Infinite Particle Physics

Chapter 4 – Multiple-Plane Formation In Nuclei

Why Should We Consider Multiple Planes?

There are two reasons why we should suspect that nucleons cluster in multiple planes in large nuclei:

1) The experimental evidence, using high-energy electron probes, is that the size of nuclei seems to increase as the cube root of the atomic mass-number, A, thus suggesting that nucleon clustering processes tend toward a roughly spherical form. Although planar nuclide forms might yield spherical type statistics, due to their being present in three mutually orthogonal cardinal-plane isomers, their inferred size would increase as the square-root, rather than the cube-root of A.

2) The ratio of neutrons to protons increases progressively with atomic number, Z. If single-plane nuclides (small Z nuclides) seem happiest (highest abundance) when p = n, and small nuclides with odd Z are happiest with p = n+1, why, then, should large nuclides have any different neutron requirements for their nuclide planes. Does not this excess of neutrons suggest that they serve another function? Could they, perhaps, site between multiple p/n nuclide planes, anchoring these planes with intermediate diagonal bonds? Here would be a way to stabilize these parallel p/n planes against differential motion during movement through the lattice, so that stable inter-plane paraxial bonds could form, thereby adding to the average number of bonds per nucleon in the nuclide cluster.

Some Fundamental Insights Leading To Our Goal

Suppose we ask ourselves the following question:

- *Why does a mixture of x-p's & y-n's always evolve into a nuclide whose ground state has a precisely reproducible mass-deficit?* Does this not imply that, no matter how chaotic the precursor mix of p's & n's is, they always self-organize into *the same nuclide structure,* with the same numbers and types of bonds?

This self-evident insight leads to another pertainent question:

- *Why & how do the randomly sited p's & n's of the precursor cluster move to their final ground-state locations?*

There are two obvious "why's":

1) *Each proton* in the mixture seeks to move as far away from other protons as it can (mutual repulsion provokes movement).

2) *Each nucleon* always gravitates toward the strongest bonding location available in its vicinity (because energy evolved in forming stronger bonds deprives weaker bonds of the mass-energy needed for their formation).

There are also two obvious "how's":

1) *Protons can separate from each other by inter-nucleon charge-exchanges*, whereby proton and neutron "entities" are able to move freely in opposite directions throughout the nucleon cluster. The mutual repulsion of protons causes proton "entities" to move *outwardly* until their movement is halted by reaching the cluster's perimeter. Conversely, *inward* neutron "entity" movement is halted by approaching the cluster's neutron-rich center. *It is important to perceive* that inter-nucleon charge-exchanges can take place *only between protons and neutrons*, because these charge-exchanges can occur only where there is an inter-nucleon charge-gradient. You will perceive that this requirement results in a final structure in which proton and neutrons *alternate in all diagonal directions*.

2) *Nucleons can shift their locations to find stronger bonding relationships*, because their inter-nucleon bonds *are continually being jostled, or severed*, and subsequently reformed, over and over again, during nucleosynthesis. And these bond-breaking processes continue, to a lesser extent, everywhere in space, as a result of a nuclide's momentum carrying it *through successive grain-boundaries* of the space-lattice crystal. You will appreciate that successive grains will inherently have different cardinal directions. Therefore, nuclide planes will be required to *bend* as they pass through each grain boundary, in order to adapt to the new cardinal orientations; this bending will weaken or rupture bonds along a line parallel to the grain-boundary, particularly so in multiple-plane nuclei. There is also the probability that various grain-boundary irregularities, such as step-dislocations, may be present at the point of pass-through; these dislocations may create more severe nuclide disturbances, even splitting the nuclide temporarily.

At What Size Will Nucleon Clusters Form Multiple Planes?

Answer: Multiple planes will form whenever this geometry *yields greater nuclide mass-deficit* than the same numbers of protons & neutrons can achieve in a single plane.

Two factors favor single-plane structures:

1) With all the nucleons in one plane, *the ratio of area to perimeter will be highest*, yielding a higher percentage of internal nucleons (6-8 shared bonds/nucleon), and a lower percentage of edge nucleons (3-5 shared bonds/nucleon).

2) There may be *more opportunities for groups of four nucleons to be in the 2-cycle alpha-type charge-exchange cycle* (this change increases mass-deficit -28.30-2(-7.72) ≈ -12.86 MeV (≈ 5 bonds).

But, there are also two factors favoring multiple planes;

1) *Total mass-deficit is enhanced by interplane bonds:* In structures with five nuclide planes (this is the expected number), *paraxial bonds* between planes 1 & 3, 2 & 4, and 3 & 5, will add to the bonds formed within each plane. Perimeter neutrons in planes 2 & 4 also can form notch diagonal bonds with planes 1 & 3, and planes 3 & 5. These added pb's & db's tend to compensate for the loss of

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bonds which result from the lesser numbers of higher-bonding interior nucleons in five-plane structures, and, as atomic number increases, will eventually cause total mass-deficits to exceed those of single-plane structures of the same numbers of protons & neutrons.

2) *Mass-deficits due to* <u>*nucleon pairings*</u> *will increase* in five-plane structures, due to the inherently smaller dimensions of the constituent planes, and due, also, to the opportunities for pairings *between* planes. The smaller row and column sizes make the in-and-out shifts implicit in nucleon pairings more easily accommodated.

Why Do Multiple-Plane Nuclei Have <u>Five</u> Planes?

Why <u>five</u> planes? Why not two, three, four, or six? Here are the reasons:

1) **Multiple-planes need anchoring:** Imagine, for example, two parallel p/n planes of the same geometry stacked one above the other, spaced a typical paraxial-bond spacing of 9ü, with protons above protons, and neutrons above neutrons. This structure won't hold together, because paraxial bonded nucleons are *unstable in translation* unless stabilized by a diagonally-bonded intermediate nucleon, as I have explained in Fig. 3-1, p. 3-1.

   However, *intermediate notch neutrons* can bond <u>stably</u>, *only* if they are *part of an* <u>*extensive*</u> *plane*. Here is why: U-notches can't attract single nucleons! Having two attracting db's, plus one repelling db, for a net bonding of just 1db per plane, a single "notch" site is unable to attract a nucleon away from any planar notch site, because planar notch sites have a minimum of 3 bonds (2db, 1pb).

2) **<u>Two</u> intermediate planes are necessary to achieve bond parity with paraxially-bonded p/n planes:** Even an extensive intermediate neutron plane will not be able to attract nucleons from adjacent p/n planes to fill its central region, because these central sites would have one-shared-pb less bonding. *Two* intermediate planes correct this disparity, by providing the opportunity for inter-plane pb's. In fact, because of their *notch bonds*, paired intermediate planes, when they are sizable, can *exceed the average bonds/nucleon* of the *outer* p/n planes, and, hence, attract nucleons away from them. (This is because paired interplane "notch" nucleons add *two* shared-db's/notch nucleon to each intermediate plane, while adding *just one* shared-db/notch nucleon to each of the outer planes.

Why Are Intermediate Planes Comprised Exclusively Of Neutrons?

Neutron-only intermediate planes are a direct result of p/n "entity" movements between the five planes, as the precursor p's & n's self-organize. This "entity" movement can occur only through face-diagonal charge-exchanges between protons and neutron, and, hence, the final structure must end up with proton-containing planes having neutrons *alternating* in all face-diagonal directions. You will see that intermediate planes *must consist exclusively of neutrons to achieve this geometry*, because, *if* any protons were in layers 2 & 4, they would be *diagonally adjacent* to protons in layers 1, 3 & 5.

Since we have inferred that T-slant neutrons can exist in both slant forms, planar clusters of neutrons can be imagined which have the same bonding prospects as those composed of p/n mixtures. However, a neutron-only plane could not form in isolation from p/n planes, because there could be no possibility of inter-nucleon charge-exchanges to stabilize it against disruption. But, if neutron "rafts" *are located between p/n planes* (in a five-plane structure), these "rafts" will be *shielded from external destabilizing influences.*

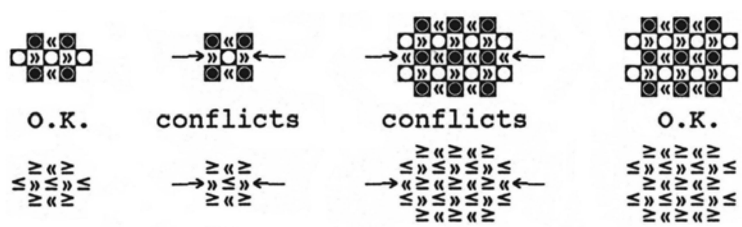
What Determines The Geometry Of Planes 1, 3, & 5?

- **The requirement for U-notches, leads to square, or rectangular planes:** Interplane-neutron rafts can bond only at perimeter U-notches, and this bonding will be maximized if all the protons forming them are in a linear arrangement. (Recall that the perimeter nucleons will tend to be protons, because they repel each other, and can move outwardly by inter-nucleon charge-exchanges).

- **Raft neutrons can orient in either of two directions in rectangular rafts**, but, because of slant considerations, they can bond only to two of the four sides of a rectangular, or square, p/n plane. This restriction occurs because the nucleon "slants" required for bonding within the interplane neutron rafts are opposite to those required for orthogonal u-notch bonding. I show the nature of these conflicting slant requirements in the lower "aerial" view below in Fig. 4-1, where I have replaced the normal proton and neutron symbols in the upper schematics with these slant symbols:

```
≥ = three-high stack of 9ü-spaced, right-slant protons
≤ = three-high stack  of 9ü-spaced, left-slant neutrons
» = 9ü-spaced pairs of right-slant interplane neutrons
« = 9ü-spaced pairs of left-slant interplane neutrons
```

Fig. 4-1 Bonding Conflicts In Orthogonal U-Notches



I show the repulsive "notch" locations with arrows. Any interplane neutron trying to locate here will have one equivalent diagonal bond *subtracted* from the number of shared bonds it could otherwise form with other neutrons in the growing interplane neutron "rafts". Thus, neutrons tend to avoid these locations.

The Above Analysis Forced A Change Of Viewpoint

I arrived at this multiple-plane point in my nuclide investigation thinking that all p/n nuclide planes always contained at least as many neutrons as protons, and that

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interplane neutrons would be comprised only of (what I call) *extra neutrons* (A-2Z). The preceding analysis persuaded me that I was wrong — that the formation of interplane neutron rafts requires an excess of protons in the nuclide planes, to insure that an adequate number of dual-proton u-notches are available around the nuclide perimeter to anchor the interplane neutron rafts. This requirement releases some of the n = p neutrons to join forces with the extra neutrons to form these rafts.

