# Observational data for strong quark influence on the radioactive decay of atomic nuclei

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## Abstract.

Protons and neutrons are the constituents of the atomic nucleus, as demonstrated by experimental data. However, the radioactive half-life is poorly explained by the Z/A numbers. Replotting the existing half-life data with the Up and Down quark numbers transforms the plots, making them predictive, and reveals new, hidden structures. Those structures show an insight into the quarks in their natural, unperturbed states in the nucleus.

Key words : Quarks. Preons. Radioactive half-life

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**Current view of the radioactive properties of the atomic nucleus**

The atomic theory of the nucleus consisting of proton and neutrons can be shown graphically in the Karlsruhe Nuclide Chart (Soti, Z., Magill, J., Dreher, R., 2018). This shows order within the isotopes. The elements cluster into groups. The ratio of neutrons to protons is an indicator of which isotope may be stable, and which may be unstable (Fig. 1).

The chart is also semi-chaotic, and clumpy. There are clusters of stability, and adjacent clusters of instability.

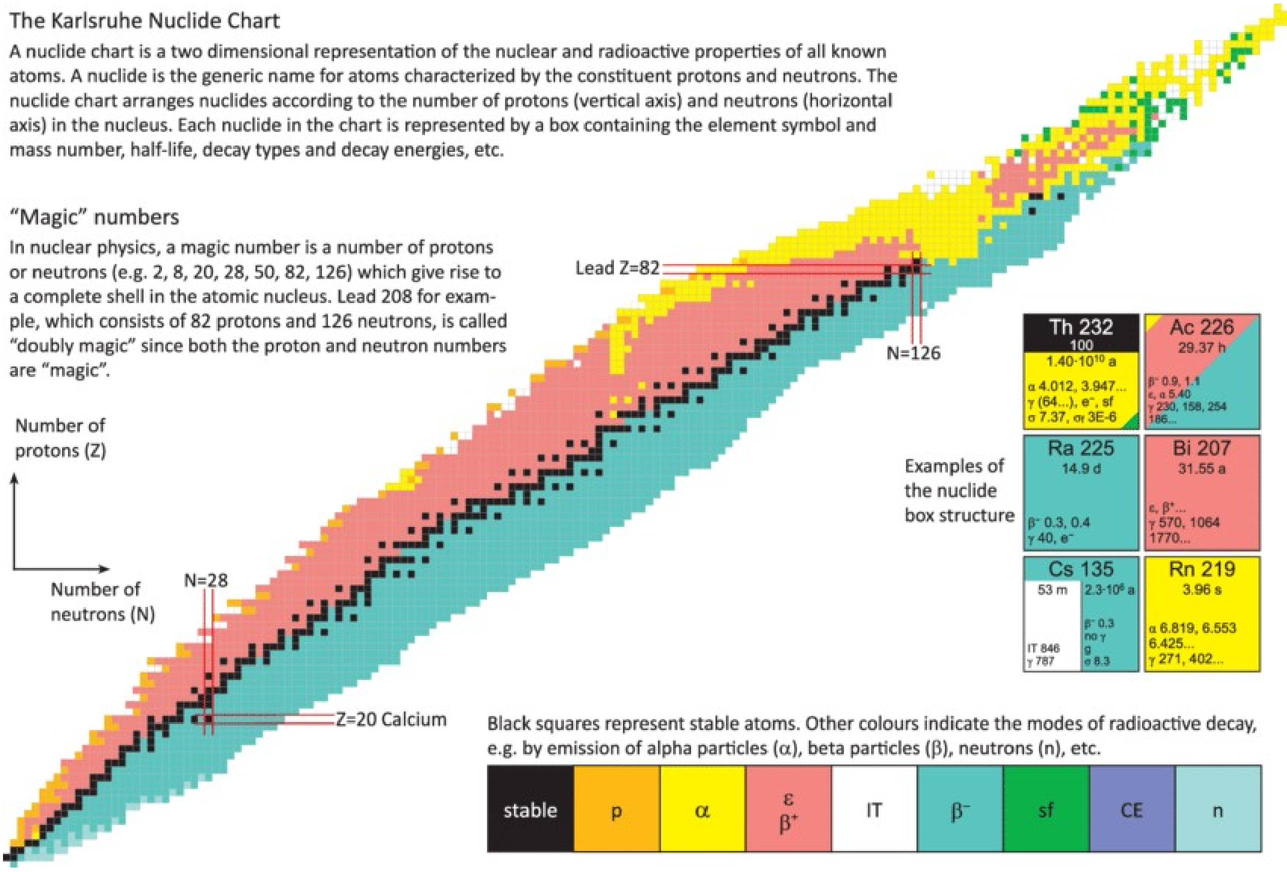



Fig. 1 Chart of the nuclides. A clear structure can be seen, as well as many observational anomalies

