produced in fission we also obtained a strong Xe^{135} activity after electromagnetic separation of the fission gas. Because of the ideal character of the β-spectrometer samples obtained by electromagnetic separation of the radioactive isotopes, it will be of interest to report our results on Xe^{135}.

The activity at mass number 135 was collected on thin commercial Al foils (0.15 mg/cm²). These foils perhaps seem to be too thick for measurements of the β-spectrum in the low energy region. Nevertheless, it is a fact that the Fermi plot of Xe^{135} is a straight line from the upper limit 905±10 kev down to 50 kev (Fig. 1). In the case of the 4.4-hr Kr^{85} β-spectrum[3] when the same weight of Al foil was used as a backing, the Fermi plot was straight from the end point 817 down to 35 kev. In both these cases the β-spectra belong to the allowed group, and the deviations from the straight line of the Fermi plot does not set in before $E < 0.05 \cdot E$ max. Because of the quite negligible thickness of our carrier-free electromagnetically separated samples, we conclude that the thickness of the sample is relatively more critical than the sample backing when investigating the low energy region of β-spectra.

Thus, the β-spectrum of Xe^{135} is simple and has an allowed form. We also obtain $ft = 3 \cdot 10^6$, classifying the β-spectrum in the allowed group.

The K and L conversion lines corresponding to a γ-ray energy of 248±2 kev were found, which is in good agreement with the results of Peacock et al. $e^- - \beta^-$ coincidence measurements in the β-spectrometer showed a strong coincidence effect. The mass difference between Xe^{135} and Cs^{135} would then correspond to 1.15 Mev.

Kr^{79}.—Absorption measurements[4] have shown that Kr^{79} decays by K-capture and positron emission with a half-life of 34.5 hr. A γ-ray of the energy 0.2 Mev has also been reported.[4]

In order to get more detailed information on Kr^{79}, Kr was irradiated in the Harwell pile and then electromagnetically separated for a β-spectrometer investigation. Two activities at mass numbers 79 and 85, with the half-lives 34±4 hr and ∼4 hr, were the only ones present when the β-spectrometer investigations started. Figure 2 shows the β-spectrum of Kr^{79}. The decay of this
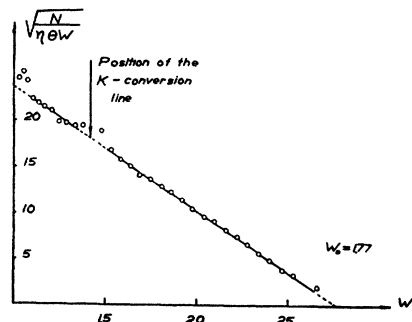

FIG. 1. Fermi plot of Xe^{135}.

isotope is associated with a very strong K-capture, as can be seen from the large intensity of the Auger lines $K - 2L$ ($A1$ in Fig. 2) and $K - L - M$ ($A2$ in Fig. 2), characteristic of Br as compared with the β-spectrum. In a separate investigation the β-particles were identified as positrons by the use of helical baffles in the lens spectrometer. No negatrons in addition to conversion and Auger electrons were found. We estimate the ratio of the intensity of K-capture to positron emission to be about 10. This value is somewhat uncertain because of G-M window (cut-off ∼6 kev) absorption correction for the Auger lines, but it is definitely lower than the value 50 reported by Woodword et al.[5]

The Fermi plot of the β-spectrum of Kr^{79} is a straight line from the upper limit, 595 kev, down to 110 kev. The same weight of Al foil as in the case of Kr^{85} and Xe^{135} was used as collector foil, and we notice that the low energy deviation starts earlier than expected if the positron spectrum is simple and has the allowed form.
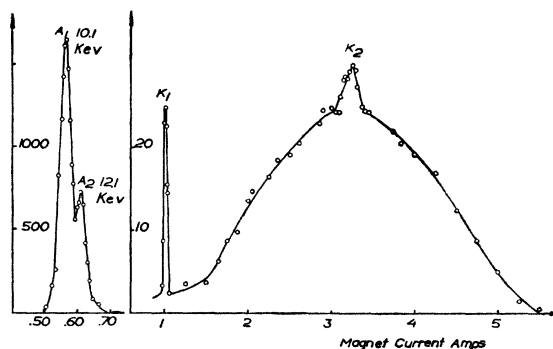

FIG. 2. β-spectrum of Kr^{79}. To the left, the low energy region in a magnified scale.

