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DECAY SCHEMES OF Mo^{91} AND Mo^{91m}

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ABSTRACT

Seven previously unreported gamma rays in the decay of Mo^{91} g.s. were observed and had their energy and intensity measured.

For Mo^{91m} two new gamma rays were observed and the levels fed by its decay were identified with $\ell = 1$ levels found by (He^3, d) reaction.

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I. INTRODUCTION

The nucleus Nb^{91} with 41 protons and a magic number of neutrons, is expected to present a relatively simple low energy level spectrum. In fact, results of rather extensive studies of the nuclei in the region of the Zirconium isotopes indicate that the low-lying, states can be relatively well described by assuming the participation of relatively few shell-model levels 1-4).

Information about the levels of Nb^{91} has been obtained by (He^3, d) reaction 5) and by the decay of both Mo^{91} and Mo^{91m} (6 - 8). In the present work these decays were re-investigated by using very efficient high-resolution Ge(Li) detectors (22 and 30 cm^3), expecially to check the existency of two positive parity states observed in a previous study of the γ decay of Mo^{91} (8). These states are in strong disagreement with the theoretical calculations (3).

II. EXPERIMENTAL METHOD

The sources were prepared by irradiating metalic Mo (enriched to 95% in Mo^{92}) in the bremsstrahlung beam of the linear accelerator of C.B.P.F. The maximum energy varied from 20 to 22 MeV and irradiations were performed using up to 300 mg.

Irradiations times of about 2 min and 45 min were employed for producing short lived isomer and ground state activity, respectively.

Magnetic register system was also used to facilitate the determination of the half-life of each gamma-ray.

Because of the non-linearity of the electronic equipment over the whole energy range 0-4 MeV, the spectrometer calibration curve was determined by using well-known standard gamma rays in order to fit a polynomial in C (channel number) using a least-squares method. The degree of the polynomial was selected on the basis of a χ^2 value. The best fit was obtained with a parabolic curve.

Very thick absorbers of Pb and Cu were used to reduce the intensity of annihilation radiation. The efficiency curve was constructed with a Co^{56} source in the same geometry as the final measurements.

III. EXPERIMENTAL RESULTS

III.a) The Decay of the g.s. of Mo^{91}.

Seven gamma rays were observed decaying with a half-life of 15.5 min. They are reported in Table I. The intensities were arbitrarily normalized to I (1636 kev) = 100.

Fig. I shows a typical pulse height spectrum taken with absorbers of 14 mm of Pb and 6 mm of Cu.

The interpretation of the spectrum is particularly delicate since the difference in energy between some pairs of gamma-rays were of about 511 Kev. The very prominent double-escape peak of the 3147 kev and the single-escape peak of the 2630 kev transition rendered difficult the identification of the 2119 kev line. Special care was taken in discouting from the 3147 kev gamma ray the sum-peak contribution due to 2631 kev transition plus the annihilation peak.

The most straighforward interpretation of the results is to attribute an excited level in Nb^{91} to each observed γ-ray.

III.b) The Decay of Mo^{91m}

Fig. 2 shows a typical gamma spectrum observed after a short irradiation time.

The gamma rays decaying with a 68 sec half-life are given in table II. The intensities were normalized to I (1507 kev) = 100. The resulting decay scheme is shown in fig. 3.

The levels fed by the decay of Mo^{91m} are easily identified with $\ell = 1$ levels found by (He^3, d) reaction 5). Adopting the β^+/IT ratio and the relative intensity of the most energetic beta branch given in ref. 6, we found the beta branches intensities and log ft values given in fig. 3 It is worth noting that the log ft values are lesser for some highly excited $l = 1$ states than for the first excited state. On the other hand the spectroscopic strength $(2 j + 1) C^2S$ found [5]) for the first 1/2 state is relatively larger than for other $\ell = 1$ states.

IV. DISCUSSION

Auerbach and Talmi [3] have calculated the levels of Nb^{91} considering only protons in the 2 p 1/2 and 1 g 9/2 orbits.

The presence of many $\ell = 1$ states and the values of log ft and spectroscopic factors suggest that the 2 p 3/2 orbit is also of fundamental importance in the description of the low-lying negative parity states and that all the observed $\ell = 1$ levels contain appreciable amounts of configuration mixing.

In fact, the spin-orbit splitting in this p-shell is estimated to be only 1 - 1.5 MeV. There is experimental evidence[5] that the p 3/2 orbital is not completely filled in Zr^{90} and it is then reasonable to suppose that at least some of the high-lying negative parity states fed by the decay of Mo^{91m} correspond to states with spin 3/2 and considerable p 3/2 single particle strengths.