For example, Technetium. Z=43 is in the middle of the chart but does not have a single stable isotope. Comparing that with its neighbours, Molybdenum Z=42 has four stable and two observationally stable isotopes, while Ruthenium Z=44, on the other side, has five stable and two observationally stable isotopes. A single proton can totally destabilise a complete set of isotopes.

Another example of an anomaly is found in Argon Z=18, with two stable and one observationally stable isotope, and some very unstable isotopes between them. A single neutron seems to destabilise the nucleus. An even more extreme case is Indium Z=49. The isotope 114, which is unstable, is completely surrounded by stable isotopes with Z +/- 1 and N +/1.

The chart of the nuclides gives groupings according to the Z number, which follows the chemical element interpretation. Why should the chemical properties of the element be relevant when considering the properties of a nucleus? In a universe devoid of electrons, the nucleus could still exist. A better ordering of the nucleus is needed.

## Notes on the data preparation used in this article

A spreadsheet was prepared to record the following data (Fig. 2)

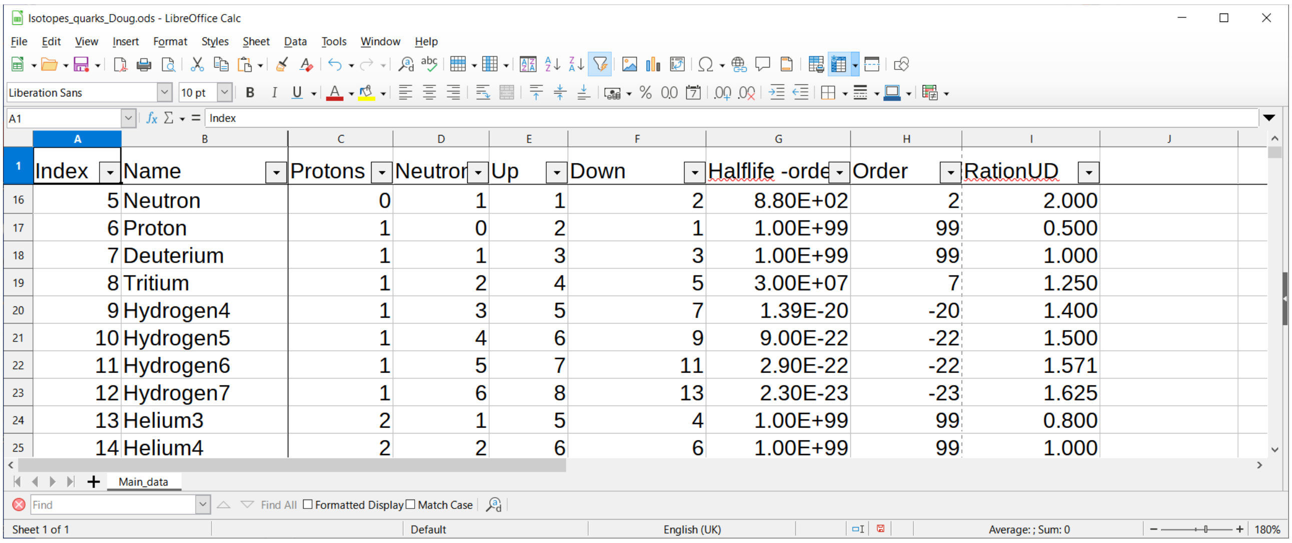
Isotope name,
Number of protons,
Number of neutrons,
Number of Up quarks,
Number of Down quarks,
Half life of isotopes ( in seconds ),
Half life ( order of magnitude).

