Gene H. Barbee
July 2013 revised Feb 2014

Title: A Simple Model of Atomic Binding Energy

Abstract

A Top-down approach to Fundamental Interactions, viXra:1307.0082 [2] presents the author's attempt to understand if there is an information code underlying nature. Once the energy components were understood, a model for the neutron and proton was developed. The proton model is presented in Reference 2 and repeated below under the next heading. The proton model shows that there is a 10.15 mev orbit that losses energy and is responsible for the binding energy curve. The goals of this paper are to verify the value 10.15 mev and present a simple model of atomic binding energy,.
Literature cites "water drop" models for binding energy that are admittedly empirical. Quantum physicists have suggested that there should be "electron like" shells inside atoms but to the author's knowledge they remain unclear. If there are shells the nucleons should fall into lower energy states releasing the remainder as binding energy. The author explored this possibility. Empirically, the model was successful but no explanation could be found for why a nucleon occupied a given shell.
The first part of the binding energy curve rises quickly and then levels off as saturation occurs. When the author compared the shape of the curve to a probability based model a simple relationship was discovered. The relationship is almost identical to the fundamentals presented in reference 2.

Information contained in the proton mass table

Information from the proton mass model is used to understand fundamental interactions. The energy values in the box add to the exact mass of the proton (938.2703 mev). There are three main components, each with a mass and kinetic energy. The total mass and kinetic energy on the left side of the box (959.56 mev) is balanced by fields on the right hand side of the box.

ll g228	CALCULATION OF PROTON MASS			Mass and Kinetic Energy					Field Energies		
mass	Energy-mev	strong field	Energy-mev	Mass	Difference ke	Strong residual ke	Neutrinos	Expansion ke	Strong & E/M	Gravitationa	spin
ke		grav field		mev	mev	mev	mev	mev	field energy	Energy	
15.432	101.947	17.432	753.291	101.947	641.880				-753.29		0.5
12.432	5.076	10.432	0.687							-0.69	
13.432	13.797	15.432	101.947	13.797	78.685				-101.95		0.5
12.432	5.076	10.432	0.687							-0.69	
13.432	13.797	15.432	101.947	13.797	78.685				-101.95		-0.5
12.432	5.076	10.432	0.687							-0.69	
		-0.296	-2.72E-05			10.151		20.303	expansion ke		
ıarge		equal and opposite charge						0.000	expansion pe		
10.408	0.67	0.075		0.000	0.000	-0.671	0.671	v neutrino			
-10.333	0										
ates here to form proton and electron				129.541	799.251	**938.272013**	**PROTON MASS**				0.5
10.136	0.51	10.333	0.62	**0.511**	0.111				5.44E-05	-0.622	0.5
0.197	2.47E-05	0.296	2.72E-05	**ELECTRON**			2.47E-05	e neutrino			
				130.052	0.111		0.671	20.303	-957.185	-2.683	
90.000		90.000									
								Total m+ke	Total fields		
								Total positive	Total negative		
								959.868	-959.868	0.00E+00	difference

The proton stores constants that underlie nature.							
Extracted from the proton table, the values below are the source of the four fundamental interactions.							
	Mass (m)	Ke	gamma (g)	R	Field (E		
	(mev)	(mev)		meters	(mev)		
Gravity	938.272	9.883	0.9896	**7.3543E-14**	-2.683		
Electromagne	0.511	1.36E-05	0.99997	**5.2911E-11**	-2.72E-05		
Strong	129.541	799.251	0.1395	**2.0928E-16**	-957.18		
Strong residu	928.792	10.151	0.9892	**1.4292E-15**	-20.303		

Orbital kinetic energy in the proton

Physicists believe there are three quarks (unmeasurable independently) inside the proton and it is reasonable to model them as a small bundle of mass and kinetic energy contained by the strong interaction. The quark mass plus kinetic energy from the model is 129.5+799.25-.67=928.12 mev. There is however, an additional kinetic energy of 10.15 mev that makes up the total mass of the proton (938.27 mev). This value changes during fusion.

