The factor 2 mentioned above has been applied in the derivation of Eq. (A4). Then, the relationship

$$\begin{Bmatrix} j_q & j_q & 0 \\ J & j_h & j_c \end{Bmatrix} = \frac{(-1)^{J+j_q+j_c}}{[(2J+1)(2j_q+1)]^{1/2}} \delta(J,j_h)$$

gives the result of Eq. (5).

The derivation of Eq. (7) for $\Delta E(J)_{\text{block}}$ is similar to that given above, except that the contributing terms of the wave function are restricted to those with $j_{pq}=$ odd. As is explained in the text, it is necessary to use an unantisymmetrized wave function because, on the one hand, the antisymmetrized form vanishes when $j_{pq}=$ odd [see Eq. (A1)] and, on the other hand, it is precisely these ordinarily vanishing terms that are desired in the derivation of the effective blocking interaction. Moreover, it seems that the factor of 2 mentioned above should not be applied in this case. Formation of the diagonal matrix elements of H_{block} using Eqs. (A2) and (A3) gives

$$\Delta E(J)_{\text{block}} = {}_{\text{NAS}}\langle j_q j_c JM | H_{\text{block}} | j_q j_c JM \rangle_{\text{NAS}} = (2j_c+1) \sum_{j_h} D_{qh}{}^2 x_{qh}{}^2 \sum_{j_{pq}=\text{odd}} (2j_{pq}+1) \times \begin{Bmatrix} j_q & j_q & j_{pq} \\ J & j_h & j_c \end{Bmatrix}^2, \quad \text{(A5)}$$

which by virtue of the symmetry relations for the 6-j symbols is equivalent to Eq. (7).

PHYSICAL REVIEW VOLUME 159, NUMBER 4 20 JULY 1967

Decay Properties of Neutron-Deficient Osmium and Rhenium Isotopes. II. The $A=180$ Decay Chain*

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The decay properties of Os^{180} and Re^{180} have been investigated using Ge(Li), anthracene, and NaI(Tl) detectors in singles and coincidence measurements. A solvent extraction method for rapid milking of daughter rhenium activities from osmium was used to confirm the genetic relationship between 21.5-min Os^{180} and 2.45-min Re^{180}. No radiations other than K x rays were detected in Os^{180} decay and it is concluded that this isotope decays by electron capture with a log ft value in the range 4.7±0.3 In Re^{180} decay the following radiations were identified: K x rays (105), γ rays of energies 103.6±0.3 (26), 232.6±1.0 (1.2), 750.8±1.0 (0.8), 826.4±0.8 (11), and 902.2±0.5 keV (100), and a single positron group of endpoint 1.76±0.4 MeV (8). Relative intensities are given in parentheses. A Re^{180} decay scheme which is consistent with all the observations, including γ-γ coincidence measurements, is proposed; its most interesting feature is a two-quasiparticle state ($J^\pi=2^-$) at 1006 keV, which de-excites almost exclusively to the first excited state of W^{180}. The disintegration energy of Re^{180} was determined to be 3.78±0.04 MeV.

I. INTRODUCTION

SINCE the discovery of 2.45-min Re^{180} in 1955,[1] no investigation of the W^{180} levels populated in its decay has been reported. This is in striking contrast with the large volume of published work describing attempts to locate and characterize the levels of the analogous nucleus W^{182} populated in the β decay of Ta^{182} and Re^{182}. Extensive data on the ground-state rotational band of W^{180} have resulted from (α,xn) reaction spectroscopy studies[2] and a 5.2-msec metastable state at 1525 keV has been recently characterized[3] as a 8^- state which de-excites by a strongly K-forbidden $E1$ transition to the 8^+ member of the ground-state band. Graetzer *et al.*[4] have used conversion-electron spectroscopy to investigate the vibrational states of W^{180} populated in the $Ta^{181}(p,2n)W^{180}$ reaction.

