

Geometric Model for Nuclear structure

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Abstract: We first prove that nuclear structure is not randomly arranged nucleons. We then develop a geometric model for nuclear structure using JP data from the Internet. The model shows why Be($p = 4, n = 4$) is unstable while Be(4, 5) is stable. It predicts correctly the mode of decay of unstable isotopes and it predicts the daughter isotope. It also predicts why Tc(43, $n = 54$ or 53) is unstable and why Tc(43, 52) is not allowed and why all other isotopes of Tc are unstable. There is also a clear indication of why nuclei of $p > 26$ require energy to form. Knowing the relative position of the particles may make field computations easier. The model also explains why an isotope can have zero Orbital Angular Momentum. Also shown is why the magic number 8 yields a threshold of minimal binding energy. The model predicts that 16 should also be a magic number for stability. It also predicts that for nuclei with $A = 22$ or more has the formula for radius as follows: $R = R_0 (2^*Z)^{1/3}$ and not $R = R_0 (A)^{1/3}$. Thus the model predicts smaller radii for heavy nuclei. It is predicted that for F(9,9) decaying to O(8,10) there would be released 4 photons per nucleus. The transition energies i.e. frequencies for this decay is computed. It is shown how to calculate transition energies. It is predicted that Na(11, 11) with JP = 3+, will behave anomalously w.r.t. the Electromagnetic Interaction, as will the stable Ge(32, 41) at JP = 9/2+, Kr(36, 47) at JP = 9/2+, Rh(45, 58) at JP = 1/2-, Pd(46, 59) at JP = 5/2+ and Ag(47, 60) at JP = 1/2-. There are a few other properties one would not see without the model.

Keywords: Nuclear Structure, Orbital Angular Momentum, Transition Energies.

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Theorem 1

Nuclear structure is not nucleons arranged at random.

Proof:

We must assume Orbital Angular Momentum (OAM) comes from the particle's distance from the center of gravity of the nucleus. Or (as will be proven) its distance from the z-axis that goes through the center of gravity. If we assume the particles are arranged at random then the same isotope would have a varying OAM value (as we vary the configuration). This is not what the data says. The data says there is a ground state for every isotope, with definite JP, that is stable, with maybe some excited states of different JP, that are unstable. Moreover: Uranium fission would have produced variable daughter nuclei if the nucleons were arranged at random. QED.

We will later prove that some nucleons go into the extra dimensions.

Data Availability:

The data we used is available at ref. [1]. The data can be accessed by the element name. My data may be checked against this.

The model for H is easy: just one proton. Deuterium has the structure as in figure 1.1:

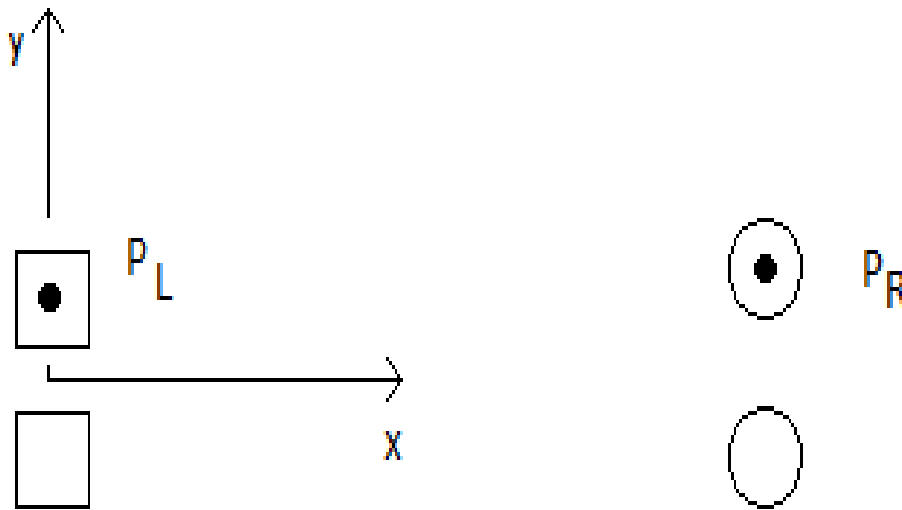


Figure 1.1: Deuterium's structure.

where squares with dots are protons and squares with nothing are neutrons, circles with dots are unfilled proton orbitals, and circles are unfilled neutron orbitals. The two diagrams are stacked on top of each other in the z-direction (out of the page). Deuterium must have $J^P = 0^-$. Note that as drawn in Figure 1.1 OAM is not quite zero, in reality, the two filled orbitals are on top of each other at the center of the axis-system since they do not share the same quantum numbers even if OAM is zero.

We call P_L and P_R : "orbital layers". Orbital layer "P" has $OAM = 0$.

As drawn Deuterium has $J = 0$ and this is not what the data says. To get $J = 1$ we have to give the structure as in Figure 1.1.1:



Figure 1.1.1: Deuterium's structure.

This is since orbital layer Q has $OAM = +1$ for every L orbital and -1 for every R orbital (they are not on top of one another). They are drawn like this but in reality, these layers are arranged next to each other in the z-direction. The radius (along the z-axis) is: $R = R_0 \times 8^{1/3} = 2.4 \text{ fm}$.

We must define a way to keep nuclei from spinning around an axis perpendicular to the x-axis. Let a nucleus emit a photon of the right energy to stop a nucleus that is forced to spin around such an axis every time it is about to start spinning.

$He(2, 2)$ is stable with $J^P = 0^+$. Its structure is shown in Figure 1.2:

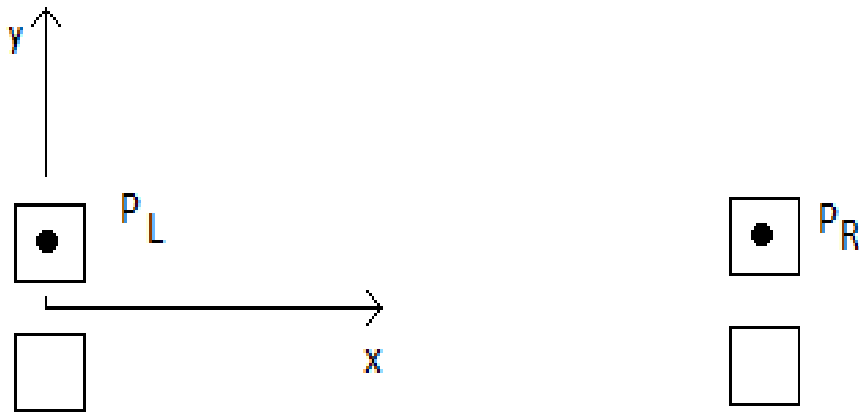


Figure 1.2: He(2,2)'s structure.

Since spin is paired and OAM is zero we have $J^P = 0^+$ (positive parity for an even amount of neutrons). We call this "orbital layer P" for a reason to become clear later. For the nucleus to have zero OAM we must define it not to rotate around an axis perpendicular to the x-axis. To this end, we must define spacetime to favor the nucleus not spinning. The proton and neutron are on top of each other and have $L = 0$. The nucleus has the distance between the two layers as $R = R_0 4^{(1/3)} = 1.905 \text{ fm}$.

There is an issue with $L = 1$ for level Q nucleons: also single distance nucleons of level R has $L = 1$ (in units of \hbar). Since $L = rmv$ we must allow for this by specifying a larger radius and slower speed for single distance R-layer nucleons. Then we can't fix the r and v by specifying the nuclear force must equal the centripetal force and by specifying its energy level. But the nuclear force must balance with the Coulomb force.

Theorem 2

The nucleons rotate in the left and right parts of a layer (not layer P) in opposite directions around the z-axis.

Proof:

This is since He(2,2) have zero Total Angular Momentum (TAM), (see Figure 1.2 above). QED.

He(2, 1) is also stable with $J^P = 1/2^+$. Its structure is as in Figure 1.3:

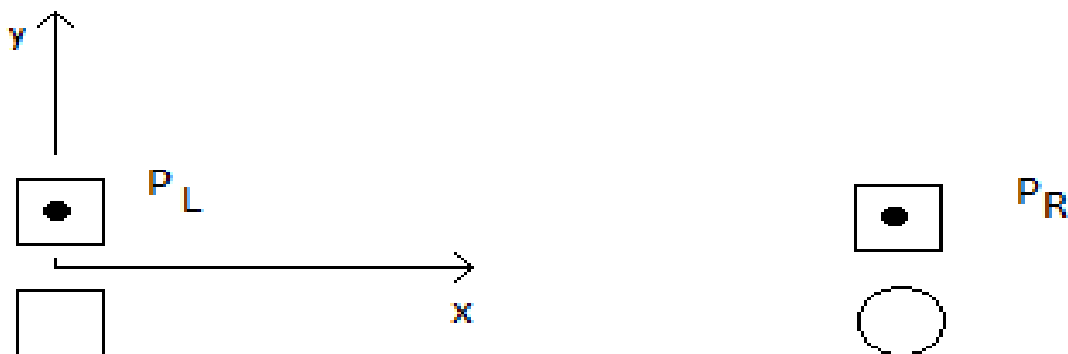


Figure 1.3: He(2,1)'s structure.

Since one unpaired spin exist and OAM is zero we have $J^P = 0 + 1/2^- = 1/2^-$. Parity is (-) since there is an odd number of neutrons. So J agrees with the data and parity does not agree. The data must be checked. I won't lose sleep over this since it is the only nucleus not agreeing.

The model follows the structure of the chemical table of the elements. Therefore we need another four orbitals. Li(3, 3) is stable with $J^P = 1^-$. Its structure is as in Figure 1.4:



Figure 1.4: Li(3,3)'s structure.

Since the orbitals in layer Q have a unit of OAM each we have: $J = 1 + 0 = 1$, and the isotope has odd neutrons, so $P = (-1)$ so parity agrees. I count only unsymmetrical filled orbitals since the rest cancel.

The next level (labeled as R) has 6×2 orbitals so they are arranged in a hexagon. The OAM assignment is as in Figure 1.5:

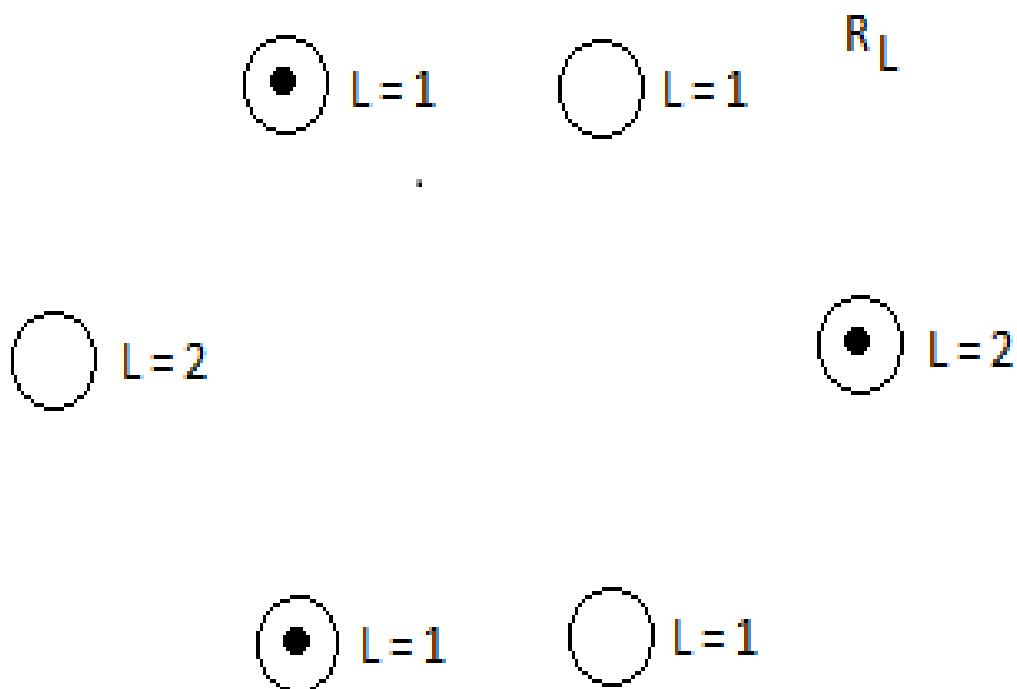


Figure 1.5: The R orbital layer.

Li(3, 4) is stable with $J^P = 3/2^-$. The Q layer is ignored and orbitals from layer R get filled. Its structure is as in Figure 1.6:

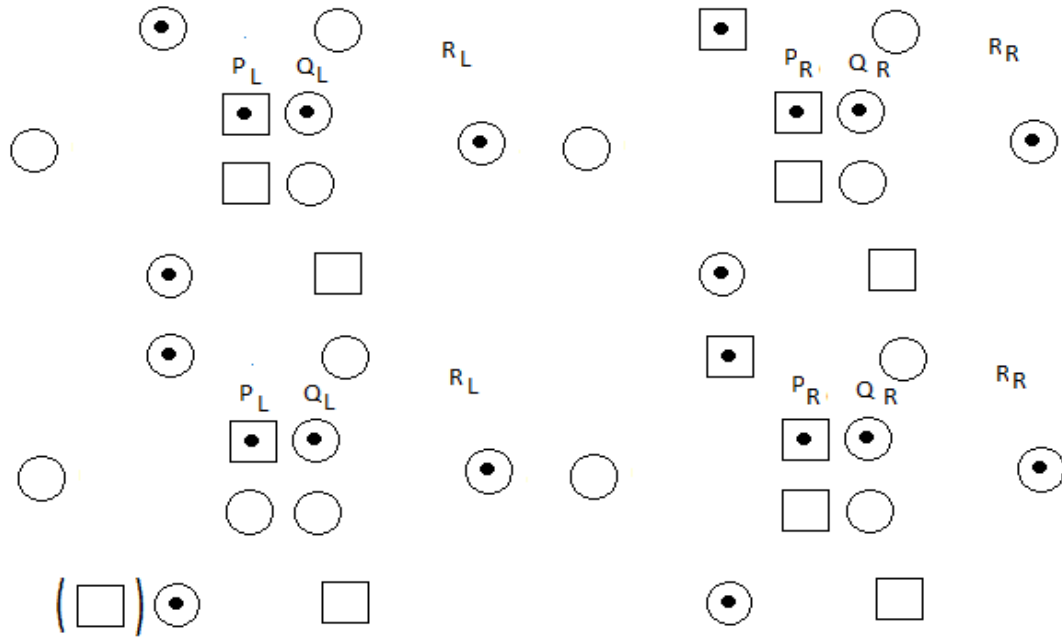


Figure 1.6: Li(3,4)'s structure.

I can find a $J^P = 3/2^+$ state. To get $J^P = 3/2^-$ we need the second diagram in Figure 1.6: $J = |1 - 1 - 1| + 1/2 = 3/2$ and parity = -1 (odd, even) agrees with the data. The neutron in brackets resides in the extra dimensions and does not contribute OAM or parity, it's spin pairs.

Theorem 3

Some neutrons go into the extra dimensions.

Proof:

From Figure 1.6 we see Li(3, 4) has $J^P = 3/2^+$ without the extra dimensions (ED) filling. The second diagram shows that one neutron of (Li(3, 4) $J^P = 3/2^-$) goes to the ED. If the theorem wasn't so we have that Li(3,4) with $J^P = 3/2^+$ would be stable and it is not. QED.

We will see that neutrons fill so that $Z = N$ in the ordinary dimensions, with more neutrons filling ED orbitals.

Be(4, 4) is unstable due to an alignment of protons. We state its structure as in Figure 1.7:



Figure 1.7: Be(4, 4)'s structure.

With the extra neutron in R_L protons across P_L and Q_L no longer aligns due to the strong force between the neutron in layer R_L and one proton in Q_L. Also the two protons in P_R, Q_R would not line up anymore but would have a x,y-component to their orientation. Be(4, 5) is stable with $J^P = 3/2^-$. Its structure is as in Figure 1.8:

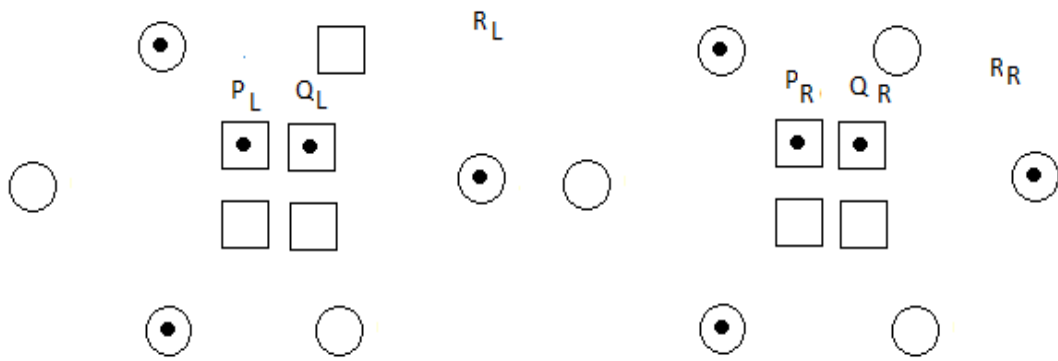


Figure 1.8: Be(4, 5)'s structure.

$J = 1 + 1/2 = 3/2$ and parity is (-) due to the odd amount of neutrons.

B(5, 5) is stable with $J^P = 3^+$. Its structure is as in Figure 1.9:

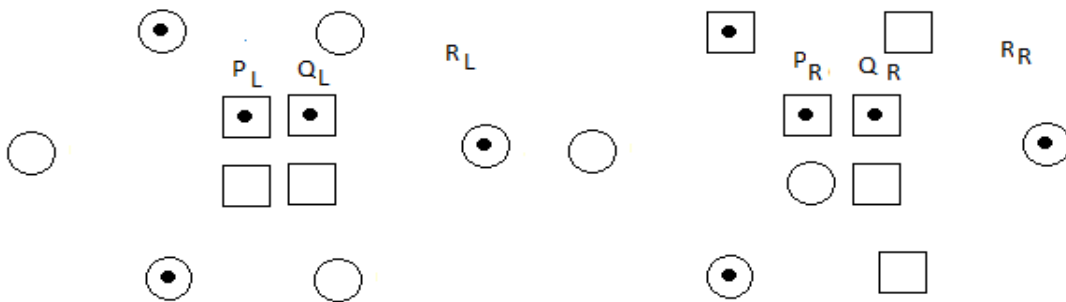


Figure 1.9: B(5, 5)'s structure.

$J = |1 + 1 + 1| = 3$ agrees with the data and parity is -1, does not agree. We can make parity agree like in figure 1.6.

The stability rules are as follows:

1. A nucleus is unstable if one or more protons in a ring are unbalanced.
2. A nucleus is unstable if two or more neutrons are unbalanced.
3. A nucleus is unstable if its OAM is 6 or more.

C(6, 6) is stable with $J^P = 0^+$. Its structure is as in Figure 1.10:

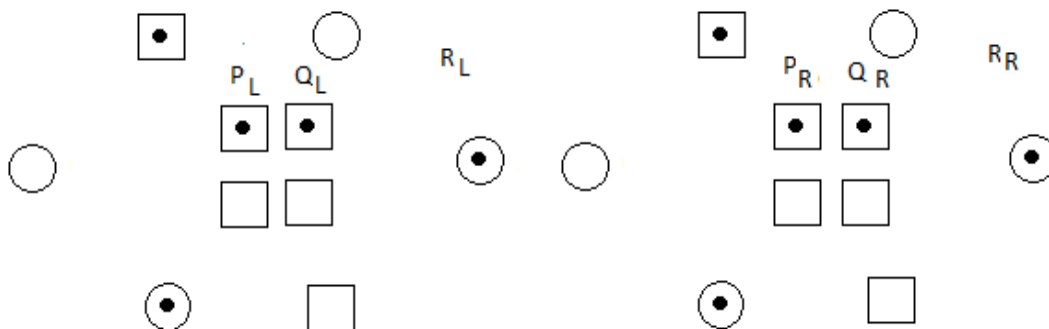


Figure 1.10: C(6, 6)'s structure.

$J^P = 0^+$ agrees.

$C(6, 7)$ is also stable with $J^P = 1/2^-$. Its structure is as in Figure 1.11:

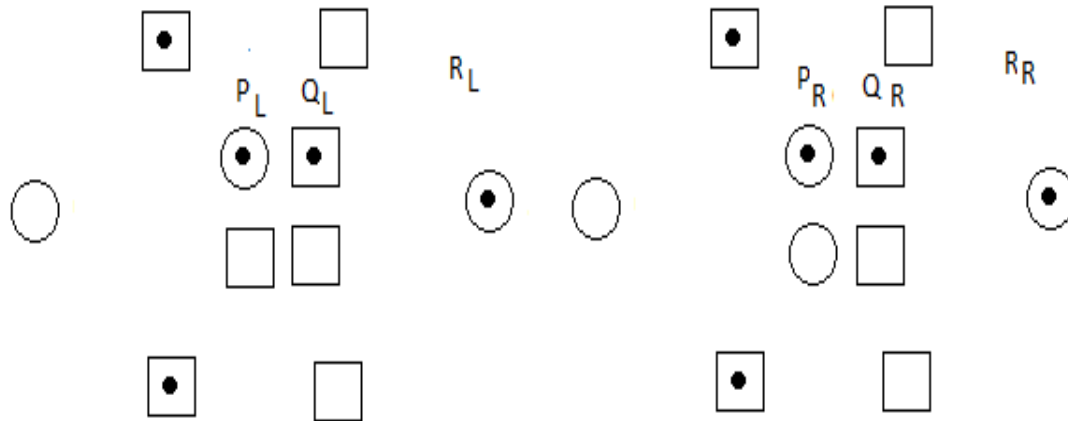


Figure 1.11: $C(6, 7)$'s structure.

