average loss for aluminum, as calculated from the Bethe-Bloch formula,[2] included for contrast. A slight correction for resolution to the apparent peak location has been applied to the experimental values, the correction being about 0.04 to 0.28 kev for aluminum points and 0.26 to 1.02 kev for tin points, in a total loss from 5 to 44 kev. It can be seen that the agreement is excellent; however, other workers[10] report that a similar set of measurements, which appeared while this work was still in progress, show only "reasonable" agreement.

For the resolution used, quantitative measurement of the energy distribution is not possible; however, the line shape as a function of foil thickness (Fig. 2) is in qualitative agreement with Landau's theory.

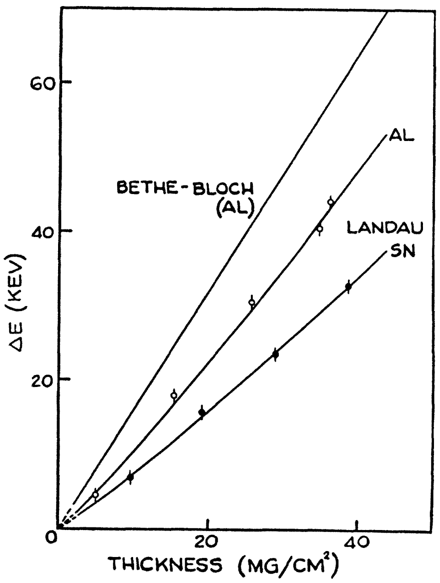

FIG. 1. Probable energy loss *versus* thickness curves for Al(○) and Sn(●) foils. Solid lines are from Landau's theoretical expression. The curve for *average* loss in Al (Bethe-Bloch) is given for comparison.

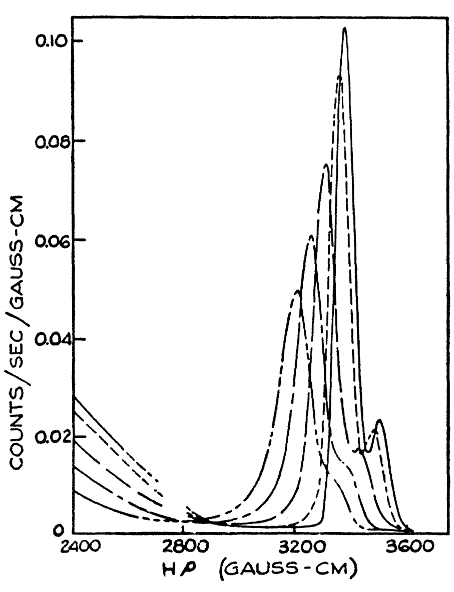

FIG. 2. Experimental line shape (points not shown) as a function of Al thickness (0, 5.2, 15.5, 25.8, 36.2 mg/cm²).

Further work, using lines of different energies, and with other foil materials, is now in progress.

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Effect of Finite Range Interactions in the (jj) Coupling Shell Model

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RACAH has presented as an argument[1] against the jj coupling model the statement that for identical particles with Majorana interaction the spin of the ground state is not always that of the odd nucleon. The basis of this statement is the fact that the statistical weight of singlet coupling for particles in equivalent orbits is given by the expectation value of the operator:

$$\Sigma S_{ik} = \Sigma(\tfrac{1}{4} - \mathbf{s}_i \cdot \mathbf{s}_k).$$

This expectation value attains a maximum for minimal I consistent with the exclusion principle, and would thus predict $I=\frac{3}{2}$ for three particles or three holes in a shell.

For identical particles, the Majorana operator is

$$\Sigma P_{ik} = \Sigma(-\tfrac{1}{2} - 2\mathbf{s}_i \cdot \mathbf{s}_k),$$

so it leads to the same conclusions. If one chooses the interaction potential of a pair of nucleons as

$$V_{12} = P_{12}\{V_0 \exp[-(r_{12}/r_0)^2]\}$$

where r_0 is a parameter giving the range of nuclear forces, one sees that Racah's considerations apply to the case of infinite range, r_0. It is known[2] that with spin-orbit coupling, a δ-function radial dependence gives for the spin of the ground state, the spin of the odd nucleon. Since this is the case of zero range, an investigation has been made to see at what range this level crosses the level $I=\frac{3}{2}$.

