entirely accounted for by the simple theory based on a Thomas precession

$$\omega_T = a \times v / 2c^2, \quad (1)$$

proportional to the acceleration a and velocity v of a nucleon endowed with an intrinsic spin.[4-6] The analysis of the magnetic moments of the three-nucleon nuclei involves the graphic concept of exchange currents[7] representing the transport of charged mesons responsible for some of the inter-nucleon interactions. Certain types of mesons which may be responsible for nuclear forces (π-mesons with spin 1) are carriers of spin as well as of charge, and one may anticipate on the basis of similar graphic concepts that the process of meson exchange which binds a circulating nucleon to the rest of the nucleus involves a predominantly centripetal acceleration of the meson momentarily associated with the circulating nucleon. This meson acceleration is expected to be much greater than the centripetal acceleration of the nucleon, since the exchange process may be expected in effect to take place many times per revolution. Although one does not have at hand a sufficiently complete analysis of the energetics of meson fields, it seems plausible to suppose that this large acceleration a of the meson, together with the tangential component of v which the meson would have in common with the circulating nucleon, should give rise to a Thomas precession of the meson spin much more rapid than that of the intrinsic nucleon spin previously derived from (1). Even if somewhat suppressed by a weighting factor representing the ephemeral association of the meson and nucleon (as enters, for example, in the interpretation of anomalous nucleon magnetic moments),[8] this might still give a spin-orbit coupling $\sigma \cdot \omega_T$ much larger than that arising from precession of the nucleon spin alone. (A factor of ten or more seems to be needed by the empirical conjectures.) During the meson's fleeting association as part of the circulating nucleon, the meson spin has the direction of the nucleon spin of which it is a part (that is, a nucleon with spin up is part of the time a nucleon with spin down and a meson with spin up), and the directions of a and v are the same as before, so the sign of the coupling is the same as that arising from a Thomas precession of an intrinsic nucleon spin, which is satisfactory. From these graphic considerations, it seems more likely that a spin-orbit coupling belonging to each individual nucleon would arise from this second-order relativistic effect than from the second-order perturbation theory with a tensor interaction, as treated by Dancoff[6] in the simple case of He^5 with only one circulating nucleon.

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The Interpretation of the K^{42} Radioactivity*

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A NUMBER of recent studies have been concerned with the occurrence of a characteristic forbidden type of energy distribution in several well-known beta-radioactive transitions. The necessary theoretical conditions[1] are

(1) Gamow-Teller selection rules govern the beta-process,
(2) the transition is first-forbidden, with $\Delta I = \pm 2$ and a change in parity.

For this situation the beta-spectrum differs from the allowed shape by a factor G, which, if Z is small, has the approximate form $G \sim (W_0 - W)^2 + W^2 - 1$. Here W is the electron energy and W_0 is the total energy release, both in units mc^2. The factor G emphasizes the relative number of high-energy particles and may also emphasize low-energy particles if $W_0 \geqq 2$. The FK (Fermi-Kurie) plot (computed as though the transition were allowed) tends to bulge upward at high energy, and may also curve upward at low energy, thus producing an S-shaped plot.

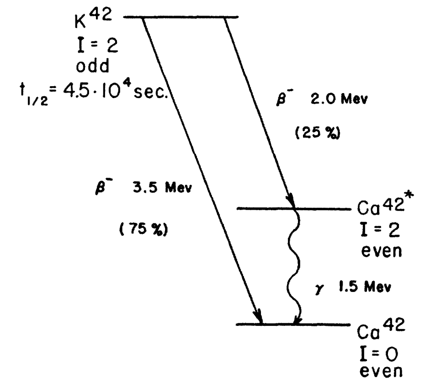

FIG. 1. Decay scheme of K^{42}.

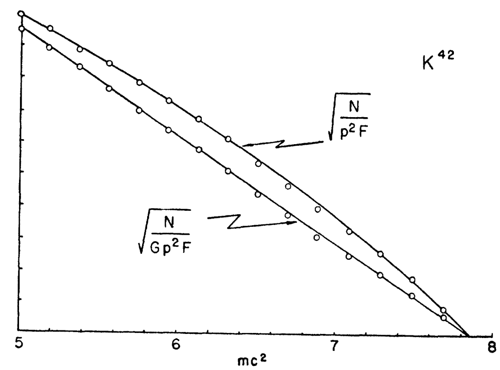

FIG. 2. FK plots for K^{42}, using data due to Siegbahn. Upper curve "allowed" plot, lower is "forbidden" plot.

Beta-distributions of the type described above have been measured for Y^{91} by Langer and Price[2] and by Osobà,[3] for Cs^{137} by Mitchell and Peacock[4] and by Osoba,[3] for Y^{90} and Sr^{90} by Braden, Slack, and Shull,[5] and for Rb^{86} by Mitchell.[6]

The product ft provides a means of classifying transitions as allowed or forbidden to various degrees.[7] Here t is the half-life and f is the integral of the allowed probability function $P(W)$ over the available energy range. For the first-forbidden transitions discussed above $P(W)$ is modified by the factor G; consequently in this case the product $(W_0^2-1)ft$ should be more nearly constant than ft.

Using the shell model[8] as a guide, it is possible to select a group of beta-transitions between ground states wherein a change of parity is likely and for which the ft product is characteristic of first- or second-forbiddenness according to the empirical scheme of Konopinski. When these are reclassified according to the magnitude of $(W_0^2-1)ft$, it is found that the isotopes Y^{91}, Cs^{137}, Y^{90}, Sr^{90}, and Rb^{86}, for which the forbidden shape has already been observed, fall into a select category. For these isotopes, the product $(W_0^2-1)ft$ has values close to 10^{10}, whereas it is smaller by a factor of 10 or more for other transitions marked by a change in parity (according to the shell model). This suggests that $(W_0^2-1)ft \sim 10^{10}$ provides a rough criterion whereby one can pre-select the first-forbidden transitions for which $\Delta I = \pm 2$.

