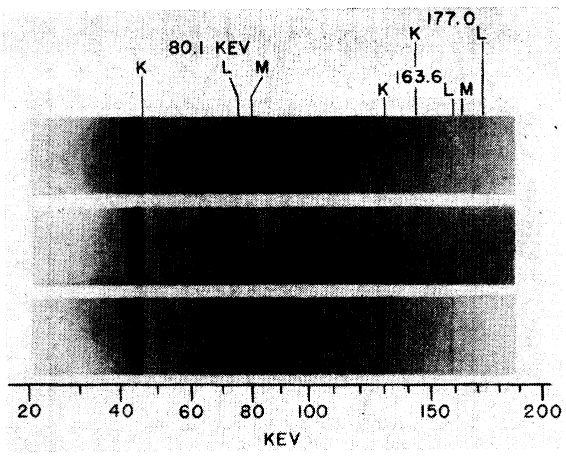

FIG. 1. Successive exposures showing the increased darkness of electron lines due to the 12-day 163.6 gamma-ray.

Using the reported[2] energies of three of the gamma-rays, as measured in a crystal spectrometer by DuMond and his associates, as a calibration standard, the gamma-energies are now found to be: 28.0 (Auger X), 80.1, 163.6, 177.0, 284.1, 364.2, 637, and 723 kev. In every case the conversion electron lines have *K-L* differences characteristic of xenon. The 723-kev gamma-ray, whose conversion electrons were about half as abundant as those for the 637-kev gamma, has not been previously reported.

All gamma-rays except the 163.6 kev are found to decay with a half-life of 8 days. The 163.6-kev gamma-ray has a longer half-life as shown in Fig. 1 and is presumably associated with a 12-day metastable state in xenon as found to exist by Brosi, De Witt, and Zeldes. Figure 1 shows successive exposures for the energy region 20 to 190 kev, with the time of each of the three exposures adjusted so that the electron lines associated with an 8-day half-life should appear equally dark on successive photograms. Electron lines associated with the longer 12-day half-life should then appear relatively stronger in the later exposures. It is evident that the *K*, *L*, and *M* lines for the 163.6-kev gamma-ray do appear to grow stronger relative to the neighboring electron lines of comparable intensity caused by the 177-kev gamma-ray. The upper limits of the two beta-distributions are found to be 600±3 kev and 305±10 kev.

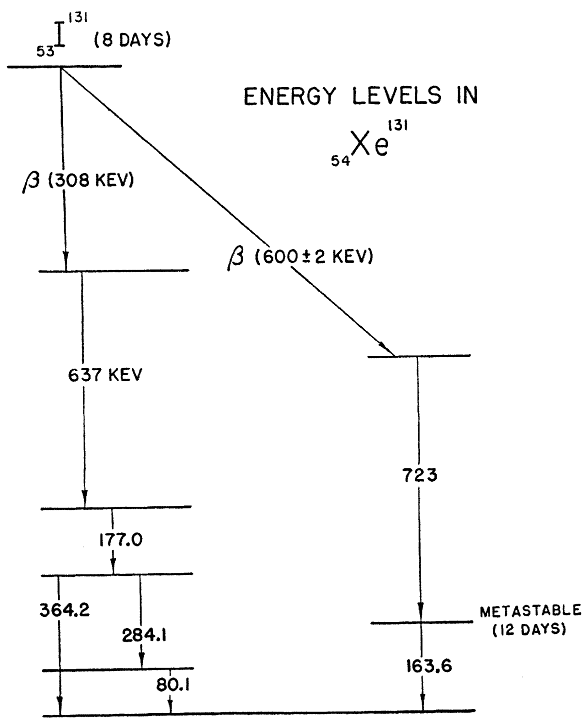

FIG. 2. Possible decay scheme for I^{131}.

It is of interest that these known energies can be accommodated by a level scheme as shown in Fig. 2 in which a branching occurs with exactly the same over-all energy in each branch. While this proposed scheme appears to be highly satisfactory energetically and can also be reconciled with present coincidence measurements, it does not satisfy observations on the relative intensities. The more abundant 600-kev beta-transition is in sequence with the less copious 723-kev gamma-emission and the less intense 305-kev beta is followed by the more intense gamma-emissions. Also, the metastable state in xenon is considered as following the 723-kev gamma-ray since the half-life of this gamma-ray is 8 days. Any alternate scheme must allow isomers of different energy for the parent isotope.

