Description of Long-Lived Isomers in $^{254}_{101}Md_{153}$

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Spectroscopic data in respect of Trans-Fermium nuclei beyond the N=152 deformed shell closure are very rare, and rarer still is a credible interpretation of such data [1]. Presently available experimental information [1,2] on the lightest such nucleus $^{254}_{101}Md_{153}$ provides a typical instance illustrating this feature. This nucleus, first observed in 1970 [2], 'was found to decay by EC with a $t_{1/2}$=10(3) m'; these experiments also 'indicated another $t_{1/2}$=28(8) m isomer'. Even 45 years later no attempt to characterize these results has been reported anywhere [1]. The latest Nuclear Data Sheets [2] mentions 8 different assignments for ^{254}Md ground state (gs) and low-lying states. Presently we seek to investigate the low-energy level structures in ^{254}Md and thereby deduce its gs spin-parity (J^{π}) and two-quasiparticle (2qp) configuration and also characterize its earlier indicated long-lived isomers. Our analysis employs the Two Quasi-particle Rotor Model (TQRM) which has been extensively and effectively used to describe the level schemes of various doubly odd deformed nuclei over the past three decades [3]. In particular, level structures of the isotonic ^{252}Es [4] and isotopic ^{250}Md [5] neighbours have been investigated earlier by us using this formalism.

In our 3-step TQRM, the relevant 1qp configuration space is mapped using the experimental n-orbital energies from a recent study [6] of N=153 ^{253}Fm levels and p-orbital energies from (Z±2) neighbours [1]. These data are respectively entered in the first column and top row of Table 1. Physically admissible K=│Ωp ± Ωn│ 2qp bands arising from the coupling of these 1qp Nilsson orbitals form the subject of Table 1. Entries in each box therein are the 2qp band quantum numbers K_T (spins-parallel triplet) and K_S (spins-antiparallel singlet) according to the GM rule; the numbers within parentheses are summed (Ep + En) energies in keV, which provide a zeroth order estimate of $E_x(K_T)$, with $E_x(K_S)$ estimated ~100 keV above it. Finally, the 2qp bandhead energies are evaluated in the TQRM formulation [3,4] using the model parameters obtained by fitting the experimental spectra of isotonic ^{252}Es and ^{250}Bk neighbours [3,4]; E_{GM} ~ 100 keV is taken as default value alternatively. Partial ^{254}Md level scheme thus obtained is shown in Fig.1 in the context of characterizing the suggested two isomers. A critical examination of these data leads us to the following conclusions.

Table 1: Listing of physically admissible 2qp GM doublet bands in $^{254}_{101}Md_{153}$ from coupling of the observed 1qp p-orbitals from (Z±2) neighbours (top row) and n-orbitals from ^{253}Fm [1,4,6] (first column). Numbers within parenthesis in each box are the summed [E(p_i) + E(n_j)] energies in keV.

p_i \ n_j	p_0: 0 7/2$^-$[514↓] K_T K_S	p_1: 40 1/2$^-$[521↓] K_T K_S	p_2: ~ 400 7/2$^+$[633↑] K_T K_S	p_3: ~ 500 9/2$^+$[624↑] K_T K_S
n_0: 0 1/2$^+$[620↑]	3^- 4^- (0)	0^- 1^- (40)	4^+ 3^+ (~ 400)	5^+ 4^+ (~ 500)
n_1: 124 3/2$^+$[622↓]	2^- 5^- (124)	2^- 1^- (164)	2^+ 5^+ (524)	3^+ 6^+ (624)
n_2: 140 7/2$^+$[613↑]	0^- 7^- (140)	3^- 4^- (180)	7^+ 0^+ (540)	8^+ 1^+ (640)
n_3: 330 11/2$^-$[725↑]	2^+ 9^+ (330)	5^+ 6^+ (370)	9^- 2^- (770)	10^- 1^- (870)

