The Relation of Particle Numbers to Atomic Numbers

J. Yee,[1,2] Y. Zhu,[1,3] G.F. Zhou[1]

[1] *Electronic Paper Display Institute, South China Academy of Advanced Optoelectronics, South China Normal University, Higher Education Mega Center, Guangzhou 510006 CHINA*
[2] *ZTE USA Inc, Milpitas, California, 95035 USA*
[3] *China Telecom Imusic Ltd, Guangzhou, Guangdong, 510081 CHINA*

Dozens of subatomic particles have been discovered in high energy experiments and more particles are likely to be found in particle accelerators and neutrino experiments around the world. Our goal, that we seek in this paper, is to create a new model for predicting the next particle and its energy level. Our hope is that a new model also provides a better understanding of subatomic particles that can lead to advancements in quantum and energy sciences.

In this paper, we take the first steps of simplifying particles into a linear function that organizes particles based on their particle number, similar to how atoms are arranged by atomic number. This repeats the method that was used to organize atomic elements and create the Periodic Table of Elements in the 1800s. Now, the same process can be used for subatomic particles.

The solution to linearize particles into a predictable function is not as simple as atomic elements, but it does exist. As with everything in physics, mathematics describes the universe in which we live and the same holds true for subatomic particles. We will introduce an equation that fits particles into a function that enables the prediction of future particle energies. It also predicts the exact mass of the elusive neutrino. Particles are first organized by particle numbers, similar to atomic numbers in the Periodic Table of Elements, and then charted against their known CODATA energy levels. The results will show similarities between particles and atomic elements – numbers where both are known to be more stable than their counterparts.

Background – Atomic Numbers and Mass

In 1869, Dmitri Mendeleev presented *The Dependence Between the Properties of the Atomic Weights of the Elements* to the Russian Chemical Society, which included the first version of the Periodic Table of Elements.[1] By relating atomic elements and their atomic mass, Mendeleev was able to predict undiscovered elements and their masses by arranging them into a periodic table.

Until the 1900s, atomic elements were fundamental. Gold was gold. Silver was silver. Then, in 1911, Ernest Rutherford discovered the proton. Following his discovery of the atomic nucleus, Antonius van den Broek proposed that the atomic number in the Periodic Table of Elements was the nuclear charge of the element.[2] Now, it is accepted that the proton is the particle that creates each of the atomic elements in the table. For example, gold consists of 79 protons (Z=79); silver has 47 protons (Z=47). What seemed complex before the Periodic Table of Elements and the discovery of the proton is now simplified to basic atomic components: protons, neutrons and electrons.

The arrangement of the periodic table by Mendeleev and the linking to the proton as the atomic number by van den Broek was possible because of a linear arrangement of atomic mass to atomic number. As elements were discovered, their atomic mass fit into a predictable sequence. This is shown in Figure 1.

