decay of Ti^{51} or from that of Cr^{51}. If present, this line has an intensity of less than 3 percent compared with the 0.325-Mev line. In addition, Kern *et al.*[3] reported a gamma ray of energy 0.237 Mev in the decay of Cr^{51}, which so far has not been confirmed.[2,5,11]

Ca^{43}:—By means of the scintillation spectrometer we have confirmed the existence of a gamma line at 0.375 Mev. Its intensity is 25 percent compared to the total positron intensity in the beta decay of Sc^{43} This line had already been reported by Haskins *et al.*[7] The line could be clearly separated from the Compton distribution of the annihilation line by a method proposed by A. H. W. Aten, Jr. The spectrum was first measured with a thin source and was then remeasured with the source covered by a perspex absorber opposite to the crystal. The intensity of the annihilation peak was then found nearly doubled. Subtraction of the two curves, after normalization to the same annihilation peak height, yielded the 0.375-Mev gamma line.

Mn^{53}:—No gamma line was found by Nelson *et al.*[12] in the positron decay of Fe^{53}. From (p,n) reactions, however, a level at 0.370 Mev is reported.[8] We have investigated the scintillation spectrum of Fe^{53} by the method described above, and we found a gamma line at 0.370 Mev with an intensity of 30 percent compared to the total positron spectrum, which classifies the transition to this level as allowed.

Application of Edmonds and Flowers' results[1] indicates that low-lying excited levels should occur both from the coupling of $f_{7/2}$ identical particles and from mixed proton-neutron configurations. In the case of 23 and 25 odd nucleons, no exclusive assignment to one or the other coupling mechanism can be given so far for the experimentally known low-lying levels. However, with 21 or 27 odd nucleons, the occurrence of such levels could be accounted for by mixed configurations.

From the available data on nuclear energy levels in this region, the following preliminary conclusions can be derived:

1. In nuclei with 23 and 25 protons or neutrons the first excited levels are found below 0.5 Mev in all cases investigated.

2. In nuclei with 21 and 27 protons or neutrons no states below 1.0 Mev have been found. It seems therefore that mixed configurations of $f_{7/2}$ protons with $f_{7/2}$ neutrons do not give rise to low-lying levels.

3. The first single-particle level in all investigated odd-mass nuclides with 21, 23, 25, or 27 identical nucleons is found between 1.0 and 1.5 Mev.

4. In V^{49} two low-lying levels have been found exceptionally close to the ground state (possibly forming the triad $J=7/2$, $5/2$, and $3/2$), in complete agreement with the theoretical predictions;[1] this seems to be the first clear cut case in which all three competing levels appear.

The following cases have been reported as possible exceptions to the conclusions 2 and 3:

Sc^{45}:—An indication was reported[13] for the existence of a ≤ 4 percent 0.45-Mev gamma ray in the positron decay of Ti^{45}. Studying this decay, both by means of the scintillation spectrometer and with a $\beta\gamma$-coincidence apparatus, revealed no evidence for this line. The number of coincidences per positron was compared with that of Cu^{64} and F^{18}. Taking three times the standard error as limit, the intensity of the 0.45-Mev line is less than $1\frac{1}{2}$ percent.

TABLE I. Excited states below 1.0 Mev in odd-mass nuclei with 23 and 25 protons or neutrons.

Z	N	Nuclide	Levels (Mev)	Method	References
23	26	V^{49}	0.060 or 0.091	$Cr^{49}(\beta^+)$	this work
			0.151		this work
23	28	V^{51}	(0.237)	Cr^{51}(E.C.)	3
			0.325	Cr^{51}(E.C.); $Ti^{51}(\beta^-)$; $V(p,p')$	3, 4, 5
			0.48	$V(p,p')$	5
18	23	A^{41}	0.50	$A(d,p)$	6
20	23	Ca^{43}	0.375	$Sc^{43}(\beta^+)$	this work; 7
25	28	Mn^{53}	0.38	$Fe^{53}(\beta^+)$; $Cr^{53}(p,n)$	this work; 8
25	30	Mn^{55}	0.13	$Mn^{55}(p,p')$	5
22	25	Ti^{47}	0.16	$Sc^{47}(\beta^-)$	9

Cr^{51}:—From (p,n) reactions Stelson *et al.*[14] report the possible existence of levels at 0.78, 1.17, 1.42, and 1.53 Mev. Muckerjeeh *et al.*[2] reported a gamma ray of 1.5 Mev, following an allowed (not l-forbidden) partial positron spectrum in Mn^{51}.

