PARTICLE PHYSICS PRIMER

INTRODUCTION

My Esteemed Reader, my work reported in the two formal articles hosted at this web site has been made available to the general public. Since the posting of these articles I have been asked by several readers, "What is a lepton"? Oops, such a question makes the reading of my work a bit disconcerting, when you don't even know what it is that is being discussed. Thus the objective here is to give a brief orientation of how the topics of discussion, **LEPTONS and PHOTONS**, fit in with other scientific basics with which everyone in industrialized societies are familiar.

The articles as hosted on this site offer no introductory discussion to set a frame for the subject matter. This is because they were originally intended for formal peer review journals in a very specific field, particle physics. Such a discussion there would have been unnecessary and edited out by journal editors. Now that these articles are hosted by this scientific research and development web site, there is a different audience of readers other than academic physicists. These articles were not intended for other journals whose intent is not only to convey some new information but also to "popularize" some specific subject matter. That is to say these articles have not been "dumbed down". The mathematics and science are still there. My readers still need to have some minimal technical, scientific, mathematic, or engineering background and a minimal understanding of calculus, chemistry, and physics. But minimal understandings are all that are necessary. No advanced degree, and certainly no degree in physics is necessary to read and follow the discussions in these articles.

WHAT IS A LEPTON

Leptons and photons are elementary subatomic particles. They are from the world and size realm of the physicists. This is many orders of magnitude smaller than the realm where the elements of chemistry are found. And that in tern is of course many orders of magnitude smaller that the consensus world realm which we humans inhabit. The lepton family is comprised of the well known electron and its two bigger but highly unstable brothers, the muon and tau. The photon is of course a single or discrete electromagnetic wave. We are all familiar with visible photons when we turn on a light switch or invisible ones when we open a cell phone. There are several good publicly available primers at web sites which describe the features found in this subatomic realm of the particle physicists. These can be found at the following two sites (plus many more).

www.Wikipedia.org, any and all of the search words; neutrinos, leptons, quarks, photons, elementary particle, etc at this site will give an essential part of the picture.
www.Particleadventure.org, has a wonderful pictorial chart.

The explanations and organization of this subject matter given at these web sites is quite sufficient to orient the reader as to what is being discussed in my papers. Never-the-less, I wish to also present my own organization of this subject matter. For example, in the web sites listed above a person will find that particle physicists tend to lump the neutrinos together with the charged leptons. You will find that I have separated the two groups or classes, only ascribing the name lepton to the electron, muon and tau. You will also find that the physicists tend to use their own vocabulary to segregate themselves from the other scientists, particularly from chemists and biologists. For example, an individual type of elementary particle, in my papers I simply call it an elementary particle, a variety, or a species (more in line with biological thinking). Whereas physicists call an individual type of elementary particle a flavor. Don't try to eat them, you will get a stomach ache. Likewise a group of similar type particles, as might appear in a column of a periodic table, I refer to these as a group (like chemistry), a class, or a family. Physicists are more fascinated with what would be a row across a periodic table, calling it a generation.

Unlike the Periodic Table of the Elements of Chemistry which has over 100 elements, there are only a few basic or elementary particles in physics. According to how a person counts and categorizes these basic physics "objects" there are only from 22 to 34 of them. To orient my reader, Table 1 below shows a very small selected cut taken from the Periodic Table of the Elements. The emphasis here is to refresh the reader about this Periodic Table of Chemistry, some of its key features, the hows and whys of its organization. Then in Table 2 further on, you will see an arrangement of the elementary particles of physics. Table 2 is a proposed Periodic Table of The Particle of Physics. The emphasis of Table 2 is of course to build on or bridge from the organization in Table 1. These two tables again are quite adequate to orient the reader as to the subject matter of my papers.

THE LONG VERSION

For those readers for whom high school science classes might have been a long time ago, I offer a brief refresher.

