roughly the order of 1.5 Mev. The $(g_{9/2})^2$ state is depressed by somewhat more than the $(p_{1/2})^2$ state from the diagonal energy contribution, but the extra effects of configuration interaction should act principally in the $(p_{1/2})^2$ state,[5] adding the order of 0.5 Mev to its depression. The two states of the $p_{1/2}g_{9/2}$ configuration are depressed by a much smaller amount due to the poor overlap of the single particle states, perhaps by a few tenths of an Mev. In the limit of short-range forces, the 4− state is not shifted,[5] and the 5− is shifted downward by a small amount. One concludes that the occurrence of the 5− isomeric state (below the 4−) and its excitation energy are in accord with simple shell theory. Also, one expects that the spin 0 state of the $(g_{9/2})^2$ configuration might lie below the 5− state, because of the much greater mutual interaction of two equivalent than of two inequivalent particles.

A hypothetical level diagram is presented in the right side of Fig. 1, adjusted to fit what is now known experimentally. In addition to the 5− state discussed above,[2] and the new 0+ state just discovered,[3] there has been observed in the decay of $_{41}Nb^{90} \rightarrow {}_{40}Zr^{90}$ a level at 2.23 Mev,[7] which appears not to be the 5− state because of its rapid decay to the ground state and because the energy difference is outside experimental error. This state could be interpreted as the 2+ state of the $(g_{9/2})^2$ configuration. The small 0–2 separation (~0.5 Mev) of this configuration must then be attributed to the configuration interaction of the 0+ state. In a usual even-even nucleus, the 0–2 spacing is substantially increased by configuration interaction. In this nucleus it may be decreased because of the unusual circumstance that there is another 0+ state below the one of interest. According to the semiempirical formulas of Moszkowski,[8] the 5− to 2+ 70-kev $E3$ transition should be slower by a factor of about 100 than the 5− to 0+ 2.3-Mev $E5$ transition. The observation of the ground-state transition only is therefore reasonable.

Regarding other nuclei in the neighborhood, we make two remarks. First, the nucleus $_{38}Sr_{50}^{88}$ does not show a double closed shell character. This may be attributed to the ease of exciting the $p_{1/2}$ state and/or a substantial $p_{3/2}$-$p_{1/2}$ mixing. Second, most odd-even nuclei in the region show a $g_{9/2}$-$p_{1/2}$ energy difference small compared to the 0.9 Mev in $_{39}Y_{50}^{89}$. This is not necessarily in contradiction to a simple shell picture, since the other nuclei have multiparticle configurations. For example, in $_{41}Nb_{50}^{91}$ the "$p_{1/2}$" and "$g_{9/2}$" states should more correctly be called $g_{9/2}^2p_{1/2}$ and $p_{1/2}^2g_{9/2}$, and these three-particle configurations should not have the same spacing as the single-particle levels.

Aside from its interest as a double closed shell nucleus, Zr^{90} calls to attention the way in which the beta- and gamma-decay selection rules can cause low-lying levels to go unobserved in conventional experiments. Shell theory predicts many low-lying states which have not been observed (see, e.g., reference 5). Experiments designed specifically to look for such levels in nuclei with simple shell configurations would be of great aid in theoretical analysis and in formulating a quantitative theory of nuclear structure.

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Evidence for a 0+ First Excited State in Zr^{90}†

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EVIDENCE has been found for the existence of the 0+ level in Zr^{90} predicted by Ford.[1] By using a strong source of Y^{90} in the 40-cm radius of curvature magnetic spectrometer, an internal conversion line was observed corresponding to a transition of 1.75 Mev. The intensity of the line relative to that of the 2.26-Mev beta spectrum is 0.005 percent. The line was observed on repeated runs and its shape was determined with good statistical accuracy by recording 10^5 counts at each experimental point. The full width at half-maximum was 0.5 percent. A weak positron distribution, presumably arising, at least partly, from pairs, was also observed in the spectrometer. The maximum energy of the positron distribution was at about 0.8 Mev. The intensity of the positron distribution relative to the beta spectrum is 0.020 ± 0.010 percent. A search for gamma radiation with a NaI scintillation spectrometer indicated that there is no gamma-ray line in the region of 1.75 Mev with an intensity of as much as 0.0005 percent. Measurements on the 0.3 percent gamma ray of Y^{91} at 1.2 Mev confirmed our estimates of the detectability of the apparatus. The 1.75-Mev transition is therefore assumed to be that of a monopole between two 0+ states of Zr^{90}.

