pretation of the band at 4μ, and there seems to be no reason why it should not be interpreted as $\nu_3+\nu_4$. An examination of the behavior of this band at low temperatures would perhaps be the best method of checking its assignment as a sum, rather than a difference, of two fundamentals.

The writer wishes to acknowledge the benefit of discussing this matter with Professor Barker.

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[1] E. F. Barker, Phys. Rev. **55**, 657 (1939).

Magnetic Anisotropy of Nickel at 20°K

The only experiments on ferromagnetic anisotropy that have been carried out below the temperature of liquid nitrogen are those of Honda, Masumoto and Shirakawa[1] on nickel in liquid hydrogen. Their results indicate a large increase in the anisotropy as the temperature is lowered from 77° to 20°K, the constant K_1 changing by a factor of about 5. On the other hand, Brukhatov and Kirensky[2] have found that in the temperature range from 77° to 350°K, the constant is given by the relation

$$K_1 = K_0 e^{-aT^2} \qquad (1)$$

which predicts an increase of but 20 percent in going from 77° to 20°K. Accordingly we have undertaken, with the kind cooperation of Drs. H. A. Boorse and S. L. Quimby of Columbia University, to measure again the anisotropy constants at 77° and 20°K, using this time the more accurate method of torques.

The ratio of the constants was found to be about 1.2 (accuracy about 10 percent), as compared with the ratio 5 derived from the data of Honda, Masumoto and Shirakawa and 1.21 from the equation of Brukhatov and Kirensky. Our absolute values at 77°K and above are very close to those of Brukhatov and Kirensky. Thus our work extends the validity of this equation to lower temperatures (see Fig. 1) and shows that there is no unusual behavior in the ferromagnetic anisotropy at these low temperatures. This clarifies the theoretical situation since Van Vleck[3] in his discussion of the wave-mechanical theory of anisotropy, has not been able to find any basis for a difference in variation with temperature of the constants for iron and for nickel.

The crystal of nickel used was grown[4] in pure hydrogen from high purity nickel kindly supplied by Mr. E. Wise of the International Nickel Company. It was cut in the form of a disk with planes parallel to (100) and edges rounded to a semi-circle. The thickness was 0.29 cm, the largest diameter 1.38 cm. The liquid hydrogen was introduced into the Dewar flask surrounding the crystal through a straight Dewar tube of stainless steel connected directly to the bottom of the liquefier. The flask and crystal and torsion-measuring apparatus[5] were then removed to the electromagnet for measurement of the torque when the field was inclined at various angles to [011], the direction of easiest magnetization in the (100) plane. The highest field used was about 4000 oersteds. This was not sufficient

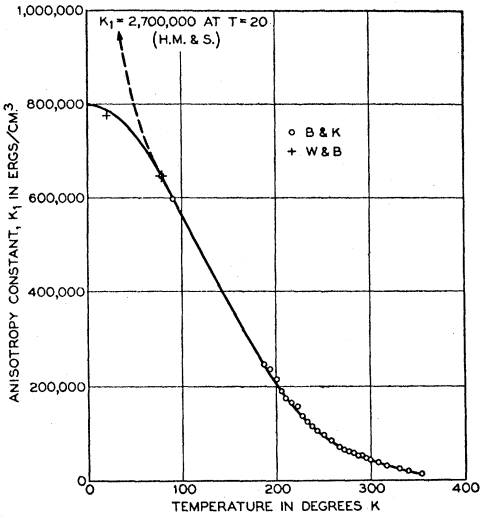

FIG. 1. Anisotropy constant of nickel as dependent on temperature. Data from 77° to 350°K, inclusive, by Brukhatov and Kirensky. Data at 77° and 20°K by the authors, adjusted slightly to fit the former data at 77°K. Curve calculated from Eq. (1) using $K=800{,}000$, $a=0.000034$.

to permit observation of the torque at saturation, but was so near this point that the ratio of the constants at 77° and 20°K could be determined with some accuracy. Saturation was later observed at 77°K in a field of about 5000 oersteds.

We wish to express our appreciation to Dr. Boorse and Dr. Quimby and others of the Cryogenic Laboratory of Columbia University, for supplying the liquid hydrogen.

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[1] K. Honda, H. Masumoto and Y. Shirakawa, Sci. Rep. Tohoku Imp. Univ. **24**, 391 (1935). The anisotropy constant was derived by one of us (R. M. B., J. App. Phys. **8**, 575 (1937)) from their magnetization curves for the [100] and [110] directions. A similar calculation by L. W. McKeehan (Phys. Rev. **52**, 18 (1937)) yielded an even higher value of K_1. Its value is somewhat uncertain on account of the extrapolation of the magnetization curves to saturation.
[2] N. L. Brukhatov and L. V. Kirensky, Soviet Phys. **12**, 602 (1937).
[3] J. H. Van Vleck, Phys. Rev. **52**, 1178 (1937).
[4] By Mr. O. L. Boothby, using the method described by P. P. Cioffi and O. L. Boothby, Phys. Rev. **55**, 673 (1939).
[5] Similar in design to that described by H. J. Williams, Rev. Sci. Inst. **8**, 56 (1937).

The Disintegration of Mesotrons

In order to test the hypothesis of the spontaneous decay of mesotrons we have compared the absorption of the mesotron component of cosmic radiation in air and in carbon.

The mesotrons were detected by the coincidences of three Geiger-Müller tubes arranged in a vertical plane. The counters were shielded with 10 cm of lead on each side to prevent coincidences from the air showers. Also, 12.7 cm of lead was placed between the counters in order to cut off the soft component.