The range of half-lives of isotopes can vary over many orders of magnitude. The data set used records all half-lives in seconds. Then the order of magnitude is noted.

Some examples
Half life 3.45E5 seconds is noted as 5
Half life 3.45E-5 seconds is noted as -5

Stable isotopes are noted as 99
Observationally stable isotopes are noted as 98

There are quite a number of radionuclides with extremely short but unknown half-life times. They are arbitrarily noted as -88


Isotopes_quarks_Doug.ods - LibreOffice Calc

| Index | Name | Protons | Neutror | Up | Down | Halflife -orde | Order | RationUD |
|---|---|---|---|---|---|---|---|---|
| 5 | Neutron | 0 | 1 | 1 | 2 | 8.80E+02 | 2 | 2.000 |
| 6 | Proton | 1 | 0 | 2 | 1 | 1.00E+99 | 99 | 0.500 |
| 7 | Deuterium | 1 | 1 | 3 | 3 | 1.00E+99 | 99 | 1.000 |
| 8 | Tritium | 1 | 2 | 4 | 5 | 3.00E+07 | 7 | 1.250 |
| 9 | Hydrogen4 | 1 | 3 | 5 | 7 | 1.39E-20 | -20 | 1.400 |
| 10 | Hydrogen5 | 1 | 4 | 6 | 9 | 9.00E-22 | -22 | 1.500 |
| 11 | Hydrogen6 | 1 | 5 | 7 | 11 | 2.90E-22 | -22 | 1.571 |
| 12 | Hydrogen7 | 1 | 6 | 8 | 13 | 2.30E-23 | -23 | 1.625 |
| 13 | Helium3 | 2 | 1 | 5 | 4 | 1.00E+99 | 99 | 0.800 |
| 14 | Helium4 | 2 | 2 | 6 | 6 | 1.00E+99 | 99 | 1.000 |