Positive parity states are best described by theoretical calculations (34). Calculated levels at 1.62 MeV ($7/2^+$) and 1.71 MeV ($9/2^+$) correspond probably to the strongly populated 1.580 and 1.636 MeV levels.

As discussed in ref. 3, deviations between calculated and experimental energies may well be around 0.1 MeV. Any positive parity level was neither calculated nor observed below 1.5 MeV.

Levels reported at 0.80 MeV and 1.04 MeV in ref. 8 were not confirmed, thus removing the discrepancy with theoretical calculations noted in ref. 3.

* * *

See after references, note added in proof.

TABLE I

Gamma-rays from the decay of $Mo^{91\ g.s}$

Energy (keV)	Relative intensity
1580.5 ± 0.4	70 ± 5
1636.3 ± 0.4	100
1789.1 ± 0.5	15 ± 3
2119.2 ± 0.6	⩽8
2630.8 ± 0.5	39 ± 6
3027.0 ± 0.5	29 ± 4
3147.5 ± 0.6	16 ± 2

TABLE II

Gamma-rays from the decay of $M_o^{91\,m}$

Energy (keV)	Relative intensity
652.7 ± 0.4 (I.T.)	260 ± 30
1032 ± 1	⩽3
1207.6 ± 0.4	82 ± 7
1507.0 ± 0.4	100
2238.5 ± 0.6	2.5 ± 0.5

