The Unusually High Distribution of Prime Numbers in the Periods of the Periodic Table

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Abstract: The instability of nuclei that follows (A – Z)/Z > 1 is well known. The question is whether there are regions of greater instability in this overall instability curve due to the presence of prime atomic numbers. An analysis of the lifetime of dominant isotopes allows us to determine if prime atomic numbers have a statistically-significant impact in reducing isotope lifetime.

I. Problem

As can be seen in Figure 1, there is a larger than average number of elements which have an atomic number that is a prime number in the first and third period of the periodic table.

There is a band of instability in the periodic table as more neutrons are added to the nucleus as shown in Figure 2. The decay rates are somewhat predictable until some regions are reached, and then instability is present. At the same time, there are a statistically significant number of primes in the first few odd periods of the periodic table. Could these the instability of the periodic table be related to the atomic number being a prime number and why would this be the case?

Examining the first period of the periodic table, we see four elements with prime atomic number up to element 37 and we know there are 12 prime numbers in the list of 1 to 37, so the probability of randomly having four elements that have a prime atomic number up to element 37 is as follows:

$$Prob(4:37) = (12/37)(11/37)(10/37)(9/37) = .0063 \quad (1)$$

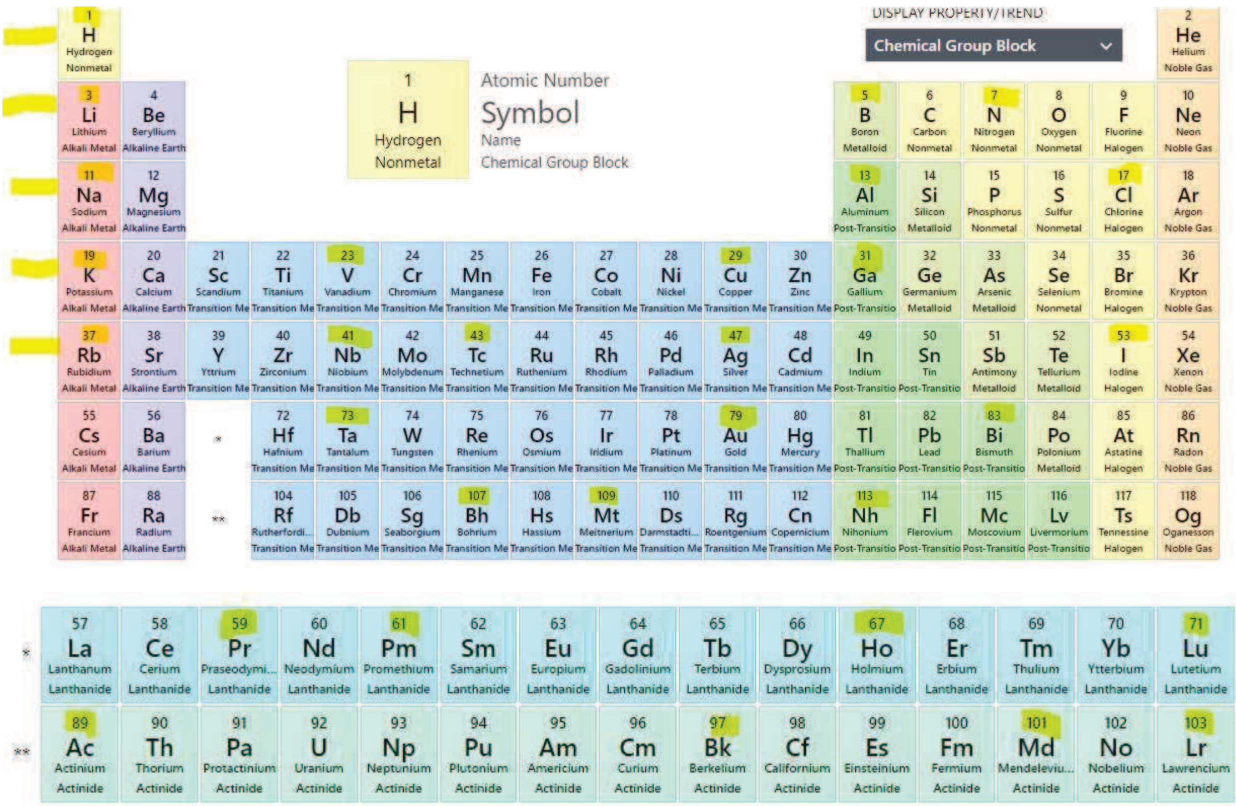

Figure 1. Elements with an Atomic Number that is Prime