Recently, Hofstetter and Daly[5] have disproved the existence of the 20-hr positron-emitting isomer previously assigned to Re^{180}. Evidence for a new isotope, 21.5-min Os^{180}, has been independently reported by two groups[5,6] but no characteristic Os^{180} radiations were identified in either case. This paper describes more detailed investigations of the radiations emitted in the decay of Os^{180} and Re^{180}. Many of the experimental

* Supported in part by the U. S. Atomic Energy Commission under Contract AT(11-1)-1672.
† From the Ph.D. thesis of K. J. Hofstetter, Purdue University, February, 1967.
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procedures, including chemical separations, have been described previously and the evidence for mass assignments has been discussed.[5]

II. EXPERIMENTAL PROCEDURES AND RESULTS

A. Spectroscopic Apparatus

A number of lithium-drifted germanium spectrometers were used at different times in the course of the work to measure γ-ray singles spectra. The best results were obtained using a spectrometer which incorporated a 3-cc Ge(Li) detector, a liquid-nitrogen-cooled F.E.T. preamplifier and an 800-channel pulse-height analyzer. This system had a resolution of 2.3 keV for the 662-keV γ rays of Cs^{137}. Gamma-ray energy standards used throughout this work have been listed previously.[5] The full-energy-peak efficiency for the detector was calibrated versus photon energy using standardized radioactive sources. As the accuracy of intensity measurements using Ge(Li) spectrometers appears to be currently in question,[7] this calibration curve was used only over narrow energy ranges in determining the relative intensities of close lying γ rays which could not be resolved in NaI(Tl) spectrometry. In all other cases a calibrated 3 in.$\times$3 in. NaI(Tl) crystal was preferred for relative intensity measurements.

Gamma-gamma coincidence investigations were carried out using a spectrometer consisting of two 3 in. $\times$3 in. NaI(Tl) detectors in conjunction with a 200$\times$100 two-parameter analyzer.[8] A fast-slow coincidence system was employed and the coincidence resolving time 2τ was 144 nsec. Singles spectra were stored in the $X=0$ and $Y=0$ planes for a known fraction of each counting period and these were used in correcting for random coincidence events. Coincidence data was also accumulated for many hours after the decay of the Os^{180} and Re^{180} activities in order to determine effects due to longer-lived radioisotopes of osmium and rhenium which were always present in the radioactive sources. Interference from the longer-lived activities was not a very serious problem in the coincidence measurements and accurate corrections for their presence could be applied.

Positron endpoint energies were measured with a collimated $1\frac{1}{2}$ in. $\times$1 cm anthracene scintillation spectrometer, which was calibrated using Sn^{113}, Cs^{137}, and Bi^{207} conversion electron sources and a P^{32} β source. A conventional NaI(Tl)-NaI(Tl) annihilation coincidence spectrometer with a resolving time of $2\tau=80$ nsec was used to measure positron intensities.

B. The Decay of Os^{180}

The identification of the new isotope Os^{180} (21.5 min) among the products of 33 MeV He^3 ion bombardments of enriched W^{180} was based on the following observations.[5] When sequential γ spectra of a freshly isolated osmium fraction were recorded, the 902-keV γ-ray characteristic of Re^{180} decay was observed to grow in very rapidly before decaying with a 21.5-min half-life. The results were consistent with a 21.5-min parent feeding a 2.5-min daughter activity but the statistics which could be accumulated during the grow-in period left much to be desired. In addition, it could be argued that the 21.5-min half-life might be associated with a previously unobserved Re^{180} isomer which was populated in the β-decay. A very rapid and efficient method of milking rhenium daughter activities from osmium was therefore developed using an equilibrium Os^{182}-Re^{182} mixture as a tracer. It involves solvent extraction of OsO_4 into organic solvents and when carried out carefully, with appropriate back-washing procedures, it results in practically quantitative separation of the elements.[9] In applying the method to the $A=180$ decay chain, speed was of prime importance and emphasis was placed on isolating most of the rhenium with a minimum of osmium contamination.

Enriched W^{180} (7%) which had been bombarded with 33-MeV He^3 ions was dissolved together with 30 mg of osmium carrier and OsO_4 was distilled from $10M$ HNO_3 into a centrifuge cone containing $6M$ NaOH and 20 mg of rhenium carrier. Starting 5 min after the chemical separation, sequential γ spectra of the osmium distillate were recorded and the 902-keV γ ray was observed to decay with a 21.5 min half-life. After 24 min the solution was removed from the spectrometer and made $12M$ in HNO_3. Four volumes of chloroform was added, the phases were equilibrated for 10 sec and the chloroform was removed. Four volumes of CCl_4 was then added, the phases were again equilibrated for 10 sec and the aqueous phase, which contained the bulk of the rhenium activity, was separated and replaced in the γ spectrometer; the entire solvent extraction procedure took 45 sec. The decay of the 902-keV γ activity in the separated aqueous phase (Fig. 1) was cleanly resolved into a strong 2.5 min component and a weak 22-min component. The relative intensity of the 238-keV γ ray of Os^{181} before and after the chemical separation showed that the aqueous phase contained about 6% of the original osmium, a percentage which accounted entirely for the 22 min component in the 902 keV γ-ray decay. This experiment demonstrated in a convincing manner that the 21.5 min half-life does indeed belong to Os^{180} and that the decay of Os^{180} to 2.45-min Re^{180} does not involve an inter-

