SYSTEMATICS OF MAGNETIC DIPOLE TRANSITIONS

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ABSTRACT

An empirical approach to distinguish between *l*-allowed and *l*-forbidden magnetic dipole transitions is made. The reduced lifetimes of these transitions are calculated and their variation with neutron number is studied. It is observed that their general tendency is to remain constant while *l*-forbidden and *l*-allowed odd-proton magnetic dipole transitions are distinguishable from their reduced lifetimes, it is not so in the case of odd-neutron transitions. A slight increase in reduced lifetime with neutron number is observed for fixed proton number.

INTRODUCTION

THE remarkable success of the single particle shell model in accounting for angular momenta and parities of low lying states of odd-A nuclei has extended its applicability in many cases. Experimentally the spins and parities of excited states can be determined from a knowledge of the type (Electric or Magnetic) and multipolarity of the radiation, which are known by measuring internal conversion coefficient, without any detailed knowledge of the wave functions of initial and final states. Comparison of experimentally determined gamma transition probabilities with the ones calculated on the basis of some specific assumptions yields valuable information on the wave functions of the initial and final states. Various authors have compared the electromagnetic transition rates with the single particle estimate, to know how far the shell model of nuclear structure is able to explain the properties of excited states. But it has not been possible to obtain qualitative agreement in the case of *l*-forbidden magnetic dipole transitions. Since the dipole moment operator does not change the orbital angular momentum, the initial and final state angular momentum should be the same for magnetic dipole transition. Those transitions which do not obey this shell model rule are called *l*-forbidden transitions.

There have been many[1–4] attempts to explain the behaviour of *l*-forbidden transitions using modified shell structure. Among these the one[4] based on the assumption that *l*-forbidden transitions occur owing to the admixture of other configurations in the initial or final states of the radiating particle is somewhat fruitful. Recently, Sorenson[5] has discussed the effect of quadrupole vibrations on *l*-forbidden Ml transition and finds that even for non-deformed nuclei that collective quadrupole effects are important. But the fastness of *l*-forbidden Ml rates for odd-N nuclei cannot be explained. The compilation of experimental data by Way *et al.*,[6] gives the average value of the ratio of observed lifetime of the forbidden transitions to the theoretical value of allowed transitions, as 60 for odd-neutron nuclei and 300 for odd-proton nuclei. Earlier, De waard[3] reported marked regularities in the short-lived isomeric transitions of the *l*-forbidden magnetic dipole transitions. It was noticed that these transitions give points in a log energy (E_γ) *versus* lifetime, τ_γ plot that are closely grouped along two straight lines, the line given by log $\tau l = -10\cdot0 - 3$ log. E_γ closely matches transitions in odd-proton nuclei, the one given by log $\tau = -11\cdot7 - 3 \log E$ those in odd-neutron nuclei. Alvager[7] observed that log $(\tau.\, E_\gamma{}^3)$ is almost constant for *l*-forbidden transitions of the type $d_{3/2} \leftrightarrow S_{1/2}$ and also pointed out the tendency of the value of reduced lifetime to increase with neutron number for fixed proton number.

In recent years there have been many investigations on the properties of low excited state, the gamma transitions of which are found to be *l*-forbidden. The purpose of the present paper is to compile the data available on *l*-forbidden as well as *l*-allowed transitions and to observe the trend in the values of reduced lifetimes with neutron number and arrive at some sort of systematics, from which one can possibly distinguish between *l*-allowed and *l*-forbidden M1 transitions without any precise knowledge of the orbital angular momentum of the states involved in transtion.

ANALYSIS OF DATA AND RESULTS

Data on *l*-forbidden and *l*-allowed transitions are taken from recent publications references for which are given in Tables I to VI. The *l*-forbidden transitions are classified according to the type of transition, such as $d_{3/2} \leftrightarrows S_{1/2}$, $f_{5/2} \leftrightarrows P_{3/2}$ and $g_{7/2} \leftrightarrows d_{5/2}$. But in the case of *l*-allowed transitions, as the number of cases in each type of transition is small, all types of transitions are taken together. In each case a graph of $\log_{10} (\tau_\gamma E_\gamma{}^3)$ *versus* N, the neutron number is plotted. E_γ is the energy in Mev, and τ is given by

$$\tau\ (M1) = 1\cdot44\,(1 + \alpha_t)\,(1 + E2/M1)\,T_{1/2}$$

TABLE I

τE_r^3 for odd-neutron l-*forbidden Ml transitions of the type* $d_{3/2} \leftrightarrow S_{1/2}$