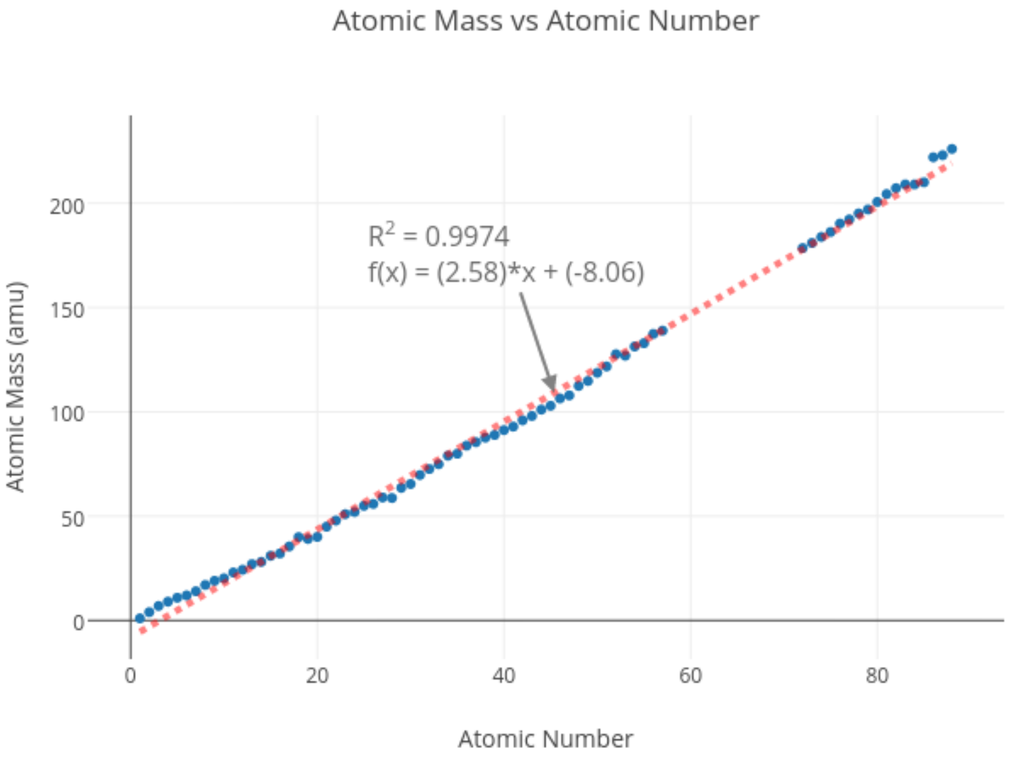


Figure 1. Atomic Number vs Atomic Mass. Hydrogen (Z=1) to Ununoctium (Z=118).[3]

For example, hydrogen has an atomic number of one (Z=1) and an atomic mass of 1.008 amu.[4] Helium has an atomic number of 2 (Z=2) due to its two protons and an atomic mass of 4.003 amu (stable helium has two neutrons in addition to the protons). By plotting the atomic numbers and mass (in blue in Fig. 1), it yields a predictable line (in red in Fig. 1).

What once seemed complex was simplified with a math function that allowed the prediction of undiscovered atomic elements.

Simplifying Particle Mass into a Linear Function

Currently, the world of subatomic particles is nearly as complex as the discovery of new atomic elements in the 1800s. Atomic elements were simplified to be based on the number of protons in the nucleus, yet as we dig deeper into the constructs of the proton, it becomes a complex world again. A proton can be smashed into another proton at high energies to create various new particles. This leads to a question. Why would nature go from complex (dozens of elements) to simple (protons, neutrons and electrons) back to complex (dozens of subatomic particles) as we get smaller and smaller?

The search for a building block to unite subatomic particles – analogous to the proton as the building block for elements – begins with an approach similar to the one Mendeleev used in the 1800s when elements were organized by number and mass/energy. However, unlike atomic elements, a function that organizes particles into a predictable sequence is not as apparent.

Our objective is to find commonality in the masses of major particles. Unfortunately, plotting the currently known energies of particles ranging from 2.2 eV for the neutrino to 125 GeV for the Higgs boson doesn't yield helpful results. Thus, to find a linear solution, each particle is divided by an undetermined value of X. This X becomes the equation we need to resolve to find the linear solution.

$$E_{(K)} = \frac{E_{particle}}{X} \qquad (1)$$

As it will be shown in the next section, when the results are plotted linearly, a relatively simple mathematical equation can be used to arrange particles into a chart that is similar to Fig. 1 – atomic numbers vs atomic mass. The equation introduces a new variable for particle number, **K**, represented in integers (1, 2, 3, etc). Particle number (K) is equivalent to atomic numbers (Z) in atomic elements.

It turns out that particle energies are nearly linearized when dividing their energies by the fourth power of K (i.e. K^4). It requires a summation equation also based on the particle number K to be complete. This equation is found below in Eq. 2. The detailed explanation and derivation of the equation is found in *Particle Energy and Interaction*.[5]

$$X = (K^4) \sum_{n=1}^{K} \frac{n^3 - (n-1)^3}{n^4} \qquad (2)$$

After substituting Eq. 2 into Eq. 1, a new equation (Eq. 3) will be used as the method to reduce the energy to a lower form. In Eq. 3, the energy associated with each particle number (K) is calculated for many of the known subatomic particles. This equation was used for each K value from K=1 to K=118, following the Periodic Table of Elements which also has a range of 118 elements (Z=1 to Z=118).

$$E_{(K)} = E_{particle} \left(\frac{1}{(K^4) \sum_{n=1}^{K} \frac{n^3 - (n-1)^3}{n^4}} \right) \qquad (3)$$