The Importance Of Adequate Numbers Of U-Notch Neutrons

How many U-notch interplane neutrons are needed for adequate anchoring of paraxially-bonded nuclide planes? Answer: *at least eight* — two each on opposite ends of each of the two opposing interplane-neutron rafts. We can infer that the opposite-end requirement is necessary to stabilize against rotational misalignment of the three nuclide planes, while *two* notch neutrons at each end of an extensive interplane raft are necessary to make the interplane notch-bonding competitive with p/n plane notch locations.

What Is The Minimum Size Of Neutron Rafts For Stability?

What means can we use to determine the minimum size that will permit an interplane neutron raft to form (in competition with a single plane arrangement). I can think of three avenues of approach:

1) We can compute bonds/neutron vs. raft size and see what size approaches the bonds/nucleon of single-plane nuclides.

2) We can graph the numbers of extra-neutrons (A-2Z) vs. atomic number for the most-abundant isotope of each element. If neutron-only rafts form, we should see step changes in the numbers of extra-neutrons as atomic number increases.

3) We can imagine & draw various nuclide structures, with the aim of uncovering which type of structure, single-plane, or multi-plane, best explains the regions of stability and instability, which exist among the isotopes of a variety of elements.

Approach #1 — Calculating Bonds/Nucleon

To get a feel for this, we can examine a curve for the average mass-deficit/nucleon vs. atomic-mass number, A, in any nuclear physics text. We see that it climbs in jagged fashion from about -7.6 MeV at A = 12, peaks at -8.7 MeV at A ≈ 60, and declines slowly from there to a mass-deficit value of -7.6 MeV at A = 238. These binding energy values correspond to about 3 to 3.5 bonds per nucleon (6 to 7 shared bonds), so any raft large enough to have this many bonds/neutron may be able to form.

How Bonding Of Interplane Neutrons Varies With Raft Size

We shall begin by computing the number of bonds/neutron in the four structures of Fig. 4-2, where we should imagine that the two neutron rafts (indicated by "»" & "«") are in planes 2 & 4 of a five plane structure with three identical proton-rich p/n planes (where the symbols, "*" & "*", indicate *three-layer stacks* of p's & n's, respectively). Our interest is in comparing the bonds/nucleon of these two all-neutron planes with the bonds/nucleon of the entire structure, to see whether the bonding of the neutrons in these two intermediate planes is adequate to allow them to form in competition with the bonding opportunities available in the three p/n planes. Notice that the chevron symbols for the dual interplane neutrons give adequate "slant" clues to determine the "slants" of the p/n nucleons:

Fig. 4-2 Bonds Per Neutron For Various Widths Of Neutron Rafts

Number of raft neutrons & p/n nucleons

10 + 24	16 + 33	22 + 42	28 + 51	Bond
ipn p/n	ipn p/n	ipn p/n	ipn p/n	Type
4 + 12	10 + 24	16 + 33	22 + 42	hpb
4 + 9	6 + 12	8 + 15	10 + 18	vpb
5 + 16	8 + 22	11 + 28	14 + 34	ippb
4 + 12	8 + 18	12 + 24	16 + 30	lrdb
8 + 12	8 + 18	12 + 24	16 + 30	rldb
8 + 8	12 + 12	16 + 16	20 + 20	nodb
33 + 59	52 +106	75 +140	98 +174	totals
33/10=3.30	52/16=3.25	75/22=3.41	98/28=3.50	b's/n
102/34=3.00		215/64=3.36		/(p+n)
	158/49=3.22		272/79=3.44	/(p+n)

The left column in each section lists the bonds associated with the *two neutron rafts*; the right column lists those of the *three p/n planes.* The "Bond Type" column gives the *directions* of the pb's & db's by prefixes, where: h = horizontal, v = vertical, ip = inter-plane, lr = left-right slant, rl = right-left slant, no = notch bonds. Since notch bonds bridge between neutron & p/n planes, I have added *half* to each group's column.
The desired results of this study are at the bottom. The upper row(s) gives the average bonds/neutron of the *two neutron rafts*; the lower rows give the bonds/nucleon for the *entire particle*.

Despite its complexity, the above analysis yields only a crude understanding, because many necessary elements have been ignored, such as the mass-deficit differences between pb's and db's, the variable bond spacings due to translational "breathing", and variable added mass-deficits due to nucleon pairings. For insight into pairing potential, notice that *all* of the interplane neutrons are inherently paired, because the two rafts are equal distances from one of the particle's planes of symmetry; this is also true of the *upper and lower rows* of the p/n planes. But, the nucleons of the *center row* can pair *only when there is an* <u>*even*</u> *number* of nucleon "stacks".

Now, let's see the effect of adding two more rows to Fig. 4-2:

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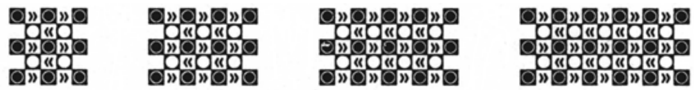
Fig. 4-3 Bonds Per Neutron For Larger Sizes Of Neutron Rafts

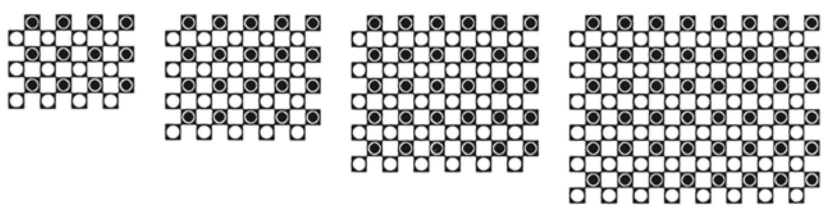


Number of raft neutrons & p/n nucleons

16 + 39	26 + 54	36 + 69	46 + 84	Bond
ipn p/n	ipn p/n	ipn p/n	ipn p/n	Type
6 + 24	16 + 39	26 + 54	36 + 69	hpb
10 + 24	16 + 33	22 + 42	28 + 51	vpb
8 + 26	13 + 36	18 + 46	23 + 56	ippb
8 + 24	16 + 36	24 + 48	32 + 60	lrdb
8 + 24	16 + 36	24 + 48	32 + 60	rldb
8 + 8	12 + 12	16 + 16	20 + 20	nodb
48 +130	89 +192	130 +254	171 +316	totals
48/16=3.00	89/26=3.42		171/46=3.72	b's/n
		130/36=3.61		b's/n
178/55=3.24		384/105=3.66		/(p+n)
	281/80=3.51		487/130=3.75	/(p+n)

Our analysis of these five-plane structures reveals this: all of the structures show greater bonds/nucleon for the two neutron planes, than for the entire particle. We can infer, then, that any of these five plane structures *could* form, but only if their total mass-deficit exceeds a single-plane form with the same p's & n's. So let us look, now, at bonds/nucleon in various single-plane arrangements:

Fig. 4-4 Bonds Per Nucleon In Single-Plane Structures

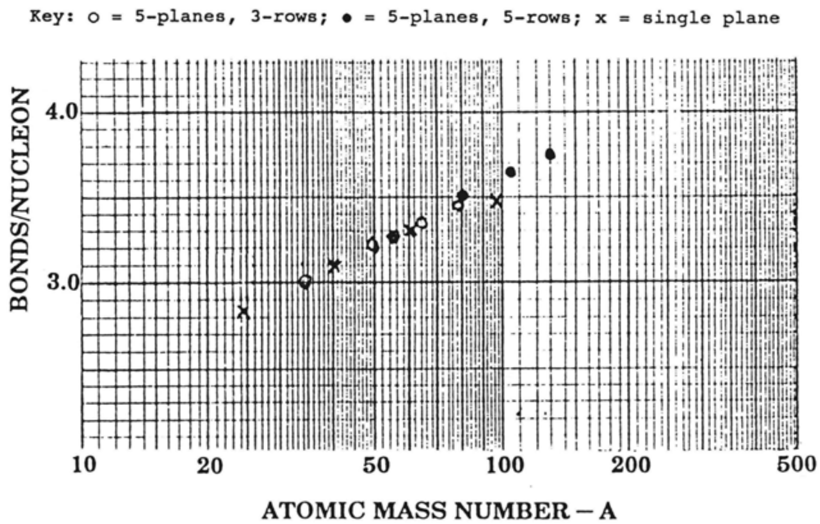


Number of p/n nucleons

24	40	60	96	Bond
18	32	50	84	hpb
16	30	48	80	vpb
17	31	50	84	lrdb
17	31	50	84	rldb
68	124	198	332	total
68/24=2.83		198/60=3.30	332/96=3.46	bonds
	124/40=3.10			/(p+n)

These differences will be easier to see, if they are plotted:

Fig. 4-5 Bonds Per Nucleon Vs. Atomic Number



Where is the Crossover Point Between Single → Multiple-Plane?

Looking at the x's on the semi-log plot of Fig. 4-5, we see that, by Atomic Mass Number A = 96, the bonds/nucleon of that single-plane structure is considerably below the trend-line of the five-plane structures. Yet, at A = 24, the "x" is somewhat *above* the five-plane trend-line. The intermediate data points don't permit an accurate determination of the crossover point, but we can probably say that this preliminary study points to somewhere between A = 40 → 55.

