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An onium model of particles with only electrons and protons

Ray Fleming
101 E State St. #152 Ithaca NY 14850
rayrfleming@gmail.com

In an ideal simplified theory of everything there is one field, one force, and one or two particles. This paper investigates how the known unstable particles or resonances can be modeled as onium compounds composed entirely of electrons and protons. Positronium is the basic onium compound with an electron and positron orbiting in a metastable state. The components of the onium compounds that make up the particles are determined from their decay products. Pions are relativistic positronium as discovered by Sternglass and Feynman. Kaons are pionium, D mesons are kaonium, and B mesons are Donium. The J/Psi appears to be an eta prime-kaonium meson with an eta prime meson orbited by two kaons. The upsilon and its resonances are two B mesons in nested orbits. The baryons are similar with the lambda and sigmas having a non-relativistic nucleon orbited by a muon or pion. The more energetic baryons are trionium compounds such as the Xi baryons which are a nucleon orbited by two electron-positron pairs in nested orbits and the omega which is a sigma orbited by two pions. Charmed baryons are a nucleon or a baryon orbited by two relativistic kaons, while the bottom baryons have two relativistic D mesons in orbit. The W, Z, Higgs, and top are relativistic protonium resonances. In this manner it is possible to account for all known particles and resonances as nothing more than onium compounds containing electrons and protons.

1. Introduction

While many physicists attempt to improve physics by adding layers of complexity, others desire to find the simplest possible theory of everything. This paper investigates the latter possibility with all particles being combinations of only one or two elementary particles. Whether we consider the electron and proton to be one or two particles depends ultimately on whether the proton is a state of the electron or vice versa. That is a subject related to other papers by the author.[1][2]

There are far more resonances than can be accounted for by simple combinations of 5 quarks—10, including antimatter—in combinations of two or three at a time. No resonances are thought to contain a top quark. Consequently, the standard model relies on spin excitation states to explain many resonances. For example, the upsilon resonances include 1S, 1P, 2S, 2P, 3S, 3P, and 4S states.

The standard model also relies on numerous total angular momentum states. Delta baryons for example are said to have total angular momentum states of 1/2, 3/2, 5/2, 7/2, 9/2, 11/2, 13/2, and 15/2 and nucleons (N) have almost that many. Note that the term "resonances" is used throughout since it is a more appropriate term than "particles" when discussing unstable combinations of elementary particles.

There are also onium compounds where two particles or resonances, typically a matter-antimatter pair, orbit each other. The two non-relativistic base states are positronium and protonium, an electron-positron and proton-antiproton respectively. The quark model also includes the quarkonium compounds listed below and nearly 50 of their excitation states.

A. Charmed eta meson – charm and anticharm
B. Bottom eta meson – bottom and antibottom
C. Phi meson – strange and antistrange
D. J/Psi meson – charm and anticharm
E. Upsilon meson – bottom and antibottom

Given the success of onium modeling with spin and angular momentum excitation states to describe a large percentage of the known and suspected resonances, it is worth investigating whether all resonances, other than electrons, protons, and the special case where electrons and protons combine to form neutrons, can be accounted for as onium resonances containing electrons and/or protons.

It is also important to note that while the base state mass-energy of resonances is attributed to quark mass in the standard model, it is necessary for spin and angular momentum excitation states to have additional relativistic energy to account for increases in mass-energy. Without relativistic mass-energy, the standard model cannot account for the extra mass, so in that way, the standard model already accepts it. Instead of considering relativistic mass-energy a partial fix, we can consider the idea that all the mass-energy of resonances, above the mass of the constituent electrons, protons, and neutrons, is relativistic.

2. Relativistic Positronium

Historically, the acceptance of an onium model of resonances hinges on the acceptance of the existence of relativistic positronium. The relativistic positronium solution was first discovered by Milne (1948).[3] But it was deep in a book and his discovery was forgotten by most.

