SUB-STRUCTURE LAWS OF PARTICLE MASSES AND CHARGES—A NEW SYSTEMATIC CLASSIFICATION OF SUBATOMIC PARTICLES

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ABSTRACT: *This research paper completes a systematic classification of subatomic particles (and anti-particles) by the way in which their masses, charges, and stabilities occur. The conventionally elementary particles are numerically divided in several new classes. Thus, a new, simple basis is given for a more complete eventual substantiation of how the masses and charges of all the massive sub-atomic particles of observable matter in their exotic proliferations, from the cosmic microneutrinos to the multi-quark hadrons, occur as a single, continuously linked and systematically regular structure of quantized composite mass with conserved charge. What the more fundamental nature of the two enumerated micro-quanta building blocks can be and why they work together in a way that enables this structuring of the known massive particles and their varying mass and charge combinations also remains to be addressed. Zonal relations within this classification define a more significant grouping of the LQ particles than by the conventional three "generations."*

Key Words: Leptons, quarks, neutrinos, composite particle sub-structures, mass power law, regularity of mass proliferations, classification of particles, massive sub-atomic particles, hadrons, stability of particles, numbers of quarks

THIS research paper began as a possible different way of graphing the data from a prior precedent note (Howard, 2005) by charge ratio and mass coordinates. Working with the empirical data compiled by the Particle Data Group (PDG) (Eidelman et al., 2004) on all the massive subatomic Standard Model (SM) particles, from the neutrinos to the hadrons, that paper derived a sub-structure power law for the numerical regularity of quantized lepton and quark/anti-quark (LQ) particle masses and conserved charges, in consistency with the PDG data. The basis for the law was empirical derivation of a generalized universal mass microquantum with a 1/6 either positive or negative microquantum of charge, of which the conventionally elementary LQ particles would be composed in pairs of these components. Through that law the masses of LQ particles can be estimated as composite particles by applying a function of: (a) the sixth power of the number of their components, which are linked in pairs; and (b) the ratio of the number of pairs of components with a net charge (in each of those pairs) to the total number of pairs (including the neutral pairs).

The new graph (Fig. 1) of that prior data, plus several new estimated particle masses discovered herein, becomes the framework of a more fundamental master

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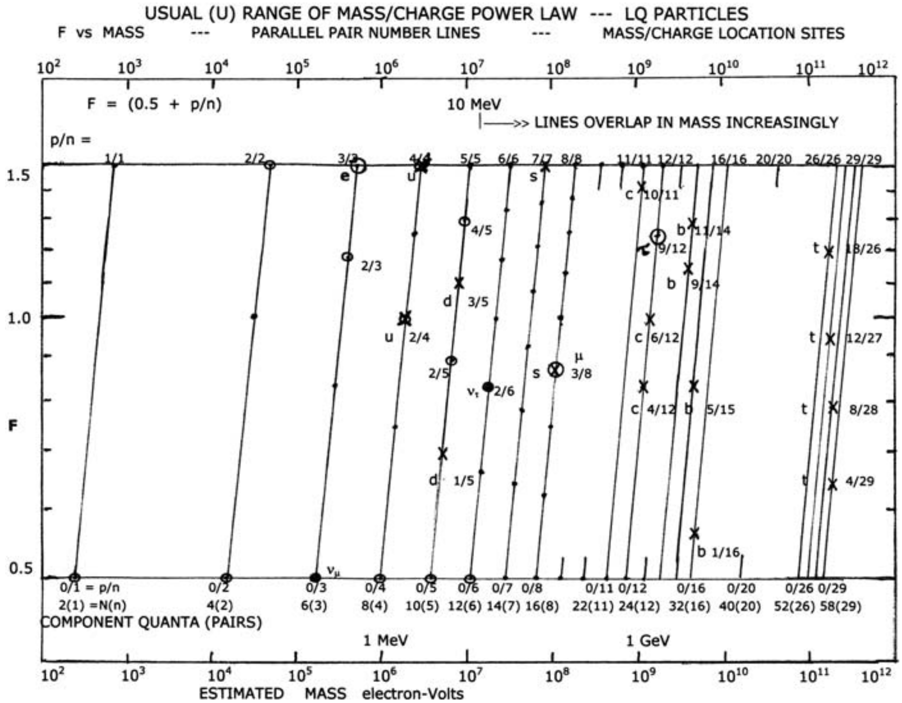


FIG. 1. Baseline graph, of a particle charge function F versus estimated masses of the quarks/anti-quarks and leptons (LQ) (including the neutrinos), for their improved classification by analysis as composites. F increases with mass in quantized steps along the steep, parallel, slightly curved lines. Note the start of line overlap. Empty mass/charge site dots are omitted, as are empty lines. Neutrinos are small circles; two are solid with Greek letter names. The electron e, the muon mu, and the tau, are larger open circles. Quarks/anti-quarks have first letter names by Xs, with three shared sites. See Fig. 2 for p/n ratios at occupied sites on pair number lines, and see text for details.

plan of the interlocking mass and charge characteristics of the conventionally elementary LQ particles beyond the scope of the original paper, but as necessary consequences of the prior microquantal components. Those results lead herein to a new exponential law of mass and charge distributions for further systematic distinctions between those regular estimated mass/charge values which are optional under the power law but cannot be occupied by the various SM types of LQ particles, and those systematically specific quantal values which were already considered occupied by correlation in the prior note with empirical data for these particles from the internationally verified PDG biennial report (Eidelman et al., 2004).

The interaction herein of these two laws results in specific, empiricly correlated, LQ mass/charge combinations which are primarily constrained by relative stability and cyclic regularities as composites of the mass and charge microquanta (rather than by PDG mass correlations alone). These features define zones of a new classification of the massive subatomic LQ particles, including the quark/anti-quark sets, which affects many aspects of the mass and charge characteristics of hadrons composed of these quarks. As a further result of this paper, the prior confirmation (Howard, 2005) of two quark masses for each of the three light quarks (and their anti-quarks) by construction from those quarks of the proliferated PDG masses of baryon hadrons of the Omega minus group and of the N nucleon group (Amsler and Wohl, 2004) can now be considered to be a clear substantiation, not only of the specific quark masses derived under this system within the very broad uncertainties ($\pm$24 to 45%) of the PDG data (Eidelman et al., 2004) for the three light quarks, but also of the new system of classification of LQ particles and extension of its zoning distinctions into the hadrons. Similar considerations apply to the prior correlation (Howard, 2005) of neutrino masses with empirical neutrino oscillations (Bahcall et al., 1998; Branco et al., 2004; Caldwell and Mohapatra, 1993; Chacko et al., 2004; Groom, 2004; Olive, 2004; Barger et al., 2002; Valle, 2003; Kayser, 2004; Nakamura, 2004; Babu and Barr, 2000; King, 2003; Ross, 2003; Fukuda et al., 2000). Under the prior power law of LQ particles and their derivative hadrons, this system applies directly in this paper over the law's previously defined (Howard, 2005) Usual (U) mass range, which omits only the PDG mass limit of the electron neutrino at its Extremely (E) small mass value range isolated at five orders of magnitude below the smallest definite PDG mass of any other LQ particle, and two orders of magnitude below the usual range of the law. That direct application implies that this more comprehensive new system extends also into the Medium (M) and E ranges of the prior note, by its methods, to include the extremely small neutrino mass data accounted for therein as reported in the literature on cosmic or astrophysical, multi-valued, and degenerate neutrino masses (e.g., Kayser, 2004; Olive, 2004; Vogel and Piepke, 2004; Rodejohann, 2002; Elgaroy and Lahav, 2003; Ellis et al., 2002; Ross, 2003; Chacko et al., 2004; Albright, 2004; Hannestad, 2003). These two extensions into hadrons and lighter neutrinos apply new classification effects to all subatomic massive particles (except bosons).