Calculations were carried out for three particles in the $1d_{5/2}$ and $1f_{7/2}$ shells, these being the first two cases where the spin of $\frac{3}{2}$ differs from that of the odd nucleon. Spin-orbit coupled functions were used whose radial dependence is the harmonic oscillator function with no nodes,

$$R_l(r) = N_l r^l \exp[-(r/r_l)^2],$$

where l refers to the orbital angular momentum. Energy levels were obtained whose separation depends only on the contribution from the unfilled shell and hence on the ratio (r_l/r_0). These contributions to the energy are plotted in Fig. 1 in units of $(-V_0)>0$. In the $1d_{5/2}$ case, the level $\frac{3}{2}$ is lower for $(r_d/r_0)<0.755$. In the $1f_{7/2}$ case, the $\frac{3}{2}$ level is lowest for $(r_f/r_0)<0.738$, 5/2 is lowest for $0.738<(r_f/r_0)<0.787$, and for greater (r_f/r_0), 7/2 is the ground state.

In order to see at what range these cross-overs occur, the value of r_l may be correlated with empirical nuclear constants. This is done by calculating the square-well problem to give the nuclear radius as $1.48\times10^{-13}A^{\frac{1}{3}}$, and also the experimental binding energy of the last nucleon. The oscillator wave function is then picked

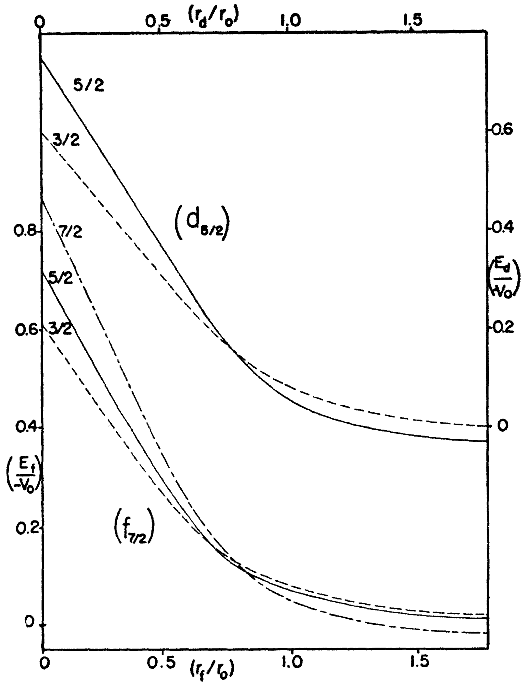

FIG. 1. Energy levels as a function of (r_l/r_0).

to give the closest fit to the square-well function, and as these can be matched quite closely, r_l can be determined.

The $(d_{5/2})^3$ configuration is expected between $A=19$ and $A=25$. The calculation gives: at $A=19$, 5/2 lower for $r_0<3.5\times10^{-13}$ cm; at $A=25$, 4/1 lower for $r_0<3.8\times10^{-13}$ cm. The $(f_{7/2})^3$ configuration is expected between $A=43$ and $A=55$. The limits are: At $A=43$, 7/2 lowest for $r_0<3.75\times10^{-13}$ cm, 5/2 lowest in the interval 3.75×10^{-13} cm$<r_0<4.0\times10^{-13}$ cm, 3/2 lowest for $r_0>4.0\times10^{-13}$ cm. At $A=55$, 7/2 lowest for $r_0<4.1\times10^{-13}$ cm, 5/2 lowest in the interval 4.1×10^{-13} cm$<r_0<4.35\times10^{-13}$ cm, 3/2 lowest for $r_0>4.35\times10^{-13}$ cm. The usually accepted value for r_0 is about 2.8×10^{-13} cm, so the estimated cross-over points lie close to the region of physical interest, especially for the light elements.

Experimentally one finds a spin of $\frac{3}{2}$ for Na^{23}, and the β-decay scheme for Ne^{23} can be understood[3] with an excited state of 5/2 for Na^{23}. In the β-decay of O^{19} one would like to assume a spin of $\frac{3}{2}$ for its ground state.[4] Also the β-decay of Na^{25} to Mg^{25} (experimental spin of 5/2) shows a smaller ft value for decay to the excited state than to the ground state. These three cases all involve $(d_{5/2})^3$ configurations, which could give a spin of $\frac{3}{2}$ if the cross-over actually lies somewhat lower, and thus account for the experimental results.

