is formed both by this reaction and the more probable (α, pn). Bombardment of Ag with approximately 40 Mev α-particles produced a good yield of the long-lived Cd, a small or possibly zero yield of the 6.7 hr. Cd. This latter yield will be further checked.

The bombardment of Ag with approximately 20-Mev deuterons also produced in the surface layers of the target a Pd activity of 13 hr. half-life. Rall[4] has assigned this activity to Pd^{109}, so in this case it is formed by the reaction $Ag(d, 2p)Pd$. An absorption measurement gave 1.0 Mev as the upper limit of the β-spectrum, in satisfactory agreement with the 1.08 Mev reported by Kraus and Cork.[5] The threshold of the reaction is $E_{max}+2M_H-M_D$ or about 2.5 Mev. However, the low probability that protons be ejected through the barrier with low energy explains the fact that Krishnan[6] with 9-Mev deuterons observed no Pd activity, and that the yield here was observable only at high bombarding energies. No other Pd activity was found. Pd^{107} must have a very short half-life to have escaped detection in other investigations, or a half-life greater than 25 years to be undetected in this case.

I wish to thank Dr. Moyer for the use of the enriched samples and Dr. J. G. Hamilton and the members of the 60″ cyclotron crew for the bombardments.

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Beta- and Gamma-Ray Energies of Several Radioactive Isotopes*

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THE thin magnetic lens spectrometer constructed by Wilkinson and Rall at the Metallurgical Laboratory and now in use at Clinton Laboratories has been used to obtain data on the beta- and gamma-ray energies of several additional radioactive isotopes.

All activities were produced by slow neutron irradiation of the elements or their compounds in the Clinton pile. All samples, with the exception of the dysprosium compound, were spectroscopically analyzed for impurities. In no cases did the combination of factors, such as amount of impurity, cross section of impurity for slow neutron capture, and period of any activity due to the impurity, appear to be such that the impurity could be responsible for any observed gamma-rays.

Table I summarizes the results obtained. The gamma-ray energies are probably correct within 2 percent except where the approximation sign indicates less reliable data. The last column gives rough estimates on the relative intensities of gamma-rays from most of the isotopes. These may be in error by as much as 50 percent.

TABLE I. Energies of beta- and gamma-rays.

Isotopes	Beta-ray End points (Mev)	Gamma-rays (Mev)	Rel. intensities of gamma-rays
26.8 hr. As^{76}		0.57	5
		1.25	2
		1.84	very weak
		2.15	very weak
24.1 hr. W^{187}	0.6 and 1.3	0.48	3
		0.69	2
14.1 hr. Ga^{72}		0.64	1
		0.84	6
		2.25	6
26.5 d. Cr^{51}		0.32	
18 hr. Re^{188}		0.16	4
		0.48	1
		0.64	2
		0.94	2
		1.43	1
51.5 d. $Hg^{203 \text{ or } 205}$	<0.3	0.28	
40 hr. La^{140}		0.335	1
		0.49	10
		0.83	20
		1.63	100
		~2.3	5
46 hr. Sm		0.11	
		~0.6	
60 d. Sb^{124}	0.53 and 2.25		
2.8 d. Sb^{122}	1.36 and 1.94		
11 d. Ge^{71}	~0.6[a]	~0.5[b]	
67 hr. Mo^{99}		0.24[c]	
		0.75	
2.5 hr. Dy^{165}		0.37[d]	
		~1.0	

[a] Probably positrons.
[b] Possibly annihilation radiation.
[c] Preliminary data; no chemical separation, but these gamma-rays are probably not from 6.1-hr. activity of element 43. Data indicate that other gamma-rays may also be present.
[d] Preliminary data; other gamma-rays may also be present.

Details of these studies will appear in the *Volume of Collected Papers on Nuclear Physics of the Plutonium Project Record.*

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The Abundance of He^3 in Atmospheric and Well Helium

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BY means of a 60° mass spectrometer we have just completed an investigation of the relative abundances of the helium isotopes. The average value for the He^4/He^3 ratio in two samples of atmospheric helium from the Air Reduction Sales Company was found to be 9×10^5,[1] and that for two samples of well helium 7×10^6. These values should not be in absolute error by more than 25 percent. The relative He^3 concentrations are within 10 percent. The He^3 peak was completely resolved from HD. In all cases the He^4/He^3 ratio was independent of pressure and amount of hydrogen impurity. The ionization efficiency curve for the He^3 peak agreed within experimental error with that for He^4 and was distinctly different from that for HD.

Alvarez and Cornog[2] have reported the existence of He^3 as a result of observation of a mass three beam in the Berkeley 60″ cyclotron and gave He^4/He^3 ratios of 10^8

and 10^7 for well and atmospheric helium, respectively. In a private communication Dr. Alvarez has indicated that owing to difficulties in shimming the cyclotron and to the fact that different detecting devices were used for He^3 and He^4 in their work, it is possible that their absolute determination of the He^3 abundance might be in error. However, since the same experimental arrangements were used for air and well helium[1] their relative He^3 concentrations should be correct. Our relative concentrations are in good agreement with their values, and since at present we see no reason to doubt our absolute determinations, it appears that He^3 is approximately ten times as abundant as has been assumed heretofore.