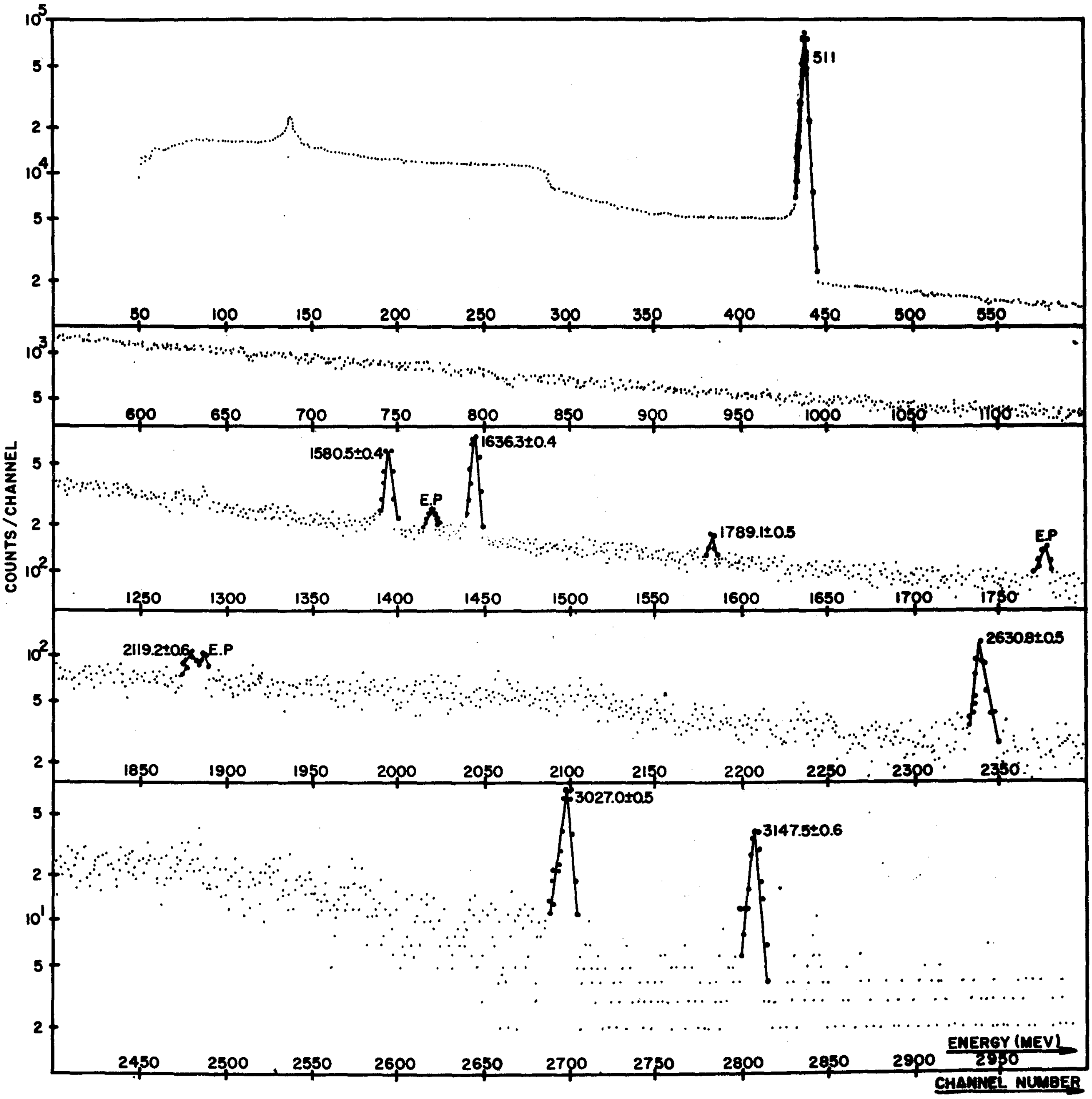
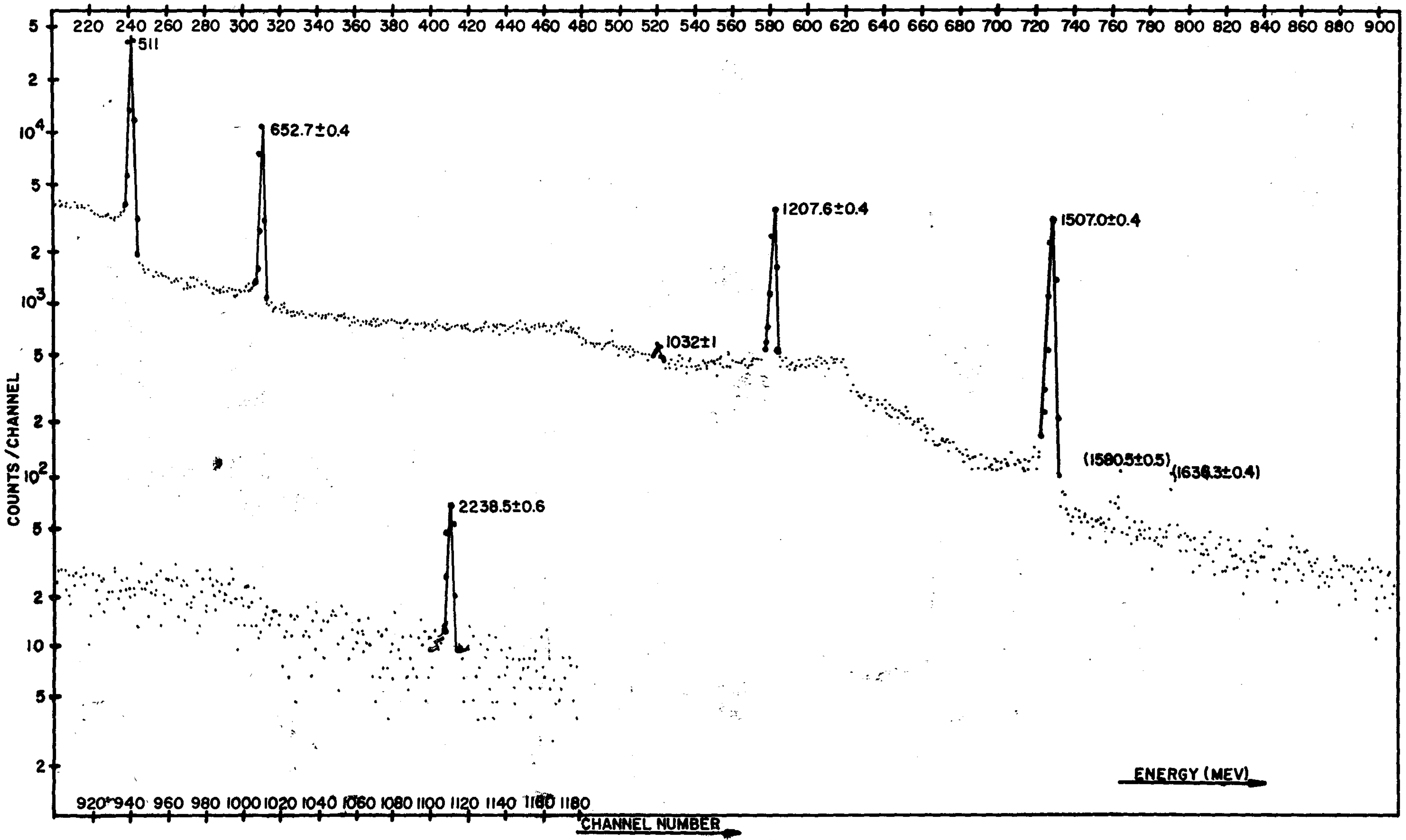


FIG. 1

Spectrum of γ-rays from Mo^{91}

FIG. 2



Spectrum of γ-rays from Mo^{91m}. Peaks due to the decay of Mo^{91} an indicated in parentheses.