Therefore, there does appear to be a statistically higher number of elements that are prime in the first few odd periods of the periodic table than would be expected from a normal distribution. The instability of nuclei as $(A - Z)/Z > 1$ is well known as shown in Figure 2. The question is whether there are regions of greater instability in this overall instability curve due to the presence of prime atomic numbers. An analysis of the lifetime of dominant isotopes allows us to determine if prime atomic numbers have a statistically-significant impact in reducing isotope lifetime.

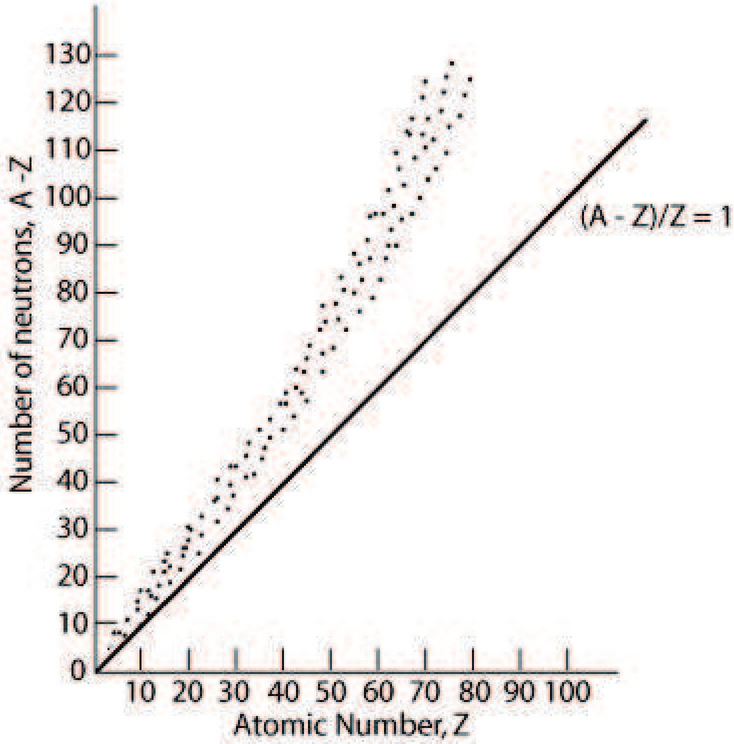

Figure 2. Instability regions as the atomic number increases

II. Hypothesis

Some aspects of energy levels in the nucleus (where protons in the nucleus define atomic number) exhibit a increase or lack of stability based on a prime number relationship. Because Schrodinger's equation describes how atoms work together using a complex wave function and the Riemann-Zeta function describes how primes work together using complex exponential functions, it may be that Schrodinger's equation and the Riemann-Zeta function are related in a way that defines the periodicity of the periodic table.

III. Discussion

Examining the lifetimes of isotopes in Table I, we see that heavier elements in the periodic table start to decay with element 43 with a lifetime of 6 million years, and element 61 with a lifetime of 25.6 years are both islands of instability surrounded by a range of approximately 20 elements that are stable in each of these cases (the first case of element 43 has stability going back to Hydrogen). Then at element 83 and all elements afterwards, we witness permanent instability. At elements 89, 101 and 103 we see that the lifetime drops significantly from the average of previous lifetimes in each case compared to the lifetimes between element 83 to element 97.