Fig. 2 Spreadsheet showing the data used

**Does the quark model help to provide a better chart?**

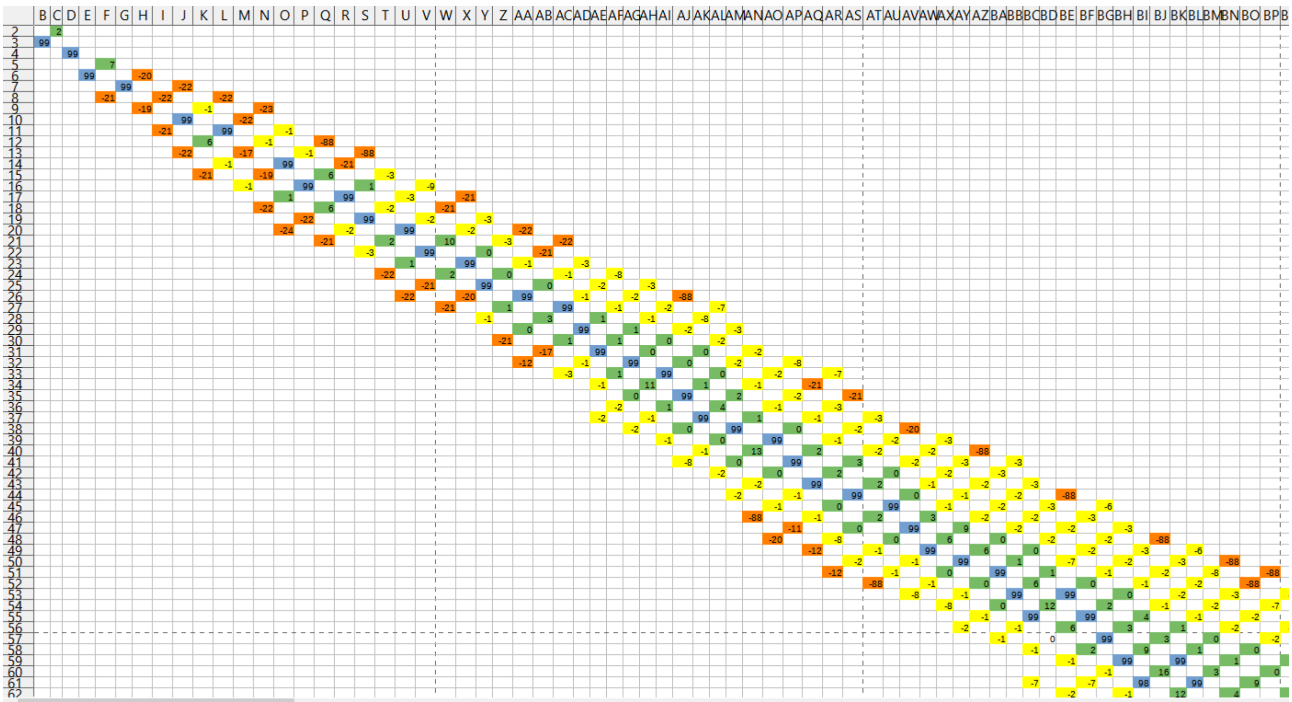
The quick answer is yes.

A proton consists of two Up quarks and one Down quark. A neutron consists of one Up quark and two Down quarks. It is a simple task to replace the nucleons with their quarks, and create a new chart based on the Up and Down quark numbers: a scattergram plotting the NumUp, vs NumDown and the order of magnitude of the half-life.

The new chart is far more complete and reveals several points of interest (Fig. 3).

The classic chart plots an element parallel to the X or Y axis. Elements in the new chart are shown along the diagonal. The structure envelope is now more cigar-shaped, rather than a banana. However, a cursory glance shows a dramatic change.

Fig 3. Plot of nuclides, Down quark (x axis) vs Up quark (y axis).
Note: Y increase downwards. Blue is stable. Green half-life > 1 second , Yellow half-life <1 second, Orange half-life < 10E-9 second



In the classic Chart each line represents a chemical element. In the new plot, lines are formed of constant quark number; that is, Num Up + Num Down = constant. In this work these lines are designated IsoQuarkNum lines, or IQN lines.