$J = 0 + 1/2 = 1/2$ agrees and parity as (-1) agrees.

We look at the unstable $C(6, 8)$ at $J^P = 0^+$ as in Figure 1.12:

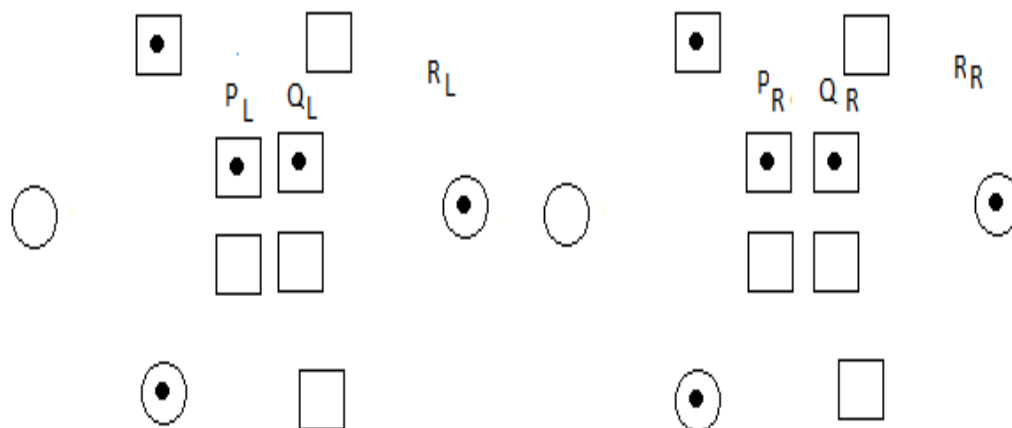


Figure 1.12: $C(6, 8)$'s structure.

$J = 0 + 0 = 0$, parity is $(+1)$ agrees. We see it will decay by nuclear beta decay to $N(7, 7)$. Note that it can decay in two equivalent ways, which one would not see without the model. Also note that the decay would leave the nucleus in an excited state with one unpaired neutron in R_L decaying to a proton and jumping to R_{R2L} (double distance = $2L$). It will emit a photon of very low energy since the proton orbital that the decayed neutron must jump to is at nearly the same energy level.

$N(7, 7)$ is stable with $J^P = 1^+$. Its structure is as in Figure 1.13:

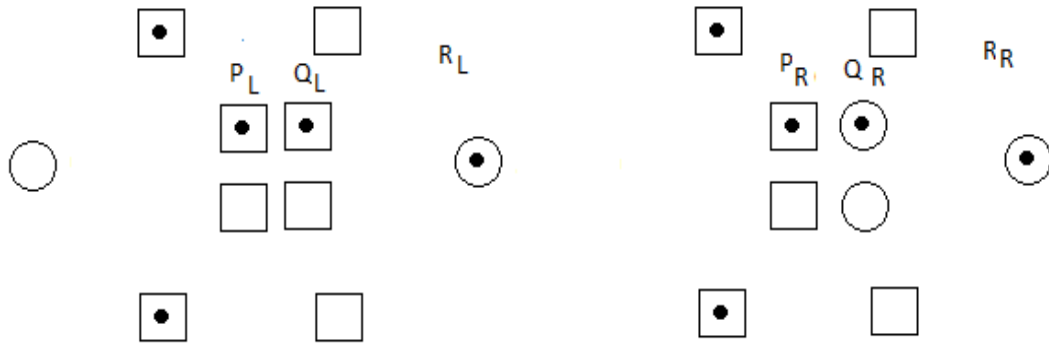


Figure 1.13: N(7, 7)'s structure.

OAM of Q is 1 and agrees while parity is -1 and does not agree. To get the parity to agree we need to put one neutron into the extra dimensions where it contributes neither OAM nor parity. The modified structure is as in Figure 1.14:

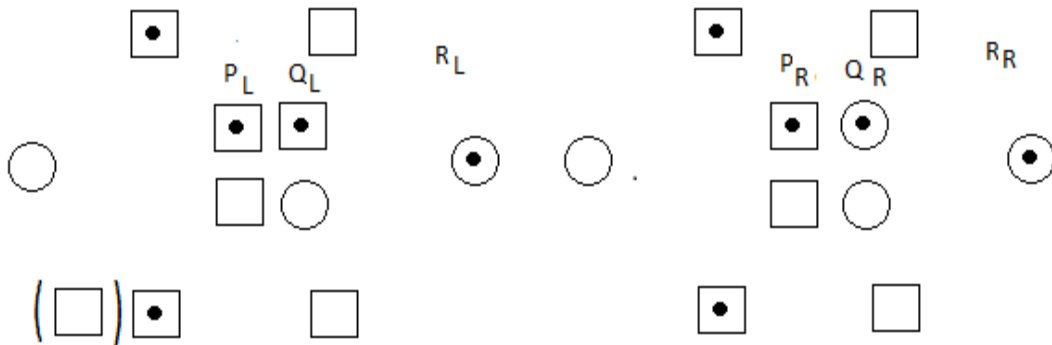


Figure 1.14: N(7, 7)'s structure.

where the neutron in brackets is in the extra dimensions (ED). Now parity agrees. Note that the spin of the neutron in ED can still pair with the proton in Q_L . Also note: the isotope has a $J^P = 2^+$ stable state formed by placing a neutron and proton from R_R into Q_R . This is a prediction to be verified.

It can be seen why the number 8 is a magic number for the stability of an isotope: the next orbitals in layer R are at double distance from the center and requires more binding energy.

O(8, 8) has an easy structure. O(8, 9) is stable with $J^P = 5/2^+$. Its structure is as in Figure 1.15:

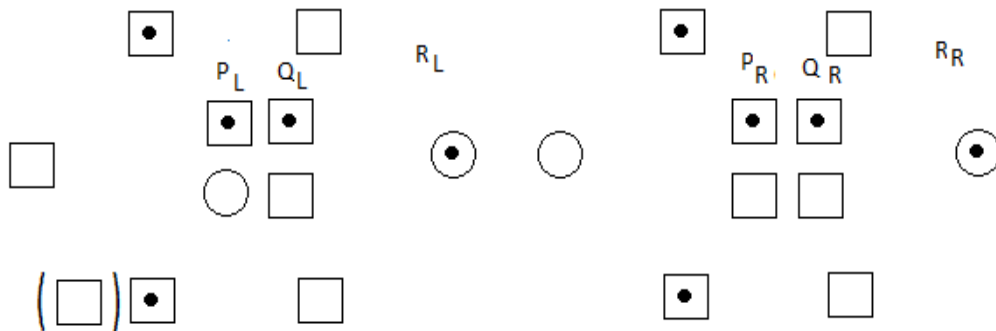


Figure 1.15: O(8, 9)'s structure.

$J = 2 + 1/2 = 5/2$ because of the neutron in R_L . Parity $(+ - - + - +) = (+1)$ and J agrees. This nucleus has $R = R_0 (2 \cdot 8)^{1/3} = 3,024 \text{ fm}$.

We see that the next proton and neutron would go to double distance. This is why "8" is a magic number.

$O(8, 10)$ is stable with $J^P = 0^+$. Its structure is as in Figure 1.16:

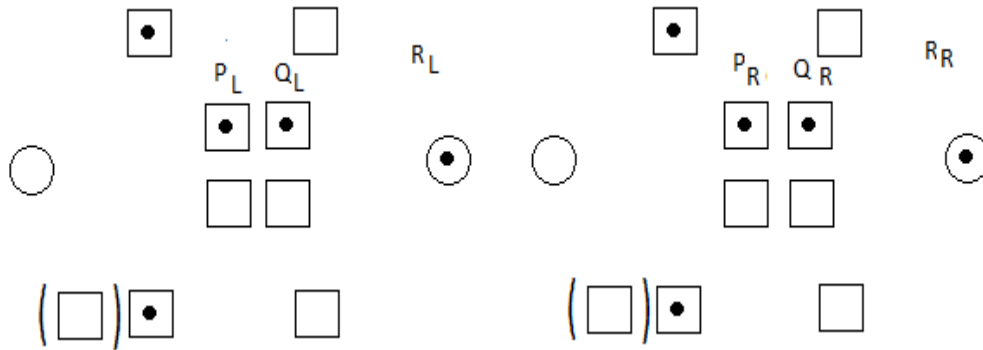


Figure 1.16: $O(8, 10)$'s structure.

$J = 0 + 0$ due to all orbitals being symmetrical, parity is positive for an even amount of neutrons not in ED. There must be ED orbitals to fill since $O(8, 10)$ is stable. If there was no ED orbitals the two neutrons above would have to go into $L = 2$ orbitals and is unstable since then there are two neutrons unbalanced.

$O(8, 12)$ is unstable with $J^P = 0^+$. Therefore there is no more ED orbitals in this layer.

$F(9, 9)$ is unstable with $J^P = 1^+$. Its structure is as in Figure 1.17:

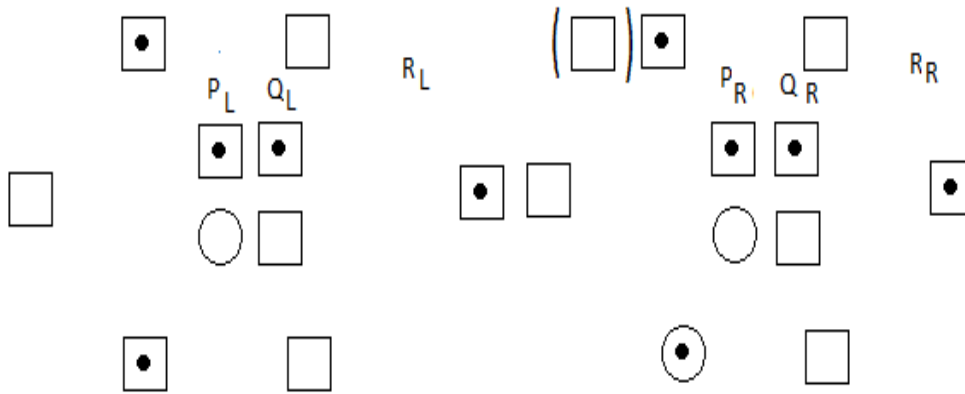


Figure 1.17: $F(9, 9)$'s structure.

$J = 1$ because of the proton in R_L . Parity is $(- + - + - +) = (+1)$ so J and P agrees with the data. The isotope is unstable due to two protons in layer P being unbalanced. The nucleus will decay by proton conversion to $O(8,10)$ and the added neutron will go into ED of R_L .

$F(9, 10)$ is stable with $J^P = 1/2^+$. Its structure is as in Figure 1.18:

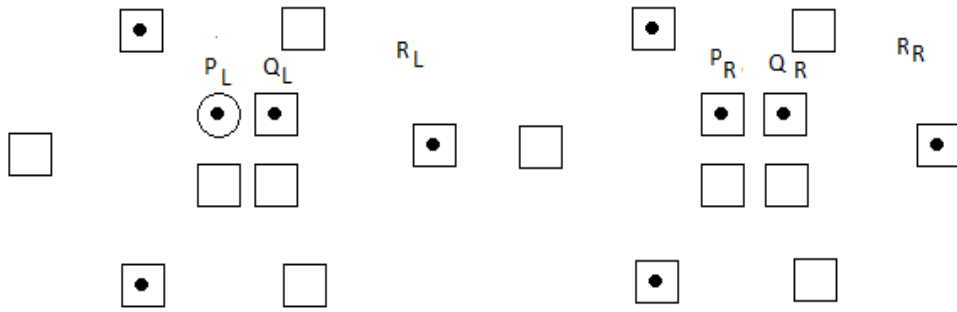


Figure 1.18: F(9, 10)'s structure.

$J = 1/2$ since one neutron is unpaired in spin and all the other orbitals are filled. Parity is positive for ten neutrons, J and P agrees with the data.

Ne(10, 10) has structure: all orbitals (P, Q, R) thus far filled see [13]. Ne(10, 11) is stable with $J^P = 3/2^+$. Ne(10, 11) has structure: all orbitals filled and one neutron in layer S. Ne(10, 12) is stable with $J^P = 0^+$. It has structure: all orbitals (P, Q, R) filled and two extra-dimensional ED neutron orbitals filled. Since the two ED neutrons does not contribute to the radius of the nucleus it's radius is: $R = R_0 (2 \cdot 10)^{1/3} = 3.26 \text{ fm}$ and not $R = R_0 (22)^{1/3} = 3.36 \text{ fm}$.

Na(11, 12) is stable with $J^P = 3/2^+$. It has structure as in Figure 1.19:

P, Q, R layers full,



Figure 1.19: Structure of Na(11, 12).

$J = 1 + 1 - 1 + 1/2 = 3/2$ and parity is positive: agrees with the data.

The next layer (T) is again a hexagon with its L values as previously (Figure 1.5 of ref. [13]).

Na(11, 11) is unstable with $J^P = 3^+$. It has structure layer Q, R totally filled, and as in Figure 1.20:

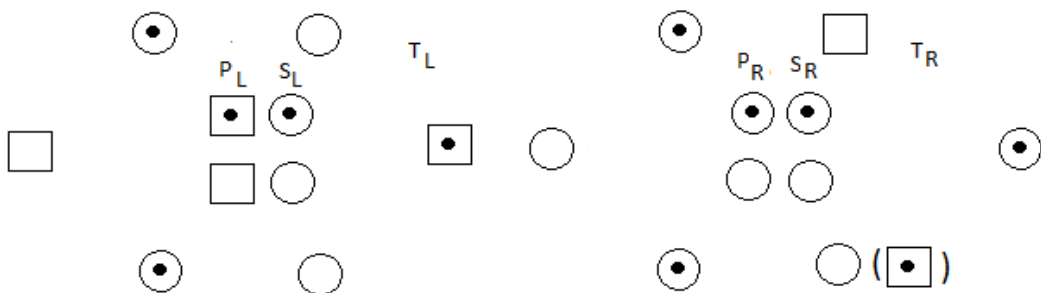


Figure 1.20: Structure of Na(11, 11).

$J = |2 + 2 - 1| = 3$ and $P = (+1)$ from: $(- +)$, agrees with the data. This is unstable because of the P orbital being unfilled. It has a proton in the ED. It is predicted that this isotope will behave anomalously w.r.t. the Electromagnetic Interaction due to one proton in the ED. It is predicted to decay by positron emission to the following (see Figure 1.21) (layer P, Q, R totally filled):

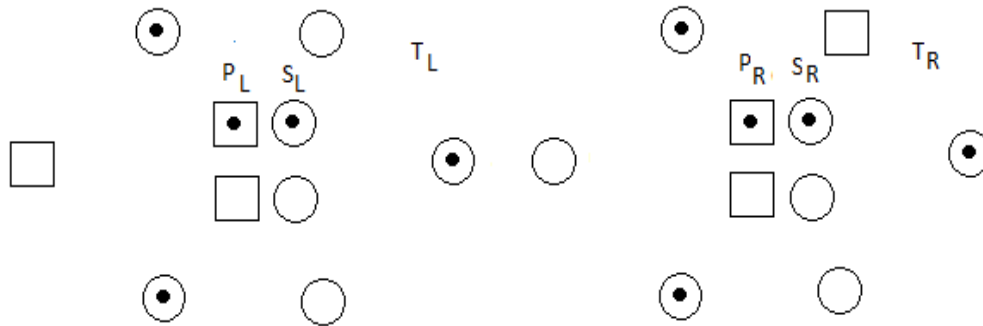


Figure 1.21: Structure Na(11, 11) will decay to. This is Ne(10, 12) with $J = |2 - 1| + 1/2 = 3/2$ and parity $(- +) = (+1)$. It is unstable and will decay by electron emission.

Mg(12, 12) has all its P, Q, R, S orbital layers filled, with $J^P = 0^+$.

We assume all nuclei further on has layers P, Q, R totally filled unless stated otherwise.

Mg(12, 13) is stable with $J^P = 5/2^+$. It has structure as in Figure 1.22:

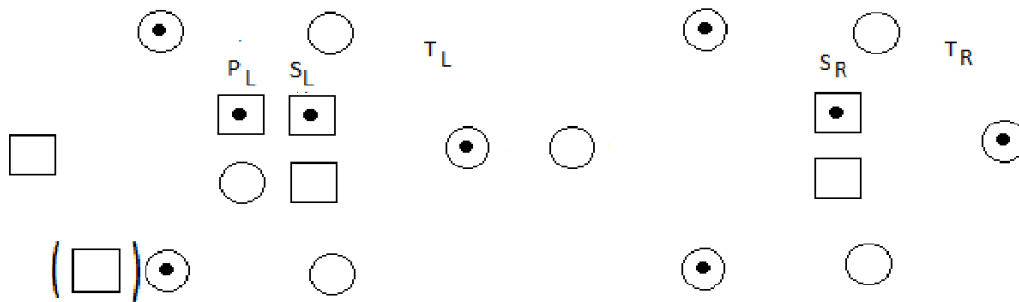


Figure 1.22: Structure of Mg(12, 13).

$J = |2 + 0| + 1/2 = 5/2$ and parity is positive $(+ - +)$: agrees with the data. Note that previous layers are just shown if all their orbitals are not filled. We see that Mg(12, 13) with $J^P = 3/2^+$ can also be stable: just move the neutron in T_L to a $L = 1$ orbital.

Mg(12, 14) is stable with $J^P = 0^+$. Its structure is as in Figure 1.23:

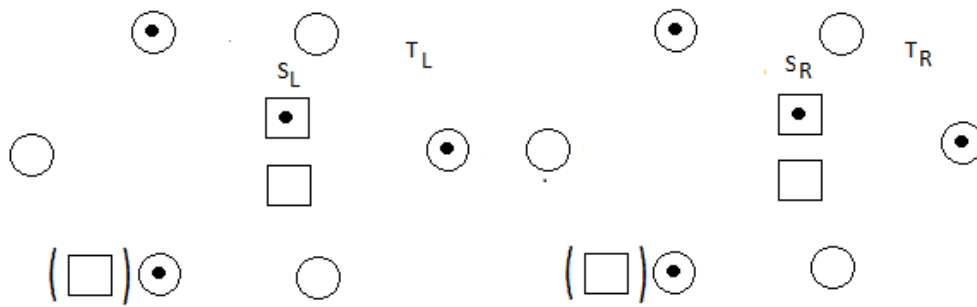


Figure 1.23: Structure of Mg(12, 14).

$J^P = 0^+$ is seen instantly.

Al(13, 14) is stable with $J^P = 5/2^+$. Its structure is as in Figure 1.24

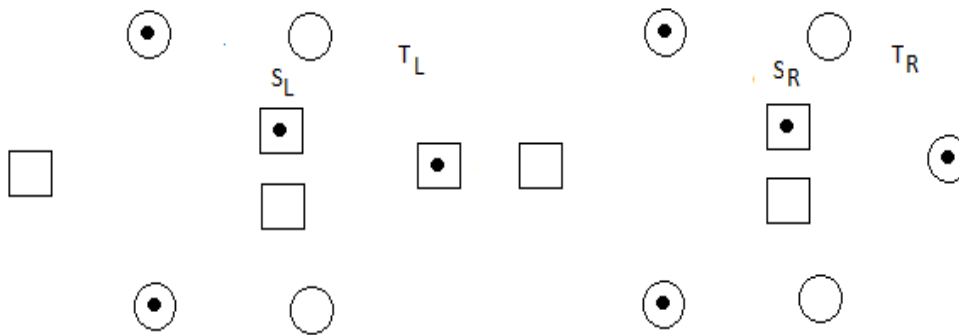


Figure 1.24: Structure of Al(13,14).

$J = |2 + 2 - 2| + 1/2 = 5/2$ and parity is positive (- + - +): agrees with the data. That the $J = 3/2$ isotope is not in the data may be because then the protons are too close together. For some reason Al(13, 16) is not in the data. The formula predicts a radius of: $R = R_0 (2 \cdot 13)^{1/3} = 3.55$ fm. Since the orbitals are the same as for O(8,8) this model predicts $R = 3,024$ fm for this nucleus.

Si(14,14) is stable with $J^P = 0^+$. This is easy to construct from Al(13, 14).

Si(14, 15) is stable with $J^P = 1/2^+$. Its structure is as in Figure 1.25:

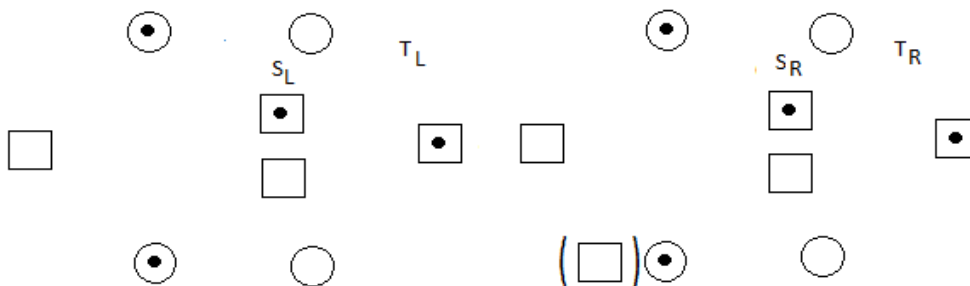


Figure 1.25: Structure of Si(14, 15).