Nucleus	E_r (Kev.)	Transition	τ (Ml)	τE_r^3	$\log (\tau E_r^3)$	Reference
$_{48}Cd_{36}{}^{111}$	340	$3/2^+ \rightarrow 1/2^+$	$2\cdot 28\times 10^{-11}$	$8\cdot 98\times 10^{-13}$	$\overline{13}\cdot 9$	1
$_{48}Cd_{65}{}^{113}$	300	$3/2^+ \rightarrow 1/2^+$	$5\cdot 15\times 10^{-11}$	$1\cdot 39\times 10^{-12}$	$\overline{12}\cdot 14$	1
$_{50}Sn_{69}{}^{119}$	24	$3/2^+ \rightarrow 1/2^+$	$1\cdot 89\times 10^{-7}$	$2\cdot 61\times 10^{-12}$	$\overline{12}\cdot 41$	2
$_{52}Te_{69}{}^{121}$	214	$3/2^+ \rightarrow 1/2^+$	$3\cdot 26\times 10^{-9}$	$3\cdot 19\times 10^{-11}$	$\overline{11}\cdot 50$	2
$_{52}Te_{71}{}^{123}$	159	$3/2^+ \rightarrow 1/2^+$	$3\cdot 3\times 10^{-10}$	$1\cdot 32\times 10^{-12}$	$\overline{12}\cdot 1$	3
$_{52}Te_{73}{}^{125}$	35	$3/2^+ \rightarrow 1/2^+$	$4\cdot 4\times 10^{-8}$	$1\cdot 87\times 10^{-12}$	$\overline{12}\cdot 27$	3
$_{54}Xe_{75}{}^{129}$	40	$3/2^+ \rightarrow 1/2^+$	$1\cdot 25\times 10^{-8}$	$8\cdot 0\times 10^{-13}$	$\overline{13}\cdot 9$	1, 2
$_{54}Xe_{77}{}^{131}$	80	$3/2^+ \rightarrow 1/2^+$	$1\cdot 87\times 10^{-9}$	$9\cdot 62\times 10^{-13}$	$\overline{13}\cdot 98$	2
$_{56}Ba_{77}{}^{133}$	11·7	$3/2^+ \rightarrow 1/2^+$	$3\cdot 3\times 10^{-7}$	$5\cdot 28\times 10^{-13}$	$\overline{13}\cdot 72$	4

TABLE II

τE_r^3 for odd-proton l-*forbidden Ml transitions of the type* $d_{3/2} \leftrightarrow S_{1/2}$

Nucleus	E_r (Kev.)	Transition	τ (Ml)	τE_r^3	$\log (\tau E_r^3)$	Reference
$_{79}Au_{114}{}^{193}$	38	$1/2^+ \rightarrow 3/2^+$	$6\cdot 99\times 10^{-7}$	$3\cdot 83\times 10^{-11}$	$\overline{11}\cdot 5$	5
$_{79}Au_{116}{}^{195}$	65	$1/2^+ \rightarrow 3/2^+$	$6\cdot 66\times 10^{-8}$	$1\cdot 83\times 10^{-11}$	$\overline{11}\cdot 26$	5
$_{79}Au_{118}{}^{197}$	77	$1/2^+ \rightarrow 3/2^+$	$1\cdot 21\times 10^{-8}$	$5\cdot 55\times 10^{-12}$	$\overline{12}\cdot 74$	5
$_{81}Tl_{120}{}^{201}$	330	$3/2^+ \rightarrow 1/2^+$	$1\cdot 60\times 10^{-10}$	$6\cdot 00\times 10^{-10}$	$\overline{12}\cdot 78$	6
$_{81}Tl_{122}{}^{203}$	279	$3/2^+ \rightarrow 1/2^+$	$2\cdot 29\times 10^{-12}$	$4\cdot 97\times 10^{-14}$	$\overline{14}\cdot 69$	7
$_{81}Tl_{124}{}^{105}$	205	$3/2^+ \rightarrow 1/2^+$	$9\cdot 66\times 10^{-9}$	$8\cdot 32\times 10^{-11}$	$\overline{11}\cdot 9$	7

TABLE III

τE_r^3 for odd-proton l-forbidden Ml transitions of the type $f_{5/2} \leftrightarrow P_{3/2}$

Nucleus	E_r (Kev.)	Transition	τ (Ml)	τE_r^3	log (τE_r^3)	Reference
$_{23}V_{28}^{51}$	610	$3/2^- \to 5/2^-$	$3{\cdot}12\times10^{-11}$	$7{\cdot}09\times10^{-12}$	$\overline{12}{\cdot}85$	8
$_{29}Cu_{34}^{63}$	963	$5/2^- \to 3/2^-$	$8{\cdot}4\ \times10^{-13}$	$7{\cdot}5\times10^{-13}$	$\overline{13}{\cdot}87$	9
$_{23}Cu_{36}^{65}$	1114	$5/2^- \to 3/2^-$	$11{\cdot}9\times10^{-13}$	$1{\cdot}64\times10^{-12}$	$\overline{12}{\cdot}21$	10
$_{33}As_{42}^{75}$	280	$5/2^- \to 3/2^-$	$5{\cdot}61\times10^{-10}$	$1{\cdot}23\times10^{-11}$	$\overline{11}{\cdot}09$	11
$_{47}As_{60}^{107}$	99	$5/2^- \to 3/2^-$	$7{\cdot}20\times10^{-10}$	$6{\cdot}99\times10^{-13}$	$\overline{13}{\cdot}84$	7, 12
$_{47}As_{62}^{109}$	109	$5/2^- \to 3/2^-$	$9{\cdot}38\times10^{-10}$	$1{\cdot}15\times10^{-12}$	$\overline{12}{\cdot}06$	7, 12