ANALYTIC QUANTAL RELATIONS IN THE MASS/CHARGE SYSTEM OF LQ PARTICLES—Figure 1 displays the prior empirical charges and estimated masses (Howard, 2005) (plus a few discovered herein) of SM LQ particles over the ten orders of magnitude of the usual range of the quantal mass estimates as previously defined. In this new graphical form, the estimated masses m_p in electron-Volts in log format are the base for plotting the log of the charge factor F in the quantized power law for each of these masses in the usual LQ range (Eqn. 6., Howard, 2005):

$$m_p = (2m_u/3)N^6 F, \tag{1}$$

where

$$F = \{0.5 + (n_{\pm}/n)\} = \{0.5 + (p/n)\}. \tag{2}$$

Here N (which equals $2n$) is the number of universal charged component quanta with charges of +1/6 or −1/6, m_u is the mass of each component quantum at 10.9525 electron-Volts (as calibrated in the equation by the PDG mass of the electron rounded to 0.511 MeV), n is the number of the organized pairs of components including the neutral pairs (with +1/6 and −1/6 charge), and $n_{\pm}$ (or for greater distinctiveness in this note, $p \leq n$) is the number of charged pairs of components (whether charged + or −1/3 per pair of like 1/6 charges.) As a modifying function of the charged-pair ratio p/n, F ranges from 0.5 when $p = 0$, to 1.5 when $p = n$.

The graph (Fig. 1) plots the quantized options under the power law of all the possible mass and charged-pair ratio combinations (including two neutrino and two quark options not previously discovered) within the defined usual range for LQ particles, though many of these optional mass/charge sites can not be occupied by the much smaller number of LQ particles listed by the PDG. This paper must demonstrate, as a necessity of its classification system, the processes and structured mass/charge relations behind the empirical data which constrain the mass and charged-pair ratio combinations of the LQ particles to a cyclicly repeated pattern of defined sites rather than their being randomly scattered in the excess of available sites or constrained only by empirical data.

The [mass, (charged-pair ratio function)] site coordinates of the quantized mathematical points in these graphs are henceforth called mass sites, sites, mass points, or points, and are identified by charged pair numbers. The empty sites that are not occupied by an estimated mass for an empirical PDG/SM particle are noted on the lines of plots by a dot without a symbol.

There is a slightly curved, steeply sloped line on the plot for each number of quantal components (and pairs of them) denoted, for example, as 6(3) or 24(12) for the line. All of these pair number lines have the same mean slope, due to the same factor of 3 between the high mass and low mass ends of each line in the range of the function (Eqn. 2). The steepness of the slopes is due to the suitable scales for the two axes. The F scale of charged-pair ratio functions has half an order of magnitude with a central value of 1, which is within 0.01% of the average for all the prior sites correlated with PDG listed particles (Table 1, Howard, 2005). Due to a system start with a single pair and the mass increase as N^6, the mass scale requires ten orders of magnitude.

Each pair number line has a mass point at its low mass end denoted as 0/3 or 0/12, etc., with a $p/n = 0$ for zero charged pairs, meaning all pairs neutral, having a plus 1/6 and a minus 1/6 charge quantum, on separate mass quanta in each pair. In ascending mass (and charged pair) order on each line for each pair number (Eqn. 1), as controlled (Eqn. 2) by factor F, there is a mass point site for each quantal step in progressively charging the pairs on that line to fully charged with no neutral pairs remaining, and a $p/n = 1$. There is one more point on each line than its pair number. At the top of each low mass line the mass/charge sequence has a single step count to the bottom of the next higher line (like the fly-back of an oscilloscope trace, as indicatively dotted three times with progression arrows at the low mass side of Fig. 2).

Since the number of mass points becomes densely crowded on the graph lines beyond the 16(8) pair number line, the empty mass point dots are omitted, and only each occupied mass point is marked, as by 4/12 for the fourth charged pair out of 12 pairs for the 24(12) line. The mass estimate may thus be calculated quickly (Eqns. 1 and 2), or read very approximately on the particle mass axis (Fig. 1), or looked up (for most sites) by pairs and charges (Table 1, Howard, 2005). The empty high mass lines for pair numbers are not completed, or not indicated on the graph

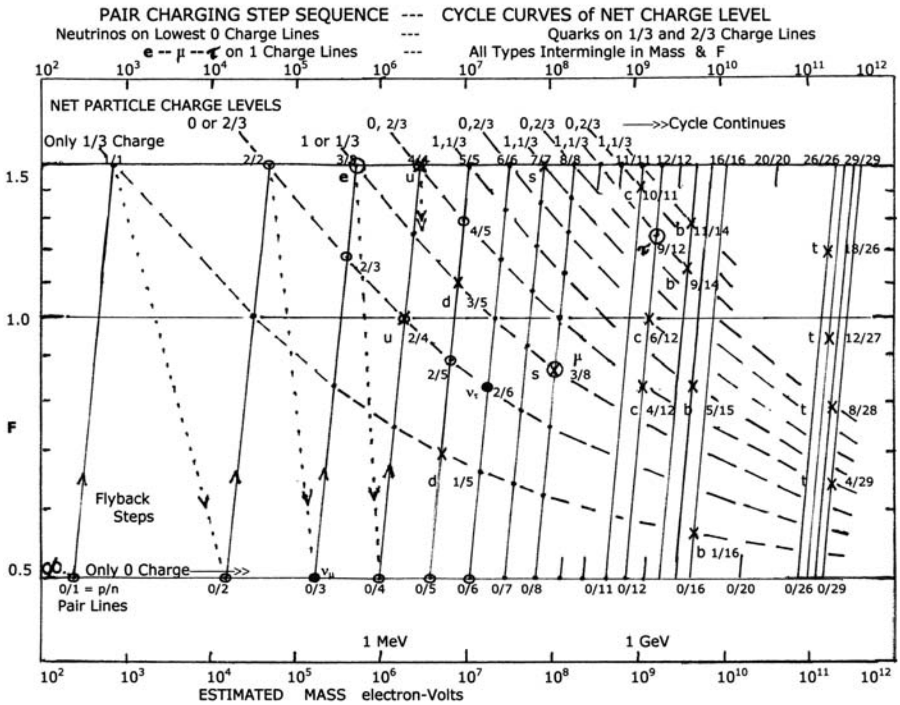


FIG. 2. Repeat of Fig. 1, adding two elements: A dotted indication with arrows of the flyback step sequence in mass/charge sites from line to line. And the cyclic curved and dashed lines (omitted in the top right corner) of net charge levels, with increasing step ratios of charged component pairs p (either positive or negative) to total pairs n, including neutral pairs of components with opposite charges. See text for details.

margins. However, in a later section on a new equation, the quantized steps on the omitted sites and lines are counted in a series summation of the total number of steps to each site. (If more detail is needed, see the expanded back-up of this paper in the website for the prior paper.)

BROADEST SYSTEMATIC MASS/CHARGE CONSTRAINTS IN LQ PARTICLES—At just above the 10 MeV (or 10^7 eV) mass level, more exactly at 10.901 MeV where the 12(6) pair number line begins at site 0/6 (Fig. 1), it is overlapped in mass by the 0.05 MeV higher mass of the 5/5 site at the top of the lower pair number line 10(5). At this point, the regular increases of mass from line to line and along each line is disturbed by decreasing initially with the fly-back step (Fig. 2) rather than increasing. The lines overlap progressively more and more as mass increases so that the charge/mass sequences are increasingly disturbed or compromised in numeric effect.

As the broadest effect, over the next two orders of magnitude in mass (plus a one step margin) above the overlap line at 10.9 MeV there are very few empiricly correlated occupied sites in this otherwise unmarked transitional zone (Fig. 1) compared to the numbers of correlated sites in a lower mass zone below this transition and in a higher mass zone above this transition. This is a broadly generalized initial classification of LQ particle mass and charge ratio sites into three very gradually separated logarithmic zones of a distribution pattern which is natural, by correlation of its data (Table 1, Howard, 2005) with PDG empirical data (Eidelman, et al., 2004).