Because of the rather weak sample, we cannot come to any conclusion about this deviation.

Except for the uncertain low energy deviation, the positron spectrum is simple and the high energy component (0.9–1 Mev) reported by other investigators[4,5] must be due to impurities. Using the approximate branching ratio 10 for K-capture and positron emission, we obtain $ft = 2 \cdot 10^6$, which places the positron spectrum in the allowed group.

Two conversion lines (K_1 and K_2 in Fig. 2) having the energies 30.3 and 249 kev were found. These lines are most probably K lines corresponding to the γ-energies 44 and 263 kev, respectively. If the positron emission is followed by the 263-kev γ-ray, we obtain a rough value for the K conversion coefficient α_K of this γ-ray. $\alpha_K \sim 0.016$, and indicates that the γ-transition is to be associated with electric quadrupole or magnetic dipole radiation.

Feenberg and Trigg[6] have given the probability ratio for positron emission and K-capture to the same level. For the positron energy 595 kev, we obtain $f_K : f_+ = 10$ (from the curves of Feenberg and Trigg). This value is close to that obtained from our experiments, suggesting that the main part of the K-capture and the positron transitions lead to the same level, probably that from which the 263-kev γ-ray is emitted.

We wish to express our sincere thanks to Dr. W. T. Arrol at the Isotope Division, Harwell, for much good advice regarding the rare gas irradiations. Without the prompt service from Harwell, it would not have been possible to perform the measurements on Kr^{79} and Xe^{125}.

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Crystal Structure Transitions in Antiferromagnetic Compounds at the Curie Temperature*

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THE antiferromagnetic compounds MnO, FeO, CoO, and NiO undergo crystal structure transitions near their Curie temperatures.[1–3] Above their Curie temperatures all four compounds have the NaCl structure with the metal atoms alone forming a face-centered cube. Below the Curie temperature, the crystal structure of CoO is deformed to tetragonal symmetry, while the structures of the other three compounds are deformed to rhombohedral symmetry. The authors[3] have suggested that these transitions are due to the fact that the magnetic atoms can increase their exchange interaction energy by shifting their positions. The purpose of this letter is to point out that the crystal structure
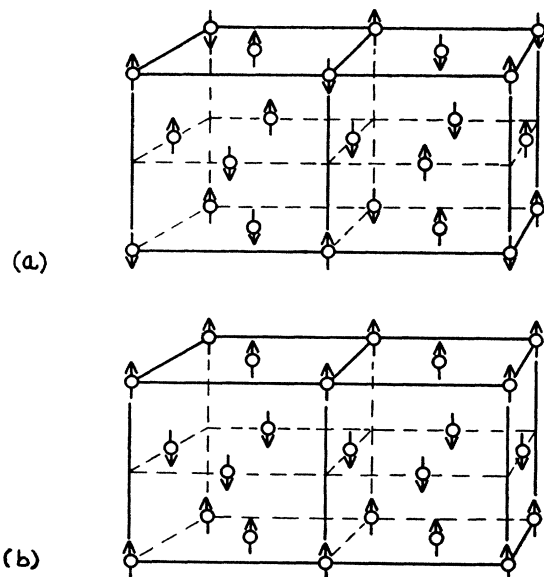
FIG. 1. Possible magnetic structures for a face-centered cubic lattice. (a) Antiferromagnetic next-nearest-neighbor ordering. (b) Antiferromagnetic nearest-neighbor ordering.

transitions can be correlated with the magnetic structures of these compounds.