$J = 0 + 1/2 = 1/2$ and parity is (- + - +) = positive: agrees with the data.

Si(14, 16) is stable with $J^P = 0^+$. Its structure is easy to construct from Si(14, 15).

P(15, 16) is stable with $J^P = 1/2^+$. Its structure is as in Figure 1.26:

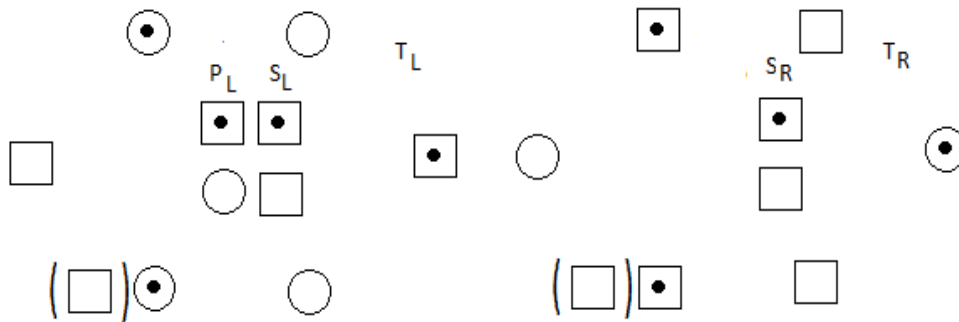


Figure 1.26: Structure of P(15, 16).

$J = |2 + 2 - 1 - 1 - 1 - 1| + 1/2 = 1/2$, parity is $(+ - + - +) =$ positive: agrees with the data.

S(16, 16) is stable with $J^P = 0^+$. Its structure is easy to construct from P(15,16). This has magic number*2.

Cl(17, 18) is stable with $J^P = 3/2^+$. Its structure is as in Figure 1.27:

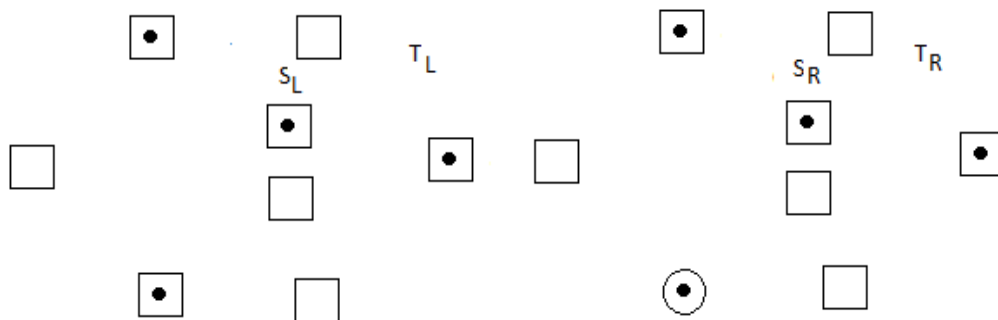


Figure 1.27: Structure of Cl(17, 18).

$J = |1 + 1 - 1| + 1/2 = 3/2$ and parity of 8 neutrons is positive: agrees with the data.

Ar(18, 20) is stable with $J^P = 0^+$. Its structure is (less two ED neutrons) as in Figure 1.28:

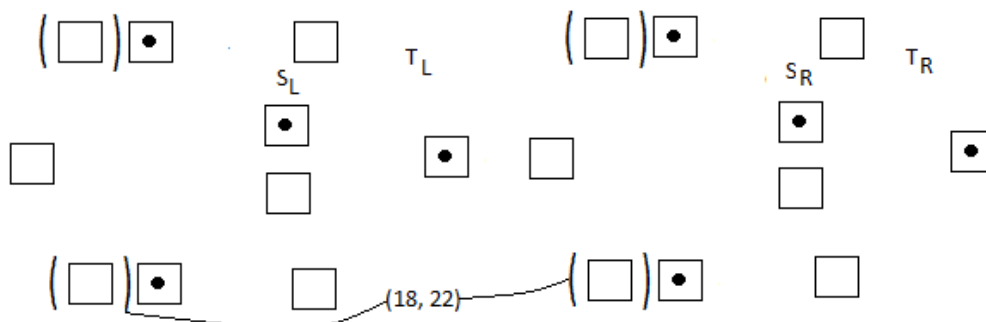


Figure 1.28: Structure of Ar(18, 20).

$J = 0$ is seen at a glance, parity too.

Ar(18, 22) is also stable with $J^P = 0^+$, therefore there must be two more extra-dimensional neutron orbitals (see figure 1.28). These two orbitals are just activated if all the orbitals of level T are filled.

The next layer is two decagons plus two orbitals in the center of each. See figure 1.29.

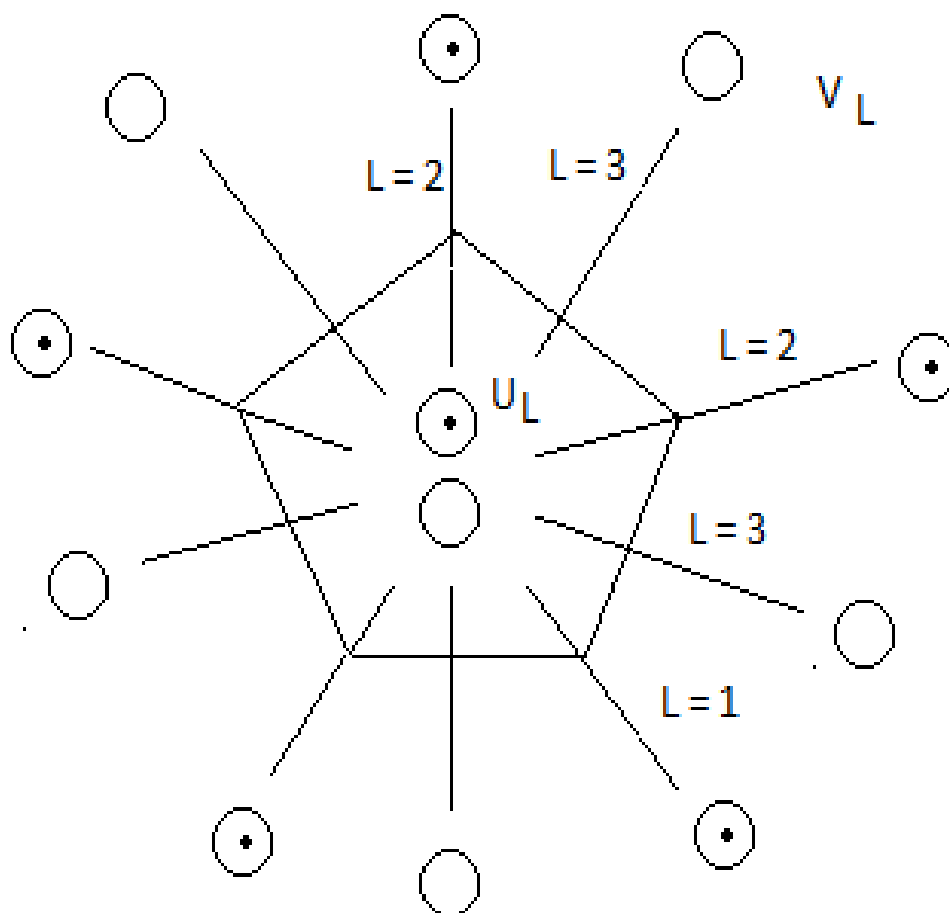


Figure 1.29: Orbital layers U and V.

The OAM of the orbitals are as shown, symmetry applies.

K(19, 20) is stable with $J^P = 3/2^+$. Its structure is (layers P - T full not ED's, K(19, 22) is in Figure 1.30):

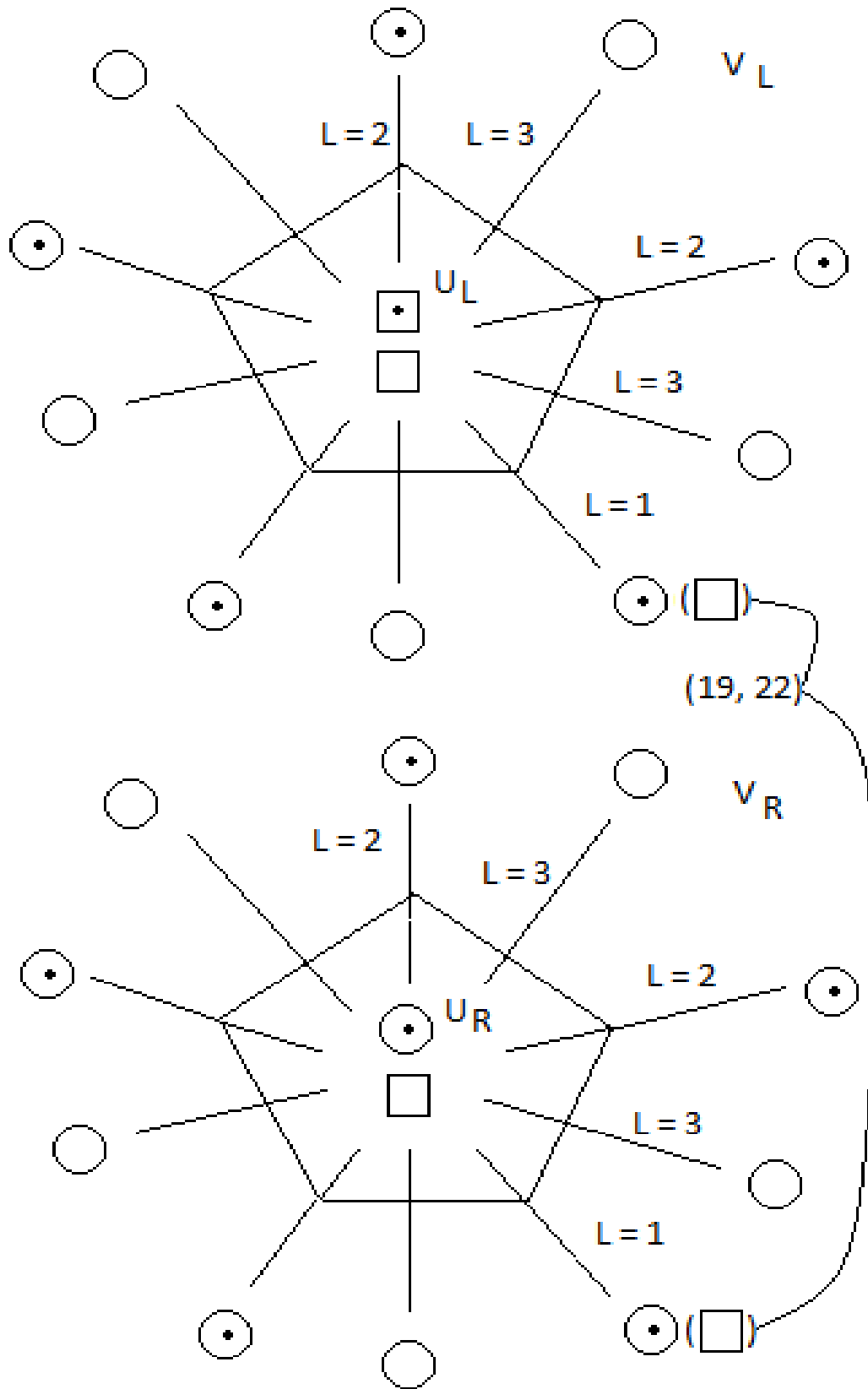


Figure 1.30: Structure of $K(19,20)$.

J is seen to be $= 1 + 1 - 1 + 1/2 = 3/2$, parity is even: agrees with the data.

K(19, 19) is unstable with $J^P = 4^-$ although it has a long lifetime. Its structure is as in Figure 1.31:

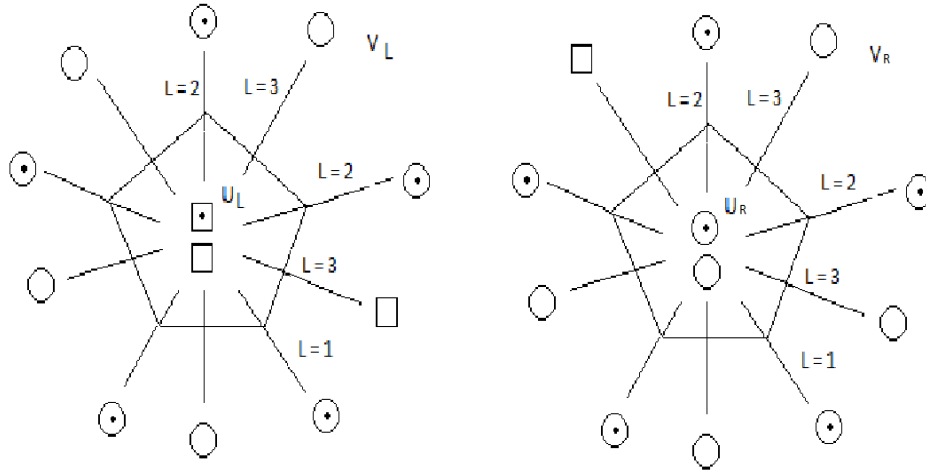


Figure 1.31: Structure of K(19, 19).

J is $|2 + 3 - 1| = 4$ and parity is odd (-1). It is seen to be unstable because two neutrons are unbalanced. A reason must be found for why $J^P = 8^-, 7^-, 6^-, 5^-, 3^-, 1^-$ and 2^- are not in the data. Here it is: a rule can be that (rule 4) the farthest from z-axis orbitals get filled if the center two are occupied and the nearest to the z-axis fills if the center two are not occupied. This one will beta- decay to Ca(20, 20) with $J^P = 0^+$.

Ca(20, 20) is stable with $J^P = 0^+$. Its structure is as in Figure 1.30, just with an extra proton in U_R .

Ca(20, 21) is unstable with $J^P = 7/2^-$. Its structure is as in Figure 1.32:

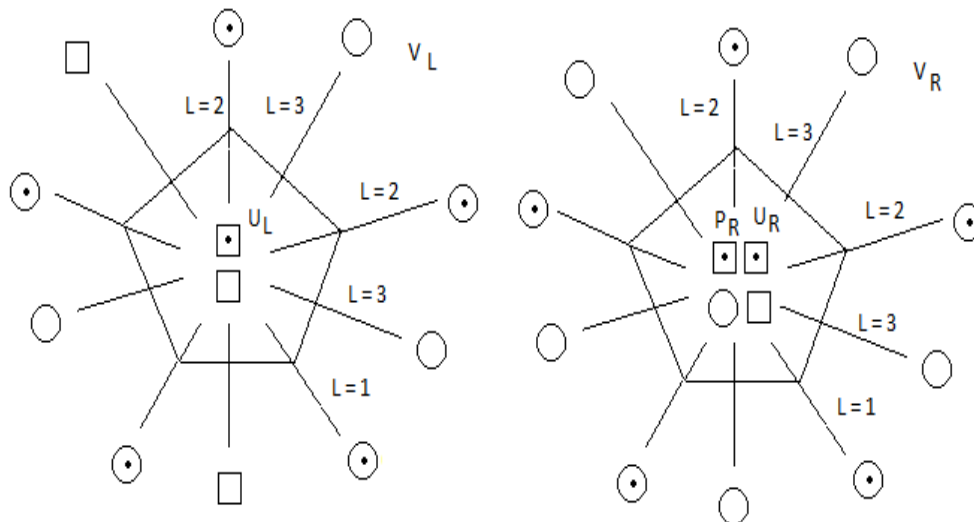


Figure 1.32: Structure of Ca(20, 21).

$J = |2 + 1| + 1/2 = 7/2^-$ as required. It will beta- decay to: (21, 20) with $J^P = 6^+$.

Sc(21, 24) is stable with $J^P = 7/2^+$. Its structure is P, Q, R, S, T fully filled, layer U and V as in Figure 1.33:

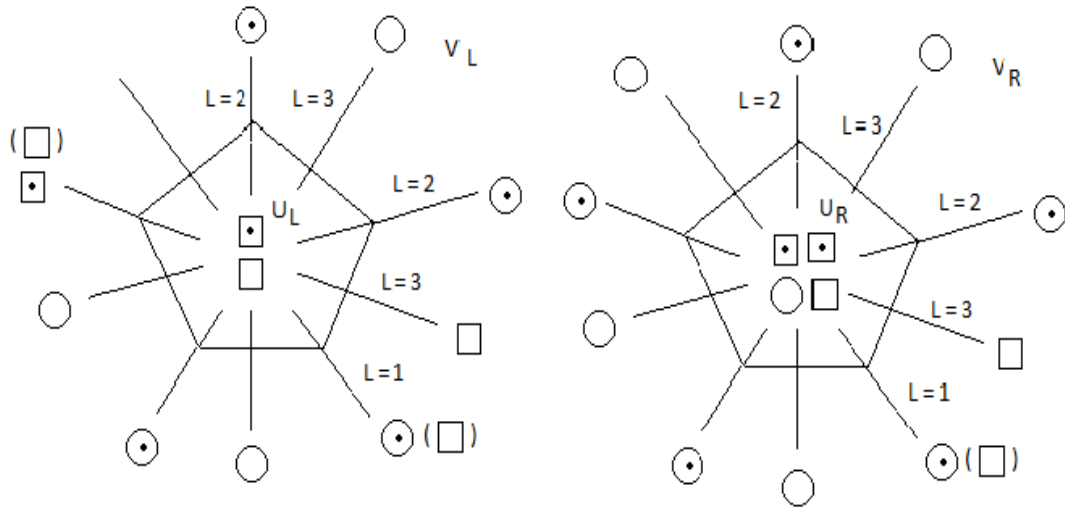


Figure 1.33: Structure of Sc(21, 24).

$J = |3 + 3 - 3| + 1/2 = 7/2$ and parity is (-1): agrees with the data. Because of the neutron orbital in P_R we start counting parity with +, then + - + -. We have: (21, 22) is unstable so the two ED neutrons are required for stability. The formula predicts $R = R_0 (2 \cdot 21)^{1/3} = 4.171$ fm for this and every layer V nucleus that has a L = 3 orbital filled.

Ti(22, 24) is stable with $J^P = 0^+$ and Ti(22, 22) is unstable so two ED neutrons are required for stability.

Ti(22, 25) is stable with $J^P = 5/2^-$. Its structure is: layer P to S totally filled and as in Figure 1.34:

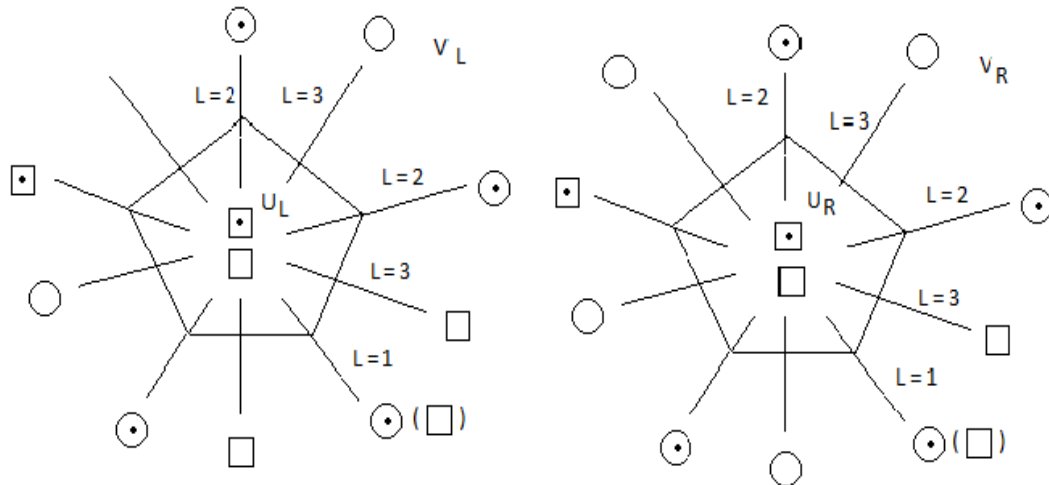


Figure 1.34: Structure of Ti(22, 25).

$J = 2 + 1/2 = 5/2$, Parity = (-1) agrees with the data.

Ti(22, 27) is stable. Its structure is that of Figure 1.34 plus two more ED neutrons.

V(23, 28) is stable with $J^P = 7/2^-$. Its structure is: P to T totally filled (not ED) and as in Figure 1.35:

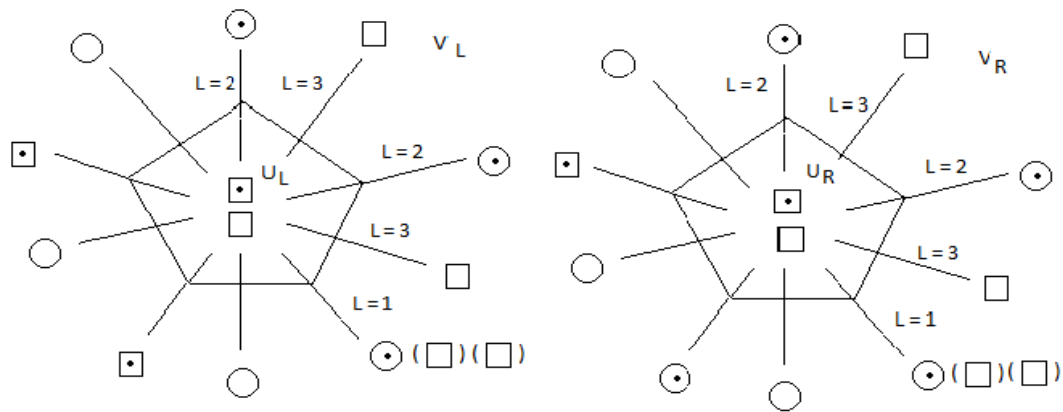


Figure 1.35: Structure of $V(23, 28)$.

