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The discovery of particle rest mass energy as the aspects of six or seven part photon rockets

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Abstract: A model is presented that discovers the rest mass energies of sub-atomic particles. The model is created by dividing the rest mass of a photon rocket into six or seven equal parts, which produces two generalized photon rockets. The rockets are uniquely efficient in that the ratios of payload relativistic mass to payload rest mass apparently reflect the minimum energy needed for same species pair creation and pair photo-production. The rest mass energies of particles to about 1200MeV are discovered to within their narrow handbook ranges as the various aspects of the rockets. Major discoveries include: An approximation of the pion masses from a starting knowledge of electron mass and the Rydberg Constant; An examination of nucleon-nucleon energy levels that provides explanations for pion transfer between nucleons and for the stability of the proton; Minimum energy discoveries that account for the gaps between certain adjacent particles in the mass spectrum.

Keywords: Relativity; photon; rocket; mass; particles

Abbreviations: TRME for total relativistic mass-energy; RME for rest mass energy; KE for kinetic energy; EE for emitted energy; CEM for conservation of energy and momentum.

1. Introduction.

It has long been known that certain sub-atomic particles exist as naturally occurring photon or neutrino rockets. Therefore, a theory of particle rest mass that is based on the relativistic photon rocket is in line with what particles are in nature. The purpose of this paper is to demonstrate that the energy equivalent of particle rest mass can be accurately determined from an examination of two generalized photon rockets. The rockets are created by dividing the rest mass of a hypothetical photon rocket into 6 or 7 equal parts. The 6 part rocket consists of a payload part and 5 fuel load parts. The 7 part rocket consists of a payload part and 6 fuel load parts.

The question becomes: What is the relationship between 6 or 7 part photon rockets and the rest mass energies of sub-atomic particles? The answer is found in the minimum energy needed to create a same species mass pair. For example: If a relativistic proton gives up its relativistic mass in a collision and creates a proton antiproton pair, then the relativistic proton must have relativistic mass in excess of twice its rest mass, otherwise there is insufficient energy to create the pair. What is unique about the 6 or 7 part rockets is that their relativistic payloads appear to have just enough relativistic mass (i.e. KE) to create a same species mass pair. The payload relativistic masses of the rockets are $\left(\mathbf{2}\frac{\mathbf{1}}{\mathbf{12}}\right)$ and $\left(\mathbf{2}\frac{\mathbf{4}}{\mathbf{7}}\right)$ times the payload rest masses, and the corresponding TRME values are $\left(\mathbf{3}\frac{\mathbf{1}}{\mathbf{12}}\right)$ and $\left(\mathbf{3}\frac{\mathbf{4}}{\mathbf{7}}\right)$ times the payload rest masses, which appear sufficient for same species pair creation. Furthermore, pairs can also be created by the natural phenomenon of pair photo-production. The 6 or 7 part rockets produce EE that is $\left(\mathbf{2}\frac{\mathbf{11}}{\mathbf{12}}\right)$ and $\left(\mathbf{3}\frac{\mathbf{3}}{\mathbf{7}}\right)$ times the payload RME, which seems sufficient for the photo-production of a pair equal to twice the payload rest mass.

It is important to note that other photon rockets consisting of equal parts also produce payload relativistic mass on the order of 2 to 3 times the payload rest mass. However, the other rockets have multi part payloads and more total parts. Therefore, the 6 or 7 part photon rockets are *numerically efficient* in that they have the fewest parts that produce payload relativistic mass in the range of 2 to 3 times the payload rest mass. Our hypothesis follows.

Since it is assumed the KE and EE of the rockets reflect the minimum energy needed for same species pair creation and pair photo-production, then it is hypothesized that particle RME can be discovered directly as an aspect of a 6 or 7 part rocket. A 6 or 7 part photon rocket has six aspects: total RME, fuel load RME, payload RME, TRME, KE and EE. By discovering particle RME as an aspect of a rocket we demonstrate that discrete particle masses may have originated in the minimum work associated with *numerically efficient* same species pair creation.