Approach #2 — Looking At Experimental Data

Now, for some experimental data. In Fig. 4-6, I plot the number of "extra" neutrons (A-2Z) vs. atomic number, Z, for the *most abundant*, and *second most abundant* isotope, for all the even-Z elements:

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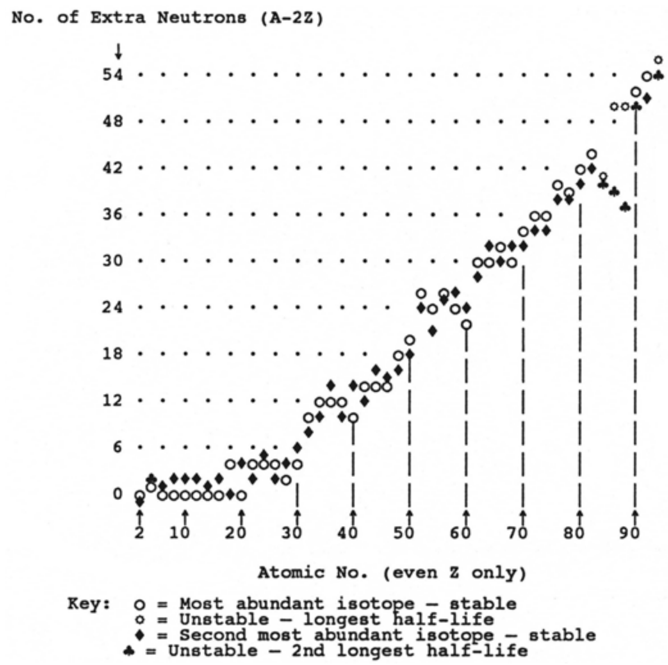
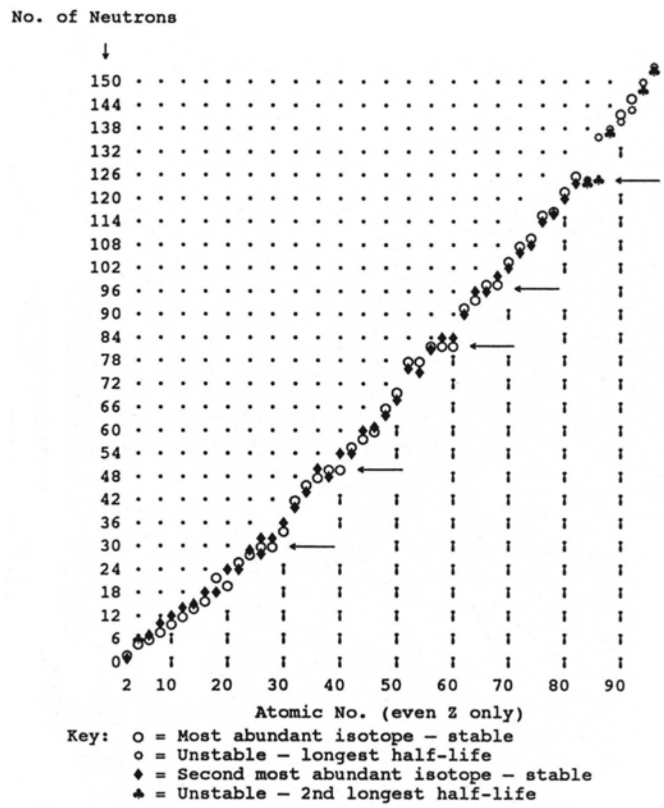
Fig. 4-6 Evidence For Single To Multiple Plane Transitions



In the above plot of "extra" neutrons vs. atomic number, we should perceive that *horizontal lines* of A-2Z neutrons suggest p/n plane extension activity, while *vertical jumps* in these numbers suggest a change in the form of the nuclide structures. On the other hand, *reverse slopes* in A-2Z plots, such as between A = 36→40, 56→60, 64→68, & 82→88, indicate that protons have been added *without any change* in the number of neutrons. We can make these zones of static neutron numbers appear as horizontal lines (delineated by arrows in Fig. 4-7, below) simply by plotting the *total neutrons* in each element's most abundant isotope vs. Z:

Fig. 4-7 Evidence Of Constant Neutron Plateaus



Let's begin by examining the uppermost of these constant neutron regions, i.e. between the elements Osmium, Z = 76, and Astatine, Z = 85. There are two reasons why I suggest that we start with these very large nuclides:

1) Larger size exacerbates the problems of nuclide instability, and these instabilities provide useful clues to nuclide structures.

2) Nuclides containing close to two hundred nucleons are certain to have adopted a five-plane structure; thus we can safely ignore any single-plane alternatives.

We shall focus our attention on the elements between Z = 75 and Z = 96, with particular attention to the region between Polonium, Z = 84, and Protoactinium, Z = 91, where there exists a strange bifurcation of nuclide stability, in which *two* separated peaks of nuclide half-lives occur. The lower-mass group of this bifurcation is noteworthy in having a constant number of neutrons throughout this eight-element region. This is much more evident in the plot of Fig.4-8, below, where I have added the odd-Z elements. We shall see that IPP can explain both the bifurcation, and this neutron plateau:

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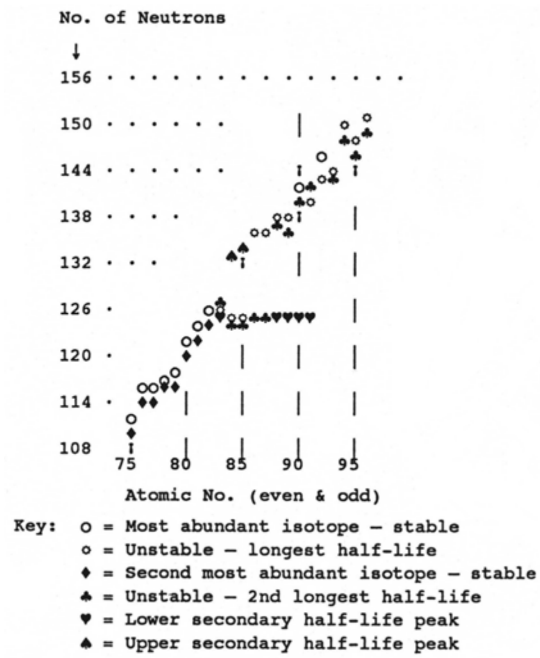
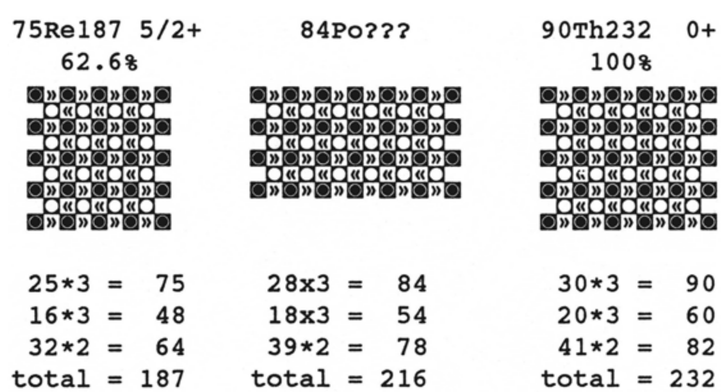
Fig. 4-8 Neutron Constancy And Bifurcation Z = 75 → 96



Since most of this bifurcating activity takes place among the elements between the two stable isotopes, 83Bi209 and 90Th232, let's see if we can find plausible five-plane structures for these two isotopes. For Thorium 90, we assume that the protons are evenly divided between planes 1, 3, & 5, so we factor 30 = 6x5 to get the dimensions of one of the three p/n planes. However, Z = 83 is *not* divisible by three, so we must look for the closest factors we can get to this number: e.g. 7x4x3 = 84, 5x5x3 = 75, or 9x3x3 = 81, although the last rectangle seems excessively long and narrow to be plausible. Whichever we choose, we will presume that we can add or subtract protons to, or from, these complete cores to obtain Z = 83. Let's look at these "core" structures first. We shall add as many interplane neutrons as these structures will hold, because we are looking for the most abundant, or longest half-life isotopes:

Fig. 4-9 Suggested Five-Plane Structures For Z = 75, 84, 90

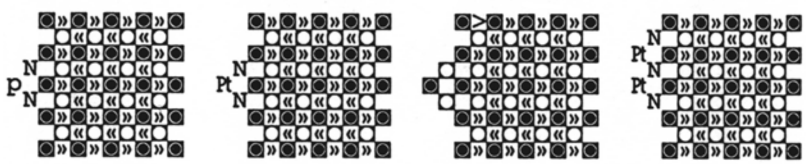


It is gratifying to see that our five-plane "saturated" structures for Z = 75 and Z = 90 correlate with the most abundant isotopes of these elements (Rhenium 187, and Thorium 232). However, the 7x4x3 structure is far removed from the longest half-life Polonium isotope, 84Po209 (half-life = 105 ± 5 y.). So, rejecting this form, we are led to assume that all the elements between Rhenium and Thorium are formed by proton additions to one "side" of the Rhenium "core" structure. Let's pursue this idea:

Since the perimeter of 75Re187 (in Fig. 4-9) is "saturated" with protons, any addition of protons to this core will require neutron intermediaries, to satisfy our postulate that no proton can site diagonally adjacent to another proton. The number of these added neutrons will scale with the number of added protons, but not directly, as we shall see. For one thing, when their numbers increase sufficiently to begin forming neutron 3-stacks, they create additional interplane neutron sites, which often become filled in the most abundant stable isotopes, or longest half-life unstable ones. These geometric effects should become clear as we proceed:

Fig. 4-10 "Saturated" Structures For Z = 76, 77, 78, 79

76Os192 0+	77Ir193 3/2+	78Pt195 1/2-	76Au197 3/2+
41.0%	62.7%	33.8%	100%



25*3+1 = 76	25*3+2 = 77	26*3 = 78	25*3+4 = 79
16*3+4 = 52	16*3+4 = 52	18*3 = 54	16*3+6 = 54
32*2 = 64	32*2 = 64	31*2+1 = 63	32*2 = 64
total =192	total =193	total =195	total =197

<u>Meaning of Added Symbols</u>

p or n = single p or n in plane #3

Pt or N = dual p's or n's in planes #1 & #3

If we check the *Table of the Isotopes*, we see that adjacent isotopes are often nearly as abundant as the most abundant isotopes shown in the above schematics: e.g. 76Os190 (26.4%), 76Os189 (16.1%), 76Os188 (13.3%), 77Ir191 (37.3%), 78Pt194 (32.9%), 78Pt196 (25.3%). We will explore the reasons for these, later. Now:

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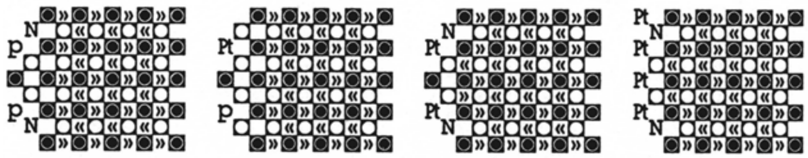
Fig. 4-11 "Saturated" Structures For Z = 80, 81, 82, 83

80Hg202 0+	81Tl205 1/2+	82Pb208 0+	83Bi209 9/2-
29.65%	70.48%	52.4%	100%



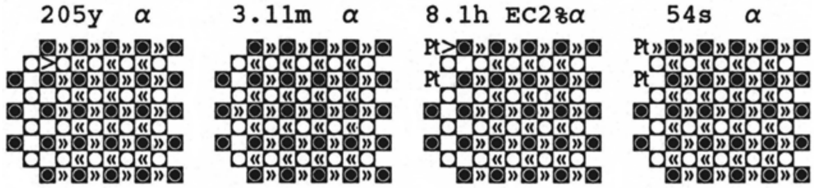
26*3+2 = 80	26*3+3 = 81	26*3+4 = 82	25*3+8 = 83
18*2*4 = 58	20*3 = 60	18*3+4 = 58	18*3+4 = 58
32*2 = 64	32*2 = 64	34*2 = 68	34*2 = 68
total =202	total =205	total =208	total =209