Helium from different geological sources including radioactive minerals will be investigated in further studies.

While the problem of concentrating He^3 from natural sources remains a formidable one, the higher value for the abundance brings it closer to reality. Also since measurements are in the range of a good mass spectrometer, the results of concentration processes can be evaluated.

The mass spectrometer used in this investigation was built from a grant from the Graduate School. This research was made possible through a grant from the Research Corporation.

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The Hyperfine Structure of the Microwave Spectrum of Ammonia and the Existence of a Quadrupole Moment in N^{14} *

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GOOD[1] has reported the existence of a hyperfine structure for many of the lines of the inversion spectrum of ammonia, $N^{14}H_3$, which falls in the microwave region near 1.25 cm. This feature had not been predicted theoretically. Of the possible explanations, the interaction of a quadrupole moment of the N^{14} nucleus with the electrical field of the other charges in the molecule seems the most likely and has been widely discussed. Another possibility, magnetic spin-spin interaction of the nuclei, is theoretically of too small a magnitude and does not fit in other ways.

In order to test the quadrupole hypothesis, a quantum-mechanical treatment of the interaction has been carried out and the results compared with accurate measurements of the hyperfine structure spacings.

The equations, the derivation of which will be published separately, are as follows for the frequency difference between the central line and each of the four satellites:

$$h\Delta\nu = \pm(\tfrac{3}{16})Q(\partial^2V/\partial z^2)\{1-[3K^2/J(J+1)]\}[(J+1)/(2J+3)],$$

$$h\Delta\nu' = \pm(\tfrac{3}{16})Q(\partial^2V/\partial z^2)\{1-[3K^2/J(J+1)]\}[J/(2J-1)],$$

in which Q is the so-called nuclear quadrupole moment' $\langle\rho(3z^2-r^2)\rangle_{Av}$ and J and K are the total angular momentum and axial angular momentum quantum numbers for the rotation of the molecule. V is the electrostatic potential at the nitrogen nucleus owing to the charges outside that nucleus. Z is along the symmetry axis. These formulas assume that the molecule is of the symmetrical top type, that the spin of the N nucleus is unity, and that the magnetic couplings of the nuclei are negligible.

The hyperfine structure for the (J, K) 11, 22, 33, and 44 lines of $N^{14}H_3$ was measured with an apparatus using a wave guide absorption cell and a sweeping technique in which the carrier was frequency modulated, so that sidebands are produced which cause images of the central absorption line to be displayed. These are compared in frequency with the satellite lines. The results are given in the Tables I and II. Since the absolute values of Q and $\partial^2V/\partial z^2$ are not known, only ratios of splittings can be predicted theoretically.

It is seen that the agreement is excellent. Furthermore no hyperfine structure has been detected for $J=3$, $K=2$, for which the theory predicts zero splitting, or for higher J values, for which a further theoretical treatment predicts a lower relative intensity for the satellites.

Since N^{15} is reported[2] to have a nuclear spin of $\frac{1}{2}$ units, it should not show this effect. Therefore a sample of ammonia containing 60 percent N^{15} was prepared from ammonium nitrate procured from the Eastman Kodak Laboratory and its inversion spectrum examined in a simple wave guide absorption apparatus similar to that used by Hershberger.[3] Lines ascribed to $N^{15}H_3$ were found at 24560(77), 23928(66), 23686(11, 10), 23406(55), 23049(44), 22769(33), 22640(22) megacycles, the probable quantum numbers being given in parenthesis. Although the hyperfine structure of the $N^{14}H_3$ lines 11, 22, 33, and 44 was clearly observed with the same sample of ammonia, no hyperfine structure was seen on the $N^{15}H_3$ lines.

We therefore conclude that the hypothesis that the hyperfine structure of $N^{14}H_3$ is caused by a quadrupole interaction is strongly supported by several types of observations.

TABLE I. Hyperfine structure spacings in $N^{14}H_3$ in megacycles/sec. from the central line.

JK	$\Delta\nu$	$\Delta\nu'$	JK	$\Delta\nu$	$\Delta\nu'$
11	0.60	1.57	33	1.72	2.34
22	1.30	2.05	44	1.91	2.48
		(all values ±0.05)			

TABLE II. Calculated and observed ratios.

JK	$\Delta\nu JK/\Delta\nu 11$ obs.	calc.	$\Delta\nu' JK/\Delta\nu' 11$ obs.	calc.	$\Delta\nu' JK/\Delta\nu JK$ obs.	calc.
11					2.62	2.50
22	2.17	2.14	1.31	1.33	1.58	1.56
33	2.87	2.78	1.49	1.50	1.36	1.35
44	3.18	3.18	1.58	1.60	1.30	1.26

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