<u>The Unusually High Distribution of Prime</u> <u>Numbers in the Periods of the Periodic Table</u>

Jonathan Harney

jonathanmharney@gmail.com

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. <u>Problem</u>

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:

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

1 H Hydrogen Nonmetal				1	Ato	mic Numb	a contraction of the second seco			Constant of	nical Gr		77092.098 -	*	2 He Helium Noble Gas
3 Li Lithium Aikali Metal	4 Be Beryllium Alkaline Earth			H Hydroger	Sy Nam	mbol				5 B Boron Metalloid	6 C Carbon Nonmetal	7 N Nitrogen Nonmetal	8 O Oxygen Nonmetal	9 F Fluorine Halogen	10 Neon Noble Gas
11 Na Sodium Alkali Metal	12 Mg Magnesium Alkaline Earth			Nonmeta	I Cher	nical Group	Block			13 Al Aluminum Post-Transitio	14 Si Silicon Metalloid	15 P Phosphoru Nonmetal		17 Cl Chlorine Halogen	18 Ar Argon Noble Ga
19 K Potassium Alkali Metal			22 Ti Tianium Itanium Ne Transiti	ium Chromium	C. C	Iron	27 2 Co N Cobalt Nic nsition Me Transiti	i Cu cel Copper	30 Zn Zinc Me Transition Me		32 Ge Germanium Metalloid	33 As Arsenic Metalloid	34 Se Selenium Nonmetal	35 Br Bromine Halogen	36 Kr Krypton Noble Ga
37 Rb Rubidium Alkali Metal	38 Sr Strontium Alkaline Earth Ti	and the second	40 Zr N Niob nsition Me Transiti	b Mo	43 TC Technetium Transition Me		45 4 Rh P hodium Pallar nsition Me Transiti	d Ag Silver	48 Cd Cadmium Me Transition Me	49 In Indium Post-Transitio F	50 Sn Tin Post-Transitio	51 Sb Antimony Metalloid	52 Te Tellurium Metalloid		54 Xe Xenon Noble Ga
55 CS Cesium Alkali Metal	56 Ba Barium Alkaline Earth		72 Hf Ta tafnium Tanta	a W Ium Tungsten	75 Re Rhenium		77 7 Ir P Iridium Platiin Insition Me Transiti	t Au Gold	80 Hg Mercury	81 TI Thallium Post-Transitio F	82 Pb Lead	83 Bi Bismuth Post-Transit	84 Po Polonium Metalloid	85 At Astatine Halogen	86 Rn Radon Noble Gi
87 Fr Francium Alkali Metal	88 Ra Radium Alkaline Earth		104 10 Rf D Dubr nsition Me Transiti	b Sg		Hassium M	109 11 Mt Darmst eitnerium Darmst nsition Me Transiti	s Roentgeni	112 Cn um Copernicium Me Transition Me	113 Nh Nihonium Post-Transitio F	114 Fl Flerovium Post-Transitio		116 LV I Uvermoriu Io Post-Transit		118 Og Oganesso Noble Ga
57 La Lanthanum Lanthanide	58 Ce Cerium Lanthanide	59 Pr Praseodymi Lanthanide		61 Pm Promethium Lanthanide	62 Sm Samarium Lanthanide	63 Eu Europium Lanthanide	64 Gd Gadolinium Lanthanide	65 Tb Terbium Lanthanide	66 Dy Dysprosium Lanthanide	67 Ho Holmium Lanthanid		r um 1	69 Tm Thulium	70 Yb Ytterbium Lanthanide	71 Lu Lutetic Lanthar
89 Ac Actinium Actinide	90 Th Thorium Actinide	91 Pa Protactinius Actinide	92 U Uranium Actinide	93 Np Neptunium Actinide	94 Pu Plutonium Actinide	95 Am Americium Actinide	96 Cm Curium Actinide	97 Bk Berketium Actinide	98 Cf Californium Actinide	99 Es Einsteiniur Actinide	10 Fr Fermi Actin	n ium Me	101 Md ndeleviu	102 No Nobelium Actinide	103 Lr Lawrence Actini

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.