In the simplest terms, the electron family of three leptons at the three large open circle symbols (Fig. 1), each with the distinctive net charge of 1, is the only family of the LQ particles to have an even distribution of its members over the three mass zones. The electron (e) itself is established at site 3/3 in the lowest mass zone, as an identical mass/charge cross reference to the PDG empirical values for all LQ particle estimates (Howard, 2005). The muon (Greek letter mu, μ) mass estimate is in the center of the transition zone at site 3/8, which is 1.5% higher than the very precise PDG mass. Finally, the tau (Greek letter tau, τ) particle estimate is in the highest mass zone at site 9/12, which is 1.9% lower than the precise PDG mass. The quark/anti-quark family at the X symbol sites, with net charges of either 1/3 or 2/3 of the electron charge, has two sets in the low mass zone, the up (uX) set at estimated sites 2/4 and 4/4 and the down (dX) set at 1/5 and 3/5. There is a single quark set in the transition zone, the strange (sX) estimates at 7/7 and 3/8. Aside from the tauon, the high mass zone is otherwise made up entirely of three quark sets, the charm (cX) set, the bottom (bX) set, and the top (tX) set, with a total of 11 estimated possible sites that correlate within small deviations (Table 1, Howard, 2005) with the typical wide PDG empirical mass uncertainties for all quarks (Eidelman, et al., 2004). The neutrino family of particles, with neutral or no charge, is symbolized on the plot by small circles (sometimes filled and with a Greek letter nu name for most direct correlation with a PDG empirical upper limit for a neutrino mass). The neutrino family is almost entirely restricted, except for two members on the 12(6) pair number line at the lower edge of the transition zone, to the low mass zone in conformity with the PDG empirical upper limit of mass on the most massive member, the tau neutrino (nu sub-tau, ν_τ). As a result, only the muon and the strange quark set of two particle masses are isolated near the center of the transition zone where they might be affected by initial establishment of overlap effects on site/mass distribution. Their joint occupance of site 3/8 (Howard, 2005), in correlation with similar PDG empirical masses (Eidelman, et al., 2004), is a by-product of a systematic process discussed in the next section.

The gradually phased-in constraint of particles into three large zones of mass and charged-pair sites is different in many ways from the conventional sharp separation into three "generations" of particles. As an outstanding difference requiring further study in later sections, the estimated three sites that correlate with the PDG 2004 empirical mass uncertainties of the charm quark (cX) are clearly in the highest and least regular mass zone near the four bottom quark sites (bX) rather than being closely associated in a single conventional generation with the strange quark (sX) and consequently located well within the transitional zone.

ANOTHER GENERAL CYCLE OF MASS/CHARGE/ANTI-PARTICLE RESTRICTION ZONES—Along the low mass horizontal border line for the value of $F = 0.5 + 0$ for zero charged pairs, any LQ particles can only be neutrinos with 0 (zero) net charge. A curved line (Fig. 2) of medium length dashes connects all of the first steps above the 0 charge level on each pair number line. These are all sites with 1 charged pair, at which the net charge level of particles occupying the site can only be 1/3. Likewise, a curved dashed line connects all the 2 charged pair sites where the net charge levels of particles can only be 0 or 2/3, since the two charged pairs may neutralize each other or may both be either positive or negative 1/3. Particles on the dashed line for 3 charged pair steps, which passes through the electron site, can only have net charge levels of 1/3 or 1. Since there are no observed LQ particles in the PDG empirical data (Eidelman et al., 2004) with net charge levels of 4/3 or higher, the possible net charge levels for any sites must alternate between the odd set of 1/3 or 1 and the even set of 0 or 2/3 in zonal cycles in this way across the graph of particle sites in logarithmically spaced diagonal curves in progression from curve to curve toward the corner of the figure (Fig. 2) where the highest mass pair number lines have the most charged pairs and highest mass step sites. (Curved lines for more than 11 charged pair steps have been omitted as confusingly overcrowded.) In the 6th order equation (Eqn. 1) of the power law, the charge element in the *F* factor (Eqn. 2) excludes the mass value sites by zones on every alternate curved net charge line, or 50% of the mass value site availabilities, for any particular kind of LQ particle by its charge characteristic in having an odd or even number of 1/3 charges.

The normal charged particles of normal matter are also restricted by these cyclic zones to having negative charge in the odd charge level zones and positive charge in the even charge level zones. Anti-particles are reversed with positive charge in odd zones and negative in even zones. No other mass/charge distinction for anti-matter is needed. Other findings herein apply to both.

It is evident that any particle's specific occupation of optional mass/charge value sites (Fig. 2), as a particular type of particle with a particular set of charge characteristics, is constrained by at least two, or more, different types of zones within the power law equation system, in addition to constraints by the empirical data with which it must correlate. It will require the full system of incremental limits under the power law, and a new law, to find all the systematic constraints on empirical data as well as on the estimated sites of this system.

THE NEUTRINO LOW MASS ZONING—At this point the sole interference with distribution of particles in zones defined by overlap of the pair number lines (Fig. 1) is the PDG empirical upper mass limit for neutrinos, with the tau neutrino at <18.2 MeV, which allows two overlapped sites at 2/6 and 0/6. In view of the otherwise complete correlation with the overlap effect, this system marginally implies an eventual reduction of the empirical limit to about the 4/5 site mass of 9.49 MeV, if not to the 6.57 MeV of the 2/5 cite on the same net charge curve as 2/6 (Fig. 2).

Since only 0 net charge lines are open to occupation by the 0 charge neutrinos, and they are otherwise constrained only by upper mass limits in the PDG empirical data on the three types of neutrinos (Eidelman et al., 2004), there is a definite implication that neutrinos could exist at every potentially neutral site with mass lower than the PDG mass upper limit of <18.2 MeV for the SM tau neutrino, as indicated by the small circles (Fig. 2). That implication is directly consistent with the structural basis of multiply valued neutrinos in the prior power law paper (Example 4 of Appendix C, Howard, 2005) for the widely studied empirical observations of neutrino "mass oscillations" (e.g., Fukuda et al., 2000; Groom, 2004; Nakamura, 2004; Bahcall et al., 1998; Fritzsch and Xing, 2004; Branco et al., 2004; Ellis et al., 2002; Gouvea and Valle, 2001; King, 2003; Ross, 2003; Valle, 2003; Catani et al., 2004; Lunardini and Smirnov, 2003; Jung et al., 2004; Fukuyama and Okada, 2002; Bernabeu et al., 2003.). This potential neutrino occupation of all the possible neutral sites below the line overlap is also consistent with the repeated findings in the literature of either degenerate interchangeability of neutrino types or the inability to exclude more than three types of neutrinos (e.g., Kayser, 2004; Rodejohann, 2002; Elgaroy and Lahav, 2003; Xing, 2002; Ross, 2003; Kaus and Meshkov, 2004; Albright, 2004; Joshipura, 1995). These well studied uncertainties on neutrino masses combine: (1) With the reports in the literature of very small neutrino masses cited in the introduction. (2) With the fact that the PDG Listings for neutrinos (Eidelman, et al., 2004) only show upper limits of masses for three types of neutrinos. And (3) with the demonstration (Example 4 of Appendix C, Howard, 2005) that application of the power law system of the multiple neutrino mass options provides the first direct explanatory mechanism for the observed neutrino oscillations between masses and apparent types of neutrinos. As a result, this combination of permissions and uses for multiple neutrinos effectively requires that in this system the neutrinos occupy all the mass sites to which they are constrained in the prior sections (two of which sites are recognized in this more complete systematics for the first time). Thus, neutrinos occupy within this level of system constraints all optional LQ sites with masses less than (or equal to) that of the tau neutrino site, on the net charge level curves for 0, 2, and 4 charged pairs (Fig. 2).

Overview of Masses and Charges of the Quark Sets—The joint occupancies at the 2/4 and 4/4 mass sites of neutrinos at 0 net charge with the two members of the up quark set at 2/3 net charge is a normal result of the power law system in the net charge level curves. The up quarks/anti-quarks with their 2/3 net charge levels are already constrained to these two specific sites at 1.914 and 2.871 MeV by the PDG mass uncertainties of about $\pm 45\%$ around the mean of the upper and lower empirical mass limits of 1.5 to 4.0 MeV (Eidelman et al., 2004), and by the site mass substantiations in providing, with the down quark sites (Example 3 of Appendix C, Howard, 2005), a basis for the observed proliferation of the N nucleon hadron masses (Amsler and Wohl, 2004; Eidelman et al., 2004), as well as by both general constraints already considered. The reason for the empirical inability to reduce the large quark uncertainties is thus proven to be that multiple quark sites of a type are used by nature as hadron components.

In the heavy quarks (Fig. 2), there are, on two or more pair number lines, three correlated sites for the charm quark set and four sites each for the bottom and top quark sets. (Since each quark set has the same net charge level at all its sites, the sites on a single line must be an even number of steps apart. That necessity does not apply in fly-back stepping between lines from even to odd pair number lines, but does apply in stepping from odd to even pair lines.)

The up quark set of two masses at +2/3 (even number) net charge level on a single pair number line and the down quark set of two masses at −1/3 (odd number) net charge on an adjacent parallel line have the simplest individual cases and joint mass/charge site relations of all the quark sets (Fig. 2). The significant features are emphasized by the heaviest slightly curved lines of Figure 3. As indicated by the arrows and the vertical dashed reference line, these lines for each set (taken in a continuous direction along the *F* axis projection) slope positively upward with increases of mass. The lines connecting between the two higher masses for the two sets and their two lower masses complete a near quadrilateral figure that is almost a parallelogram of indicated regularities of mass and charge relations. The highest estimated mass of the down set is distinctly below the 10 MeV region at which the pair number lines begin to overlap with increasing mass. These features take significance by the differences from the other quarks.