TABLE IV

τE_r^3 for odd-proton l-forbidden Ml transitions of the type $g_{7/2} \leftrightarrow d_{5/2}$

Nucleus	E_r (Kev.)	Transition	τ (Ml)	τE_r^3	log (τE_r^3)	Reference
$_{51}Sb_{70}^{121}$	70	$7/2^+ \to 5/2^+$	$2{\cdot}98\times10^{-8}$	$1{\cdot}02\times10^{-11}$	$\overline{11}{\cdot}01$	13
$_{51}Sb_{70}^{121}$	37	$7/2^+ \to 5/2^+$	$6{\cdot}00\times10^{-8}$	$3{\cdot}04\times10^{-12}$	$\overline{12}{\cdot}48$	14
$_{55}Cs_{76}^{131}$	123·7	$5/2^+ \to 7/2^+$	$1{\cdot}02\times10^{-7}$	$1{\cdot}93\times10^{-10}$	$\overline{10}{\cdot}28$	15
$_{55}Cs_{78}^{133}$	81	$5/2^+ \to 7/2^+$	$2{\cdot}48\times10^{-8}$	$1{\cdot}32\times10^{-11}$	$\overline{11}{\cdot}12$	16
$_{55}Cs_{80}^{135}$	248	$5/2^+ \to 7/2^+$	$4{\cdot}4\ \times10^{-10}$	$6{\cdot}26\times10^{-12}$	$\overline{12}{\cdot}79$	4
$_{57}La_{80}^{137}$	10	$5/2^+ \to 7/2^+$	$1{\cdot}67\times10^{-7}$	$1{\cdot}67\times10^{-13}$	$\overline{13}{\cdot}22$	17
$_{57}La_{82}^{139}$	166	$5/2^+ \to 7/2^+$	$2{\cdot}6\ \times10^{-9}$	$1{\cdot}19\times10^{-11}$	$\overline{11}{\cdot}07$	18
$_{59}Pr_{82}^{141}$	145	$7/2^+ \to 5/2^+$	$4{\cdot}2\ \times10^{-9}$	$1{\cdot}28\times10^{-11}$	$\overline{11}{\cdot}1$	18, 23
$_{59}Pr_{84}^{143}$	57	$7/2^+ \to 5/2^+$	$5{\cdot}4\ \times10^{-8}$	$1{\cdot}00\times10^{-11}$	$\overline{11}{\cdot}0$	18
$_{61}Pm_{84}^{145}$	61	$7/2^+ \to 5/2^+$	$2{\cdot}9\ \times10^{-8}$	$6{\cdot}58\times10^{-12}$	$\overline{12}{\cdot}8$	18
$_{61}Pm_{86}^{147}$	91	$5/2^+ \to 7/2^+$	$1{\cdot}12\times10^{-8}$	$8{\cdot}43\times10^{-12}$	$\overline{12}{\cdot}92$	18, 21
$_{63}Eu_{84}^{147}$	229	$7/2^+ \to 5/2^+$	$3{\cdot}2\ \times10^{-10}$	$3{\cdot}84\times10^{-12}$	$\overline{12}{\cdot}57$	18
$_{63}Eu_{86}^{149}$	160	$7/2^+ \to 5/2^+$	$7{\cdot}5\ \times10^{-10}$	$3{\cdot}07\times10^{-12}$	$\overline{12}{\cdot}45$	18
$_{63}Eu_{88}^{151}$	21	$7/2^+ \to 5/2^+$	$1{\cdot}47\times10^{-7}$	$1{\cdot}36\times10^{-12}$	$\overline{12}{\cdot}1$	18, 22

Table V

τE_{γ}^{3} *for odd-neutron* l-*allowed Ml transitions*

Nucleus	E_r (Kev.)	Transition	τ (Ml)	τE_r^3	log (τE_r^3)	Reference
${}_{26}\mathrm{Fe}_{31}{}^{57}$	14	$3/2^- \rightarrow 1/2^-$	$1\cdot73\times10^{-6}$	$5\cdot18\times10^{-12}$	$\overline{12}\cdot71$	19
${}_{34}\mathrm{Se}_{43}{}^{77}$	246	$1/2^- \rightarrow 3/2^-$	$1\cdot1\times10^{-10}$	$1\cdot63\times10^{-12}$	$\overline{12}\cdot21$	20
${}_{36}\mathrm{Kr}_{47}{}^{83}$	9·3	$7/2^+ \rightarrow 9/2^+$	$2\cdot48\times10^{-7}$	$2\cdot1\times10^{-12}$	$\overline{12}\cdot3$	17
${}_{42}\mathrm{Mo}_{53}{}^{95}$	203	$5/2^+ \rightarrow 3/2^+$	$1\cdot46\times10^{-9}$	$1\cdot21\times10^{-11}$	$\overline{11}\cdot08$	20
${}_{48}\mathrm{Cd}_{63}{}^{111}$	95	$3/2^+ \rightarrow 5/2^+$	$6\cdot49\times10^{-11}$	$5\cdot56\times10^{-13}$	$\overline{13}\cdot74$	1
${}_{48}\mathrm{Cd}_{65}{}^{113}$	282	$3/2^+ \rightarrow 5/2^+$	$6\cdot89\times10^{-10}$	$1\cdot54\times10^{-11}$	$\overline{11}\cdot18$	1
${}_{54}\mathrm{Xe}_{77}{}^{131}$	284	$5/2^+ \rightarrow 3/2^+$	$3\cdot21\times10^{-11}$	$7\cdot36\times10^{-13}$	$\overline{13}\cdot86$	2
${}_{80}\mathrm{Hg}_{119}{}^{199}$	208	$3/2^- \rightarrow 1/2^-$	$2\cdot24\times10^{-10}$	$2\cdot02\times10^{-12}$	$\overline{12}\cdot30$	7