A^{39}:—From the β^- decay of Cl^{39} a 0.35-Mev first excited state was proposed.[15] Reinterpretation of the experimental results places the first excited state at 1.35 Mev.[16]

A detailed discussion of these results will be published in *Physica*, together with a survey of the positions of nuclear energy levels in odd-mass nuclei with 13 to 27 odd particles, showing some regularities.

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Temperature Dependence of the Nuclear Susceptibility of He^3 between 1.2°K and 4.2°K†

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THE extent to which liquid He^3 behaves as an ideal Fermi-Dirac gas has recently been the object of considerable study.[1–6] Experiments to date have failed to give a unique answer to this problem. The measurement of the temperature dependence of the nuclear magnetic susceptibility of liquid He^3 would allow a quantitative check on this question. At sufficiently low temperatures the spins of the particles of an ideal Fermi-Dirac gas would be expected to line up antiparallel and this would cause the spin magnetic susceptibility to deviate from the classical $1/T$ law and finally to become temperature-independent. Goldstein[2] has discussed the magnetic properties of He^3. It appears unlikely that conventional methods of susceptibility measurements can be extended to indicate more than the already demonstrated[7] absence of nuclear ferromagnetism in this liquid.

We have succeeded in measuring directly the temperature dependence of the nuclear susceptibility of He^3 by observing the strength of the nuclear magnetic resonance absorption signal in He^3 gas at 4.2°K and 900-mm pressure and in the liquid from 2.8°K to 1.2°K. The results of the experiment are given in Fig. 1. It is seen that the nuclear susceptibility of liquid He^3 follows a $1/T$ law down to the lowest temperature reached. There is no evidence in this temperature range of the degeneracy expected of an ideal Fermi-Dirac gas[2,8] of the same density. At 4.2°K and 900-mm pressure the curve for an ideal Fermi-Dirac gas is theoretically only 4 percent above the classical $1/T$ curve.[8] This point was used to fix the relative position of the Fermi-Dirac curve and the $1/T$ curve. Possible error in the measurements should not exceed 10 percent, even in the gas where the signal is weakest. It is impossible, however, to ascertain from these results whether the gas point shows the 4 percent degeneracy expected of an ideal Fermi-Dirac gas.

Nuclear magnetic resonance in He^3 has already been observed by Anderson[9] in the gas at room temperature. In the present

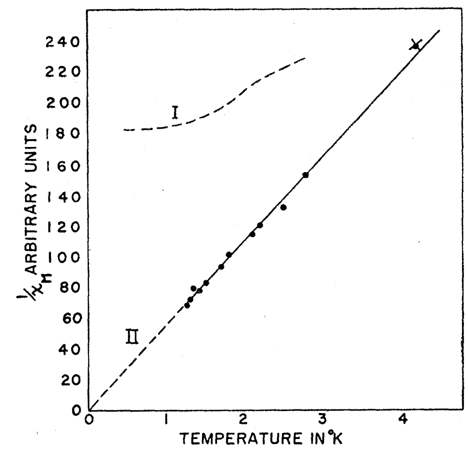

FIG. 1. Graph of the reciprocal of the molar nuclear susceptibility χ_M of He^3 *vs* the absolute temperature. Curve I including the x at 4.2°K represents the curve for an ideal Fermi-Dirac gas of the same density as the He^3. The dots represent the experimental points in the liquid below 2.8°K and in the gas at 4.2°K and 900-mm pressure.

experiment He^3, in a field of about 10 000 gauss, was condensed inside a coil which formed part of the resonant circuit for the input to a 30 mc/sec receiver.[10] The signal was displayed on a scope and the amplitude was measured from photographs of the scope trace. The He^3 sample, 20 cc of He^3 gas at S.T.P., was obtained from the Stable Isotope Division of the Oak Ridge National Laboratory and was concentrated by us by fractional distillation to better than 99 percent purity as determined by vapor pressure measurements. The temperature of the He^3 was determined directly from its vapor pressure and checked against the temperature of the bath.