Based on the proton mass model the weak field energy does not result from a separate energy transition. (In some literature this is called the strong residual force, but we are seeking the energy change responsible for binding energy). The proton and neutron mass models have a total energy of 959.86 mev, but the neutron only has only 939.56 mev. The total energy balance is zero if we consider the 20.3 deficit (959.86-939.56) as a field that surrounds the central mass (130.834 mev) similar to the manner in which the electromagnetic field surrounds the electron and proton. As nucleons fall into the weak field, the released energy binds the neutrons and protons inside atoms.

Fundamental release of atomic energy

Reference 2 identifies 1.5e78 as the number of protons in the universe based on the results of WMAP [9]. This makes the probability (P) of one proton 1/1.5e78. The author believes that nature uses Shannon [15] type information theory and makes N=- ln(P) a fundamental number of nature (ln stands for natural logarithm). The inverse relationship is E=e0*exp(N) where exp stands for the natural number e (2.71) to the power N. Reference 2 shows how nature's particles relate to N=180. For example, the electron, energy and N are related by the relationship E=e0*exp(N) where the number N=10.136 represents the electron since E=2.025e-5*exp(10.136)=0.511 mev, the energy of the electron. In other words e0/P is the electron energy where e0=2.025e-5 mev and P=1/exp(10.136).

The fundamentals of binding energy appear to be based on the same approach. For example, the probability of a neutron in lithium 3 is given by P=1/exp(2/3). The 2 means there are two types of particles (protons and neutrons) and 3 is of course the number of neutrons for lithium. Next N=-ln(P)=2/3. Note that in this case N is a number smaller than 1. Following a similar approach in the paragraph above, energy would be modified by P to give the energy release. The value e0 is 10.15 mev for binding energy, the value given above for "kinetic energy in the neutron orbit". Energy release for the neutron contribution to lithium is 10.15/exp(2/3)=5.21. In the table below the basic probabilistic approach above is applied to the fundamentals of atomic binding energy. Note that heavy atoms can have over 144 neutrons which give a potential release of 10.01 mev of atomic binding energy, indicating that the curve is approaching "saturation" at 10.15 mev.

Fundamentals of neutrons				e0=2.025e-5 mev	
neutrons	P =1/neutrons		N=- lnP	E=e0*exp(N)	
1.49E+78	6.71E-79		180		
	P electron				
	3.96E-05		10.136	0.511	Electron
Fundamentals of atomic binding energy				e0=10.15	
neutrons	P=1/exp(2/neutrons)		N=-ln(P)	E=e0/exp(N)	
3	0.51		0.67	5.21	Lithium
144	0.99		0.01	10.01	Plutonium

The values based on the fundamentals above (5.21 for Lithium and 10.01 for Plutonium) will be called the "fundamental release" of atomic energy.

Consider now that neutrons are re-converted protons and both release energy as they fuse. The following calculations illustrate that the total fundamental release is the weighted contribution from the protons and neutrons. The weighted average is darkened in the table below. All energy is quoted in mev (million electron volts).

				(p*10.15*EXP(-2/p)+(n*10.15*EXP(-2/n))/(p+n)				
protons	(10.15*EXP(-2/protons))			(weighted average)				
p		neutrons	(10.15*EXP(-2/neutrons))					
1	1.374	n		1.374				
2	3.734	2	3.734	3.734				
3	5.211	4	6.156	5.751	5.751=(3*5.211+4*6.156)/7			
4	6.156	5	6.804	6.516				
5	6.804	6	7.273	7.060				
6	7.273	7	7.627	7.464				
7	7.627	8	7.905	7.775				
8	7.905	9	8.127	8.023				
9	8.127	10	8.310	8.224				
10	8.310	11	8.463	8.390				
110	9.967	272	10.076	10.044				

Lithium7 has 4 neutrons and 3 protons and the calculation above gives a total binding energy of 5.751 mev. This is close to the NIST [8] value of 5.644 mev but the difference is significant and there are two additions needed. The binding energy curve is based on two additional processes: retained energy and isotope number energy.