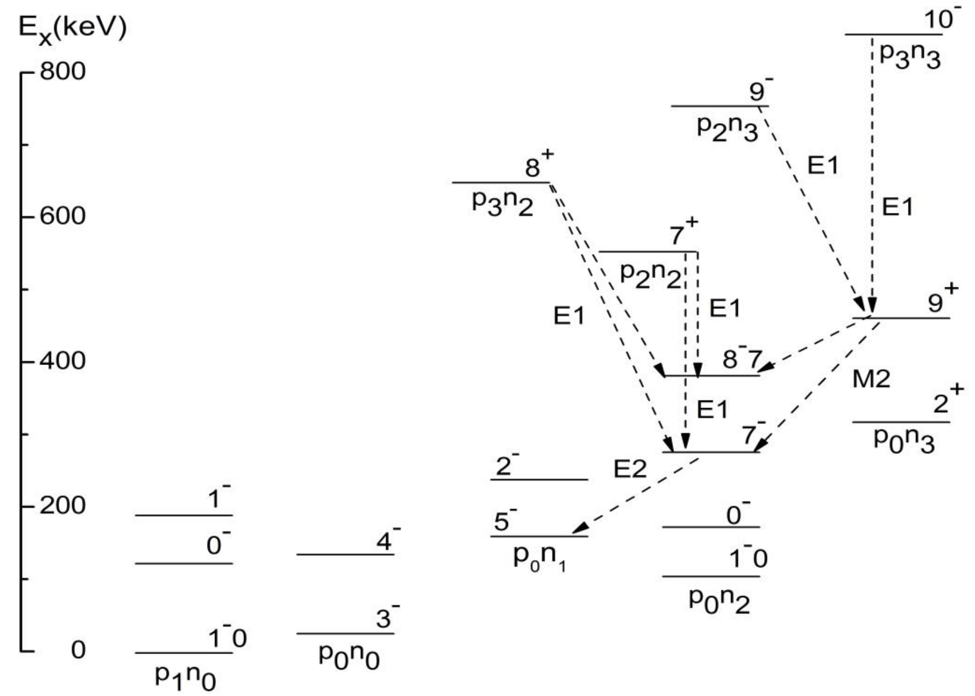

Fig. 1: Partial level scheme of ^{254}Md including low-lying (< 250 keV) low-spin and all the high-spin (≥7) bands. Arrows therein denote the lowest multipole decay path for each high-spin (K≥7) state.

(a) The lowest-lying levels in ^{254}Md spectrum correspond to the very closely spaced low-spin $1^-0\{p_1:1/2^-\otimes n_0:1/2^+\}$ and $3^-\{p_0:7/2^-\otimes n_0:1/2^+\}$ configurations. Our present set of input parameters places the 1^-0 level lower than the 3^- level, and hence designates it as the ^{254}Md gs.

(b) Existence of two isomers with comparable $t_{1/2}$ values, each with %ε ≤100 decay mode, normally requires ΔK≥5. Having identified a low spin gs, we examine location of all the physically admissible high-spin (K≥7) 2qp structures (Fig.1). It is evident therein that each K≥7 state admits of a low multipole (ΔI≤2) em decay path. Consequently we categorically rule out a high-spin structure as a long-lived ^{254}Md isomer.

(c) Examining possible alternatives, we find that the pair of low-lying 1^-0 and 3^- levels offer such a possibility. The two levels have same n_0 constituent, while the proton orbitals, namely $p_07/2^-$ & $p_11/2^-$, differ by ΔK=ΔΩ=3. The current data tables [1] reveal that in $_{101}$Md (A=245, 247, 249) and $_{103}$Lr (A=253 & 255) isotopes these p orbitals occur as close-lying isomers with comparable $t_{1/2}$ in each case. Occurrence of ΔK=3 isomers with $t_{1/2}$ ~ m in ^{166}Lu has also been pointed out earlier by us [7].

Considering all these factors, we arrive at the following assignments for ^{254}Md isomer pair:

10 m	gs	$1^-0\{p_1:1/2^-[521]\otimes n_0:1/2^+[620]\}$
28 m	0+x	$3^-3\{p_0:7/2^-[514]\otimes n_0:1/2^+[620]\}$

Investigations of these and other distinctive features of ^{254}Md level scheme are being pursued.

References

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