Notice that the most abundant isotope of Mercury (80Hg202) has symmetrically-placed lone outrigger protons, rather than a single asymmetrically-placed proton two-stack (which would seem to be favored, because it would yield an additional paraxial bond). Reason: the nuclear spin of 0+ suggests a symmetrical structure, and this symmetry probably creates more mass-deficit than the two-stack pb, through additional nucleon pairings. Notice, also, that these single protons are flanked by neutron two-stacks, as is the lone outrigger proton of 76Os192. Single neutrons would bond these protons just as well, and, in fact, produce the second most abundant isotopes, 76Os190 (26.4%) & 80Hg200 (23.1%)

Bismuth is the last stable element. The longest half-life isotopes of the next four elements, Polonium, Astatine, Radon, and Francium, decay primarily by alpha emission, although some decay by electron capture, by β^+, or by β^- emission. It is also with these elements that the first evidence of bifurcation occurs, so I will show isotope structures for both the lower and upper half-life peaks:

Fig. 4-12 Half-Life-Peak Structures For Z = 84, 85

84Po209 1/2-	84Po218 0+	85At210 5+	85At219 ?
205y α	3.11m α	8.1h EC2%α	54s α



28*3 = 84	28*3 = 84	27*3+4 = 85	27*3+4 = 85
20*3 = 60	20*3 = 60	20*3 = 60	20*3 = 60
32*2+1 = 65	37*2 = 74	32*2+1 = 65	37*2 = 74
total =209	total =218	total =210	total =219

Notice that, beginning with Polonium, all the outrigger neutrons are three-stacks, even for the lower-half-life-peak isotopes. *It is this "saturation" of outrigger neutrons which accounts for neutron plateau at 125 neutrons*, which we see in Fig. 4-8. Clearly, these 12 outrigger neutrons are able to bond the six more protons that attach between Polonium 209 & Thorium 215, without the need for further neutron additions.

As you examine the structures for the lower and upper half-life peaks for all the elements through Thorium, you will perceive that we need to find answers to the following questions:

1) Why should adding one more interplane neutron to these lower-half-life-peak structures decrease their half-lives? Where would this additional neutron site, and how would its presence increase the propensity for alpha emission?

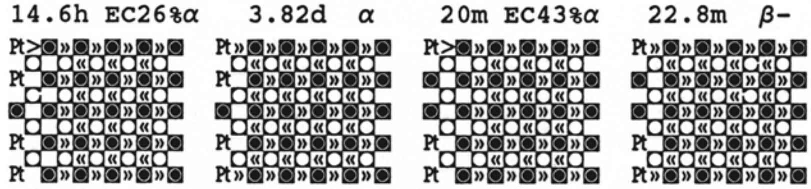
2) What accounts for the changing numbers of interplane neutrons utilized in the upper half-life peaks, as Z increases?

3) And some general questions: What structural features determine the modes of decay? Where does the emitted alpha particle originate? Which proton captures the orbital electron, or emits a β^+ particle? Which neutron is susceptible to β^- decay?

I will explore these questions a few pages hence. Now, let us continue our investigation of half-life peaks:

Fig. 4-13 Half-Life-Peak Structures For Z = 86, 87

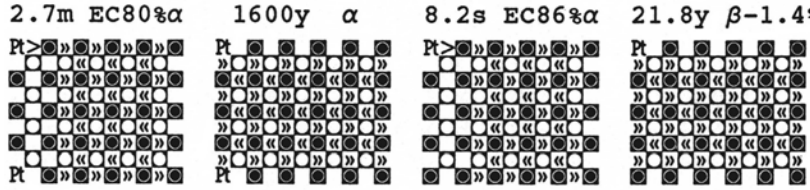
86Rn211 1/2-	86Rn222 0+	87Fr212 5+	87Fr223 3/2+
14.6h EC26%α	3.82d α	20m EC43%α	22.8m β-



26*3+8 = 86	26*3+8 = 86	27*3+6 = 87	27*3+6 = 87
20*3 = 60	20*3 = 60	20*3 = 60	20*3 = 60
32*2+1 = 65	38*2 = 76	32*2+1 = 65	38*2 = 76
total =211	total =222	total =212	total =223

Fig. 4-14 Half-Life-Peak Structures For Z = 88, 89

88Ra213 1/2-	86Ra226 0+	89Ac214 5+	89Ac227 3/2-
2.7m EC80%α	1600y α	8.2s EC86%α	21.8y β-1.4%α



28*3+4 = 88	28*3+4 = 88	29*3+2 = 89	29*3+2 = 89
20*3 = 60	20*3 = 60	20*3 = 60	20*3 = 60
32*2+1 = 65	39*2 = 78	32*2+1 = 65	39*2 = 78
total =213	total =226	total =214	total =227

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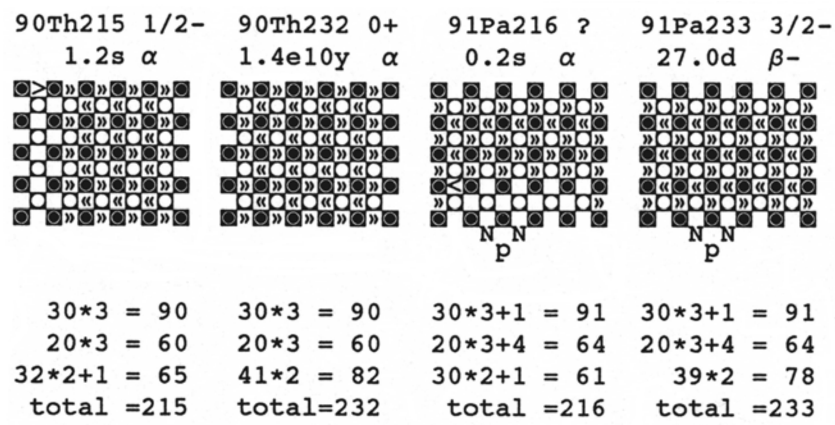
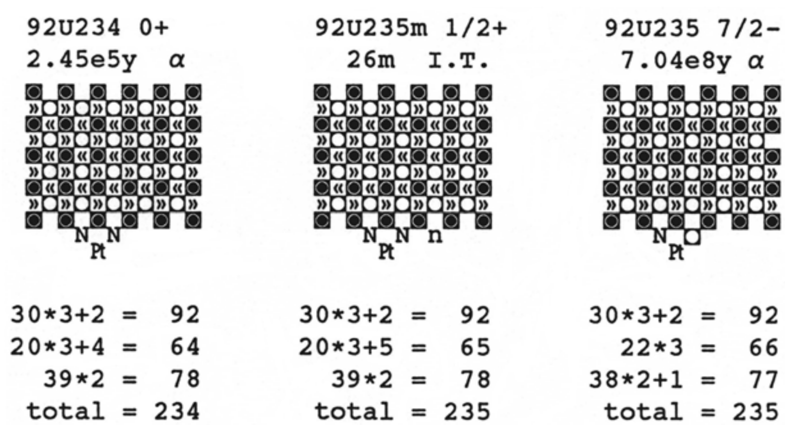
The most plausible structures for both Radium 226 and Francium 227 requires a field-shift of the interplane neutron locations, so that they are "pinned" on the four-notch sides, rather than on the five-notch sides, as in the preceding structures. This field shift results in a "saturated" ipn raft with four fewer interplane neutrons. This four-notch pinning is also manifest in Protoactinium, whose upper half-life peak, 91Pa233, has the same number of neutrons as 90Th232, despite requiring four n's to bond its outrigger proton:

Fig. 4-15 Half-Life-Peak Structures For Z = 90, 91



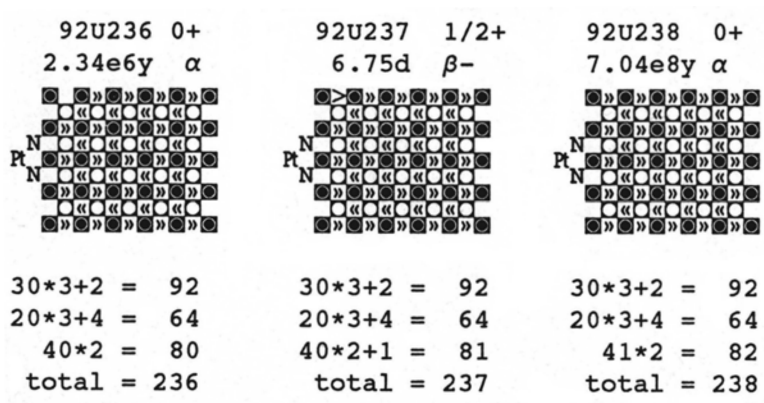
This shift from five-notch to four-notch "pinning" of interplane-neutron (ipn) fields occurs among the lower isotopes of Uranium:

Fig. 4-16 Four-Notch Pinning Of IPN Fields In U234 & U235



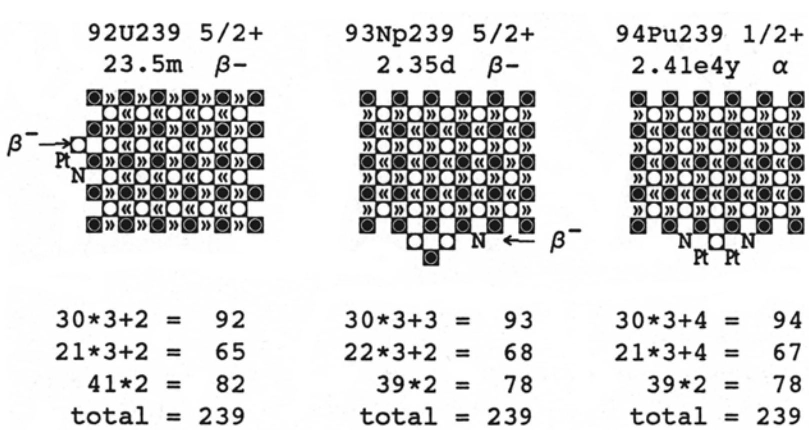
Now, notice, below, that the interplane neutron field shifts back to the Thorium configuration for isotopes U236, U237, & U238. **Here is a plausible explanation for nuclear fission of U235**, since the capture of a single thermal neutron will provoke a complete interplane-neutron field rearrangement, which, depending upon where this neutron lands, may destabilize the structure sufficiently to cause it to split apart. Since the lower-Z fragments utilize fewer interplane neutrons, a few n's are released in this splitting process.