Element Atomic Number	Element Symbol	Element Name	Element Lifetime	Prime Atomic Number?
1	H	Hydrogen	Stable	Non-Prime
2	He	Helium	Stable	Prime
3	Li	Lithium	Stable	Prime
4	Be	Beryllium	Stable	Non-Prime
5	B	Boron	Stable	Prime
6	C	Carbon	Stable	Non-Prime
7	N	Nitrogen	Stable	Prime
8	O	Oxygen	Stable	Non-Prime
9	F	Fluorine	Stable	Non-Prime
10	Ne	Neon	Stable	Non-Prime
11	Na	Sodium	Stable	Prime
12	Mg	Magnesium	Stable	Non-Prime
13	Al	Aluminium	Stable	Prime
14	Si	Silicon	Stable	Non-Prime
15	P	Phosphorus	Stable	Non-Prime
16	S	Sulfur	Stable	Non-Prime
17	Cl	Chlorine	Stable	Prime
18	Ar	Argon	Stable	Non-Prime
19	K	Potassium	Stable	Prime
20	Ca	Calcium	Stable	Non-Prime
21	Sc	Scandium	Stable	Non-Prime
22	Ti	Titanium	Stable	Non-Prime
23	V	Vanadium	Stable	Prime
24	Cr	Chromium	Stable	Non-Prime
25	Mn	Manganese	Stable	Non-Prime
26	Fe	Iron	Stable	Non-Prime
27	Co	Cobalt	Stable	Non-Prime
28	Ni	Nickel	Stable	Non-Prime
29	Cu	Copper	Stable	Prime
30	Zn	Zinc	Stable	Non-Prime
31	Ga	Gallium	Stable	Prime
32	Ge	Germanium	Stable	Non-Prime
33	As	Arsenic	Stable	Non-Prime
34	Se	Selenium	Stable	Non-Prime
35	Br	Bromine	Stable	Non-Prime
36	Kr	Krypton	Stable	Non-Prime
37	Rb	Rubidium	Stable	Prime
38	Sr	Strontium	Stable	Non-Prime
39	Y	Yttrium	Stable	Non-Prime

40	Zr	Zirconium	Stable	Non-Prime
41	Nb	Niobium	Stable	Prime
42	Mo	Molybdenum	Stable	Non-Prime
43	Tc	Technetium	6.02 million y	Prime
44	Ru	Ruthenium	Stable	Non-Prime
45	Rh	Rhodium	Stable	Non-Prime
46	Pd	Palladium	Stable	Non-Prime
47	Ag	Silver	Stable	Prime
48	Cd	Cadmium	Stable	Non-Prime
49	In	Indium	Stable	Non-Prime
50	Sn	Tin	Stable	Non-Prime
51	Sb	Antimony	Stable	Non-Prime
52	Te	Tellurium	Stable	Non-Prime
53	I	Iodine	Stable	Prime
54	Xe	Xenon	Stable	Non-Prime
55	Cs	Cesium	Stable	Non-Prime
56	Ba	Barium	Stable	Non-Prime
57	La	Lanthanum	Stable	Non-Prime
58	Ce	Cerium	Stable	Non-Prime
59	Pr	Praseodymium	Stable	Prime
60	Nd	Neodymium	Stable	Non-Prime
61	Pm	Promethium	25.56 y	Prime
62	Sm	Samarium	Stable	Non-Prime
63	Eu	Europium	Stable	Non-Prime
64	Gd	Gadolinium	Stable	Non-Prime
65	Tb	Terbium	Stable	Non-Prime
66	Dy	Dysprosium	Stable	Non-Prime
67	Ho	Holmium	Stable	Prime
68	Er	Erbium	Stable	Non-Prime
69	Tm	Thulium	Stable	Non-Prime
70	Yb	Ytterbium	Stable	Non-Prime
71	Lu	Lutetium	Stable	Prime
72	Hf	Hafnium	Stable	Non-Prime
73	Ta	Tantalum	Stable	Prime
74	W	Tungsten	Stable	Non-Prime
75	Re	Rhenium	Stable	Non-Prime
76	Os	Osmium	Stable	Non-Prime