Neutrino (K=1). The neutrino, as the lightest known particle, was used as the baseline for the value K=1. It can be considered the equivalent of hydrogen in atomic elements, occupying the first position in the table. A value of 2.2 eV is used for the rest energy of the neutrino, which is on the high end of the known range for the neutrino. All calculations use CODATA energy values for subatomic particles.[6] [7]

An example calculation is shown below in Eq. 4. Using Eq. 3, and inserting a value of one (1) for K, it results in 2.2 eV. The neutrino is now the baseline in this model, and since its units are measured in electron volts (eV), the remaining particles will also be converted to eV.

$$E_{(1)} = 2.2 \left(\frac{1}{(1^4) \sum_{n=1}^{1} \frac{n^3 - (n-1)^3}{n^4}} \right) = 2.2 \qquad (4)$$

Electron (K=10). Another example using Eq. 3 is the electron. It has a CODATA rest energy of 511 MeV, or 0.511 x 10^6 eV. This replaces the energy value of the particle ($E_{particle}$) in Eq. 3. After trial and error, a value of K was found at K=10. This value (10) is replaced in the equation in two places (K^4) and again in the summation. The result is 23.8925.

$$E_{(10)} = 0.511 \cdot 10^6 \left(\frac{1}{(10^4) \sum_{n=1}^{10} \frac{n^3 - (n-1)^3}{n^4}} \right) = 23.8925 \tag{5}$$

Higgs boson (K=117). Similarly, the Higgs boson was calculated using Eq. 3. A value of 125.3 GeV, or 125.3 x 10^9 eV was used, along with a K value of 117 (K=117). The result is 280.3.

$$E_{(117)} = 125.3 \cdot 10^9 \left(\frac{1}{(117^4) \sum_{n=1}^{117} \frac{n^3 - (n-1)^3}{n^4}} \right) = 280.3 \tag{6}$$

Results – Particle Numbers and Mass

Many of the particles were calculated and then placed into a chart (Fig. 2) based on their particle number K. Some particles were excluded due to overlapping particle numbers. When this occurred, the neutral charge particle was used as the energy value. For example, the neutral kaon has a rest energy of 497.6 MeV and the charged kaons have a rest energy of 493.7 MeV. Both would occupy the slot with particle number 39 (K=39), so the neutral charge value is used. Note that the same occurrence happens in atomic elements. Lithium, as an example with Z=3, has atomic weight differences for ^{6}Li and ^{7}Li at 6.02 amu and 7.02 amu respectively.[8]

Fig. 2 is constructed to be similar to the comparison of atomic numbers to atomic mass (Fig. 1). In Fig. 2, particle numbers (K) are listed from 1 to 118 on the horizontal axis. The vertical axis lists the reduced particle energy calculated using Eq. 3, in electronvolts (eV).

