Atomic Mass Defect Alternative

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Introduction

This book Atomic Mass Defect Alternative provides an alternate explanation for the atomic mass defect. This anomaly in particle physics currently has a different explanation. The simple definition of this defect is the atom's measured mass is not equal to the total of the masses of its subatomic particle components, which are protons and electrons. A neutron in the nucleus is a combination of those 2. The number of electrons in orbit around the nucleus equals the net charge of the nucleus, which is the number of protons having no attached electron. Neutrons. Neutrons have no net charge so their number does not affect the number of orbiting electrons.

Each atom of an element has a specific number of protons and electrons.

The current explanation for this mass defect proposes the change in the atom's measured mass from expected was lost from the atom but somehow converted into something called nuclear binding energy

Using binding in the name of this energy implies it can sustain a force in a nucleus. Unfortunately, no explanation is provided to justify any of the assumptions including a) its calculation (which is only a change in units), b) the application of either a new form of energy or a new force having no defined mechanism.

There is no evidence for protons having a reduced mass after ejection from a nucleus

My alternate explanation proposes a new behavior for a proton based on the observational evidence. A proton is compressed while in a nucleus against other positive protons, causing a slight reduction in its measured mass. There is no mass in the nucleus which is lost. There is no conversion of mass into a new undefined form of energy called nuclear binding energy. The nucleons are held within the nucleus by the electrostatic force between adjacent charged particles.

The basic mistake or misunderstanding is that a new energy from the mass defect is a behavior at the level of the atom. However, the change in measured mass occurs at the level of the nucleons.

This book presents the case a mass defect originates in the individual nucleons.

Nuclear binding energy is simply the excuse when ignoring a proton's mass is affected when compressed against other positive protons in a nucleus.

Mass defect is the measured reduction in a proton's mass while compressed in a nucleus. After ejection from the nucleus, the proton's mass returns to normal.

All 118 elements are included here, and as many of their measured isotopes, to cover many instances of this behavior.

My alternate explanation proposes a new behavior for a proton based on the observational evidence. There is no mass in the nucleus which is lost and converted into converted into a new undefined form of energy called nuclear binding energy. The nucleons are held within the nucleus by the electrostatic force between adjacent charged particles.

Nuclear binding energy is simply the excuse when ignoring a proton's mass is affected when compressed against other positive protons in a nucleus. The binding energy explanation is based on mass defect being a behavior of the atom, probably because it is measured for the atom. However, the mechanism driving the measured difference occurs at the level of the nucleons, not the atom.

All 118 elements are included here, and many of the measured isotopes to cover most instances of this behavior.

2 Fundamental Particles

The current descriptions of the fundamental particles in the Standard Model are provided here to set the context.

A small number of subatomic particles are observed in nature, meaning outside of particle accelerators.

From Wikipedia:

"In particle physics, an elementary particle or fundamental particle is a subatomic particle that is not composed of other particles."

The important two particles are the electron and proton.

The Standard Model claims there are more, including quarks. The others are not involved in the atomic mass defect behavior.

2.1 Definition of several terms in this document

Elementary or fundamental particle, from Wikipedia:

In particle physics, an elementary particle or fundamental particle is a subatomic particle with no substructure, i.e. it is not composed of other particles.

Observation:

The simple rule for an elementary particle is: it contains no other particles.

2.2 Electron

Excerpt from Wikipedia:

The electron is a subatomic particle, symbol
e^- or β^-, whose electric charge is negative one elementary charge. Electrons belong to the first generation of the lepton particle family, and are generally thought to be elementary particles because they have no known components or substructure.

(Excerpt end)

Observation:

The electron is elementary only because particle colliders have been unable to break one. Perhaps someday, someone will accomplish this feat, resulting in an electron getting a new particle classification, depending on the detectable fragments. The fragments could be either a) debris with each having no measurable characteristics. or b) a particular new fragment which could enable a theory for the mechanism driving a negative charge.

Even the use of "generally thought" confirms this rule is based on a judgment.

Particle physics needs a rule which is based on some physical evidence rather than on only the limits of accelerator technology.

2.3 Quark

From Wikipedia:

"A quark is a type of elementary particle and a fundamental constituent of matter. Quarks combine to form composite particles called hadrons, the most stable of which are protons and neutrons, the components of atomic nuclei. Due to a phenomenon known as color confinement, quarks are never found in isolation."

Observation:

Despite this description, a neutron is certainly not one of the most stable. A neutron outside a nucleus disintegrates into its 2 components, 1 proton and 1 electron, in a few minutes. When a nucleus has too many neutrons, sometimes it will eject its electron leaving only the proton.

A quark is not consistent with the electron and proton particles because it is never found in isolation.

A quark is only a fragment remaining after the destruction of a proton. Otherwise, it is "never found.

There is no justification for a quark to be fundamental, when worthless debris, other than justifying the LHC and serving as the foundation of the Standard Model and its many cascading assumptions. Science requires experiments to be repeatable and having independent confirmation. Only someone having their own LHC could attempt checking a conclusion dependent on the LHC.

If this latter statement is too restrictive for some people, I wrote a book titled LIGO Legacy about LIGO making elaborate claims and even earning a Nobel Prize in Physics. Unfortunately for the credibility of physics, LIGO does not provide evidence for their creative claims. The LIGO system reacts to the ripple in the crust during the periodic solar and lunar events. Knowing this, LIGO detections are predictable, as I did in November 2019.

This mistake of the wrong source was never addressed by LIGO, despite LIGO and NSF being informed of the predictions and confirmations of the terrestrial source. I will doubt extravagant claims without convincing evidence.

Quarks contribute nothing to our understanding of an atom.

2.4 Proton

Excerpt from Wikipedia:

A proton is a subatomic particle, symbol p or p^+, with a positive electric charge of +1e elementary charge and a mass slightly less than that of a neutron."

Although protons were originally considered fundamental or elementary particles, in the modern Standard Model of particle physics, protons are classified as hadrons, like neutrons, the other nucleon.

Protons are composite particles composed of three valence quarks: two up quarks of charge +2/3e and one down quark of charge −1/3e. The rest masses of quarks contribute only about 1% of a proton's mass. The remainder of a proton's mass is due to quantum chromodynamics binding energy, which includes the kinetic energy of the quarks and the energy of the gluon fields that bind the quarks together. Because protons are not fundamental particles, they possess a measurable size; the root mean square charge radius of a proton is about 0.84 to 0.87 fm (or 0.84×10^{-15} to 0.87×10^{-15} m).

In 2019, two different studies, using different techniques, have found the radius of the proton to be 0.833 fm, with an uncertainty of ±0.010 fm.

(Excerpt end)

Observation:

The quarks do not sum up to the mass of a proton. They have only 1%. If quarks are the components of a proton, then the claims of sub-particles (or substructure immediately fail.

A proton should be a fundamental particle. A proton exhibits no substructure. Only in a particle collider is such debris observed

A proton can be broken into 3 fragments, but they cannot be combined again to get a functional proton. Indeterminant fragments from a high velocity collision are certainly not components or substructure.

A proton exhibits mass and charge so if the set of fragments is claimed to be its components or substructure then there must be evidence these fragments either share or contribute to the known behaviors of the original particle. For a proton, there is no such evidence for the fragments being legitimate components. The 1 % is not evidence, but instead shows this theory is wrong. They are no different than fine dust particles remaining after an explosion. The original object's structure is not found in the dust.

The 3 fragments have no evidence that any of them was a component of an important behavior, like mass or charge.

Because quarks provide nothing to improve our understanding of a proton, quarks should be ignored when explaining behaviors of an atom and its 3 components, electron, proton, and neutron.

2.5 Neutron

From Wikipedia:

"The neutron is a subatomic particle, symbol
n or n^0, which has a neutral (not positive or negative) charge and a mass slightly greater than that of a proton."

Observation:

The following statement is not in Wikipedia because it is this book's conclusion.

A neutron is a proton having an adjacent electron.

Therefore, a neutron is correctly not a fundamental particle because it is a combination of

2.5.1 Neutron's mass

One might expect the mass of a neutron is measured directly. That is not the case. Its value uses the assumption of nuclear binding energy. This book proposes an alternate explanation of atomic mass defect, which is sometimes used to define nuclear binding energy.

Excerpt from Wikipedia:

The mass of a neutron cannot be directly determined by mass spectrometry due to lack of electric charge. However, since the masses of a proton and of a deuteron can be measured with a mass spectrometer, the mass of a neutron can be deduced by subtracting proton mass from deuteron mass, with the difference being the mass of the neutron plus the binding energy of deuterium (expressed as a positive emitted energy). The latter can be directly measured by measuring the single 0.7822 MeV gamma photon emitted when neutrons are captured by protons (this is exothermic and happens with zero-energy neutrons), plus the small recoil kinetic energy) of the deuteron (about 0.06% of the total energy).

The energy of the gamma ray can be measured to high precision by X-ray diffraction techniques, as was first done by Bell and Elliot in 1948. The best modern (1986) values for neutron mass by this technique are provided by Greene, et al. These give a neutron mass of:

[mass] neutron = 1.008644904 u

The value for the neutron mass in MeV is less accurately known, due to less accuracy in the known conversion of u to MeV:

[mass] neutron = 939.56563 MeV/c^2.

Another method to determine the mass of a neutron starts from the beta decay of the neutron, when the momenta of the resulting proton and electron are measured.

(Excerpt end)

Observation:

There are many assumptions to get the precise result, including a recognized issue with the “less accuracy” of the conversion from a gamma ray wave length to its equivalent mass.

The mass defect behavior appears driven by compression during fusion. The current accepted measured mass of a neutron was calculated by using the atom with a proton and neutron in its nucleus, so the conditions inherently involved a mass defect, which is a behavior lacking a good explanation in the standard model.

This technique is suspicious.

This brings into doubt whether the measured mass, defined with much precision, is actually verified to that accuracy.

Calculations using many significant digits must beware factors lacking the precision of other values when claiming the final precision.

The neutron behaves like 2 distinct particles but when in a nucleus, it can exhibit a reduced reactivity to other masses. This is the conclusion after the comparison between the 2 atoms having 3 nucleons but different sets.

The 2 distinct charge behaviors appear intact but the reactivity to other masses is changed slightly only while bonded.

When the split occurs, each charge components gets its original mass reactivity component.

The split is accompanied by a neutrino having little or no mass reactivity and no charge reactivity.

When an electron and proton unite to form a neutron, the mass reactivity, from the accepted value) is less than the sum.

This confirms the mass behavior is not just an addition. The mass reactivity of a neutron is not driven by the sum at its creation. In other words, a neutron can exhibit a difference in its expected mass while in a nucleus. This is called a mass defect. Mass defect is explained in the Periodic Table section in this book.

2.6 Neutrino

From Wikipedia:

A neutrino (denoted by the Greek letter ν) is a fermion (an elementary particle with spin of ½) that interacts only via the weak subatomic force and gravity. The neutrino is so named because it is electrically neutral and because its rest mass is so small (-ino) that it was long thought to be zero. The mass of the neutrino is much smaller than that of the other known elementary particles.

neutrinos in one of three leptonic flavors: electron neutrinos (ν_e), muon neutrinos (ν μ), or tau neutrinos (ν τ), in association with the corresponding charged lepton

Although neutrinos were long believed to be massless, it is now known that there are three discrete neutrino masses with different tiny values, but they do not correspond uniquely to the three flavors.

(Excerpt end)

Observation:

A neutrino is not relevant to atomic mass defect.
The mass remains “tiny” for each neutrino.

However, this lack of definition and no precise mass value for particle detection means verification is awkward for its “elementary” status.

2.7 Muon

From Wikipedia:

The muon from the Greek letter mu (μ) used to represent it) is an elementary particle similar to the electron, with an electric charge of −1 e and a spin of ½, but with a much greater mass. It is classified as a lepton. As with other leptons, the muon is not known to have any sub-structure – that is, it is not thought to be composed of any simpler particles.

Muons have a mass about 207 times that of the electron.

The dominant muon decay mode (sometimes called the Michel decay after Louis Michel) is the simplest possible: the muon decays to an electron, an electron antineutrino, and a muon neutrino.

(Excerpt end)

The muon is not consistent with other elementary particles:

a) It decays very quickly
b) Because the muon decays, then those fragments should be considered the muon’s components.
c) Despite its known decay, the muon remains an elementary particle in the Standard Model. It is even explicitly “similar to the electron” which never decays.
d) Its mass is 207x an electron but it decays into only 1 electron plus 1 muon neutrino plus 1 electron antineutrino.

All types of neutrinos currently have a mass of “small but non-zero.”

Therefore, the decay of a muon results in the loss of mass equivalent to more than 206 electrons. This result should be a crisis for particle physics, but the loss of mass is just ignored. The muon is not an important particle in the Standard Model regarding an atom.

The muon is lacking a credible definition and has a very brief life. Its status as an elementary particle cannot be justified.

The muon has no role in any atomic behaviors.

|However, the set of characteristics for the muon breaks the quark model of a proton.

Colliding many protons results in a particle, the muon, having a mass between proton and electron. The quark model having 3 specific quarks for 1 positive proton cannot explain this intermediate mass value and the negative charge. The 3 quarks in a proton cannot be components of another particle having a smaller mass and opposite charge. Quarks are debris. I know of no experiment to break any of the 3 quarks into smaller debris. The lack of that test is not confirmation that quarks cannot be broken into tinier pieces, or more debris. No data is never evidence.

Like quarks, muons should be relegated to whatever method is used to describe anomalies, like debris from particle accelerators, which include muons and quarks.

3 Atomic Nucleus

The size of some atomic nuclei has been measured.

Excerpt from Wikipedia:

The diameter of the nucleus is in the range of 1.7566 fm (1.7566×10^{-15} m) for hydrogen (the diameter of a single proton) to about 11.7142 fm for uranium. These dimensions are much smaller than the diameter of the atom itself (nucleus + electron cloud), by a factor of about 26,634 (uranium atomic radius is about 156 pm (156×10^{-12} m)) to about 60,250 (hydrogen atomic radius is about 52.92 pm).