Observations of the beta-spectrum were made by Dr. E. Salmi and will be presented elsewhere.

* This investigation was made possible by the joint support of the AEC and ONR.

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Magnetic Structure of Magnetite and Its Use in Studying the Neutron Magnetic Interaction

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THE interaction of the magnetic moment of a neutron with the atomic magnetic moments existing in magnetic substances has been shown by Bloch,[1] Schwinger,[2] and Halpern and Johnson[3] to give rise to scattering effects comparable in magnitude to those produced by the nuclear short range interaction. This magnetic interaction has been studied experimentally in ferromagnetic substances by means of the so-called single and double-transmission types of experiments for which the most noteworthy and complete descriptions have been given recently by Hughes, Wallace, and Holtzman[4] and by Fleeman, Nicodemus, and Staub.[5] Further studies performed with neutron reflection by magnetized mirrors have been discussed by Hughes and Burgy.[6] We have been investigating the Bragg scattering of neutrons produced by paramagnetic and antiferromagnetic substances and by unmagnetized and magnetized ferromagnetic substances and these have yielded information on the magnetic structure of the samples and on the magnitude and directional properties of the interaction which exists between the neutron's magnetic moment and the atomic magnetic moment.

A study of the magnetic scattering properties of Fe_3O_4 is of interest in that (a) it gives a direct check on the magnetic structure and (b) that its magnetic properties make it very favorable for use in studying the directional properties associated with the magnetic scattering of neutrons. This oxide is a member of the ferrite series and is ferromagnetic. Néel has suggested the magnetic structure to be of *ferrimagnetic* type,[7] that is, that some of the ferrous and ferric ions which make up the lattice are coupled antiferromagnetically. On this picture the balancing of the parallel and antiparallel moments is not complete and Néel has been able to explain quantitatively the resultant ferromagnetism of the lattice. Neutron diffraction studies have been made on several samples of Fe_3O_4, principally on a very pure powder sample kindly furnished by Professor A. von Hippel. The neutron intensities are sensitive to both the magnetic structure and the chemical crystallographic structure and the observed pattern agrees excellently with that calculated on the basis of Néel's model.

On the basis of this structure the neutron diffraction pattern for Fe_3O_4 gives a (111) reflection which arises almost wholly from magnetic scattering with only about two percent nuclear scattering contribution. This very interesting property of this reflection can be used in studying the directional effects of scattering when the sample is magnetized. Halpern and Johnson[3] have given for the intensity of scattering of unpolarized neutrons by a ferromagnetic material

$$I=b(C^2+q^2D^2)$$

with C the nuclear scattering amplitude, D the magnetic scattering amplitude, and b a proportionality constant. The term q^2 is a function of the angle α between the scattering vector and the magnetization vector and is given as $\cos^2\alpha$ in the original theory developed by Bloch[1] and as $\sin^2\alpha$ in the later treatment of Schwinger[2] and Halpern and Johnson.[3] The angular function depends on the assumed form of the magnetic interaction of the neutron with the magnetic medium. This can be related to the question of whether the neutron is affected by H or B on the average in the magnetic medium. Bloch[8] and Ekstein[9] have discussed this angular dependence and although they express themselves in conversation as expecting the Schwinger treatment to be correct, they both suggest that the selection of one or the other, or possibly a composite of the two interactions, should be left to experiment. With this in mind, the (111) powder diffraction ring of Fe_3O_4 was investigated when the sample was magnetized in different directions with typical results shown in Fig. 1. When