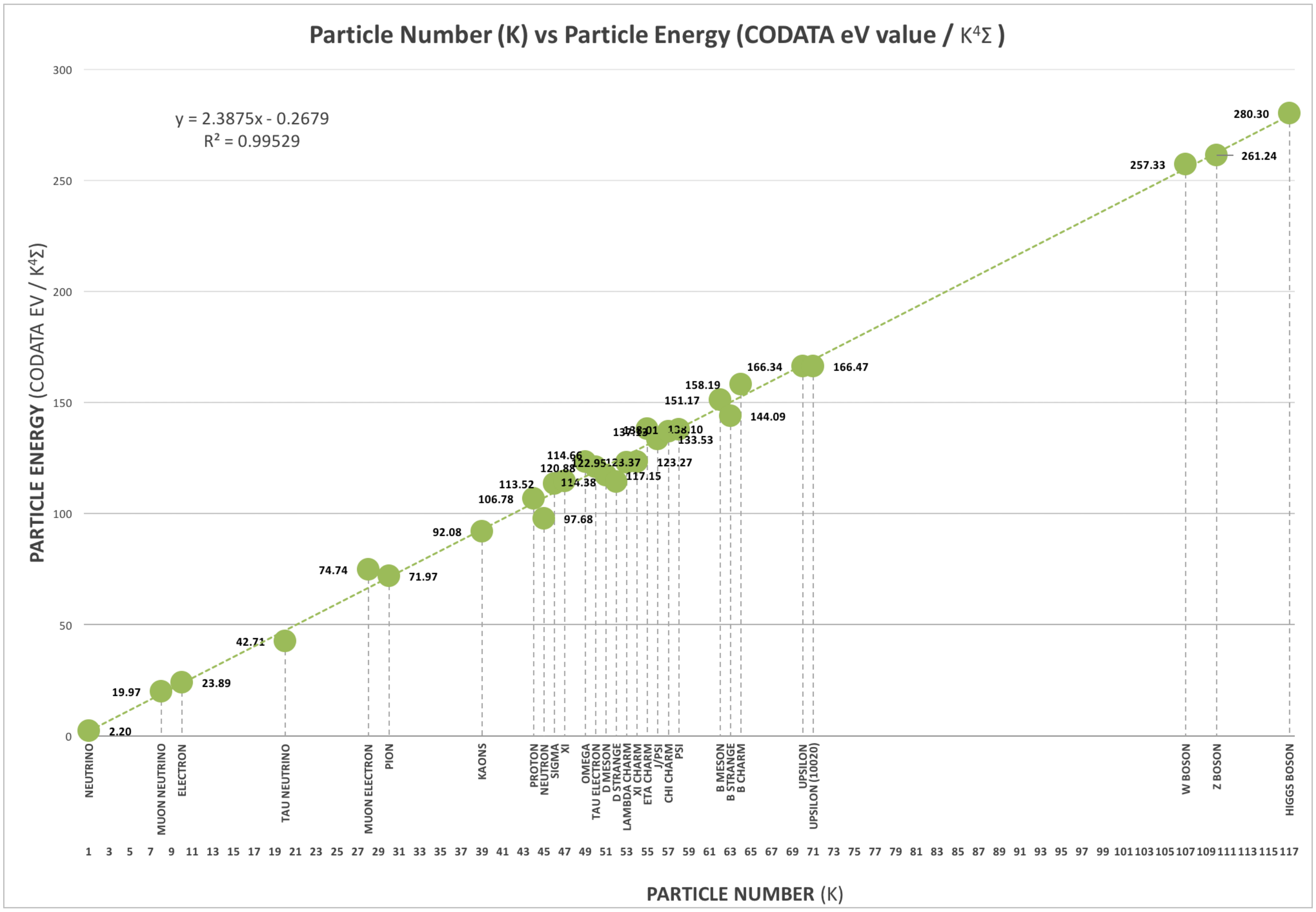


Figure 2. Mapping of subatomic particles to particle number (K), similar to atomic number (Z). The Y axis is CODATA values of particles in eV divided by a value that is based on the particle number (refer to Eq. 3).

The mapping of subatomic particles to particle numbers yields an extraordinary similarity to atomic elements as it becomes linear, now producing a function that can predict not only the energy values of remaining particles, but also how many particles may be waiting to be discovered.

A few observations about these results:

- The data fits well within the trendline with small deviations, as indicated by an R-squared value of 0.995.
- The slope of the line in Fig. 2 for particles is y=2.3875x. The slope of the line for atomic elements in Fig. 1 is y=2.58x.
- The slope of 2.3875 in Fig. 2 may provide the exact rest energy of the neutrino. With a particle count (K=1), this would imply a value of 2.3875 eV instead of 2.2 eV.
- Beginning with the proton at K=44, until K=59, there is a cluster of subatomic particles. This is not surprising since many of these particles are found in particle accelerator experiments by smashing protons at high energies.
- The Higgs boson appears at particle number K=117, near the end of the Periodic Table (118 elements). However, it is still likely that particles could be found with higher energy levels beyond K=118. When including neutrons, in addition to protons, atomic elements have nucleon counts that exceed 118.