$J = 3 + 1/2 = 7/2$, Parity = (+), so parity does not agree. Therefore we redo the structure. It reads as in Figure 1.36:

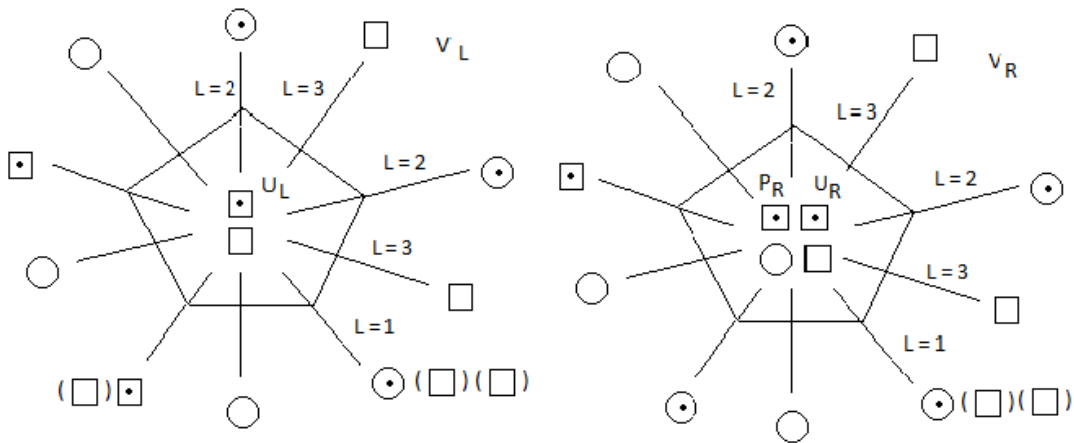


Figure 1.36: Structure of $V(23, 28)$.

Now Parity = (-) so parity now agrees with the data. The strong force must leak into the ED for $V(23, 28)$ to be stable.

$Cr(24, 28)$ is stable with $J^P = 0^+$. It is shown in Figure 1.37:

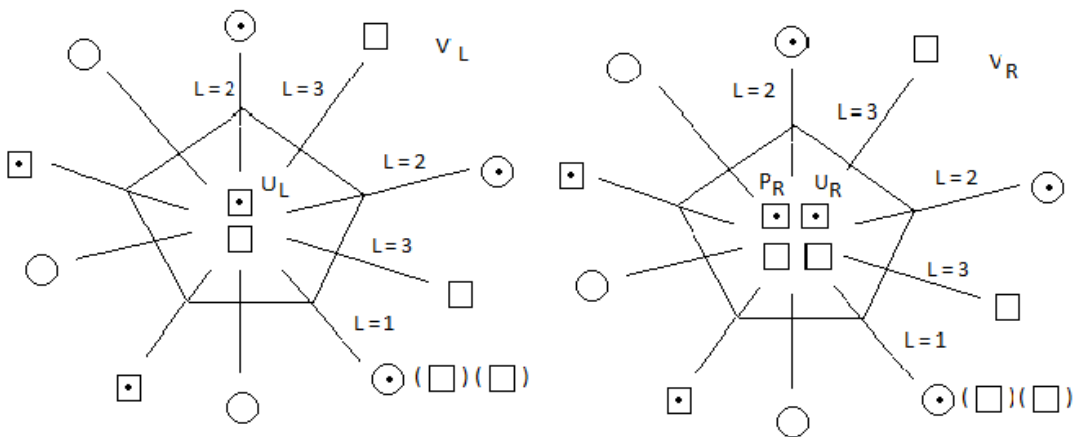


Figure 1.37: Structure of $Cr(24, 28)$.

$J^P = 0^+$ is seen to agree with the data.

Cr(24, 29) is stable with $J^P = 3/2^-$. It has the same structure as Figure 1.37, just with an extra neutron in V_R with $L = 1$, and J^P would agree with the data.

Mn(25, 30) is stable with $J^P = 5/2^-$. Its structure is as in Figure 1.38:

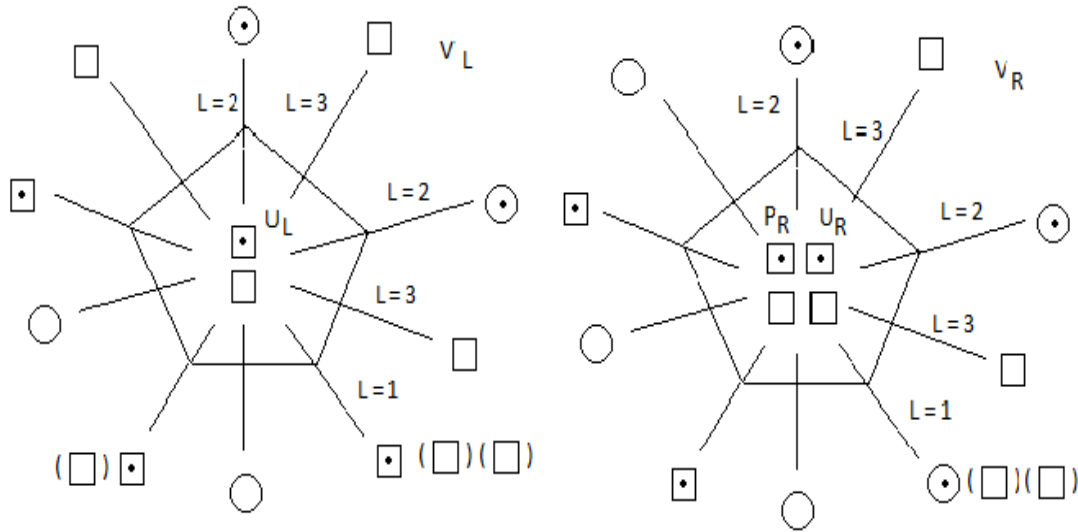


Figure 1.38: Structure of Mn(25, 30).

$J = 1 + 1 + 1/2 = 5/2$ and parity = (-1), agrees with the data.

Fe(26, 28) is stable with $J^P = 0^+$. Its structure is: layers P to T fully filled and as in Figure 1.39:

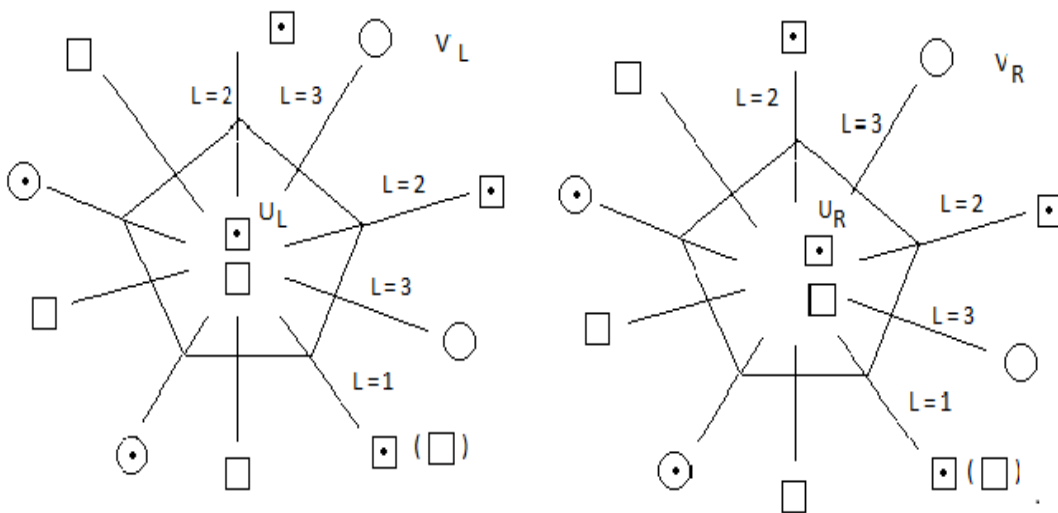


Figure 1.39: Structure of Fe(26, 28).

$J^P = 0^+$ is easily seen. It agrees with the data. One can see why isotopes larger than Fe(26, 28) requires energy to fuse: two $L = 3$ orbitals are the only possible continuation.

Fe(26, 31) is stable with $J^P = 1/2^-$. Its structure is: layers P to T totally filled (not ED) and as in Figure 1.40:

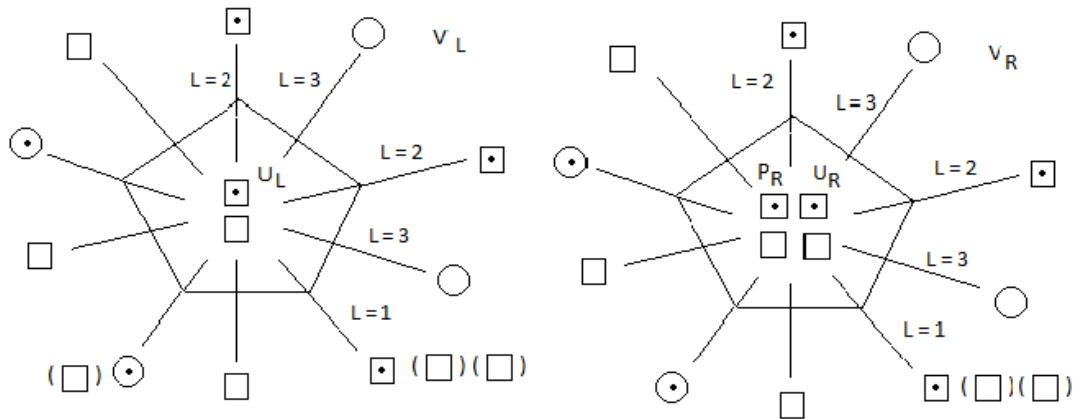


Figure 1.40: Structure of Fe(26, 31).

$J = 0 + 1/2 = 1/2$ agrees with the data. Parity (+) does not agree with the data. There is an indication that nuclei larger than Fe requires energy to form: there is just $L = 3$ orbitals left to fill, clearly requiring more binding energy. We redo Fe (26, 31):

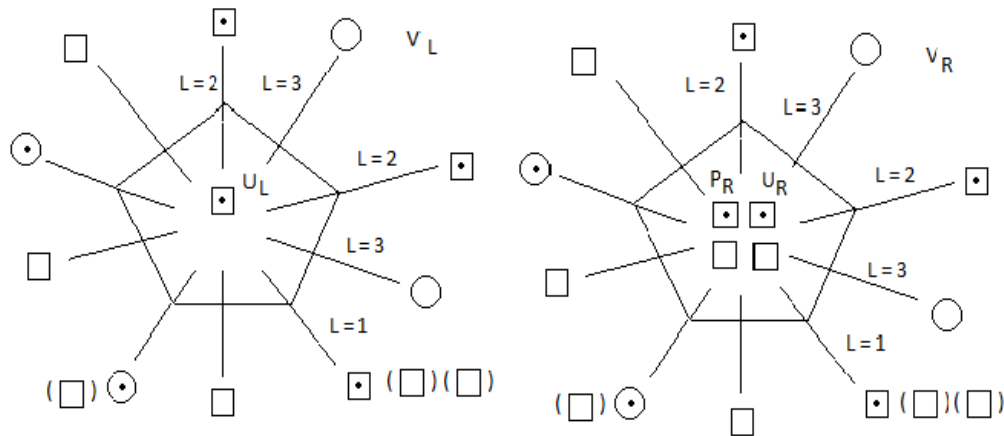


Figure 1.40.1: Structure of Fe (26, 31).

Now parity is -.

Co(27, 32) is stable with $J^P = 7/2^-$. Its structure is: layer P to T totally filled and as in Figure 1.41:

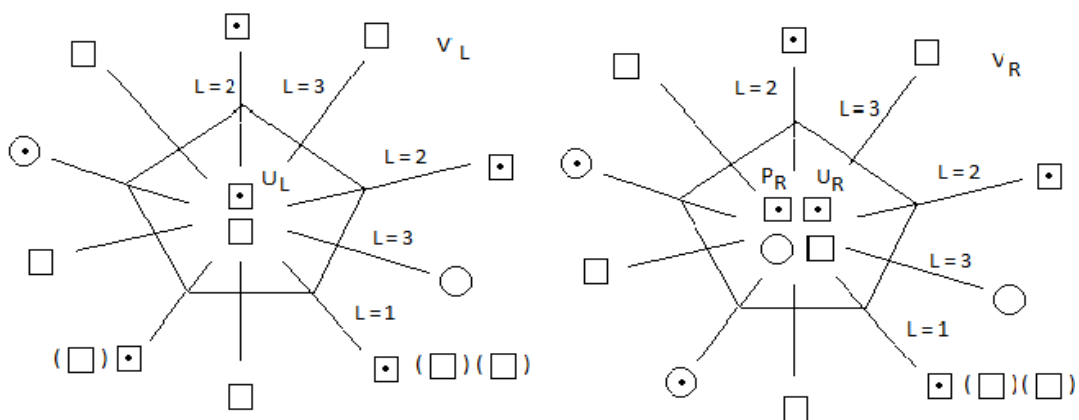


Figure 1.41: Structure of Co(27, 32).

$J = 3 + 3 - 3 + 1/2 = 7/2$ and parity = (-1) agree with the data.

Ni(28, 30), Ni(28, 32), Ni(28, 34), Ni (28,36) are all stable with $J^P = 0^+$. The diagrams are easy.

NI(28, 33) is stable with $J^P = 3/2^-$. Its structure is: layer P to T totally filled, and as in Figure 1.42:

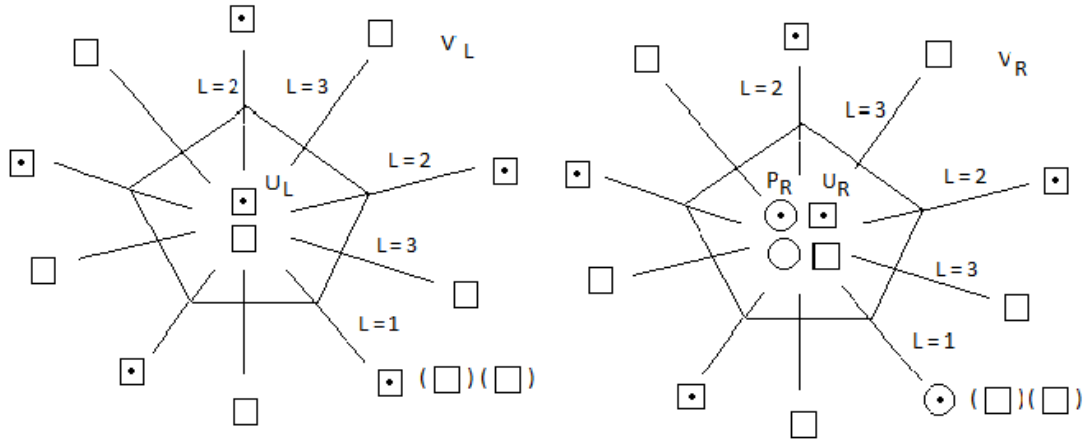


Figure 1.42: Structure of Ni(28, 33).

$J = 1 + 1/2 = 3/2$, due to the proton in V_L at $L = 1$, parity = (-1) agree with the data. We see that this isotope may fuse with Hydrogen and give off energy since only the $L = 1$ orbital is open and it is a proton orbital and the proton can fall to the empty P_R orbital.

Cu(29, 34) and Cu(29, 36) are stable, both with $J^P = 3/2^-$. Cu(29,34)'s structure is P till T totally filled and as in Figure 1.43:

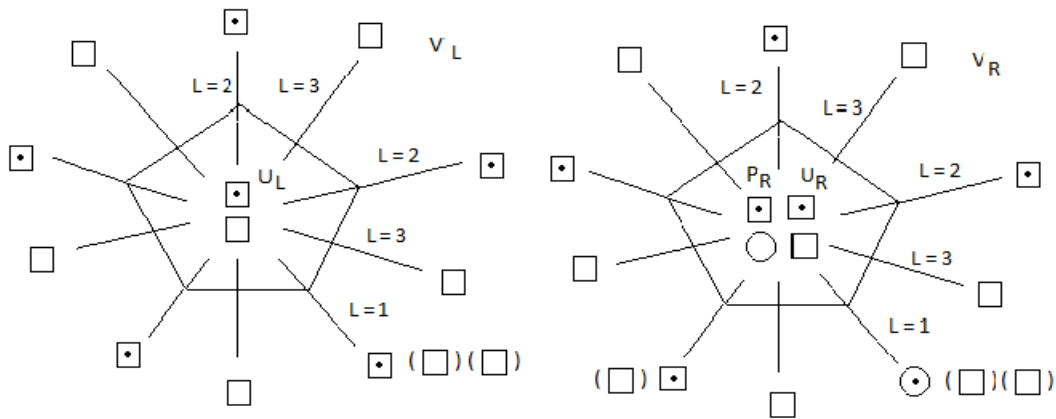


Figure 1.43: Structure of Cu(29, 34).

$J = 1 + 1/2 = 3/2$, parity = (-1), agrees with the data. Cu(29,36) is easy and just adds two ED neutrons to the above. We see that this nucleus may fuse with Hydrogen, but it won't give up energy.

Zn(30,34) with $J^P = 0^+$ has an easy structure: all of P to V totally filled with 4 ED neutrons. Zn(30,36) has 6 ED neutrons and Zn(30, 38) is stable with the same structure except for 8 ED neutrons.

Zn(30,37) is stable with $J^P = 5/2^-$. It has the following structure: all of P to V totally filled with 6 ED neutrons in layer V and as in Figure 1.44:

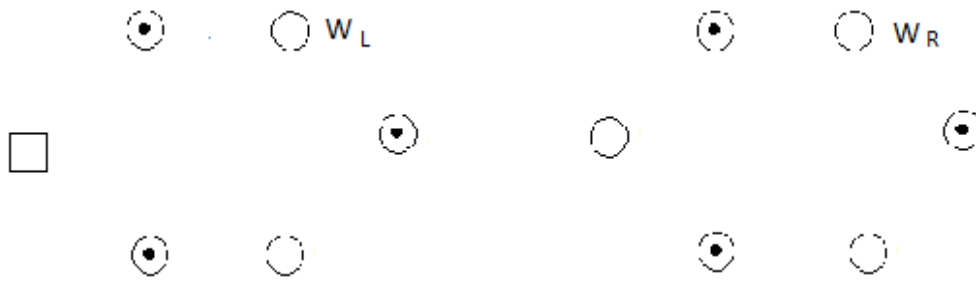


Figure 1.44: Structure of Zn(30,37).

$J = 2 + 1/2 = 5/2$ and parity is negative, agree with the data. Why the $J = 3/2$ state is not in the data is a problem.

In the following, if not stated we assume previous structures (P to V) to be totally filled (not the ED) unless indicating otherwise.

Ga(31, 38) is stable with $J^P = 3/2^-$. It has structure as in Figure 1.45:

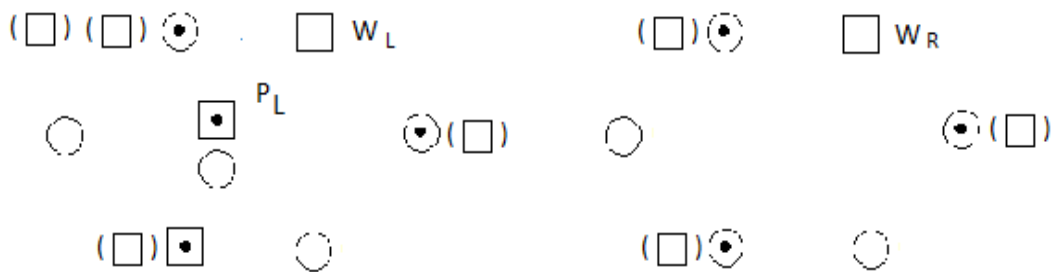


Figure 1.45: Structure of Ga(31,38).

$J = 1 + 1/2$ due to the proton in W_L and the unpaired neutron. Parity counts odd neutrons so $P = (-1)$ and J agrees with the data.

Ga(31,40) has the same structure as Figure 1.45, just with 2 more ED neutrons.

Ga(31, 39) is unstable with $J^P = 1^+$. It has structure as in Figure 1.46:

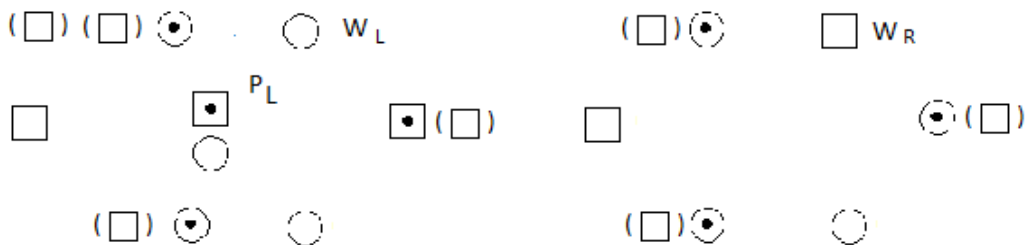


Figure 1.46: Structure of Ga(31, 39).