Chemistry – Molecules, Atoms, Nuclei, and Electrons

At a small enough scale, all material in the physical world consists of molecules. Molecules are the basic repeating building blocks of all large bodies of solid matter. For example; minerals within rocks, single strands of polymer, the smallest internal parts of cells, and the basic blocks within the atmosphere all can be identified as distinct molecules. Molecules in tern consist of distinct ordered combinations of the elements of chemistry. If proper precautions are taken, molecules can be isolated and their exact sequences of chemical elements can be identified. All molecules of the same type exhibit the same physical properties and reaction behaviors. For reactions of the same set of molecules, conducted under the same conditions, the reaction products are always the same. For those reactions which produce a multitude of products, the ratios of the various products are always the same.

Repeating the discussion of the molecules at yet a smaller scale, we have the elements of chemistry. These elements combine to make the molecules. The elements like the molecules can be isolated. Atoms of the same element all have the same physical properties and show the same reaction behaviors. For a long time during the development of the science of chemistry the individual atoms of the elements were viewed as the smallest distinguishable building blocks of the physical universe. At the scale of existence of humans this is still true, that the atoms of the elements of chemistry are the basic building blocks of any practical relevance.

Some of the chemical elements, such as gold, occur in nature in their elemental form and have been known by humans for thousands of years. Some can be isolated easily and some are readily accessible due to their abundant presence on the surface of the earth. Overall there are about 91 elements which occur naturally and are accessible to humans on or in the upper crust of the planet. Most of these were first isolated in the 1700 and 1800's with the development of the science of chemistry. There are a few holdouts due to either their scarcity or to their chemical similarity to other elements with which they are found. These required some of the more sophisticated techniques or modern hardware of the first part of the 20th century to be isolated and their existence verified. The remainder of the actual 100+ elements are radioactive and have long since decayed away in nature. The only existence of these radioactive elements now are those quantities produced by humans from nuclear reactions.

With the discovery of dozens of elements the obvious question arose. "How can this be", that the basic building blocks of the physical universe come in dozens of different forms? Why is it that many these supposedly most elementary of all forms come in varieties which essentially duplicate the properties of some of the others? Why do many of the elements have similar physical and/or chemical properties? Why do some combine with others one way but yet others apparently refuse to combine that way? During the 1800's Mendeleyev proposed a solution to these mysteries.

Again we have size regression. The atoms of the elements of chemistry obviously are not the most elementary or basic building blocks of the physical universe. After some high level disputes amongst the early chemists, it became obvious that the atoms were not indivisible. The atoms have a core (nucleus) which retains or carries the identity of the atom. And there is a "surface" feature, the electrons, which can leave the atom and go off to combine with other atoms. The nucleus of the atom is responsible for almost the entire mass of the atom and some of the other physical properties related to this "weight". The surface electrons which can come and go determine most of the physical and chemical properties of the atom. Mendeleyev proposed a Periodic Table in which the various elements with similar properties were just repeating heavier members of the same families. Mathematicians and the early physicists helped show why these properties repeated.

Thus slowly a "full" picture developed. The nucleus of atoms consisted of charged particles, protons, and neutral particles, neutrons. The protons needed particles to balance the overall charge of the atoms. These were the electrons which "flew" around the outside. The Periodic Table of the elements was arranged based on the count of the number of the protons in the nucleus of the atoms. Although the presence of the neutrons helps in determining the mass of the atom, the distinctness of an atom in terms of physical and reaction properties is determined by the interplay of the charged particles, the protons and the electrons. Thus, the elements in the Periodic Table were named or distinguished according their number of protons. Thus for example, calcium element number 20 has 20 protons and 20 electrons. Thus the success of the Periodic Table, 90+ elements could be reduced to combinations of 3 even more elementary subatomic particles, electrons, protons, and neutrons.

What the mathematicians helped show was how and why certain numbers of surface electrons behaved as they did. They developed the mathematics of the electrons as wave patterns or shells around the exterior of the atoms. How these energy patterns repeat as they do can directly be linked to or explained as discrete solutions to mathematical equations. These equations have been formulated to precisely model the nature of the different atoms with their varying number of protons and electrons. These mathematical models have been overwhelmingly demonstrated to be the correct models. This knowledge is all that modern chemists and chemical engineers need. On a practical level, all we care about is the repetition of certain chemical properties as we go from row to row in the Periodic Table. To the chemist and chemical engineer it is the understanding and manipulation of the elements for their desired properties that is important. This knowledge creates all the wonderful stuff with which we in modern societies are familiar.