Table VI

τE_{γ}^{3} *for odd-proton* l-*allowed Ml transitions*

Nucleus	E_r (Kev.)	Transition	τ (Ml)	τE_r^3	log (τE_r^3)	Reference
${}_{23}\mathrm{V}_{28}{}^{51}$	320	$5/2^- \rightarrow 7/2^-$	$3\cdot04\times10^{-9}$	$9\cdot95\times10^{-11}$	$\overline{11}\cdot99$	8
${}_{25}\mathrm{Mn}_{30}{}^{55}$	128	$5/2^- \rightarrow 7/2^-$	$3\cdot5\times10^{-10}$	$7\cdot34\times10^{-13}$	$\overline{13}\cdot86$	20
${}_{29}\mathrm{Cu}_{34}{}^{63}$	669	$1/2^- \rightarrow 3/2^-$	$3\cdot00\times10^{-13}$	$8\cdot98\times10^{-14}$	$\overline{14}\cdot95$	9
${}_{47}\mathrm{Ag}_{60}{}^{107}$	324	$3/2^- \rightarrow 1/2^-$	$1\cdot05\times10^{-12}$	$3\cdot57\times10^{-14}$	$\overline{14}\cdot55$	7
${}_{47}\mathrm{Ag}_{62}{}^{109}$	309	$3/2^- \rightarrow 1/2^-$	$8\cdot33\times10^{-12}$	$2\cdot46\times10^{-13}$	$\overline{13}\cdot39$	7
${}_{51}\mathrm{Sb}_{70}{}^{121}$	506	$3/2^+ \rightarrow 5/2^+$	$3\cdot0\times10^{-12}$	$3\cdot88\times10^{-13}$	$\overline{13}\cdot58$	14
${}_{79}\mathrm{Au}_{114}{}^{193}$	258	$5/2^+ \rightarrow 3/2^+$	$2\cdot34\times10^{-7}$	$4\cdot01\times10^{-9}$	$\overline{9}\cdot60$	5
${}_{79}\mathrm{Au}_{118}{}^{197}$	279	$5/2^+ \rightarrow 3/2^+$	$3\cdot51\times10^{-11}$	$7\cdot63\times10^{-13}$	$\overline{13}\cdot88$	5
${}_{81}\mathrm{Tl}_{122}{}^{203}$	401	$5/2^+ \rightarrow 3/2^+$	$2\cdot29\times10^{-12}$	$1\cdot46\times10^{-13}$	$\overline{13}\cdot16$	
${}_{81}\mathrm{Tl}_{124}{}^{205}$	410	$5/2^+ \rightarrow 3/2^+$	$3\cdot19\times10^{-12}$	$2\cdot2\times10^{-13}$	$\overline{13}\cdot34$	7

Where α_t = Total internal conversion coefficient, and $T_{1/2}$ = Half life of the state in sec. The theoretical line for proton transition given by Moszkowski[8], is drawn on each graph assuming the statistical factor to be unity. Calculations for nuclei in deformed region are not made as the single particle model is not a good approximation in that region.

L-FORBIDDEN TRANSITIONS

In Fig. 1 the log (τE_r^3) values are plotted against neutron number for odd-neutron transitions of the type $d_{3/2} \leftrightarrow S_{1/2}$. It can be seen that the values of log (τE_r^3) are almost constant and lie in the neighbourhood of $\overline{12}$. log (τE_r^3) values show a tendency to increase slightly with neutron number for fixed proton number. Only Te^{121} deviates from these conclusions. This may be because of the fact that the upper limit of the lifetime is considered for calculation. Precise determination of the half life of 214 Kev. excited level may bring the value of log (τE_r^3 near $\overline{12}$).

