Pb^{208}. The latter factor is nearly compensated by the fact that for V a change in a produces appreciable potential changes only well inside the nucleus, while $\mathcal{E}_r r^2$ is largest at the nuclear surface where fg is largest.

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* Assisted by the joint program of the AEC and ONR.

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Ferromagnetic Resonance in Single Crystals of Cobalt-Zinc Ferrite

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(Received November 26, 1951)

WE succeeded in growing single crystals of Co-Zn ferrite, and its ferromagnetic resonance was observed at 9310 Mc from room temperature to the Curie temperature.

Single crystals of the ferrite were prepared as follows: 6.7 g Fe_2O_3, 1.9 g CoO, 1.4 g ZnO, and 12 g borax were mixed, kept at 1320°C for 3 hours in a platinum crucible, cooled at a rate of 1°C/min until 1150°C, and then the current was turned off.

A crystal used in the present experiment was a beautiful octahedral crystal, about 1 mm^3 in volume. The Curie point of this crystal was observed from the resonance experiments at *ca* 340°C. Moreover, from Guillaud's Curie temperature data[1] for various compositions of Co-Zn ferrites, our crystal seems to have the composition $Co_{0.7}Zn_{0.3}Fe_2O_4$.

A crystal was cut at the (100) plane into two pyramid-type specimens, and one of them was mounted at the bottom of the resonant cavity so as to make the (100) plane consistent with the direction of both the rf magnetic field and the dc magnetic field.

The experimental procedure and method were given in previous papers.[2,3]

Resonance fields and line half-widths from room temperature to *ca* 300°C were observed, and the results of measurements made with the [110] and [100] directions respectively parallel to the dc static field are shown in Fig. 1.

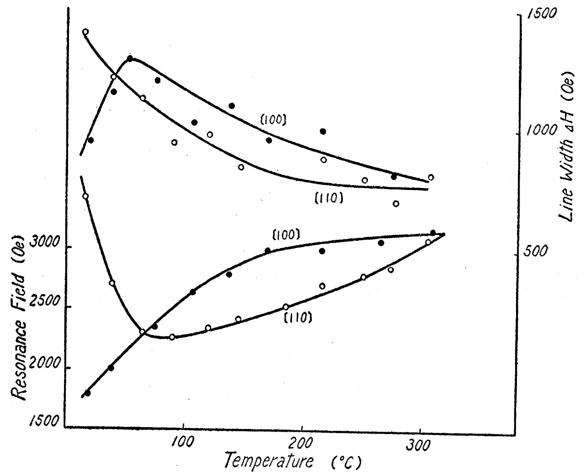

FIG. 1. Variation of the resonance field and the line half-width with temperature for the [110] and [100] directions in a single crystal of $Co_{0.7}Zn_{0.3}Fe_2O_4$.

The curves of resonance field *vs* temperature for these two directions cross at *ca* 70°C, and the line width for the [100] direction has a maximum value near this temperature.

Sintered polycrystalline specimens of the same composition were used to determine the demagnetizing factor N and magnetic saturation values M_s of the single crystal. Namely, resonance experiments were performed from room temperature to the Curie point for various specimens (a sphere 2 mm in diameter; a disk 0.25 mm in thickness and 3.12 mm in diameter; and a pyramid form whose base was 1 mm along the edges).

A second peak at lower magnetic field was always observed in the case of the experiment with polycrystalline specimens from *ca* 70°C to 100°C, as we had previously reported in the experiment with Mn-Zn single crystals,[4] and this "double peak" seems to have also an intimate relation with the phenomena in which the anisotropy energy K_1 changes its sign.

The demagnetizing factor N and the saturation magnetization M_s at each temperature were calculated from the resonance fields of polycrystalline specimens, and substituting these values in Kittel's resonance formula,[5] K_1 and g of the single crystal were determined for each temperature as shown in Table I in the fourth and the last column, respectively. The g-factors of the single crystal near room temperature could not be determined with sufficient accuracy because of a considerable increase in the value of K/M_s and NM_s in Kittel's formula, so these values are marked with asterisks.

TABLE I. Crystalline anisotropy energy K_1 and g-factors, as functions of temperature.

Temp. °C	g_p	M_s gauss	$K_1 \times 10^5$ ergs/cm^3	g
20	2.07	516	2.36	1.91*
40	2.10	450	1.34	1.92*
60	2.11	381	0.16	1.96*
80	2.12	338	−0.21	2.06
120	2.15	269	−0.41	2.12
160	2.16	203	−0.34	2.12
200	2.17	134	−0.21	2.17
240	2.18	61	−0.07	2.16
280	2.19	8	−0.01	2.15

In Table I g-factors obtained from the experiment with a spherical polycrystalline specimen, whose diameter is 2 mm, are also included in the second column, g_p. The values of g and g_p at high temperatures coincide satisfactorily with one another within the limits of error.

Experiments at a wavelength of 1.2 cm are being planned.

Details of the present experiment will be published in Science Reports of the Research Institute of Tohoku University.

The writers wish to express their thanks to Miss Kōko Takahashi for her assistance during the course of the experiment.

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Low Energy γ-Transitions in Some Rare Earth Isotopes*

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(Received January 3, 1952)

SEVERAL of the rare earths, when activated by neutron capture, decay by β-emission followed by an internally converted γ-transition of about 100 kev energy. In most cases, these energies have been well determined previously.[1] In order to obtain relative intensities of conversion lines and assign transition

TABLE I. Energies, intensities, and multipole assignments.