(Excerpt end)

Observation:

Uranium has from 235 to 238 nucleons.

The diameter change from 1 to 235 nucleons is from 1.7566 fm to 11.7142, or roughly a range of the size multiplier at about 7.

A study concluded it is difficult to measure the diameter of a nucleus and its distribution of the neutral neutrons. A link is in References.

Its title: Charge, neutron, and weak size of the atomic nucleus

The study included a measurement of the charge radius of the Calcium-40 and -48 nuclei.

Excerpt: "Our results for the charge radii are 3.49(3) fm for ^{40}Ca and 3.48(3) fm for ^{48}Ca"

Excerpt from Wikipedia: for Charge Radius:

The rms charge radius is a measure of the size of an atomic nucleus, particularly the proton distribution. It can be measured by the scattering of electrons by the nucleus. Relative changes in the mean squared nuclear charge distribution can be precisely measured with atomic spectroscopy.

The problem of defining a radius for the atomic nucleus is similar to that of defining a radius for the entire atom; neither atoms nor their nuclei have definite boundaries. However, the nucleus can be modeled as a sphere of positive charge for the interpretation of electron scattering experiments: because there is no definite boundary to the nucleus, the electrons "see" a range of cross-sections, for which a mean can be taken. The qualification of "rms" (for "root mean square") arises because it is the nuclear cross-section, proportional to the square of the radius, which is determining for electron scattering.

(Excerpt end)

Observation:

Apparently, adding 8 neutrons caused a tiny reduction of 0.01 fm in the charge radius, so the volume is not directly related to its particle count. This implies compression of the spheres can reduce their size. This measurement was the basis for considering compression causing a size reduction which also results in a measured mass reduction - also known as a mass defect.

The basic mistake or misunderstanding is that a new energy from the mass defect is a behavior at the level of the atom. However, the change in measured mass occurs at the level of the nucleons.

In the cited study, comparing nucleons 1 to 48 resulted in charge radius 4x, which is a not a similar ratio.

Protons and neutrons are considered of comparable size.

If the number of spheres in a volume is increasing faster than the volume, then there must be some compression of the spheres for that result.

Using the proton radius above, its volume is 8.78E-16 m^3

Using the Uranium diameter above, its radius is 5.87E-15 m for a volume of 8.48E-43 m^3

That volume can hold 298.7 protons except that quantity allows no space. Protons are spheres, not a liquid. A liquid can fill available space with uniform density when gravity levels it at the top surface.

Sphere packing is an awkward topic here when having no information about the arrangement of nucleons for each element which have different counts.

A random packing of equal spheres generally has a density around 64%.

That density value probably means the Uranium measured nucleus can hold 64% of the maximum number of protons, which results in a capacity of 191.

The reference does not identify which uranium isotope was measured. Their counts of nucleons are similar.

All would have the same result: the nucleons are being fused and compressed, resulting in a smaller volume than possible by random packing.

The calcium-40 and 48 nuclei can be checked here also.

The calcium-40 nucleus's nucleon capacity is 40.2 when packing at 64%.

Calcium-48 size was measured smaller than Ca-40 and its capacity is 39.8.

One could expect the process of getting a nucleon added to a nucleus requires substantial force for the new object to adhere to the rest and that action could cause deformations to the joiner and perhaps to others already bound together.

Conditions in a stable nucleus are not clear.

The very few measured nuclei seem to have their nucleons densely packed suggesting no space between adjacent particles.

There is an unanswered question: when 2 protons are physically adjacent (or in physical contact), is there an active repulsive Coulomb's force between them?

The combination of a stable of 3He and an unstable di-proton indicates a neutron is critical to nucleus stability. One must note adding more neutrons to a stable nucleus can often make it unstable.

This is the case with 2H + n^0 becoming 3H which has a half-life of 12.32 y.

The strong force is the name assigned to the force maintaining the nucleons together, but it has a poorly defined origin or mechanism.

Excerpt from Wikipedia:

In nuclear physics and particle physics, the strong interaction is the mechanism responsible for the strong nuclear force, and is one of the four known fundamental interactions, with the others being electromagnetism, the weak interaction, and gravitation. At the range of 10^{-15} m (1 femtometer), the strong force is approximately 137 times as strong as electromagnetism, a million times as strong as the weak interaction, and 10^{38} times as strong as gravitation.

In the context of atomic nuclei, the same strong interaction force (that binds quarks within a nucleon) also binds protons and neutrons together to form a nucleus. In this capacity, it is called the nuclear force (or residual strong force). So the residuum from the strong interaction within protons and neutrons also binds nuclei together.

As such, the residual strong interaction obeys a distance-dependent behavior between nucleons that is quite different from that when it is acting to bind quarks within nucleons.

Additionally, distinctions exist in the binding energies of the nuclear force of nuclear fusion vs nuclear fission.

(Excerpt end)

Observation:

Atomic nuclei “binding energies” will be described in the section titled Mass Defect.

Mass defect is a phenomenon which arises in the atomic nucleus.

Other than hydrogen, every atom has at least 1 neutron.

A neutron is assumed to be a proton having an adjacent electron.

The description of the strong force (above) is like the nuclear force description.

Excerpt from Wikipedia:

The nuclear force (or nucleon–nucleon interaction or residual strong force) is a force that acts between the protons and neutrons of atoms.

Neutrons and protons, both nucleons, are affected by the nuclear force almost identically. Since protons have charge +1 e, they experience an electric force that tends to push them apart, but at short range the attractive nuclear force is strong enough to overcome the electromagnetic force. The nuclear force binds nucleons into atomic nuclei.

The nuclear force is powerfully attractive between nucleons at distances of about 1 femtometre (fm, or 1.0×10^{-15} metres), but it rapidly decreases to insignificance at distances beyond about 2.5 fm. At distances less than 0.7 fm, the nuclear force becomes repulsive.

This repulsive component is responsible for the physical size of nuclei, since the nucleons can come no closer than the force allows.

By comparison, the size of an atom, measured in angstroms (Å, or 1.0×10^{-10} m), is five orders of magnitude larger. The nuclear force is not simple, however, since it depends on the nucleon spins, has a tensor component, and may depend on the relative momentum of the nucleons.

(Excerpt end)

Observation:

The undefined mechanism of the strong force could be explained like this:

The force of compression required to fuse together nucleons must overcome the force of repulsion between protons. Nucleons are observed to drop each volume so this result requires the particles are adjacent. The compression force is from one side and the force of reaction is from the other side. From compression, the sphere could reduce its volume.

When the surfaces of the 2 positively charged particles touch, the direction of the mutual Coulomb’s force changes from repulsion to attraction.

This force is strong enough to enable stability but not permanence. If the physical connection is disturbed, the mutual attraction can return to repulsion.

Radioactive decay steps include neutron or alpha particle ejection from a nucleus.

With this explanation, both the strong and weak forces go away. Both are instances of electrostatic force between charged particles in the nucleus in mutual contact.

The weak force is exerted the moment the mutual Coulomb's force between protons in contact changes direction to repulsion.

The strong and weak forces apparently need an updated description.

4 Mass Defect

The phenomenon called mass defect requires a new explanation in particle physics.

This book proposes the change in measured mass is not converted into energy, but instead this difference in mass is a temporary change in a proton while compressed into a nucleus.

On the atomic scale, a difference in mass can be observed between expected and measured in an atomic nucleus. The difference could be more or less than expected. The difference is called a mass defect. When it is less then expected, it can be called a mass deficit. The measured mass value of a particular isotope is never more than expected.

In this book, data for the mass of isotopes of the elements are from Wikipedia. Links are in References.

The nucleus consists of protons and neutrons, but each neutron is a combination of proton and electron.

The mass defect is an apparent change in the protons and neutrons in the nucleus during the process of fusion requiring compression.

Here are 2 sources to compare their descriptions of the behavior.

Mass defect has this description, from Britannica:

The observed atomic mass is slightly less than the sum of the masses of the protons, neutrons, and electrons that make up the atom. The difference, called the mass defect, is accounted for during the combination of these particles by conversion into binding energy, according to an equation in which the energy (E) released equals the product of the mass (m) consumed and the square of the velocity of light in vacuum ©; thus, $E = mc^2$.

(Excerpt end)

Observation:

A difference is not always explained by this mass/energy relationship. This book offers another explanation.

Wikipedia uses another name and has no topic for an atom's Mass Defect.

In Wikipedia, the topic "mass defect" refers to an anomaly in a spiral galaxy brightness profile near its core.

Wikipedia calls the atomic mass defect behavior something else.

Excerpt 1 from Wikipedia:

Nuclear binding energy is the minimum energy that would be required to disassemble the nucleus of an atom into its component parts. These component parts are neutrons and protons, which are collectively called nucleons. The binding energy is always a positive number, as we need to spend energy in moving these nucleons, attracted to each other by the strong nuclear force, away from each other. The mass of an atomic nucleus is less than the sum of the individual masses of the free constituent protons and neutrons, according to Einstein's equation $E=mc^2$. This 'missing mass' is known as the mass defect, and represents the energy that was released when the nucleus was formed.

Excerpt 2 from Wikipedia (found below the above excerpt:

Mass defect (also called "mass deficit") is the difference between the mass of an object and the sum of the masses of its constituent particles. Discovered by Albert Einstein in 1905, it can be explained using his formula $E = mc^2$, which describes the equivalence of energy and mass. The decrease in mass is equal to the energy given off in the reaction of an atom's creation divided by c^2. By this formula, adding energy also increases mass (both weight and inertia), whereas removing energy decreases mass. For example, a helium atom containing four nucleons has a mass about 0.8% less than the total mass of four hydrogen nuclei (which contain one nucleon each). The helium nucleus has four nucleons bound together, and the binding energy which holds them together is, in effect, the missing 0.8% of mass.

(Excerpts 1&2 end)

Observations:

The nuclear binding energy description in Wikipedia has all values in MeV.

Mass defect is a difference between measured and expected mass values. The periodic table of the elements has the atom's measured mass value in atomic mass units, or amu.

The calculation of the expected mass value uses the mass values of the proton and electron in amu, not MeV. This document and its supporting spreadsheets will consistently use amu for all mass values.

Converting all mass values from amu to MeV does not contribute to an explanation of the mass defect behavior. The obvious result after the conversion is all values are much higher.

1 amu = 931.4932 MeV.

Maxwell defined a mechanism using fields for the electric and magnetic forces.

There is no defined mechanism for how this binding energy holds nucleons together.

The electric force can hold together opposing charges, as defined by Coulomb's law.

The electric force is affected by the vacuum permittivity or epsilon-naught, which is the capability of an electric field to permeate a vacuum.

A body having an electric charge will have that charge on its outer surface.

When 2 protons are compressed together in a nucleus, there will be no space between their surfaces. An electric field requires a distance between charges so in this case, the distance is zero.

The electric force diminishes by inverse-square of distance.

I can find no on-line reference describing the electric force between adjacent charges, where the mutual distance is zero.

Every atom has at least 1 neutron in its nucleus except hydrogen which is only 1 proton.

Therefore, the nucleus will have electrons in contact with protons in the nucleus so those opposing charges attract maintaining their mutual force of attraction.

The electrostatic force between the non-moving charges in the nucleus holds them together.

If the equilibrium of protons in contact is lost ana separation occurs, the electrostatic force of repulsion returns causing an ejection. This election is currently claimed to result from an undefined weak force lacking a defined mechanism. This election is really the result of the electrostatic force which is always active in the nucleus,

There is no need for this undefined entity called nuclear binding energy.

The section Mass Defect explains the mass defect arises during the compression of a proton into a nucleus. The proton's mass is reduced because its volume was reduced by the compression of its volume. No mass was converted to energy requiring it to be lost from the proton. Any protons, or neutrons ejected from a nucleus do not have a reduced mass. The reduction comes from compression, not lost when converted to energy. When the compression is removed the proton's measured mass will be normal.

The entire periodic table is reviewed in the Periodic Table section to find whether any isotopes have "extra mass." not a mass defect.

If this book's conclusions are accepted, the descriptions for mass defect must be updated, including the removal of mentions of Einstein and the related mass/energy calculations. Mass defect is a change in measured mass, not a change in energy after converting mass values into values having units of energy.

The name of mass converted to energy could be called "do not understand compression of protons in a nucleus.

This naming is somewhat like dark matter which could be called "do not understand plasma physics and the role of magnetic fields."

This chart has the mass defect for the elements from 1 to 118. The mass defect increases as the nucleus size increases. though this plot uses the atomic number.