The heaviest line connecting the two estimated (and PDG correlated) mass/charge sites of the strange quark set (Fig. 4) at −1/3 (odd number again) charge level is nearly an order of magnitude above the line overlap boundary in the center of the transition zone (where the higher mass site is jointly occupied with the muon particle). Like the up and down quark sets, these two site masses for the strange quark set have been substantiated (Example 2 of Appendix C, Howard, 2005) by accounting in this case for the proliferation of masses of the Omega minus baryon hadrons. But the heavy line for the strange quark set has a very steep negative slope, as indicated by the down arrow and the vertical dashed reference line. Rather than being on a single line, these sites are on two pair number lines, neither of which is adjacent to the single pair line for the down quark set. The upper and lower lines from the down set, slope positively with increasing mass. The resulting second nearly quadrilateral figure (quad) is very broad compared to the first quad, oppositely shaped, and much less like a parallelogram of mass site regularities.

Beginning with the charm quark set at the end of the transitional two orders of mass magnitude above the line overlap boundary, the slopes of the lines between sites in a set are not only negative, they are also more irregular and broken in this high mass zone. The charm quark set is the lightest set in which an estimated (and empirically correlated) site on a lower pair number line is higher in mass, 1.1665 GeV at site 10/11, than an overlapped site on a higher pair number line, 1.1628 GeV at site 4/12, with overlap at $p/n \geq 1/3$. All three quark sets in the high mass zone have this diagnostic feature. Irregularities in the resulting third, fourth, and fifth pseudo-quads increase steadily with line overlap, which is at $p/n \geq 1/2$ by site 8/16 (an empty site).

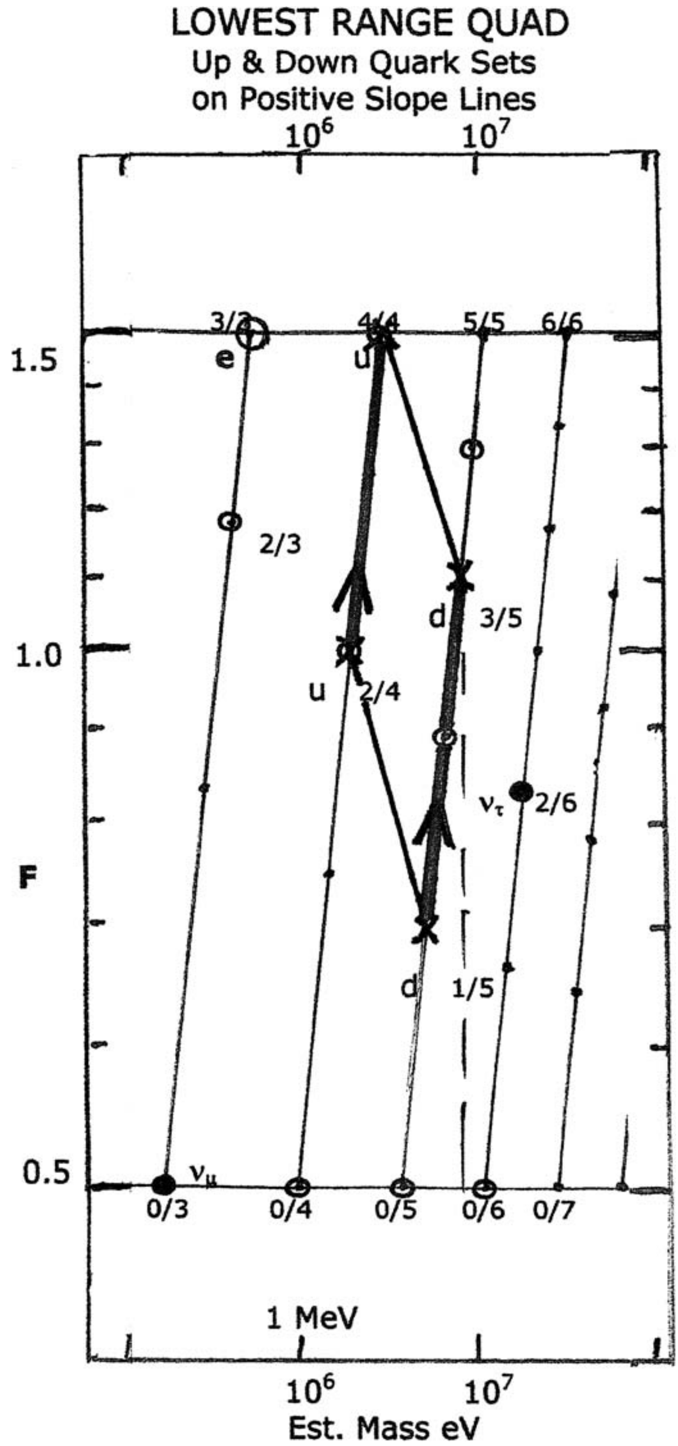
The increased overlap transition of the third quad is also a boundary between the conventional three light quarks, for which *current* mass values are used in the cited PDG data, and the three heavy quarks, for which *running* mass values are used (Eidelman et al., 2004). This SM/PDG distinction further validates, in some degree, the separation of the strange and charm quarks in the new system of particle classification.

Closure of Negative Factors in Quark Mass/Charge Constraints—Since, as noted earlier, the two mass sites in each of the three light quark sets are already substantiated (Appendix C, Howard, 2005) by accounting for proliferated hadron masses, there is a strong implication that similar constrainment by substantiation should eventually be documentable for at least two presently occupied sites of each of the three highest mass quark sets [both by further selection among the very large, proliferated number (Manohar and Sachrajda, 2004; Amsler and Wohl, 2004; Hoehler and Workman, 2004) of PDG validated (but still too fragmentarily documented) empirical hadron groups (Eidelman et al., 2004), and also by further systematics in exponent splitting (Fig. 1D, Eqn. l, and Examples 2 and 3 of Appendix C, Howard, 2005)]. This definite implication indicates sufficiently that all the large numbers of empty sites above the tau neutrino mass which are excluded and not now occupied by quark mass estimates (Fig. 5) may be considered negatively excluded from all occupancy by LQ particles, until proven otherwise.

The accumulated negative restrictions from occupancy of mass value sites by empirical PDG particles still leaves a relatively small number of sites unoccupied without stated reason. From this point, the primary emphasis shifts to establishing occupancy of sites in particle classes through positive constraints, including strong similarity with more definitely occupied sites or site location patterns and cyclic regularities. (A few negative factors will arise from necessities for particle stability.)

Systematic Regularity of Quark Mass Comparison Ratios—Such irregular variations as those that the quads (Fig. 5) make visible have always been problematic in any overall search for regularity in quark masses or for definite masses. Over the decades since the discovery of quarks a great deal of effort has been expended on these questions (e.g., Treiman, 1999; Close et al., 1987; Manohar and Sachrajda, 2004; Amsler and Wohl, 2004; Dugne et al., 2002; Gsponer and Hurni, 1996; Salam, 2000; Kim, 1998: Luty and Mohapatra, 1997; Close, 2000; Hayakawa, 1997). In the quads there are also signs of cycles of the power law effects (across the overlap transition zone into both the upper and lower zones) which might tie the disparate appearances into a common classification systematics. There are two different possible measures of any distribution regularity among LQ particles in Figure 5. The first would be measurable similarities or cyclic variations of log mass increment multiples or anti-log mass comparison ratios horizontally along the mass axis. The next would be similarities or cyclic variations, due to the charged pair ratio effect on mass, of measures taken vertically along the F axis.