The re-conversion process

Reference 2 reviewed the neutron to proton decay (conversion) process N → P e- av ke (e- , av and ke refer to the electron, the anti-neutrino and kinetic energy required to balance the process). The electron quad table (reproduced below) indicates that the electron initially has 0.111 mev of kinetic energy (explained in reference 2).

As a proton, the electron quad of the proton mass model contains these energies:

(0+1)			-0.296	-2.72E-05					20.303	expansion ke	
Total proton charge			equal and opposite charge						0.000	expansion pe	
	10.408	0.67	0.075		0.000	0.000	-0.671	0.671	v neutrino		
-10.33	-10.333	0									
Neutron separates here to form proton and electron					129.541	799.251	**938.272013**	**PROTON MASS**			
10.33	10.136	0.51	10.333	0.62	**0.511**	0.111				5.44E-05	-0.622
	0.197	2.47E-05	0.296	2.72E-05	**ELECTRON**			2.47E-05	e neutrino		
					130.052	0.111		0.671	20.303	-957.185	-2.683
	90.000		90.000						Total m+ke	Total fields	
									Total positive	Total negative	
									959.868	-959.868	0.00E+00

But as a neutron, the electron quad of the mass model contains these energies:

10.408	0.67	0.075		0.000	0.000					
-10.333										
10.333	0.6224	0	2.02E-05	0.6224	0.000		2.02E-05		-2.02E-05	
0	2.02E-05	10.333	0.6224							-0.6224
				130.163	799.251	**939.5653531**	2.02E-05	20.303	-957.185	-2.683
90.000	sum	90.000				**NEUTRON MASS**		Total m+ke	Total fields	
								Total positive	Total negative	
								959.868	-959.868	0.000E+00
						130.16				

The decay energy balance can be written N (939.565)→ P (938.272) + e- (0.511 +.111) +av (0.671). (This accounts for the neutron/proton mass difference of 1.293 mev). This process is reversed during fusion. The neutrino energy of 0.671 mev is ejected according to the binding energy model, but regained. At high temperature and pressure there is a chance that the electron/proton can regain the 0.111 ke lost from the decay. The reverse process for the proton to neutron re-conversion is as follows: P (938.272) + e- (0.511) + ke (0.111) → N (938.27) + v (0.622). The re-converted neutron undergoes a properties re-conversion and reverts to a neutron from the standpoint of charge, etc. The kinetic energy it absorbs is the "difference kinetic energy" (0.111=27.2e-6+.622-0.511-2.4e-5). Since it is a subtraction of four values linked with the electron quad, some of the values may contain properties (spin and charge) that balance the re-conversion. The proton actually gains the two neutrinos lost in the decay process from a neutron to a proton (energy 0.6709+0.6224=1.293 mev. The electron is absent after the conversion to a neutron. It is converted to energy 0.622 mev energy 0.511 mev+0.111 mev absorption. Re-conversion and a gain of energy on the order of 0.111 are pre-requisites for fusion. The process involves new-neutrons and protons falling into weak field energy. More than half of the incoming protons become neutrons because neutrons can lose more energy. (See the paragraph below entitled "Prediction of excess neutrons over protons…"). The other portion of the incoming protons is accepted without conversion.

Summarizing, the requirement for fusion is that the environment must provide energy. In this model, if the electrons and protons gain 0.111 mev and are in proper contact they fuse. This amount of energy is large compared to the kinetic energy available from even a very hot environment. For example the sun's core temperature of 1.5e7 degrees K provides 0.002 mev. (A probabilistic process appears to limit the reaction rate. A simplified way to think about this is a Boltzmann type calculation like P=exp(-.05/0.002)=1e-11, where -0.05 mev is a barrier energy and 0.002 mev is kinetic energy from the environment. The low probability that the barrier energy will be achieved helps understand the low reaction rate at this temperature (a description of solar fusion is contained in reference 14). The barrier energy is very simple in this model. It is the retained kinetic energy described below.