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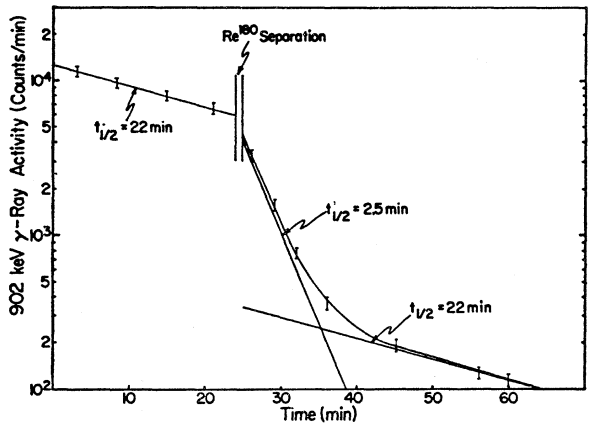

FIG. 1. The decay of the 902.2-keV γ-ray activity in an Os^{180}-Re^{180} equilibrium source. At time $t=24$ min, a chemical separation was performed which removed 94% of the osmium.

mediate isomeric state having a half-life longer than 1 min.

A Ge(Li) spectrum of an osmium source containing Os^{180} is shown in Fig. 2. Despite careful searches, we have been unable to detect any γ rays decaying with a half-life of 22 min other than those characteristic of Re^{180} decay. Particular attention has been paid to the γ-ray energies listed in Ref. 6, but we have concluded that none of these are γ rays of Os^{180}. However we should point out that very low energy γ rays (<40 keV) would probably not have been seen in our measurements because of attenuation in the windows of the Ge(Li) spectrometers. Table I shows the relative intensities of 103.6 and 902.2-keV γ rays and K x rays

TABLE I. Relative intensities of principal radiations in Os^{180}-Re^{180} and pure Re^{180} sources.

	Intensity[a] in Os^{180}-Re^{180}	Intensity[a] in pure Re^{180}
K x-ray	180	105
103.6-keV γ ray	26	26
902.2-keV γ ray	100	100

[a] Normalized to an intensity of 100 for the 902-keV γ ray.

measured with an Os^{180}-Re^{180} equilibrium source and with a pure Re^{180} source. Under conditions of transient equilibrium, 88.6 Os^{180} disintegrations occur per 100 disintegrations[10] of Re^{180} and it is shown later that the 902.2-keV γ ray is virtually 100% abundant in Re^{180} decay. It is then easily calculated from the data in Table I that 84.6 ± 9.0 K x rays are emitted per 100 disintegrations of Os^{180}. Assuming a K/L capture ratio of 6.6 and a K fluorescent yield for $Z=75$ of 0.94, the observed K x-ray intensity is in good agreement with the K x-ray yield expected to accompany the electron-capture decay of Os^{180}; there is no evidence for excess K x rays arising from such processes as internal conversion.

It is tempting to infer that Os^{180} decays by electron capture directly to the ground state of Re^{180}. However, semiempirical mass computations[11–13] indicate that the Os^{180} disintegration energy is 1.6 ± 0.5 MeV. This implies that the β decay of Os^{180} has a $\log ft$ of 4.7 ± 0.3, a value which indicates that an allowed β transition is involved. As the ground state of even-even Os^{180} must be 0^+ and it is likely that the Re^{180} ground state has $J^\pi=1^-$, there is a real difficulty here. This problem is