In Table 1, a selected cut from the Periodic Table of The Elements of Chemistry is shown. The usual presentation of the Periodic Table has been rearranged to emphasize analogies found for the leptons. Also shown are examples of what chemists clearly know to be compounds or composites of the basic elements. Again this is to compare / contrast with how the physicists currently think about the basic building blocks with which they deal.

One of the main purposes of the presentation in Table 1 is to show the increasing mass of the elements with each row as we go downward in the Periodic Table. The numerical values listed with each element are their atomic weights. As just discussed, this increasing mass is almost totally determined by the nucleus of the element, and has little to no dependence on their exterior electron shells. But it is the electron shells which give the elements their chemical properties that are of importance to chemists and chemical engineers. The compressed notation for these electron shells and their mathematical formulations usually appear in most Periodic Tables. Here on the left of the abbreviated version, Table 1, only the key or highest S shell is shown. All the underlying shells are identical and do not need to be repeated. The other upper shells such as P and D shells are intentionally not shown here. The mathematics of the S electron shells are such that these shells are described radially outwards by their corresponding Laguerre $L_n(r)$ orthogonal polynomial. That is the 3s electron shell is mathematically described by the L_3 orthogonal polynomial.

The importance of this whole layout is to show how the mathematics of this chemistry Periodic Table, specifically that of the S electron shells and their descriptor $L_n(r)$ orthogonal polynomials, increase "coincidentally" with the increasing mass of the elements. This same relationship was found for the column of the three leptons.

TABLE 1

PERIODIC TABLE OF THE ELEMENTS OF CHEMISTRY

SELECTED ELEMENTS – REARRANGED ORDER

Group	O	I	VII	II	VI	III	V
Key Valence	0	+1	-1	+2	-2	+3	-3
Key Shell 2s	Neon 20.183	Lithium 6.939	Fluorine 18.9984	Beryllium 9.0122	Oxygen 15.9994	Boron 10.811	Nitrogen 14.0067
Key Shell 3s	Argon 39.948	Sodium 22.990	Chlorine 35.453	Magnesium 24.312	Sulfur 32.064	Aluminum 26.9815	Phosphorus 30.9738
Key Shell 4s	Krypton 83.80	Potassium 39.102	Bromine 79.909	Calcium 40.08	Selenium 78.96	Gallium 69.72	Arsenic 74.992

EXAMPLES of COMPOSITES

Binary Compounds – Homogenous	H_2, O_2, N_2
Binary Compounds – Heterogeneous	HF, NaCl, KI, CO
Ternary Compounds – Stable	H_2O, CO_2, N_2O, HCN
Ternary Compounds – Unstable, nonexistent	HO_2, C_2O, NCN
Complex Forms – Stable in isolation	NH_3, CH_4, V_2O_5, CH_3-CH_2OH
Complex Forms – Unbalanced cannot be isolated	NO_3-, NH_4+, CO_3-
Temporary, Reaction intermediary, High energy	CH_3O-, $CH_3C(OH)_2$+, $C(CH_3)_3$+

Nuclear Chemistry – Isotopes and Their Reactions

The number of neutrons in the nucleus of atoms can vary since these particles "don't do anything" except keep the protons from getting in each others way. Lower down in the Periodic Table the number of neutrons never varies beyond some number slightly greater than or slightly less than that of the number of protons. In general across the whole Periodic Table the ratio of the neutrons to the number of protons in an element's nucleus is approximately 1.4 neutrons to 1 proton.

A quick definition is needed. An isotope refers to the total number of protons plus neutron found in the nuclear core of an element. For example, element number 92 Uranium has 92 protons, but it can also have several isotopes due to different number of neutrons present with the 92 protons. Thus we have ^{235}U (92 protons plus 143 neutrons), ^{238}U (92 protons plus 146 neutrons), etc. Probably the three other best known nuclear isotopes are those of hydrogen. Hydrogen ^1H just has a single proton for its core. ^{2}H or deuterium has a single proton and a neutron. Deuterium is naturally occurring and stable. Finally ^{3}H or tritium has a single proton and 2 neutrons. Tritium is unstable. With the advent of 20th century technology, people not only isolated the distinct chemical elements, they began isolating the several isotopes of each element.