Fig. 4-17 Thorium-Type Interplane-N Fields In U236 → 238



Notice, in U236, that a pair of interplane neutrons transfers to an outrigger location to bond the outrigger proton 2-stack. Now, let's see why the ipn fields shift in the β^- decay of U239→Pu239:

Fig. 4-18 Transition Of U239 → Np239 → Pu239



I have reasoned that the shift from five-notch to four-notch pinning occurs in the U239 → Np239 decay, because the resulting outrigger proton 3-stack needs two additional neutrons for adequate bonding, and borrowing a pair from the interplane neutrons, like U236, would not leave β^- susceptible neutrons (indicated by arrows), nor produce a structure with spin 5/2+, but rather 1/2+.

Plutonium 239, like U235, fissions, because Pu240 is a five-notch ipn-pinned structure. Thus, the addition of a thermal neutron may result, again, in turbulent reshuffling and splitting:

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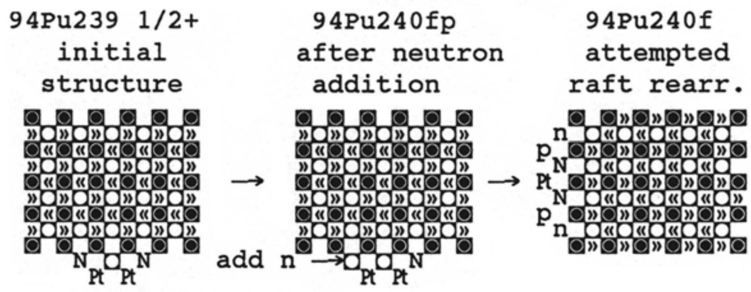
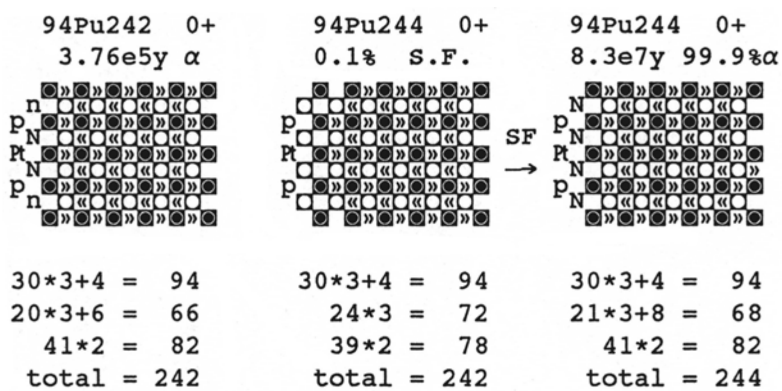
Fig. 4-19 Fission Scenario Of Pu239



Like U236, Pu240 borrows an ipn pair to bond its outrigger protons symmetrically (for maximum nucleon pairings). Replacing this in Pu242, below, extends the half-life of α-emission from 6537±10 to 3.76e5 years, as "saturation" of ipn rafts would suggest. The more symmetrical Pu244, with even longer half-life, has an alternative form with a tendency (0.1%) to fission "spontaneously":

Fig. 4-20 "Spontaneous" Fission Of 94Pu244



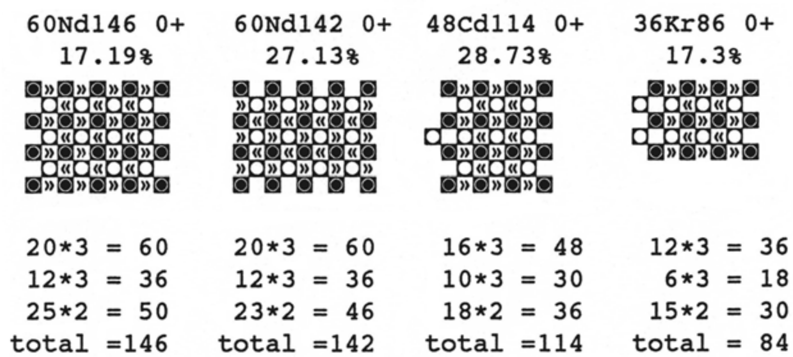
As I show, above, there are two plausible structures for Pu244, and the slight possibility of fission may be due to a slight probability of the middle structure forming (by borrowing two pairs of interplane neutrons), rather than the right-hand "saturated" structure forming. If we presume that the right-hand structure has *only an insignificant* mass-deficit advantage, then the middle structure could be nearly as stable, yet it could tend to rearrange to the right-hand structure upon receiving a sufficient destabilizing impulse. This attempted transformation would obviously require the transfer of four outrigger neutrons into the vacant interplane locations, a reshuffling which may be enough to cause fission:

Lower-Z Evidence Of "Saturation" = Greatest Abundance

I want to give you a modest reinforcement of the notion that greatest abundance correlates with "saturation", by examining some smaller five-plane arrays. The smaller doubly-saturated elements should be Z = 3x4x5 = 60 (Neodymium), Z = 3x4x4 = 48

(Cadmium), and 3x3x4 = 36 (Krypton). These factors yield maximum abundance for Z = 60 & 48, but the saturated 3x3x4 form of Z = 36 yields the last stable isotope, 36Kr86, rather than the most abundant, 36Kr84, which takes the 3x2x6 form, as I show in Fig. 4-22:

Fig. 4-21 Lower-Z Doubly-Saturated Structures Z = 60, 48, 36



Some comments about the above structures:

- It is somewhat surprising to find that the second, 3-notch-pinned structure for Neodymium has higher abundance than the first, 4-notch-pinned one. Perhaps the second structure provides greater opportunities for nucleon pairings, with greater mass-deficit/nucleon.

- Another surprise is the outrigger 3-stack of neutrons in the central row of 48Cd114. Here it is clear that this addition promotes pairing of these neutrons, by making an even number of 3-stacks in this central row. We should notice that the "core" structure without this addition, 48Cd111, 1/2+, is a stable isotope (12.80%), as are the two intermediate isotopes, 48Cd112 (24.13%) & 48Cd113 (12.22%).

- The stable Krypton isotopes below 36Kr86 seem (in my imagination) to skip back-and-forth between two proton arrangement, the expected 3x3x4 form, and a narrow, elongated 3x2x6 form:

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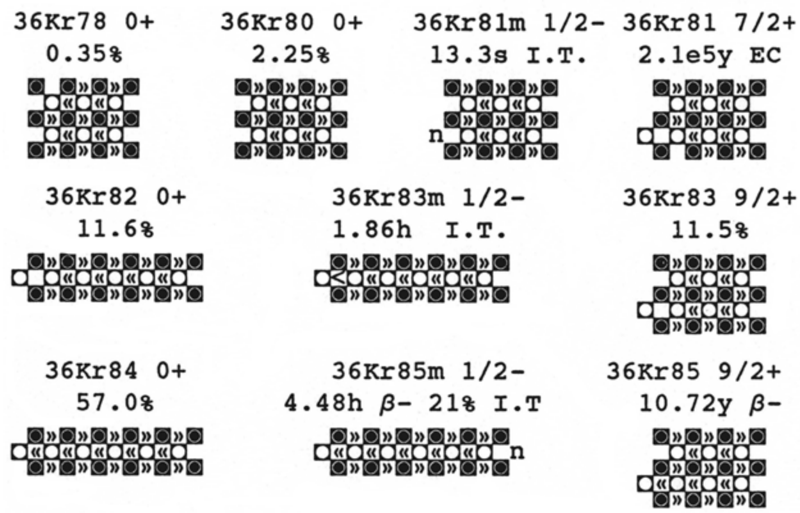
Fig. 4-22 Structures Of Krypton Isotopes Below 36Kr86



For those of you willing to focus on the nucleon placement in each of these diagrams, I would like to explain my reasons for choosing each structure:

- 78 - Although I have shown you few examples, I have found many cases where stable isotopes can occur with one pair of ipn's missing.

- 80 - This doubly-saturated form is clearly stable. It has low abundance, because the 3x2x6 forms develop greater mass-deficit/nucleon, due to their larger numbers of ipn notch bonds.

- 81m - Added neutron can bond only to one of the 12 outrigger sites.

- 81 - Ipn notch pair rearranges to outrigger location, because this results in greater mass-deficit (one less pb, but perhaps greater pairing opportunities. Also, the measured spin, 7/2+, suggests a form with greater asymmetry, but possessing bilateral symmetry.

- 82 - Here, the sudden jump in percent abundance over Kr80 suggests a change in form, but the much greater abundance of Kr84 alerts us to the possibility of an incompletely filled ipn raft.

- 83m - A neutron added to Kr82 plausibly ends up in the vacant interplane site, which, being asymmetric, accounts for the minus spin parity. This site is sheltered from β^- decay; hence, its only decay opportunity is through internal rearrangement (I.T.).

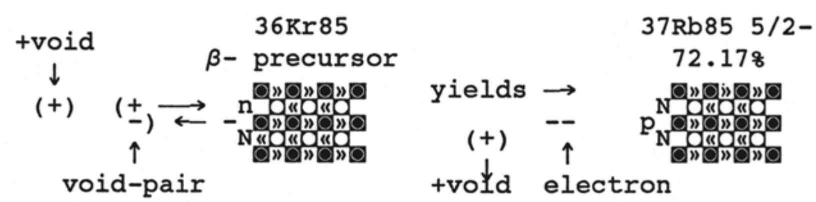
- 83 - The fact that internal transition of Kr83m yields a stable structure causes us to look for a *saturated* form, with good bonding of the added neutron. The spin of 9/2+ seems plausible for this form.

- 84 - This doubly-saturated form plausibly has maximum abundance.

- 85m - A neutron adding to Kr84 can site only in one of the three right-hand outrigger locations. Two of these are asymmetric, accounting for the minus spin parity. All three sites have minimum bonding (1pb+2db) and perimeter exposure, making them ripe for β^- decay (79%), in competition with internal transition (21%).

- 85 - This structure is the analogue of Kr83, but with an added pair of ipn's. Notice that these ipn's have lesser bonding (1.5pb+2db) than the others in the raft. This opens them, in a borderline way, to β^- decay, although, of course, what drives this decay is the ability of the resulting proton to form a structure with greater mass-deficit than the precursor structure. Here is an imagined scenario for this:

Fig. 4-23 Beta Minus Decay Scenario For 36Kr85 → 37Rb85



Much remains obscure in the above scenario, but the basic process is that one of the five neutrons involved in this β^- decay migrates into a more vulnerable site (say as a result of a grain-boundary transit), and then engages in a charge-exchange with a proximate void pair (electron neutrino), which results in a negative excess (ejected by the neutron) fusing with the -void of the void pair to form an electron, and the +void component of the void-pair migrating to the neutron, whereupon it collapses to a c-void, converting neutron to proton. Essential to this scenario is the simultaneous presence of a +void (muon neutrino), which provides the charge gradient needed to affect the charge-exchange. The muon neutrino (+void), unchanged by the β^- decay, simply moves on.