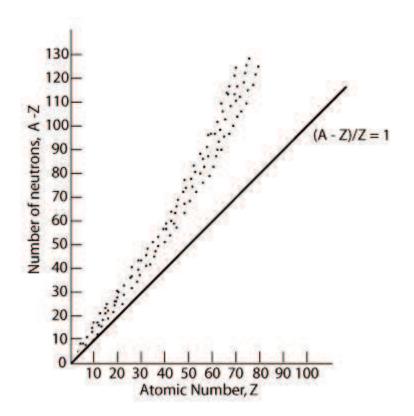


Figure 2. Instability regions as the atomic number increases

II. <u>Hypothesis</u>

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	Element	Element	Element	Prime Atomic Number?
Atomic Number	Symbol	Name	Lifetime	· · ·
1	Н	<u>Hydrogen</u>	Stable	Non-Prime
2	Не	<u>Helium</u>	Stable	Prime
3	Li	<u>Lithium</u>	Stable	Prime
4	Ве	<u>Beryllium</u>	Stable	Non-Prime
5	В	Boron	Stable	Prime
6	С	<u>Carbon</u>	Stable	Non-Prime
7	Ν	<u>Nitrogen</u>	Stable	Prime
8	0	<u>Oxygen</u>	Stable	Non-Prime
9	F	<u>Fluorine</u>	Stable	Non-Prime
10	Ne	<u>Neon</u>	Stable	Non-Prime
11	Na	<u>Sodium</u>	Stable	Prime
12	Mg	<u>Magnesium</u>	Stable	Non-Prime
13	AI	Aluminium	Stable	Prime
14	Si	<u>Silicon</u>	Stable	Non-Prime
15	Р	Phosphorus	Stable	Non-Prime
16	S	<u>Sulfur</u>	Stable	Non-Prime
17	Cl	<u>Chlorine</u>	Stable	Prime
18	Ar	Argon	Stable	Non-Prime
19	К	Potassium	Stable	Prime
20	Са	<u>Calcium</u>	Stable	Non-Prime
21	Sc	<u>Scandium</u>	Stable	Non-Prime
22	Ti	<u>Titanium</u>	Stable	Non-Prime
23	V	<u>Vanadium</u>	Stable	Prime
24	Cr	<u>Chromium</u>	Stable	Non-Prime
25	Mn	Manganese	Stable	Non-Prime
26	Fe	Iron	Stable	Non-Prime
27	Со	<u>Cobalt</u>	Stable	Non-Prime
28	Ni	<u>Nickel</u>	Stable	Non-Prime
29	Cu	<u>Copper</u>	Stable	Prime
30	Zn	Zinc	Stable	Non-Prime
31	Ga	<u>Gallium</u>	Stable	Prime
32	Ge	<u>Germanium</u>	Stable	Non-Prime
33	As	<u>Arsenic</u>	Stable	Non-Prime
34	Se	<u>Selenium</u>	Stable	Non-Prime
35	Br	Bromine	Stable	Non-Prime
36	Kr	<u>Krypton</u>	Stable	Non-Prime
37	Rb	<u>Rubidium</u>	Stable	Prime
38	Sr	<u>Strontium</u>	Stable	Non-Prime
39	Y	<u>Yttrium</u>	Stable	Non-Prime

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

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

114	FI	<u>Flerovium</u>	2 m	Non-Prime
115	Мс	<u>Moscovium</u>	1.5 m	Non-Prime
116	Lv	Livermorium	173 ms	Non-Prime
117	Ts	Tennessine	72 ms	Non-Prime
118	Og	<u>Oganesson</u>	7 ms	Non-Prime

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

IV. <u>Results</u>

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.