The question arises: What is the cosmological basis for a direct relationship between the aspects of the rockets and particle rest mass? We suspect that because *numerically efficient* same species pair creation is an efficient form of reproduction and because efficient reproduction is a recognized form of natural selection, then numerically efficient same species pair creation may have selected the mass spectrum from a chaos of masses that emerged in the early stages of the big bang.

Of course, our hypothesis depends for the most part upon how closely computed mass values match up against well established experimental values. Our standard for accuracy follows.

All particles below 1200 MeV are discovered to within the (±) range for the particle as specified by a handbook[1]. The only exceptions are the n-pion and muon, which are discovered to two decimal places of their principal handbook values. Particle RME may be discovered more than once with tiny variations in which case at least one of the values will meet the accuracy standard.

Having presented our major hypothesis we are ready to state the papers primary objectives, which are listed below by section number.

Sec. 2, Describes the photon rocket calculations. Dimensionless factors that relate payload RME to the other aspects of the rocket are derived from the definition of photon rocket KE. Sample calculations are given and conventions established for representing charged and uncharged particles.

Sec. 3, Discovers the RME of all leptons, mesons, and hadrons under 1200 MeV. Rest masses are computed from a starting knowledge of electron RME and the Rydberg Constant. Side by side comparisons between computed RME values and the handbook are given. Calculations are shown in detail. Nothing is hidden.

Sec. 4, Provides an interpretation of pion transfer between nucleons and a rationale for the stability of the proton through an examination of nucleon-nucleon energy levels.

Sec. 5, Consists of a series of discoveries that highlight the minimum work aspects of the theory by explaining the gaps that exist between certain particles in the mass spectrum. The gaps between the omega and the rho and between the nucleons and the eta prime are explored.

Sec. 6, Results and conclusions.

2. Photon rocket calculations and conventions.

As stated in the introduction, 6 or 7 part rockets have six aspects: total RME, fuel load RME, payload RME, TRME, KE and EE. We need to put the calculations into a form that makes it easy to calculate all the aspects of a rocket from knowledge of one of the aspects. The definition for photon rocket KE states: *KE equals fuel load RME squared divided by twice total RME*. Assume each part of a 6 or 7 part rocket equals unity. Then, for the 6 part rocket, $\mathbf{TRME} = \mathbf{1} + \mathbf{5^2 12^{-1}} = \mathbf{3\frac{1}{12}}$, $\mathbf{KE} = \mathbf{5^2 12^{-1}} = \mathbf{2\frac{1}{12}}$ and $\mathbf{EE} = \mathbf{5} - \mathbf{5^2 12^{-1}} = \mathbf{2\frac{11}{12}}$, and for the 7 part rocket, $\mathbf{TRME} = \mathbf{1} + \mathbf{6^2 14^{-1}} = \mathbf{3\frac{4}{7}}$, $\mathbf{KE} = \mathbf{6^2 14^{-1}} = \mathbf{2\frac{4}{7}}$ and $\mathbf{EE} = \mathbf{6} - \mathbf{6^2 14^{-1}} = \mathbf{3\frac{3}{7}}$.

[1] D. R. Lide (Editor) *CRC Handbook of Chemistry and Physics*, 87th Edition, (CRC Press, Taylor & Francis Group, Boca Raton FL, 2006).

The above dimensionless factors when multiplied by payload RME give the aspect of the rocket associated with the factor. For example, suppose the total RME of the 7 part rocket equals, $\mathbf{292\ MeV}$**.** Then, $\mathbf{TRME} = \frac{1}{7}(\mathbf{292})\left(\mathbf{3}\,\frac{4}{7}\right)$**,** $\mathbf{KE} = \frac{1}{7}(\mathbf{292})\left(\mathbf{2}\,\frac{4}{7}\right)$ and $\mathbf{EE} = \frac{1}{7}(\mathbf{292})\left(\mathbf{3}\,\frac{3}{7}\right)$. As a second example, suppose the EE of the 6 part rocket equals $\mathbf{631\ MeV}$ and we wish to compute the rocket's KE. Then, $\mathbf{KE} = (\mathbf{631})\left(\mathbf{2}\,\frac{1}{12}\right)\left(\mathbf{2}\,\frac{11}{12}\right)^{-1} = \mathbf{450.7142856\ldots MeV}$.