The absorption in air was measured by counting coincidences at different heights from Chicago up to the top of Mt. Evans, Colorado, (4300 m). The absorption in carbon

was measured by putting layers of graphite above the counters.

It was consistently found that the mass absorption in air was considerably larger than that in carbon. One set of measurements, for instance, gave the following results: Mt. Evans (4300 m, atmospheric pressure 618 g/cm²) without graphite: 11.9±0.07 coinc./min. *Ibid.*, under 84 g/cm² graphite: 11.0±0.057 coinc./min. Echo Lake (3240 m, atmospheric pressure 700 g/cm²) without graphite: 9.7±0.046 coinc./min.

Thus the additional air layer of 82 g/cm² between Mt. Evans and Echo Lake reduced the intensity of the mesotrons by more than twice as much as did the graphite screen of 84 g/cm². It is obvious that this large difference cannot be ascribed to the difference in stopping power of air and carbon. We see, therefore, definite evidence for the disintegration of the mesotrons.

The above results show that 1.3 mesotrons out of 11 disintegrate while traveling a distance of $4.30\times10^5-3.24\times10^5=1.06\times10^5$ cm. Their mean-free-path for the distintegration is, therefore, $L=1.06\times10^5/\log(11/9.7)=8.5\times10^5$ cm.

L is connected with the lifetime τ_0 by the formula: $c\tau_0=\mu cL/p$ where μ is the mass and p the momentum of the mesotrons. At sea level the average value of $\mu c/p$ was estimated to be about 0.07.[1] Assuming tentatively the same value in our case, one finds $\tau_0=2\times10^{-6}$ sec.

A fuller account of these experiments will be published later. The writers acknowledge with thanks the helpful discussions and support given to this work by Professor A. H. Compton. They also wish to express their appreciation for the facilities made available in Colorado by Dr. Joyce Stearns, as well as for the assistance of Mr. O. E. Polk and Mr. W. Bostick.

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[1] B. Rossi, Cosmic Ray Symposium, Chicago, June, 1939; Rev. Mod. Phys. July–October (1939).

Magnetic Spectrograph Investigation of N^{13} Gamma-Radiation

Richardson[1] has reported that the decay of N^{13} is accompanied by a gamma-ray of 280±30 kev in addition to the well-known positron annihilation radiation. This gamma-ray is estimated to occur in 40 percent of all N^{13} disintegrations which take place.

The same radiation has been reported by Lyman[2] who estimates it to occur in 20±15 percent of all disintegrations; and by Watase and Itoh[3] who estimate it to occur in 20 percent of all disintegrations. The estimates of Richardson and of Watase and Itoh are uncertain by a factor of two. In view of the general interest in N^{13}, it has seemed desirable to make further observations on this radiation, using a method which is free from statistical errors.

The N^{13} gamma-ray spectrum was explored by measuring the energy and intensity of the secondary electrons ejected from lead and aluminum foils of equivalent thickness. The magnetic spectrograph used was of the usual semi-circular focusing type, constructed largely of lead. The slit jaws and other parts nearest the radioactive source were faced with graphite in order to minimize the background. The radioactive sources were produced by bombarding 0.5 mm thick graphite plates with 4.3-Mev deuterons. Eastman "No Screen" x-ray film was used, and was developed for eight minutes in D19 developer at 66°F.

The Pb and Al foils were placed in contact with the radioactive sources. A particular gamma-ray will eject both photoelectrons and recoil electrons from lead, but only recoil electrons from aluminum because of the different Z dependence of the two effects. The photoelectrons from a particular gamma-ray, having an initially homogeneous velocity, will appear on the spectrogram as a group with a sharp upper energy limit followed by a gradual decrease in intensity toward lower energies because of a straggling in the emitting foil. The recoil electrons ejected by the same gamma-ray under these conditions will have a much less homogeneous energy distribution because their energies depend greatly upon their directions of emission with respect to those of the quanta.

In this experiment the photoelectron spectrum of lead irradiated by N^{13} gamma-radiation was isolated from the recoil spectrum as well as from the instrumental background. This was done by successive exposures with lead and aluminum secondary emitters, the latter distribution being subtracted from the former. The relative photoelectron intensities due to any gamma-rays present may thus be directly compared without making any estimates of the contribution of recoil electrons as was necessary in the experiments of Watase and Itoh.

The data are shown in Fig. 1, which gives the film opacity as a function of $H\rho$. Because of differences in source intensities it was necessary to multiply the aluminum ordi-

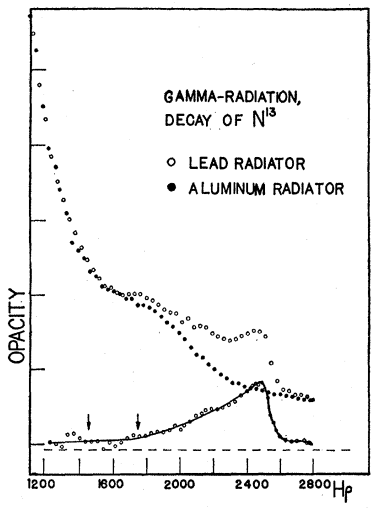

FIG. 1. Photometric measurements of films exposed to secondary electron spectra from lead and aluminum irradiated by N^{13} gamma-radiation. The lowermost curve is the difference between the Pb and Al data. The vertical arrows indicate the $H\rho$ region corresponding to lead K photoelectrons from a gamma-ray of 280±30 kev.