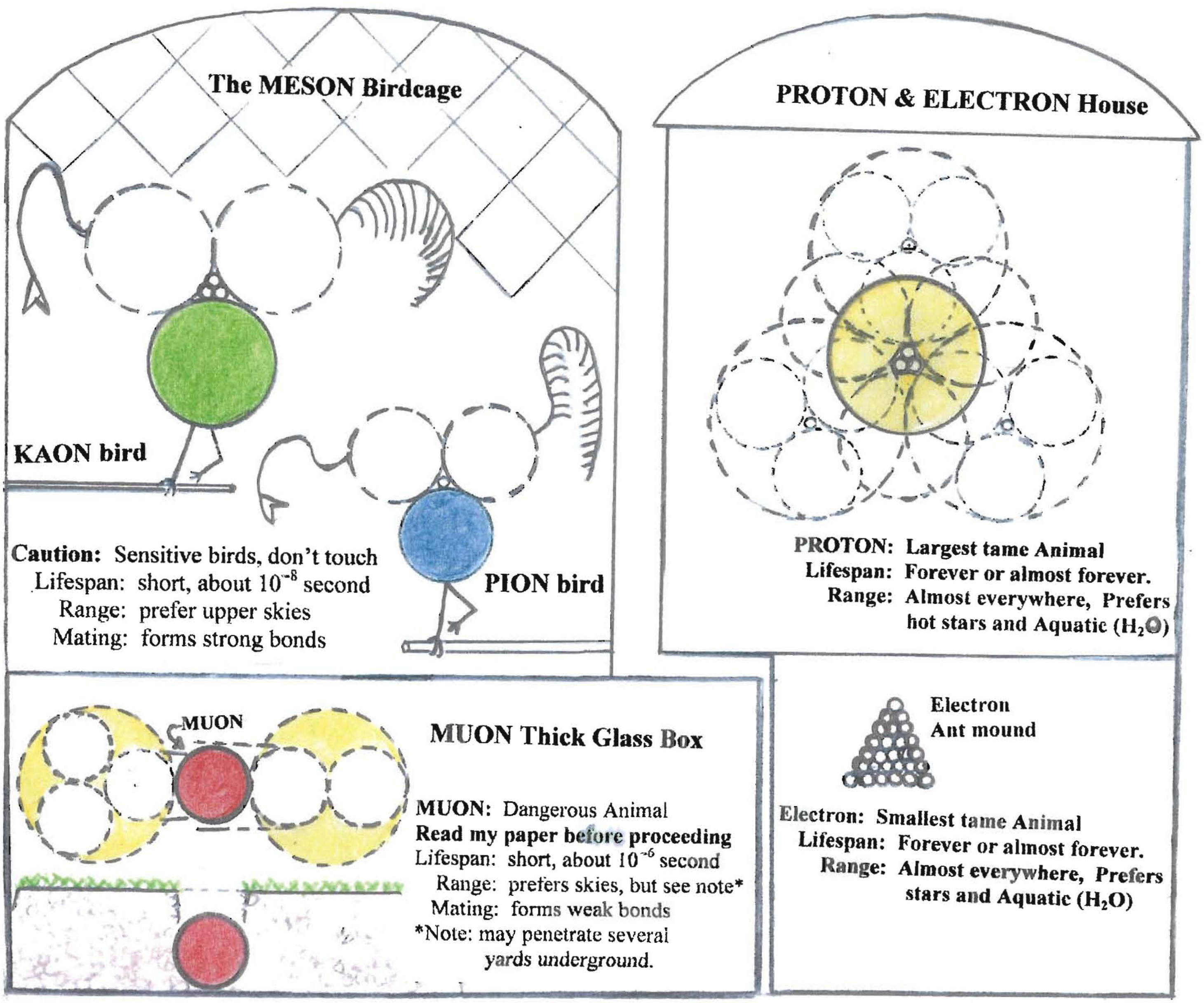
Particle Mass Ratios and Similar Geometric Volume Ratios

. . . The different sized animals in the physics 'Particle Zoo' . . .

