PENETRATION EFFECTS IN M1 TRANSITIONS IN ^{233}U

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1. INTRODUCTION

Because of the finite nuclear size the internal conversion processes take place partly within the nucleus itself. The probability for such a process can be neglected for allowed gamma transitions; for hindered however, conversion within the nuclear volume can considerably contribute to the measured conversion coefficient ("penetration effects"). If this is the case, the measured conversion coefficients yield information about the particular nuclear structure. Malmskog et al [1] have found the M1 transitions in ^{233}U to be by a factor from 20 to 1000 hindered as compared to the single-particle estimates; penetration effects could be thus expected in those transitions.

In this work we examined whether the nuclear structure effects on the M1 conversion processes in ^{233}U could be reasonably well described within the frame of simple Nilsson model. Experimental penetration parameters were deduced for six $|\Delta K| = 1$ transitions and compared with model values.

2. EXPERIMENTAL RESULTS

Conversion intensities were measured on the $\pi\sqrt{2}$ double-focusing beta spectrometer at the Vinča Institute, seven times for each of the transitions of 75, 86, 103, 300, 312 and 340 keV. Weighted mean values from these measurements are listed in Table I and compared with the data given by Albridge et al [2]. Errors in their results are estimated to 20% and within those limits the agreement is satisfactory. Using our conversion intensities, the measured conversion coefficient α_K(312 keV) = = 0.69 (7) from Bisgard et al [3] and gamma intensities from ref. 2, the conversion coefficients for the quoted transitions were deduced. They are listed in Table II.

Table I

Relative Conversion Electron Intensities

E_γ	SHELL	PRESENT WORK		REF. 2
75,13	L_I	27.9	(1)	31.8
	L_{II}	3.38	(7)	4.44
	L_{III}	0.26	(3)	0.44
86.45	L_I	30.9	(1)	34.8
	L_{II}	3.97	(8)	4.81
	L_{III}	0.42	(8)	0.96
103.6	L_I	8.76	(8)	8.89
	L_{II}	1.28	(6)	1.63
	L_{III}	0.28	(4)	0.37
299.8	K	18.40	(8)	19.3
	L_I	3.31	(2)	2.99
	L_{II}	0.46	(1)	0.45
311.7	K	100		100
	L_I	17.29	(4)	17.0
	L_{II}	2.43	(3)	1.59
340.3	K	8.89	(5)	8.52
	L_I	1.61	(1)	1.85
	L_{II}	0.24	(1)	0.24
	L_{III}	0.022	(6)	-

Table II

Conversion Coefficients

E_γ	SHELL	I_e (pres.work)		I_γ (ref.2)		α (exp)	α(M1) (ref.4)	α(E2) (ref.4)
75	L_I	27.9	(1)	3.4	(3)	8.2 (7)	7.59	0.837
86	L_I	30.9	(1)	7	(1)	4.4 (6)	5.03	0.483
103	L_I	8.76	(8)	2.7	(3)	3.2 (4)	2.98	0.252
300	K	18.40	(8)	26	(2)	0.71(7)	0.848	0.0762
312	K	100		143	(14)	0.69(7)	[a]·0.763	0.0708
340	K	8.93	(4)	16	(1)	0.55(4)	0.601	0.06.00

a. This value was taken from Bisgard et al [3]

3. DETERMINATION OF PENETRATION PARAMETERS

If the transition is a mixture of M1 and E2 com-
ponents the conversion coefficient for the i-th shell (or sub-
shell) is:

$$\alpha_i = |\alpha_i(E2)\delta^2 + \alpha_i(M1)(1+B_1^i\lambda + B_2^i\lambda^2)| |1 + \delta^2|^{-1} \qquad (1)$$

where α_i(E2) and β_i(M1) are the theoretical "no penetration"
conversion coefficients; B_1 and B_2 are the penetration coeffici-
ents; $\delta^2 = I_\gamma(M1)/I_\gamma(E2)$ and $\lambda = P(M1)/G(M1)$ is the ratio of the pe-
netration matrix element to the gamma matrix element. Our re-
sults are analysed in the $\lambda - \delta^2$ plane with the values for α, β
and B calculated from refs. 4 and 5. Results of the analysis for
the 86 and 312 keV transitions are presented in Figs. 1 and 2.
Experimental values of the penetration parameters are given in
Table III and are compared with the theoretical values obtained
by interpolation of Nilsson matrix elements from refs. 6 and 7.
The parameters used were $\beta = 0.277$, $g_s = 0.6g_s$(free) and $g_R = Z/A$.

