Intrinsic Structures in highly n-deficient odd-odd nucleus ^{158}Ho

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The observed [1] level scheme for the highly neutron-deficient odd-odd nucleus ^{158}Ho (which has 7 neutrons less than the stable isotope ^{165}Ho) has several distinctive features. Firstly, it has 3 long-lived isomers with comparable half-lives, namely, an 11.3m 5^+ ground state, a 28m 2^- isomer at 67.2 keV and a 21.3m 9^+ isomer. As listed in the latest [1] Nuclear Data Sheets (NDS), Sood et al. [2] had earlier reported two-quasiparticle (2qp) configuration for these 3 isomers, placed the 9^+ isomer at ~180keV, and also assigned 2qp configuration to the 29ns isomeric state at E_x=156.9 keV. However, the latest NDS evaluation of ^{158}Er ε-decay [1], while incorporating the allowed-unhindered decay to a newly identified 1^+ level at 146.90 keV [3] superseding the earlier reported 139.2 keV 1^- level, does not include any characterisation whatsoever of the other 9 levels of ^{158}Ho populated in this decay. The present study reports the results of such an investigation, based on a critical examination of the available configuration space and the results of Quasi-Particle Rotor Model (QPRM) calculation of various 2qp bandhead energies.

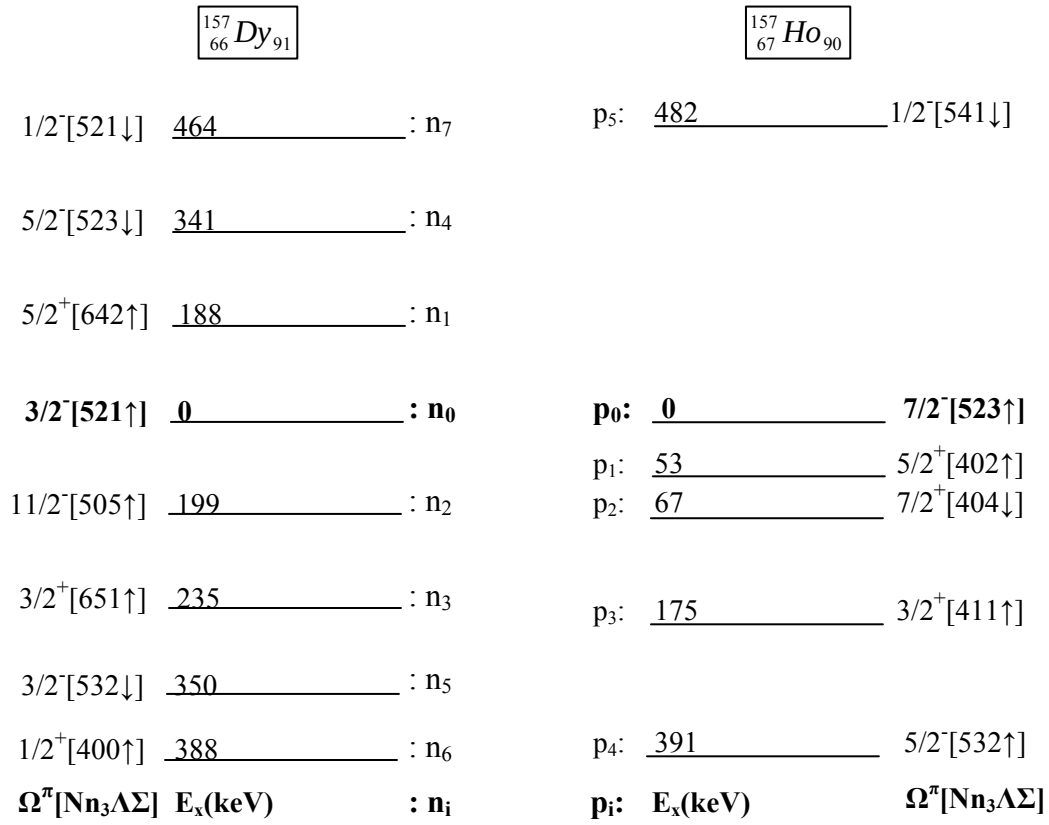

Fig. 1: Experimental [4] excitation energies of N=91 (^{157}Dy) and Z=67 (^{157}Ho) n and p Nilsson orbitals in (A-1) isotone/isotope relevant to the level spectra of odd-odd ^{158}Ho. Following convention of Jain et al. [5], the particle/hole states are placed above/below the respective Fermi level.