In the first quad in order of mass, the parallel pair number lines of the up and down quark set values give a horizontal mass comparison ratio across the quad of a rounded value of 3.8147/1 when measured at any F value, but this is most readily measured at the maximum or minimum values from the equations (1, 2). Direct numeric comparison across the fourth, apparently nearly similar but oppositely sloped, pseudo-quad was only possible at one F value, that of $1/2 + 1/3$, at site 4/12 with a mass of 1.1628 GeV, and at site 5/15 with a mass of 4.436 GeV. The horizontal mass comparison ratio across the fourth quad between these two newly noted points is 3.8149/1, which compares well with the first quad. This is the constant ratio


LOWEST RANGE QUAD
Up & Down Quark Sets
on Positive Slope Lines
10^6
10^7
1.5
1.0
0.5
F
3/3
e
4/4
u
5/5
6/6
2/3
d
3/5
u
2/4
ντ
2/6
d
1/5
νμ
0/3
0/4
0/5
0/6
0/7
1 MeV
10^6
10^7
Est. Mass eV

between the two second pair number lines per quark set (counted with increasing mass), which includes more of the step counts within the set than the first pair number line where there are two or more such lines. (This correlates with analysis of charged pair step counts in a later section.)

Following this indication of a second line emphasis in each set brings the third quad (or pseudo-quad) in mass order to a closely harmonic relation in horizontal mass comparison ratio across the quad at a rounded 11.39/1 ratio. This ratio is surprisingly similar to 3 times the first quad ratio of 3.8147/1 or 11.444/1, with a deviation of 0.47%.

The second quad in mass order is distorted due to bridging from a positive slope on a single line to the transition zone of negative slope between two lines. To bridge this gap reasonably, the second line rule might be adapted toward a line and a half intermediate if two definite points of measurement can be specified. Since the higher down quark mass site is near the perpendicular bisector of the strange quark set mass line (Fig. 5), its best match would be the antilog of the mean log of the two strange set mass estimates of 82.467 MeV and 107.19 MeV or the geometric mean of those values at 94.019 MeV. The near horizontal mass comparison ratio between this and the higher down quark mass value of 8.03183 MeV is 11.7058/1. This ratio is 2.28% higher than the 11.445/1 multiple by 3 of the 3.815/1 ratio for the first undistorted quad.

The mass comparison ratio by the second line rule across the fifth quad, between the bottom and top quark sets, is 34.014/1. That is slightly below 9 times the first quad ratio of 3.815/1 or 34.335/1, with a deviation of 0.94%. That brings the overall series to 1, 3, 3, 1, 9 as a form of regularly cyclic series of harmonic ratios between quark set mass values. (For expanded back-up of elements of this paper see the website for the prior reference, Howard, 2005.)

QUARK MASS/CHARGE REGULARITIES BY RELATIVE *F* FACTOR AND STABILITY—The upper vertex of the first quad in the up quark set (Fig. 5) is at the fully charged end of a pair number line and on a 0 or 2/3 net charge line (Fig. 2). The lower vertex for the set is at minimum separation of two steps and net charge lines on the same pair number line. It cannot be four charge lines lower, since that line has only 0 charged pairs. Neither can this kind of alignment be found on any lower mass pair number line (though there are two single sites for 2/3 charge with three step separation on the next two lower pair lines). In this sense the up quark set is forced to the highest *F* level to have least and simplest mass. From this, and from the positioning of these particles on these graphs (Fig. 2), it appears that a 2/3 charge particle with less than four pairs is unable to form a quark/anti-quark that could interact with any other or similar quark(s) to compose a functional/stable hadron, and that the equivalent is

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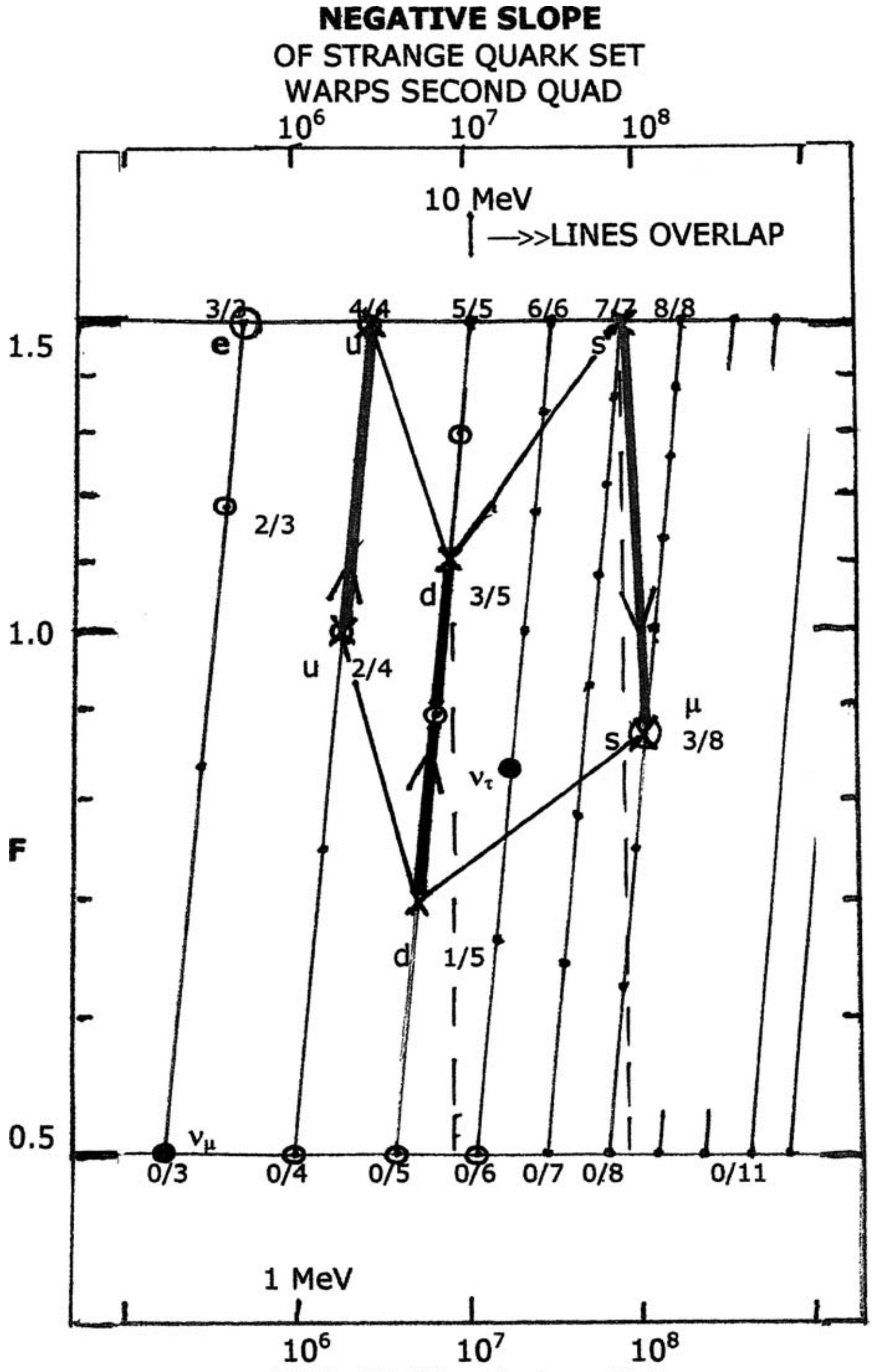
FIG. 3. The segment of the graph that contains the nearly quadrilateral figure (quad, not a parallelogram) formed by the lines connecting the four sites occupied in this system by the up and down quark sets at the lowest mass range of the six kinds of quark sets. Note the dashed vertical reference and the positive slopes with arrows. See text for details.


NEGATIVE SLOPE
OF STRANGE QUARK SET
WARPS SECOND QUAD
10^6
10^7
10^8
10 MeV
—>>LINES OVERLAP
3/3
4/4
5/5
6/6
7/7
8/8
1.5
e
u
s
2/3
d
3/5
1.0
u
2/4
μ
s
3/8
ν_τ
F
d
1/5
0.5
ν_μ
0/3
0/4
0/5
0/6
0/7
0/8
0/11
1 MeV
10^6
10^7
10^8
EST. MASS electron-Volts

true for any 1/3 charge particle with less than five pairs. Otherwise, the down quarks could evidently move along the net charge curves to the three pair number line to become the lowest mass quarks and co-occupy one site with the electron, or might interlink with the up quarks on the four pair line; but they do neither. In correlation with empirically observed nature (Eidelman et al., 2004), the down quark set in this graph can only be one pair number line above the up quark set and one net charge curve step below. Here, for the least, and therefore simplest, mass the down set is not forced to the highest available *F* site on the pair line, but is constrained below it.