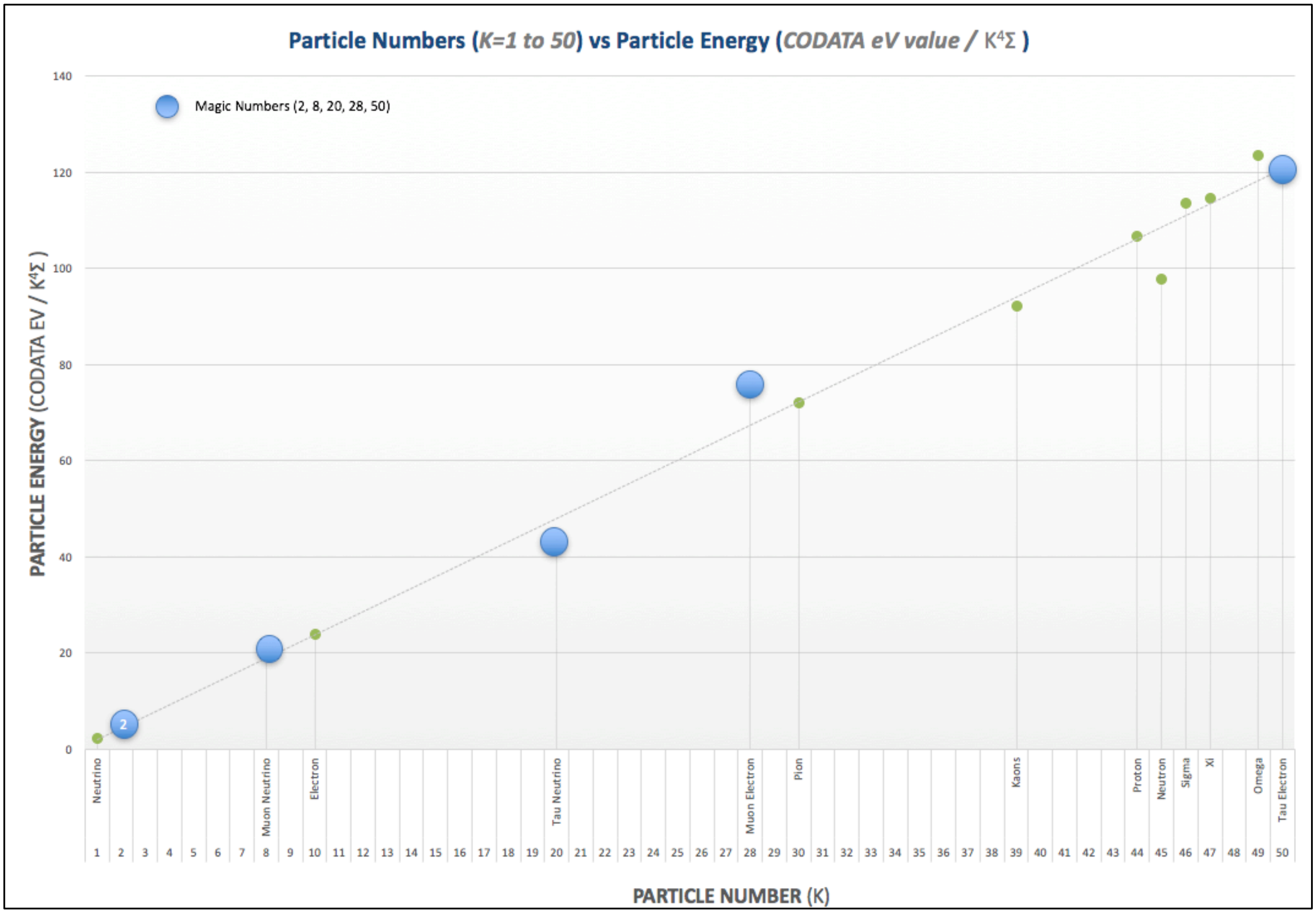
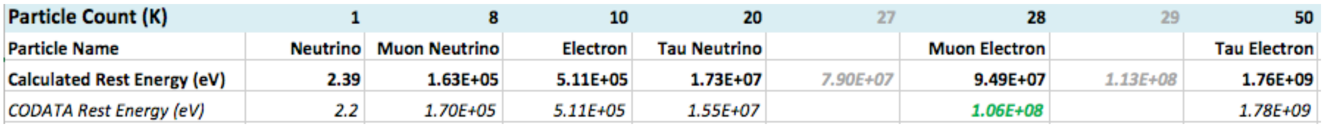


Figure 3. Particle Number (K) vs Particle Energy for the first 50 particle numbers. Magic numbers found in atomic elements are apparent also in particle numbers. The magic numbers of stability map to leptons in the neutrino and electron family of particles.

Focusing on the first 50 particle numbers, two more findings are observed:

- The stable particles (neutrino, electron and proton) fit exactly on the trendline. Although this may be merely a coincidence because the pion and tau electron also fit on the trendline, yet both of these particles decay.
- The leptons (neutrino and electron family of particles) are found at particle numbers that match stable atomic elements. In atomic elements, these are known as magic numbers. The first five magic numbers are 2, 8, 20, 28 and 50. This leaves the possibility of finding a neutrino particle at K=2 since this energy value does not match a known particle.