A simplified treatment by Carl R. Littmann 1-8-2010

"**Particle zoo ...** From **Wikipedia**, the free encyclopedia Jump to: navigation, search
.... In particle physics, the term **particle zoo** is used colloquially to describe a relatively extensive list of the known elementary particles that almost look like **hundreds of species in the zoo.**"

Welcome to the **PARTICLE ZOO**: Children's Section:
Only Animals with the simplest simplex structure allowed



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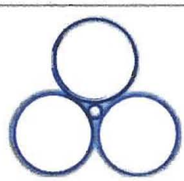
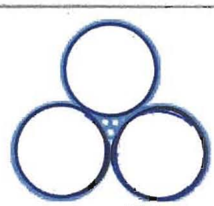
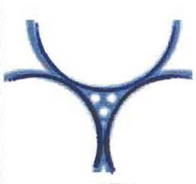
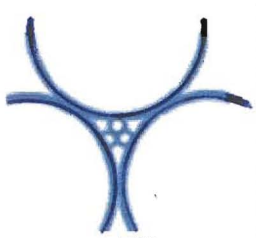
ABSTRACT: In physics, there are various important particles with different masses. And in geometry, there are various important patterns with different volumes. In the tables below, we show important cases where some particle mass ratios are nearly equal to some spherical volume ratios in basic geometry. After first displaying each applicable table below, along with a basic description; we will later discuss all tables and contents in more detail.

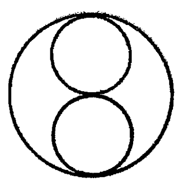
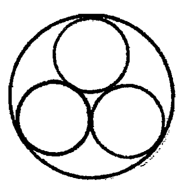
TABLE I (Cases showing spheres surrounding spheres; and where the volumetric sphere ratio nearly equals the particle mass ratio**:** Cases involving the pion, kaon, proton, and electron.)

Geometric Pattern (Centers of all spheres coplanar)	(See Pattern) **Volumetric Ratio**	(Important Particles) **Ratio of Masses**	**ave. Mass Ratio**
 case 'A' R/r = 6.4641/1	1 large sphere to 1 small sphere (centered in the pattern): **270.10/1**	pion$^+$ or pion$^-$ to electron: 273.13/1, pion^o to electron: 264.14/1	**270.13/1**
 case 'B' R/r = 9.89898/1	3 large spheres to 3 small spheres (all 3 smaller spheres also same size) **970.00/1**	Kaon$_s^o$ or Kaon$_L^o$ to electron: 973.92/1 Kaon$^+$ or Kaon$^-$ to electron: 966.04/1	**969.98/1**
Close Up Views  case 'B' R_1/r =9.89898/1 &  case 'C' R_2/r =13.9282/1	$[3R_1^3 + 3R_2^3]/6r^3$ = **1836.00/1,** i.e. 6 equal small spheres with radius r; 3 intermediate size spheres with radius R_1 as in case B; and 3 large spheres with radius R_2 (case C)	Proton (or antiproton) to electron: **1836.15/1** Neutron (or antineutron) to electron: 1838.68/1	**1837.42/1**

In the above Table I, the mass ratios for the pion and the kaon particles (relative to an electron mass) were calculated very simply and directly. But the proton particle mass ratio was calculated by averaging two related, compelling patterns – a method not quite as direct.

In Table II, below, we also calculate the muon to proton mass ratio by averaging two related, compelling patterns. That pattern analogy was 'discovered' somewhat later than those in Table I, because it involved the comparison of spheres inside of spheres, not the little spheres remaining outside the interior of larger spheres and only surrounded by several larger spheres. And unlike Table I, Table II involves comparing the muon mass (a particle with mass much greater than the electron) to a particle with even greater mass than the electron or the muon, i.e., the proton!