Equations use standard particle symbols to represent RME values. Charged particles have only a subscript such as: p_1 , e_1 , μ_1 , π_1 , K_1 , μ_1. Symbols for neutral particles are subscripted, and if necessary superscripted such as: n_1 , π_1^0 , K_1^0 , η_1 , ρ_1 , ω_1 . If identical RME values for a particle are discovered the subscript remains the same. The same particle with slightly different RME values will have progressive subscripts such as: π_1^0 , π_2^0 , π_3^0 ...

3. The discovery of particle RME as the aspects of 6 or 7 part photon rockets.

This section discovers the RME of all particles under 1200 MeV that appear in the footnoted handbook. For calculation purposes we shall assume a beginning knowledge (in MeV units) of electron RME as, $\mathbf{e} = \mathbf{0.511\ MeV}$ and the handbook Rydberg Constant as, $\mathbf{hcR_\infty} = \mathbf{0.013605698\ MeV}$. The preceding values are used in the next paragraph to approximate the pions, which in turn are used to discover other particles.

Assume the 6 or 7 part rockets have the same total RME. Further assume the difference in EE between the rockets equals the RME of an electron. The preceding conditions are given by, $\mathbf{EE_7} - \mathbf{EE_6} = \frac{1}{7}\pi_1\left(\mathbf{3}\,\frac{3}{7}\right) - \frac{1}{6}\pi_1\left(\mathbf{2}\,\frac{11}{12}\right) = \mathbf{e}$. Solving for (π_1) gives, $\pi_1 = \mathbf{138.6775406\ldots}$ **,** which falls about $\mathbf{0.89\ MeV}$ short of the c-pion handbook value. Decreasing the EE between rockets by the energy associated with the Rydberg Constant $(\mathbf{hcR_\infty})$ gives the equation, $\mathbf{EE_7} - \mathbf{EE_6} = \frac{1}{7}\pi_1^0\left(\mathbf{3}\,\frac{3}{7}\right) - \frac{1}{6}\pi_1^0\left(\mathbf{2}\,\frac{11}{12}\right) = \mathbf{e} - \mathbf{hcR_\infty}$ **.** Solving for (π_1^0) gives, $\pi_1^0 = \mathbf{134.9851643\ldots}$, which closely matches the n-pion handbook value, handbk, $\pi^0(\mathbf{134.9764} \pm \mathbf{0.0006})$**.** It will be recalled that $(\mathbf{e} - \mathbf{hcR_\infty})$ represents electron mass-energy at the ground state of a Bohr hydrogen atom, which is the electron's least massive state.

In the above equations, when the difference in EE between the rockets varies between the electron mass states, $(\mathbf{e})$ and $(\mathbf{e} - \mathbf{hcR_\infty})$, then the total RME of each rocket varies between the pion mass states, (π_1) and (π_1^0). The preceding pion discoveries are the centerpiece of our theory and immediately lead to the discovery of all other particles.

We make three key discoveries. First, the sum of pion pairs equals the RME of the eta meson, $\mathbf{2\pi_1 + 2\pi_1^0 = \eta_1 = 547.3254080 \ldots}$ **,** handbk, $\mathbf{\eta(547.30 \pm 0.12)}$**.** Second, setting the c-pion approximation (π_1) equal to the TRME of the 6 part rocket discovers the RME of an n-pion pair $(2\pi_2^0)$ as total RME as, $\mathbf{totRME = 6(\pi_1)\left(3\frac{1}{12}\right)^{-1} = 2\pi_2^0 = 2(134.9294990 \ldots)}$. Third, setting eta pair RME $(2\eta_1)$ equal to the total RME of the 7 part rocket discovers proton RME $(\mathbf{p_1})$ as the fuel load as, $\mathbf{fuelRME = \frac{6}{7}(2\eta_1) = p_1 = 938.2721280 \ldots}$, handbk, $\mathbf{p(938.27231 \pm 0.00028)}$.