Retained kinetic energy

The incoming protons gain energy from their environment (i.e., the core of the sun). When energy conditions allow, protons are accepted into the developing atom and they retain part of the supplied energy. After considering the fundamental release, the binding energy falls with increasing atomic number (and is quite evident for large atomic number) as more energy is retained inside the atom. Retained energy follows the relationship: Eretained (mev) = -0.101/4*protons. This is related to the value 0.111 given in the proton mass model as the kinetic energy of the electron. This energy may be stored in compressed charges (literature refers to a coulomb barrier since protons resist bringing more positive charge into the nucleus).

Addition for isotope number

Without a second addition, the difference between the published and predicted value *cycles* slightly within one atomic number for the several isotopes of that atom. The section below entitled “Prediction of excess neutrons” below is the source of the correction for the isotopes. Neutrons release slightly more energy than protons and the isotopes either have an excess or deficit of neutrons. The following equation gives the addition:

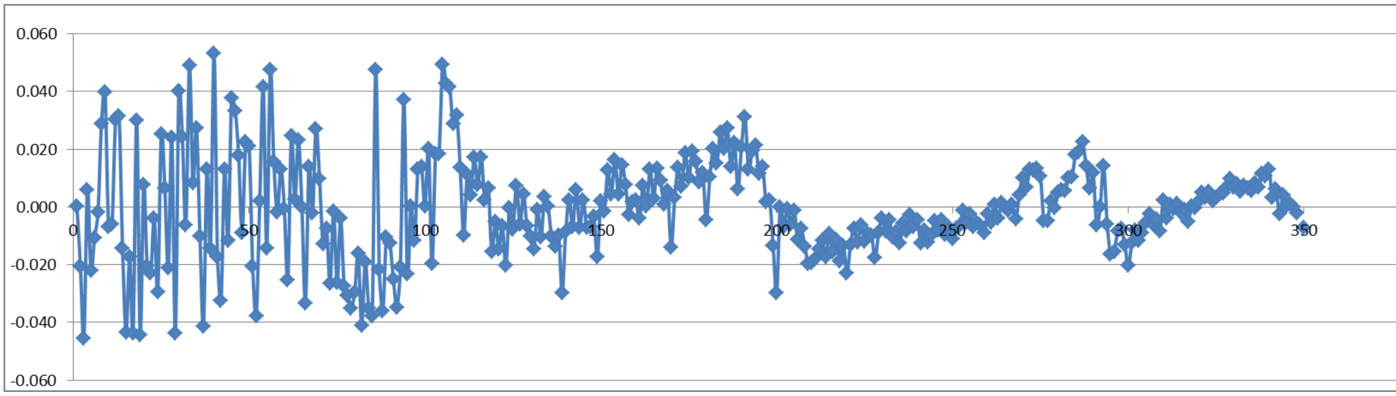
Addition for isotope number= 1.293*(exp(excess neutrons/220)-1) mev. Excess neutrons equal the predicted number of neutrons minus actual number. Predicted neutrons=protons+protons/(exp(1.293/(Eretained)). Of course 1.293 mev is the difference in energy between the neutron and proton.