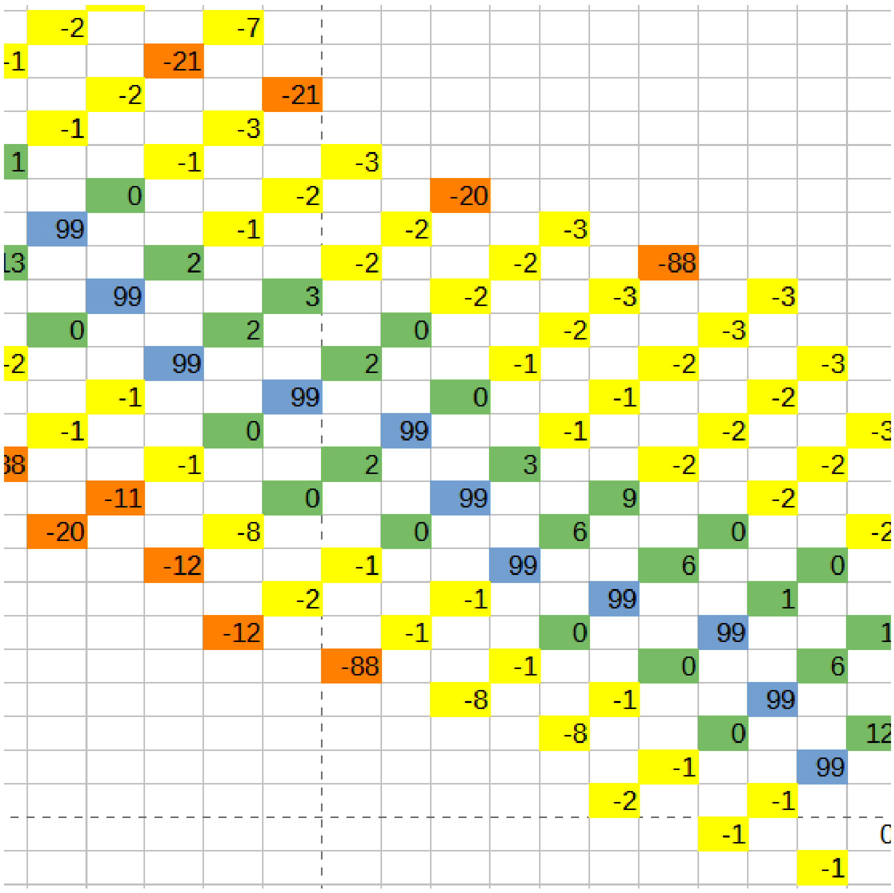



Fig 4 above. A closer look reveals how a single combination of Up and Down quarks yield a stable isotope. Blue 99 is stable, surrounded by increasingly unstable isotopes.

Many of the IQN lines have a single stable, or observationally stable, isotope near the centre. Interestingly, other isotopes along the IQN line are not stable, and they are more unstable the further away they are from the stable isotope.

For example, IQN line = 81

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| -2 | -2 | 0 | 99 | 2 | -1 | -2 | -3 |

The new chart has a predictive power far beyond the traditional chart. It is a gateway to producing formulae and functions to support more analyses.

**An important observation of structure in the new data.**

To a large extent, the first 70% of the chart shows essentially the same structure: a central stable isotope with unstable isotopes either side. That could be visualised as a half cylinder. The highest point shows stability, while points down the slope represent greater instability.

Starting at IQN = 2295, however, a new and wholly unexpected structure emerges.

From there, the half cylinder appears inverted. The centre of the cylinder is now more unstable than its IQN neighbours (Fig. 5). It is a “Valley of Death”. Any isotope in that zone is doomed to be unstable.
The classic chart of the nuclides has a clumpy region, without structure, while the boundary of the valley is clearly defined in the new plot.