We may presume that the relative long half-life of 36Kr85 is due to the very slight probability of the simultaneous occurrence of a destabilizing encounter with a grain-boundary, along with the proximity & precise geometric alignment of void-pair and assisting +void.

The *inverse* of this scenario is IPP's explanation of **electron capture**. Here, a susceptible (weakly-bonded) proton undergoes a charge-exchange with a proximate electron to produce a void-pair and transmute itself into a neutron. This transmutation, again, requires the catalytic assistance of a lone void, in this case, a -void, to affect the charge-exchange, and, likewise, requires that the resulting neutron can site where it can induce a larger nuclide mass-deficit.

The *opposite* of the β^- decay scenario, whereby a *proton* charge-exchanges with a void-pair, catalyzed by a minus void, to produce a positron and a neutron, is IPP's explanation of β^+ **decay**.

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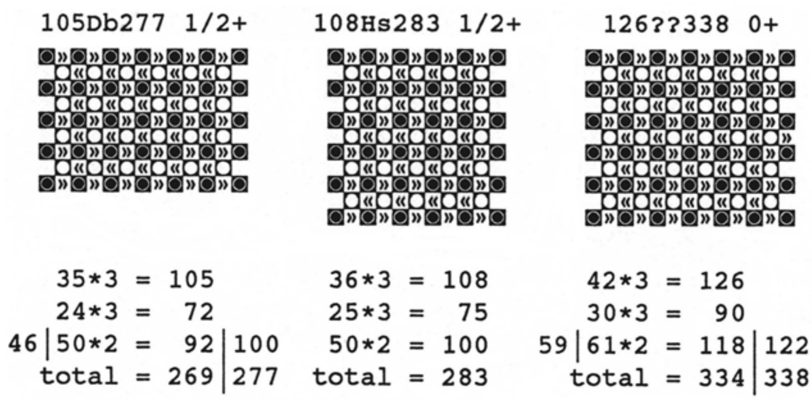
Upper-Z Islands Of Stability

Before we move on to our next topic, α-emission, it may be of interest to speculate about the possibility of stable trans-Uranium elements. I have demonstrated, I hope to your satisfaction, that stable (and very long half-lives) appear to correlate with "saturated" rectangular structures, possessing "saturated" ipn rafts. This insight leads me to predict that the structures, below, might have very long half-lives, should it be possible to make them. For the rectangular proton arrays, I give totals for both directions of notch pinning:

Fig. 4-24 Very Long Half-Life Structures?



Why Alpha Emission Occurs

Alpha emission can occur whenever a contiguous group of 2p & 2n are bound to the nuclide core with less binding mass-energy than they would achieve if they were to split-off and join together as an alpha particle (whose binding mass-energy is -28.30 MeV). Of course, any 2p/2n group which had this lesser binding energy would never have attached, so our challenge is to find alpha-decay configurations which might logically arise through nucleon migrations, brought on by further nucleon attachments, by passage through a grain-boundary, or by other forms of external excitations.

Let's investigate these matters in two stages:

1) Let's look for 2p/2n configurations with low binding energy.

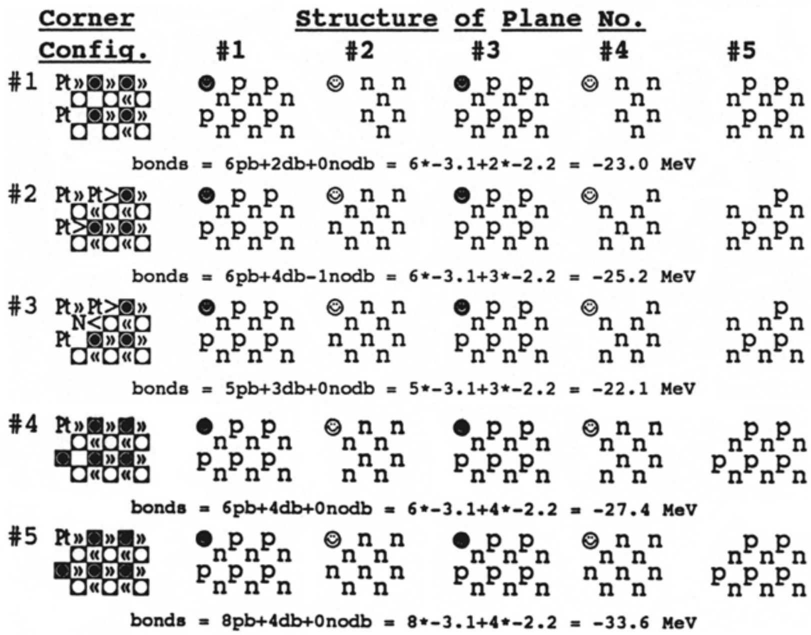
2) Then, let's look for stable structures with plausible nucleon-migration pathways to these low-binding configurations.

A moments reflection tells us that we must seek these low-binding sites at the "corners" of a nuclide, because "corner" protons have one less diagonal bond than "edge" protons. It will also be necessary that this corner location be occupied by a proton 2-stack, rather than a 3-stack, to avoid the impediment of breaking two additional bonds, a pb & a nodb.

In Fig. 4-25, I show several low-bonding "corner" configurations, where I have indicated the precursor nucleons of an emitted α-particle with "*" = p, "*" = n: Below each structure is a crude calculation of the binding mass-deficit of the corner 2p/2n group.

If this mass-deficit is less than an alpha particle's mass-deficit (-28.30 MeV), we may suspect that the separation of an α is possible:

Fig. 4-25 Corner Configurations With Low 2p/2n Bonds



You will see that I have clarified the bond relationships of these precursor nucleons by showing the structures of each of the five planes. If α-emission is to occur, these 2p/2n bond totals will need to be less than the alpha's mass-deficit (-28.30 MeV). I have used crude average mass-deficit values for the three types of bonds to calculate the binding mass-deficits of 2p's and 2'n of each diagram. These were obtained from Chapter 3 calculations, as follows:

pb = 1/2(-3.27 -2.86) = -3.065 ≈ 3.1 MeV
(He3 p→p, paired, p. 3-8, p→n , unpaired, p. 3-14)
db = -2.22 ≈ -2.2 MeV (from page 3-5)

Notice that calculation for #'s 1, 3, 4, & 5 show zero nodb's. We should perceive that the vacating notch ipn's form no net diagonal bonds to the p/n "half" notch that remains after the proton 2-stack departs, because they see equal attractive & repulsive db influences. Corner structure #2 yields one repulsive nodb, because of the adjacent proton 2-stack; this configuration clearly promotes α-emission, as would the single interplane db of #3.

Secondary features of the nuclide structure, such as the numbers of 3-stacks in rows or columns, or nuclide size, or the specific nucleons that participate in pairing relationships, may alter the mass-deficits of the bonds that must be broken to achieve α-particle separation. Thus, you should view the above calculations as very tentative. However, they do provide a sense of the relative susceptibility of these configurations to α-emission.

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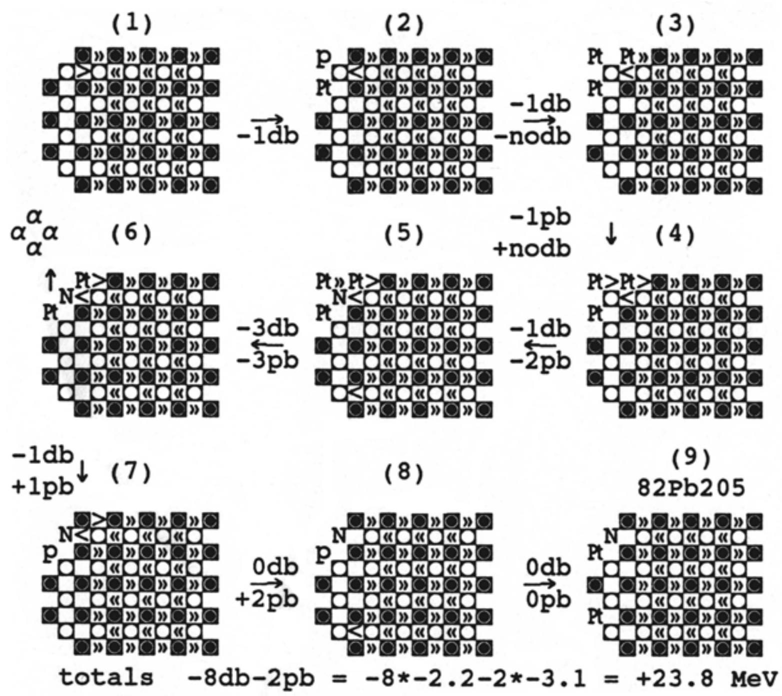
Now, let's return to our two suggested structures for the two half-life peaks of Polonium to see whether we can imagine plausible nucleon migration scenarios which might result in "corner" nucleon configurations like the above structures #1, #2, #2A, or #2B. Since neither 84Po209, nor 84Po218 has a corner proton "2-stack", we must explore, first, how the protons of the left column could rearrange to produce one. We look, first, at 84Po209:

Fig. 4-26 Nucleon Migration Scenario For α-Emission: 84Po209



When we look at the totals of the bonds that must be broken, along with the additional bonds that are gained (and lost) from the final rearrangement after the alpha particle has separated, we see that the rearrangement into the two-state charge-exchange of the departing alpha particle (-28.30 MeV) contributes more than sufficient mass-energy to effect the α-emission. If we look at the *Table of the Isotopes*, we find the measured decay energy is 4.976 MeV, which is reasonably close to our calculation (28.3 -23.8 = 4.5 MeV). To some extent this is just luck, considering the crudity of our diagonal and paraxial bond mass-deficit assumptions. But this example should persuade you that IPP's concept of α-emission has merit.

I shall refrain from exploring additional α-emission scenarios, because, to be truly convincing, they must be approached from a much more sophisticated understanding of nuclear bonds, which only the future will bring. However, we should have enough insight, now, to answer the three questions I posed on page 4-8:

1) *Why does adding a neutron to a lower half-life peak isotope create an isotope with shorter α-emission half-life?* Clearly, a neutron adding to 84Po209 will pair with the single interplane neutron, and this combination can move into the alpha emitting notch by breaking fewer bonds (1pb less) than the movement of the two

neutrons shown in Fig. 4-26; thus, less external energy is required to reshuffle the nucleons into the α-emitting structure.