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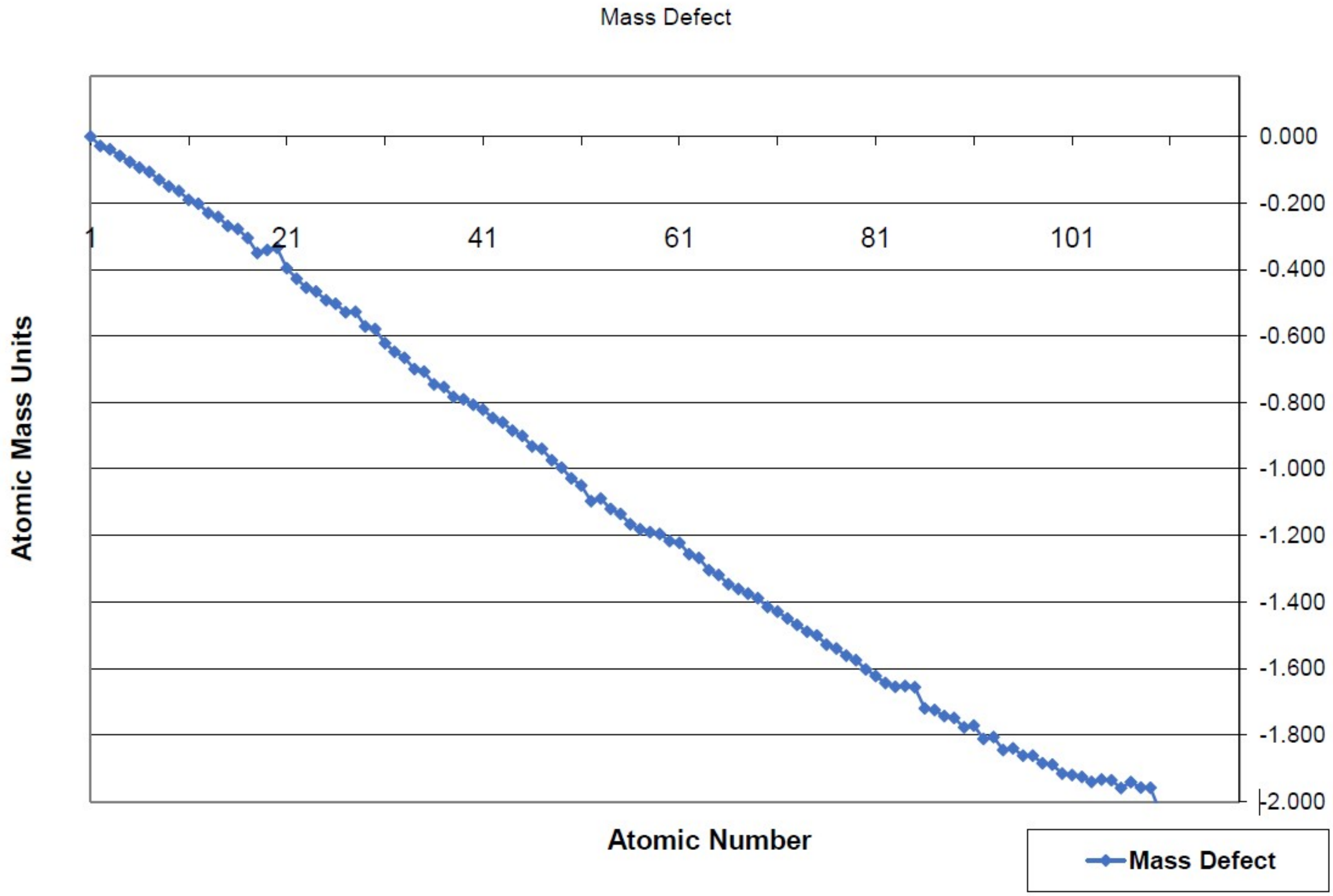


The mass defect value seems related to the atomic number. It is actually related to the number of nucleons. More neutrons are added as the atomic number increases.

A chart from many isotopes. Presented in a later section, shows the mass defect for the individual nucleons will vary in a relatively narrow range. As the number of nucleons increases, the sum of their individual changes will increase in a like manner.

5 Data Files

5.1 Elements Data File

All the elements in the periodic table are analyzed for their mass defect.

This reference file is Z-Elements-AMD in .xls format, for Microsoft Excel, and is compressed in a .zip format for convenient distribution.

Z-Elements-AMD.zip

Note: The main worksheet has over 1600 rows, with more than 1 row per element. Compressing that content into a smaller page is quite impractical.

The columns include the atomic mass details to calculate the average neutron mass for each isotope, including when the difference between consecutive isotopes is1 neutron.

A work sheet with consistent formulae enables efficiency in this analysis. These data sets are used to justify the author's conclusions.

5.2 Isotope Data File

All the long-life isotopes in the periodic table are analyzed for a mass defect

Here, a long-life isotope is one which is either stable or its half-life is long enough for its measured mass value to have enough digits after the decimal for valid calculations among each set.

The author compiled data from all elements and their long-life isotopes to compare each for their measured value against the sum of their components.

A reference file in the .zip format is available with this spreadsheet of element isotope data

ZIsotopes.zip

Note: The main worksheet, created with MS Excel, named Elements, has over 900 rows. A second worksheet, titled MD, has about 120 rows for the Mass defect value per element. This worksheet has the basis for the mass defect chart.

Compressing that content into many pages is quite impractical.

The phenomenon called mass defect requires a new explanation in particle physics.

The process toward that goal begins with the analysis of this behavior among all the elements.

A work sheet with formulae expedites this analysis.
Each element has a mix of entries and calculations.
There are only 2 manual entries:

a) its defined number of protons,
b) the isotope's nominal atomic weight or sum of its nucleons,

This is entered twice; once as an integer; again, as part of the element's isotope name.

There is 1 copy and paste entry:

Its measured atomic weight is saved as text, so there can be no changes, like from rounding. Consistency of digits after the decimal point enables the best comparison of values.

The masses of the electron and proton have 10 digits after the decimal point.

Microsoft Excel handles up to this precision. That is sufficient for this book.

From these few entries, the sum of an atom's particles can be calculated. This is called the predicted mass.

These entries enable calculating a) the number of neutrons in the atom and b) the average mass of all the neutrons in the nucleus.

Unfortunately, few elements have their measured mass value stated with 10 digits after the decimal.

Therefore, those calculations inherently lack consistent accuracy with the particles.

Consistent formulae in the spreadsheet perform identical steps of analysis for every isotope.

The measured mass value subtracts the predicted mass to obtain the mass defect for this element. It is the nature of an atomic nucleus to have a deficit due to the nucleon compression during fusion. When the measured is greater than predicted, there is an entry error.

EMI = Expected Mass of Isotope, or its Nominal Mass.
NP = number Protons, or the atomic number.
NN = number Neutrons, from NM - NP
MCN = Mass change per Neutron, from a calculation

The nominal mass of a neutron = $m_p + m_e$

EMI = (NP * mp) + (NN * ($m_p + m_e$))

The simpler calculation of the isotope's expected mass:

EMI = NM * (mp + me)

The calculation of MCN:

MCN = (MM – EMI) / NN

In simple terms, each atom has a difference in mass between measured and expected, or predicted by the sum of its particles.

If the neutrons in the nucleus changed their apparent mass by MCN, then that explains that mass defect.

Every atom, except for the hydrogen isotope ^{1}H and the helium isotope ^{3}He, has more neutrons than protons in its nucleus.

The mass defect is more likely to be attributed to the neutrons, not the protons. The simplest way for an atom to become another isotope is by fusing another neutron into the nucleus. This book treats mass defect as a neutron behavior though it is actually a nucleus behavior. When using isotopes which are changes in the number of neutrons, there is little visibility to proton changes.

5.1 Calculating Neutron Mass
With a measured mass of a particular isotope, it is possible to calculate the mass of the neutrons by subtracting the mass of the protons and the orbiting electrons.

NM = Nominal Mass of the Isotope, or sum of its nucleons.
MM = Measured Mass of Isotope.
NP = number Protons, or the atomic number.
NN = number Neutrons, from NM – NP

The measured nominal mass of an atom is assumed to be this sum:

$MM = (NP * (m_p + m_e)) + (NN * n^0)$

Where m_e is the orbiting electron and n^0 is the neutron in the nucleus.

The average neutron mass can be calculated from:

$n^0 = (MM - (NP * (m_p+m_e)) / NN$

Average Neutron Mass will be used frequently so it will be ANM in the Section 15 Periodic Table.

The accepted mass of a neutron is never used for calculating the mass of an atom from its components because the accuracy of the neutron's measured mass is uncertain. The next section provides measurements of a neutron for ever element.

A neutron has no electrical charge and decays in a few minutes when outside a nucleus.

Therefore, its mass is currently calculated by analysis of deuterium whose nucleus is only 1 proton and 1 neutron.

Unfortunately, as noted elsewhere in this book, the process of creating a nucleus requires much force of compression so the result is a mass defect.

The author's analysis presented in section 12's data file calculates the neutron's mass for each consecutive isotope, where the difference is only 1 neutron between the 2 isotopes.

Because of the inevitable mass defect caused by variations in a fusion sequence, the calculated neutron mass from each isotope varies across the many isotopes, though the neutrons for one element's isotopes are similar within the set.

6 Mass of Proton

All the Mass defect value of the hydrogen atom directly implies the accepted mass value of a proton is too high. The following describes the history of that value and the recommended new mass value for a proton.

6.1 Definition of the atomic mass unit

The current atomic mass unit definition has a recommended change in this book.

This change can affect the claim of a mass defect, where the sum of the particles in an element does not add up to the element's measured atomic mass.

Some definitions from Wikipedia:

The dalton or unified atomic mass unit (symbols: Da or u) is a unit of mass widely used in physics and chemistry. It is defined as 1/12 of the mass of an unbound neutral atom of carbon-12 in its nuclear and electronic ground state and at rest. The atomic mass constant, denoted mu, is defined identically, giving $m_u = m(^{12}C)/12 = 1$ Da.

By definition, the mass of an atom of carbon-12 is 12 daltons, which corresponds with the number of nucleons that it has (6 protons and 6 neutrons). However, the mass of an atomic-scale object is affected by the binding energy of the nucleons in its atomic nuclei, as well as the mass and binding energy of its electrons.

Therefore, this equality holds only for the carbon-12 atom in the stated conditions, and will vary for other substances. For example, the mass of one unbound atom of the common hydrogen isotope (hydrogen-1, protium) is 1.007825032241 Da, the mass of one free neutron is 1.00866491595 Da, and the mass of one hydrogen-2 (deuterium) atom is 2.014101778114 Da.

In general, the difference (mass defect) is less than 0.1%; exceptions include hydrogen-1 (about 0.8%), helium-3 (0.5%), lithium (0.25%) and beryllium (0.15%).

1 u or 1 Da = $1.66053906660 \times 10^{-27}$ kg

1 1 u = 1822.888486209 m_e

1 u = 1822.888486 m_e

m_p = proton mass = 1.007276466621 u

e = electric charge = 1.602176634 $\times^{-19}$ C
proton charge = +1e

m_e = mass electron = $5.48579909070 \times 10^{-4}$ u
electron charge = -1e

(Excerpt end)

Observation:

Data came from several Wikipedia topics.

Excerpt from Wikipedia:

In physics, the proton-to-electron mass ratio, μ or β, is simply the rest mass of the proton (a baryon found in atoms) divided by that of the electron (a lepton found in atoms). Because this is a ratio of like-dimensioned physical quantities, it is a dimensionless quantity, a function of the dimensionless physical constants, and has numerical value independent of the system of units, namely:

$\mu = m_p/m_e = 1836.15267343$.

(Excerpt end)

Observation:

$1/\mu = 5.4462 \times 10^{-4}$

m_e uses this value and the proton mass.

At this point, the integrity of these assigned values could be checked.

However, the definition of 1 dalton does not provide the ^{12}C mass which was used for the calculation.

The particles in the ^{12}C atom, of 6 protons, 6 electrons, and 6 neutrons, which are each a proton and electron pair, can be summed with the result of 12.0873176 u

This is from:

12 times 1.007276466621 u for 6 protons and 6 neutrons

+

12 times $5.48579909070 \times 10^{-4}$ u for sum of 6 neutrons plus 6 pairs of a proton and orbiting electron.

Its current measured value in the Carbon isotopes topic is “exactly 12”

If the 12. value was actually used for calculating 1 Dalton then that use was a mistake. This isotope’s mass value has a mass defect.

The mass of protium, or ^{1}H, is provided and will be used for a better basis for calculating particle masses.

^{1}H = 1.007825032241

This atom is simply 2 particles:

$^{1}H = m_p + m_e$.

Using the two individual values the sum is 1.007825046530

My Excel value is slightly higher than from Wikipedia.

The current masses of an electron and proton do not add up to the mass in a protium atom.

There can be **no** other reason for this difference than the mass values, 1 or more of the 3 numbers involved, are wrong.

The protium (^1H) mass calculation can be from a different calculation using only one particle mass, not two:

$^1H = \mu\, m_e + m_e$ or $^1H = (\mu + 1)\, m_e$

This equation requires a high level of certainty of the precision of both the μ value and the ^1H value.

.

This result is 1.007825046538

This is not the measured value so either ^1H is wrong or m_e is wrong.

The m_e can be calculated with:

$m_e = {}^1H / (\mu + 1)$

with ^1H = 1.007825032240 (Excel fails with last digit as 1

This is spec: $m_e = 5.48579909070 \times 10^{-4}$ u

The new result is $m_e = 5.485799012873 \times 10^{-4}$

Calculation using 10 digits, m_e = 0.0005485799

Though the last digit is dropped for Excel, the result was slightly higher, but this is a debatable number of significant digits for a valid comparison.

This is not the current m_e so either ^1H is wrong or μ is wrong – or the current m_e is wrong. This topic proposes m_e must change.

The m_p can be calculated using m_e and the ^1H spec value:

$m_p = {}^1H - m_e$

With the calculated m_e value, m_p = 1.007276452331
Or 1.0072764523 with only 10 decimal digits

Compare with result from ^{12}C: 1.007276466621

This is the result with the new m_p and m_e ^1H=
1.007825032232
Compare with this spec value: ^1H = 1.007825032241

The 2 new values sum to a slightly lower ^1H by only at the limit of the software precision.

Both the old pair and the new pair add up to slightly less than the current atomic mass value, but beyond the significant digits.

My Excel 2003 handles up to 10 digits after the decimal point. The numbers add up with that precision.

I cannot define a new mass for an electron with a suitable number of significant digits, if more than 10 are required.

One could expect the community of people working with particle physics have a vested interest in agreeing on the correct values.

The atomic mass values for the elements are rarely, if ever specified with more than 10 digits after the decimal.

All analysis of mass defect in this book uses the recommended proton mass value, not the public value which results in the mistake of a mass defect for protium which is a mistake. This book's goal is to be practical.

The current mass values are apparently wrong by a tiny amount. I expect there must be an agreement among many contributors for any change in mass of the 2 fundamental particles.

This simple exercise using only ^{1}H and μ indicates physicists must confirm both values to the required precision, before assigning a mass value to the electron and proton if this alternate ^{1}H baseline is used instead of ^{12}C.

The precision of the two crucial input values affects the precision of the resulting particle mass values.

It is simply impossible for there to be "nuclear binding energy" in a nucleus consisting of only a proton.