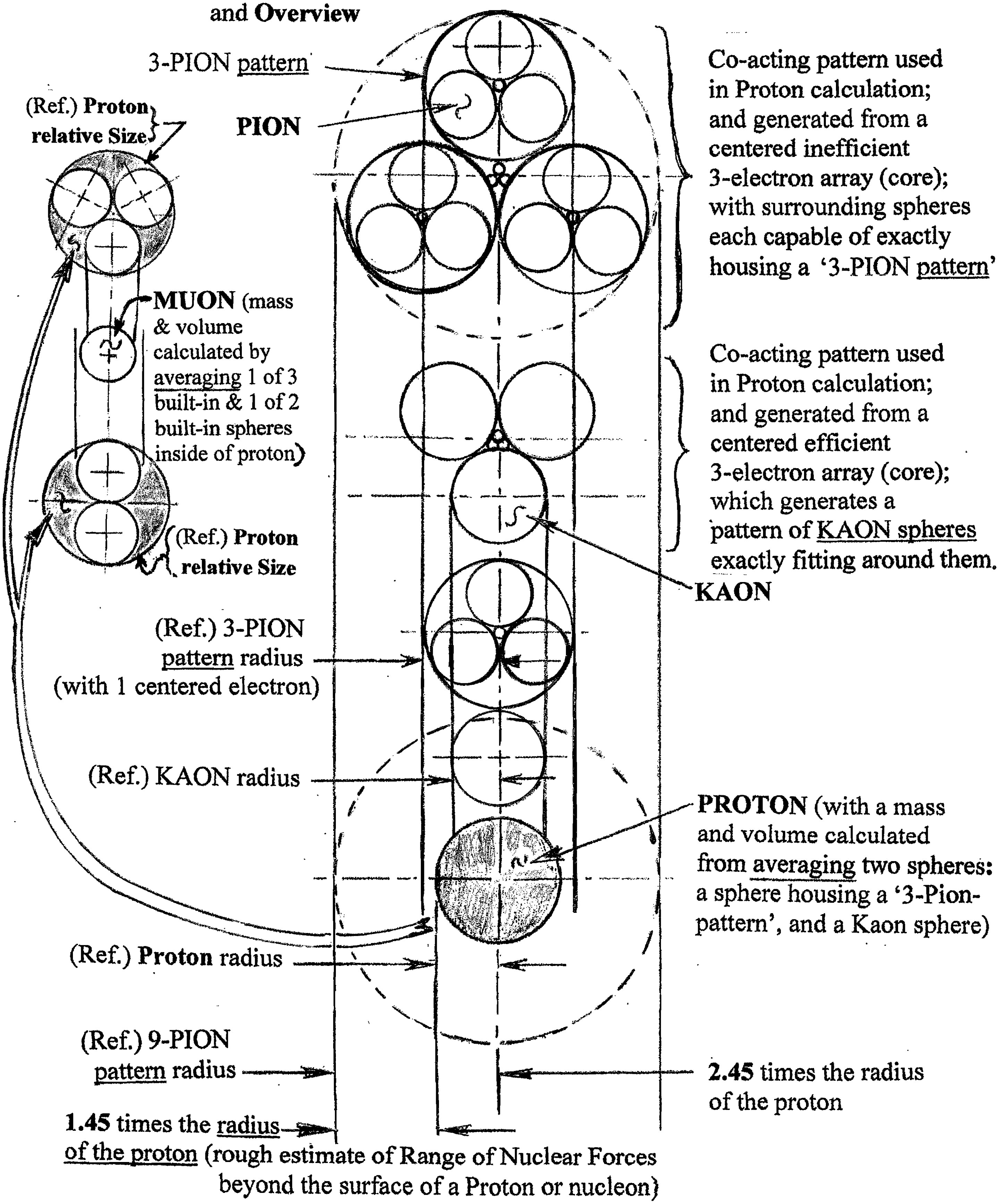
TABLE II (A case of spheres inside of spheres, and where the average of volumetric ratios is nearly equally to the muon to proton mass ratio.)

Geometric Pattern (Centers of all spheres spheres are coplanar)	(See Pattern) **Volumetric Ratio**	(Important Particles) **Ratio of Masses**
 case 'D' $r_1/R = 0.5/1.0$  case 'E' $r_2/R = 0.46410/1.0$	$1836.15\ [(r_1/R)^3 + (r_2/R)^3]\ [1/2]$ = **206.54**, i.e. 2 large, proton-sized spheres, each of radius R; and each proton equivalent to 1836.15 electron masses; and inside the first proton (see case 'D') are 2 equal small spheres of radius r_1, and inside the second proton (see case 'E') are 3 equal smaller spheres of radius r_2. (Note that the ref. 206.54 volume is compared to 1836.15 units of volume chosen for the large sphere for making comparisons)	Actual Muon or anti-muon particle with mass expressed in terms of equivalent electron masses: **206.77**, compared to the proton's 1836.15 electron masses

Note in the above calculations; we did compare the muon mass to the proton's greater mass by comparing modest sized spheres to a much larger sphere that they were entirely inside of. We just imagined, for making simple comparisons, that the large sphere contained, say, 1836.15 units of volume, since there are 1836.15 equivalent electron masses in a proton!

We now move on to Table III below for a helpful overview of the two previous tables and the general subject.