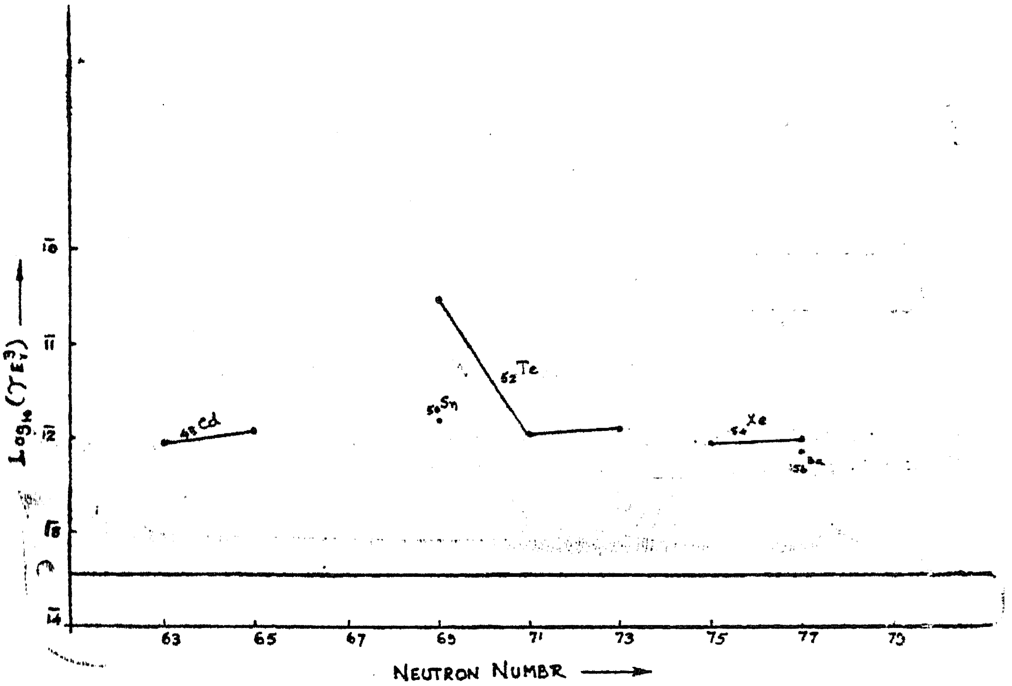

FIG. 1. Variation of $\log_{10}$ (τE_r^3) with neutron number for odd-neutron l-forbidden Ml transitions of the type $d_{3/2} \leftrightarrow S_{1/2}$, Isotopes are connected by lines.

It is unfortunate that data on only a few cases of odd-proton transition of the type $d_{3/2} \leftrightarrow S_{1/2}$ is available to make any definite conclusions. Within the context of the limited data, it can be remarked that even though log (τE_r^3) values do not show a tendency to remain constant they are scattered around

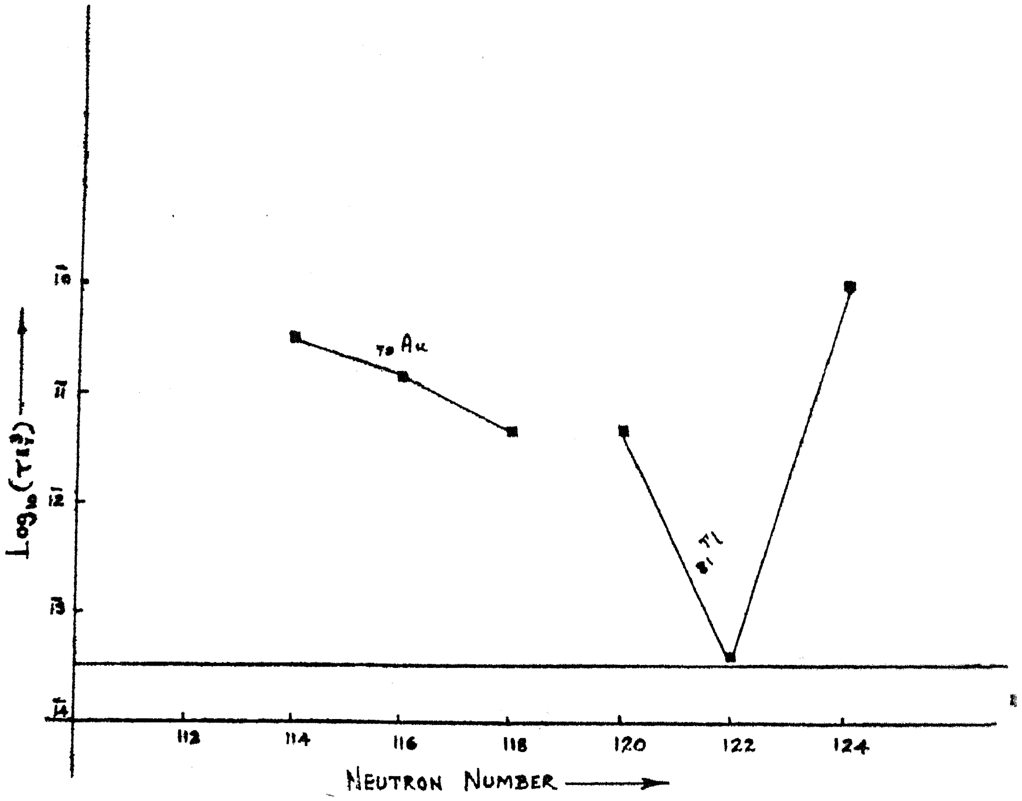

FIG. 2. Variation of log$_{10}$ (τ E$_r^3$) with neutron number for odd-proton *l*-forbidden M1 transitions of the type $d_{3/2}\leftrightarrow S_{1/2}$, Isotopes are connected by lines.