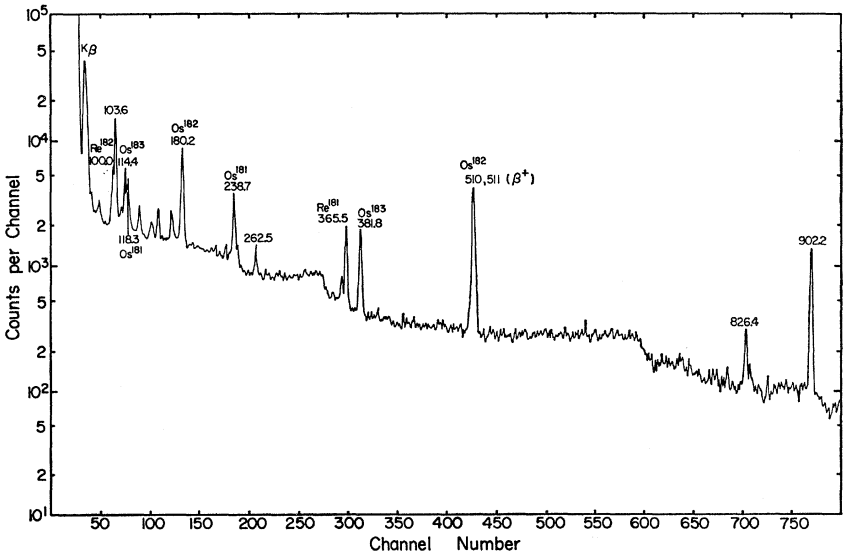

FIG. 2. The spectrum of γ rays from a source containing Os^{180} in transient equilibrium with Re^{180}.

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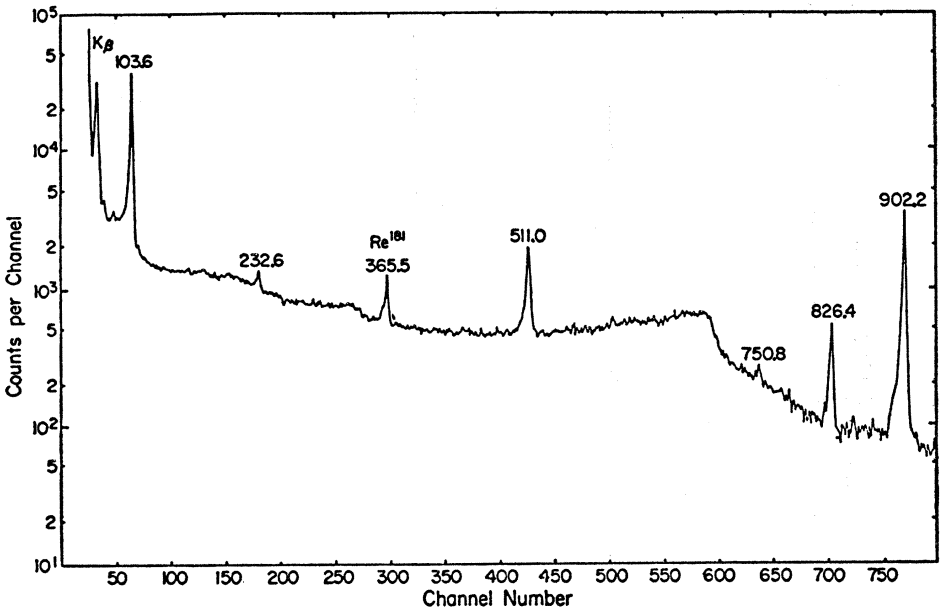

FIG. 3. The γ-ray spectrum of 2.45-min Re^{180}.

discussed further in Sec. III and a possible explanation is proposed.

C. The Decay of Re^{180}

The 2.45 min activity of Re^{180} was produced in these studies by the reactions $Ta^{181}(He^3,4n)$ and $Ta^{181}(\alpha,5n)$ using 33-MeV He^3 ions and 65-MeV α particles. In practically all cases, chemical separations were performed in order to eliminate interfering activities, particularly those of Ta^{182m} and F^{18}. The sources for γ spectrometry were prepared by dissolving the tantalum foil together with Re^{+7} carrier, precipitating Re_2S_7 from acid solution and mounting the precipitate for counting.

In using Ge(Li) detectors to obtain γ spectra, the statistics which could be accumulated were limited not by source intensity but by the maximum count rates which could be maintained without sacrificing spectral resolution. The best γ spectra were obtained by moving the source relative to the detector at such a rate that the analyser deadtime remained unchanged over a period of 10 min. The improvement in statistics which resulted from even longer counting periods was more than offset by the increased interference from strong γ radiations of the longer-lived rhenium isotopes, particularly Re^{181}. One of the best γ spectra obtained is illustrated in Fig. 3 and the energies of the γ rays which were identified with certainty are listed in Table II. The relative intensities of the strongest γ rays were measured using a calibrated 3 in. $\times$ 3 in. NaI(Tl) crystal and are accurate to within $\pm 10\%$, at worst. The intensities of the weaker γ rays were estimated from the Ge(Li) spectra and they could be in error by as much as $\pm 25\%$, as subtractions of large Compton-scattering backgrounds were necessary. The statistics obtained were such that a 600-keV γ ray having an intensity of less than 0.5 would not have been identified and a 1000-keV γ ray with an intensity less than 1.0 would probably have gone undetected.