2) *What accounts for the changing numbers of ipn's in the upper half-life peaks as Z increases?* We see that this occurs because, as outrigger neutrons become numerous enough to form 3-stacks, each 3-stack creates an additional site for an ipn pair.

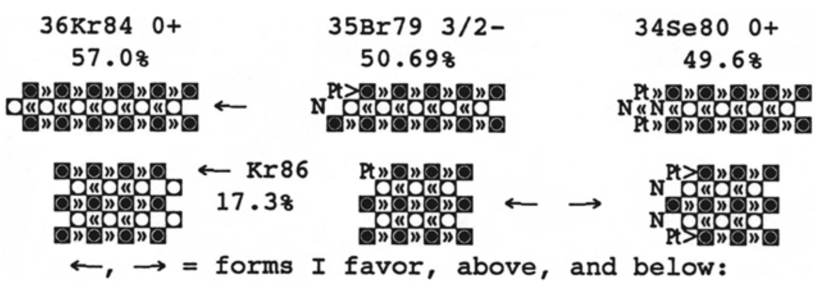
3) *What structural features are associated with the various decay modes?* I have explained beta emission and electron capture in Fig. 4-23 and following text, fission in Figs. 4-16, 4-19, & 4-20, and alpha decay in Figs. 4-25 & 4-26.

Now, I want to return to our goal of determining at what Z-number nuclear structures switch from single-plane to five-planes. Let's continue looking backwards through the Periodic Table from our last "doubly-saturated" structure, 36Kr84.

Locating The Point Of Transition From Five Planes → Single

It seems reasonable to suppose that the transition from five-plane to single-plane will be telegraphed by the failure of "saturated" five-plane structures to correlate with an element's most abundant isotope. Let's look backwards through the periodic table, element by element, beginning with Krypton:

Fig. 4-27 "Saturated" Structures Below Z = 36



You will recall that I demonstrated on page 4-11 that the proton three-stacks oscillate back & forth between three-row and two-row structures in various Krypton isotopes. This trend evidently continues for a while, as Z-number decreases, as we see, below.

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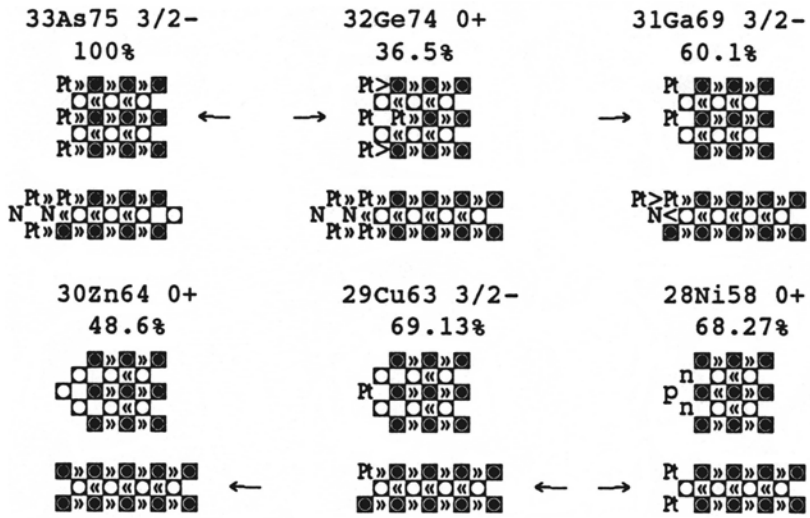
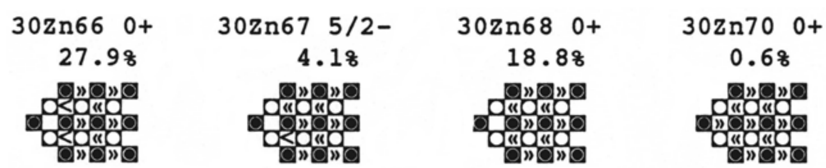
Fig. 4-28 Most Abundant Isotopes Of As → Ni



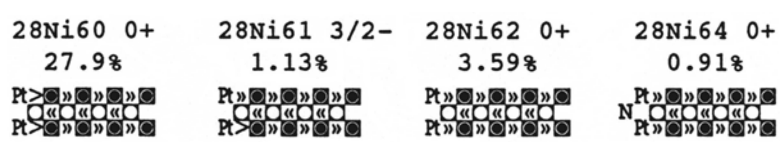
The most abundant isotope of zinc, like that of Krypton, favors the two-row structure, but it seem clear that the higher stable isotopes of zinc favor the three-row form:

Fig. 4-29 Higher Stable Isotopes Of Zinc



However, the lower A-numbers of the stable isotopes of elements below copper clearly indicate that these elements prefer the two-row structures, even for the higher stable isotopes, as I demonstrate for those of nickel, below:

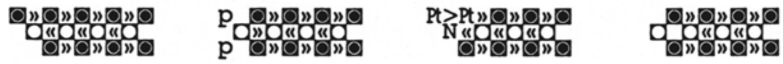
Fig. 4-30 The Other Stable Isotopes Of Nickel



Beginning with Nickel, and excepting Cobalt, the neutron numbers associated with the most abundant isotopes no longer produce plausible "saturated" interplane-neutron rafts. *Hence, this may be the point below which elements adopt the single-plane structural form.*

Fig. 4-31 The Most Abundant Isotopes Of Co,Fe,Mn,Cr?

27Co59 7/2-	26Fe56 0+	25Mn55 5/2-	24Cr52 0+
100%	91.72%	100%	83.79%



In the next chapter I shall take up the single-plane elements in ascending order, and attempt to find the single-plane → five-plane transition from this opposite perspective.

Now I want to take a detailed look at IPP's concept of electron capture in nuclei, because it will clarify some of the subtle aspects of charge-exchanges which we have not yet considered:

How Electron & Proton Charge-Exchange To Produce A Neutron

In Fig. 4-23, I gave a rudimentary explanation of the beta minus decay of 36Kr85 to 37Rb85, suggesting that the process was effected by a charge-exchange between an outrigger neutron and a visiting void-pair, yielding a proton plus an electron. Now, let's look closely at the inverse process, an electron charge-exchanging with a proton to produce a neutron plus a void-pair. Here are some necessary sub-details of this scenario:

- To understand why an electron is able to supply a -void to a charge-exchange process, we should perceive that our term, *replacement defect*, suggests that we can consider an electron to be a combination, or fusion, of two half-charge defects, a *-excess* merged into a *-void*. Hence, as a preliminary to a charge-exchange, these two components of the electron (-excess & -void) need to be split apart (so one can move relative to the other).

- This splitting requires sufficient excess local shrinkage in the electron's vicinity to allow its *-excess component* to acquire, momentarily, an independent identity, i.e. to become a -muon. This metamorphosis to IPP's half-charge muon would seem to require at least 105/2 = 52.5 MeV of undedicated shrinkage.

- *But* we must remember that this mass figure applies to a particle stretching to infinity in equal radial increments of shrinkage, and we only require the -excess to exist long enough for the -void component of the electron to charge-exchange with the proton. Clearly, much less shrinkage is required to initiate this brief metamorphosis. In fact, experiments tell us that protons can convert to neutrons by electron capture whenever there is a nearby source of mass-energy greater than 0.79 MeV, an amount which is just sufficient mass-energy increment to allow the neutron to form (938.27 + 0.51 + 0.79 = 939.57 MeV). Of course, this calculation ignores the variable momentum imparted to the nue, also produced in this conversion.

- This electron splitting and charge-exchange process may be clearer when diagrammed, as I do in the following schematic:

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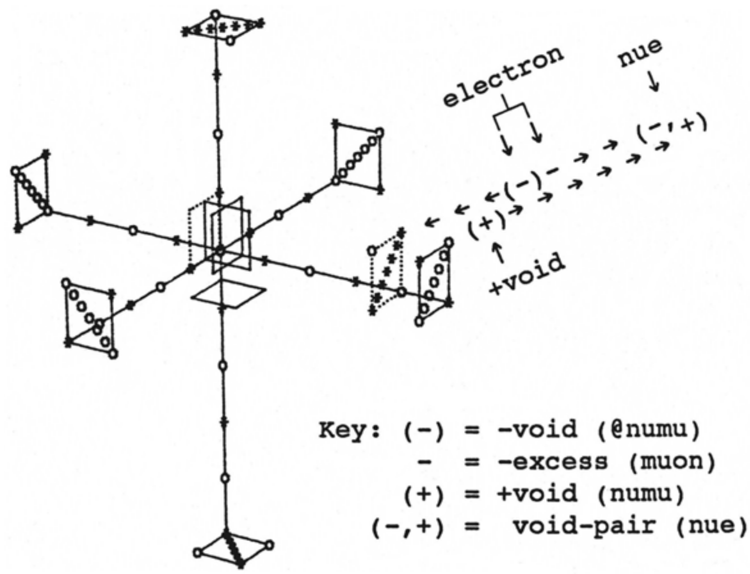
Fig. 4-32 Electron-Splitting In p + e → n + nue Conversion



Analysis Of Fig. 4-32

We shall suppose that an electron's center passes just a few lattice units away from the +x defect of a proton, while this proton is in its p1 state, as shown above (9ü, 9ü, 9ü spacings, mass 933.11 MeV). We shall also suppose that there is sufficient momentary local undedicated shrinkage to "split" the electron into -void & -excess components, as shown, and that the electron's strong charge-presence interrupts the proton's internal charge-exchange sequence, and induces an external charge-exchange with the split electron. Due to the huge mass disparity between the electron's components (-void <<1meV, -excess ≈ 52.5 MeV), only the -void enters into the charge-exchange, while the -excess moves slowly outwardly, because of the mutual repulsion of the two split components.

Now, when the electron's -void component undergoes its charge-exchange with this +x defect, the result is a -c-void 1ü closer to the particle center, as shown by the dotted tab. This change converts the proton to a neutron in its low-mass n1 state (spacings 8ü, 9ü, 9ü, mass 866.93 MeV), releasing momentary shrinkage in the amount of 933.11 - 866.93 = 66.18 MeV. This shrinkage sustains the -excess component of the split electron long enough for the +void, released by the charge exchange, to be attracted outwardly towards it.

Where Does The Electron Splitting Energy Come From?