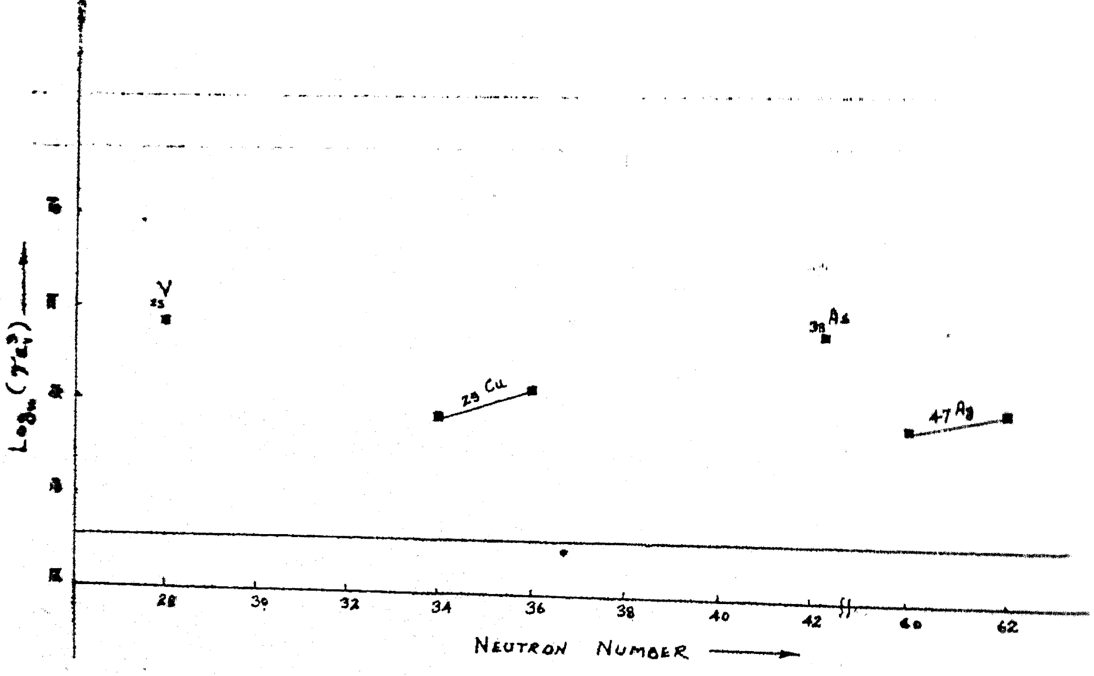

FIG. 3. Variation of log$_{10}$ (τ E$_r^3$) with neutron number for odd-proton *l*-forbidden M1 transitions of the type $f_{5/2}\leftrightarrow_{3/2}$, Isotopes are connected by lines.