TABLE III **Visual Aids for some other Particle Relationships and for a rough estimation of the Range of Nuclear Forces and Overview**



Further Discussion of Tables and history behind them:

In all patterns presented in this paper; the spheres barely touch each other. And the patterns are somewhat analogous to 'close packing' of spheres.

Mathematically, a spherical Volume ratio is equal to the Cube of the ratio of their Radii.

In Table II, our muon mass estimate (206.54 times the electron's) is not quite the 206.77 empirical muon value, but only a fraction of an electron off. In fact, it would have been closer had we chosen for our large enclosing sphere, the neutron (which has 1838.68 times the mass of the electron) instead of the proton (which has 1836.15 times the electron's mass); i.e., or if we had we chosen some value between the proton and neutron. However, in our simple treatments, we attempt no specific 'doublet or dynamic or other refinement'; we leave the geometric result 'in the raw'. (Some scientists have attempted more refined, involved or complex treatments of some particles in this article, and may be of interest [3- 4].)

The particles presented in the tables above, the main subject of this paper, are so basic and of such great importance that their existence was established before 1950! During 1950, investigative equipment and methods advanced; and many more particles were discovered, and the masses of some previous particles were determined more precisely.

It seems appropriate to separate the Table II, for the muon, from Table I, for several reasons: Historically, the muon initially fooled the scientific community. It did not turn out to be classifiable as a 'meson'; and it had properties quite different from most particles [5]. Also, by constructing those analogies shown in Table I, we had 'used up' all the basic patterns involving 'spheres outside of spheres, i.e., spheres surrounding spheres, but **not** inside of them *[6]. Although that method had yielded good analogies for Pions, Mesons, and Protons;* there were simply no more basic patterns left there to try to match the muon. So recently, by resorting to 'combinatorics' involving spheres inside of spheres; I found a rather well fitting analogy for the Muon's mass! [7]

If, in Table II, we had attempted to closely fit 4 spheres inside the large sphere, by arranging those small spheres in a square-shaped planar pattern; a slippage or swiveling of small spheres out of the pattern would have occurred. And they would have all slip around, migrating toward a more efficient tetrahedral arrangement, and excess 'wiggle room' would have resulted. Of course, a 'swiveling around' might also occur for the closely packed two-sphere case and three-sphere case, but their sphere patterns and combinatorics would remains intact, and no wiggle room would result! (There is, of course, nothing wrong with an aesthetic close-packed tetrahedral layout of spheres – but that would be a more advanced complexity, i.e., a riveting up to a three dimensional non-planar layout in our simplest 'combinatorial game'.)

My present opinion is that (despite the super-success and usefulness of the tetrahedron and other advanced constructs in more complicated chemical and physics applications) – yet, at the most elemental level, 'nature' seems to prefer using the most basics patterns or 'simplices', (i.e., alternate spelling: 'simplexes'). That led to my "Children's Particle Zoo" theme.

In Table I, it can be shown by calculations that that 3-Pion pattern shown in case 'A' would *exactly* fit inside any one of the very large spheres shown in case 'C' in Table I. That is shown in greater detail near the top of Table III.

But the size of those large spheres was *originally* chosen using a simpler criterion: So that when each was directed inline with each touching electron in the 3-electron core (a most inefficient packing) – that those three large spheres would then barely extend around that '3-electron pattern'. (See Table I, case 'C'). However, it was also noticed, finally - many years later, that the '3-pion pattern' would also fit exactly inside each of those large spheres. Thus, *in hindsight, the largest '3-sphere pattern' could have also been generated by using 3 of the '3-pion pattern'.*

Where our analogy for an empirical particle required us to *average two* large spherical volumes, we also note this: The empirical particle represented does, in fact, have spin, i.e., the proton and muon each have 'spin ½ '.

For each particle analogy in this paper, at least one pattern, having *an equilateral triangular array* of spheres, was required. An eminent mathematician noted that an equilateral triangle exemplifies the simplest structure in two dimensions -- from a *combinatorics* viewpoint [8].

Notice the great extension of the largest pattern shown in Table III. It extends appreciably beyond the proton's surface. That pattern was one of the two we needed in our calculation of the proton mass; and that is also the pattern that can *exactly* enclose 3 sets of the '3-pion pattern'. It is interesting that H. Yukawa predicted the existence of a particle (later to be called the pion) to explain how one nucleon could extend its nuclear force to a distant nucleon -- 1.4 'fermi' distance away [9]. *Perhaps the '9-pion pattern' in Table III infers something like that.*

Very Important: Real particles seem to maintain their unique mass values for some time, as if they were largely determined by patterns in space -- instead of actually being wedged in on all sides by other real particles to constrain and maintain their size. It seems possible that 'space' itself may have 'structure'; perhaps even shifting between patterns. In his later years, Heisenberg serious entertained the concept of 'quantized space' [10]. (That is explored somewhat more in a more advanced and speculative paper at my website – a longer version than this, but with nearly identical title.)