Historically the overall puzzle still was not complete. Now the obvious question became why 91 or so naturally occurring elements? Why not less or more? Why doesn't the Periodic Table go on forever? Why, what is this radioactive thing? The first answer is philosophical. The number of elements terminates because everything in the physical universe terminates, has boundaries, or limits. Nothing physical goes on forever. Only conceptual mathematical sequences can be viewed as infinite. So how in this specific case does the number of distinct elements terminate? The short, simple layman's answer is; because the nucleus of the atoms gets so big that "it falls apart under its own good looks".

The long answer to these questions is the same. The nucleus of the atoms, all above the first one, hydrogen, contain an increasing number of protons "packed" in a very tight space. Since all the protons are alike and have a positive charge, they "don't like each other" no more than do bull elks in the same meadow. We again have repetition. The nuclear cores of the atoms have an organization, structure, or layers of their own, similar to the electron shells around the outside. The neutrons mixed in the nuclear core of the atoms keeps the protons somewhat insulated from each other. Thus the whole nuclear core doesn't instantly come unglued as the protons try to get away from each other. Ultimately though with a large enough nuclear core nothing can save it. About where we reach element number 90 Thorium and 92 Uranium the nucleus of these elements start self destructing. Thus the radioactive thing.

Historically people didn't stop with just isolating the different isotopes of the elements, they began investigating the reactions of the different isotopes. That is reactions that happen with the nuclear core of the elements, as well as the chemical reaction behaviors of the surface electrons. People began exposing the various elements of the Periodic Table to the radiation, alpha particles, emitted during the natural decay of the two native radioactive isotopes of Th and U. Additionally, it is relatively easy to produce protons by simply stripping off the only surface electron from the hydrogen nucleus. Protons and electrons due to their electrical charge both can be accelerated and focused with electromagnets, and thus bombarded into selected target materials. Eventually researchers learned to make just about anything radioactive. Thus "artificial" radioactivity. Each isotope of each element behaves differently after ingesting excess particles into their nuclear core. Some restabilized themselves by emitting electrons or positrons discussed shortly. Some spit out neutrons or just regurgitated alpha particles. Thus researchers during the 1900s learned to make designer elements, isotopes with nuclear cores intended for some specific purpose.

Chemists and physicists rapidly identified several modes of radioactivity. Low down in the Periodic Table, wherever there are nuclear instabilities, the nucleus of the atoms try to stabilize themselves by ejecting particles. Neutrons can disintegrate or decay into protons which have slightly less mass. This reaction process ejects beta particles, fast electrons, which keep the net reaction balanced electronically. Protons can capture incoming fast electrons and turn into neutrons. Protons which pick up enough energy can turn into neutrons and spit out positron particles, fast anti-electrons, which keep the overall charge of the reaction balanced. There are several such simple reaction schemes of a single particle splitting into two major pieces plus some left over energy. Or equally, reactions of two particles combining with enough energy to become one. In all such reactions which occurred at this subatomic or nuclear scale the net result of the whole reaction was such that the sum of the charges of the reactants plus the products always remained balanced. That is, after the reaction there was no net change in the charge of the system (or the universe) compared with before the reaction. With these as the only observed reactions, scientists automatically concluded or made up a law of conservation of charge.

At the high end of the Periodic Table, the heavy elements show a different behavior. The nuclear cores of these elements, just like top heavy modern corporations, start downsizing. These elements spit out pairs of protons and neutrons, alpha particles or helium nuclei. The two naturally occurring radioactive elements ^{232}Th and ^{235}U do exactly that. Thus we find that there is nothing magical, inherently sinister, or cursed about uranium. Uranium is just another metal like all the rest with which we are familiar. One of its natural isotopes just happens to have an unstable nucleus.