The 103.6-keV photopeak clearly corresponds to the well known 2^+-0^+ transition in the ground-state rotational band of W^{180}. The energy of the 4^+-2^+ transition in this band has been measured by others[2–4] to be 234 keV; in all our measurements, the energy of the weak Re^{180} γ ray in this neighborhood has appeared to be less than 233 keV and it is doubtful whether it corresponds to the 4^+-2^+ transition. The intense 902-keV photopeak was carefully examined for evidence of structure but none was found; using the high-resolution spectrometer the full width of half-maximum for this peak was 2.7 ± 0.2 keV as compared with 2.6 ± 0.2 keV for the 898-keV photopeak of Y^{88}. An unsuccessful search was made for a γ ray at 1006 ± 1 keV and if such a γ ray is emitted in Re^{180} decay, its intensity is certainly less than 1% of the intensity of the 902-keV γ (Fig. 4).

The positron branching ratio was measured with a NaI(Tl)-NaI(Tl) annihilation coincidence spectrometer, which was calibrated using a standardized Na^{22}

TABLE II. Principal γ rays observed in the decay of 2.45-min Re^{180}.

E_γ (keV)	Relative intensity[a]
K x ray	105
76.0 ± 0.4	0.5
103.6 ± 0.3	26
232.6 ± 1.0	1.2
511 (β^+ annihilation)	14
750.8 ± 1.0	0.8
826.4 ± 0.8	11
902.2 ± 0.5	100

[a] Normalized to an intensity of 100 for the 902 keV γ ray.

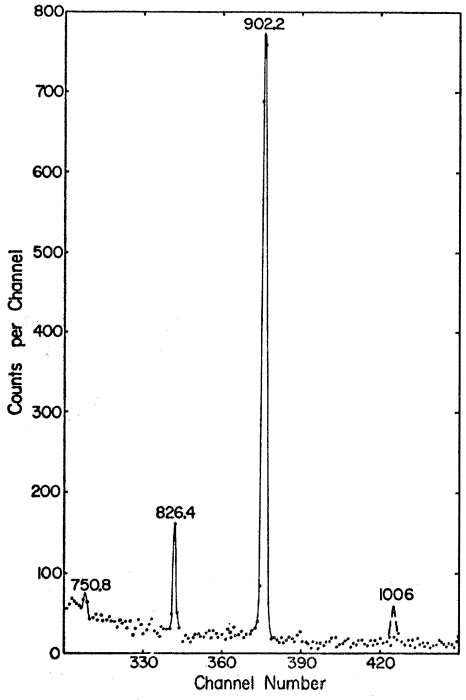

FIG. 4. A region of the Re^{180} γ spectrum showing the 826- and 902-keV photopeaks. The dashed curve represents the photopeak which would have been seen in this spectrum if 1006-keV γ rays were emitted in Re^{180} decay with an intensity of 5% of the 902.2-keV γ intensity.

source. The positron coincidence rate and the 902-keV γ-ray intensity were measured simultaneously and the intensity ratio of positrons to 902-keV γ's was determined to be 0.080 ± 0.010. The positron end point energy was determined to be 1.76 ± 0.04 MeV using the anthracene scintillation spectrometer. A correction for contributions to the anthracene spectrum due to γ rays was made by storing a spectrum with an absorber between the source and detector, multiplying by the appropriate decay factor and subtracting the result from the original spectrum. Fig. 5 shows Fermi-Kurie plots for a Re^{180} source and for a P^{32} source which was used for energy calibration.

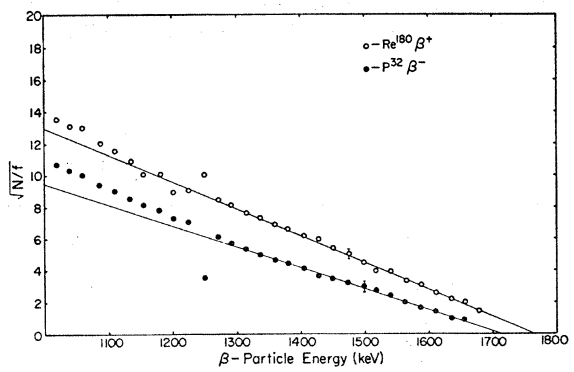

FIG. 5. Fermi-Kurie plots of Re^{180} and of P^{32}, which was used for energy calibration.