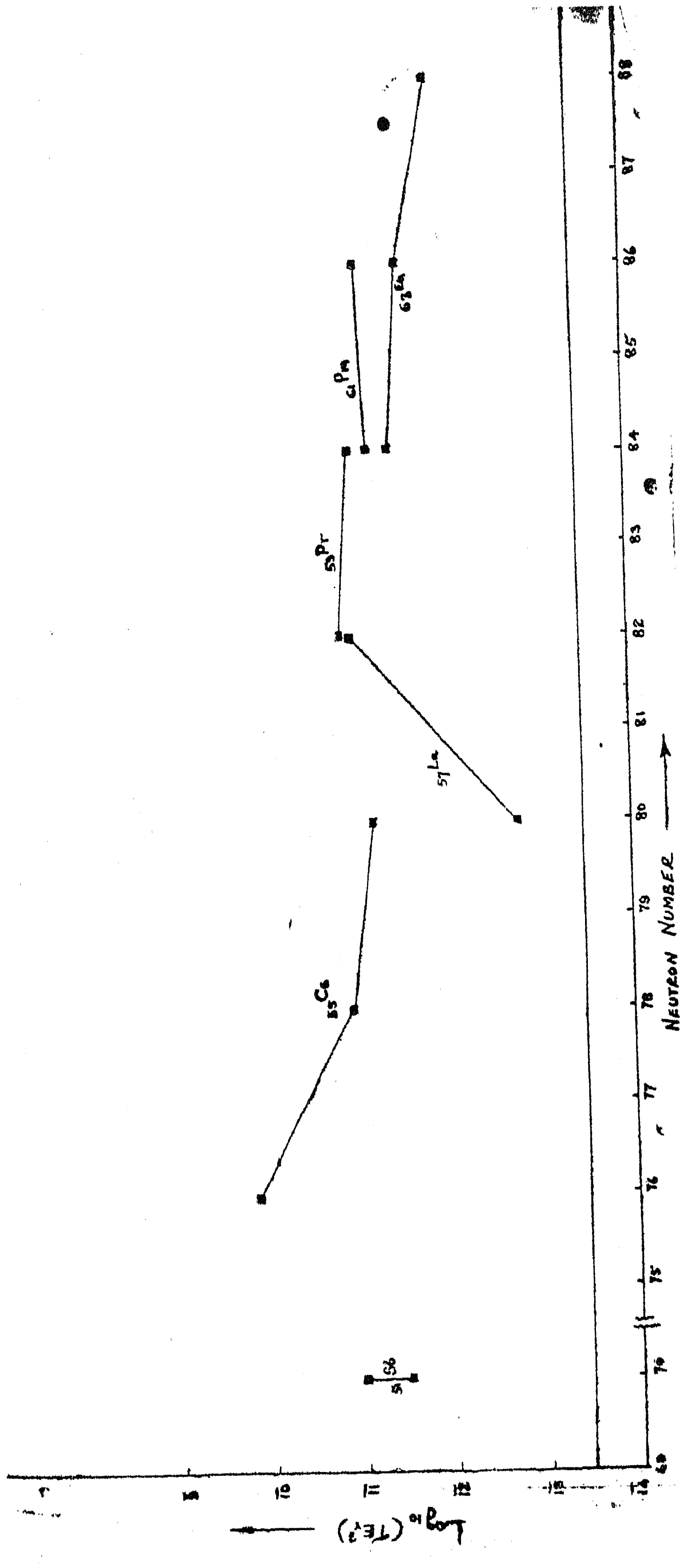

FIG. 4. Variation of $\log_{10}(\tau E_\gamma^3)$ with neutron number for odd-proton *l*-forbidden M1 transitions of the type $g_{7/2} \leftrightarrow d_{5/2}$. Iso are connected by lines.

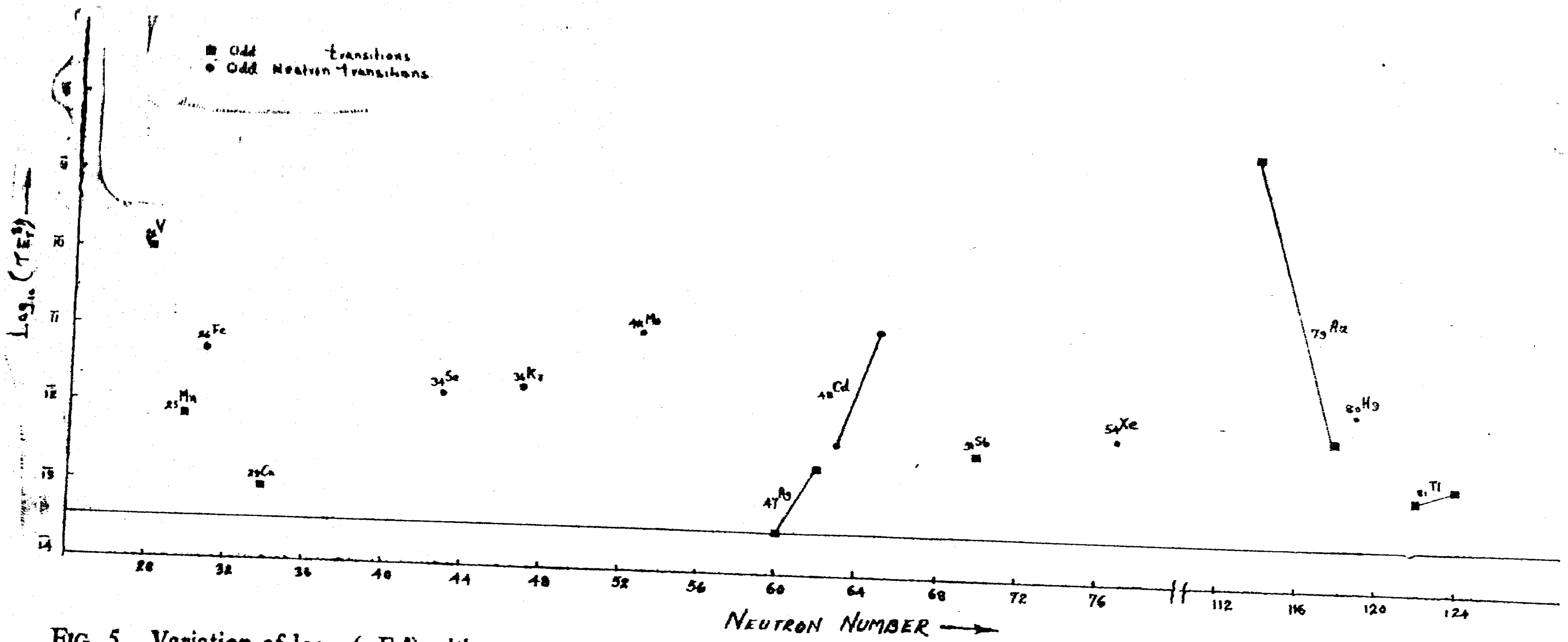

FIG. 5. Variation of $\log_{10}(\tau E_r^3)$ with neutron number for l-allowed MI transitions indicates odd-neutron transitions. Isotopes are connected by lines. ● indicates odd-neutron transitions. ☐ indicates odd-proton transitions.