Using the protium atom should be a better choice for defining the atomic mass unit because:

a) it consists of only the 2 fundamental particles,
b) it does not have18 particles (6 x proton, 6 x electron, 6 x neutron) like ^{12}C,
c) it has no possible mass defect,
d) it is not clear how or whether mass defect is accommodated in the current ^{12}C algorithm,
e) it makes sense to use the unbreakable electron as the benchmark for defining atomic mass units,
f) it is consistent with the updated atomic model treating the electron and proton as fundamental particles,
g) the issue with this selection is it requires an accurate proton-to-electron mass ratio,
h) the precision of m_e depends on the precision of only ^1H and μ

The recommendation is a change to ^1H for calculating masses should be considered "again."

The amu has a history worth noting about its element selection, described in this story:

Atomic Mass Unit Definition (AMU)

Excerpt:

John Dalton first suggested a means of expressing relative atomic mass in 1803. He proposed the use of hydrogen-1 (protium). Wilhelm Ostwald suggested that relative atomic mass would be better if expressed in terms of $1/16^{th}$ the mass of oxygen. When the existence of isotopes was discovered in 1912 and isotopic oxygen in 1929, the definition based on oxygen became confusing.

Some scientists used an AMU based on the natural abundance of oxygen, while others used an AMU based on the oxygen-16 isotope. So, in 1961 the decision was made to use carbon-12 as the basis for the unit (to avoid any confusion with an oxygen-defined unit). The new unit was given the symbol u to replace amu, plus some scientists called the new unit a Dalton. However, u and Da were not universally adopted. Many scientists kept using the amu, just recognizing it was now based on carbon rather than oxygen.

At present, values expressed in u, AMU, amu, and Da all describe the exact same measure.

(Excerpt end)

Stating just “Wilhelm Ostwald suggested” does not provide his reason for it being “better.” The subsequent discovery of isotopes indicated the selection probably was not better.

After trying protium first, then oxygen, then carbon, one can conclude protium should have remained the standard. It could be awkward to change the benchmark element for a third time, by a return to the initial choice.

A hydrogen-2 (deuterium) atom can be checked with the new particle masses because ^2H mass is provided. Its nucleus is a proton and neutron.

Measured: $^2H = 2.014101778114$

$^2H = m_p + m_e + \ \ (m_p + m_e)$

Or it is twice ^1H

To expect: t 2.0156500644

This is more than the specified mass.

When using the old calculated values:

Measured $^2H = 2.015650093$

The differences are tiny, but notable. There is the expected, non-quantified, binding energy between the 2 nucleons.

With new particle masses, the difference is -0.000000029

Therefore, there is a known mass defect with the deuterium atom using the current particle masses. This is with either pair of values of electron and proton mass, based on either ^{1}H or ^{12}C.

This is the expected result because the measured is less than the sum, resulting in a mass deficit, which is called nuclear binding energy. The proton is binding with the neutron.

This comparison has 2 alternate explanations:

1) a neutron exhibited a loss in mass.
2) a neutron exhibited a loss in its reactivity to other masses.

This book suggests the second. No mass is becoming energy.

The difference between sets for ^{1}H ^{12}C can be compared for their summation for ^{12}C.

^{12}C is measured at 12.0

Using the respective values for m_p and m_e, the results are:

From spec values ^{12}C = 12.09390056

From ^{1}H values ^{12}C = 12.0939004

There is a very small difference in the calculated values, beyond the number of significant digits (4 after decimal point) in the ^{12}C value.

However, the values which were supposed to result in exactly 12.0096 but their sum clearly failed to do so.

Both sets exhibit a mass defect because they do not match the measured atomic mass value,

The proton and electron mass values, derived from ^{12}C failed to result in exactly 12.0096. Because that was the goal of that algorithm, the algorithm failed. It did not account for nuclear binding energy.

That observation leads to a recommendation to use protium, which is the only atom having no possible binding energy.

Conclusion of atomic mass analysis:

This exercise suggests the current proton mass value is a tiny bit high.

The value derived from protium might be closer to the "correct" value if this is the only way to calculate the mass of a proton and electron.

Instead of recommending a change, the current value for the mass of an electron can remain unchanged, for now.

The big change in particle physics is explaining the observed mass defect.

Mass defect is currently explained as an awkward mass to energy conversion possibly suggested by Einstein.

By the slight reduction in the proton mass, the mass defect in the protium atom is removed, as it should be, because the simplest nucleus has nothing to bind.

As a result, all elements will have a small reduction in their calculated mass defect.

7 Periodic Table

All the long-life isotopes in the periodic table are analyzed for a mass defect

Here, a long-life isotope is one which is either stable or its half-life is long enough for its measured mass value to have enough digits after the decimal for valid calculations among each set.

The author compiled data from all elements and their long-life isotopes to compare each for their measured value against the sum of their components.

Note: The main worksheet, using MS Excel, has over 850 rows. Compressing that content into a smaller page is quite impractical.

Since everyone does not have spreadsheet software, small portions of the spreadsheet, from each element, will be included in the book. For a complete picture of the mass defect behaviors across the periodic table, the spreadsheet should be consulted. The file information is in section 14 Isotope Data File.

Section 7 follows the numbering pattern of 7.X where X is the element's atomic number.

Each element will have these data when available:

ANM or Average Neutron Mass. The summed mass of the protons and electrons is subtracted from the isotope's measured mass and then divided by the number of neutrons to obtain this average mass per neutron. A nucleon (proton or neutron) cannot be measured individually.

A nominal neutron is 1 proton + 1 electron or 1.0078250322

Isotope	Change w/+Neutron	Unexpected Change
1H	0.0000000000	0.0000000000
2H	1.0062767459	-0.0015482864
3H	1.0019475039	-0.0058775284

These are the 3 columns:

1) Isotope has the atomic weight and the element
   The isotope in bold is the element's nominal atomic weight.
2) Change w/+Neutron has the change in mass after adding 1 neutron. This value is from subtracting one isotope from the other. This change value is blank or zero for the first.
3) Unexpected Change has the difference between that change and a nominal neutron whose mass was shown above and is greater than 1.0
   Among the many isotopes, the Unexpected Change value will vary from more or less than 1.0

7.1 Element 1 is Hydrogen or H
Hydrogen is the combination of 1 proton and 1 electron.
These are the hydrogen isotopes.

Isotope	Change w/+Neutron	Unexpected Change
H	0.0000000000	0.0000000000
2H	1.0062767459	-0.0015482864
3H	1.0019475039	-0.0058775284

The first neutron fused to the proton lost mass due to its compression. The second lost more than the first.

7.2.4 Element 2 is Helium or He

Helium has and 2 protons and 2 neutrons.

ANM = 0.9934765948

Isotope	Change w/+Neutron	Unexpected Change
3He		
4He	0.9865739315	-0.0212511008

Adding 1 neutron increased the atom's mass by less than 1.0

The average mass of the 2 neutrons (ANM) is less than 1.0

7.3 Element 3 is Lithium or Li

Lithium has and 3 protons and 4 neutrons.

ANM = 0.9981320851

6Li		0.0000000000
7Li	1.0008805496	-0.0069444826

7.4 Element 4 is Beryllium or Be

Beryllium has 4 protons and 5 neutrons.

ANM = 0.9961765882

9Be		0.0000000000
10Be	1.0013516300	-0.0064734022

7.5 Element 5 is Boron or B

Boron has 5 protons and 6 neutrons.

ANM = 0.9950300010

10B		0.0000000000

11B	0.9963683050	-0.0114567272

7.6 Element 6 is Carbon or C
Carbon has 6 protons and 6 neutrons.
Carbon-12 does not have a true measured mass. It has a value of "exactly 12" because it was used as the benchmark atom. Section 7 addressed this mistake.

ANM = 0.9921749678

12C		0.0000000000
13C		
14C	0.9998871528	-0.0079378795
15C	1.0073573120	-0.0004677202

7.7 Element 7 is Nitrogen or N
Nitrogen has 7 protons and 7 neutrons.

ANM = 0.9926141113

13N		0.0000000000
14N	0.9973353945	-0.0104896378
15N	0.9970348944	-0.0107901378
16N	1.0059930011	-0.0018320311

7.8 Element 8 is Oxygen or O

Oxygen has 8 protons and 8 neutrons.

ANM = 0.9915392952

14O		0.0000000000
15O	0.9944688940	-0.0133561382
16O	0.9918490196	-0.0159760126
17O	1.0042171370	-0.0036078952
18O	1.0000278562	-0.0077971760

7.9 Element 9 is Fluorine or F
Fluorine has 9 protons and 10 neutrons.

ANM = 0.9927977873

17F		0.0000000000
18F	0.9988420600	-0.0089829722
19F	0.9974658629	-0.0103591693
20F	1.0015780871	-0.0062469451
21F	0.9999676500	-0.0078573822

22F	1.0030501000	-0.0047749322
23F	1.0005310000	-0.0072940322

7.10 Element 10 is Neon.

Neon has 10 protons and 10 neutrons.

ANM = 0.9914189854

18Ne		0.0000000000
19Ne	0.9961722000	-0.0116528322
20Ne	0.9905592762	-0.0172657560
21Ne	1.0014065138	-0.0064185184
22Ne	0.9975384200	-0.0102866122
23Ne	1.0030817900	-0.0047432422
24Ne	0.9991437000	-0.0086813322

7.11 Element 11 is Sodium, or Na

Sodium has 11 protons and 12 neutrons.

ANM = 0.9923373821

22Na		0.0000000000
23Na	0.9945532400	-0.0132717922
24Na	0.9909177570	-0.0169072752
25Na	1.0007952630	-0.0070297692
26Na	0.9967560100	-0.0110690222
27Na	1.0017476600	-0.0060773722
28Na	0.9995359700	-0.0082890622
29Na	1.0047404000	-0.0030846322

7.12 Element 12 is Magnesium or Mg

Magnesium has 12 protons and 12 neutrons.

ANM = 0.9909284425

22Mg		0.0000000000
23Mg	0.9945532400	-0.0132717922
24Mg	0.9909177570	-0.0169072752
25Mg	1.0007952630	-0.0070297692
26Mg	0.9967560100	-0.0110690222
27Mg	1.0017476600	-0.0060773722
28Mg	0.9995359700	-0.0082890622
29Mg	1.0047404000	-0.0030846322

7.13 Element 13 is Aluminum or Al

Aluminum has 13 protons and 14 neutrons.

ANM = 0.9914152136

24Al		0.0000000000
25Al	0.9904807700	-0.0173442622
26Al	0.9964635500	-0.0113614822
27Al	0.9946465500	-0.0131784822
28Al	1.0003716800	-0.0074533522
29Al	0.9985431100	-0.0092819222
30Al	1.0025148000	-0.0053102322

7.14 Element 14 is Silicon or Si

Silicon has 14 protons and 14 neutrons.

ANM = 0.9905268631

26Si		0.0000000000
27Si	0.9943708900	-0.0134541422
28Si	0.9902218450	-0.0176031872
29Si	0.9995681303	-0.0082569019
30Si	0.9972754717	-0.0105495605
31Si	1.0015930530	-0.0062319792
32Si	0.9987883100	-0.0090367222
33Si	1.0038255000	-0.0039995322
34Si	1.0005980000	-0.0072270322

7.15 Element 15 is Phosphorus or P

Phosphorus has 15 protons and 16 neutrons.

ANM = 0.9910241572

29P		0.0000000000
30P	0.9965130900	-0.0113119422
31P	0.9954485086	-0.0123765236
32P	1.0001456414	-0.0076793908
33P	0.9978180600	-0.0100069722
34P	1.0019202000	-0.0059048322
35P	0.9996682000	-0.0081568322

7.16 Element 16 is Sulfur or S

Sulfur has 16 protons and 16 neutrons.

ANM = 0.9904294162

30S		0.0000000000
31S	0.9946502400	-0.0131747922
32S	0.9925141644	-0.0153108678
33S	0.9993877355	-0.0084372967
34S	0.9964081001	-0.0114169321
35S	1.0011653100	-0.0066597222
36S	0.9980483800	-0.0097766522
37S	1.0040448100	-0.0037802222

7.17 Element 17 is Chlorine or Cl

Chlorine has 17 protons and 18 neutrons.

ANM = 0.9908792857

33Cl		0.0000000000
34Cl	0.9963104900	-0.0115145422
35Cl	0.9950902000	-0.0127348322
36Cl	0.9994541300	-0.0083709022
37Cl	0.9975957600	-0.0102292722
38Cl	1.0021078400	-0.0057171922
39Cl	0.9999977800	-0.0078272522
40Cl	1.0024118000	-0.0054132322

7.18 Element 18 is Argon or Ar

Argon has 18 protons and 22 neutrons.

ANM = 0.9918878429

36Ar		0.0000000000
37Ar	0.9992312050	-0.0085938272
38Ar	0.9959557900	-0.0118692422
39Ar	1.0015809000	-0.0062441322
40Ar	0.9980701238	-0.0097549084
41Ar	1.0021174762	-0.0057075560
42Ar	0.9985454000	-0.0092796322
43Ar	1.0025900000	-0.0052350322
44Ar	0.9992878000	-0.0085372322
45Ar	1.0031159000	-0.0047091322
46Ar	0.9999977000	-0.0078273322

7.19 Element 19 is Potassium or K

Potassium has 19 protons and 20 neutrons.

ANM = 0.9912058361

38K	0.9957052300	-0.0121198022
39K	0.9946253670	-0.0131996652
40K	1.0002916830	-0.0075333492
41K	0.9978270880	-0.0099979442
42K	1.0005770520	-0.0072479802
43K	0.9983323900	-0.0094926422
44K	1.0008523000	-0.0069727322
45K	0.9991045000	-0.0087205322
46K	1.0012901000	-0.0065349322
47K	0.9996800000	-0.0081450322
48K	1.0036796000	-0.0041454322
49K	1.0028696000	-0.0049554322

7.20 Element 20 is Calcium or Ca

Calcium has 20 protons and 20 neutrons.