Binding energy results

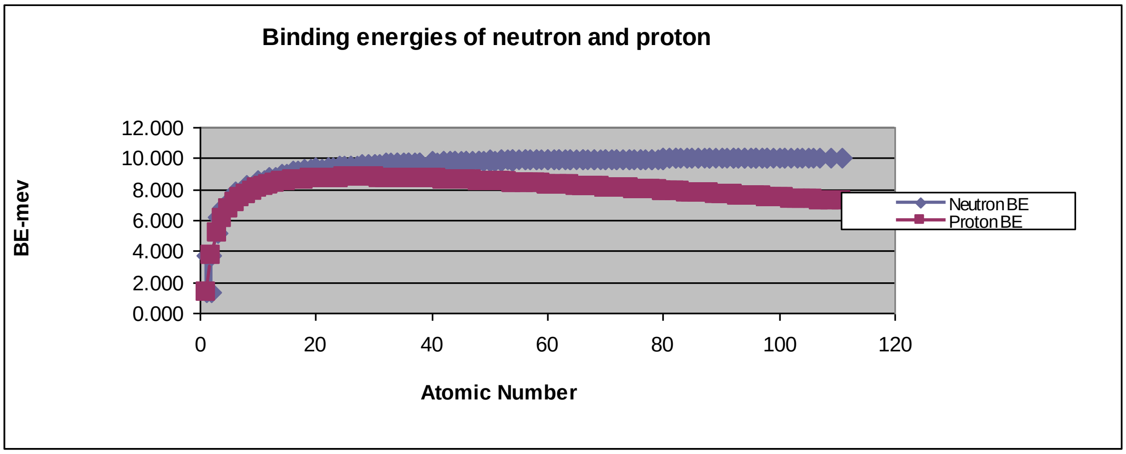
The following data is a combination of NIST [8] data for published binding energy compared against the author’s binding energy model. Two additions (the additions are usually negative numbers) were made to the fundamental release. To summarize, binding energy =weighted fundamental energy release+retained energy+isotope number energy. There was another correction sometimes required that the author believes can be easily identified. Some of the predicted values are multiples of 0.111 mev higher or lower (this is the energy associated with the electron kinetic energy that initiates fusion). This correction only appears in the steeply rising portion of the curve. In addition, there were two atoms that were obviously different. The fundamental release from Helium (2,2) was exactly doubled. Secondly, it appears that Carbon (6,6) retains an extra 0.622 mev (a neutrino like energy) for some reason.