In the $(f_{7/2})^3$ case, the experimental spin of V^{51} is 7/2, thus indicating that elements in this part of the periodic table are on the other side of the cross-over region. For heavier nuclei in higher shells, the δ-function approximation is approached, and it seems reasonably certain to conclude that the (jj) model will give the spin of the ground state as that of the odd nucleon. The only remaining exception to the (jj) rule for the spin of odd nuclei is Mn^{55}, which has an experimental spin of 5/2. Since this has a proton configuration of three holes in the $f_{7/2}$ shell, it might be explained by saying that in the $f_{7/2}$ shell elements are still quite close to the cross-over region, and the close-lying 5/2 and 7/2 levels can be inverted by some small perturbation.

The author is indebted to Professor M. G. Mayer for suggestions and helpful discussion.

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Os^{182} and Os^{183}, New Radioactive Osmium Isotopes*

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TWO new neutron-deficient radioactive isotopes of osmium have been produced by proton bombardment of rhenium metal in the Berkeley 184-in. cyclotron and the proton linear accelerator. The half-lives are 12.0±0.5 hr. and 24.0±1 hr. which have been assigned to Os^{183} and Os^{182}, respectively.

To obtain a pure osmium fraction, the bombarded rhenium metal was placed in a small distilling flask, osmium carrier added, then dissolved with nitric acid. Osmium tetraoxide was distilled in a stream of air and collected in 6*N* NaOH as sodium osmate. Both osmium and rhenium were precipitated as the sulfides by bubbling hydrogen sulfide through warm acidified solutions of each to which hydroxylamine hydrochloride had been previously added to reduce the nitric acid. Similar chemistry was employed to determine the osmium-rhenium parent-daughter relationships.

Bombardment of rhenium (Re^{185}, 37.07 percent; Re^{187}, 62.93 percent) with 25-Mev protons in the linear accelerator produced the known[1] 97-day Os^{185} and a 12.0-hr. osmium activity which was shown to be the parent of the[2] 120-day Re^{183}. Magnetic counter and absorption data show that the 12.0-hr. Os^{183} decays by electron capture, and emits conversion electrons of energies 0.15 Mev and 0.42 Mev, and gamma-rays of energies 0.34 Mev and 1.6 Mev. The relative abundances of these radiations, calculated from absorption data, are as follows: 0.15 Mev e^- : 0.42 Mev e^- : L x-rays : K x-rays : 0.34 Mev γ : 1.6 Mev γ = 0.18 : 0.009 : 0.53 : 1 : 0.18 : 0.10.

With 40-Mev protons in the 184-in. cyclotron, an additional activity of 24-hr. half-life was formed which decayed to the[2] 12.7-hr. Re^{182}. The 24-hr. Os^{182} decays by electron capture, no positrons having been detected. Analysis of the radiations was limited by the growth of Re^{182} and the decay of Os^{183} in the Os^{182} samples.

* This research was done under the auspices of the AEC.
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Sheath Formation in Ion-Neutralized Electron Beams

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BY "ion-neutralized electron beam" is meant an electron beam in which positive ions exist with a density equal to the beam electron density. Such beams may be formed when positive ions are produced, and trapped in the potential depression of a beam until the potential depression disappears by virtue of neutralization of electron space charge. The resulting medium is similar to a plasma except that the electrons are beam electrons and do not exist as an electron gas. The ions, however, do exist as a gas. This type of beam, and associated effects, are discussed in detail in a forthcoming paper by Linder and Hernqvist.[1]

A necessary condition for the existence of such beams is that the surrounding walls be unipotential, or nearly so. Thus, when neutralization is complete, the space is field-free, and the beam potential equals the wall potential. However, if the collector electrode (anode) is varied from beam potential V_0 to potential V, a sheath forms. Within the sheath, ions are swept out, and the beam is unneutralized; outside the sheath, ion-neutralization persists.

A theory of such sheath formation yields for the sheath thickness x,

$$x=\frac{1.5(10^{-3})V_0^{\frac{3}{4}}}{J^{\frac{1}{2}}}\left[\left(\frac{V}{V_0}\right)^{\frac{1}{2}}+2\right]\left[\left(\frac{V}{V_0}\right)^{\frac{1}{2}}-1\right]^{\frac{1}{2}},$$