Low mass simplicity appears to be associated in all types of particle observations with high comparative numbers present in ordinary stable matter (Treiman, 1999; Close, 2000). (This has similarity to minimum prerequisites or assumptions in establishing strong principles.) In this baseline group, definite constraints to a cycle in the higher *F* values for the most simple and lowest mass quark sites that can be functional, sets the stable cyclic site location pattern in the first quad. From the up quark, probably the most numerous quark in nature from its uud predominance in the proton of hydrogen, through the down quark, the other quark in hydrogen protons, and turning back to high *F* for the strange quark set, the quark set locations proceed in order of lower stability with increasing mass in this characteristic V pattern of the quads (Fig. 5).

The vertical placement pattern is repeated in the fourth quad in step with the mass comparison ratio pattern repetition. The fourth quad, as drawn, shows the upper line from the charm quark set going to the bottom quark set at site 9/14 that is one net charge line down from the charm site (similarly to the first quad), not to the less regularly cyclic bottom quark site at 11/14 which is one net charge line higher than the charm site, and therefore not similar to the first quad pattern. This implies that the 11/14 site may occur rarely, if at all, in hadron formations, and it is linked to the quad in this graph only as a dashed spike.

The fifth quad would be more regular in this cycle (Fig. 5) if its top quark set returned its high vertex to one step below fully charged, like the charm quark set. This would match the return of the first two quads to the same *F* level as at the beginning. There is an appropriate mass option of 166.518 GeV at the 24/25 site (not shown in Figs. 1 and 2), as indicated by the dashed line above the fifth quad. This site is only 1.556% below the PDG lower mass limit for the top quark set (Eidelman et al., 2004). Whether it would be suitable for composite structure in any hadron is thus implied to have a positive answer when there is sufficient PDG hadron data.

The sequence of net charge levels with increasing mass in the quark sets also has a distinct cycle like both the mass comparison ratio cycle and the cycle of

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FIG. 4. A larger segment of the basic graph contains the two quads formed by the six estimated sites occupied by the up, down, and strange quark sets in correlation with the wide PDG mass uncertainties. Note that the strange set is an order of magnitude above the line overlap boundary in a gradually phased-in transition zone, has its two sites on two pair number lines, has a negatively sloped connecting line, and makes the second quad very irregular. See text for reasons and particle classification effects.

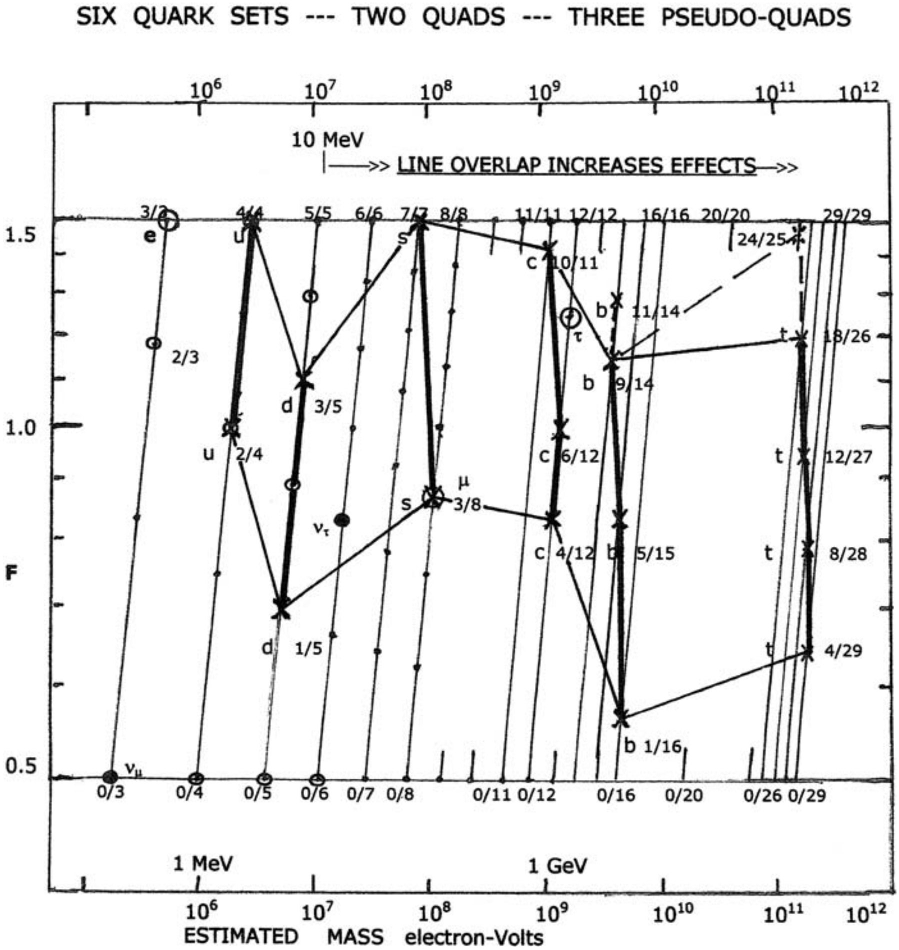

FIG. 5. All five quads/pseudo-quads formed by the estimated and PDG correlated sites occupied by all six kinds of up, down, strange, charm, bottom, and top quark sets. A systematicly zoned particle classification pattern of mass distribution emerges, including the apparent increase of irregularity with three to four estimated sites per quark set in a high mass zone well above the line overlap and the separation of the strange and charm quarks to different gradually separated zones. Dashed lines indicate more regular possible changes. See text for details.

vertical placement of the quad vertices on the *F* axis scale. This sequence is: Up quark set, 2/3. Down, 1/3. Strange, 1/3. Charm, 2/3. Bottom, 1/3. Top, 2/3. In simpler ratios it is 2, 1, 1—2, 1, 2. With the indicated divided phrasing, this correlates exactly with the sequence of the quads in separating the charm quark set from the strange quark set in different particle classification zones and in matching the 2, 1 sequence to the first and fourth quads with similar shapes (Fig. 5) and also with the same mass comparison ratio noted earlier. The divided phrasing corresponds with the transition distortions due to line overlap in the third quad. The quad mass comparison ratio series may also be phrased as 1, 3—3—1, 9 for the three particle classification zones.

If anything were changed in the site sequences for either of these cycles to make it more perfect, it could not be done without completely disrupting the other. They are interlocked together by the natural sequence of the presently occupied and PDG correlated sites.

The first two quark sets were noted earlier to be positively constrained in specific lowest mass sites (for their charges) in the graph of mass distributions (Fig. 2). By cyclic sequences from the first two sets, the rest of the quark sets and their quads are constrained to other specific sites of combined mass and charge organized in a particle classification system of a low to minimal mass zone of simpler and most stable particles with no overlap of pair number lines, which is gradually phased from the overlap boundary into a sparsely occupied central transitional zone of slowly increasing line overlap, and a high mass zone of unstable particles with more sites in complex mass/charge sequences due to overlap at $p/n \geq 1/3$.

The concurrence of three different kinds of regular cycles in the mass and charge of quarks emphasizes the positive interlocking nature of the quantally estimated mass/charge site distributions of the quarks/anti quarks constrained by the particle classification distinctions of the mass power law of the LQ particles as composites of the microquanta derived under that law (Howard, 2005). In this particle classification confirmation through the systematics of the quark masses and charges, this power law system begins to confirm independently the empirical PDG validated observations of the quark masses as distinct from the SM grouping of LQ particles into three generations with associated attempts to find only six specific mass values among quarks.

Derivation of a New Exponential Law for LQ Mass Distributions—The steps of charged pair change along the pair number lines (Figs. 1, 2) may be summed as a base for an equation for the masses of the LQ particles as a function of the series sum. Such an equation may give a more general test of the constrained regularity of the combined mass and charge classifications of the LQ particles than the cycles seen in the five quark quads, and a more suitable test in the electron family of only three particles.