				Simple probability model					0.9
			extra	-0.00055	average	-0.101	electrostatic retention		10.145
			retention	0.01741	stand dev	-0.004	isotope n correction		Weight avg
			neg	Pub BE-prec	Energy	Isotope N	**Binding Energy**		Fundamental
	protons	neutrons	.11 correctio	mev	retention	correction	**Published**	**prediction**	P*10.15
H	1	0		0.000	0	0.0000	0.000	0.000	0.000
D	1	1	-2	-0.037	-0.0253435	0.0000	1.115	1.152	1.373
1.14									
180									
T	1	2	0	0.000	-0.0253435	-0.0060	2.915	2.914	2.946
He3	2	1	-4	-0.020	-0.050687	0.0061	2.490	2.510	2.946
He4	2	2	-3	-0.045	-0.050687	0.0000	7.075	7.120	7.464
Li	3	3	2	0.006	-0.0760305	0.0000	5.334	5.328	5.209
Li7	3	4	0	-0.022	-0.0760305	-0.0060	5.644	5.666	5.748
Be	4	5	1	-0.011	-0.101374	-0.0060	6.492	6.503	6.513
B	5	5	-2	-0.002	-0.1267175	0.0000	6.476	6.478	6.800
0	5	6	0	0.029	-0.1267175	-0.0060	6.952	6.923	7.056
C	6	6	-1	0.040	-0.152061	0.0000	7.681	7.641	7.891
	6	7	2	-0.007	-0.152061	-0.0060	7.491	7.497	7.460
	6	8	1	-0.006	-0.152061	-0.0120	7.558	7.564	7.630
N	7	7	0	0.030	-0.1774045	0.0000	7.477	7.446	7.624
	7	8	1	0.032	-0.1774045	-0.0060	7.717	7.686	7.772
O	8	8	3	-0.014	-0.202748	0.0001	7.977	7.991	7.901
	8	9	0	-0.043	-0.202748	-0.0060	7.767	7.810	8.019
	8	10	-1	-0.017	-0.202748	-0.0120	7.796	7.814	8.126
F	8	11	-1	-0.044	-0.202748	-0.0179	7.861	7.905	8.224
Ne	9	11	0	0.030	-0.2280915	-0.0119	8.098	8.068	8.308
	10	11	-1	-0.044	-0.253435	-0.0057	7.985	8.029	8.386
	10	12	-1	0.008	-0.253435	-0.0117	8.105	8.097	8.460
Na	11	12	-1	-0.020	-0.2787785	-0.0054	8.123	8.144	8.526
Mg	12	12	0	-0.023	-0.304122	0.0010	8.262	8.284	8.588
165	12	13	-1	-0.004	-0.304122	-0.0050	8.235	8.238	8.645
	12	14	0	-0.030	-0.304122	-0.0110	8.354	8.384	8.699
Al	13	14	-1	0.025	-0.3294655	-0.0045	8.342	8.317	8.748
Si	14	14	0	0.007	-0.354809	0.0022	8.448	8.442	8.794
	14	15	0	-0.021	-0.354809	-0.0038	8.458	8.479	8.838
	14	16	0	0.024	-0.354809	-0.0099	8.538	8.514	8.879
P	15	16	0	-0.044	-0.3801525	-0.0030	8.490	8.534	8.917
S	16	16	-1	0.040	-0.405496	0.0040	8.494	8.454	8.953
	16	17	-1	0.024	-0.405496	-0.0021	8.506	8.482	8.987
	16	18	0	-0.006	-0.405496	-0.0081	8.599	8.606	9.019
	16	20	-1	0.049	-0.405496	-0.0200	8.604	8.556	9.079
Cl	17	18	-1	0.008	-0.4308395	-0.0009	8.528	8.520	9.049
	17	20	-1	0.027	-0.4308395	-0.0130	8.592	8.564	9.106
Ar	18	18	-1	-0.010	-0.456183	0.0064	8.521	8.531	9.078
	18	20	0	-0.041	-0.456183	-0.0057	8.628	8.670	9.132
	18	22	-1	0.013	-0.456183	-0.0177	8.622	8.608	9.180
K	19	20	-1	-0.014	-0.4815265	0.0018	8.564	8.579	9.156
	19	21	-2	0.053	-0.4815265	-0.0043	8.552	8.498	9.180
	19	22	-1	-0.017	-0.4815265	-0.0103	8.595	8.613	9.202
Ca	20	20	-1	-0.032	-0.50687	0.0095	8.552	8.584	9.180
	20	22	-1	0.013	-0.50687	-0.0027	8.629	8.616	9.223
	20	23	-1	-0.012	-0.50687	-0.0087	8.619	8.631	9.244
	20	24	-1	0.038	-0.50687	-0.0147	8.682	8.644	9.264
	20	26	-1	0.033	-0.50687	-0.0266	8.703	8.670	9.301
	20	28	-1	0.018	-0.50687	-0.0383	8.710	8.692	9.335
Sc	21	24	-1	-0.009	-0.5322135	-0.0070	8.637	8.645	9.282
Ti	22	24	-1	0.023	-0.557557	0.0010	8.668	8.646	9.300
	22	25	-1	0.021	-0.557557	-0.0051	8.678	8.657	9.317
	22	26	0	-0.021	-0.557557	-0.0111	8.745	8.765	9.334
	22	27	0	-0.038	-0.557557	-0.0170	8.738	8.775	9.350
	22	28	0	0.002	-0.557557	-0.0230	8.787	8.785	9.365
V	23	27	-1	0.041	-0.5829005	-0.0090	8.717	8.676	9.365

The fifth column (in yellow) contains the difference between the latest NIST [8] binding energy data minus the binding energy predictions. The binding energy in column 4 contains an extra retention of 0.111 mev. All the others are normal. The remainder of the atoms were calculated but not presented here for brevity. For all 351 atoms (includes most isotopes), the standard deviation was 0.017 and the average from zero was -0.0006 mev. Since the predicted values are very close to the published binding energy, the points overlie each other and there was no need to present the predicted curve. The more meaningful graph is the following deviation for the 351 atoms. The vertical axis is published binding energy minus predicted binding energy in mev.