$J = 2 - 1$ due to the Proton in $L = 2$ of W_L and Neutron in W_R at $L = 1$. Parity: odd, odd so $P = (+1)$. It agrees with the data. It will beta decay to Ge(32, 38) $J^P = 0^-$ in the excited state.

Ge(32,38) is stable with $J^P = 0^+$, with the same J for Ge(32, 40), Ge(32, 42), Ge(32, 44). these are. These are easy to construct.

To get Ge(32,41) at $J^P = 9/2^+$, we need to put a proton in the ED. Here goes (as in Figure 1.47):

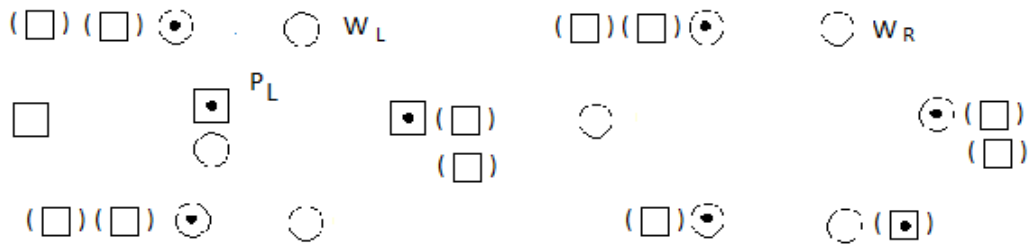


Figure 1.47: Structure of Ge(32, 41).

$J = 2 + 2 + 1/2$ with the $1/2$ due to the proton in ED of W_R . Parity counts odd, odd, so $P = (+1)$. This agrees with the data. The diagram predicts that something extraordinary will happen regarding the charge of this nucleus: the atom may be larger or smaller in the sequence than it would have been had there not been a proton in ED.

As(33, 42) is stable with $J^P = 3/2^-$. Its structure is as in Figure 1.48:

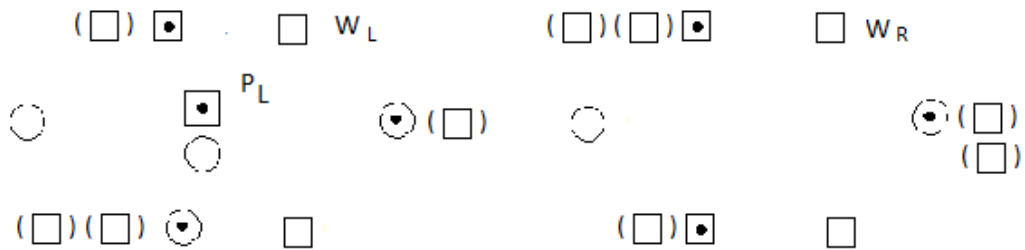


Figure 1.48: Structure of As(33, 42).

$J = 1 + 1/2 = 3/2$ and parity counts: odd, even, so $P = (-1)$. This agrees with the data. As (33,40) is unstable with $J^P = 3/2^-$. It has the structure of Figure 1.48, just with 2 less ED neutrons.

Se(34, 40) is stable with $J^P = 0^+$, the same applies to Se with 42, 44, 46 neutrons. The structure of these is easy.

Se(34, 43) is stable with $J^P = 1/2^-$. Its structure is as in Figure 1.49:

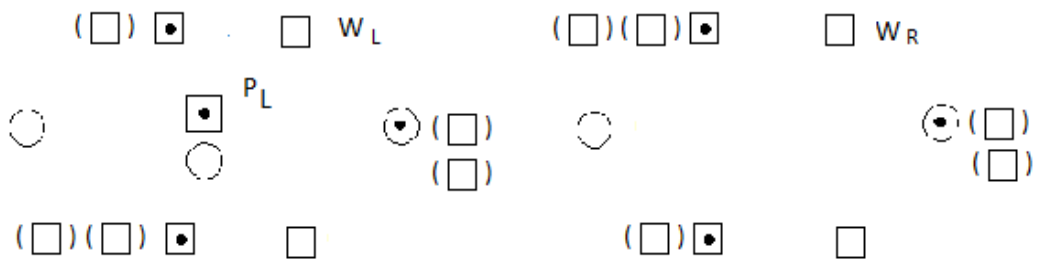


Figure 1.49: Structure of Se(34,43).

$J = 0 + 1/2$ due to the unpaired proton in P_L . Parity counts as: odd, even, so $P = (-1)$. These agree with the data.

Br(35, 44) is stable with $J^P = 3/2^-$. Its structure is as in Figure 1.50:

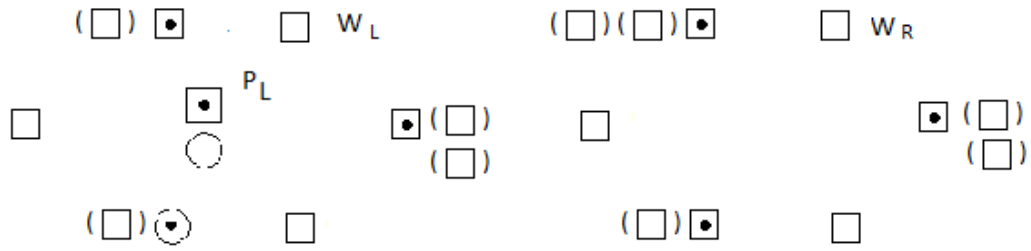


Figure 1.50: Structure of Br(35, 44).

$J = 1 + 1/2$ comes from the empty proton orbital in W_L , at $L = 1$. Parity counts as: odd, even, so $P = (-1)$, and these agree with the data.

Kr(36, 42) and Kr with 44, 46, 48, 50 neutrons is stable with $J^P = 0^+$. These are easy to construct.

Kr(36, 47) is stable with $J^P = 9/2^+$. Its structure is as in Figure 1.51:

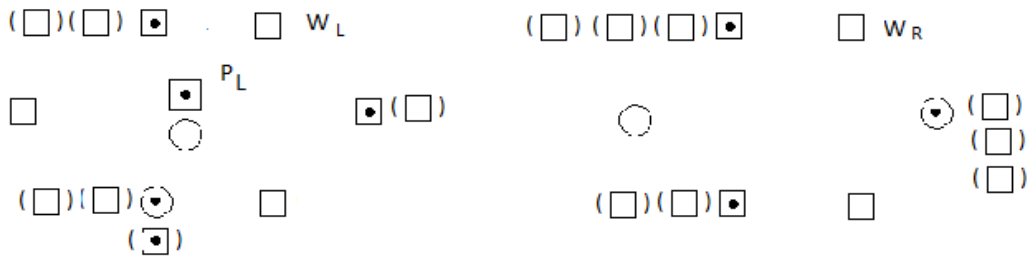


Figure 1.51: Structure of Kr(36, 47).

We see $J = 2 + 2 + 1/2 = 4 + 1/2 = 9/2$. Parity counts as: odd, odd, so $P = (+1)$. These agree with the data.

Rb(37, 48) is stable with $J^P = 5/2^-$. Its structure is as in Figure 1.52:

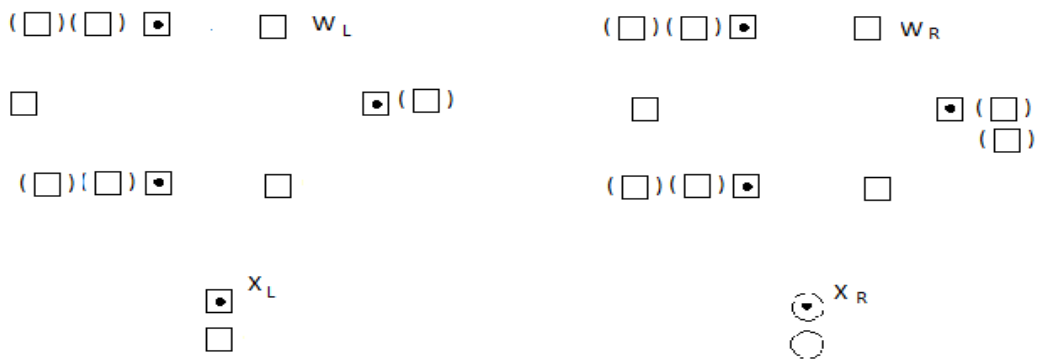


Figure 1.52: Structure of Rb(37, 48).

The proton and neutron in X_L have $L = 1$ each. So $J = 1 + 1 + 1/2 = 5/2$, parity is $(+1)$ so they agree with the data. The extra $1/2$ is because of the spin of a neutron in W_L that doesn't pair.

Sr(38, 46) and Sr with 48, 50 neutrons are stable with $J^P = 0^+$. These are easy. Sr(38, 49) is stable with $J^P = 9/2^+$. Its structure is as in Figure 1.53:

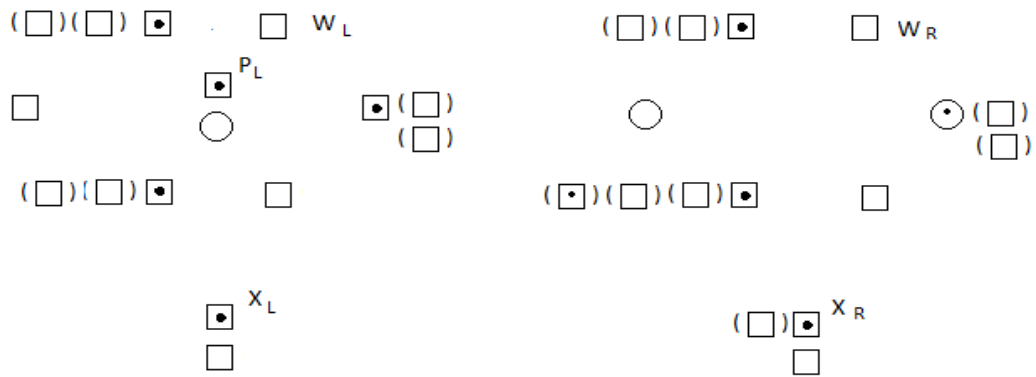


Figure 1.53: Structure of Sr(38, 46).

$J = 2 + 2 + 1/2 = 9/2$, parity is $(+--+)$ so $P = (+1)$, these agree with the data.

The next orbital layer is again 2×10 -gons with the same L distribution as before.

Y(39, 50) is stable with $J^P = 1/2^-$. Its structure is: Q to W totally filled and as in Figure 1.54:

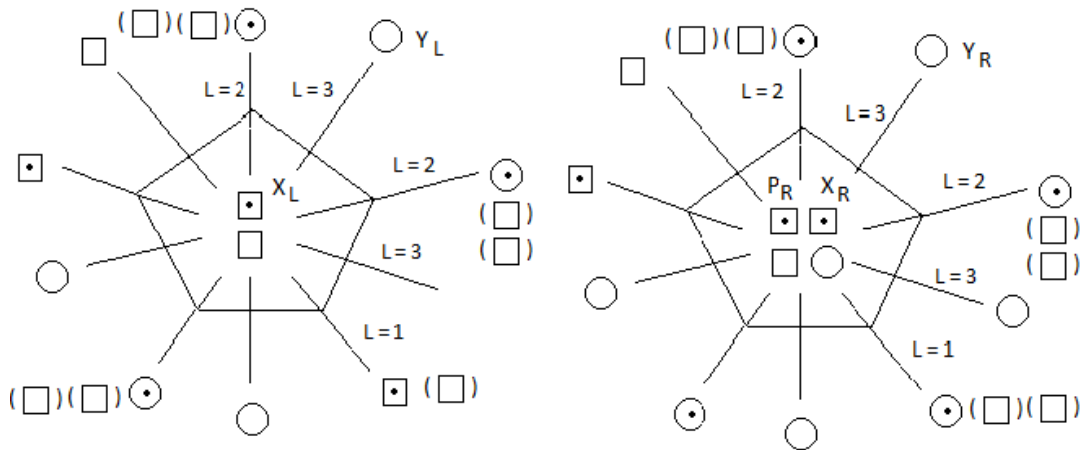


Figure 1.54: Structure of Y(39, 50).

$J = 2 \times L1$ in $Y_L - 1 \times L1$ in $Y_R - 1 \times L1$ in $X_R + 1/2 \times \text{spin neutron in } V_L$ ED = $1/2$. Parity: odd, even, = (-1) , so these agree with the data.

Zr(40,50) and Zr with 52, 54 neutrons are stable with $J^P = 0^+$. These are easy. Zr(40, 51) is stable with $J^P = 5/2^+$ has structure: Q till X (not ED) totally filled and as in Figure 1.55:

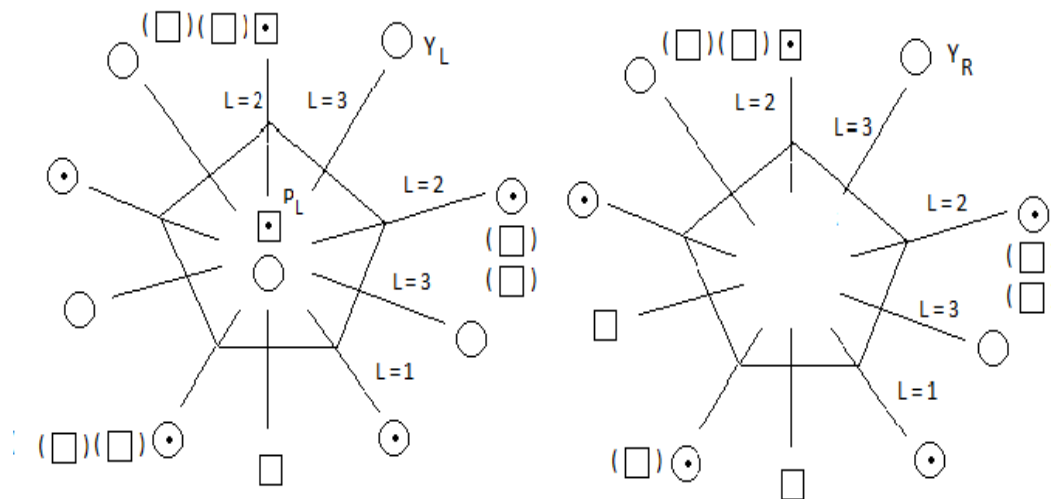


Figure 1.55: Structure of Zr(40, 51).

$J = 2$ due to the neutron in Y_R . Parity: odd, odd, = (+1), so they agree with the data.

Nb(41, 52) is stable with $J^P = 9/2^+$. Its structure is: P to X totally filled (not ED) and as in Figure 1.56:

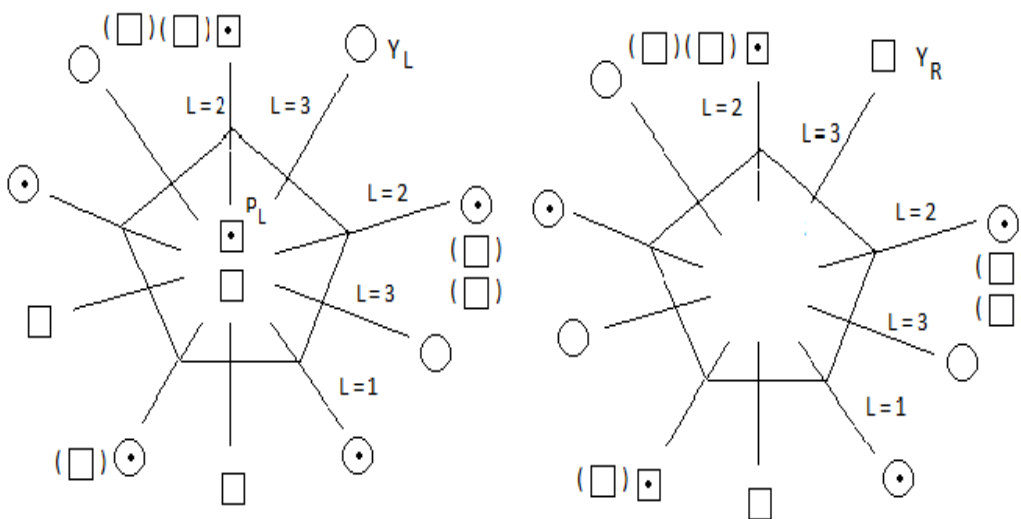


Figure 1.56: Structure of Nb(41, 52).

$J = |2 - 3 - 3| + 1/2 = 4 + 1/2 = 9/2$, and parity is: even, even, so $P = (+1)$ and these agree with the data.

Mo(42, 50) and Mo with 52, 54, 56 are stable with $J^P = 0^+$. Mo(42, 53) is stable with $J^P = 5/2^+$. Its structure is: P to X totally filled (not ED and except where shown) and as in Figure 1.57:

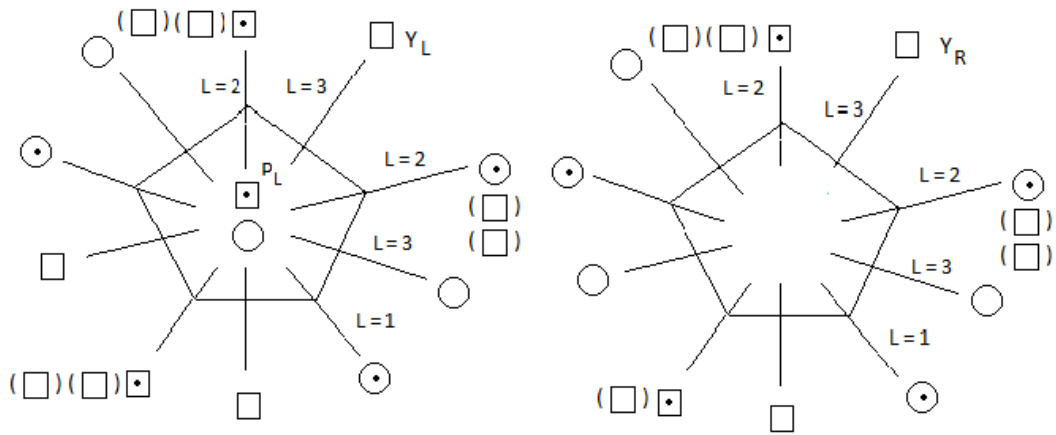


Figure 1.57: Structure of Mo(42, 53).

$J = 2$ for $1xL = 2$ in $Y_L + 1/2$ spin of neutron in $Y_L = 5/2$, parity: odd, odd, so $P = (+1)$ and these agree with the data. Now the structure of Mo(42, 55) easily follows from this.

Tc(43, 54) is unstable with $J^P = 9/2^+$ though it has a long lifetime. Its structure is: P to X totally filled (not ED) and as in Figure 1.58:

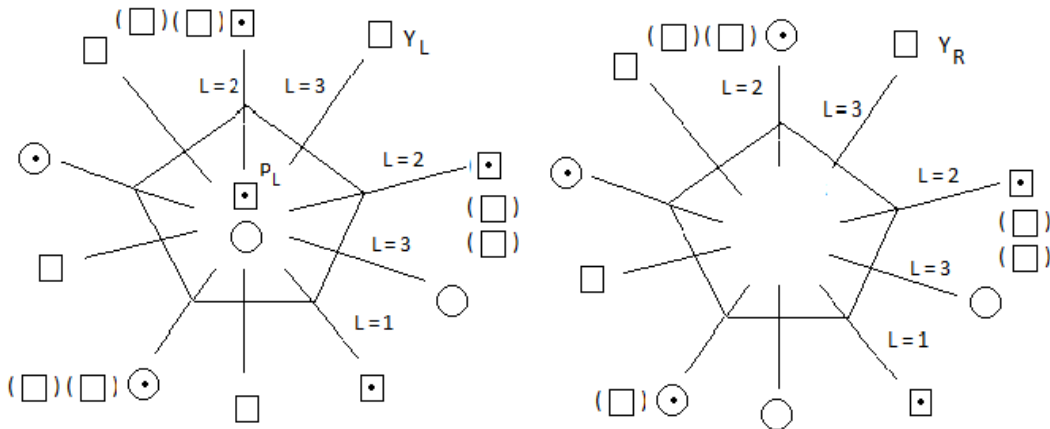


Figure 1.58: Structure of Tc(43, 54).

$J = |2 + 2| + 1/2 = 9/2$ and parity: odd, odd, so $P = (+1)$, this agrees with the data. The figure predicts instability due to two neutrons being unbalanced. It will decay by beta decay (a neutron will decay) since it has too many neutrons. Note that if we require that the $L = 3$ - orbitals fill last Tc(43,53), $J = 1$ will also be unstable since a $L = 3$ orbital will be unbalanced. This is unstable for the same reason as that "two neutrons are unbalanced."

T(43, 52), $J = 4 + 1/2 = 9/2$ is not allowed since a proton orbital must be activated (so that (43, 52) + neutron would neutron decay) and as it is, only neutron orbitals are activated. Tc(43, $n < 52$) will beta+ decay.

