Low Lying two-quasiparticle structures in odd-odd 182\_75\textsuperscript{Re107}

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The latest evaluation of the odd-odd nucleus 182\textsuperscript{Re} found in the Nuclear Data Sheets (NDS2015) [1] lists 16 energy levels below 500 keV. These levels were adopted in NDS2015 following reports on investigations in the \(\epsilon\)-decay of 182\textsuperscript{Os} [2,3] and other reaction studies [4,5]. It is observed that only two levels among these are identified bandheads with configurations assigned. While the ground state in 182\textsuperscript{Re} is established as the 7\(^+\) triplet of \(\pi 5/2[402]\otimes\nu 9/2[624]\) configuration, the singlet 2\(^+\) member of this GM doublet is not assigned to any level, even though it is expected to be low-lying. Similarly, except for the triplet 9\(^+\) from the \(\pi 9/2[514]\otimes\nu 9/2[624]\) configuration which is tentatively placed at around 445 keV, no other configurations expected with \(E_x \leq 500\) keV are assigned to the observed low lying levels.

Spin-parity assignments for most of the observed levels are uncertain. For example, the (5\(^+\)) level observed in the reaction studies of 181\textsuperscript{Ta(a, 3n\gamma)} and 182\textsuperscript{W(p,\gamma\gamma)} at around 285 keV [4,5] could also have other possible spin-parity assignments based on the observation from the authors of the report.

In our present work, we have taken up the evaluation of the low-lying bandhead energies arising from possible 2qp configurations by using a simple phenomenological model [6]. The model uses a simple formula given by:

\[
E(K: \Omega_p, \Omega_n) = E_p(\Omega_p) + E_n(\Omega_n) + E_{rot} - \left(\frac{1}{2} - \delta_{x,0}\right) \Delta E_{GM} + \delta_{x,0}(-)^k E_N
\]

The proton single particle energies are taken from the neighboring Re isotopes with \(A = 181\) and 183, while the single particle neutron energies are obtained from 180\textsuperscript{W} and 182\textsuperscript{Os} in line with the observation made in a recent report [7] on Re nuclei falling in the transitional region. The data used for evaluating the bandhead energies is presented in Table 1.

Table 1: Expected low-lying ( \(E_x \leq 525\) keV ) 2qp GM doublets in 182\textsuperscript{Re} that arise out of coupling of single particle Nilsson orbitals from respective (A±1) isotopes (proton orbitals) and isotones (neutron orbitals). Out of these orbitals \((E_p+E_n) \leq 525\) keV are considered.

<table>
<thead>
<tr>
<th>(p_i)</th>
<th>(n_j)</th>
<th>(E_x)</th>
<th>(E_{rot})</th>
<th>(\Delta E_{GM})</th>
<th>(E_N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(p_0)</td>
<td>(n_0)</td>
<td>0.00</td>
<td>5/2([402])</td>
<td>9/2([624])</td>
<td>365 keV</td>
</tr>
<tr>
<td>(p_1)</td>
<td>(n_1)</td>
<td>385</td>
<td>9/2([514])</td>
<td>525</td>
<td>1/2([541])</td>
</tr>
<tr>
<td>(n_2)</td>
<td>(300)</td>
<td>1/2([521])</td>
<td>4</td>
<td>3(</td>
<td>0)</td>
</tr>
<tr>
<td>(n_3)</td>
<td>(365)</td>
<td>5/2([512])</td>
<td>5(</td>
<td>0)</td>
<td>400 keV</td>
</tr>
<tr>
<td>(n_4)</td>
<td>(426)</td>
<td>1/2([510])</td>
<td>3(</td>
<td>0)</td>
<td>525 keV</td>
</tr>
<tr>
<td>(n_5)</td>
<td>(480)</td>
<td>7/2([514])</td>
<td>1(</td>
<td>6)</td>
<td>525 keV</td>
</tr>
</tbody>
</table>

The results of our evaluation are presented in Figure 1 where we have compared our results with the relevant adopted data in NDS2015.

While our analysis agrees with the triplet 7\(^+\) \((P_0, n_0)\) assignment to the ground state in 182\textsuperscript{Re}, we obtain the energy of the singlet 2\(^+\) of this combination as 65 keV. We hence identify the 2\(^+\)
level in NDS2015 occurring at ’0.00 + x’ (‘x being the offset having a value between 50 and 60 keV) with the singlet 2+ 2p0, n0 state.

The triplet 2(p0, n1) is evaluated by us to lie around 290 keV. This could probably correspond to the ’235.73 + x’ energy level with a tentative (2−) assignment adopted in the NDS2015.

The energy level at 279.22 + x’ is tentatively assigned (5−) by NDS2015 based on the strong 95.7 keV gamma decaying to the lower lying 4+ level at (0.00 + x). While the authors of this work unambiguously assign the transition ΔJ = 1 based on their γ(θ) measurements, they add that intensity balance measurements could give this gamma either an M1 or E1 multipolarity. NDS2015 considers an M1 character and adopts (5−) for this level, making it a rotational band member of the lower lying 2+ level at 65 keV. Instead, we propose that if E1 multipolarity is adopted for the 95.7 γ from this level, then a spin parity of 5− becomes admissible, thus identifying this level with the triplet 5−(p0, n2). The NDS2015 level at (379.22 + x) keV is tentatively assigned (1,2−) based on a high intensity 379.22 keV E1(M2) γ to the lower 2+ level at (0.00 + x) keV.

Another high intensity gamma of 115.92 keV with M1(E2) character was also found to decay to the 1− level at (263.278 + x) keV level in 182Re. This information, coupled with the considerably high E2 admixture in the 115.92 keV gamma (as suggested by the mixing ratio of δ < 1.4) enables us to suggest that the (379.22 + x) keV is the triplet 3−(p0, n1). The unassigned (9+ ) level at 443.15 keV in NDS 2015 comes close to the triplet 9−(p1, n0) in our evaluation. The NDS 2015 1− level at (438.28 + x) keV is identified by us to be the possible triplet 1−(p0, n4). Finally, the previously configuration unassigned level at (461.3 + x) keV with a tentative spin parity of (4−) is determined in our evaluation as the likely triplet 4−(p2, n0).

References