In the preceding equation the RME of an eta pair was set equal to total RME. If a single eta (η_1) is set equal to the total RME, then a c-pion pair $(2\pi_2)$ is discovered as the rocket's TRME given by, $\mathbf{TRME = \frac{1}{7}(\eta_1)\left(3\frac{4}{7}\right) = 2\pi_2 = 2(139.6238286 \ldots)}$. About 23% of eta mesons decay to the pion triplet by, $\mathbf{\eta \to \pi^+\pi^-\pi^0}$. Remarkably, replacing (η_1) in the preceding equation with its decay product the pion triplet $(2\pi_2 + \pi_2^0)$, reduces the rocket's TRME from a c-pion pair to a muon pair given by, $\mathbf{TRME = \frac{1}{7}(2\pi_2 + \pi_2^0)\left(3\frac{4}{7}\right) = 2\mu_1 = 2(105.6574378 \ldots)}$, handbk, $\mathbf{\mu(105.6583890 \pm 0.000034)}$.

The omega, rho and eta prime are discovered as follows. Setting proton RME $(\mathbf{p_1})$ equal to the total RME of the 6 part rocket discovers the RME of the omega as the fuel load as, $\mathbf{fuelRME = \frac{5}{6}p_1 = \omega_1 = 781.8934400 \ldots}$, handbk, $\mathbf{\omega(781.94 \pm 0.12)}$. Setting $(\mathbf{p_1} + \pi_2)$ equal to EE, discovers the rho (ρ_1) as KE as, $\mathbf{KE = (p_1 + \pi_2)\left(2\frac{1}{12}\right)\left(2\frac{11}{12}\right)^{-1} = \rho_1 = 769.9256834 \ldots}$, handbk, $\mathbf{\rho(770 \pm 0.8)}$. Setting the eta (η_1) equal to the EE of the 7 part rocket discovers the eta prime as fuel load RME as, $\mathbf{fuelRME = 6\eta_1\left(3\frac{3}{7}\right)^{-1} = \eta_1' = 957.8194638 \ldots}$, handbk, $\mathbf{\eta'(957.78 \pm 0.14)}$.

A free neutron decays by, $\mathbf{n \to p + e + \overline{\nu}_e}$, where ($\mathbf{\overline{\nu}_e}$) is the decay mass of the electron antineutrino. Since we already have values for proton and electron RME, then neutron RME can be calculated if we can discover the electron antineutrino decay mass ($\mathbf{\overline{\nu}_e}$) . Surprisingly, setting the difference between pions $(\pi_2 - \pi_2^0)$ equal to the total RME of the 6 part rocket discovers the decay mass (ν_1) as the payload as, $\mathbf{payRME = \frac{1}{6}(\pi_2 - \pi_2^0) = \nu_1 = 0.782388267 \ldots}$ Neutron RME can now be computed as, $\mathbf{n_1 = p_1 + e + \nu_1 = 939.5655163 \ldots}$, which falls within the neutron's handbook range, $\mathbf{n(939.565630 \pm 0.00028)}$. The kaons are discovered next.

The $(\mathbf{K^\pm})$ is discovered by setting KE equal to $(\mathbf{n_1} + \pi_1^0)$, which discovers $(\mathbf{n_1})$ plus the c-kaon decay mass $(\mathbf{K_1 - e})$ as EE given by, $\mathbf{EE = (n_1 + \pi_1^0)\left(3\frac{3}{7}\right)\left(2\frac{4}{7}\right)^{-1} = (n_1 + K_1 - e)}$, where, $\mathbf{K_1 = 493.6797247 \ldots}$, handbk , $\mathbf{K(493.677 \pm 0.016)}$. The $(\mathbf{K^0})$ is discovered by setting KE equal to $(\mathbf{p_1} + \pi_1)$, which discovers $(\mathbf{p_1 + K_1^0})$ as EE as, $\mathbf{EE = (p_1 + \pi_1)\left(3\frac{3}{7}\right)\left(2\frac{4}{7}\right)^{-1} = (p_1 + K_1^0)}$, where, $\mathbf{K_1^0 = 497.6607640 \ldots}$, handbk, $\mathbf{K^0(497.672 \pm 0.03)}$. Discoveries of pion RME follow.