Ru(44, 52) and Ru(44) with 54, 56, 58, 60 neutrons is stable with $J^P = 0^+$. These are easy to construct, Ru(44,55) is stable with $J^P = 3/2^+$, its structure is: P_R till X totally filled and as in Figure 1.59:

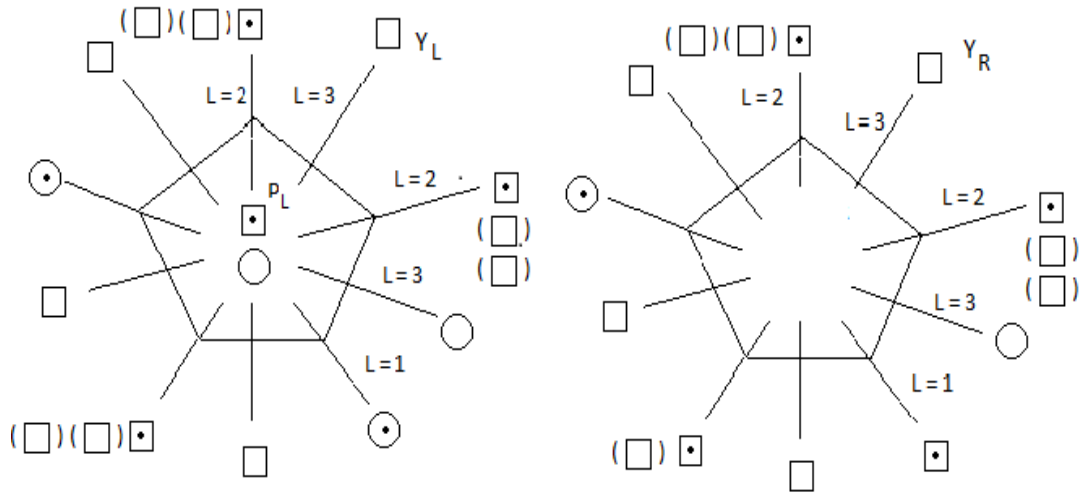


Figure 1.59: Structure of Ru(44, 55).

$J = 1 + 1/2$ from the neutron in Y_L . Parity: odd, odd so $P = (+1)$ and these agree with the data. This required value of J conflicts with the "L = 3 fills last"-rule. Ru(44, 57) looks the same except for two more ED neutrons.

Rh(45, 58) is stable with $J^P = 1/2^-$. Its structure is P_R to X totally filled (not ED) and as in Figure 1.60:

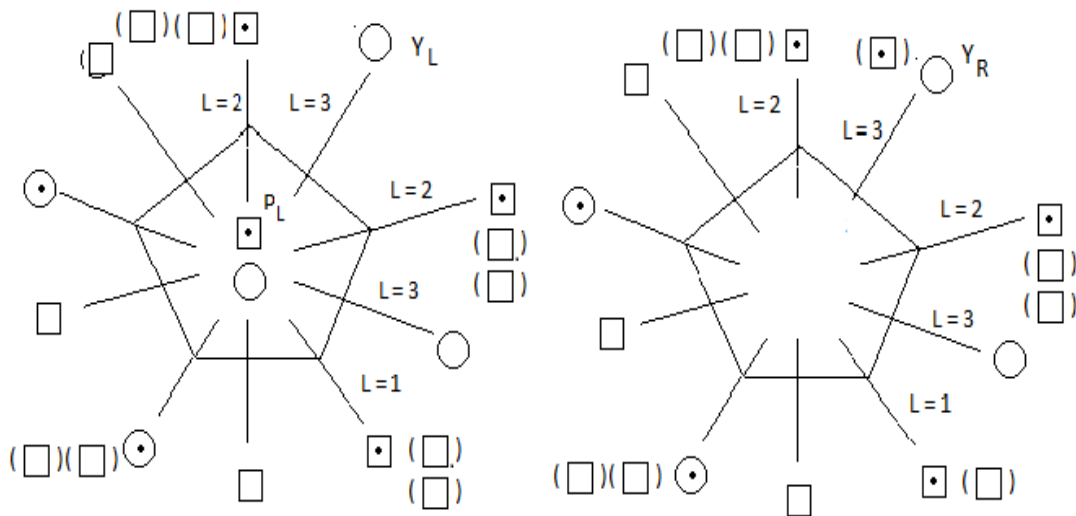


Figure 1.60: Structure of Rh(45, 58).

$J = 0 + 1/2$ due to the proton in ED of Y_R . Parity: odd, even, so $P = (-1)$ and this agree with the data.

Pd(46, 56) and Pd(46) with 58, 60, 62, 64 neutrons is stable with $J^P = 0^+$. These are easy to construct. For the sake of finding out how many ED orbitals to assign we draw out: Pd(46, 64) as in Figure 1.61:

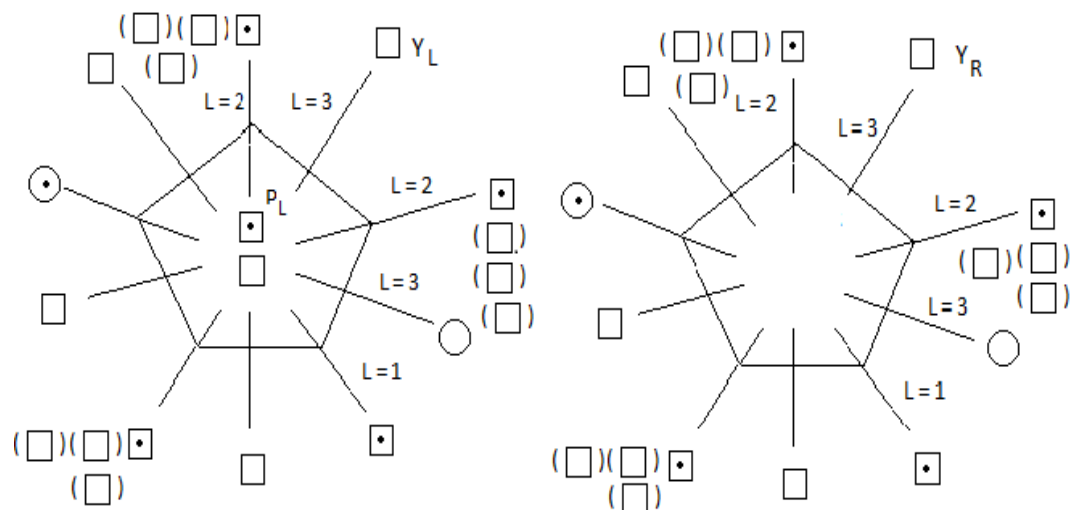


Figure 1.61: Structure of Pd(46, 64).

$J = 0$ and parity: even, even, so $P = (+1)$ and these agree with the data.

Pd(46, 59) is stable with $J^P = 5/2^+$. Its structure is: P_R to X totally filled (not ED) and as in Figure 1.62:

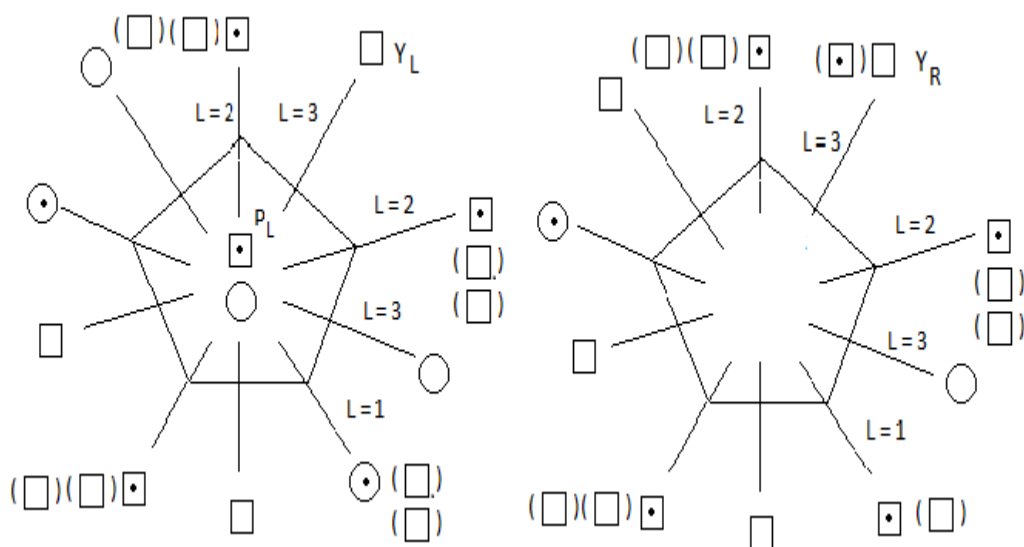


Figure 1.62: Structure of Pd(46, 59).

$J = | 1 + 1 | + 1/2 = 5/2$ and parity: odd, odd, so $P = (+1)$ and these agree with the data. This J value is in conflict with the "L = 3 orbitals fills last"-rule.

Ag(47, 60) is stable with $J = 1/2$ and $P = -$. Its structure is: P_R to X totally filled and as shown in figure 1.63:

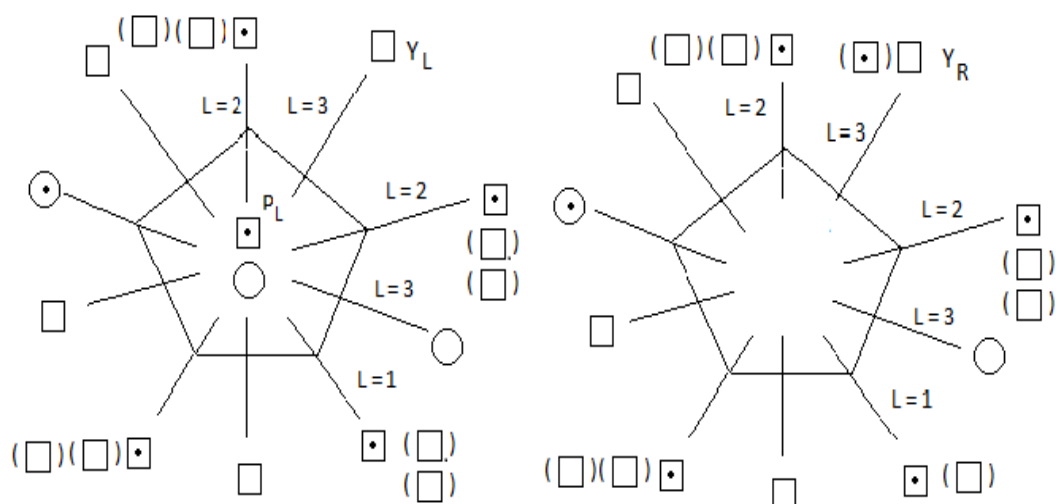


Figure 1.63: Structure of Ag(47, 60).

$J = 0 + 1/2$ due to the proton in ED of Y_R . Parity: odd, even, so $P = (-1)$ and these agree with the data.

Ag(47, 59) is unstable with $J^P = 6^+$. Its structure is P_R to X totally filled (not ED) and as in Figure 1.64:

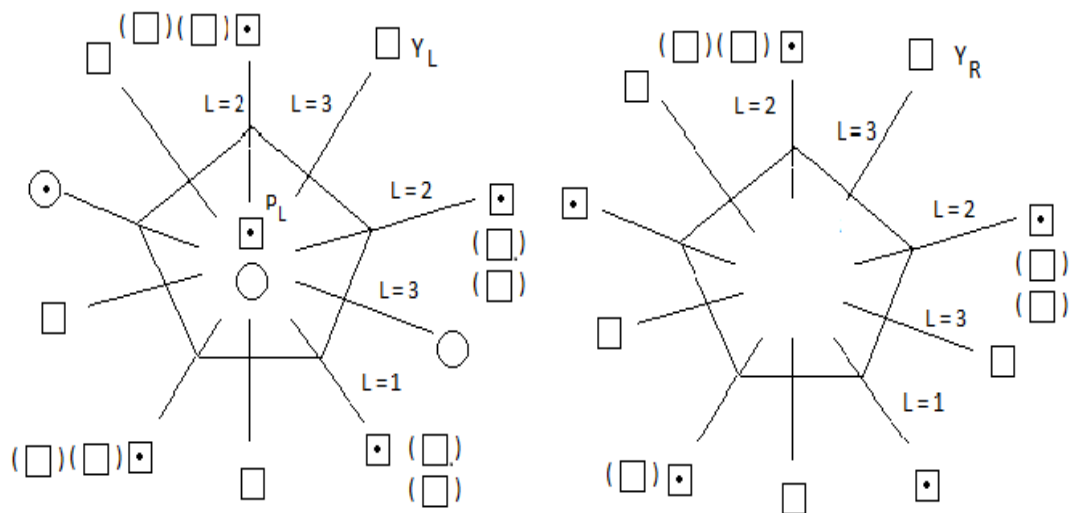


Figure 1.64: Structure of Ag(47, 59).

$J = | 3 + 3 | = 6$, parity: odd, odd, so $P = (+1)$ and this agree with the data. This is unstable because of the large OAM. It will decay to: Ag(47, 59) with $J = 0$, but this isn't in the data.

Cd($p = 48, n = 58, 60, 62, 64, 66, 68$) are all stable with $J^P = 0^+$.

The next orbital layer is again two hexagons with all L values double of what they were in level W.

Cd(48, 63) is stable with $J^P = 1/2^-$. Its structure is P_R to X totally filled (not ED) and as in Figure 1.65:

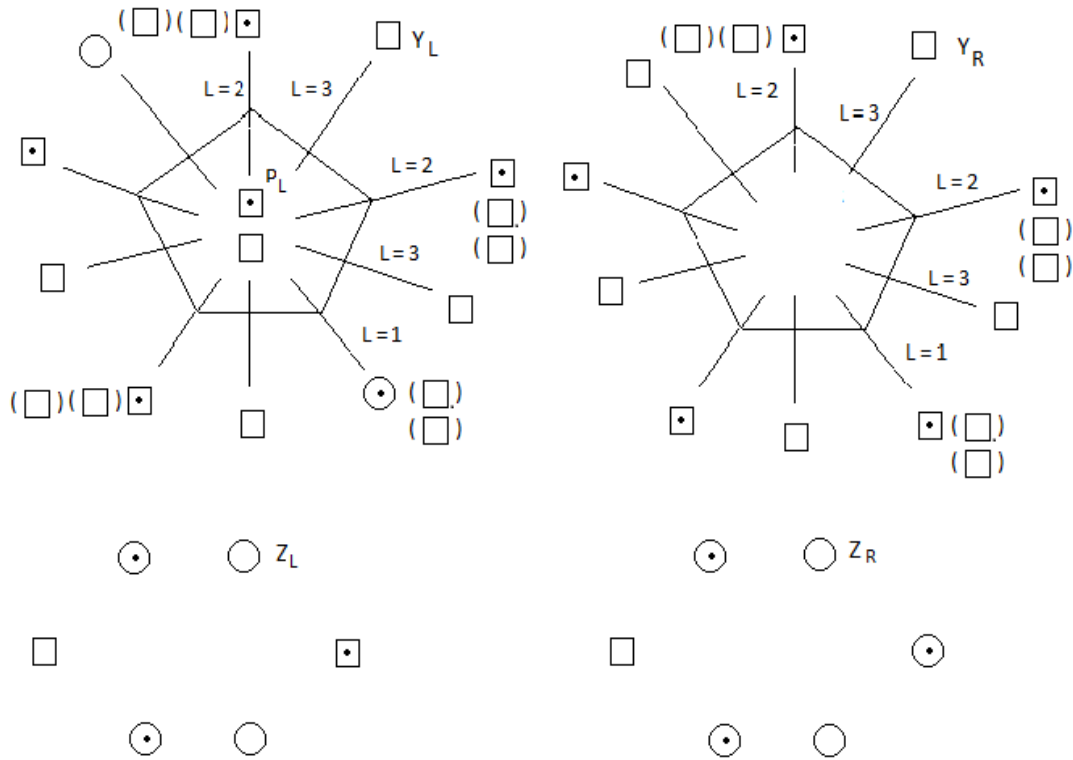


Figure 1.65: Structure of Cd(48, 63).

$J = |-1 - 1 + 2 + 2 - 2| + 1/2 = 1/2$, parity: odd, even, so $P = (-1)$ and this agree with the data.

In(49,64) is stable with $J^P = 9/2^+$. Its structure is P till Y totally filled (not ED) and as in Figure 1.66:

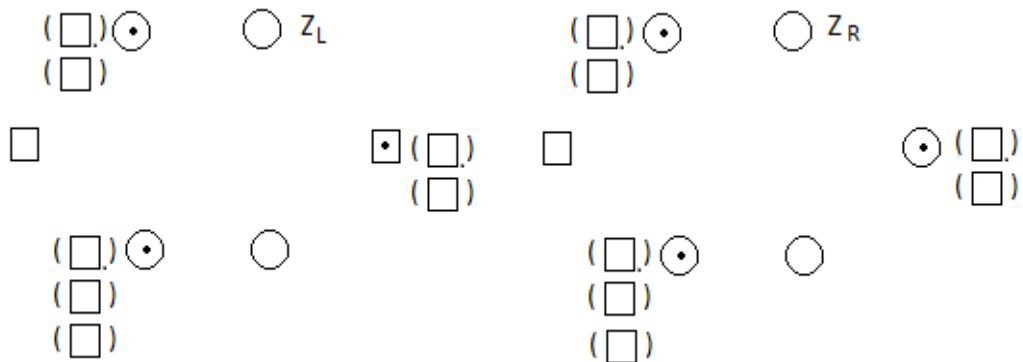


Figure 1.66: Structure of In(49,64).

$J = |4 + 4 - 4| + 1/2 = 9/2$ and parity: even,even, so $P = (+1)$ and this agree with the data.

Sn(50,n = 62, 64, 66, 68,70, 72, 74) are stable with $J^P = 0^+$. These are easy to construct. Sn(50, 65) is stable with $J^P = 1/2^+$. Its structure is: P till Y totally filled (not ED) and as in Figure 1.67:

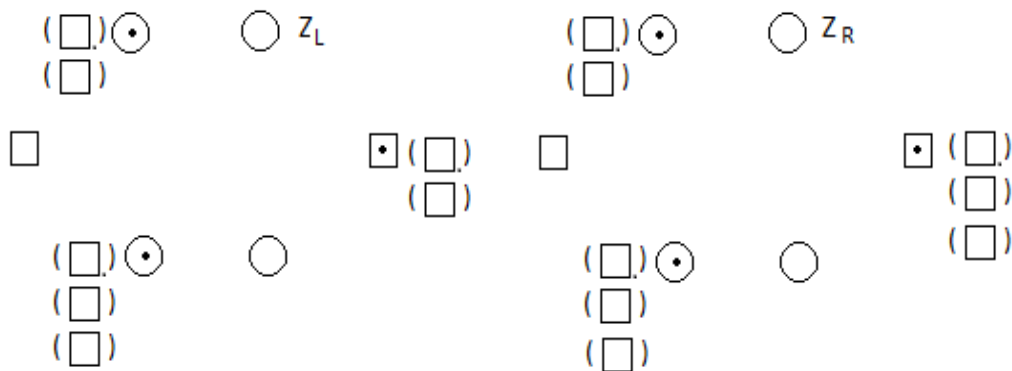


Figure 1.67: Structure of Sn(50, 65).

J is easily seen = $0 + 1/2$, parity: even,even, so $P = (+1)$ and this agrees with the data.

Sb(51, 70) is stable with $J^P = 5/2^+$. Its structure is: P to Y totally filled (not ED) and as in Figure 1.68:

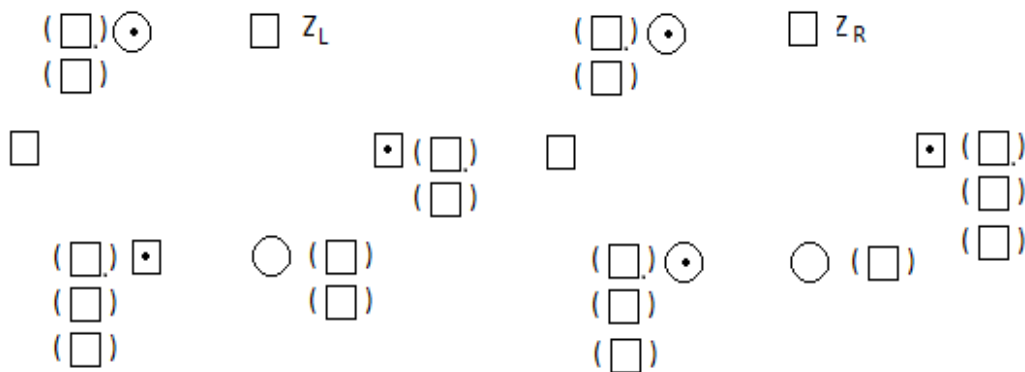


Figure 1.68: Structure of Sb(51, 70).

$J = 2 + 1/2 = 5/2$, parity: even, even, so $P = (+1)$ and this agree with the data.

Sb(51, 72) has $J = 3+3-3+1/2$ or $2+2-1+1/2$ depending on $p = 52, 53, 54$. I (53,77) is stable with $J^P = 3/2^+$. By this level Z must look like in Figure 1.69:

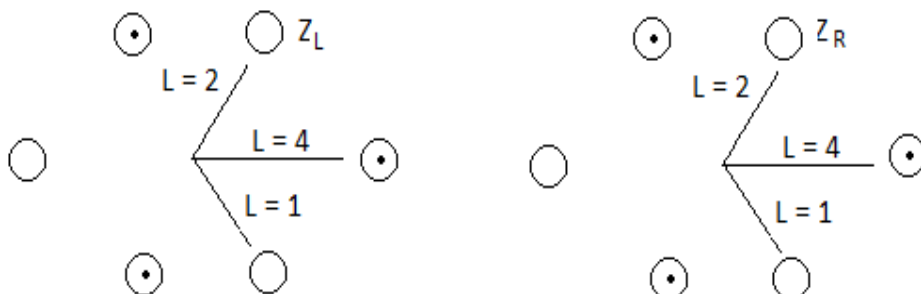


Figure 1.69: Orbital level Z.