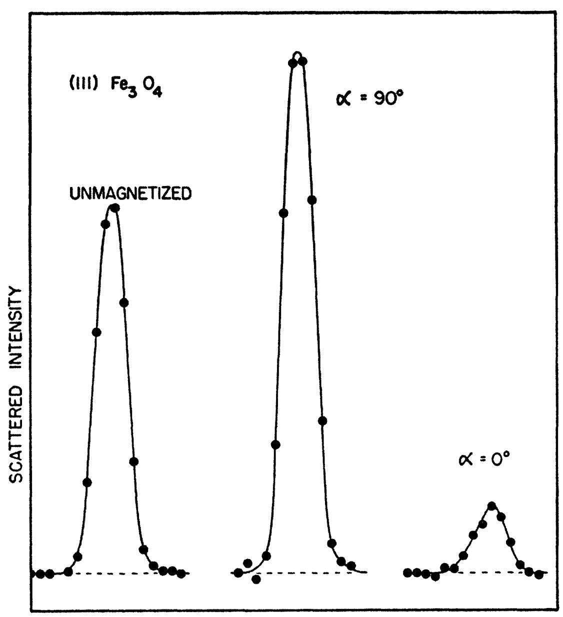

FIG. 1. Effect of sample magnetization in different directions upon the (111) Fe_3O_4 neutron diffraction peak.

$\alpha=90°$, the intensity has increased over that for the unmagnetized sample and when $\alpha=0°$, the intensity falls to a very low value. After correcting the intensities for residual nuclear scattering and second-order contaminant (of half-wavelength), values of q^2 have been evaluated for several angles with the result shown in Fig. 2. Within the experimental uncertainty of perhaps two percent the agreement with the Schwinger-Halpern-Johnson theory is quite satisfactory.

The pronounced dependence of neutron scattering intensity

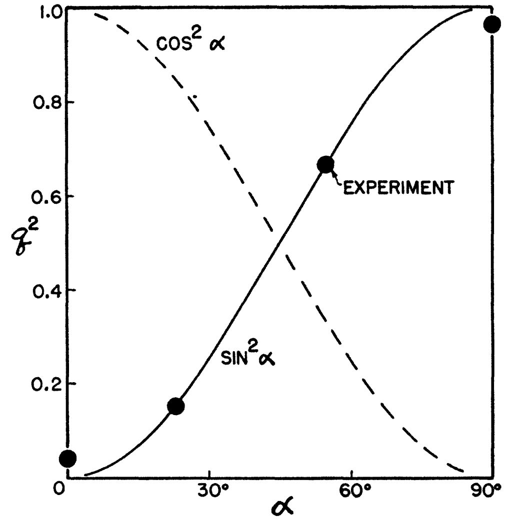

FIG. 2. Variation of q^2 with the angle α between the scattering and magnetization vectors. The experimental points have been normalized to the unmagnetized value of $q^2=2/3$.

with magnetization direction suggests that this reflection might have interesting application as a fast neutron shutter. In a single crystal reflection large neutron currents are attainable and rapid field variations with the small fields required for saturation of single crystals can be achieved in this or other members of the ferrite series.

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Differential Multiplicity in Meson Production*

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IT has been pointed out previously[1] that data on the multiplicity of meson production as a function of the energy of the primary particle can be obtained from an analysis of experiments on geomagnetic effects of the hard component of cosmic rays. In the present note recently published results of Conversi[2] will be used for an evaluation of the *differential multiplicity;* that is, of the average number of mesons in a given energy interval, for various primary energies.

The increase, ΔN_μ, in the meson flux between two latitudes, θ_1 and θ_2, must be ascribed to the increase in the primary flux, ΔN_p, between these same latitudes. On dividing ΔN_μ by ΔN_p we obtain, therefore, the number of mesons of the particular energy, E_μ, recorded in the experiment, produced per primary particle of the energy interval defined by the latitude cutoffs at θ_1 and θ_2. Conversi's measurements of the meson intensity in the energy interval 0.224 Bev$\leq E_\mu \leq$0.255 Bev at an altitude of 30,000 ft and between 9° and 59°N, thus give us a picture of the differential multiplicity, $m(E_\mu, E_p)$, at least for one meson energy, and over a range of primary energies from 0.5 to 14 Bev.

Unfortunately, the statistical errors of Conversi's data are comparatively large, so that not much weight can be given to the exact shape of the multiplicity curve. It was necessary to base the present analysis on his graphs, and the values of N_μ used are summarized, together with the corresponding values of N_p taken from the paper of Winckler *et al.*[3] in Table I.