The γ-γ coincidence studies were carried out using sources of Re^{180} in transient equilibrium with its Os^{180} parent, which was produced in the reaction W^{182}-$(\alpha,6n)Os^{180}$ by bombarding enriched W^{182} (96%) with 80-MeV α particles. The measurements were continued for several hours in order to identify coincidences due to the presence of 105-min Os^{181}, 22-h Os^{182}, 10-h Os^{183m} and 14 h Os^{183} in the sources. An attempt was also made to obtain coincidence data using a 2.45-min Re^{180} source, but here the statistics obtained were much

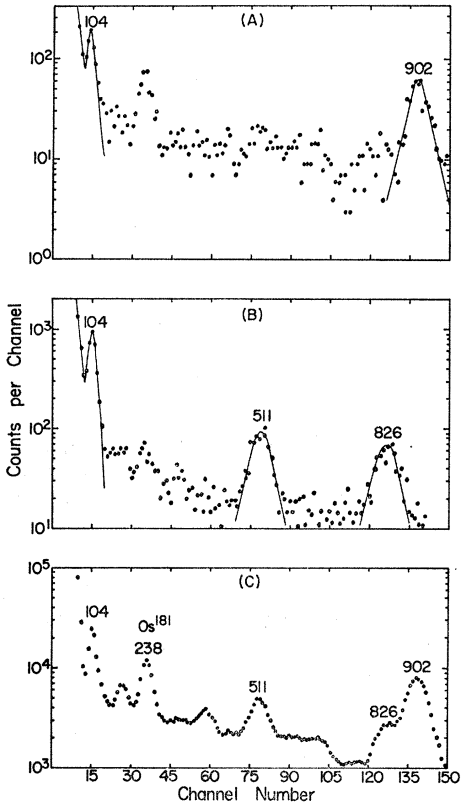

FIG. 6. (A) Spectrum of γ rays in coincidence with 815–840-keV γ rays. (B) Spectrum of γ rays in coincidence with 880–920-keV γ rays. (C) Singles γ spectrum from the Os^{180}-Re^{180} source used in the coincidence measurements.

poorer. Figure 6 shows the key results of the coincidence measurements. These are:

(1) The 902-keV γ ray is in coincidence with the 103.6 and 826 keV γ rays and with the positrons.

(2) The 826-keV γ ray is in coincidence with the 103.6-keV γ ray but not with the positrons.

Other results (not illustrated) are that all the strong Re^{180} γ rays are in coincidence with K x rays and that the positrons and 103.6-keV γ rays are in coincidence. The strong 238-keV photopeak seen in the 815–840-keV spectrum was shown to be due to coincidences between Os^{181} γ rays.

III. DECAY SCHEME AND DISCUSSION

The level scheme which is consistent with all the observed data is shown in Fig. 7. The total conversion coefficient of the 103.6-keV $E2$ transition is about 3.2[14] so the intensity balance at the 103.6-keV level is satisfactory within the accuracy of the intensity measurements. The observed K x-ray intensity can also be completely accounted for as a sum of the K x rays accompanying electron-capture events and those arising from K conversion in the 103.6-keV transition. The resulting Re^{180} disintegration energy 3.78 ± 0.4 MeV is comparable with semiempirical mass predictions of 3.48,[11] 4.20,[12] and 4.33 MeV[13]; as the mass of W^{180} is accurately known,[15] this result can readily be used to calculate the Re^{180} ground-state mass. The weak 76.0-keV and 750.8-keV γ rays very probably occur in cascade between the 1832- and 1006-keV levels but they have not been included in the decay scheme as we have no evidence about the order of these transitions.

A highly unusual feature of the decay scheme is the absence of detectable transitions from the 1006-keV level to the 0^+ and 4^+ levels in the ground-state rotational band of W^{180}. If the 1006-keV level were a member of a β or γ vibrational band the branching to either one or other of these levels should be over an order of magnitude greater than has been observed. In a study in which conversion-electron spectroscopy was used to investigate the levels of W^{180} populated in the reaction $Ta^{181}(p,2n)W^{180}$, Graetzer *et al.*[4] observed a strong 904 ± 3-keV transition in coincidence with 103.6-keV γ rays. It seems likely that the 902.2 ± 0.5-keV γ ray observed in Re^{180} decay corresponds to the same transition. Graetzer *et al.* inferred that the parent level was at 1008 keV and that it probably was the 2^+ member of the β vibrational band ($K=0$). The 1008-keV transition to the W^{180} ground state was not observed and the evidence for a transition to the 4^+ member of the ground-state band was weak. The large intensity of the conversion lines corresponding to the 904-keV transition was taken as evidence for an appreciable electric monopole component in the transition. The results of the present studies cannot however be explained on this basis.