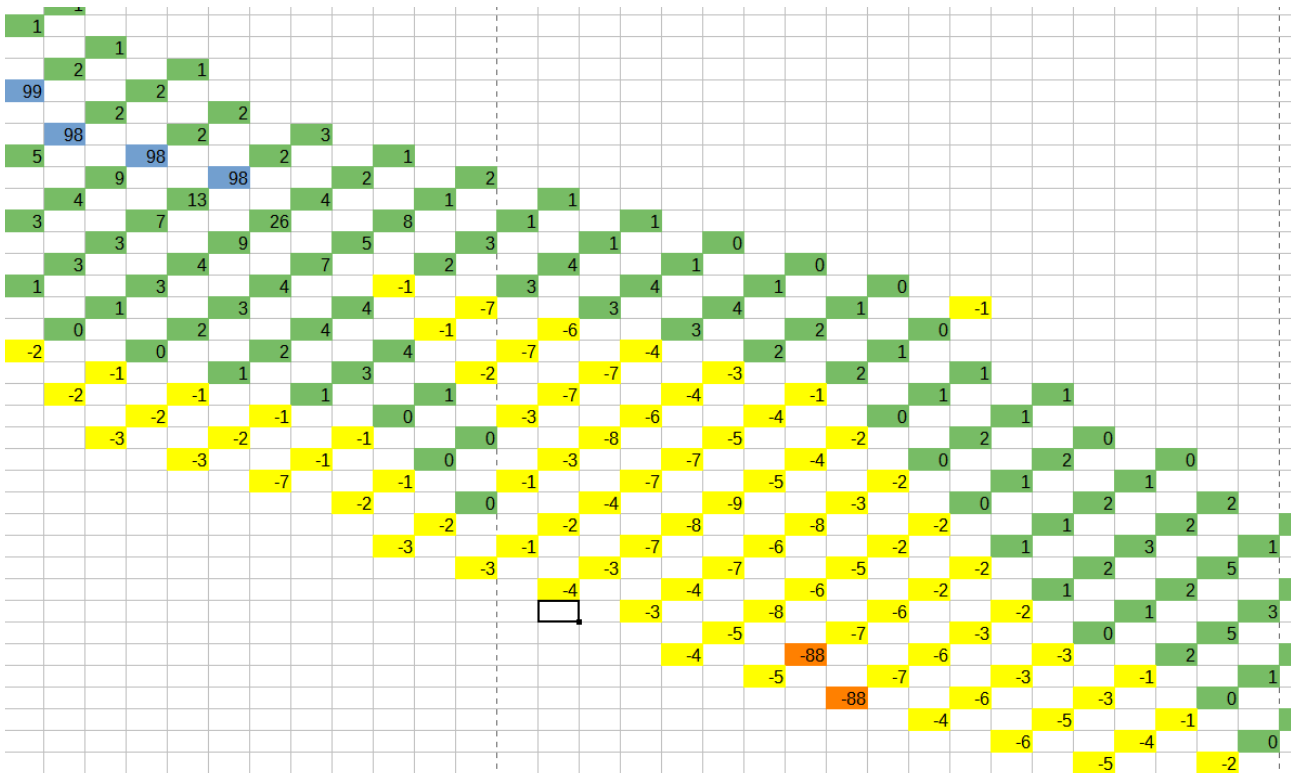


Fig. 5  Part of the new plot, showing the Valley of Death

After a while the Valley of Death subsides but is never replaced with any clear structure.  It could be that the number of points becomes too sparse. It also may have implications for the speculated Islands of stability ( Oganessian Y. ,2012 ) which appear with much higher Z and N numbers. Based on the current data, there is no reason to suggest that any further stability will appear.

**Is that the end of the story?**

The impetus for creating the new chart was to provide a better representation and to remove anomalies. To that end, the chart is partially successful. But there are still some anomalies.

Essentially, there is still clumpiness and lack of smoothness. In places, there are multiple stable isotopes on an IQN line. There is also a new set of semi-random alignments along lines of IsoUpNum and IsoDownNum. (Fig. 6)

A point of interest to note is that there is some periodicity. The stable isotopes are separated by steps of three, in either rows, or columns.

Fig 6. Examples of clumpiness in the Up and Down quark plotting. Note that several stable Blue isotopes appear clumped along the same row or column.