Sb(51, 72) is stable with $J^P = 7/2^+$. Its structure is P to Y totally filled (not ED) and as in Figure 1.71:

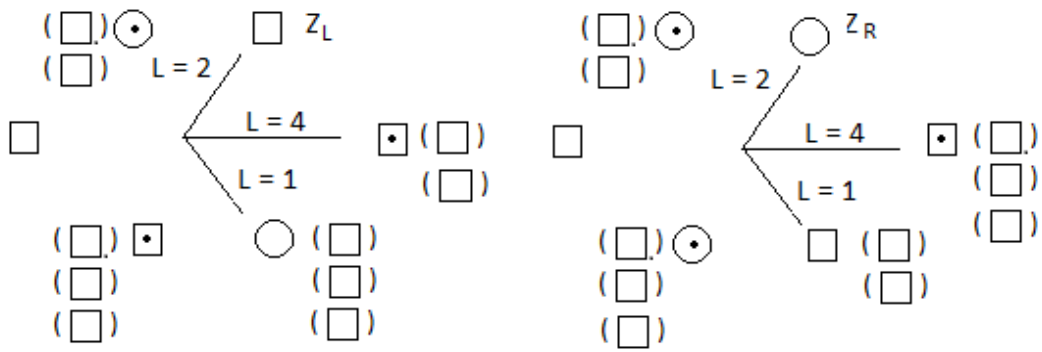


Figure 1.71: Structure of Sb(51, 72).

$J = |2 + 2 - 1| + 1/2 = 7/2$ and parity: even, even, so $P = (+1)$ and these agree with the data.

Te(52, n = 68, 70, 72, 74) are stable with $J^P = 0^+$. These are easy to construct. Te(52, 73) is stable with $J^P = 1/2^+$. Its structure is P till Y totally filled (not ED) and as in Figure 1.72:

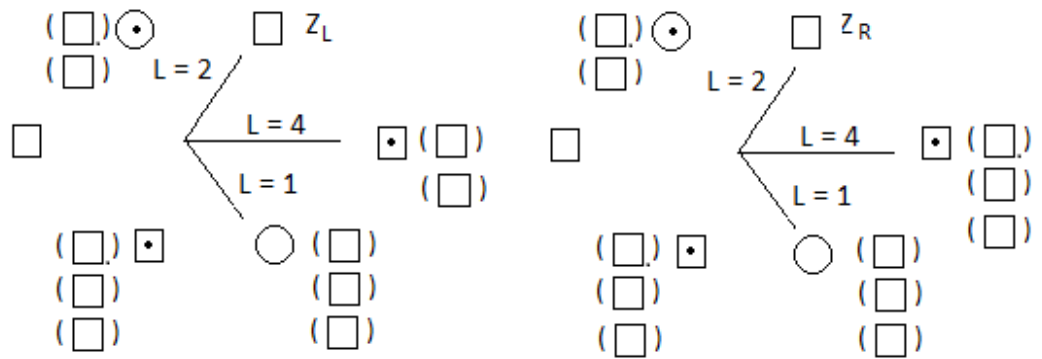


Figure 1.72: Structure of Te(53, 73).

$J = 0 + 1/2$ is easily seen, parity: even, even, so $P = (+1)$ and these agree with the data.

I(53, n = 72,74,76,78) is stable with $J^P = 0^+$. These are easy: put a proton in ED. I(53, 77) is stable with $J^P = 3/2^+$. Its structure is (maybe): P till Y totally filled (not ED) and as in Figure 1.73:

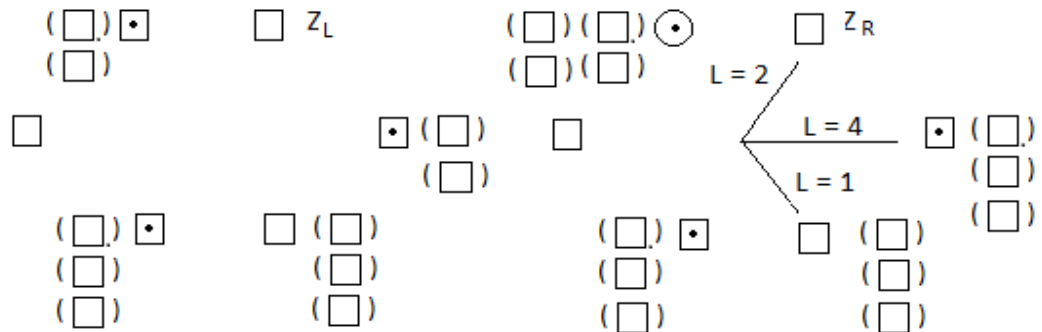


Figure 1.73: Structure of I(53, 77).

$J = 1$ is easy to see, parity: even, even, so J does not agree with the data, and I don't see how we could get $(+ 1/2)$ to add to J since the number of neutrons is odd, but so is the protons. I(53,75) $J^P = 1/2^+$ has a similar problem.

Xe(54, n = 72, 74, 76, 78, 80), are stable with $J^P = 0^+$. Xe(54, 80) has the structure: P till Y totally filled (not ED) and as in Figure 1.74:

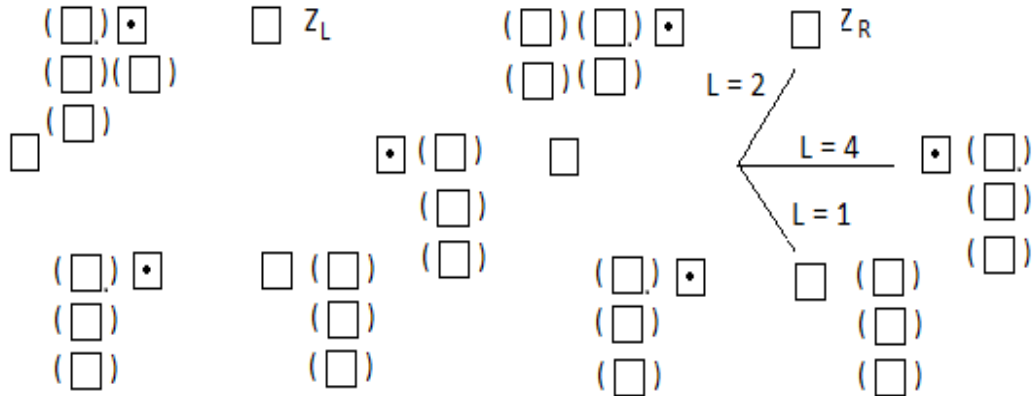


Figure 1.74: Structure of Xe(54, 80).

For the next two nuclei we need layer A with its nucleons having 3 OAM each.

Cs(55, 78) is stable with $J^P = 7/2^+$. Its structure is P to Y totally filled (not ED) and as in Figure 1.75:

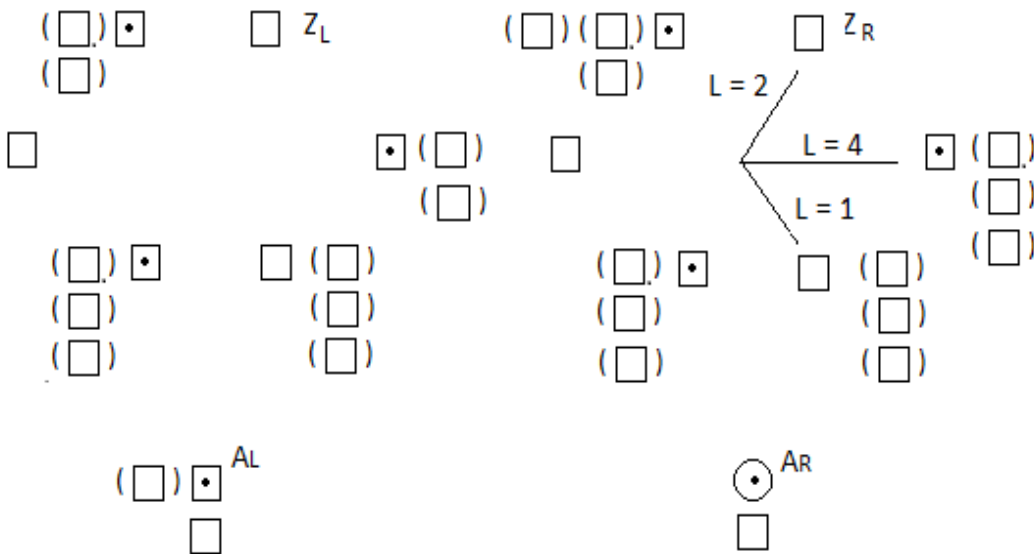


Figure 1.75: Structure of Cs(55, 78).

$J = |3 + 3 - 3| + 1/2 = 7/2$ parity: even, even, so $P = +1$ and these agree with the data.

Ba(56, n = 74, 76, 78, 80, 82) are stable with $J^P = 0^+$. Their structure is: P to A totally filled, with the appropriate number of neutrons in ED of layer Z. Ba(56, 79) is stable with $J^P = 3/2^+$. Its structure is: P_R to A totally filled (not ED) and another neutron in the new layer B at $L=1$, with appropriate ED neutrons in level B and the neutron from P_L into ED of B. Ba(56, 81) looks the same as Ba(56, 79) only with two more neutrons in ED of B.

Level B is two 14-gons (see Figure 1.76).

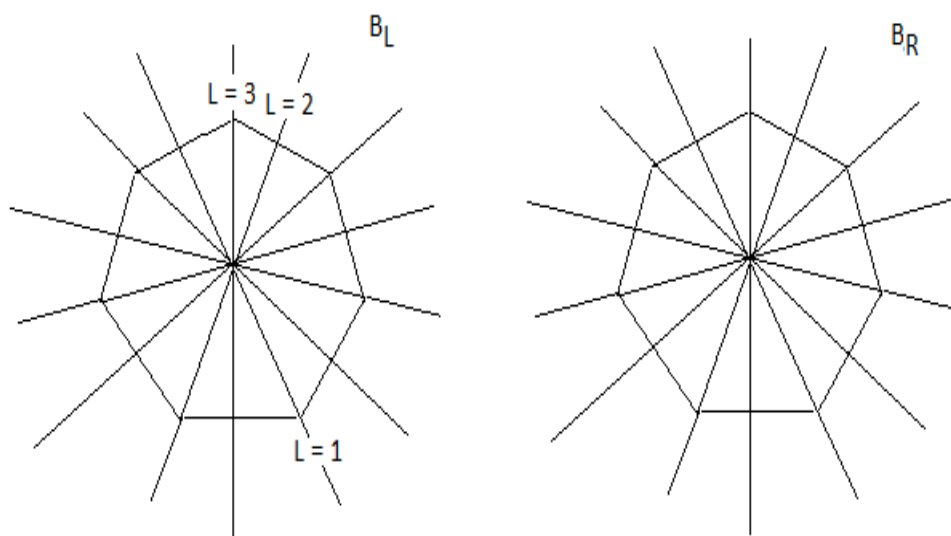


Figure 1.76: Orbital level B.

We have the 14-gons, but we must still determine the L values of four legs of the diagram.

La (57, 82) is stable with $J = 7/2^+$. Its structure is pictured in the next figure.

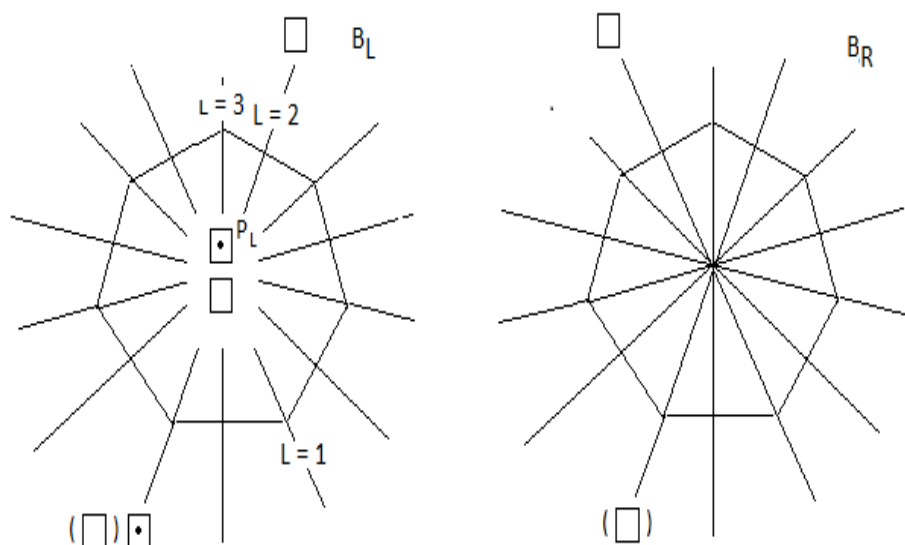


Figure 1.77: Structure of La (57, 82)

Previous protons = 56, previous neutrons = 79. $J = |2 + 2 - 1| + 1/2 = 7/2$, parity: even, even, = +. No other La isotope is stable.

Ce(58, 82), Ce(58,80), Ce(58,78) are all stable with $J = 0$, $P = +$. They are easy to draw.

Pr (59, 82) is stable with $J = 5/2$, $P = +$. Its structure is shown in the next figure:

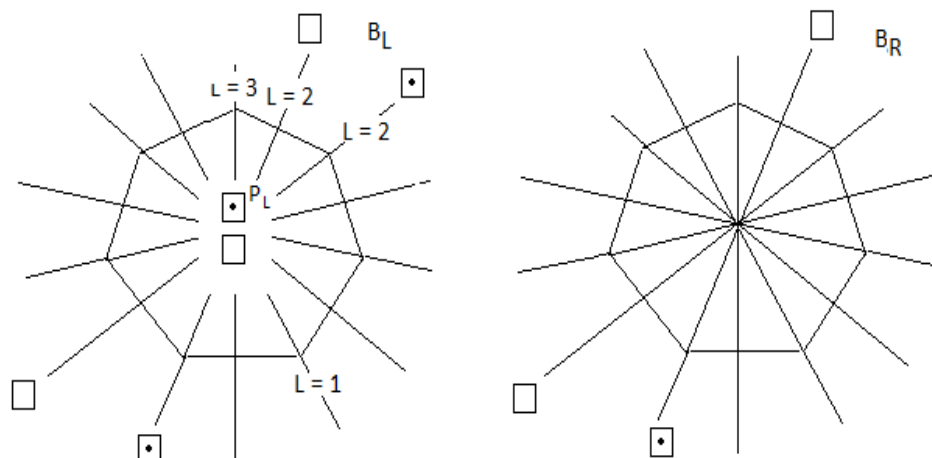


Figure 1.78: Structure of Pr (59, 82)

Previous protons: 56, previous neutrons: 78. $J = |2+2-2-2+2+2-2| + 1/2 = 5/2$, P: even, even, $P = +$.

Nd (60, 82, 86, 88) are stable and easy to draw.

Nd (60, 83) is stable with $J = 7/2$, $P = -$. Its structure is drawn in the following figure:

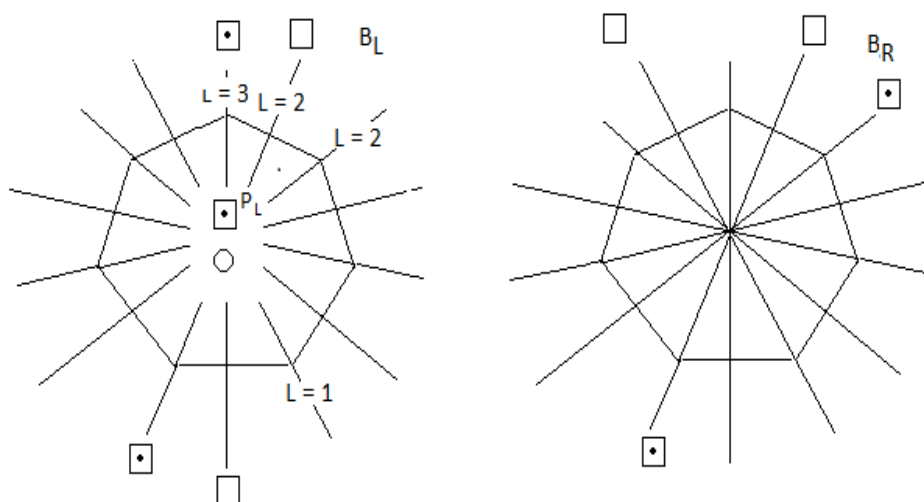


Figure 1.79: Structure of Nd (60,83)

Previous protons = 56, previous neutrons = 79. $J = |3 + 3 - 2 - 1| + 1/2 = 7/2$, P: odd, even, $P = -$. Here the proton in B_R with $L = 2$ is balanced by the neutron in B_R with $L = 1$.

Nd (60, 85) is stable with $J = 7/2$, $P = -$. It is drawn just like in Figure 1.79, just with two neutrons in the ED.

Pm (61, 86) is unstable. It has no stable isotopes. Pm (61, 84) is unstable because it can only have $L = |2+2+1/2| = 9/2$, if the four $L = 1$ and four $L = 2$ orbitals fills first (too large an L). The reason for Pm (61, 85) to be unstable is unknown. It does have a large half-life. Its structure is shown in the following figure.

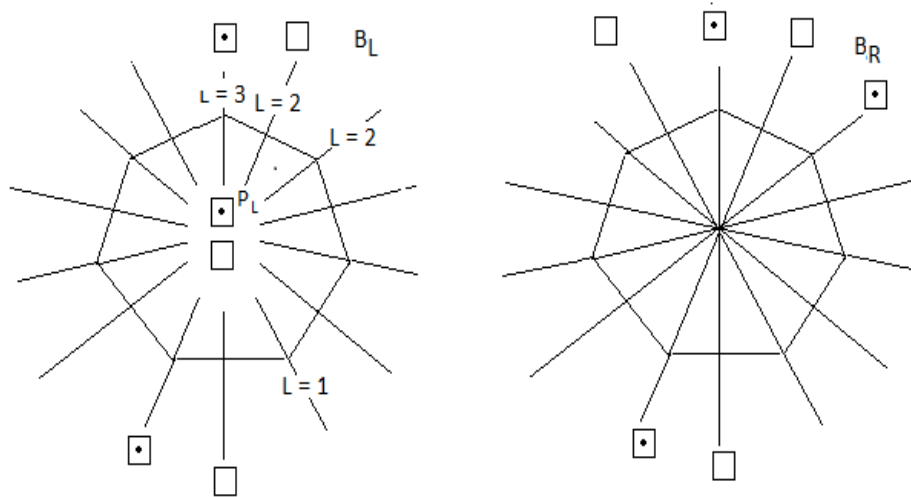


Figure 1.80: Structure of Pm (61, 85)

Previous protons: 56, previous neutrons: 79. $J = |-2-1| = 3$, P even, odd, P = -, checked.

Sm (62, 82) is stable with $J = 0$, parity = +. Its structure is shown in the following figure:

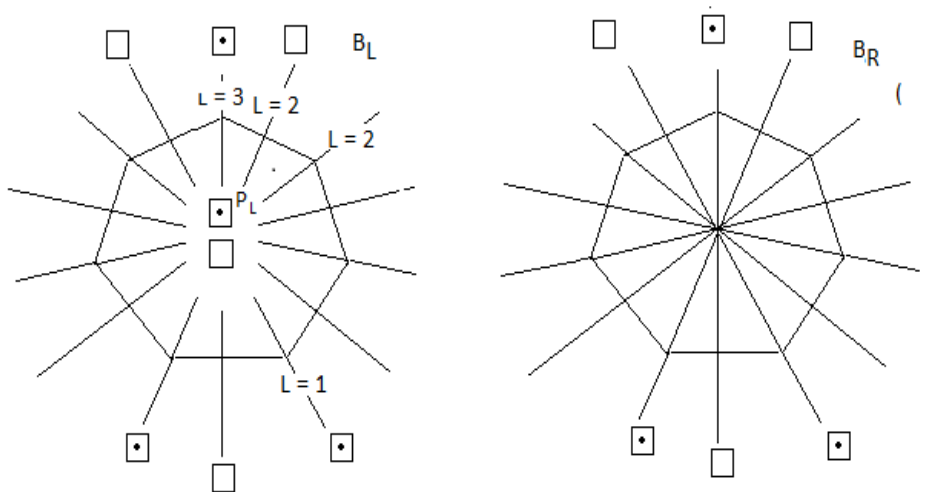


Figure 1.81: Structure of Sm (62, 82).

Previous protons = 56, previous neutrons = 76, where some neutrons are taken from ED of layer A. $J = 0$, P = + are easy to calculate. Sm (62, 88 or 90 or 92) looks the same as figure 1.81 except for the appropriate neutrons in the ED.