The c-pion is discovered by setting neutron RME $(\mathbf{n_1})$ equal to EE, which discovers $(\pi_3 - \mathbf{e} + \pi_1^0)$ as the payload as, $\mathbf{payRME} = \mathbf{n_1}\left(3\frac{3}{7}\right)^{-1} = \pi_3 - \mathbf{e} + \pi_1^0$, where $\pi_3 = \mathbf{139.5657788}\ldots$. Also, setting the n-kaon decay mass $(\mathbf{K_1^0} - \mathbf{2e})$ equal to TRME discovers c-pion decay mass $(\pi_4 - \mathbf{e})$ as payload RME, $\mathbf{payRME} = (\mathbf{K_1^0} - \mathbf{2e})\left(3\frac{4}{7}\right)^{-1} = (\pi_4 - \mathbf{e})$, where, $\pi_4 = \mathbf{139.5698539}\ldots$, which falls within the c-pion's narrow handbook range, $\pi^{\pm}(\mathbf{139.56995} \pm \mathbf{0.00035})$. The n-pion decay mass $(\pi_3^0 - \mathbf{2e})$ is also discovered as pay load RME by setting proton RME $(\mathbf{p_1})$ equal to the rocket's total RME as, $\mathbf{payRME} = \frac{1}{7}\mathbf{p_1} = \pi_3^0 - \mathbf{2e}$, where, $\pi_3^0 = \mathbf{135.0608754}\ldots$ **.**

The $\mathbf{K^*(892)^{\pm}}$ and $\mathbf{K^*(892)^0}$ are discovered as follows. Setting the KE of the 6 part rocket equal to the n-kaon plus the c-pion decay mass $(\mathbf{K_1^0} + \pi_2 - \mathbf{e})$ discovers the $\mathbf{K^*(892)^{\pm}}$ as EE as, $\mathbf{EE} = (\mathbf{K_1^0} + \pi_2 - \mathbf{e})\left(2\frac{11}{12}\right)\left(2\frac{1}{12}\right)^{-1} = \mathbf{K_1^*} = \mathbf{891.4830296}\ldots$, handbk, $\mathbf{K^*(891.66 \pm 0.26)^{\pm}}$. Setting $(\mathbf{n_1} + \pi_1^0 + \mathbf{e})$ equal to the total RME of the 6 part rocket discovers the $\mathbf{K^*(892)^0}$ as the fuel load as, $\mathbf{fuelRME} = \frac{5}{6}(\mathbf{n_1} + \pi_1^0 + \mathbf{e}) = (\mathbf{K_1^*})^0 = \mathbf{895.8847355}\ldots$, handbk, $\mathbf{K^*(896.1 \pm 0.28)^0}$.

The $\mathbf{a_0(980)}$, $\mathbf{f_0(980)}$ and $\emptyset(\mathbf{1020})$ are discovered as follows. The $\mathbf{a_0(980)}$ decays by, $\mathbf{a_0} \to \boldsymbol{\eta} + \pi^0$. Setting $(\boldsymbol{\eta}_1 + \pi_1^0)$ equal to the KE of the 6 part rocket discovers an $\mathbf{a_0(980)}$ pair as total RME as, $\mathbf{totRME} = 6(\boldsymbol{\eta}_1 + \pi_1^0)\left(2\frac{1}{12}\right)^{-1} = \mathbf{2a_1} = \mathbf{2(982.5272230}\ldots)$, handbk, $\mathbf{a_0(983.4 \pm 0.09)}$. The $\mathbf{f_0(980)}$ decays by, $\mathbf{f_0} \to \mathbf{2}\pi^{\pm}$. Setting $(\mathbf{2}\pi_2)$ equal to the payload of the 7 part rocket discovers an $(\mathbf{f_0})$ pair as total RME as, $\mathbf{TRME} = 7(\mathbf{2}\pi_2) = \mathbf{2f_1} = \mathbf{2(977.3668002}\ldots)$ **,** handbk, $\mathbf{f_0(980 \pm 10)}$. The $\emptyset(\mathbf{1020})$ decays by, $\emptyset \to \mathbf{2K^{\pm}}$ and $\emptyset \to \mathbf{K_S^0} + \mathbf{K_L^0}$. Setting $(\mathbf{2K_1} + \mathbf{2K_1^0} + \mathbf{2e})$ equal to the total RME of the 6 part rocket discovers the RME of the $\emptyset(\mathbf{1020})$ meson as the rocket's TRME as, $\mathbf{TRME} = \frac{1}{6}(\mathbf{2K_1} + \mathbf{2K_1^0} + \mathbf{2e})\left(3\frac{1}{12}\right) = \emptyset_1 = \mathbf{1019.402919}\ldots$, handbk, $\emptyset(\mathbf{1019.413 \pm 0.008})$**.**