| | FY | FZ | GA | GB | GC | GD | GE | GF | GG | GH | GI | GJ | GK | GL | GM | GN | GO | GP | GQ | GR | GS | GT | GU | GV | GW | GX | GY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 156 | | -1 | | | -1 | | | | | | | | | | | | | | | | | | | | | | |
| 157 | 0 | | | -1 | | | -1 | | | | | | | | | | | | | | | | | | | | |
| 158 | | | -1 | | | -1 | | | -1 | | | | | | | | | | | | | | | | | | |
| 159 | | 0 | | | -1 | | | -1 | | | | | | | | | | | | | | | | | | | |
| 160 | 1 | | | 0 | | | -1 | | | -2 | | | | | | | | | | | | | | | | | |
| 161 | | | 0 | | | 0 | | | -1 | | | -2 | | | | | | | | | | | | | | | |
| 162 | | 0 | | | 1 | | | -1 | | | -1 | | | -2 | | | | | | | | | | | | | |
| 163 | 98 | | | 3 | | | 1 | | | -1 | | | -1 | | | | | | | | | | | | | | |
| 164 | | | 3 | | | 2 | | | 0 | | | -1 | | | -1 | | | | | | | | | | | | |
| 165 | | 22 | | | 22 | | | 1 | | | 0 | | | -1 | | | -2 | | | | | | | | | | |
| 166 | 99 | | | 1 | | | 3 | | | 0 | | | -1 | | | -1 | | | | | | | | | | | |
| 167 | | | 99 | | | 3 | | | 3 | | | 0 | | | -1 | | | -1 | | | | | | | | | |
| 168 | | 2 | | | 99 | | | 0 | | | 2 | | | 0 | | | -1 | | | -2 | | | | | | | |
| 169 | 3 | | | 4 | | | 99 | | | 2 | | | 1 | | | -1 | | | -1 | | | | | | | | |
| 170 | | | 3 | | | 2 | | | 99 | | | 0 | | | 1 | | | -1 | | | -1 | | | | | | |
| 171 | | 2 | | | 5 | | | 5 | | | 99 | | | 1 | | | 0 | | | -1 | | | -2 | | | | |
| 172 | 1 | | | 2 | | | 4 | | | 2 | | | 4 | | | 0 | | | 0 | | | -1 | | | -1 | | |
| 173 | | | 2 | | | 3 | | | 98 | | | 99 | | | 98 | | | 0 | | | 0 | | | -1 | | | -2 |
| 174 | | 1 | | | 2 | | | 3 | | | 6 | | | 5 | | | 7 | | | 0 | | | -1 | | | -1 | |
| 175 | 0 | | | 1 | | | 3 | | | 3 | | | 99 | | | 99 | | | 98 | | | 0 | | | -1 | | |
| 176 | | | 0 | | | 1 | | | 3 | | | 2 | | | 98 | | | 6 | | | 5 | | | 0 | | | -1 |
| 177 | | 0 | | | 1 | | | 2 | | | 4 | | | 6 | | | 99 | | | 7 | | | 12 | | | 0 | |
| 178 | -1 | | | 0 | | | 1 | | | 1 | | | 3 | | | 5 | | | 99 | | | 6 | | | 3 | | |
| 179 | | | -1 | | | 0 | | | 2 | | | 2 | | | 29 | | | 6 | | | 99 | | | 5 | | | 3 |
| 180 | | | | | 0 | | | 0 | | | 2 | | | 1 | | | 4 | | | 6 | | | 4 | | | 4 | |
| 181 | | | | -1 | | | 0 | | | 1 | | | 2 | | | 3 | | | 98 | | | 99 | | | 31 | | |
| 182 | | | | | | -1 | | | 0 | | | 1 | | | 2 | | | 1 | | | 6 | | | 3 | | | 3 |
| 183 | | | | | | | | -1 | | | 0 | | | 1 | | | 3 | | | 4 | | | 99 | | | 14 | |
| 184 | | | | | | | | | | 0 | | | 0 | | | 1 | | | 2 | | | 2 | | | 99 | | |
| 185 | | | | | | | | | -1 | | | 0 | | | 1 | | | 2 | | | 5 | | | 5 | | | 99 |

## Conclusions

The replot of half-life data has yielded several new features. The spine of stability, with just a single stable isotope is interesting in itself. The “valley of death” was wholly unexpected. That needs further investigation. The reappearance of the clumpiness itself is interesting, because the clumpiness now shows some periodicity.

The replot has made the half-life more ordered. The periodicity does suggest that a deeper order still may exist. It is possible that first hints of preons ( the postulated component particles of quark ) are to be found in the data. More research is needed to explain these features.

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