ANM = 0.9903045111

40Ca		0.0000000000
41Ca	0.9996870540	-0.0081379782
42Ca	0.9963399100	-0.0114851222
43Ca	1.0001486000	-0.0076764322
44Ca	0.9967150700	-0.0111099622
45Ca	1.0007048000	-0.0071202322
46Ca	0.9975017000	-0.0103233322
47Ca	1.0008534000	-0.0069716322
48Ca	0.9979815000	-0.0098435322
49Ca	1.0030999800	-0.0047250522

7.21 Element 21 is Scandium or Sc

Scandium has 21 protons and 24 neutrons.

ANM = 0.9913160926

45Sc		0.0000000000
46Sc	0.9992600000	-0.0085650322
47Sc	0.9972356000	-0.0105894322
48Sc	0.9998235000	-0.0080015322
49Sc	0.9977930000	-0.0100320322
50Sc	1.0021640000	-0.0056610322

7.22 Element 22 is Titanium or Ti

Titanium has 22 protons and 26 neutrons.

ANM = 0.9913767535

46Ti		0.0000000000
47Ti	0.9991315000	-0.0086935322
48Ti	0.9961832000	-0.0116418322
49Ti	0.9999237000	-0.0079013322
50Ti	0.9969212000	-0.0109038322
51Ti	1.0018238000	-0.0060012322
52Ti	1.0002820000	-0.0075430322

7.23 Element 23 is Vanadium or V

Vanadium has 23 protons and 28 neutrons.

ANM = 0.991570848

47V		0.0000000000
48V	0.9973448000	-0.0104802322
49V	0.9962624000	-0.0115626322
50V	0.9986424000	-0.0091826322
51V	**0.9968010000**	-0.0110240322
52V	1.0008160000	-0.0070090322

7.24 Element 24 is Chromium or Cr

Chromium has 24 protons and 28 neutrons.

ANM = 0.9913160926

49Cr		0.0000000000
50Cr	0.9947085000	-0.0131165322
51Cr	0.9987232000	-0.0091018322
52Cr	0.9957401000	-0.0120849322
53Cr	1.0001419000	-0.0076831322
54Cr	0.9982310000	-0.0095940322
55Cr	1.0019593000	-0.0058657322
56Cr	0.9998134000	-0.0080116322

7.25 Element 25 is Manganese or Mn

Manganese has 25 protons and 30 neutrons.

ANM = 0.9914139765

51Mn		0.0000000000
52Mn	0.9973547000	-0.0104703322
53Mn	0.9957246000	-0.0121004322
54Mn	0.9990688000	-0.0087562322
55Mn	0.9976862000	-0.0101388322
56Mn	1.0008598000	-0.0069652322
57Mn	0.9993805000	-0.0084445322

7.26 Element 26 is Iron or Fe

Iron has 26 protons and 30 neutrons.

ANM = 0.9910495154

53Fe		0.0000000000
54Fe	0.9943011000	-0.0135239322
55Fe	0.9986844000	-0.0091406322
56Fe	0.9966429000	-0.0111821322
57Fe	1.0004565000	-0.0073685322
58Fe	0.9978816000	-0.0099434322
59Fe	1.0016011000	-0.0062239322

7.27 Element 27 is Cobalt or Co

Cobalt has 27 protons and 32 neutrons.

ANM = 0.9913099728

54Co		0.0000000000
55Co	0.9935394000	-0.0142856322
56Co	0.9978403000	-0.0099847322
57Co	0.9964521000	-0.0113729322
58Co	0.9994614000	-0.0083636322
59Co	0.9974422000	-0.0103828322
60Co	1.0006221000	-0.0072029322
61Co	0.9986587000	-0.0091663322

7.28 Element 28 is Nickel or Ni

Nickel has 28 protons and 31 neutrons.

ANM = 0.9908143806

57Ni		0.0000000000
58Ni	0.9955494000	-0.0122756322
59Ni	0.9990038000	-0.0088212322
60Ni	0.9964397000	-0.0113853322
61Ni	1.0002696000	-0.0075554322
62Ni	0.9972891000	-0.0105359322
63Ni	1.0013243000	-0.0065007322
64Ni	0.9982966000	-0.0095284322
65Ni	1.0021183000	-0.0057067322
66Ni	0.9990550000	-0.0087700322

7.29 Element 29 is Copper or Cu

Copper has 29 protons and 35 neutrons.

ANM = 0.9915096647

60Cu		0.0000000000
61Cu	0.9960928000	-0.0117322322
62Cu	0.9991262000	-0.0086988322
63Cu	0.9970135000	-0.0108115322
64Cu	1.0001667000	-0.0076583322
65Cu	0.9980253000	-0.0097997322
66Cu	1.0010793000	-0.0067457322
67Cu	0.9988615000	-0.0089635322
68Cu	1.0018806000	-0.0059444322
69Cu	0.9998184000	-0.0080066322
70Cu	1.0029630000	-0.0048620322

7.30 Element 30 is Zinc or Zn

Zinc has 30 protons and 35 neutrons.

ANM = 0.9912711438

63Zn		0.0000000000
64Zn	0.9959306000	-0.0118944322
65Zn	1.0000988000	-0.0077262322
66Zn	0.9967924000	-0.0110326322
67Zn	1.0010939000	-0.0067311322
68Zn	0.9977169000	-0.0101081322
69Zn	1.0017061000	-0.0061189322
70Zn	0.9987690000	-0.0090560322

7.31 Element 31 is Gallium or Ga

Gallium has 31 protons and 39 neutrons.

ANM = 0.9916578316

65Ga		0.0000000000
66Ga	0.9988542000	-0.0089708322
67Ga	0.9966127000	-0.0112123322
68Ga	0.9997784000	-0.0080466322
69Ga	0.9975935000	-0.0102315322
70Ga	1.0004484000	-0.0073766322
71Ga	0.9986793000	-0.0091457322
72Ga	1.0016650000	-0.0061600322
73Ga	0.9988084000	-0.0090166322
74Ga	1.0017713000	-0.0060537322
75Ga	0.9995542000	-0.0082708322
76Ga	1.0023274000	-0.0054976322
77Ga	1.0003267000	-0.0074983322
78Ga	1.0024539000	-0.0053711322

7.32 Element 32 is Germanium or Ge

Germanium has 32 protons and 41 neutrons.

ANM = .9920258017

69Ge		0.0000000000
70Ge	0.9962829000	-0.0115421322
71Ge	1.0007036000	-0.0071214322
72Ge	0.9971248000	-0.0107002322
73Ge	1.0013831000	-0.0064419322
74Ge	0.9977189000	-0.0101061322
75Ge	1.0016811000	-0.0061439322
76Ge	0.9985437000	-0.0092813322
77Ge	1.0021460000	-0.0056790322

7.33 Element 33 is Arsenic or As

Arsenic has 33 protons and 42 neutrons.

ANM = 0.9913160926

74As		0.0000000000
75As	0.9976678000	-0.0101572322
76As	1.0007975000	-0.0070275322
77As	0.9982533000	-0.0095717322

7.34 Element 34 is Selenium or Se

Selenium has 34 protons and 45 neutrons.

ANM = 0.9913160926

74Se		0.0000000000
75Se	1.0000470000	-0.0077780322
76Se	0.9966902000	-0.0111348322
77Se	1.0007004000	-0.0071246322
78Se	0.9973951000	-0.0104299322
79Se	1.0011900000	-0.0066350322
80Se	0.9980222000	-0.0098028322
81Se	1.0014712000	-0.0063538322

7.35 Element 35 is Bromine or Br

Bromine has 35 protons and 45 neutrons.

ANM = 0.9921034038

77Br		0.0000000000
78Br	0.9997670000	-0.0080580322
79Br	0.9971911000	-0.0106339322
80Br	1.0001922000	-0.0076328322
81Br	0.9977613000	-0.0100637322
82Br	1.0005135000	-0.0073115322
83Br	0.9983759000	-0.0094491322
84Br	1.0012990000	-0.0065260322
85Br	0.9991290000	-0.0086960322
86Br	1.0031900000	-0.0046350322
87Br	1.0019130000	-0.0059120322

7.36 Element 36 is Krypton or Kr

Krypton has 36 protons and 48 neutrons.

ANM = 0.9922876217

77Kr		0.0000000000
78Kr	0.9956948	-0.0121302322
79Kr	0.9997172	-0.0081078322
80Kr	0.996297	-0.0115280322
81Kr	1.000213	-0.0076120322
82Kr	0.9968916	-0.0109334322
83Kr	1.0006524	-0.0071726322
84Kr	0.997371	-0.0104540322
85Kr	1.0010203	-0.0068047322
86Kr	0.99808343	-0.0097416022
87Kr	1.00274413	-0.0050809022

7.37 Element 37 is Rubidium ot Rb

Rubidium has 37 protons and 48 neutrons.

ANM = 0.9921304905

85Rb		0
86Rb	0.999377682	-0.0084473502
87Rb	0.998013107	-0.0098119252

7.38 Element 38 is Strontium or Sr

Strontium has 38 protons and 50 neutrons.

ANM = 0.9921652206

84Sr		0.0000000000
85Sr	0.999508	-0.0083170322
86Sr	0.996327731	-0.0114973013
87Sr	0.999616766	-0.0082082661
88Sr	0.99673476	-0.0110902721
89Sr	1.001838443	-0.0059865893

7.39 Element 39 is Yttrium or Y

Strontium has 39 protons and 50 neutrons.

ANM = 0.9920134409

85Y		0.0000000000
86Y	0.998453	-0.0093720322

87Y	0.9959897	-0.0118353322
88Y	0.9986254	-0.0091996322
89Y	0.9963472	-0.0114778322
90Y	1.0013036	-0.0065214322
91Y	1.0001531	-0.0076719322
92Y	1.001644	-0.0061810322
93Y	1.000634	-0.0071910322
94Y	1.002012	-0.0058130322
95Y	1.001226	-0.0065990322
96Y	1.00307	-0.0047550322
97Y	1.002243	-0.0055820322

7.40 Element 40 is Zirconium or Zr

Zirconium has 40 protons and 51 neutrons.

ANM = 0.9920126375

85Zr		0.0000000000
86Zr	0.995	-0.0128250322
87Zr	0.998346	-0.0094790322
88Zr	0.995411	-0.0124140322
89Zr	0.998663	-0.0091620322
90Zr	0.9958144	-0.0120106322
91Zr	1.0009414	-0.0068836322
92Zr	0.999395	-0.0084300322
93Zr	1.0014352	-0.0063898322
94Zr	0.9998392	-0.0079858322
95Zr	1.0017274	-0.0060976322
96Zr	1.0002308	-0.0075942322
97Zr	1.0026797	-0.0051453322

7.41 Element 41 is Niobium or Nb

Niobium has 41 protons and 52 neutrons.

ANM = 0.9920298419

87Nb		0.0000000000
88Nb	0.99797	-0.0098550322
89Nb	0.995088	-0.0127370322
90Nb	0.997847	-0.0099780322
91Nb	0.995731	-0.0120940322
92Nb	1.000198	-0.0076270322
93Nb	0.9991841	-0.0086409322
94Nb	1.0009058	-0.0069192322
95Nb	0.9995519	-0.0082731322

96Nb	1.0012652	-0.0065598322
97Nb	0.9999976	-0.0078274322

7.42 Element 42 is Molybdenum or Mo

Molybdenum has 42 protons and 54 neutrons.

ANM = 0.9921486694

92Mo		0
93Mo	1.000002	-0.0078230322
94Mo	0.9982753	-0.0095497322
95Mo	1.0007538	-0.0070712322
96Mo	0.9988374	-0.0089876322
97Mo	1.001342	-0.0064830322
98Mo	0.99938332	-0.0084417122
99Mo	1.00230708	-0.0055179522
100Mo	0.9997651	-0.0080599322

7.43 Element 43 is Technetium or Tc

Technetium has 43 protons and 55 neutrons.

ANM = 0.9921952657

97Tc		0.0000000000
98Tc	1.000851	-0.0069740322
99Tc	0.9990387	-0.0087863322
100Tc	1.0014031	-0.0064219322

7.44 Element 44 is Ruthenium or Ru

Ruthenium has 44 protons and 57 neutrons.

ANM = 0.9923031698

95Ru		0.0000000000
96Ru	0.997185	-0.0106400322
97Ru	0.999957	-0.0078680322
98Ru	0.997732	-0.0100930322
99Ru	1.0006523	-0.0071727322
100Ru	0.9982802	-0.0095448322
101Ru	1.0013626	-0.0064624322
102Ru	0.9987672	-0.0090578322
103Ru	1.0019745	-0.0058505322
104Ru	0.9991092	-0.0087158322
105Ru	1.00232	-0.0055050322

106Ru	0.999576	-0.0082490322
107Ru	1.002581	-0.0052440322
108Ru	1.00026	-0.0075650322
109Ru	1.00303	-0.0047950322
110Ru	1.00094	-0.0068850322
111Ru	1.00356	-0.0042650322
112Ru	1.00127	-0.0065550322

7.45 Element 45 is Rhodium or Rh

Rhodium has 45 protons and 58 neutrons.

ANM = 0.9922996129

102Rh		0.0000000000
103Rh	0.998661	-0.0091640322
104Rh	1.001152	-0.0066730322
105Rh	0.999038	-0.0087870322

7.46 Element 46 is Palladium or Pd

Palladium has 46 protons and 61 neutrons.

ANM = 0.9925439593

101Pd		0.0000000000
102Pd	0.99732	-0.0105050322
103Pd	1.000478	-0.0073470322
104Pd	0.997949	-0.0098760322
105Pd	1.001049	-0.0067760322
106Pd	0.998401	-0.0094240322
107Pd	1.001647	-0.0061780322
108Pd	0.998759	-0.0090660322
109Pd	1.002058	-0.0057670322
110Pd	0.999203	-0.0086220322
111Pd	1.002518	-0.0053070322
112Pd	0.999643	-0.0081820322
113Pd	1.002836	-0.0049890322
114Pd	1.000213	-0.0076120322
115Pd	1.003317	-0.0045080322
116Pd	1.00048	-0.0073450322
117Pd	1.00368	-0.0041450322
118Pd	1.00114	-0.0066850322

7.47 Element 47 is Silver or Ag

Silver has 47 protons and 61 neutrons.