77	Ir	Iridium	Stable	Non-Prime
78	Pt	Platinum	Stable	Non-Prime
79	Au	Gold	Stable	Prime
80	Hg	Mercury	Stable	Non-Prime
81	Tl	Thallium	Stable	Non-Prime
82	Pb	Lead	Stable	Non-Prime
83	Bi	Bismuth	2.76×10^19 y	Prime
84	Po	Polonium	147.1 y	Non-Prime
85	At	Astatine	11.7 h	Non-Prime
86	Rn	Radon	5.516088 d	Non-Prime
87	Fr	Francium	31.7 m	Non-Prime
88	Ra	Radium	2.31×10^3 y	Non-Prime
89	Ac	Actinium	31.4311 y	Prime
90	Th	Thorium	2.0285×10^10 y	Non-Prime
91	Pa	Protactinium	47279 y	Non-Prime
92	U	Uranium	6.4498×109 y	Non-Prime
93	Np	Neptunium	3.0952×106 y	Non-Prime
94	Pu	Plutonium	1.14×108 y	Non-Prime
95	Am	Americium	1.065×104 y	Non-Prime
96	Cm	Curium	2.25×10^7 y	Non-Prime
97	Bk	Berkelium	1991 y	Prime
98	Cf	Californium	1.3×10^3 y	Non-Prime
99	Es	Einsteinium	1.865 y	Non-Prime
100	Fm	Fermium	145.02 d	Non-Prime
101	Md	Mendelevium	74.31 d	Prime
102	No	Nobelium	5.56 h	Non-Prime
103	Lr	Lawrencium	14.4 h	Prime
104	Rf	Rutherfordium	18.9 h	Non-Prime
105	Db	Dubnium	8.33 h	Non-Prime
106	Sg	Seaborgium	2.78 h	Non-Prime
107	Bh	Bohrium	2.17 h	Prime
108	Hs	Hassium	1.39 h	Non-Prime
109	Mt	Meitnerium	43.3 m	Prime
110	Ds	Darmstadtium	5.833 m	Non-Prime
111	Rg	Roentgenium	14.5 m	Non-Prime
112	Cn	Copernicium	58.3 m	Non-Prime
113	Nh	Nihonium	28.3 m	Prime

114	Fl	Flerovium	2 m	Non-Prime
115	Mc	Moscovium	1.5 m	Non-Prime
116	Lv	Livermorium	173 ms	Non-Prime
117	Ts	Tennessine	72 ms	Non-Prime
118	Og	Oganesson	7 ms	Non-Prime

Table I. The Association of Element Lifetime and Prime Atomic Number

IV. Results

From an analysis of the change in stability of elements in the periodic table, there are indications of more significant change due to the atomic number being a prime number. In the first period of the periodic table there are five out of seven elements that are prime and there are many regions of stability or instability (measured by decay lifetime) of the artificial elements that are associated with the atomic number being a prime number. From the spreadsheet showing the regions of stability change in the periodic table, we see element 43 (with a lifetime of 6 million years) and element 61 (with a lifetime of 25.6 years), which are both islands of instability with the surrounding elements being stable indefinitely for up to 10 or more elements in each direction of the periodic table. There is also element 83 which indicates a change from most elements being indefinitely stable to most elements being unstable and having shorter lifetimes.

V. Conclusions

There is significant indication that the atomic numbers that are prime contribute to the stability of the periodic table and that the decay times of elements that are prime are significantly different and usually lower in time than the elements surrounding them. Elements with prime atomic numbers are shown to indicate the change in stability.