Baryons in the region from the nucleons to 1200MeV consist of a lambda (Λ) and three sigmas, $(\Sigma^0, \Sigma^+, \Sigma^-)$. The lambda is discovered by assuming the shortfall in the c-pion (π_1) is due to the absence of electron antineutrino decay mass, $\pi_5 = \pi_1 + \boldsymbol{\nu}_1 = \mathbf{139.4599289}\ldots$, which discovers the lambda (Λ_1) as the RME of 4-c-pion pair as, $\Lambda_1 = \mathbf{8}\pi_5 = \mathbf{1115.679431}\ldots$**,** handbk, $\Lambda(\mathbf{1115.683 \pm 0.006})$. The three sigmas are discovered from the 6 part rocket as follows.

Setting the KE equal to $(\mathbf{2}\pi_5 + \pi_3^0 - \mathbf{2e})$ discovers the (Σ^+) as total RME given by, $\mathbf{totRME} = 6(\mathbf{2}\pi_5 + \pi_3^0 - \mathbf{2e})\left(2\frac{1}{12}\right)^{-1} = \Sigma_1^+ = \mathbf{1189.321152}\ldots$ **,** handbk, $\Sigma^+(\mathbf{1189.37 \pm 0.07})$. Setting KE equal to $(\mathbf{2}\pi_3 + \pi_1^0)$ discovers the (Σ^0) as total RME as, $\mathbf{totRME} = 6(\mathbf{2}\pi_3 + \pi_1^0)\left(2\frac{1}{12}\right)^{-1} = \Sigma_1^0 = \mathbf{1192.656157}\ldots$, handbk, $\Sigma^0(\mathbf{1192.642 \pm 0.024})$. Setting payload RME equal to $(\pi_3 + \mathbf{2}\pi_1^0 + \mathbf{2e})$, discovers the (Σ^-) as the rocket's EE as, $\mathbf{EE} = (\pi_3 + \mathbf{2}\pi_1^0 + \mathbf{2e})\left(2\frac{11}{12}\right) = \Sigma_1^- = \mathbf{1197.461141}\ldots$, handbk, $\Sigma^-(\mathbf{1197.449 \pm 0.030})$.

This completes the discovery of particle RME up to about 1200 MeV. It needs to be emphasized that the algebra of photon rocket equations allows the same particle to be discovered in different ways. For instance, proton RME $(\mathbf{p_1})$ can be rediscovered as EE by setting the payload of the 7 part rocket equal to the sum of the original pion approximations $(\pi_1 + \pi_1^0)$ as, $\mathbf{EE} = (\pi_1 + \pi_1^0)\left(3\frac{3}{7}\right) = \mathbf{p_1}$.

4. How the model accounts for pion transfer between nucleons and proton stability.

To account for pion transfer between nucleons and the stability of the proton the fuel load of the 7 part rocket is set equal to the RME of a proton antiproton pair and the rocket's EE is examined. The fuel load is then increased in successive increments as per the relationship, $\mathbf{2p_1 + 2\nu_1 + 2e = 2n_2}$.

We begin by setting the fuel load of the 7 part rocket equal to the RME of a proton antiproton pair RME $(\mathbf{2p_1})$, which gives EE equal to proton RME plus n-pion decay mass $(\pi_3^0 - \mathbf{2e})$ as, $\mathbf{EE} = \frac{1}{6}\mathbf{2p_1}\left(3\frac{3}{7}\right) = \mathbf{p_1} + \pi_3^0 - \mathbf{2e}$. Remarkably, increasing the fuel load by the decay mass of an electron antineutrino positron neutrino pair $(\mathbf{2\nu_1})$ increases the n-pion decay mass portion of the EE to the RME of an n-pion given by, $\mathbf{EE} = \frac{1}{6}(\mathbf{2p_1 + 2\nu_1})\left(3\frac{3}{7}\right) = \mathbf{p_1} + \pi_4^0$, where, $\pi_4^0 = \mathbf{134.930340}\ldots$, which falls about 0.04 MeV short of the n-pion handbook value, handbk, $\pi^0(\mathbf{134.9764 \pm 0.0006})$. Increasing the fuel load again by the RME of an electron positron pair $(\mathbf{2e})$ gives, $\mathbf{EE} = \frac{1}{6}(\mathbf{2p_1 + 2\nu_1 + 2e})\left(3\frac{3}{7}\right) = \mathbf{p_1 + e} + \pi_5^0$, where, $\pi_5^0 = \mathbf{135.0060340}\ldots$.