If one assumes that the "unique" comparative half-life, $(W_0^2-1)ft$, is the same for the feeding of the 1.75-Mev level as for the beta transition to the Zr^{90} ground state, then one should expect transitions to the excited state with an intensity of 0.11 percent. However, if

the 1.75-Mev level arises from the excitation of two protons to a $(g_{9/2})^2$ configiration, one may expect some additional forbiddenness. In such a transition, the 39th proton of Y^{90} must change from a $p_{1/2}$ to a $g_{9/2}$ state, in addition to the ordinary single particle transformation of a $d_{5/2}$ neutron into a $g_{9/2}$ proton. For this reason, a reduced intensity for the transition to the 1.75-Mev level may be expected.

Very precise measurements on the beta spectrum of Y^{90} gave no indication of any other group of beta rays between 0.5 Mev and the end point at 2.26 Mev. This fact, combined with the absence of any gamma radiation (other than bremsstrahlung) suggests that the 1.75-Mev level is the first excited state of the even-even nucleus Zr^{90}.

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[1] Kenneth W. Ford, preceding Letter [Phys. Rev. **98**, 1516 (1955)]. We are indebted to Professor Ford for stimulating discussions of the theoretical aspects of the problem.

New Element Mendelevium, Atomic Number 101*

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We have produced and chemically identified for the first time a few atoms of the element with atomic number 101. Very intense helium ion bombardments of tiny targets of 99^{253} have produced a few spontaneously fissionable atoms which elute in the *eka*-thulium position on a cation resin column.

The method of production utilized the following techniques. In a special position in the Crocker Laboratory 60-inch cyclotron a very concentrated collimated beam of 48-Mev helium ions (as much as 10 microamperes in an area $\frac{1}{32}\times\frac{1}{4}$ inch) was allowed to pass through a degrading absorber and then through a 2-mil gold foil (yielding 41-Mev helium ions). On the back side of the gold foil, approximately 10^9 atoms[1] of the 20-day 99^{253} were electroplated in the beam area. From this target the nuclear transmutation recoils were ejected in a narrow spray and caught on 0.1-mil gold foil adjacent to the target. The gold foil was quickly dissolved in aqua regia, the gold extracted with ethyl acetate, and the aqueous phase eluted through a Dowex-1 anion resin column with $6M$ HCl to complete the removal of gold and other impurities. The drops containing the actinide fraction were evaporated and the activity was then eluted through a Dowex-50 resin cation column with ammonium α-hydroxy-isobutyrate[2] to separate the various actinide elements from each other. The radiations from the various fractions were then examined with various types of counters.

The earliest experiments were confined to looking for short-lived alpha-emitting isotopes of element 101 such as 101^{255} and 101^{253} that would be expected from $(\alpha,2n)$ and $(\alpha,4n)$ reactions. For this purpose it was sufficient to look quickly in the gross actinide fraction as separated by the anion resin column alone. No alpha activity was observed that could be attributed to element 101 even when the time between the end of bombardment and the beginning of alpha pulse analysis had been reduced to 5 minutes. To ascertain that a proper recoil and chemical yield was being obtained, a small amount of Cm^{244} was included in the target so that the Cf^{246} and Cf^{244} produced by the helium ion beam would serve as a monitor.

Longer bombardments were then made, and a few spontaneous fission events were observed over a period of several hours in the actinide fractions. At this time the cation resin column procedure was then added to the chemistry so that we could distinguish between elements 101 and 100. The initial experiments were confined to fission counting of the *trans*-100 and the 100 fractions. Several experiments were consistent in their demonstration of spontaneous fissions occurring in both fractions. To determine more precisely the elution position of the element responsible for the *trans*-100 spontaneous fission activity a more elaborate experiment was undertaken. Three successive three-hour bombardments were made and in turn their transmutation products were separated quickly on a cation resin column. The isotope 99^{253} was added in each case so that together with the Cf^{246} produced it would help to calibrate the column run. Five spontaneous fission counters were then used to count simultaneously the corresponding drops of eluent from the three runs. The combined and normalized elution curve is shown in Fig. 1. That the drops did not correspond exactly in each run is indicated on the spontaneous fission histogram by the overlapping of the relative drop number limits of the activities that were placed in each counter. By combining the data from all experiments, the half-life of the spontaneous fission activity in the 101 and

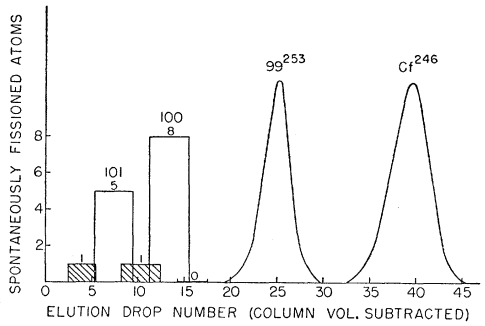

FIG. 1. Elution of elements 98–101 from Dowex-50 column with ammonium α-hydroxy-isobutyrate.