Early on there was another objective to nuclear research. That was to make a self sustaining nuclear reaction. Elements which spit out excess neutrons became the working tools for this endeavor. People first used the two natural radioactive elements to make other elements unstable or radioactive. This is not too difficult with the elements at the bottom of the Periodic Table which already have quite bulky nuclei. These man made radioactive isotopes of various elements were "designed" to be neutron emitters. The neutron emitters were used in turn to overdose the ultimate objective element with neutrons until it went unstable. These neutron processes rather than being done in accelerators as discussed above, were done in small nuclear research reactors. People found that if some of the almost unstable isotopes of various elements were bombarded with enough neutrons, that dramatic things happened quickly. For example, ^{235}U went completely unstable and totally disintegrated or fissioned. Since such reactions release vast amounts of energy which had held together the organization of the nuclear cores, we have BOOM, nuclear bombs or nuclear power production. Thus the World War II scientific effort of the United States to produce a nuclear bomb via fission was successful.

Humans also quickly reasoned how the sun works to produce the heat that it does. If enough protons and neutrons are packed together tightly enough, under enough pressure and at high enough temperature, then the hydrogen nucleus, a single proton, combines (fuses) with another proton and two neutrons to become the stable helium nucleus. Since humans could not create a controlled sun on the earth, they "cheated" in the process. They used lithium hydride LiH which is a stable and solid compound, rather than just straight gaseous hydrogen. Except they used lithium which had already been supped up with an extra neutron and tritium which had been produced ahead of time from hydrogen or deuterium. Just as with the efforts to create self sustaining fission reactions, people again used materials which had been overdosed with neutrons to try to make fusion reactions. This process of upgrading nuclear cores into larger ones, fusion, as done in suns also results in large heat releases. Again BOOM, humans created hydrogen bombs. But as they found out to produce the energy and conditions necessary to get fusion reactions to light off, the output of fission reactions was required. Thus the World War II scientific effort of Germany to produce a nuclear bomb via fusion was not successful. People still have not yet been able to build sustainable, meaning controllable, fusion devices for power production or any other purpose.

There are many web sites which discuss the isotopes, radioisotopes, decay modes, half lives, etcetera. Several starters suggested are:

www.webelements.com
http://ie.lbl.gov/education/isotopes.htm
www.iaea.org/inisnkm/nekr/indr/subjects/index.html

Particle Physics – Hadrons, Baryons, Mesons, Quarks, Leptons, Neutrinos

This is about where chemistry and physics part company. As it turns out people found that neutrons are always "slightly" unstable and ultimately always decay. They do not have to be in nuclear cores to fall apart or self destruct. Again we have the question, how is it that one of the ultimate building blocks of the universe can fall apart? Many more questions also naturally arise. How is it that protons and neutrons have almost identical masses, only different by about 1 part in 1000? Why not totally identical or widely different? Why are protons charged and neutrons neutral if they are almost identical siblings by mass? Why do the protons and electrons, which have exactly the opposite charges, have such radically difference masses. The proton is almost 1836 times more massive than the electron? Why do neutrons decay into protons and not totally fission and fall apart into a myriad of smaller subcomponents?

Physicists during the early part of the 1900s learned that the protons and neutrons obviously could not be ultimate building blocks of the physical universe, or at least not the only ones. With the development of particle accelerators and colliders during the mid to late 1900s, particles of smaller masses, electrons and positrons (anti-electrons), were smashed together. Some of these collisions produced slightly stable or even highly unstable but clearly distinct particles of large masses. By the late 1900's people had produced a whole zoo of odd short lived particles, dozens, even hundreds. Again as with chemistry only certain collisions or reactions appeared to produce product objects, larger particles. The vast majority of the collision reactions just resulted in the destruction of the colliding particles and the production of energy. In some cases this energy was carried away in the form of distinct smaller particle-objects, neutrinos.

Again many questions arose. First, how can there be this many "elementary" subatomic particles. There developed a great fascination of how different species of these basic particles could transmute into each other. Reaction rules and various conservation laws were again proposed. Also there appeared to be whole classes of particles which responded to a new or different force not seen at the size realm of chemistry. Thus the color force was added as a basic force of nature, to the two already known gravitational and electromagnetic forces. Particles, subatomic entities, responding to or possessing this force were called hadrons. These hadrons include the proton and neutron. The leptons and neutrinos do not respond to or possess this color force.