The steps logically begin, at an entry position not available on log plots (Fig. 1) of zero pair numbers 0(0) and 0/0 pairs, with 1 step to the first 0/1 site on the first pair line, followed by the usual steps. A series sum for n pair lines (p. 2, Gradshteyn and Rhyzhik, 1994), plus the p charged pairs (Eqns. 1 and 2) in the final line, yields a total step count S at a given site of the individual steps s to that specific site on a pair number line:

$$S = \sum_{s=1}^{n} s + p = \frac{n(n+1)}{2} + p = \frac{n}{2}\left(n + 1 + 2\frac{p}{n}\right). \tag{3}$$

If the masses at three sites per pair line for $p = 0$, $0.5n$, and n (where $F = 0$, 5, 1.0, and 1.5), plus the occupied sites, are graphed as a function of S on a very large scale log vs log plot (not shown), the lower curve has small triangular waves, with one for each pair number line (Fig. 1). The waves oscillate around a mean line through the points for $F = 1$ with a slope near 3. With increasing S and mass, the waves shrink in length and height to a minimum height and inversion of phase near $S = 21$, where the mass values pass the 10.9 MeV line overlap boundary (Fig. 1). Above that point the waves continue to shorten, steepen into sawteeth, and grow again in mass amplitude around the mean line with increasing S. The slope of the mean line decreases in a very shallow curve which approaches 3 asymptotically with increasing S through step 439, the highest mass site in the top quark set. If the starting step is cut by re-plotting the masses vs $(S - 1) = T$, the mean line appears to straighten to a constant slope of 3, but it actually has a small double curvature that reverses at step 20 (now the line overlap step in Fig. 1). For a singly curved equation, $S = (T + 1)$ is simpler and yields an equation in T by substitution, if needed.

From the general exponential slope, the masses of sites and particles on the complete curve must equal some function near S^3. Trials suggest:

$$m_p = \frac{2m_u}{3} S^3 S^y = \mathrm{C_m}(T + 1)^{(3+y)}, \tag{4}$$

where symbols are from prior equations (Eqns. 1, 2, and 3) except for the unknown y and obvious constant. If 2n is substituted for N (Eqn. 1), and the two equations for m_p (Eqns. 1 and 4) are equated, with substitutions (Eqn. 3), the combined equations reduce to:

$$S^y = \frac{2^8 n^3 (1 + 2p/n)}{(n + 1 + 2p/n)^3} = (T + 1)^y, \tag{5}$$

and $y = (\log S^y / \log S) = [\log (T + 1)^y / \log (T + 1)]$, if needed.

Thus, mixed exponential/power law equations (Eqns. 4 and 5), in terms of steps in the numbers of charged pairs of sub-structural components in LQ particles over their entire usual range, are an alternative to mass/charge power law equations (Eqns. 1 and 2) for testing the systematic regularity and mass/charge classifications of these particles in phased zones (implied by Fig. 5). One lepton group remains to be examined in this way.

THE THREE UNIT-CHARGED LEPTONS (UCL)—Conventionally the negative charge of the electron defines the unit charge for all subatomic particles, thus −1 (odd number) in the three UCL particles, or +1 in the anti-particles. The low mass electron matches the proton (low mass baryon) in its predominant quantities of occurrence in the atoms of ordinary natural matter with stable particle lifetime values approaching the estimate for the universe (Eidelman et al., 2004), and in its importance to many aspects of science and engineering (Dowling, 1997; Springford, 1997; Hestenes and Weingartshofer, 1991; Mac Gregor, 1992). Contrasting with the ubiquitous but isolated electron in their three large circle sites (Fig. 1), the muon (with the transitional strange quark set) and the tauon (between the high mass charm quark set and bottom quark set) are both well above the line overlap boundary and are

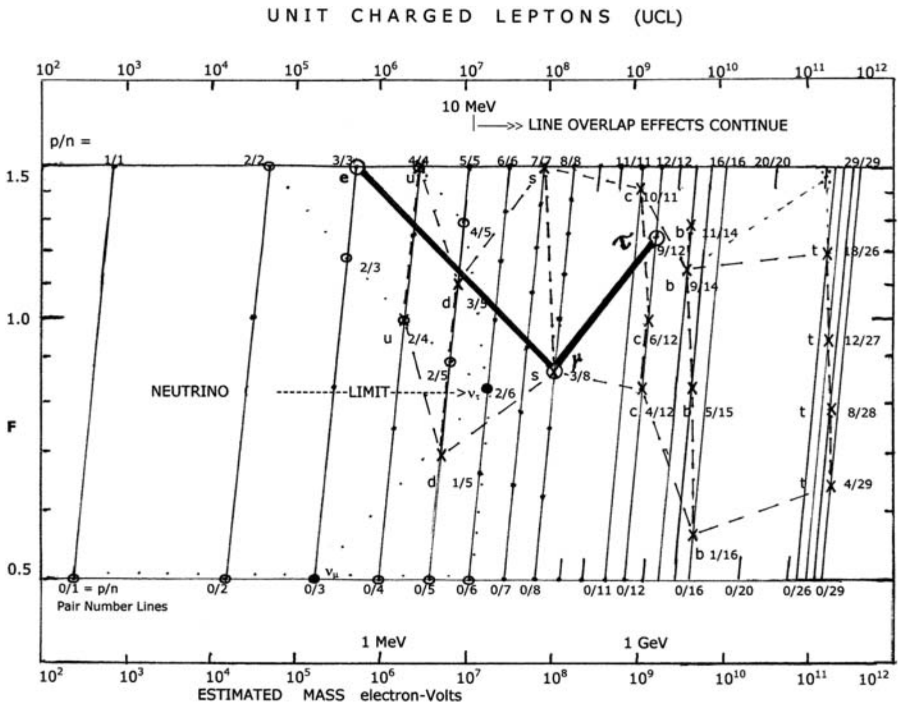

FIG. 6. The emphasized lines of connection between the three sites of unit charged leptons (UCLs) in an overlay of the particle classification zones formed by the quads of the quark sets. This illustrates derivation in the text of a new exponential law for estimated mass sites as a function of the sum of power law steps in mass/charge build-up along the pair lines. See text for details.

quite rare and unstable with mean PDG empirical lifetimes in minute fractions of a second, well beyond 30 orders of magnitude shorter than the life of the electron. This correlates with the muon's and tauon's 2 to 4 orders of magnitude larger masses than the electron's mass. All three PDG masses are listed to unusual precisions of six to eight significant figures (Eidelman et al., 2004).

The UCL estimated masses are constrained by the usual 50% cycle from other sites within the third of the graph area above the lowest 1/3, 1 net charge level curved line (Fig. 2). The stable electron is on this line at site 3/3, with the lowest possible mass for its charge at the fully charged top of the *F* scale. The muon is at 3/8, the lowest possible mass for its pair number and charge. The tauon is six curved lines higher at the 9/12 site.

The three mass/charge sites (Fig. 6) are connected by two heavy lines on a background of dashed lines for the quads of the quark sets. These two lines approximate in larger scale the cyclic dip and rise pattern of the two low mass and high mass groups of quarks. However, the 9/12 tauon is 3 steps below the top *F* line of a full cycle. In this high mass zone of heavy overlap above the charm quarks the tauon is at the mean of the highest charm quark *F* at 1 step down and the highest regular bottom quark F at 5 steps down. This is part of an overall trend toward the midzone of F with increasing mass.

Since the LQ mass estimates under the power law system (Howard, 2005) were calibrated by reference to the PDG electron mass (Eidelman, et al., 2004) rounded by 0.01% to 0.511 MeV, the estimated mass for the electron has no deviation. The muon's estimated 107.2 MeV mass deviates from the PDG empirical value by about 1.5% high. The estimated 1.744 GeV mass for the tauon deviates similarly by about 1.9% low. These opposite deviations might imply that the power law system may need a small cyclic correction factor in mass distributions for UCLs above the line overlap boundary. There is a cyclic effect in the new equations for mass as a function of charged pair step counts (Eqns. 3, 4, and 5), which, as computed next, confirms the prior site estimates. Also, within the two orders of magnitude from the electron mass to the muon mass, there are seven empty alternate sites, plus a down quark site, for unit-charged particles of potential intermediate stability, with two of these below the line overlap. Those sites and higher alternates for UCLs are bypassed in the positive cyclic effects described next.

The step number relations of the UCLs are indicative of regularity of mass distributions in a distinctive way. The UCL masses extend over a mass range in which the total additive exponent of S (Eqn. 4) ranges from just above 4 to just above 3. The electron is at step $S = 9$, with a step increment above the first step of $S - 1 = T = 8$. The muon is at step 39, with a similar increment of 38. The tauon is at 87, with a similar increment of 86. If the ratio of these $S - 1 = T$ increments for any increasing combination of two of these particles is raised by a constant power of 3.42554, this is equal to the ratio of the estimated masses of the same particles, within 0.86%. The exponential ratio is equal to the mass ratio within 0.001% for the longer range from the electron to the tau. It is higher than the mass ratio for the electron to muon range, and about equally lower for the muon to tau range, both within 0.86%. (Taken with the empirical mass deviation noted, this close correlation might have a further implication. Since their empirical lifetimes are of the order of micro-seconds or less, the muon and tau particles originate in the channels of their generation within the times of their observations. In conjunction with the deviations between their empirical masses and the power law estimates, and with the smaller deviations of their mass ratios in the exponential law, the brevity of the empirical observation period might imply a possibility for brief post-generation excitation mass increments for the empirical muon and tauon, which effect would be beyond the scope of the laws herein.)