Nucleus	Cl^{38}	A^{41}	K^{42}	Br^{84}	Rb^{86}	Sr^{89}
$(W_0^2-1)ft \times 10^{10}$	0.5	1.4	0.7	0.8	0.8	0.7

Nucleus	Sr^{90}	Sr^{91}	Y^{90}	Y^{91}	Sb^{125}	Cs^{137}
$(W_0^2-1)ft\times 10^{10}$	0.4	0.7	0.3	0.8	1.1	1.8

The criterion fits Sr^{89} and K^{42}; in both cases shell model considerations support the assignment $\Delta I=\pm 2$ and change in parity. An excellent measurement of K^{42} has already been made by Siegbahn.[9] It disintegrates (Fig. 1) by negatron emission to the ground state of Ca^{42} and also to an excited state followed by a gamma-ray. We have analyzed Siegbahn's data for the high energy component with results shown in Fig. 2 both for an allowed FK plot and again as a forbidden FK plot wherein the factor G is included. The bulging curvature of the one and the near-straightness of the other confirm the above-stated criterion as well as those aspects of the shell model and of the Fermi theory of beta-decay which are involved in this example.

The shell model associates the odd configuration $(3d)^{-1}(4f)^3$ with the ground state of K^{42}. Similarly the even configuration $(4f)^2$ may be associated with the ground state of Ca^{42} (probably $I=0$) and with low excited states ($I=2$, 4, and 6). We suggest $I=2$ and even parity for the excited state of Ca^{42} observed in the K^{42} decay. The low energy transition is thus interpreted as first-forbidden with $\Delta I=0$.

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The Magnetic Moment of Be^9 *

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THE ratio of the frequency of the nuclear magnetic resonance of Be^9 to that of the proton has been measured at 7000 gauss by the magnetic-resonance-absorption method of Pound, Purcell, and Torrey.[1] The magnet and radiofrequency bridges employed were those used by both Bitter[2] and Poss[3] in their recent nuclear-magnetic-moment determinations. However, the accuracy of the present measurement exceeds that of previous measurements with this equipment by about a factor of ten. This was accomplished by taking advantage of the almost integral ratio of the two frequencies and heterodyning the seventh harmonic of the Be^9 frequency with the fundamental of the proton frequency.

Both the proton and Be^9 resonances were obtained from a single sample consisting of an aqueous solution of beryllium fluoride. The sample container was a cylindrical section $\frac{1}{2}$-in. long and $\frac{1}{2}$ in. in diameter. The coil for the 4.2-Mc (Be^9 resonant frequency) bridge was wound around the cylinder, and the coil for the 30-Mc (proton resonant frequency) bridge was wound at right angles over the first. This technique has previously been used by F. Bitter and assures that the external magnetic field seen by the two types of nuclei is the same. The two resonances were traced on separate recording milliammeters as the magnetic field was slowly varied. The frequencies were adjusted so that the resonances occurred nearly simultaneously. From a calibration of the rate of change of magnetic field, a correction was made, when necessary, to take into account the small field differences separating the two resonances. This correction never exceeded 0.003 percent of the observed frequency ratio.

A total of ten determinations was made. From these the following value for the ratio of the resonant frequencies in the same magnetic field was obtained:

$$\nu(Be^9)/\nu(H^1)=0.1405187\pm 0.000002.$$

All ten values fall well within the above limits which were determined entirely by the uncertainty in locating the exact centers of the resonance curves.

Applying the Lamb[4] diamagnetic correction, and using the Millman and Kusch[5] value of the proton moment (2.7896 $\pm$0.0008) μ_N, the Be^9 magnetic moment is found to be

$$\mu(Be^9)=(-)(1.17619\pm 0.00034)\mu_N.$$

If, in agreement with more recent experiments, the more accurate value[6] of $(2.7926\pm 0.0006)\mu_N$, is taken for the proton moment, the following value is obtained:

$$\mu(Be^9)=(-)(1.17747\pm 0.00027)\mu_N.$$

It is to be noted that the uncertainties indicated for the Be^9 magnetic moment are determined by the uncertainty in the proton moment and not by that of the above frequency ratio.

* This work has been supported in part by the Signal Corps, the Air Materiel Command, and the ONR.

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Paramagnetic Resonance Absorption in Crystals Colored by Irradiation

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PARAMAGNETIC resonance absorption at 9350 mc produced by the irradiation of LiF with neutrons has been observed. Single crystals of LiF, which showed no resonance, were irradiated in a flux of approximately 10^{12} neutrons cm^{-2} for periods of time varying from 1 to 24 hrs. After irradiation, these crystals showed the resonance absorption described in Fig. 1, when placed at the midpoint of a resonant section of

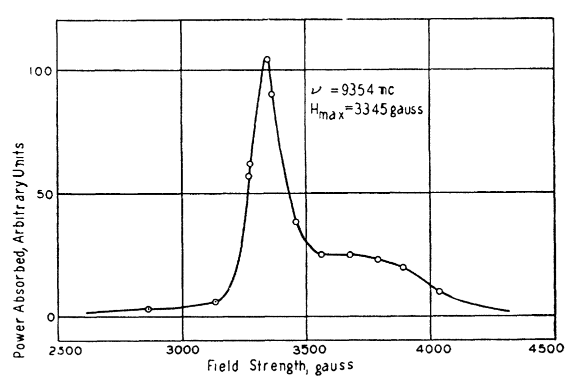

FIG. 1. Resonance absorption of LiF crystals after irradiation with neutrons.