Conclusions and notes

The tables shown in this paper display different size spheres in simple patterns. And those different volumes rather closely correspond proportionately with the different masses of important particles -- particle masses well known by the end of 1950. This treatment does not attempt to make adjustments for multiplets or other factors that might improve its accuracy and detail.

This article's main merit is hopefully its simplicity, its constructive use of basic geometric structures, and its implications for future uses of combinatorics. And for further exploring the implications that even 'space', itself, might have structure.

Optional Closing Comments and Miscellaneous

If the volume of a sphere in a pattern implies the existence of a particle that is not itself directly (empirically) detected (see Table I, case 'C'); it may be due to the following: Another more basic particle, or its particle pattern, may also be so closely related to the non-detected particle; and the "pattern's constructive result" may have 'defaulted or short-circuited' to produce the simplest or most stable particle, instead. (see Table III, top). Having voiced that speculation and other speculations; it is realized that further clarification of actions and detail would be helpful and desirable.

The above treatment uses to some extent, directly or indirectly, implicitly or explicitly, some concepts pioneered long ago. Those ranges from Huygens' ethereal space filled with spheres, (ref. 11) – to Bohr's 'liquid-drop model' of the nucleus, with its uniform density assumption.

Too many people to list here have been helpful in developing, aiding, and making possible this presentation, and I am grateful to them. Any errors or short-comings in the presentation are my own.

References and Notes

[1] I have rounded off or simplified the empirical values for some particles in my article. For more details and decimal places, see the following: Laboratory of 'NIST' (National Institute of Standards and Technology) CODATA Internationally recommended values of the Fundamental Physical Constants, http://physics.nist.gov/cuu/Constants/Index.html click category 'Atomic and nuclear'

[2] I have also rounded off or simplified some values for empirical ratios involving 'meson' particles. For more details and decimal places, see the following: R. H. Dalitz, C. Goebel, "Meson", **McGraw-Hill Encyclopedia of Science and Technology**, 7th ed., Vol. 10, p 662, (McGraw-Hill Inc., New York and other cities, 1992)

[3] G. L. Ziegler, I. I. Koch, "Prediction of the Masses of Charged Leptons", Galilean Electrodynamics **20** (4) 114-118 (2009).

[4] R. A. Stone, Jr., "The 4 PI Quantization of Fundamental Particle Mass", Apeiron **16** (4) 475-484 (2009) Note, some others no doubt have also attempted to address the masses in the 'particle zoo', but the last two references are just some examples.

[5] "Muon", **Wikipedia**, the free encyclopedia, http://www.wikipedia.org

[6] C. R. Littmann, "Particle Mass Ratios and Similar Volumetric Ratios in Geometry", J. Chem. Inf. Comput. Sci. **35** (3) 579-580 (1995)

[7] That muon to proton mass ratio 'analogy' (involving spheres packed inside a larger sphere) was devised by the author (C. R. Littmann) in September 2009; and details sent to, and acknowledged by, several recipients in 2009, beginning in late September.

[8] H. Robbins, R. Courant, **What is Mathematics?**, topic 3 in Appendix for Chap IV (Oxford University Press, New York, 1941)
[9] L. Pauling, **General Chemistry**, The Forces between Nucleons, Strong Interactions, **25**-3, pp. 809-813 (Dover Publications, Inc., Mineola, N.Y., 1988) (Note that 1 'fermi' distance is equal to 10^{-15} meter. That very small unit of length measurement is named after the great physicist Enrico Fermi.
[10] **The New Columbia Encyclopedia**, 4th ed., p. 1217, heading: 'Heisenberg, Werner' (Columbia University Press, New York and London, 1975)
[11] Note, that the possibility that aether consists of material spheres is discussed in: Christiaan Huygens's *Treatise on Light* (1678), English rendering by S. P. Thompson, 1912, University of Chicago Press, (Project Gutenberg eBook, book #14725, released 1-18-2005) http://www.gutenberg.org/etext/14725