Eu (63, 88) is stable with $J = 5/2$, P = +. Its structure is shown in the following figure:

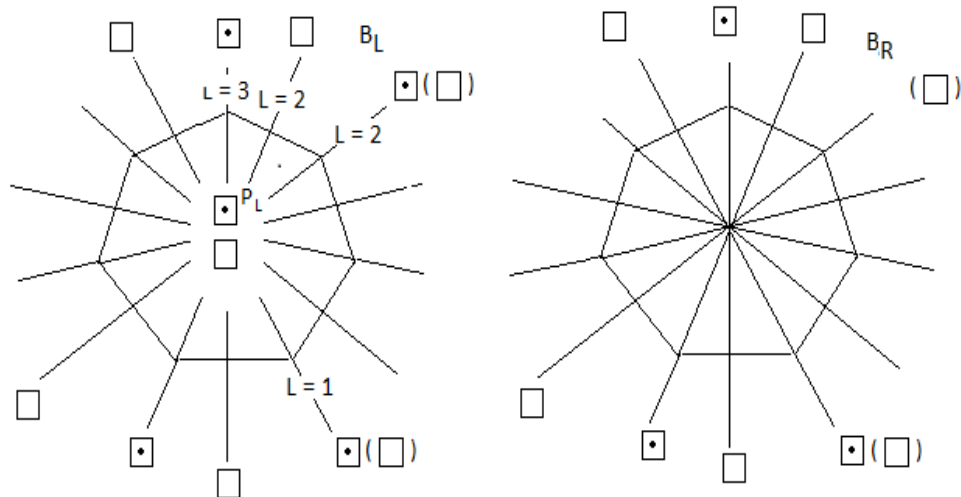


Figure 1.82: Structure of Eu (63, 88).

Previous protons = 56, previous neutrons = 75. $J = |2 + 2 - 2| + 1/2 = 5/2$, P: even, even, P = + check.

Eu (63, 90) looks the same as Figure 1.82, just with two more neutrons in ED.

Gd (64, 91) is stable with $J = 3/2$, P = +. Its structure is shown in the following figure:

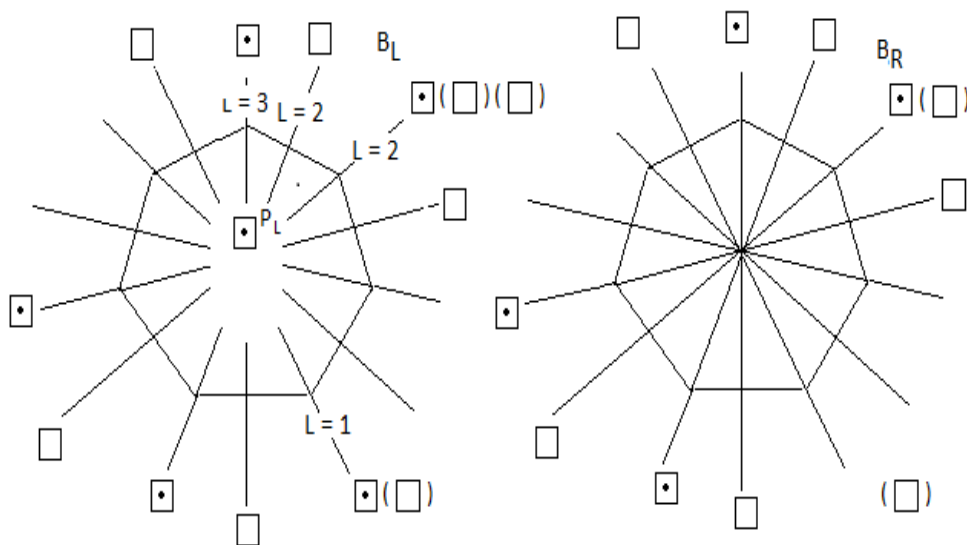


Figure 1.83: Structure of Gd (64, 91).

Previous protons = 56, previous neutrons = 76. $J = |1+1-1| + 1/2 = 3/2$, P: odd, even, P = - check.

Gd (64, 93) looks the same as Figure 1.83, just with two more neutrons in the ED. The other stable isotopes of Gd (n = 90, 92, 94, 96) all have $J = 0$, P = + and are easy to draw.

Tb (65, 94) is stable with $J = 3/2$, P = +. Its structure is shown in the following figure:

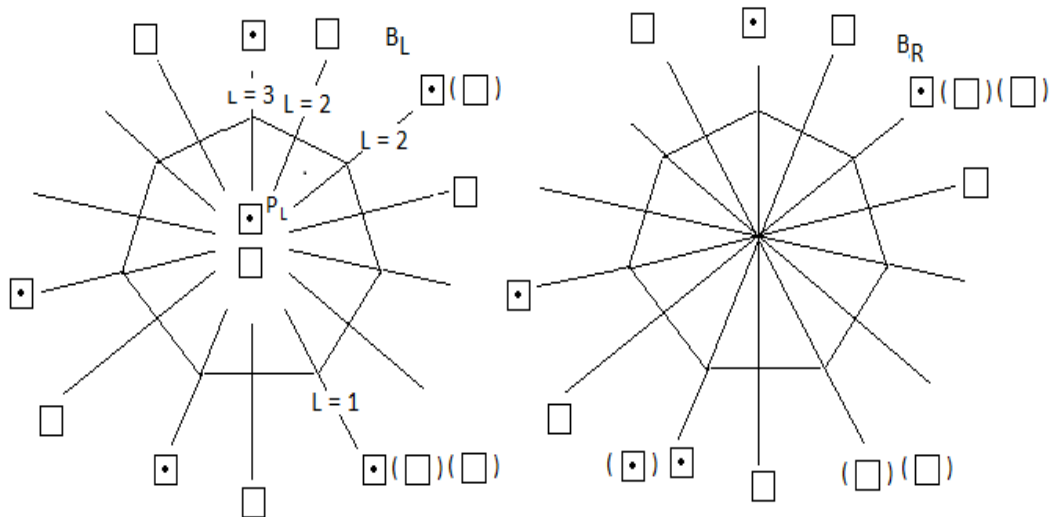


Figure 1.84: Structure of Tb (65, 94).

Previous protons = 56, previous neutrons = 79, $J = |1| + 1/2$, P: even, even, $P = +$ check.

Dy (66, 90 or 92 or 94 or 96 or 98) are stable with $J = 0$, $P = +$. These are easy to draw.

Dy (66, 95) is stable with $J = 5/2$, $P = +$. Its structure is shown in the following figure:

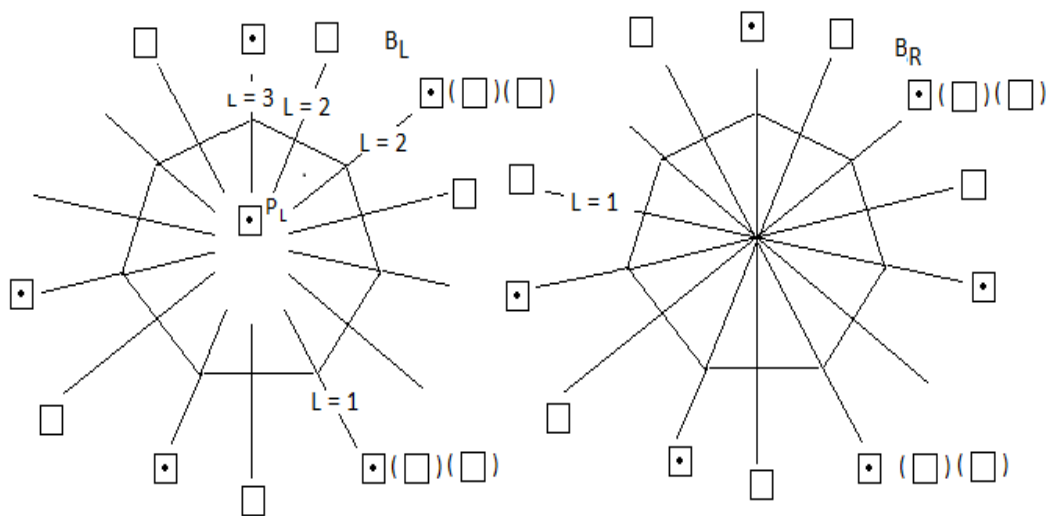


Figure 1.85: Structure of Dy (66, 95).

Previous protons: 56, previous neutrons = 79. $J = |-1-1| + 1/2 = 5/2$, P: odd, odd, $P = +$ check.

Dy (66, 97) looks similarly to structure 1.85, just with two more neutrons in ED.

Dy (66, 99) is unstable with $J = 7/2$, $P = +$. Its structure is shown in the following figure:

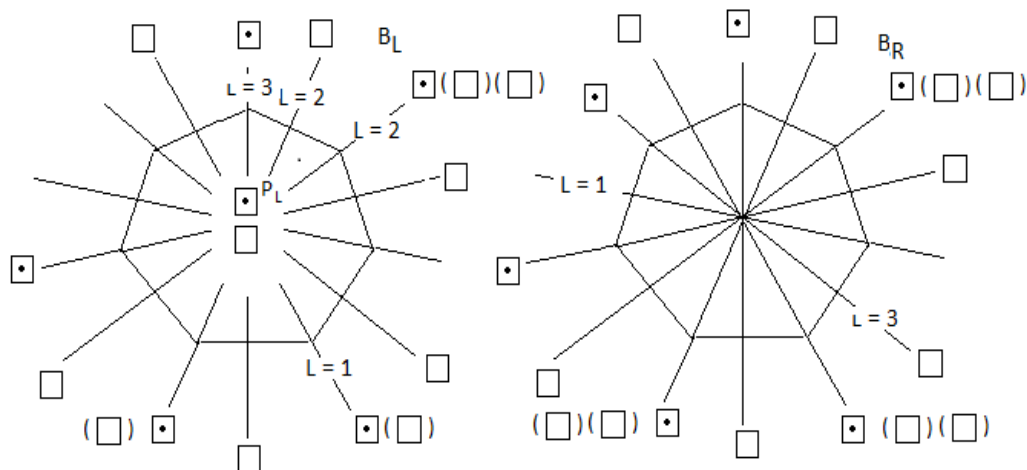


Figure 1.86: Structure of Dy (66, 99).

Previous protons = 56, previous neutrons = 79, $J = |-3 -3 +3| + 1/2 = 7/2$, P: even, even, P = + check. I don't know why this one is unstable.

Since we have the L values now (one L value is left arbitrary), we can leave the rest of the stable nuclei's structure for the reader as an exercise. We list the rest of the stable nuclei and their J^P :

p	Element	A	n	J^P
67	Ho	165	98	7/2-
68	Er	162	94	0+
	Er	164	96	0+
	Er	166	98	0+
	Er	167	99	7/2+
	Er	168	100	0+
	Er	170	102	0+
69	Tm	169	100	1/2+
70	Yb	168	98	0+
	Yb	170	100	0+
	Yb	171	101	1/2-
	Yb	172	102	0+
	Yb	173	103	5/2-
	Yb	174	104	0+
	Yb	176	106	0+
71	Lu	175	104	7/2+

72 Hf	176 104 0 ⁺	
Hf	177	7/2 ⁻
Hf	178	0 ⁺
Hf	179	9/2 ⁺
Hf	180	0 ⁺
73 Ta	181	7/2 ⁺
74 W	180	0 ⁺
W	182	0 ⁺
W	183	1/2 ⁻
W	184	0 ⁺
W	186	0 ⁺
75 Re	185	5/2 ⁺
76 Os	184	0 ⁺
Os	187	1/2 ⁻
Os	188	0 ⁺
Os	189	3/2 ⁻
Os	190	0 ⁺
Os	192	0 ⁺
77 Ir	191	3/2 ⁺
Ir	193	3/2 ⁺
78 Pt	192	0 ⁺
Pt	194	0 ⁺
Pt	195	1/2 ⁻
Pt	196	0 ⁺
Pt	198	0 ⁺
79 Au	197	3/2 ⁺
80 Hg	196	0 ⁺
Hg	198	0 ⁺
Hg	199	1/2 ⁻
Hg	200	0 ⁺
Hg	201	3/2 ⁻

Hg	202	0 ⁺
Hg	204	0 ⁺
81 Tl	203	1/2 ⁺
Tl	205	1/2 ⁺
82 Pb	204	0 ⁺
Pb	206	0 ⁺
Pb	207	1/2 ⁻
Pb	208	0 ⁺

2. Computation

We specify the energy levels of layer $R_{R,L}$ at single distance are all equal to E_{16} , using formula (11) below. Similarly for other rings we define their energy level as equal to E_M , where M is the amount of nucleons counting from layer P until the given ring of the same L is totally filled. This is more sophisticated than just using formula (11) below.

We calculate the transition energies of $F(9, 9)$ decaying by proton conversion into $O(8,10)$ after the proton decay.

As can be seen, the model is more predictive than just an energy level diagram. It can be seen that the energy levels of the R orbital layer do not have equal energy levels as one would be led to believe in the "random model".

We see by classical analysis that the excited $O(8,10)$ will emit 8 photons before becoming the stable $O(8,10)$, $J^P = 0^+$. This is for 4 transitions. Quantum mechanically the emitted photon energies is just the difference in momentum of the 4 orbitals, so just 4 photons would be emitted, where two of which have the same frequency (see the following figure):

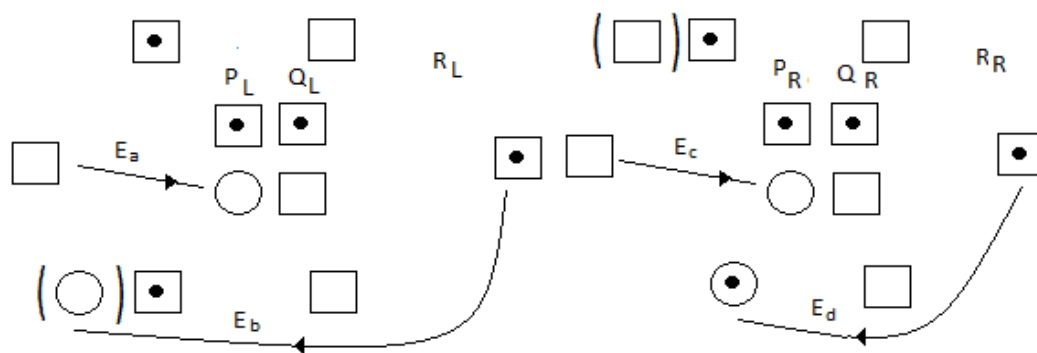


Figure 2.1. Transitions of $O(8, 10)$.

We see that all the transitions are to lower energy levels, so the reaction is exothermic.

We proceed to calculate the energy levels of transitions as indicated in the following figure (labeled by E_n). To do this we examine the model's prediction for $B(5, 4)$:

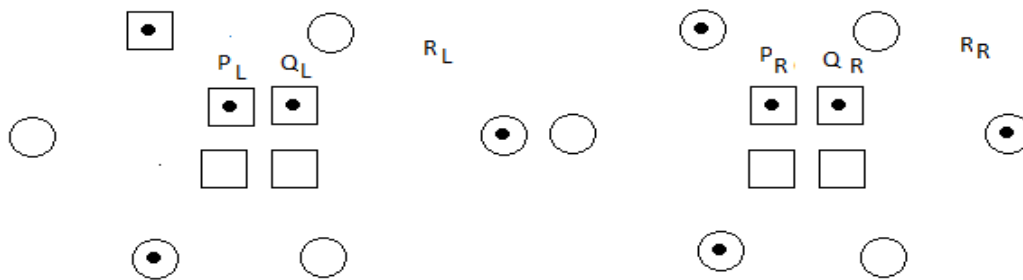


Figure 2.2. Configuration for B(5,4).

We label the energy levels by the layer they are in with a 1 or 2 for single and double distance orbitals respectively. Thus the energy level of the proton in R_L will be denoted: E_{1R} .

The measured value of the total energy of Hydrogen is $1.504 \cdot 10^{-10}$ J.

Plug this into:

$$E_T = (E_0 + (3/5)h_{bar}^2 \pi^2 / (2(m_p)L^2)(3N/\pi)^{2/3})N. \tag{10}$$

and we must find $N = 2$. Take $E_0 = 0$ and solve for N :

$$N = (E_T 40mL^2 / 3h^2(\pi/3)^{2/3})^{3/5}$$

Plugging in the values we get:

$$N = (6.0129)^{3/5} = 2.934$$

this is nearly 2, so the theory applies (the actual value of E_T may be slightly less). (10) was found at ref. [14]. Notice from the code below that we took a value for L less than the charge radius of a Hydrogen nucleus.

For the energy of the Q orbitals (we compute for E_8 and assign this to $E_{5,6,7,8}$) we compute: $E_Q = E_8$ (we use (11)):

$$E_N = E_0 + h_{bar}^2 \pi^2 / (2(m_p)L^2)(3N/\pi)^{2/3}. \tag{11}$$

set $E_0 = 0$:

$$E_Q = E_8$$

$$\begin{aligned} &= h_{bar}^2 \pi^2 / (2(m_p)L^2)(3 \cdot 8 / \pi)^{2/3} \\ &= 1.668 \cdot 10^{-10} \text{ J} = 2671 \text{ MeV}, \end{aligned}$$

this is the value for a transition from Q to P layer.

For the energy of the single distance R orbitals we compute $E_{1R} = E_N$ for $N = 16$. We get:

$$\begin{aligned} E_{1R} &= h_{bar}^2 \pi^2 / (2(m_p)L^2)(3 \cdot 16 / \pi)^{2/3} \\ &= 2.647 \cdot 10^{-10} \text{ J} = 4241 \text{ MeV} \end{aligned}$$

For the transition E_a of Figure 17.1 we compute (using (10)): $E_a = E_{20} - E_4$. We get:

$$\begin{aligned} E_a &= 20 \cdot (3/5)h_{bar}^2 \pi^2 / (2(m_p)L^2)(3 \cdot 20 / \pi)^{2/3} - 4 \cdot (3/5)h_{bar}^2 \pi^2 / (2(m_p)L^2)(12 / \pi)^{2/3} \\ &= 3.434 \cdot 10^{-9} \text{ J} = 55009 \text{ GeV}. \end{aligned}$$

Thus two photons of frequency:

$$f = E_a/h = 5.201 \times 10^{24} \text{ Hz}$$

would be emitted in the corresponding decay reaction. For E_d we compute $E_{20} - E_{16}$. So:

$$E_d = 20 \cdot (3/5) \hbar^2 \pi^2 / (2(m_p)L^2) (3 \cdot 20 / \pi)^{2/3} - 16 \cdot (3/5) \hbar^2 \pi^2 / (2(m_p)L^2) (3 \cdot 16 / \pi)^{2/3}$$

$$= 1.145 \times 10^{-9} \text{ J.}$$

so:

$$f = E_d/h = 1.728 \times 10^{24} \text{ Hz.}$$

It is my guess that $E_d = E_b$.

This must hold: $E_{1R} < E_{2R}$, so R_{1L} orbitals must fill before R_{2L} orbitals. We expect the real value of E_{2R} to be slightly larger than this formula (11) would give.

The following must hold: $2E_9 - E_{10} = 0$. We compute to see if this is so:

$$LS = 1.67 \times 10^{-101} \text{ is nearly equal to } RS = 0,$$

so the formula passes this test.

Other transition energies for other isotopes can be computed similarly.

The maximum amount by which formula (11) will be wrong for R_{1L} orbitals is:

$$E_{ERR} = E_{16} - E_9 = 1.567 \times 10^{-9} \text{ J}$$

The Visual Basic code to compute these values are shown here:

```
Imports System.Console
Module Module1
Sub Main()
    Dim E_n As Double = 1.504 * 10 ^ (-10)
    Dim pi As Double = 3.14159265
    Dim h_b As Double = 6.626 * 10 ^ (-34) / (2 * pi)
    Dim m As Double = 1.667 * 10 ^ (-27)
    Dim L As Double = 0.8751 * 10 ^ (-15)
    Dim N As Double
    Dim E_1R As Double
    Dim E_Q As Double
    Dim E As Double
    Dim E_8 As Double
    Dim E_d As Double
    Dim E_a As Double
    Dim i As Int16
```

$$N = ((E_n) * 2 * m * (L)^2 / ((h_b)^2 * \pi^2))^{\frac{3}{2}} * \pi / 3$$

$$N = 10.345 * 10^{26}$$

$$E_{1R} = h_b^2 * \pi^2 / (2 * m * L^2) * (3 * 9 / \pi)^{\frac{2}{3}}$$

$$E_Q = h_b^2 * \pi^2 / (2 * m * L^2) * (3 * 3 / \pi)^{\frac{2}{3}}$$

$$E = 2 * h_b^2 * \pi^2 / (2 * m * L^2) * (3 * 9 / \pi)^{\frac{2}{3}} - h_b^2 * \pi^2 / (2 * m * (L)^2) * (30 / \pi)^{\frac{2}{3}}$$

$$E_8 = h_b^2 * \pi^2 / (2 * m * L^2) * (3 * 8 / \pi)^{\frac{2}{3}}$$

$$E_d = 17 * (3 / 5) * h_b^2 * \pi^2 / (2 * m * L^2) * (3 * 17 / \pi)^{\frac{2}{3}} - 16 * (3 / 5) * h_b^2 * \pi^2 / (2 * m * (L)^2) * (3 * 16 / \pi)^{\frac{2}{3}}$$

$$E_a = 17 * (3 / 5) * h_b^2 * \pi^2 / (2 * m * L^2) * (3 * 17 / \pi)^{\frac{2}{3}} - 4 * (3 / 5) * h_b^2 * \pi^2 / (2 * m * (L)^2) * (3 * 4 / \pi)^{\frac{2}{3}}$$

Write(E_d) ' / 6.602 / 10 ^ (-34))

Write(" ")

Write(E_d / 6.602 / 10 ^ (-34))

'Write(E_Q * 1.602 * 10 ^ 19)

'Write(E_1R)

'Write(" ")

'Write(E_1R * 1.602 * 10 ^ 19)

'Write(E_a / 6.602 / 10 ^ (-34))

'Write(E) ' * 1.602 * 10 ^ 19)

'Write(E_8)

i = Read()

End Sub

End Module

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