For the K=1/2 → K=3/2 transitions our results con-
firm model predictions and prove the penetration effects to be
negligible in those transitions.
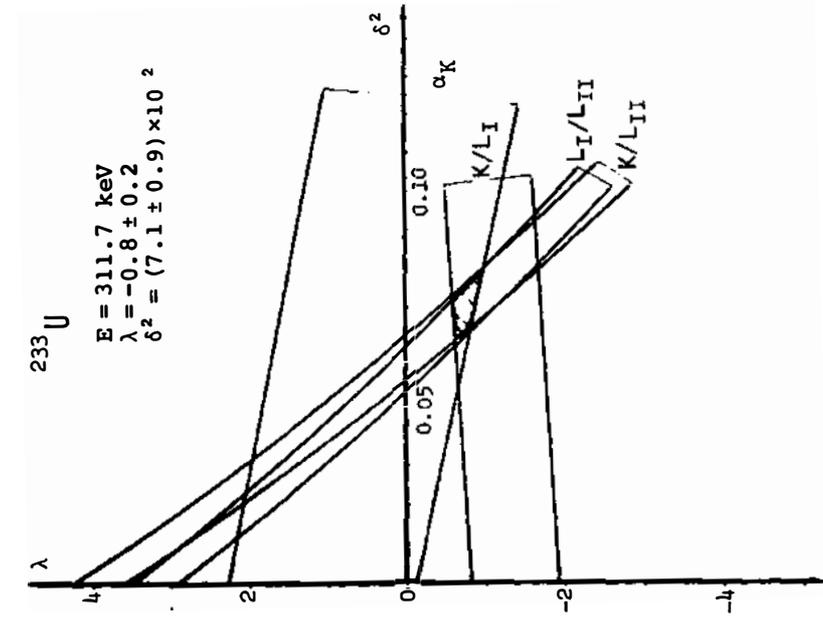
Fig. 2

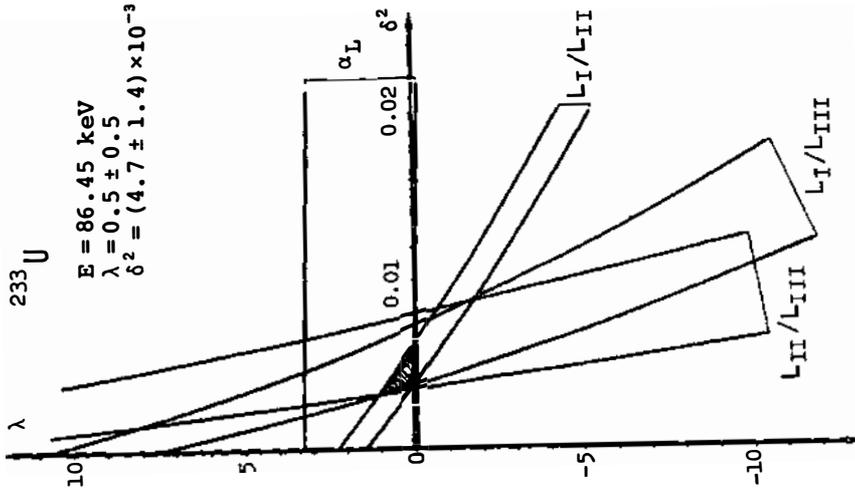Results for the 312 keV transition
analysed in the λ-δ² plane

Fig. 1

Results for the 86 keV transition ana-
lysed in the λ-δ² plane

Table III

PENETRATION PARAMETERS

$2K_i \rightarrow 2K_f$	E_γ	$2J_i \rightarrow 2J_f$	λ (exp)	λ (NILSS)
	75	3 → 5	−0.5 (6)	
1 → 3	86	1 → 3	0.5 (5)	0.026
	103	3 → 3	−1.8 (16)	
	300	5 → 7	1.8 (9)	
3 → 5	312	3 → 5	−0.8 (2)	−1.054
	340	5 → 5	10.5 (25)	

For the K=3/2→K=5/2 transitions the agreement with the experiment is much worse. The greatest deviation is found for the 340 keV transition in which the presence of the E0 admixture has been revealed [8]. Since theoretical values of penetration parameters do not depend either on the Coriolis interaction or the pairing effects [9], the cause of those deviations may be found in the interactions of the rotation-vibration or particle-vibration type.

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