An issue with relating all leptons to magic numbers is that the muon neutrino does not fit exactly into particle number 28 (K=28) in Fig. 3. However, when the first particle in the sequence (neutrino) is set to a baseline of 2.39 eV instead of 2.2 eV, according to the predicted slope from Fig. 2, the muon and tau leptons fit squarely into the magic numbers (muon neutrino – 8; tau neutrino – 20; muon electron – 28; tau electron – 50).



Particle Count (K)	1	8	10	20	27	28	29	50
Particle Name	Neutrino	Muon Neutrino	Electron	Tau Neutrino		Muon Electron		Tau Electron
Calculated Rest Energy (eV)	2.39	1.63E+05	5.11E+05	1.73E+07	7.90E+07	9.49E+07	1.13E+08	1.76E+09
CODATA Rest Energy (eV)	*2.2*	*1.70E+05*	*5.11E+05*	*1.55E+07*		*1.06E+08*		*1.78E+09*

Figure 4. Lepton particles recalculated based on a 2.39 eV rest energy for the neutrino and compared to CODATA values. Leptons now fit into magic numbers.

The new, calculated values are shown in Fig. 4. The calculated rest energy in eV is compared to the CODATA eV value. The muon electron now fits between particle counts 28 and 29 (CODATA eV value in green). The rest energy values were calculated using the Longitudinal Energy Equation from *Particle Energy and Interaction*, which is how Eq. 2 in this paper was derived. [5]

Conclusion

Using mathematics to simplify the results of particle energy experiments, we find that there is a linear function that can be used to predict new particles and their energy values. It also reveals a slope that may be proven when neutrino experiments narrow the correct value of the neutrino's mass, expected to be around 2.39 eV in the calculations of this paper.

Of greater importance in finding the function that relates particle numbers to energy is that it shows similarities to atomic elements. The slopes are nearly the same (y=2.39x for particles; y=2.58x for atomic elements), they share roughly the same number of known particle numbers and atomic numbers (117 for the Higgs boson and 118 for ununoctium) and they share a commonality that particles and atomic elements tend to be more stable, relative to others, at certain numbers (2, 8, 20, 28, 50).

This relation of subatomic particles to atomic elements brings hope that the equivalent of the proton will be discovered for particles, unifying various particles that have been found or continue to be discovered into a simpler definition of their creation. This is the process that Mendeleev used in the creation of the Periodic Table of Elements that eventually simplified our understanding of elements and the atom. Next, we may find that the same structure is true for the particles that create the atom and are responsible for its interactions with other atoms.

Acknowledgments

The authors acknowledge the support from the National Natural Science Foundation of China (Grant No. 51561135014, U1501244), Guangdong Innovative Research Team Program (No. 2011D039) and the Program for Changjiang Scholars and Innovative Research Teams in Universities Project (No. IRT13064).

References

---

[1] Wikipedia, "History of the Periodic Table", Wikipedia.com, https://en.wikipedia.org/wiki/History_of_the_periodic_table (Accessed February 11, 2017)

[2] Wikipedia, "Proton", Wikipedia.com, https://en.wikipedia.org/wiki/Proton (Accessed February 11, 2017)

[3] J. Crumbaugh, "Atomic Mass vs Atomic Number", Plot.ly, https://plot.ly/~JeffCrumbaugh/32/atomic-mass-vs-atomic-number/ (Accessed February 11, 2017)

[4] PTable, "Periodic Table of Elements", Ptable.com, http://www.ptable.com/ (Accessed February 11, 2017)

[5] J. Yee, "Particle Energy and Interaction: Explained and Derived by Energy Wave Equations", Vixra 1408.0224 (2017)

[6] S. Stanislav, "Constants of Physics and Mathematics", Extra Byte, http://www.ebyte.it/library/educards/constants/ConstantsOfPhysicsAndMath.html (Accessed February 11, 2017)

[7] NPL, "Subatomic Particles", National Physical Laboratory, http://www.kayelaby.npl.co.uk/atomic_and_nuclear_physics/4_8/4_8_4.html (Accessed February 11, 2017)

[8] WebElements, "Lithium Isotope data", Webelements.com, https://www.webelements.com/lithium/isotopes.html (Accessed February 11, 2017)