In the two preceding equations fuel load increases of $(\mathbf{2\nu_1})$ and $(\mathbf{2e})$ increased the n-pion portion of the EE to (π_4^0) and (π_5^0). Since the n-pion portions of the EE could only have come from the non-emitted nucleon, then the emission of (π_4^0) and (π_5^0) represents a rudimentary form of n-pion transfer between nucleons. Therefore, we conclude that $(\bar{\nu}_e\, \nu_e)$ and $(\mathbf{e^+e^-})$ exist in nature to facilitate n-pion transfer. We further conclude that the proton is stable because in the initial equation the proton antiproton annihilation had only sufficient energy to transfer the n-pion decay mass $(\pi_3^0 - \mathbf{2e})$ but not the n-pion rest mass.

Before leaving this section it needs to be pointed out that when the fuel load equals proton antiproton pair RME, other aspects of the rocket besides the EE are also physically significant. For instance, the rocket's total RME equals the RME of 2 eta pair given by, $\mathbf{totRME} = \frac{7}{6}\mathbf{2p_1} = \mathbf{4\eta_1}$. Also, the rocket's TRME equals the RME of 4 c-pion pair $(\mathbf{8}\pi_2)$ as, $\mathbf{TRME} = \frac{1}{6}\mathbf{2p_1}\left(3\frac{4}{7}\right) = \mathbf{8}\pi_2$. Surprisingly, the preceding equation is supported experimentally by the renowned *shower of pions* photo[2], which shows a proton antiproton annihilation creating 4 c-pion pair.

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[2] http://particleadventure.org/particleadventure/frameless/images/bubble.gif

5. Discoveries that highlight the minimum work aspects of the 6 or 7 part rockets.

This section provides minimum energy explanations for some of the puzzling gaps that exist between certain particles in the mass spectrum. For instance, the gap between the omega and rho mesons can be explained as follows.

Setting the KE of the 6 part rocket equal to the RME of 2 c-pion pair $(4\pi_2)$ discovers omega RME as EE as, $\mathbf{EE} = 4\pi_2\left(2\frac{11}{12}\right)\left(2\frac{1}{12}\right)^{-1} = \omega_1 = 781.8934400\ldots$, handbk, $\omega(781.94 \pm 0.12)$. Since the rho is just below the omega in the mass spectrum, we realize that we should be able to discover its RME by finding the c-pion decay reaction with the smallest decay energy.

The c-pion decay, $\pi^{\pm} \rightarrow \pi^0 + e + \nu$ represents the minimum increment of energy by which the c-pion decays. Replacing a c-pion pair in the preceding equation with twice the decay reaction decay mass $2(\pi_2^0 + e)$ discovers the RME of the rho meson as the rocket's EE as, $\mathbf{EE} = \left(2\pi_2 + 2(\pi_2^0 + e)\right)\left(2\frac{11}{12}\right)\left(2\frac{1}{12}\right)^{-1} = \rho_2 = 770.1801171\ldots$, handbk, $\rho(770 \pm 0.8)$**.** The two preceding equations constitute a minimum work explanation for why the rho is just below the omega in the mass spectrum.

Another puzzling gap is the gap between the nucleons and the eta prime meson. Interestingly, setting an eta prime pair $(2\eta_1^{/})$ equal to the total RME of the 7 part rocket discovers proton RME (p_1) as EE as, $\mathbf{EE} = \frac{1}{7}2\eta_1^{/}(3\frac{3}{7}) = p_1$. Since the total RME of a photon rocket splits into TRME and EE portions, then the gap between the eta prime and the nucleons is accounted for by total RME splitting into TRME and EE portions under CEM.