It appears highly probable that for the Re^{180} ground state, J^π is 1^-. The Nilsson assignment for the 105th neutron is $n\frac{7}{2}^-[514]$ and for the 75th proton $p\frac{5}{2}^+[402]$ is expected. All the known ground-state spins and parities of the odd $N=105$ isotones and of the odd rhenium isotopes are in agreement with these predictions. The odd-odd nucleus Re^{180} is therefore expected to have a 1^- or 6^- ground state and by the Gallagher-Moszkowski rules[16] the 1^- state should lie lower in energy. If the Re^{180} ground state is indeed 1^-, the observed logft value of 4.4 implies that the 1006-keV level must have negative parity and that the spin change in the β transition cannot be greater than 1. It is proposed that the level at 1006 keV is a two-quasiparticle state having the configuration $p\frac{9}{2}^-[514]$-$p\frac{5}{2}^+[402]$ and $J^\pi=2^-$. According to the Nilsson scheme, both proton states are available in W^{180}, and in the neighboring nucleus W^{182} an observed level at 1290 keV has been interpreted[17] as a 2^- two-proton state having this configuration. A strong supporting argument for the validity of this interpretation of the Re^{180} decay data is provided by the fact that the proposed β decay involves the single-particle transition $n\frac{7}{2}^-[514]\rightarrow p\frac{9}{2}^-[514]$ in which the asymptotic quantum-number selection rules[18] $\Delta\Lambda=\Delta n_z=\Delta N=0$ are obeyed and which therefore can be classified as allowed unhindered[17] in keeping with the observed logft value.

Identification of the 1006-keV level as a 2^- two-proton state also allows one to account for the anomalous branching into the ground-state rotational band. The 2^--4^+ and 2^--0^+ transitions would both be expected to be $M2$ in character but a predominantly $E1$ transition is possible for the 2^--2^+. As $K=2$ for the 2^- state, the $E1$ transition would be retarded by one degree of K forbiddenness. According to the empirical law of Rusinov,[19] one degree of K forbiddenness might be expected to result in a hindrance factor H_W relative to the Weisskopf single-particle estimate of about 10^{-2}; however this law is largely based on experimental data for the strongly hindered $\Delta K=8$ $E1$ transitions in Hf^{178} and Hf^{180} and it has not been shown that it gives consistently good agreement for transitions involving smaller degrees of K forbiddenness. A better estimate of the hindrance involved in the 902-keV transition can probably be obtained by considering the K forbidden one-particle transition $p\frac{9}{2}^-[514]$—$p\frac{5}{2}^+[402]$, whereby the 2^- two-proton state could be expected to de-excite to the 2^+ collective state. In Re^{183}, the intrinsic state $p\frac{9}{2}^-[514]$ is known to de-excite by $E1$ transitions to members of a rotational band based on the intrinsic state $p\frac{5}{2}^+[402]$ with hindrance factors H_W somewhat greater than 10^{-7}.[20] Although a hindrance of this magnitude would probably result in a small percentage admixture of $M2$ radiation in the 902-keV transition in W^{180}, the transition would still be sufficiently fast to account for the nonobservance of the 2^--4^+ and 2^--0^+ transitions in the present

[14] Obtained by adding the theoretical $E2$ K-conversion coefficient to the experimental L and M conversion coefficients reported in Ref. (3).

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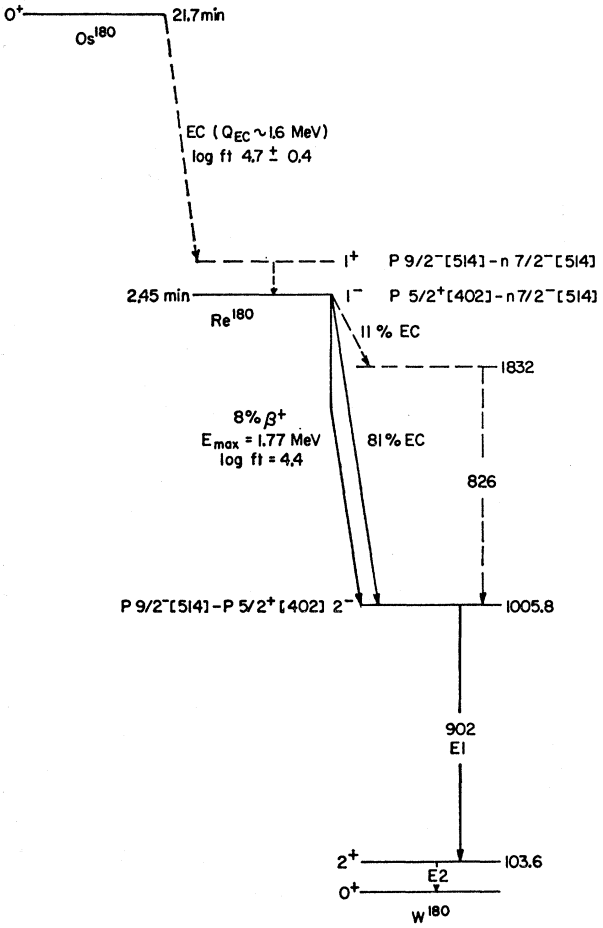