Under the conditions of the experiment, the amplitude of the nuclear magnetic resonance signal, corrected for its small effect on the Q of the coil, was proportional to the nuclear volume susceptibility.[11] The line width was observed to remain constant, being determined only by the inhomogeneity of the external magnetic field. From relaxation time measurements it was ascertained that equilibrium had always been reached between the nuclei and the lattice motions before a measurement was taken. The radio-frequency signal was kept small enough to avoid appreciable disturbance of this equilibrium. The coil was always kept full of He^3.

To obtain the molar susceptibility the Los Alamos density values were used for the liquid below 2.8°.[12] At 4.2° the density of the gas was measured experimentally and found to agree within the possible error of 5 percent with that calculated using the theoretical second virial coefficient.[13]

The nuclear spin lattice relaxation time was observed to be 60 sec in the gas at 4.2°K and 900-mm pressure, 135 sec at the critical point and 200 sec in the liquid at 2.2° and 1.2°K. The relatively short relaxation time in the gas may possibly be accounted for by a layer of absorbed oxygen on the walls of the container.

The susceptibility measurements are being continued to lower temperatures. We wish to express our appreciation to Dr. F. London for many helpful discussions which contributed materially to the conception of this experiment. We also wish to thank Mr. T. C. Chen and Dr. R. S. Smith for help with the theoretical details of the experiment and for aid in taking the measurements.

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Example of a V^+ Decay*

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IN view of the current interest in the heavy charged unstable particles,[1] it seems worthwhile to report a V^+ decay, film R-112 shown in Fig. 1, which permits detailed analysis. A heavily ionizing particle (1), of momentum 270±10 Mev/c, apparently enters the chamber from the right and decays in flight to produce a secondary (2) of minimum ionization. The estimate of the primary mass from ionization and momentum is less uncertain than the average case since the proximate meson track (3) of momentum 67±4 Mev/c is heavily ionizing and may be used for comparison. If the meson (3) is assumed to be a pion, its ionization can be computed from the known momentum, and the projected

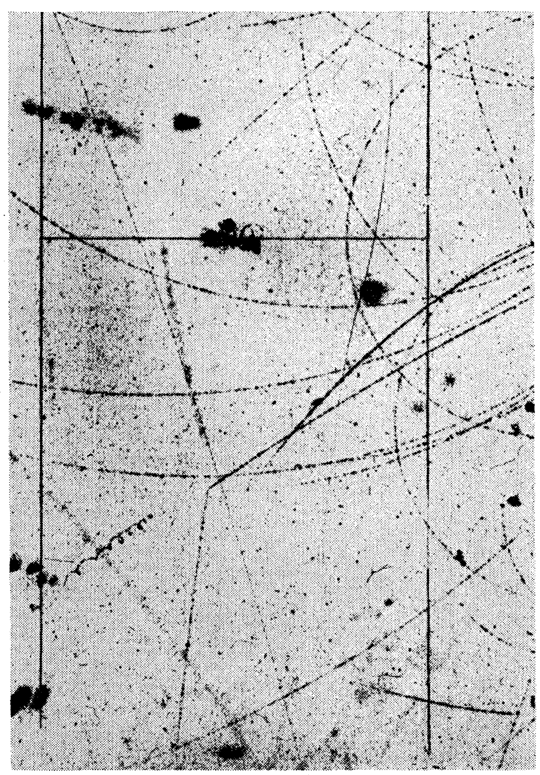

FIG. 1. Right-eye view of event R-112. The lower ⅔ of the chamber is shown.