The gap between the nucleons and the eta prime can also be accounted for by setting total RME equal to a hydrogen anti-hydrogen pair RME, $2(p_1 + e - hcR_\infty)$, which discovers the eta prime $(\eta_2^{/})$ as TRME as, $\mathbf{TRME} = \frac{1}{7}2(p_1 + e - hcR_\infty)\left(3\frac{4}{7}\right) = \eta_2^{/} = 957.9280842\ldots$**,** which is within the eta prime's handbook range, $\eta^{/}(957.78 \pm 0.14)$. Interestingly, the tiny amount of mass defect associated with the Rydberg Constant allows the TRME to fall within the eta prime's handbook range.

Before moving on we note two relationships involving KE that are particularly striking. First: setting the KE of the 6 part rocket equal to omega RME (ω_1) discovers the RME of a proton antiproton pair $(2p_1)$ as the rocket's fuel load given by, $\mathbf{fuelRME} = 5\omega_1\left(2\frac{11}{12}\right)^{-1} = 2p_1$, and also discovers an eta pair as EE as, $\mathbf{EE} = \omega_1\left(2\frac{11}{12}\right)\left(2\frac{1}{12}\right)^{-1} = 2\eta_1$. Second: setting the KE of the 7 part rocket equal to proton RME (p_1) discovers the RME of 2 eta pair $(4\eta_1)$, as the fuel load given by, $\mathbf{fuelRME} = 6\,p_1\left(2\frac{4}{7}\right)^{-1} = 4\eta_1$, and also discovers the decay mass of nine c-pion as the rocket's EE given by, $\mathbf{EE} = p_1\left(2\frac{3}{7}\right)\left(2\frac{4}{7}\right)^{-1} = 9(\pi_6 - e)$, where $\pi_6 = 139.5142782\ldots$.

6. Results and Conclusions.

By limiting the relativistic photon rocket to 6 or 7 equal parts we have been rewarded with the discovery of particle rest mass energy as the various aspects of the rockets. The deterministic accuracy of the RME discoveries to within narrow handbook ranges speaks for itself. We conclude that amongst 6 or 7 part photon rockets particle RME and CEM are so closely aligned as to be essentially one and the same. We further conclude that *numerically efficient* same species pair creation is likely cosmological condition that selected the discrete masses of the mass spectrum that emerged in the early cosmos.

Throughout the paper particle decay mass as well as particle rest mass is discovered. The comparison between decay mass and rest mass permits an interpretation of some of the troublesome problems of particle physics. For instance, Sec.(4) provides an interpretation of pion transfer between nucleons and a rationale for the stability of the proton. In Sec.(3) neutron RME is discovered based on an accurate discovery of the electron antineutrino decay mass.

We have limited our discoveries to the first twenty particles because they are well established by experiment and show off the deterministic accuracy of the model. However, there is nothing that precludes the model from exploring high energy physics.

At this stage the rocket model is confined to rest mass and decay mass does not include many of the other observed properties of particles. Your author is convinced that the model has the potential to bring in other properties through an interpretation of the 5 or 6 individual fuel load parts that make up the rocket fuel loads. As yet, a satisfying way to do this has not been found. Hopefully, the discoveries made throughout the paper will inspire others to explore and develop the model.

End of Paper

References

[1] D. R. Lide (Editor), *CRC Handbook of Chemistry and Physics,* 87th Edition (CRC Press, Taylor & Francis Group, Boca Raton FL, 2006).

[2] A. P. French, *Special Relativity,* The MIT Introductory Series (W. W. Norton & Co. Inc., New York, 1968).

[3] K. Gottfried & V. F. Weisskopf, *Concepts of Particle physics,* Volume 1 (Oxford University Press, Inc., New York, 1991).

[4] C. Baltay & A. H. Rosenfeld (Editors), *Meson Spectroscopy,* A collection of articles (W. A. Benjamin, Inc., New York, 1968).

List of Symbols

γ gamma
η eta
ϕ theta
Κ Kappa
Λ Lamda
μ mu
ν nu
π pi
ρ rho
Σ Sigma
ω omega
∞ Infinity