Figure 1 shows two possible magnetic structures for a face-centered lattice. Case (a) illustrates the arrangement of lowest energy when the most important exchange interactions are antiferromagnetic interactions between next nearest neighbors. This magnetic structure is the one discovered by Shull[4] in his neutron diffraction experiments on the four compounds listed above. This configuration consists of four interpenetrating simple cubic lattices, each arranged antiferromagnetically within itself. Actually the neutron diffraction data does not distinguish between the magnetic structure of case (a) and one in which there is no correlation of spin directions between different sublattices. As indicated below, the x-ray diffraction data seem to favor the first arrangement.

Case (b) is a possible structure when antiferromagnetic nearest neighbor interactions are most important, and is especially favorable if there are also ferromagnetic next nearest neighbor interactions.[5] So far, this structure has not been observed experimentally.

In case (a) there is a set of (111) planes and in case (b) a set of (100) planes in which all spins in a given plane are parallel but the spins in neighboring planes are antiparallel. If our argument concerning the crystal structure transitions[3] is correct, and if we assume the existence of nearest-neighbor interactions, we should expect that at the Curie temperature the crystal would expand or contract along a direction perpendicular to these planes. Therefore, structure transitions to rhombohedral and tetragonal symmetry should occur for cases (a) and (b), respectively.

As predicted by our arguments, MnO, FeO, and NiO, which have the magnetic structure of case (a), undergo transitions to rhombohedral symmetry at the Curie temperature. Rooksby and Tombs[6] have reported that MnS undergoes a transition to rhombohedral symmetry near its Curie temperature, indicating that its magnetic structure is the same as that of the oxides. Finally, Greenwald[7] has determined that Cr_2O_3, which has the corundum structure, contracts along a [111] direction at the Curie temperature. This result suggests that its magnetic structure is the one proposed by Néel[8] in which there is a set of (111) planes with alternating spin directions.

In the case of CoO, the interpretation of the crystal structure data apparently does not agree with the observed magnetic

structure. The tetragonal deformation at the Curie temperature suggests that its magnetic structure is that of case (b) with nearest-neighbor ordering, but the reported neutron diffraction work[4] indicates that the magnetic structure is actually that of case (a). We have no explanation for this discrepancy.

In order-disorder transitions in 50-50 face-centered alloys, deformations to rhombohedral and tetragonal symmetry are observed for ordering of types (a) and (b), respectively.[9] These deformations may be due to variation of ordering energy with distance, in analogy with the antiferromagnetic case.

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Evidence of Long-Range Secondary Electrons Accompanying Cosmic Rays in a Proportional Counter

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THE measurement of the ionizing power of individual cosmic-ray particles has usually been undertaken with one or two proportional counters connected in coincidence with Geiger
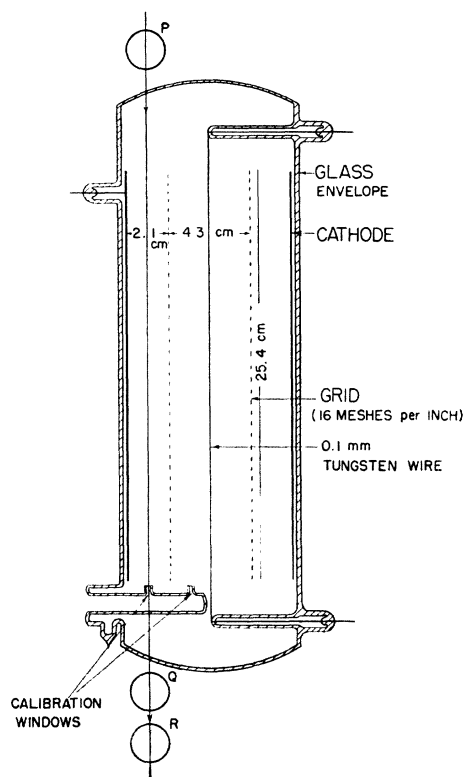

FIG. 1. The arrangement of the proportional counter.