Again we have size regression. The confusion of a multitude of hadrons was reduced by proposing yet even smaller basic building blocks. Murry Gell-Mann and Richard Feynman introduced the quarks as subconstituents of the hadrons. This proposal did an excellent job of bringing order to the hundreds of hadrons. These quark particles come in two basic varieties, the up (u) and down (d). Each has several more massive family members. Thus the quarks are in many ways analogous to or could be lined up in two columns similar to the elements of the Periodic Table of Chemistry. These quarks combine in twos and threes, apparently according to certain rules. The dozens of mesons (binaries) and hundreds of baryons (ternaries) are now understood to be composites or compounds of the more basic particles, the quarks. These compounds now are understandable as the physicists' analogies to the simple compounds of chemistry, such as N_2 and CO_2. Specifically the proton is composed of two u's and one d, (u_2d) just like H_2O. The neutron is composed of one u and two d's, (ud_2). The neutron is also unstable just like the counterpart HO_2, except that HO_2 is so unstable that it effectively doesn't exist at all. The upper members of the quark families and all the composite mesons and baryons, with the exception of the proton and neutron, decay very quickly. Thus what can be called a stable particle or a composite physics molecule is somewhat nebulous.

This success of reducing many elementary objects to a few was short lived and only partially complete. Some of the several conservation laws that humans had made up were being violated. Particles of small masses were being smashed together to produce temporary high energy reaction intermediaries, such as the "weak force" particles and many others. Because of the short lives of all the reaction products, the distinction between an elementary particle, a composite, and a temporary high energy reaction intermediary had blurred. Some of these reaction intermediaries were decaying in manners which violated the rules. The success of the idea of a sub-sub-atomic quark had explained the production of hadrons but had not explained itself. Now there are still too many basic or elementary particle-objects. There are at least 6 quarks (not counting anti-quarks), the 3 leptons (not counting anti-leptons), and the 3 neutrinos and their anti's. This was again getting to be irritating. The physicists basically had a small Periodic Table of Elementary Particles; 1 column of neutrinos, 1 column of leptons, and 2 columns of quarks. But they again had no explanation for how come there were so many of these, the most "elementary" of all building blocks of the physical universe. They had no explanation for why these building blocks had the properties that they did, particularly their highly disparate masses. And that is about where progress in subatomic particle physics stopped, 30 years ago. Physicists did not have the ever more powerful machines required to do further experimentation, particle smashing. Equally they did not have any satisfactory framework, (correlative, theoretical, or any other logical modality), to explain the information which they had already obtained.

Table 2 shows a listing of the elementary particles of physics. This table is organized to appear like the previous table which showed the elements of chemistry. The chemistry Periodic Table has Group O elements which have a zero "valence", or a preferred charge state of 0. The physics Periodic Table has those particles which have 0 charge, the neutrinos. The neutrinos only respond to gravity and thus presumably only encapsulate gravitational energy or only stabilize the gravitational force. The Periodic Table of the Elements has two columns of elements, Groups I and VII, whose preferred valences are +1 and -1 respectively. The Periodic Table of the Particles has a single column of particles, the leptons, which can be found in forms with +1 or -1 charge. The leptons respond to two forces, gravitational and electromagnetic. Thus presumably these particles stabilize these two forces as encapsulated energies or wave patterns. The two papers at this web site contain discussions of exactly this, the mathematical nature of the distinct gravitational and electromagnetic waves found for the leptons. Finally the Periodic Table of Elements has two columns, Groups II and VI whose preferred valences are +2 and -2, and two columns, Groups III and V, whose preferred valences are +3 and -3. These have less precise analogies in the Periodic Table of the Particles. There we find one column whose particles can be found in forms carrying either +2/3 or -2/3 charge, and one column whose particles can be found in forms carrying either +1/3 or -1/3 charge. Both columns of these fractionally charged particles, the quarks, respond to three forces; gravity, electromagnetism, and color.

Of course Table 2 is more complicated because it is conveying more information. But amongst all the rest of the facts the primary purpose is similar to that of the previous table. That is to show how the leptons have increasing mass directly related to an increasing Laguerre orthogonal polynomial number. That is the core finding of the research presented in the papers at this web site. The numerical values listed with each elementary particle are their masses (kg) or mass-energies (MeV/c). Not all the information shown in Table 2 is fixed or "set in concrete". For example, the neutrino masses listed are according to Wikipedia. According to Particle Adventure these masses are as follows υ_L mass $< 2.3 \times 10^{-37}$ kg, υ_M $1.6 \times 10^{-38} < m < 2.3 \times 10^{-37}$ kg, υ_H $7.1 \times 10^{-38} < m < 2.5 \times 10^{-37}$ kg.