The most plausible source for the 52.5 MeV mass-energy required for momentary -muon creation is *in the proton → neutron conversion process, itself*. We can find clues for this possibility by looking at Figs. 2-8 & 2-9 on page 2-10,11, where I show the masses of the various charge-exchange states of the proton & neutron. Notice that, although the *average* mass of the six neutron states exceeds that of the proton by 939.57 - 938.27 = 1.30 MeV, *three* of the neutron states are much lower mass than the proton (p1) states:

state #5 p1 - n2 lo = 933.11 - 874.69 = 58.42 MeV
state #6 p1 - n1 lo = 933.11 - 866.93 = 66.18 MeV
state #1 p1 - n1 lo = 933.11 - 866.93 = 66.18 MeV

You will see that these mass-energy differences exceed our requirement (52.5 MeV) for creating a -muon from the electron's -excess component, so the potential exists for freeing the electron's -void to undergo a charge-exchange with one of the proton's +c-voids, providing this exchange causes the resulting neutron to begin its charge-exchange cycle with one of its low-mass states. Of course, there is the usual Heisenberg cart-before-the-horse problem, where the muon-creating shrinkage must appear before the resulting neutron's charge-exchange makes it available, so we must look to other processes in the immediate vicinity for the source of this shrinkage. Here is a possibility:

Ambient Neutrons Provide The Initiating Mass-Energy

Neutrons in the immediate vicinity of this proton obviously will be undergoing six-state charge-exchange cycles. *Half* of these states will be successive lo-n1, lo-n2, & lo-n1 states. Hence, during this half of the charge-exchange cycle, there will be excess (undedicated) shrinkage in the proton’s vicinity equal to the neutron mass minus the average mass of these states, or:

$$939.57 - \frac{1}{3(2 \times 866.93 + 872.69)} = 70.72\,\text{MeV}$$

Several Outcomes Are To Be Expected In p→n Conversions

This neutron-producing charge-exchange scenario may seem straightforward up to this point, but, in considering the interaction between the outwardly moving +void and the lingering -excess component, I find it hard to choose among several alternatives:

1) **They capture each other to become a void-pair (nue):** This alternative requires that the -excess component continues in existence long enough to arrest the outward movement of the charge-exchanging +void, and cause it go into orbit around the much-heaver -excess. This excess/void system will then convert to a void-pair when the newly-created neutron establishes its normal charge-exchange cycle, thereby reducing the amount of local undedicated shrinkage supplied below the excess-creating value.

2) **They fail to capture each other, and both escape as ±voids (numu & @numu):** This alternative requires that the geometry of the various ambient charge influences is such as to endow the charge-exchanging +void with momentum in excess of the capture value.

3) **They merge, and annihilate each other:** When opposite-polarity voids and excesses merge they "heal" the lattice of defects. In this scenario, the shrinkage released by this annihilation is close enough to the newly created neutron that most of it will be absorbed by the increased demands of its charge-exchange cycle, as it moves from the low to high mass states. Any shrinkage in excess of this requirement will go to produce a photon *plus* particle momentum, or divide

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into equal & opposite momentum influences on close-by particles on opposite sides of the annihilation center.

Now, I want to give you some more thoughts on the mechanics of multiple plane formation. I begin with IPP's interpretation of a supernova, because this is the only cosmic process which provides high enough neutron fluxes to create multiple-plane nuclei.

Neutron Production In Supernovas

The basic process of all suns is the fusion of protons with electrons to produce neutrons, which then join with other protons to produce complex nuclides. Since the neutron's mass exceeds the sum of the masses of proton plus electron by 0.79 MeV, this conversion requires other processes to supply the needed fusion mass-energy. The most fundamental source of this energy is the thermal energy generated by gravitational compression — but this would be rapidly used up in producing neutrons, if it were not for the greater energy per neutron emitted when each neutron bonds into a nuclide. For example, bonding neutron to proton to form a deuteride releases 2.22 MeV, and bonding two neutrons and two protons into an alpha particle releases 28.30 MeV.

These proton-to-neutron conversions occur with greater rapidity during the gravitational collapse prior to ignition of a supernova. Here are some factors to consider about this process:

- This gravitational collapse occurs because all the energy-evolving processes in the stellar body have gone nearly to completion, and, thus, there is no longer sufficient plasma pressure (i.e. plasma temperature) in the solar body to resist solar gravity.

- The reason that these energy-evolving nuclear processes have ceased is because the stellar core plasma now consists of nuclei whose binding mass-deficit/nucleon is the highest possible, namely those elements in the vicinity of iron, element Z = 26.

- We can infer that the density of *free* neutrons in this central solar plasma continually diminished as the normal nuclear building process proceeded, because isolated neutrons can be produced only by electrons fusing with isolated solar protons, and these have largely disappeared, having joined with neutrons and added to existing nuclides of carbon, oxygen, etc.

- Because of this dearth of free neutrons, we also infer that multiple-plane nuclei are unlikely to be present at the start of solar collapse into a supernova, since a large excess of neutrons is required to populate their interplane neutron rafts. (Here is a compelling reason to argue that the most abundant iron isotope, Fe 56, is a single-plane structure).

- However, *after* the supernova collapse has occurred, ideal conditions will exist for proton-to-neutron conversion of *all* the nuclear protons in the highly compact, and extremely hot, core plasma of these iron-type nuclei. We should expect this conversion to occur, because this collapse brought electrons and protons very close together, and all will be impinging with sufficient relative velocity to rupture all the nuclear bonds, and with plenty left over to supply the necessary energy of proton-electron fusion to neutrons, thereby releasing as a by-product very energetic voids and void-pairs (muon & electron neutrinos).

- Astrophysicists suggest that it is the pressure of these very energetic neutrinos which overcomes the gravitational attraction, and causes the core mass of neutrons to implode & explode, creating a central black hole (body-centered cubic lattice), surrounded by a rapidly expanding shell of single-plane nuclei, which were too near the surface of the condensed solar body to be converted to neutrons. The nuclei in this shell are ripe for being transformed into multiple-plane nuclei, because they are very close together, and are being interpenetrated by a huge excess of faster moving free neutrons. It is at this point in the supernova scenario, during the transient existence of this expanding neutron-rich nuclide plasma, that IPP can offer some insight into the formation of the higher-Z nuclides of the periodic table:

Released Neutrinos Lose Momentum In Causing An Explosion

Although p + e $\rightarrow$ n conversions in the collapsing core produce only high-momentum neutrinos, these have great difficulty escaping, because of the high density of the neutron plasma. Thus, many of these neutrinos will suffer multiple reflections, each transferring some of their momentum to neutrons in each collision. One result is the intense supernova implosion & explosion, brought on by rapidly increasing neutron momentum. Another result of multiple neutrino-neutron encounters is the generation of a huge outgoing flux of *low-momentum* neutrinos in the stream of neutrinos of all energies emerging from a supernova explosion. These low-momentum neutrinos play a role in multiplane nuclear synthesis, as I now explain.

The Re-Conversion Of Neutrons To Protons + Electrons

As the exploding shell of neutron-rich nuclide plasma expands and cools, the core-created neutrons will be free again to interact with void-pairs to produce protons and electrons. However, the mean lifetime of neutron decay in this plasma should be much reduced, because these neutrons are immersed in a huge flux of low-energy neutrinos. So, as the exploding shell moves outwardly, the single-plane nuclei which survived the stellar collapse will be exposed to a continually changing mix of neutrons, protons, and electrons that swirl around them. Thus, somewhere in this cycle of expansion, conditions will be ideal for the formation of multiple-plane nuclei. I see this as occurring in two overlapping phases:

1) An early phase in which the primary additions to the single-plane core are neutrons. This will occur in a neutron-rich plasma, before many have converted to protons and electrons. I shall call this phase, "the neutron spilling-out process".

2) A later phase, during which protons and neutrons add in roughly equal numbers to an intermediate structure, consisting of a planar p/n core with partially formed superplane neutrons "rafts" bound to top and bottom. I shall term this phase, "the multiple-plane building process".

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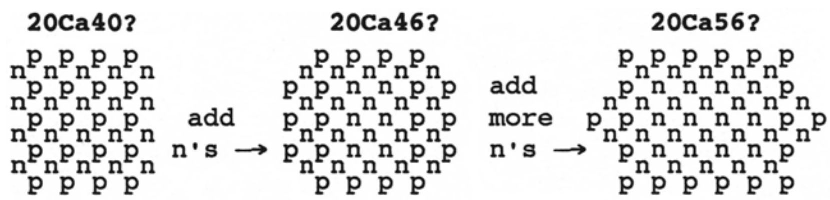
The Neutron Spilling-Out Process

Suppose we speculate about the result of immersing a medium-size single-plane nuclide, say $Ca^{20}{}_{40}$, in a dense flux of neutrons. Here is what we might expect to happen: Neutrons will attach to the nuclide perimeter in proton "notch" locations, and almost immediately migrate to the particle interior, as protons replace them through p/n inter-nucleon charge-exchanges. I show two stages of this inward neutron migration process in Fig. 4-33, below:

Fig. 4-33 A Possible Result Of Adding n's To 20Ca40?



key: p = paired proton, n = paired neutron

Although the structures, above, are probably not the most plausible structures for Ca40 (96.941%) & Ca46 (0.004%), as the next chapter will show, what I hope to convey, above, is how successive additions of neutrons will eventually lead to central instability, through accumulation of excess central neutrons. What we might expect to happen to the right-hand structure is that the central group of contiguous neutrons, being unable to stabilize their bonds by inter-nucleon charge-exchanges, will shake loose when the nuclide moves through a grain-boundary. This mass displacement will leave a central hole which the surrounding annular ring of p & n nucleons will collapse into, because, in so doing, they will achieve larger total mass-deficit. This leaves the expelled neutrons to seek other bonding possibilities in superplane locations, where they may be able to find enhanced bonding as a group, by siting some of their numbers in dual-proton "notches". Clearly, this spilling out of central neutrons is a plausible way to start the multiple-plane construction process.

It would be nice if we could verify this speculation in the laboratory, by successive additions of neutrons to the last stable isotope, Ca48, until a group of nucleons spills out all at once. There is an obvious impediment: No one knows how to form a stream of neutrons of sufficient density to create a probability that eight more will add to any one nuclide of Ca48 before β^- decay occurs. But, this difficulty should not exist in the high neutron flux of an exploding supernova!

The Multiple-Plane Building Process

Once structures have formed with super-plane neutrons located in dual-proton U-notches, further additions of protons, or even small nuclei, can bond to these notch location, by siting in the first or fifth plane. These additions, in turn, provide bonding sites for further additions of neutrons and protons, allowing these outside planes to fill out. These outer-plane sites will fill preferentially, because each additional nucleon is able to establish a paraxial bond to the central plane, in addition to its planar bonds, a bonus not available in perimeter locations of the central plane.

There is little point in speculating further about these multiple-plane building process, since there are endless ways to create a given structural possibility, and endless uncertainties. Our ability to understand the details of these processes will undoubtedly grow with time, as other minds grapple with, and expand upon, the concepts which I have introduced.

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