ANM = 0.9924291719

104Ag		0.0000000000
105Ag	0.9979	-0.0099250322
106Ag	1.00014	-0.0076850322
107Ag	0.998428	-0.0093970322
108Ag	1.000859	-0.0069660322
109Ag	0.998796	-0.0090290322
110Ag	1.001355	-0.0064700322
111Ag	0.999184	-0.0086410322
112Ag	1.001714	-0.0061110322
113Ag	0.999562	-0.0082630322
114Ag	1.002237	-0.0055880322
115Ag	0.999956	-0.0078690322
116Ag	1.0026	-0.0052250322
117Ag	1.00032	-0.0075050322
118Ag	1.0029	-0.0049250322
119Ag	1.00109	-0.0067350322

7.48 Element 48 is Cadmium or Cd

Cadmium has 48 protons and 64 neutrons.

ANM = 0.9926118164

103Cd		0.0000000000
104Cd	0.99643	-0.0113950322
105Cd	0.999619	-0.0082060322
106Cd	0.996991	-0.0108340322
107Cd	1.000159	-0.0076660322
108Cd	0.997566	-0.0102590322
109Cd	1.000798	-0.0070270322
110Cd	0.9980201	-0.0098049322
111Cd	1.001176	-0.0066490322
112Cd	0.9985797	-0.0092453322
113Cd	1.0016439	-0.0061811322
114Cd	0.9989568	-0.0088682322
115Cd	1.0020725	-0.0057525322
116Cd	0.999325	-0.0085000322

7.49 Element 49 is Indium or In

Indium has 49 protons and 66 neutrons.

ANM = 0.9927341124

103In		0.0000000000
104In	0.998386	-0.0094390322
105In	0.996374	-0.0114510322
106In	0.998791	-0.0090340322
107In	0.99683	-0.0109950322
108In	0.999403	-0.0084220322
109In	0.997453	-0.0103720322
110In	1.000014	-0.0078110322
111In	0.997938	-0.0098870322
112In	1.000429	-0.0073960322
113In	0.998526	-0.0092990322
114In	1.000856	-0.0069690322
115In	0.998964	-0.0088610322
116In	1.001382	-0.0064430322
117In	0.999254	-0.0085710322
118In	1.00184	-0.0059850322
119In	0.999491	-0.0083340322

7.50 Element 50 is Tin or Sn

Tin has 50 protons and 69 neutrons.

ANM = 0.9929283534

112Sn		0
113Sn	1.000353	-0.0074720322
114Sn	0.997608	-0.0102170322
115Sn	1.000563	-0.0072620322
116Sn	0.998399	-0.0094260322
117Sn	1.001211	-0.0066140322
118Sn	0.998651	-0.0091740322
119Sn	1.001705	-0.0061200322
120Sn	0.9988867	-0.0089383322
121Sn	1.0020408	-0.0057842322
122Sn	0.9992035	-0.0086215322
123Sn	1.0022818	-0.0055432322
124Sn	0.9995531	-0.0082719322
125Sn	1.0025102	-0.0053148322
126Sn	0.9998689	-0.0079561322
127Sn	1.002707	-0.0051180322
128Sn	1.000177	-0.0076480322
129Sn	1.002943	-0.0048820322
130Sn	1.000487	-0.0073380322
131Sn	1.003033	-0.0047920322
132Sn	1.000816	-0.0070090322

7.51 Element 51 is Antimony or Sb

Antimony has 51 protons and 71 neutrons.

ANM = 0.9928405124

115Sb		0.0000000000
116Sb	1.000196	-0.0076290322
117Sb	0.998042	-0.0097830322
118Sb	1.000693	-0.0071320322
119Sb	0.998413	-0.0094120322
120Sb	1.00113	-0.0066950322
121Sb	0.9987437	-0.0090813322
122Sb	1.001358	-0.0064670322
123Sb	0.9990403	-0.0087847322
124Sb	1.0017217	-0.0061033322
125Sb	0.9993181	-0.0085069322

7.52 Element 52 is Tellurium or Te

Tellurium has 52 protons and 76 neutrons.

ANM = 0.9933889661

120Te		0.0000000000
121Te	1.000916	-0.0069090322
122Te	0.9981079	-0.0097171322
123Te	1.0012261	-0.0065989322
124Te	0.9985479	-0.0092771322
125Te	1.0016128	-0.0062122322
126Te	0.998881	-0.0089440322
127Te	1.0019146	-0.0059104322
128Te	0.9992368	-0.0085882322
129Te	1.0021351	-0.0056899322
130Te	0.9996262	-0.0081988322
131Te	1.0022995	-0.0055255322

7.53 Element 53 is Iodine or I

Iodine has 53 protons and 74 neutrons.

ANM = 0.9913160926

125I		0.0000000000

126I	1.0009938	-0.0068312322
127I	0.998849	-0.0089760322
128I	1.001336	-0.0064890322
129I	0.999179	-0.0086460322
130I	1.001686	-0.0061390322
131I	0.9994506	-0.0083744322
132I	1.0018724	-0.0059526322
133I	0.9998	-0.0080250322
134I	1.001947	-0.0058780322

7.54 Element 54 is Xenon or Xe

Xenon has 54 protons and 77 neutrons.

ANM = 0.9932796189

126Xe		0
127Xe	1.00091	-0.0069150322
128Xe	0.9983473	-0.0094777322
129Xe	1.0012481	-0.0065769322
130Xe	0.9987286	-0.0090964322
131Xe	1.0015744	-0.0062506322
132Xe	0.9990711	-0.0087539322
133Xe	1.0017572	-0.0060678322
134Xe	0.9994838	-0.0083412322
135Xe	1.0018325	-0.0059925322
136Xe	0.999992	-0.0078330322
137Xe	1.004343	-0.0034820322

7.55 Element 55 is Caesium or Cs

Cesium has 55 protons and 78 neutrons.

ANM = 0.9932701944

131Cs		0.0000000000	
132Cs	1.0009703	-0.0068547322	
133Cs	0.999017633	-0.0088073992	
134Cs	1.001266542	-0.0065584902	
135Cs	0.999258525	-0.0085665072	
136Cs	1.0013346	-0.0064904322	

7.56 Element 56 is Barium or Ba

Barium has 56 protons and 81 neutrons.

ANM = 0.9934274765

129Ba		0.0000000000
130Ba	0.9976418	-0.0101832322
131Ba	1.0006202	-0.0072048322
132Ba	0.9981203	-0.0097047322
133Ba	1.0009462	-0.0068788322
134Ba	0.9985009	-0.0093241322
135Ba	1.0011802	-0.0066448322
136Ba	0.9988873	-0.0089377322
137Ba	1.0012515	-0.0065735322
138Ba	0.9994198	-0.0084052322
139Ba	1.0035941	-0.0042309322
140Ba	1.0017637	-0.0060613322
141Ba	1.003806	-0.0040190322
142Ba	1.002042	-0.0057830322

7.57 Element 57 is Lanthanum or La

Lanthanum has 57 protons and 82 neutrons.

ANM = 0.9934186154

134La		0.0000000000
135La	0.998463	-0.0093620322
136La	1.000663	-0.0071620322
137La	0.998854	-0.0089710322
138La	1.000618	-0.0072070322
139La	0.9992413	-0.0085837322
140La	1.0031243	-0.0047007322
141La	1.0014844	-0.0063406322
142La	1.003117	-0.0047080322
143La	1.001984	-0.0058410322

7.58 Element 58 is Cerium or Ce

Cerium has 58 protons and 82 neutrons.

ANM = 0.9933120345

132Ce		0.0000000000
133Ce	1.000055	-0.0077700322
134Ce	0.99741	-0.0104150322
135Ce	1.000226	-0.0075990322

136Ce	0.998021	-0.0098040322
137Ce	1.000634	-0.0071910322
138Ce	0.998185	-0.0096400322
139Ce	1.000662	-0.0071630322
140Ce	0.9987857	-0.0090393322
141Ce	1.0028376	-0.0049874322
142Ce	1.0009677	-0.0068573322
143Ce	1.003142	-0.0046830322
144Ce	1.001261	-0.0065640322

7.59 Element 59 is Praseodymium or Pr

Praseodymium has 59 protons and 82 neutrons.

ANM = 0.9932436085

141Pr		0.0000000000
142Pr	1.002392	-0.0054330322
143Pr	1.0007721	-0.0070529322
144Pr	1.0024881	-0.0053369322
145Pr	1.001207	-0.0066180322

7.60 Element 60 is Neodymium or Nd

Neodymium has 60 protons and 84 neutrons.

ANM = 0.9933403020

142^{Nd}		0.0000000000
143Nd	1.002091	-0.0057340322
144Nd	1.000273	-0.0075520322
145Nd	1.0024863	-0.0053387322
146Nd	1.0005433	-0.0072817322
147Nd	1.0029835	-0.0048415322
148Nd	1.0007926	-0.0070324322
149Nd	1.003256	-0.0045690322
150Nd	1.000742	-0.0070830322
151Nd	1.002938	-0.0048870322
152^{Nd}	1.000853	-0.0069720322

7.61 Element 61 is Promethium or Pm

Promethium has 61 protons and 84 neutrons.

ANM = 0.9932788337

143Pm		0.0000000000
144Pm	1.001658	-0.0061670322
145Pm	1.000158	-0.0076670322
146Pm	1.001947	-0.0058780322
147Pm	1.0004425	-0.0073825322

7.62 Element 62 is Samarium or Sm

Samarium has 62 protons and 88 neutrons.

ANM = 0.9935468580

140Sm		0.0000000000
141Sm	0.999481	-0.0083440322
142Sm	0.996722	-0.0111030322
143Sm	0.99943	-0.0083950322
144Sm	0.997371	-0.0104540322
145Sm	1.001411	-0.0064140322
146Sm	0.999631	-0.0081940322
147Sm	1.0018569	-0.0059681322
148Sm	0.9999248	-0.0079002322
149Sm	1.002362	-0.0054630322
150Sm	1.0000908	-0.0077342322
151Sm	1.0026569	-0.0051681322
152Sm	0.9998	-0.0080250322
153Sm	1.002365	-0.0054600322
154Sm	1.0001119	-0.0077131322
155Sm	1.0024309	-0.0053941322

7.63 Element 63 is Europium or Eu

Europium has 63 protons and 89 neutrons.

ANM = 0.9935816570

148Eu		0.0000000000
149Eu	0.999845	-0.0079800322
150Eu	1.001771	-0.0060540322
151Eu	1.0001482	-0.0076768322
152Eu	1.0018943	-0.0059307322
153Eu	0.9994858	-0.0083392322
154Eu	1.0017489	-0.0060761322
155Eu	0.9999141	-0.0079109322

7.64 Element 64 is Gadolinium or Gd

Gadolinium has 64 protons and 93 neutrons.

ANM = 0.9937973982

152Gd		0.0000000000
153Gd	1.0019585	-0.0058665322
154Gd	0.9991161	-0.0087089322
155Gd	1.0017564	-0.0060686322
156Gd	0.9995007	-0.0083243322
157Gd	1.0018374	-0.0059876322
158Gd	1.0001438	-0.0076812322
159Gd	1.0022848	-0.0055402322
160Gd	1.0006654	-0.0071596322
161Gd	1.0026151	-0.0052099322

7.65 Element 65 is Terbium or Tb

Terbium has 65 protons and 94 neutrons.

ANM = 0.9937948820

157Tb		0.0000000000
158Tb	1.0013885	-0.0064365322
159Tb	0.9999329	-0.0078921322
160Tb	1.0018216	-0.0060034322
161Tb	1.0004023	-0.0074227322

7.66 Element 66 is Dyprosium or Dy

Dyprosium has 66 protons and 97 neutrons.

ANM = 0.9939410214

154Dy		0.0000000000
155Dy	1.00133	-0.0064950322
156Dy	0.998529	-0.0092960322
157Dy	1.001183	-0.0066420322
158Dy	0.998943	-0.0088820322
159Dy	1.0013302	-0.0064948322
160Dy	0.9994583	-0.0083667322
161Dy	1.0017359	-0.0060891322
162Dy	0.999865	-0.0079600322
163Dy	1.0019328	-0.0058922322

164Dy	1.0004436	-0.0073814322
165Dy	1.0025285	-0.0052965322
166Dy	1.0011034	-0.0067216322

7.67 Element 67 is Holmium or Ho

Holmium has 67 protons and 98 neutrons.

ANM = 0.9939392341

163Ho		0.0000000000
164Ho	1.0014996	-0.0063254322
165Ho	1.0000886	-0.0077364322
166Ho	1.0019621	-0.0058629322
167Ho	1.0008488	-0.0069762322
168Ho	1.002387	-0.0054380322

7.68 Element 68 is Erbium or Er

Erbium has 68 protons and 99 neutrons.

ANM = 0.9939388486

158Er		0.0000000000
159Er	1.000791	-0.0070340322
160Er	0.998399	-0.0094260322
161Er	1.000912	-0.0069130322
162Er	0.998783	-0.0090420322
163Er	1.001255	-0.0065700322
164Er	0.999167	-0.0086580322
165Er	1.001526	-0.0062990322
166Er	0.9995671	-0.0082579322
167Er	1.0017551	-0.0060699322
168Er	1.000322	-0.0075030322
169Er	1.0022202	-0.0056048322
170Er	1.0008739	-0.0069511322
171Er	1.0025655	-0.0052595322

7.69 Element 69 is Thulmium or Tm

Thulmium has 69 protons and 100 neutrons.

ANM = 0.9939428608

169Tm		0.0000000000

170Tm	1.0015881	-0.0062369322
171Tm	1.000628	-0.0071970322

7.70 Element 70 is Ytterbium or Yb

Ytterbium has 70 protons and 103 neutrons.