Additionally there are many other complications of the physics particle picture which were not shown. One of the key ones being the property or concept of particles and antiparticles. All the particles responding to the electromagnetic force can come in two varieties; the particle -1, +2/3, or -1/3, or the antiparticle +1, -2/3, or +1/3. The antiparticles are designated by over bars. The best known antiparticle is probably the "anti-electron" or positron with a +1 charge, exactly opposite of the electron with a -1 charge. The neutrinos also have their anti version but this only involves a matter of their spin. The individual colored particles, the quarks, can come in three colors; red, green, or blue, but these colors are never seen in public. They always hide to make white, clear, or neutral color when compounded together to make the mesons and baryons. And just like charge can come in two varieties a plus or a minus, the colors can also have their anti varieties; antired, antigreen, and antiblue.

Lastly in Table 2 we find particles which have no analogies in the world of chemistry. These particles, the Bosons, are the "carriers" of the forces. These could be better described as moving but never-the-less stable wave forms or patterns. The Fermions, the neutrinos, leptons, and quarks just discussed are of course not stationary, but the energy wave forms that these particles are, appear to be bounded in all spatial dimensions. They, or at least the leptons, only move in space with time. Whereas the "carrier" Bosons appear to be wave patterns that are inherently unbounded in at least one spatial dimension. That is they can be described by mathematical forms which are open ended, rather than closed forms like the Fermions. It is within this general category, the Bosons, that we find the photons. These are the compliment to the leptons of the greater Fermion category in that both leptons and photons respond to both gravity and electromagnetism. The second paper at this web site shows that there is probably strong reasons for this correspondence. The mathematical descriptions discussed in this paper show that both classes of particles, the leptons and photons, have many underlying mathematical commonalities.

We have several more confusing items or "particles" in the world of physics. These are the "carriers" of "the weak force". These weak force particles are some sort of reaction product found in certain specific high energy collisions of other lighter particles. Like all the high energy collision or reaction products, the "weak force" bosons are extremely short lived even by physics standards. Thus whether we designate them as elementary particles, or as some sort of temporary composite wave forms which could be viewed simply as high energy reaction intermediaries is almost a matter of semantics. My opinion is that these wave form objects do not really represent a fundamental force or are not really "elementary" particles.

If found at the world distance and reaction time scales of chemistry, the "weak force" particles would be viewed as some not very useful nor important temporary reaction intermediary. We could find analogies in the unstable molecule (radical) CH_3O- or some short lived combustion intermediaries found in the burning of sugar $C_xH_yO_z$ to produce carbon dioxide CO_2 and water H_2O. Chemists know that the radical CH_3O-, sugar $C_xH_yO_z$, carbon dioxide CO_2, and water H_2O etcetera are not the source of carbon C, hydrogen H, and oxygen O. Rather it is C, H, and O which combine in stable configurations to produce these larger molecular entities. Again we have semantics in the physics analogy. Do we have the neutrinos, leptons, and quarks temporarily combining when smashed together under just the right conditions to produce (become the source of) the weak force particles? Or are the decaying weak particles the ultimate source of all neutrinos, leptons, and quarks? Philosophically this is a which came first argument, the chicken or the egg. In any case this discussion has no relevance to the subject matter of my papers but is only presented here because the reader will find such particles in the public literature and the two web sites listed much earlier.

Finally Table 3 gives a very simple listing of the basic forces themselves. This is added since physicists work with and discuss the "free" forces when they are not stabilized as some particle or wave form of energy. The listings of the nature of the spatial dimensions involved with the particles in Table 2 and with the forces in Table 3 are of course my own viewpoints.