$\overline{11}$. It is interesting to note that log (τE_γ^3) values for odd-proton transition are greater than the corresponding odd-neutron transition by a factor of 10. Contradictory to this the odd-neutron *l*-allowed M1 transitions are faster than the odd-proton *l*-allowed Ml transitions. For Au isotopes, log (τE_γ^3) decreases while it increases in the case of Tl isotopes as N increases. Tl^{203} is an exception to the above observation and is very close to single particle estimate.

In Table III data on *l*-forbidden odd-proton transitions of the type $f_{5/2}\leftrightarrow P_{3/2}$ are shown. In the case of V^{51} τ (Ml) is calculated from (1) the reduced transition probability B (E2 3/2↔7/2), (2) the cascade/crossover ratio for the decay of $\overline{3/2}$ level and (3) the E2/Ml mixing parameter. It is seen from Fig. 3 that log (τE_γ^3) is almost constant and lies in the neighbourhood of $\overline{12}$, which means that log (τE_γ^3) value is less than that of $d_{3/2}\leftrightarrow S_{1/2}$ odd-proton transitions and equal to that of the $d_{3/2}\leftrightarrow s_{1/2}$ odd-neutron transitions. V^{51} and As^{75} deviate from this rule. Here again it is observed that for Ag and Cu isotopes log (τE_γ^3) increases with neutron number.

Figure 4 shows the variation of log (τE_γ^3) with neutron number for odd-proton transitions of the type $g_{7/2}\leftrightarrow d_{5/2}$. The reduced lifetime of these transitions is almost constant with a value equal to $\overline{11}$. Comparing this with the other types of transition, it is observed that it is equal to the reduced life-time of $d_{3/2}\leftrightarrow s_{1/2}$ odd-proton transition while it is 10 times larger than that of $d_{3/2}\leftrightarrow s_{1/2}$ odd neutron and $f_{5/2}\leftrightarrow P_{3/2}$ odd-proton transitions. Log (τE_γ^3) value decreases in the isotopes of Cs and Pr while it increases in the isotopes of La and Pm. In the case of Eu^{151} there exists some discrepancy in the value of lifetime of 21 Kev. excited state reported by several investigators. Taking $T_{1/2} = 3\cdot 4\times 10^{-9}$ sec. reported by Berlovich *et al.*[9] the value of log (τE_γ^3) comes to $\overline{12}\cdot 1$ (shown in Fig. 4). Horen *et al.*[10] give $T_{1/2} = (9\cdot 5 \pm 0\cdot 5)\times 10^{-9}$ sec. for the same level, using which gives $\overline{12}\cdot 58$ (not shown in Figure), for log (τE_γ^3) which comes nearer to our empirical value of $\overline{11}$. Reinvestigation on the lifetime of 21 Kev. level in Eu^{151} may clarify this situation. La^{137} being nearer to and Cs^{131} being farther away from the single particle estimate deviate from the above conclusions.

L-ALLOWED ML TRANSITIONS

The variation of log (τE_γ^3) with neutron number for both odd-proton and odd-neutron transitions are shown in a single plot. Log (τE_γ^3) values for odd-proton transition are grouped around $\overline{13}\cdot 5$ which is nearly 10 times larger than the single particle estimate. This speaks of the impurity of the states involved in the transition. The situation is worse in the case of odd-neutron transitions. It is a surprise to find that the log (τE_γ^3) value for odd-neutron *l*-allowed transitions is somewhat equal to that of *l*-forbidden odd-neutron transitions of the type $d_{3/2} \leftrightarrow S_{1/2}$. In odd proton transitions, V^{51} and Au^{193}, and in odd-neutron transitions, Cd^{113} are exceptions.

CONCLUSIONS

The general tendency of log (τE_γ^3) value for each type of transition is to remain constant. In the case of *l*-forbidden transitions, the value of log (τE_γ^3) lies near $\overline{12}$ for $d_{3/2} \leftrightarrow S_{1/2}$ odd-neutron transitions and $f_{5/2} \leftrightarrow P_{3/2}$ odd-proton transitions, and $\overline{11} \cdot 0$ for $g_{7/2} \leftrightarrow D_{5/2}$ and $d_{3/2} \leftrightarrow S_{1/2}$, odd-proton transitions. In the case of *l*-allowed odd-proton and odd-neutron transitions the log (τE_γ^3) values are respectively $\overline{13} \cdot 5$ and $\overline{12} \cdot 0$. This shows that it is *not* possible to distinguish between *l*-allowed and *l*-forbidden odd-neutron transitions unless the orbital angular momenta of the two levels involved in the transitions are known. But, however, it is possible to distinguish between *l*-forbidden and *l*-allowed odd-proton transition empirically depending on their reduced lifetimes. In each type of transitions discussed above log $\leftrightarrow (\tau E_\gamma^3)$ value increases slightly except in $g_{7/2}$ $d_{5/2}$ odd-proton *l*-forbidden transitions where the value decreases with neutron number for fixed proton number.

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