ANM = 0.9940821218

164Yb		0.0000000000
165Yb	1.000791	-0.0070340322
166Yb	0.998602	-0.0092230322
167Yb	1.001068	-0.0067570322
168Yb	0.998947	-0.0088780322
169Yb	1.001293	-0.0065320322
170Yb	0.9995718	-0.0082532322
171Yb	1.001564	-0.0062610322
172Yb	1.0000557	-0.0077693322
173Yb	1.0018293	-0.0059957322
174Yb	1.0006513	-0.0071737322
175Yb	1.0024144	-0.0054106322
176Yb	1.0012952	-0.0065298322
177Yb	1.0026891	-0.0051359322

7.71 Element 71 is Lutetium or Lu

Lutetium has 71 protons and 104 neutrons.

ANM = 0.9940884088

170Lu		0.0000000000
171Lu	0.9994381	-0.0083869322
172Lu	1.0011729	-0.0066521322
173Lu	0.9998446	-0.0079804322
174Lu	1.0014069	-0.0064181322
175Lu	1.0004343	-0.0073907322
176Lu	1.0019145	-0.0059105322
177Lu	1.0010718	-0.0067532322

7.72 Element 72 is Hafnium or Hf

Hafnium has 72 protons and 106 neutrons.

ANM = 0.9941537404

174Hf		0.0000000000
175Hf	1.001463	-0.0063620322
176Hf	0.9998996	-0.0079254322
177Hf	1.0018121	-0.0060129322
178Hf	1.0004781	-0.0073469322
179Hf	1.0021173	-0.0057077322
180Hf	1.0007339	-0.0070911322
181Hf	1.0025512	-0.0052738322
182Hf	1.0014528	-0.0063722322

7.73 Element 73 is Tantalum or Ta

Tantalum has 73 protons and 108 neutrons.

ANM = 0.9942293375

180Ta		0.0000000000
181Ta	1.000531	-0.0072940322
182Ta	1.002156	-0.0056690322
183Ta	1.0012208	-0.0066042322
184Ta	1.0026354	-0.0051896322

7.74 Element 74 is Tungsten or W

Tungsten has 74 protons and 110 neutrons.

ANM = 0.9942898074

178W		0.0000000000
179W	1.001194	-0.0066310322
180W	0.999634	-0.0081910322
181W	1.001493	-0.0063320322
182W	1.0000072	-0.0078178322
183W	1.0020188	-0.0058062322
184W	1.0007082	-0.0071168322
185W	1.0024881	-0.0053369322
186W	1.0009448	-0.0068802322
187W	1.0027964	-0.0050286322
188W	1.0013285	-0.0064965322

7.75 Element 75 is Rhenium or Re

Rhenium has 75 protons and 111 neutrons.

ANM = 0.9943072854

185Re		0.0000000000
186Re	1.0020311	-0.0057939322
187Re	1.000767	-0.0070580322
188Re	1.0023613	-0.0054637322
189Re	1.0011146	-0.0067104322

7.76 Element 76 is Osmium or Os

Osmium has 76 protons and 114 neutrons.

ANM = 0.9944188118

184Os		0.0000000000
185Os	1.0015532	-0.0062718322
186Os	0.9997959	-0.0080291322
187Os	1.0019123	-0.0059127322
188Os	1.0000877	-0.0077373322
189Os	1.0023093	-0.0055157322
190Os	1.0002995	-0.0075255322
191Os	1.0024827	-0.0053423322
192Os	1.000551	-0.0072740322
193Os	1.0026709	-0.0051541322
194Os	1.0010305	-0.0067945322

7.77 Element 77 is Iridium or Ir

Iridium has 77 protons and 115 neutrons.

ANM = 0.9944354567

190Ir		0.0000000000
191Ir	1.000048	-0.0077770322
192Ir	1.002011	-0.0058140322
193Ir	1.0003214	-0.0075036322
194Ir	1.002152	-0.0056730322
195Ir	1.0009012	-0.0069238322

196Ir	1.0024204	-0.0054046322
197Ir	1.001253	-0.0065720322

7.78 Element 78 is Platinum or Pt

Platinum has 78 protons and 117 neutrons.

ANM = 0.9944823811

190Pt		0.0000000000
191Pt	1.001745	-0.0060800322
192Pt	0.999361	-0.0084640322
193Pt	1.0019494	-0.0058756322
194Pt	0.9996929	-0.0081321322
195Pt	1.0021108	-0.0057142322
196Pt	1.0001604	-0.0076646322
197Pt	1.0023887	-0.0054363322
198Pt	1.0005528	-0.0072722322
199Pt	1.0027	-0.0051250322

7.79 Element 79 is Gold or Au

Gold has 79 protons and 118 neutrons.

ANM = 0.9944778911

196Au		0.0000000000
197Au	0.9999987	-0.0078263322
198Au	1.0016736	-0.0061514322
199Au	1.0005229	-0.0073021322

7.80 Element 80 is Mercury or Hg

Mercury has 80 protons and 121 neutrons.

ANM = 0.9945809894

192Hg		0.0000000000
193Hg	1.001031	-0.0067940322
194Hg	0.998774	-0.0090510322
195Hg	1.001281	-0.0065440322
196Hg	0.999113	-0.0087120322
197Hg	1.00138	-0.0064450322

198Hg	0.999556	-0.0082690322
199Hg	1.0015109	-0.0063141322
200Hg	1.0000461	-0.0077789322
201Hg	1.0019763	-0.0058487322
202Hg	1.0003407	-0.0074843322
203Hg	1.0022295	-0.0055955322
204Hg	1.0006214	-0.0072036322

7.81 Element 81 is Thallium or Tl

Thallium has 81 protons and 123 neutrons.

ANM = 0.9946344381

200Tl		0.0000000000
201Tl	0.999856	-0.0079690322
202Tl	1.001287	-0.0065380322
203Tl	1.0002382	-0.0075868322
204Tl	1.0015193	-0.0063057322
205Tl	1.000564	-0.0072610322
206Tl	1.0016828	-0.0061422322
207Tl	1.0013087	-0.0065163322

7.82 Element 82 is Lead or Pb

Lead has 82 protons and 125 neutrons.

ANM = 0.9946739540

200Pb		0.0000000000
201Pb	1.001058	-0.0067670322
202Pb	0.999274	-0.0085510322
203Pb	1.001232	-0.0065930322
204Pb	0.9996526	-0.0081724322
205Pb	1.0014382	-0.0063868322
206Pb	0.9999835	-0.0078415322
207Pb	1.0014316	-0.0063934322
208Pb	1.0007552	-0.0070698322
209Pb	1.004438	-0.0033870322
210Pb	1.0030984	-0.0047266322
211Pb	1.0045485	-0.0032765322
212Pb	1.0031605	-0.0046645322
213Pb	1.0046835	-0.0031415322
214Pb	1.0032244	-0.0046006322

7.83 Element 83 is Bismuth or Bi

Bismuth has 83 protons and 126 neutrons.

ANM = 0.9946898494

207Bi		0
208Bi	1.0012715	-0.0065535322
209Bi	1.0006565	-0.0071685322
210Bi	1.0037217	-0.0041033322
211Bi	1.0031486	-0.0046764322
212Bi	1.0040167	-0.0038083322
213Bi	1.0030993	-0.0047257322
214Bi	1.004327	-0.0034980322
215Bi	1.003058	-0.0047670322
216Bi	1.004536	-0.0032890322

7.84 Element 84 is Polonium or Po

Polonium has 84 protons and 125 neutrons.

ANM = 0.9946010215

208Po		0
209Po	1.0011847	-0.0066403322
210Po	1.0004433	-0.0073817322
211Po	1.0037795	-0.0040455322

7.85 Element 85 is Astatine or At

Astatine has 85 protons and 125 neutrons.

ANM = 0.9945761621

210At		0
211At	1.0003483	-0.0074767322
212At	1.0032487	-0.0045763322

7.86 Element 86 is Radon or Rn

Radon has 86 protons and 136 neutrons.

ANM = 0.9951810656

Radon has no other isotopes with a half-life long enough for this analysis.

7.87 Element 87 is Francium or Fr

Francium has 87 protons and 136 neutrons.

ANM = 0.9951393978

222Fr		0.0000000000
223Fr	1.0021839	-0.0056411322

7.88 Element 88 is Radium or Ra

Radium has 88 protons and 138 neutrons.

ANM = 0.9951942534

226Ra		0.0000000000
227Ra	1.003768	-0.0040570322
228Ra	1.0018925	-0.0059325322

7.89 Element 89 is Actinium or Ac

Actinium has 89 protons and 138 neutrons.

ANM = 0.9951545234

225Ac		0.0000000000
226Ac	1.002868	-0.0049570322
227Ac	1.0016541	-0.0061709322
228Ac	1.003269	-0.0045560322

7.90 Element 90 is Thorium or Th

Thorium has 90 protons and 142 neutrons.

ANM = 0.9953084676

228^{Th}		0.0000000000
229^{Th}	1.0030209	-0.0048041322

230Th	1.0013718	-0.0064532322
231Th	1.0031705	-0.0046545322
232Th	1.001751	-0.0060740322
233Th	1.0035265	-0.0042985322
234Th	1.0020192	-0.0058058322

7.91 Element 91 is Protactinium or Pa

Protactinium has 91 protons and 140 neutrons.

ANM = 0.9951700433

Protactinium has no other isotopes with a half-life long enough for this analysis.

7.92 Element 92 is Uranium or U

Uranium has 92 protons and 146 neutrons.

ANM = 0.9954170221

232U		0.0000000000
233U	1.002479	-0.0053460322
234U	1.0013169	-0.0065081322
235U	1.0029778	-0.0048472322
236U	1.0016381	-0.0061869322
237U	1.0031622	-0.0046628322
238U	1.002058	-0.0057670322
239U	1.0035051	-0.0043199322

7.93 Element 93 is Neptunium or Np

Neptunium has 93 protons and 144 neutrons.

ANM = 0.9952808708

236Np		0.0000000000
237Np	1.0016034	-0.0062216322
238Np	1.002773	-0.0050520322
239Np	1.0019926	-0.0058324322

7.94 Element 94 is Plutonium or Pu

Plutonium has 94 protons and 150 neutrons.

ANM = 0.9955243398

236Pu		0.0000000000
237Pu	1.0023517	-0.0054733322
238Pu	1.0011502	-0.0066748322
239Pu	1.0026035	-0.0052215322
240Pu	1.0016501	-0.0061749322
241Pu	1.003038	-0.0047870322
242Pu	1.0018911	-0.0059339322
243Pu	1.0032604	-0.0045646322
244Pu	1.002201	-0.0056240322

7.95 Element 95 is Americium or Am

Americium has 95 protons and 148 neutrons.

ANM = 0.9953919124

241Am		0.0000000000
242Am	1.0027201	-0.0051049322
243Am	1.0018319	-0.0059931322

7.96 Element 96 is Curium or Cm

Curium has 96 protons and 151 neutrons.

ANM = 0.9954910656

243Cm		0.0000000000
244Cm	1.0013635	-0.0064615322
245Cm	1.0027386	-0.0050864322
246Cm	1.0017325	-0.0060925322
247Cm	1.0031303	-0.0046947322
248Cm	1.001995	-0.0058300322

7.97 Element 97 is Berkelium or Bk

Berkelium has 97 protons and 150 neutrons.

ANM = 0.9954085258

247Bk		0.0000000000
248Bk	1.002783	-0.0050420322

7.98 Element 98 is Californium or Cf

Californium has 98 protons and 153 neutrons.

ANM = 0.9955080643

249Cf		0.0000000000
250Cf	1.0015526	-0.0062724322
251Cf	1.0031809	-0.0046441322
252Cf	1.002039	-0.0057860322
253Cf	1.003507	-0.0043180322
254Cf	1.00219	-0.0056350322

7.99 Element 99 is Einsteinium or Es

Einsteinium has 99 protons and 153 neutrons.

ANM = 0.9954790968

252Es		0.0000000000
253Es	1.0018447	-0.0059803322
254Es	1.0031973	-0.0046277322
255Es	1.002251	-0.0055740322
256Es	1.003327	-0.0044980322
257Es	1.00238	-0.0054450322

7.100 Element 100 is Fermium or Fm

Fermium has 100 protons and 157 neutrons.

ANM = 0.9956216737

253Fm		0.0000000000
254Fm	1.0016694	-0.0061556322
255Fm	1.0031096	-0.0047154322
256Fm	1.00181	-0.0060150322
257Fm	1.003332	-0.0044930322

7.101 Element 101 is Mendelevium or Md

Mendelevium has 101 protons and 157 neutrons.

ANM = 0.9955930111

258Md		0.0000000000
259Md	1.002079	-0.0057460322
260Md	1.00314	-0.0046850322

7.102 Element 102 is Nobelium or No
Nobelium has 102 protons and 157 neutrons.

ANM = 0.9955597243

253No		0.0000000000
254No	1.000392	-0.0074330322
255No	1.002235	-0.0055900322
256No	1.001092	-0.0067330322
257No	1.002605	-0.0052200322
258No	1.001322	-0.0065030322
259No	1.00282	-0.0050050322

7.103 Element 103 is Lawrencium or Lr

Lawrencium has 103 protons and 159 neutrons.

ANM = 0.9956203250

260Lr		0.0000000000
261Lr	1.00137	-0.0064550322
262Lr	1.00273	-0.0050950322

7.104 Element 104 is Rutherfordium or Rf

Rutherfordium has 104 protons and 157 neutrons.

ANM = 0.9955093417

261Rf		0
262Rf	1.00116	-0.0066650322
263Rf	1.00257	-0.0052550322

7.105 Element 105 is Dubnium or Db

Dubnium has 105 protons and 157 neutrons.

ANM = 0.9954932587

262Db		0.0000000000
263Db	1.00092	-0.0069050322
266Db		
267Db	1.00144	-0.0063850322
268Db	1.0032	-0.0046250322

The Dubnium isotopes missing from the list have a half-life too brief for a valid measurement.

7.106 Element 106 is Seaborgium or Sg

Seaborgium has 106 protons and 157 neutrons.

ANM = 0.9955782911

266Sg		0.0000000000
267Sg	1.00238	-0.0054450322

7.107 Element 107 is Borhrium or Bh

Borhrium has 107 protons and 157 neutrons.