TABLE 2
PERIODIC TABLE OF THE PARTICLES OF PHYSICS

ELEMENTARY PARTICLES – FERMIONS

"Stationary" Particles (closed wave patterns), Originators & Receivers of Forces, Spin = 1/2
Wave patterns which are mathematically bounded in all spatial dimensions

Particle Group	Neutrinos	**Leptons**	Quarks	
Charge	0	± 1	± 2/3	± 1/3
Forces "Held"	Gravity	G + E/M	G + E/M + Color	
Spatial Dim.	1 probably: radial	2; 1 radial + 1 angle	3 probably; 1 radial + 2 angles	
Laguerre Poly. $L_0(r(t))$	υ_e or υ_L mass < 3.9×10^{-36} kg	**electron e^-** $9.109{,}389{,}7 \times 10^{-31}$ kg	up (u) 1.5-4 MeV/c^2	down (d) 4-8 MeV/c^2
Laguerre Poly. $L_2(r(t))$	υ_μ or υ_M mass < 3.0×10^{-31} kg	**muon μ^-** $1.883{,}532{,}7 \times 10^{-28}$ kg	charm (c) 1,150-1,350 MeV/c^2	strange (s) 80-130 MeV/c^2
Laguerre Poly. $L_4(r(t))$	υ_τ or υ_H m < 2.76×10^{-29} kg	**tau τ^-** $3.167{,}88 \times 10^{-27}$ kg	top (t) or truth 170,900 ± 1,800 MeV/c^2	bottom (b) or beauty 4,100-4,400 MeV/c^2

EXAMPLES of COMPOSITES

Compounds (Hadrons) of Colored Elementaries (Quarks)

Binary Compounds (Mesons) – Homogenous; $\pi^0 = (u\bar{u} + d\bar{d})$ or $s\bar{s}$

Binary Compounds – Heterogeneous; $\pi^\pm = d\bar{u}$ or $\bar{d}u$, $K^0 = d\bar{s}$ or $\bar{d}s$, $K^\pm = u\bar{s}$ or $\bar{u}s$

Ternary Compounds (Baryons) – Stable; proton = u_2d, analogous to H_2O

Ternary Compounds – Metastable, Unstable; neutron = ud_2, analogous to HO_2

ELEMENTARY PARTICLES – BOSONS

"Moving " Particles (open ended wave patterns), "Carriers" of Forces , Spin = 1
Wave patterns which are open or unbounded in at least 1 spatial dimension

Particle Group	Gravitons?	Photons (1)	Gluons (8)
Force "Carried"	Gravity	Electromagnetism	Color
Comments	Do not have mass spin = 2	Do not have mass Do not display charge	Do not have mass Have or display color

EXAMPLES of COMPOSITES

Complex Form, temporary high energy reaction intermediary; "Weak Force" Carriers W^+, W^-, Z^0

TABLE 3
THE FUNDAMENTAL FORCES

Force	Gravity	Electromagnetism	Color
Force Nature	Unary; G	Binary; E & M	Ternary; red, green, & blue
Encapsulated or Stabilized Form	mass Kilograms	charge Coulombs	color Whites (neutral, clear)
Spatial Strength	Inverse Square Decay w Distance	Both Have Inverse Square Decay	Non-Inverse Square Decay with Distance
Temporal Strength	Unknown Decay Modality with Time	Unknown Decay Modality with Time	Unknown Decay Modality with Time
Nature of Spatial Dimensions of Waves	1 Dim – radial	2 Dim - planar for pair. Electrical – radial Magnetism - angular	3 Dim probably - spherical for set. 1 – radial form + 2 angular forms

SUMMARY – CONCLUSIONS

Returning to the objective of this primer, the purpose of this primer was to set a frame or context for the "objects" of discussion, leptons and photons, found in the two papers at this web site. Thus we have seen how these sub-sub-atomic particles fit in the broader picture of the basic building blocks of the physical world. The leptons are one family amongst the several of the most elementary particles now known to humans. The first paper at this web site clearly shows how these particles can be described as being some manner of standing energy wave forms. The photons already have long been known to be moving wave forms of energy.

All the discussion in this primer of the atoms of chemistry, isotopes, and subatomic entities was only given as a path to orient the reader. An in depth knowledge or thorough understanding of this broad sweep of material is NOT necessary to read, follow, and understand the discussions in the papers found at this web site. I invite the reader of this primer to now go on to the formal articles at this web site. I think you will find them to be simple and yet precise to many decimals. You should find the material in these two papers to be an exciting totally new approach to particle physics.