FIG. 7. The proposed $A=180$ decay chain.

experiments. A similar case[21] occurs in Yb^{174} where a 2^- two-neutron state is populated in the β decay of 1300-day Lu^{174} and de-excites almost exclusively to the 2^+ first excited state by a K-forbidden $E1$ transition. The fact that the 2^- state in W^{180} lies about 300 keV lower in energy than a supposedly analogous state in W^{182} is surprising and no explanation is offered by the present authors. The question of whether the 904-keV transition observed in reaction spectroscopy by Graetzer *et al.* corresponds to the 902.2-keV γ ray seen in these studies must remain open; it is not clear that a 2^- two particle state would be strongly populated in a $(p,2n)$ reaction.

[21] H. J. Prask, J. W. Bichard, E. G. Funk, and J. W. Mihelich, Nucl. Phys. **29**, 100 (1962).

One other interesting possibility remains to be discussed. In the odd rhenium isotopes an intrinsic state $p\frac{9}{2}^-[514]$ occurs some hundreds of keV above the $p\frac{5}{2}^+[402]$ ground state. It is conceivable that the ground state of Re^{180} might result from a combination of $p\frac{9}{2}^-[514]$ with $n\frac{7}{2}^-[514]$ in which case J^π would be 1^+ or 8^+, with 1^+ being the more likely value. There is some evidence that unlike nucleons occupying equivalent Nilsson orbitals have a special attraction for each other; a case in point is the $p[514]$-$n[514]$ $J^\pi=1^+$ state in Ta^{178} which lies unexpectedly low in energy.[22] If the Re^{180} ground state did have the configuration $p\frac{9}{2}^-[514]$-$n\frac{7}{2}^-[514]$, $J^\pi=1^+$, not only would an Os^{180} ground state $\rightarrow$ Re^{180} ground state β transition be allowed, but allowed unhindered β transitions from the Re^{180} ground state to members of the β or γ vibrational bands in W^{180} would be possible. However, in the case of a W^{180} β band, the Re^{180} β decay would be expected to populate the 0^+ and 2^+ members approximately equally, and strong γ rays de-exciting both levels should have been seen in the Re^{180} γ spectrum. In the case of a W^{180} γ band, the 2^+ member would be preferentially populated in the β decay, but the de-excitation of the level to members of the ground-state band would have followed an entirely different intensity pattern to that observed in Re^{180} decay. The experimental evidence therefore indicates strongly that the Re^{180} ground state is 1^- as originally proposed. However, if the $p[514]$-$n[514]$ attraction were sufficiently strong to lower the 1^+ state to within a few tens of keV of the Re^{180} 1^- ground state (Fig. 7), then it would be possible to account for both the Os^{180} and Re^{180} decay data. The β decay of Os^{180} would involve the allowed unhindered single-particle transition $n[514]\rightarrow p[514]$ in keeping with the estimated logft value. Although this is an attractive speculation, which is in accord with known trends in this region, its validity remains to be tested in further experiments.

ACKNOWLEDGMENTS

We are extremely grateful to Dr. N. Johnson, Dr. H. H. Bolotin, and Dr. M. A. Wahlgren for allowing us to use their equipment. Dr. E. Eichler, Dr. N. K. Aras, Dr. G. Raisbeck, and C. Batson also helped us in various ways. Our thanks are due to Dr. R. Graetzer and Dr. Z. Grabowski for useful discussions, to Milan Oselka and Dr. E. Newman for arranging the bombardments and to the operating crews of the Argonne and Oak Ridge cyclotrons for performing them.

[22] C. J. Gallagher, Phys. Rev. **126**, 1525 (1962).