Converting (and parent) nucleus	Electron energy (kev) and shell		Energy sum (kev)	Rel. int.	Lifetime (sec)	Multipole order	$(K/L)_{\mathrm{exp}}$	$(K/L)_{\mathrm{empirical}}$[a]
${}_{61}\mathrm{Pm}_{86}^{147}$ (Nd^{147} 11 days)	46.21	K	91.40	6.4	$<5\times10^{-7}$ [b]	($M1$) or ($M1+E2$)	6.4 ± 2.0 6.6 ± 1.5[c]	7.7 ($M1$) 0.5 ($E2$)
	84.34	L_{I}	91.77	1.0				
	90.12	M_{I}	91.78					
	91.79	N_{V}	91.90					
			$\gamma=91.8$					
${}_{67}\mathrm{Ho}_{98}^{165}$ (Dy^{165} 2.5 hr)	39.34	K	94.95	6.4	$<3\times10^{-9}$ [d]	($M1$) or ($M1+E2$)	5.9 ± 2.0	7.6 ($M1$) 0.3 ($E2$)
	85.79	L_{I}	95.19	1.0				
	86.97	L_{III}	95.05	<0.2				
	92.99	M_{I}	95.12					
	94.92	N_{V}	95.08					
			$\gamma=95.1$					
${}_{68}\mathrm{Er}_{98}^{166}$ (Ho^{166} 27 hr)	23.00	K	80.47	0.13	1.7×10^{-9} [e]	($E2$)	$0.07^{+0.}_{-0.02}$	7.5 ($M1$) 0.14 ($E2$)
	70.99	L_{I}	80.74	<0.1				
	71.51	L_{II}	80.78	0.72				
	72.42	L_{III}	80.78	1.00				
	78.88	M_{III}	80.70	0.64				
	80.42	N_{III}	80.74	0.20				
			$\gamma=80.7$					
${}_{70}\mathrm{Yb}_{100}^{170}$ (Tm^{170} 127 days)	23.00	K	84.31	0.29	1.6×10^{-9} [d]	($E2$)	$0.16^{+0.2}_{-0.02}$ 0.145[d]	7.5 ($M1$) 0.145 ($E2$)
	74.28	L_{I}	84.77	<0.1				
	74.86	L_{II}	84.84	0.83				
	75.91	L_{III}	84.86	1.00				
	82.90	M_{III}	84.85	0.67				
	84.58	N_{III}	84.93	0.20				
			$\gamma=84.8$					
${}_{72}\mathrm{Hf}_{104}^{176}$ (Lu^{176} 3.7 hr)[f]	23.09	K	88.46	0.24	$<10^{-6}$ [f]	($E2$)	$0.14^{+0.2}_{-0.02}$	7.5 ($M1$) 0.14 ($E2$)
	78.12	L_{II}	88.87	0.71				
	79.33	L_{III}	88.90	1.00				
	86.78	M_{III}	88.89	0.84				
	88.40	N_{III}	88.79	0.23				
			$\gamma=88.9$					

[a] See reference 6.
[b] W. S. Emmerich and J. D. Kurbatov, Phys. Rev. **83**, 40 (1951).
[c] E. Kondaiah, Phys. Rev. **81**, 1056 (1951).
[d] See reference 1.
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multipolarities, the conversion electron spectra of some of these isotopes have been re-examined using permanent magnet 180° photographic β-spectrographs. Relative line intensities were obtained by photometric densitometry, corrections being made for film sensitivity as a function of electron energy by the use of an experimentally determined extrapolation[2] of Cranberg and Halpern's curve for low energies.[3] Although sources were of about 1.0 mg/cm^2 thickness, areas of the lines, uncorrected for source absorption and weighted by the radius were used as a measure of the conversion line intensity. In other experiments[2] this has proved to be fairly reliable. Our magnetic fields were calibrated using the energies of the I^{131} γ-rays as determined by Lind *et al.*,[4] and appropriate Xe critical absorption energies interpolated from the x-ray data of Siegbahn.[5] The magnetic fields were extrapolated for radii corresponding to energies below 45 kev. This may account for the fact that the K sum energies are consistently lower than the L sum energies.

Internal conversion spectra of the γ-transitions following the β-decay of Nd^{147}, Dy^{165}, Ho^{166}, Tm^{170}, and Lu^{176m} were examined. Table I lists the energy and intensity data obtained as well as published lifetimes and empirical K/L ratios. Intensities are normalized to the most intense L line of each spectrum.

It is apparent that these spectra arise from different types of nuclear transitions. The transitions following the decay of Nd^{147} and Dy^{165} occur in odd-even nuclei. They have comparatively high K/L ratios and one predominant L conversion line. Lifetime and K/L ratio considerations[6] predict the multipolarity of both transitions to be $M1$ or ($M1+E2$) mixtures.

The transitions following the decay of Ho^{166}, Tm^{170}, and Lu^{176m} occur in even-even nuclei, and should therefore, as a rule, be of $E2$ multipole order.[6] This is in agreement with the lifetimes and the low K/L ratios (~0.15). Here the L conversion lines consist of intense L_{II} and L_{III} groups and a weak L_{I} group. Experimental L subshell conversion data should be of assistance in assigning multipole orders.[7]

It is interesting to note that, to within ±0.2 kev, the energies of the three $E2$ transitions vary linearly with atomic number. More data are needed to determine the significance of this observation.

Our thanks are due Dr. M. Goldhaber for his constructive criticism.

* Research carried out under contract with the AEC.
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