Similar step calculations between sets for the masses in the highest equivalent F locations in the quads of the quark sets, or separately for the masses in the lowest locations, as well as similar calculations for neutrinos, have similar types of cyclicly regular outcomes, synchronized with the logarithmically graphed waves (Fig. 7) of each type of LQ particle, in mass ratios and T step count ratios, but with different specific exponents for each type of wave. (No general equation was derived for these exponents.) The percent deviations between ratios for sets in particular waves may be as much as three times higher than with the UCLs. However, even assuming that all deviations are as large as 2.5%, that is much less than the percent difference

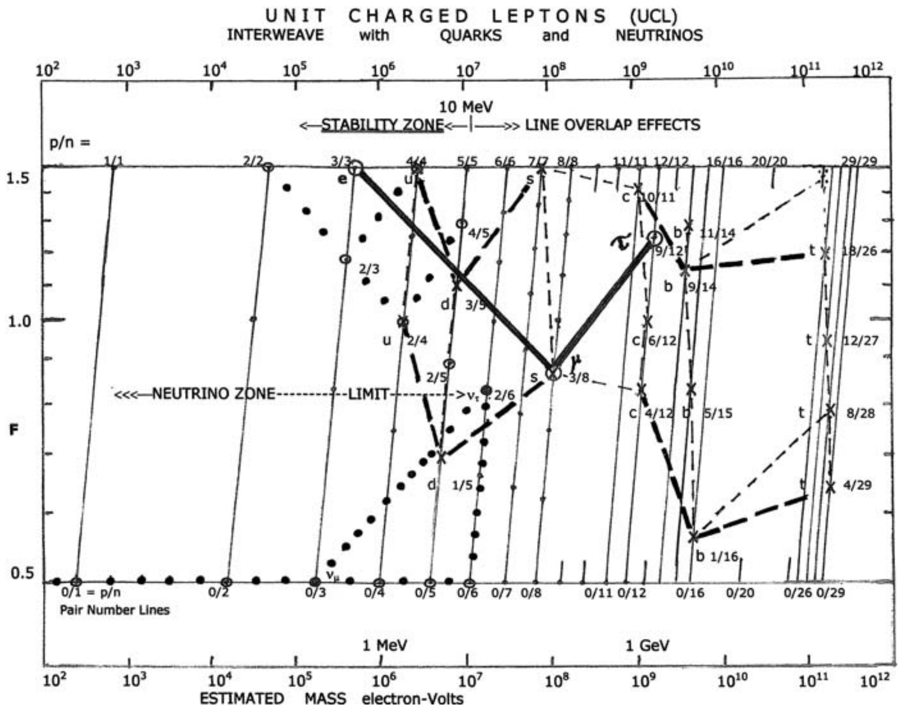

FIG. 7. Differently emphasized lines connecting each of the tyes of LQ particles from the prior figures with dots for neutrinos, dashes for quark sets, and full lines for UCLs. The regularly repeated pattern of a decrease in F with mass, followed by an increase in F with mass, and an overall trend toward the midzone of F with mass is evident in each of the three particle types. Note that the low mass zone below the line overlap transition is also the zone for the particles which are stable against self decay or which compose stable hadron particles. See text for details.

between optional unoccupied (or occupied) mass steps along a single pair number line for all cases up to the top quark set, where the decreasing percentage of step separation with mass is still about 7%. The constraints of the step process then are sufficient to prevent confusion of quantized mass/charge site designations for particles from site to site, even if adjacent sites were interchangeable, which they are not because of the 50% distribution constraints defined by the curved net charge level lines (Fig. 2), as noted earlier. Mass percent differences along the interchangeable charge curved lines would be similarly, but much more, distinguishable.

This result reveals that the equation stated in *T* (Eqn. 4) with the doubly curved median log plot (described but not shown due to the small scale of its waves) is the exponential law in which an additional, separate cyclicity (evidenced by the repeating identities of the incremental step ratio exponents) interacts with the original LQ mass power law to determine the very limited number of specific sites (in the larger numbers of regularly available, alternate mass/charge sites from the power law) to which the three different types of LQ particles are separately constrained.

This cyclicly repeated distribution of masses by particle classifications depends on the sub-structural mass/charge relations which both the power law and the exponential law (Eqns. 1 through 5) define in these conventionally elementary LQ particles as composite interactions of two stated generalized microquanta of mass and different, positive and negative, 1/6 charge.

This results in definite correlation with the empiricly observed LQ particle masses and charges, as well as the mean lifetimes of the leptons. The result is also coupled with the hadron composite relation of equation (1) of the prior paper (Howard, 2005) which has already substantiated the distribution of masses in the first two quads of the first three quarks in order of mass by demonstrating the composition of proliferated hadrons from the redefined quark masses.

Thus, a new, simple basis is given by this classification of particles/antiparticles for a more complete eventual demonstration of the masses and charges of all the massive sub-atomic particles in their current exotic proliferations as a single, continuously linked and systematicly regular structure of quantized mass possibilities with conserved charge.

What the more fundamental nature of the two enumerated microquanta building blocks of mass and charge can be that enables this structured classification of the known particles and their varying stabilities and explains why the microquanta come together to compose the particles remains to be addressed also.

Conclusion—A new systematic classification of the subatomic particles and anti-particles tells how their masses, charges, and relative stabilities occur, but leaves to further research (in progress) why the two necessary microquanta of positive or negative charge with mass can assemble to compose the particles that have mass (except for bosons). In the meantime, the classification itself resolves many problematic areas of long standing in particle physics.

The conventionally elementary particles are numericly divided in several new classes: By the number of different quantized masses with a single charge status in which each type of particle is found herein to occur; by two new cycling zonal groups of odd or even multiples of 1/3 fractional charge level (and by normal matter, with odd multiple zones negative and even multiples positive, versus anti-matter, with the new cycle zones reversed); as well as by the usual three families of zero, unit, and fractional charge; and, across these families and groups, by gradually phased, but distinctive new zones of relative cyclic regularity and stability, with the resulting general prevalences observed in nature. This coordinated classification system arises as a consequence of new analysis herein of how the two previously reported microquanta of positive and negative charge, each with the same uniform microquantum of mass, can combine under an empiricly derived power law of quantized mass and charge to compose the conventionally elementary particle/anti-particle families of the unit-charged leptons, neutral neutrinos, and fractionally charged quarks (LQ). Interaction of that power law with a related exponential law of mass and charge coordinate cyclic distributions, quantally derived herein, constrains each specific type of LQ particle from the quantized optional mass values which are not available to that kind of particle within the quantal cycles of this system of laws, and positively constrains each type of particle to the regularly cyclic, specific mass/ charge values which it can possess in the system. This systematic classification of particles independently confirms Particle Data Group (PDG) empirical uncertainties on the Standard Model (SM) single masses of both the quark and neutrino families of massive particles. That confirmation arises from new findings herein that, rather than the single SM mass in each case, there must necessarily be both multiple cyclic neutrino masses and two well constrained cyclic quark masses within the wide PDG empirical uncertainties, as respectively appropriate for each of the SM cases of the conventional three neutrinos and three light quarks. These general findings are substantiated by specific demonstrations in the prior paper of direct processes for neutrino mass "oscillation", and for construction of two major PDG observed classes of proliferating baryon hadrons by their composition from the quasi-elementary particles re-defined herein. These findings also predict substantiation of two or more cyclicly constrained masses for each of the three SM heavy quarks. There is an implication that the lowest mass neutrinos may be the most stable and numerous. The existing substantiation extends the effects of the systematic mass/charge zonal classification of the quarks/anti-quarks, as a family of the LQ particles, to the massive empirical hadron particles, which are composed of the quarks. Thus, a new, simple basis is given for a more complete eventual substantiation of how the masses and charges of all the massive sub-atomic particles of observable matter in their exotic proliferations, from the cosmic microneutrinos to the multiquark hadrons, occur as a single, continuously linked and systematicly regular structure of quantized composite mass with conserved charge. Zonal relations within this classification define a more significant grouping of the LQ particles than by the conventional three "generations."

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