Table 1: Two-quasiparticle (2qp) bands expected in ^{158}Ho based on the observed[4] 1qp orbitals in respective (A-1) isotone/isotope as seen in Fig. 1. Entries in each box are $K^{\pm}=|\Omega_p \pm \Omega_n|$ values with the spins-parallel K_T listed first and spins-antiparallel K_S next for each GM doublet. K^{π} and E_x(keV) of confirmed levels are shown in bold. Except n_2 (for 21m 9^+ isomer), only orbitals relevant to ^{168}Er EC decay are included herein. All E_x are rounded off values in keV.

n_i: E_x / p_i: E_x	**n_0: 0** **3/2⁻[521↑]**	**n_1: 188** **5/2⁺[642↑]**	**n_2: 199** **11/2⁻[505↑]**	**n_4: 341** **5/2⁻[523↓]**	**n_7: 464** **1/2⁻[521↓]**
p_0: 0 **7/2⁻[523↑]**	**5^+ 2^+** **0 75**	6^- 1^-	**9^+ 2^+** **180**	**1^+** **147** 6^+	3^+ 4^+
p_1: 53 **5/2⁺[402↑]**	4^- 1^-	5^+ 0^+		0^- 5^-	2^- 3^-
p_2: 67 **7/2⁺[404↓]**	**2^- 5^-** **67 157**	1^+ 6^+		6^- 1^-	4^- 3^-
p_3: 175 **3/2⁺[411↑]**	3^- 0^-	4^+ 1^+		1^- 4^-	1^- 2^-
p_4: 391 **5/2⁻[532↑]**	4^+ 1^+	5^- 0^-		0^+ 5^+	2^+ 3^+

The experimentally identified [4] single particle Nilsson orbitals $\Omega^{\pi}[Nn_3\Lambda\Sigma]$ and their observed excitation energies (input data for QPRM) in the respective (A-1) isotope and isotone, namely ^{157}Ho and ^{157}Dy are shown in Fig. 1. The 2qp band quantum numbers, $K^{\pm}=|\Omega_p \pm \Omega_n|$ for each (Ω_p, Ω_n) coupling expected in the odd-odd nucleus ^{158}Ho are listed in the Table 1. This table includes K-listings only for the 2qp bands with confirmed assignments (bold entries [1-3] or bands expected to be populated in ^{158}Er decay.

Our analysis confirm (entries in bold in table 1) the earlier[1-3] 2qp assignments to the 3 isomers and the two isomeric states at 146.7 keV(1.85ns) and at 156.9 keV(29ns). All the other 9 levels populated in ^{158}Ho from ^{158}Er ($I^{\pi}=0^+$) ε-decay are reported[1] to have $5.20 < \log ft < 6.25$, and hence have J=0 or 1. The observed multipolarities of respective decay restrict spin-parity still further.

The NDS adopted levels [1] list $J^{\pi}=1^-, 2^-, 3^-$ for the 91.8 keV level based on M1 γ to 2^- level. If we further note that it has log ft = 5.95 from 0^+ Er, (1f: ΔJ=0,1, Δπ=yes) the only choice left is $J^{\pi}=1^-$. A look at our table 1 for appropriate energy uniquely yields the 2qp assignment,

91.8 keV: $1^-\{p:5/2[402] - n:3/2[521]\}$ --- (1)

This (p_1-n_0) assignment is consistent with the observed M1 γ from this level to the 67 keV 2^- with (p_2-n_0) configuration. Its GM triplet partner with $K^{\pi}=4^-$ is expected to lie lower at (40±20)keV.

Preliminary analysis of the data of ε-fed levels in ^{158}Ho yields the following tentative assignments:

241 keV [1^+, p_2-n_1]; 386 keV [1^+0; p_1-n_1];
433 & 462 keV 1^+ levels: [(p_3-n_1) and p_4-n_0];
438 keV [1^-, p_2-n_4]; 663keV [1^+, p_3-n_4] --- (2)

Detailed investigations of these structures using QPRM are being pursued.

References

[1] R. G. Helmer, Nuclear Data Sheets 101 (2004) 325.
[2] P. C. Sood, R. W. Hoff and R. K. Sheline, Phys. Rev. C33 (1986) 2163.
[3] V. M. Gorozhankin et al., J. Phys. G22 (1996) 377.
[4] ENSDF (Evaluated Nuclear Structure Data File), a continuously updated file incorporating data from the latest NDS, NNDC, Brookhaven.
[5] A.K. Jain, R.K. Sheline, P.C. Sood and K. Jain, Revs. Mod. Phys., 62 (1990) 393.