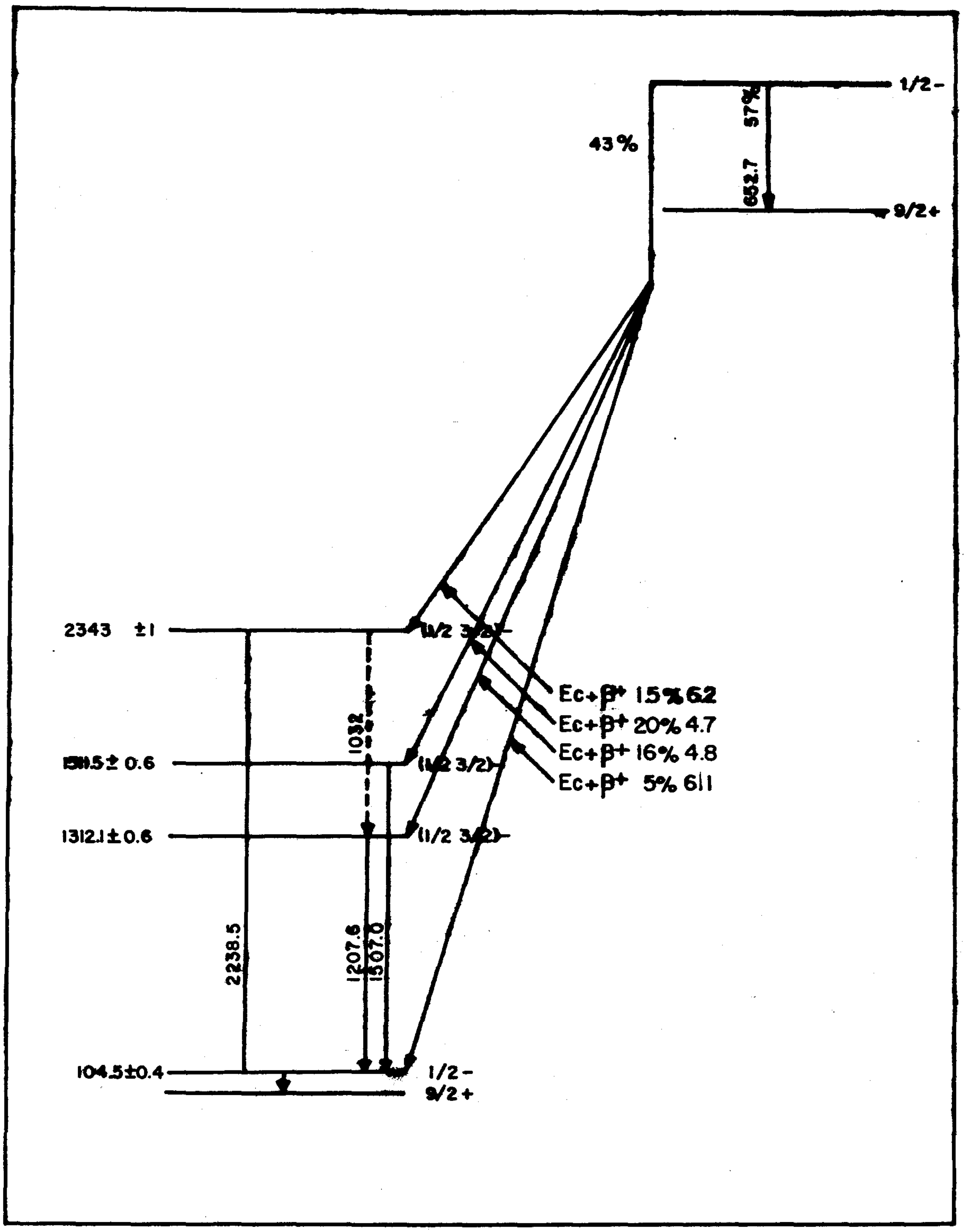


FIG. 3

Decay scheme of Mo^{91} Energies are given in kev.

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NOTE ADDED IN PROOF. After the completion of this work an work of K. Hesse and E. Finckh came to our knowledge. Their results are in fair agreement with our conclusions and confirm the non existency of the 0.80 and 1.04 Mev levels.