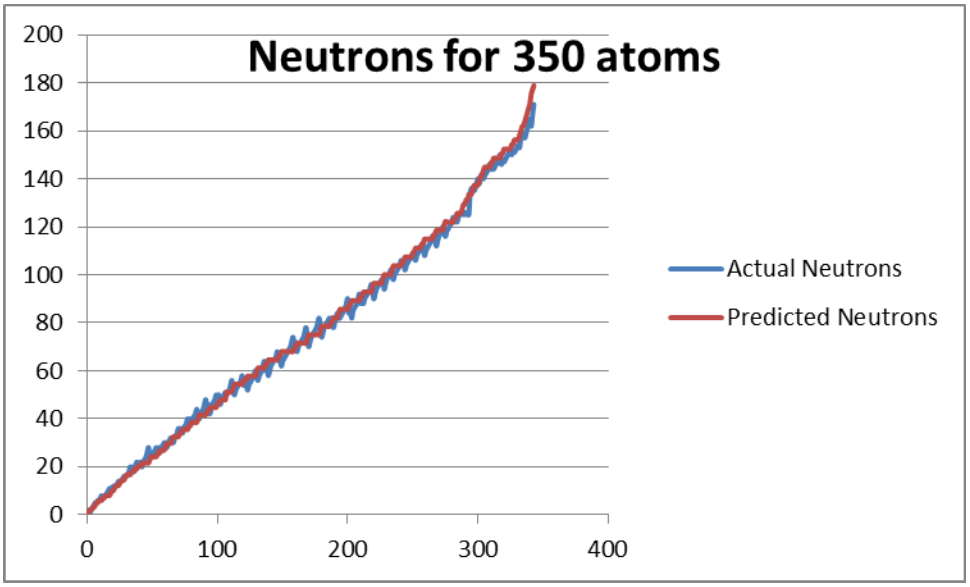
It is instructive to show the binding energy for the proton and neutron separately since it shows that the neutrons give up almost all of their kinetic energy. The proton release is less since energy is retained as described above.



Prediction of excess neutrons over protons with increasing atomic number

Excess neutrons are produced because they can give up more energy. Prediction of excess neutrons is simply a function of the energy that protons retain. Based solely on this parameter, the number of neutrons can be predicted from the number of protons.

Predicted neutrons=protons+protons/(EXP(1.293/(Eretained))



Note the ripple in the actual number of neutrons. This was the basis for the isotope number correction described above under the heading "Addition for isotope number".

Summary

A proposal regarding how nature releases binding energy is offered as verification of the proton kinetic energy value 10.15 mev. This value appears in the proton mass model presented in reference 2. A simple probabilistic model appears to model NIST data to within 0.017 mev standard deviation when two additions are applied. Reference 2 offers an internally consistent approach to the four interactions of nature and this paper extends the basic approach to binding energy.

References:

1. Barbee, E. H., *The case for a low energy gravitational scale*, viXra:1307.0085, July 2013.

2. Barbee, E. H., *A Top-down approach to Fundamental Interactions*, viXra:1307.0082, July 2013.
3. Barbee, E. H., *Application of proton mass model to cosmology*, viXra:1307.0090, July 2013.
4. Barbee, E.H., *Baryon and meson mass estimates based on their natural frequency components*, unpublished, March 2010.
5. Feynman, R.P., Leighton, R.B., Sands, M., *the Feynman Lectures on Physics, Addison-Wesley*, 1965.
6. Bergstrom, L., Goobar, A., *Cosmology and Particle Astrophysics*, Second Edition, Praxis Publishing, Ltd, 2004.
7. D. E. Groom et al. (Particle Data Group). Eur. Phys. Jour. C15, (2000) (URL: http://pdg.lbl.gov)
8. Atomic masses (for binding energy) http://physics.nist.gov/cgi-bin/Compositions/stand_alone.pl?ele=&ascii=html&isotype=some
9. Bennett, C.L. et al. *First Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Preliminary Maps and Basic Data,* Astrophysical Journal, 2001
10. Peebles, P.J.E., *Principles of Physical Cosmology*, Princeton University Press, 1993.
11. I.S. Hughes, *Elementary Particles, 3rd Edition,* Cambridge University Press.1991.
12. Barbee, E.H., *Microsoft Excel spreadsheets entitled atom2013.xls, simple1C.xls and mesonbaryon.xls*, genebarbee@msn.com .
13. Barbee, E. H., MS *excel file entitled "Natures Unifying Concepts.xls*, July 2011.
14. Adelberger et al.: Solar fusion cross sections, Rev. Mod. Phys., Vol. 70, No. 4, October 1998
15. Shannon, Claude, A Mathematical Theory of Communication, 1948.