ANM = 0.9954605831

Borhrium has no other isotopes with a half-life long enough for this analysis.

7.108 Element 108 is Hassium or Hs

Hassium has 108 protons and 159 neutrons.

ANM = 0.9955129970

Hassium has no other isotopes with a half-life long enough for this analysis.

7.109 Element 109 is Meiterium or Mt

Meiterium has 109 protons and 159 neutrons.

ANM = 0.9955076823

Meiterium has no other isotopes with a half-life long enough for this analysis.

7.110 Element 110 is Damstadtium or Ds

Damstadtium has 110 protons and 152 neutrons.

ANM = 0.9959284003

Damstadtium has no other isotopes with a half-life long enough for this analysis.

7.111 Element 111 is Roehtgenium Rg

Roehtgenium has 111 protons and 161 neutrons.

ANM = 0.9959095990

Roehtgenium has no other isotopes with a half-life long enough for this analysis.

7.112 Element 112 is Copernicium or Cn

Copernicium has 112 protons and 173 neutrons.

ANM = 0.9959578982

Copernicium has no other isotopes with a half-life long enough for this analysis.

7.113 Element 113 is Nihonium or Nh

Nihonium has 113 protons and 173 neutrons.

ANM = 0.9959420888

Nihonium has no other isotopes with a half-life long enough for this analysis.

7.114 Element 114 is Flerovium or Fl

Flerovium has 114 protons and 175 neutrons.

ANM = 0.9903316268

Flerovium has no other isotopes with a half-life long enough for this analysis.

7.115 Element 115 is Muscovium or Mc

Muscovium has 115 protons and 173 neutrons.

ANM = 1.0074919150

Muscovium has no other isotopes with a half-life long enough for this analysis.

7.116 Element 116 is Livermorium or Lv

Livermorium has 116 protons and 177 neutrons.

ANM = 1.0249813155

Livermorium has no other isotopes with a half-life long enough for this analysis.

7.117 Element 117 is Tennessine or Ts

Tennessine has 117 protons and 177 neutrons.

ANM = 0.9960165606

293Ts		0.0000000000
294Ts	1.00222	-0.0056050322

7.118 Element 118 is Oganesson or Og

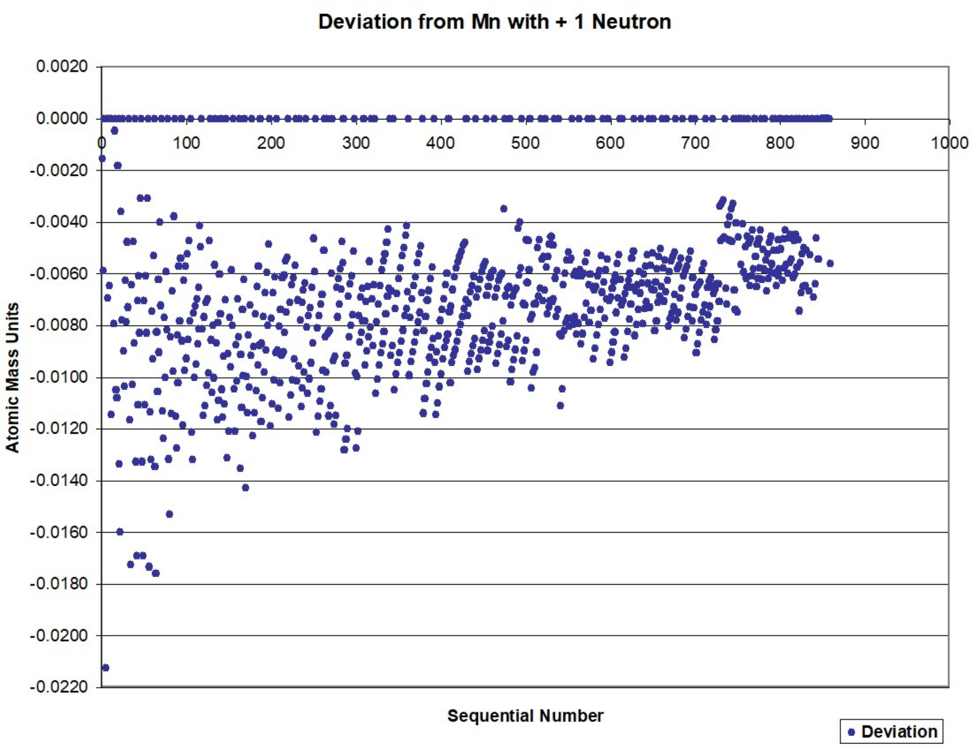
Oganesson has 118 protons and 176 neutrons.

ANM = 0.9960050068

Oganesson has no other isotopes with a half-life long enough for this analysis.

8 Chart Isotope Changes

The behavior of the change in each isotope's mass when adding 1 neutron is charted below. The change in mass is compared to the sum of a proton and electron. That sum is the expected mass of a neutron or Mn



In a single image the minor change in the mass of each neutron is clearly visible but it is always a reduction.

That the atomic mass defect has remained unexplained suggests no one ever plotted this behavior like in this image.

The change in atomic mass when adding a single neutron should be consistent (1 neutron) for all isotopes.

Instead, each element has slightly different deviation but nearly all are within a range of values, with most lying between about -0.0140 and -0.0030 where this distribution is probably driven by the configuration of nucleons when adding 1 neutron.

To put this deviation in its context, the sum of an electron and proton, or a neutron, is

1.0078250322 amu

The marks in the chart are the tiny deviations from that value.

The first isotope of each element has a deviation of 0.00 since it has no preceding isotope to compare in the spreadsheet. The chart has many marks on 0.00 but none of them are from an actual measured deviation. There is no isotope having a change in mass from the preceding isotope exactly at zero. All the isotope deviation values are non-zero.

The list of isotopes for creating this chart was by atomic number, then by its isotopes.

That outlier at the bottom left is the change from ^{3}He to ^{4}He so the mass change was rather different when adding the second neutron to 2 protons. The chart is only an overview. All the details are with each element in section 15 Periodic Table.

9 Final Conclusion

9.1 Part 1 of conclusion

Mass defect behavior presents a challenge because it originates in the atomic nucleus.

Each atom has a history of its formation. That involved the 2 fundamental particles of proton and electron, but large nuclei probably included fusing smaller nuclei to create a further combination. The current solar model based on only fusion in the core cannot explain the observed distribution of many elements. As noted in the author's book Cosmology Transition, a new solar model is being recognized which can invoke other mechanism for creating elements. A solar model is out of scope for this book but one must note the creation of elements is more complicated than the current fusion model implies. That model is known to be unable to explain the distribution of some elements. Its assumed fusion sequence inevitably encounters unstable isotopes among the steps. The creation sequence of the observed nuclei is out of scope for this book, but that uncertainty is relevant. Currently, some students are taught the mass defect leads to a mass to energy calculation which requires precise measurements for the correct change in mass. This lesson never teaches the mechanism behind the change in mass, and probably misses the importance of consistent precision of the values.

The analysis of mass defect using many isotopes results in a change in our understanding of protons and neutrons.

The proton is a fundamental particle. The discovery that it can be broken into fragments contributed nothing to our understanding of atoms.

The neutron is simply a proton with an adjacent electron.

Physicists claim to have observed 3 fragments from breaking a neutron. The most likely explanation is these are the same 3 fragments as claimed from a proton. These fragments have no defined attributes. Therefore, the situation is this:

Proton breaks into 3 fragments which do almost nothing.

Neutron breaks into 3 fragments which do almost nothing.

The quarks are claimed to account for only 1% of the proton's mass so they cannot explain a proton's observed behaviors.

There is no evidence suggesting these two sets of 3 fragments are not the same sets.

Physicists must provide evidence the 2 sets are actually different. Until then, one must assume they are just debris with their functions broken and disabled.

Because a neutron is neutral, it cannot be manipulated by electric and magnetic fields in an accelerator. A neutron loses its electron in a few minutes when outside an atom's nucleus.

Some very heavy elements eject neutrons during their radioactive decay sequence. This source is often used for neutron experiments.

Whenever a proton or neutron is forced by compression into a nucleus, the size of the proton is slightly reduced. This causes a corresponding slight reduction in its reactivity to other masses.

This is observed a reduction in the proton's measured mass. This is a behavior of a coherent particle where it appears affected by its change in volume.

This is definitely not a behavior expected from 3 independent particles.

Excerpt from Wikipedia:

In quantum chromodynamics, the modern theory of the nuclear force, most of the mass of protons and neutrons is explained by special relativity. The mass of a proton is about 80–100 times greater than the sum of the rest masses of the quarks that make it up, while the gluons have zero rest mass. The extra energy of the quarks and gluons in a region within a proton, as compared to the rest energy of the quarks alone in the QCD vacuum, accounts for almost 99% of the mass. The rest mass of a proton is, thus, the invariant mass of the system of moving quarks and gluons that make up the particle, and, in such systems, even the energy of massless particles is still measured as part of the rest mass of the system.

The internal dynamics of protons are complicated, because they are determined by the quarks' exchanging gluons, and interacting with various vacuum condensates. Lattice QCD provides a way of calculating the mass of a proton directly from the theory to any accuracy, in principle. The most recent calculations claim that the mass is determined to better than 4% accuracy, even to 1% accuracy. These claims are still controversial, because the calculations cannot yet be done with quarks as light as they are in the real world.

This means that the predictions are found by a process of extrapolation, which can introduce systematic errors. It is hard to tell whether these errors are controlled properly, because the quantities that are compared to experiment are the masses of the hadrons, which are known in advance.

(Excerpt end)

Observation:

Even after so many years since quarks were found as debris from particle collisions, a proton's mass using quarks remains a problem, with accuracy in the range of 1 to 4%, when the result is "known in advance."

Mass defect is a behavior of the individual nucleons. From the excerpt, one could suspect in QCD the nucleus is a soup of quasi-particles.

In my view based in classical physics: a nucleus is a specific number of adjacent protons and electrons held together by the electrostatic force.

There are 2 particles in a nucleus, the proton and neutron. This book uses data which enable only the neutron behavior to be measured.

Measuring a mass change after adding only 1 proton to compare 2 atoms is awkward because the neutron count can change with a proton count change for the nucleus stability.

Since a neutron is a proton having an attached electron, this description refers to only a proton for simplicity.

Observational data confirm both the size reduction and the mass reduction when these 2 particles are in a nucleus.

With a proton as a single entity having no pieces, it is reasonable to expect its reactivity to other masses could be reduced as its volume is reduced. With the proton having 3 individual quarks interacting with "vacuum condensates" for its mass behavior, it is reasonable to expect a reduction in the proton's volume should not affect the 3 quarks confined in how they perform their 2 distinct tasks of mass and charge. The observation a proton's volume affects its mass cannot be explained by the Standard Model using quarks. One could suspect the physicists never noticed this change was being measured within the nucleus. The Standard Model cannot explain how its set of 3 quarks can change the proton's mass as observed.

The Standard Model simply fails to explain a crucial behavior in every element. It is not logical to expect 3 disjointed pieces can execute 2 separate unrelated tasks. The claim a proton has 3 quarks having no measurable features must be dropped. The Standard Model should be fixed by dropping all its false quasi-particles like quarks and taking a practical approach driven by the accumulated data.

There is fundamental uncertainty when dealing with mass defect. This slight reduction in a proton's apparent mass occurs during the process of fusing particles together.

No atom has spontaneously appeared. Intergalactic Birkelund currents bring protons and electrons, as plasma filaments, to galaxies in the universe's electrical network.

Stars are composed of liquid metallic hydrogen, which is a name for a lattice of protons being maintained by free electrons. Stars have the great electrical energy at their surface, the photosphere, to compress particles together in a process called transmutation, or a Low Energy Nuclear Reaction, which is sometimes called cold fusion, as temperature from particles, in a gas and in motion, is not critical in the process.

All the observed atoms were assembled, over a time, by fusing combinations of protons and electrons.

8.2 Part 2 of conclusion

This book Atomic Mass Defect Alternative proposes the cause of an atomic mass defect is a reduction in the proton's mass when the proton particle is compressed into a nucleus.

The same reduction occurs when the proton has an attached electron when the proton is considered part of a neutron (proton + electron) The Standard Model based on quarks does not accommodate this alternate behavior of a proton during the assembly of a nucleus.

This theory arose from a simple observation. Consecutive isotopes of an element where the difference is 1 neutron consistently have an increase of less than 1 amu. This result should be impossible with a neutron having most of its mass in its proton and a tiny mass in its electron.

Therefore, when an atom has a neutron fused into its nucleus. the mass of the proton is being reduced slightly due to the force of compression against the mutual repulsion from the other protons already in the nucleus. Protons have a measured size implying an outer surface of the particle. Measurements of a few atomic nuclei are in the range expected for a sphere packing calculation (where the spheres are in physical contact for the most spheres within a volume).

This mass reduction during compression is temporary. If the proton leaves the nucleus (like during radioactive decay), then its normal mass will be measured. A proton has outside of a nucleus never been measured with a different. reduced mass value, though its measured mass was reduced slightly while in a nucleus.

There is no undefined nuclear binding energy. There is no mass to conversion in a nucleus causing nucleons to lose mass.

A nucleus is held together by the well- known electrostatic force between the charged particles densely packed into the nucleus.

The only associated change required in the Standard Model is the recognition the mass of a proton can be reduced while compressed in volume from the force fusing the proton into the nucleus.

10 References

The references in the book are available as clickable links from a page in the author's web site.

1. Start web browser
2. Go to this site: https://www.cosmologyview.com

3. Make sure the browser is on the correct home page:

Cosmology Views

4. Scroll to near the middle.
5. Select: Books by the author

This page presents information for each book.
Locate the columns for this book.

6. Locate: Atomic Mass Defect
7. Below it, locate the date of this book's edition:

10/11/2021 References

8. Select: **References** after the correct date.

The selected page will list the references in the book by page number, with a link to that reference.

Each link has the page number and the link's target indicating whether it is to a pdf, a zip (only for the spreadsheet with element data), a YouTube video, or a URL link to a web page. The user is aware of what the browser will do with the link.