It was rediscovered by Sternglass in 1960 when in Feynman's office and at Feynman's suggestion he derived the relativistic positronium solution. Feynman recognized it has the same energy as the neutral pion and could be considered to be the pion.[4][5]

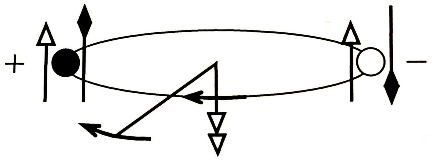

Fig. 1. A Sternglass style drawing of a neutral pion. Open arrows indicate spin direction and closed arrows indicate the direction of the magnetic moment.[3]

The basic energy of relativistic positronium is $274\boldsymbol{m_e}$ where $\boldsymbol{m_e}$ is the mass of the electron and 274 is $\sim 2/\boldsymbol{\alpha}$, with $\boldsymbol{\alpha}$ being the fine structure constant. Half of the mass-energy is due to the basic orbit and the other half is due to Thomas precession. Sternglass calculated the minimum orbital radius as 0.7×10^{-15} meters. That is well within the Compton radius of both the electron and positron. As such, the resonance appears externally like a single particle except when it decays.

Sternglass later added orbital and magnetic moment corrections to arrive at a neutral pion mass-energy of $263\boldsymbol{m_e} = 134.4$ MeV/c^2.[4] This is close to the presently known mass of 134.9766 MeV/c^2. Since the mass of the electron is approximately 0.511 MeV/c^2, we can relate the typical changes in mass-energy in onium states to units of orbital energy of ~140 MeV/c^2 per pair or ~70 MeV/c^2 per particle. Smaller incremental differences of 2 to 10 MeV/c^2 per particle are typically magnetic effects.

The relativistic solution was later confirmed by Smith (1965) and Brown (1966, 1981), but it was a paper by Schild (1963) that caused people to reject it.[6][7][8][9] Schild did not find a stable relativistic positronium solution in his different derivation. Quark theorists happily used this as an excuse to dismiss the idea of relativistic positronium even though particle physicists have since come to rely on the necessity of relativistic mass increases in excited angular momentum states of onium compounds.

Throughout the rest of the paper it will be assumed that there are both relativistic and non-relativistic onium compounds, rather than debate the derivation details. The ultimate success of the complete onium particle model is substantial evidence supporting the existence of the relativistic onium solutions.

3. Muons and Pions: The Pion-Electron Onium Resonances

The most elementary resonances after relativistic positronium—the neutral pion—are non-relativistic onium compounds of an electron and a neutral pion. Sternglass and Browne investigated those possibilities.[8][10] Interestingly, Sternglass investigated them using a pion centered laboratory frame while Browne used an electron centered laboratory frame with a relativistic electron and positron orbiting a stationary electron to form the muon and the entire pion orbiting the electron to form the charged pion. Browne's approach is intuitively more satisfying but Sternglass' works out better in some ways. These approaches give us two different muons, which might explain why some muons (Browne's) have longer lifetimes.

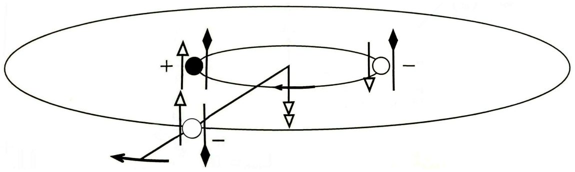

Fig. 2. A Sternglass style drawing of a negative muon with an electron in orbit with a neutral pion. The outer electron is non-relativistic.[3]

The Sternglass muon is shown in Figure 2. This drawing represents only a single electron in non-relativistic orbit, even though it could be interpreted to show a relativistic electron and the possibility of a pair of outer electrons. The Sternglass model of the positive pion is in Figure 3.

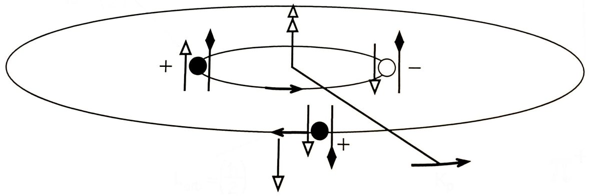

Fig. 3. A Sternglass style drawing of a positive pion with a positron in orbit with a neutral pion. The outer positron is non-relativistic.[3]

The lower energy—Sternglass muon—onium state occurs when the onium orbit is in the same direction as the pion orbit. In the higher energy charged pion the electron orbit is opposite the pion orbit. Sternglass' derivation of the muon mass-energy resulted in 206.7$\mathbf{m_e}$ = 105.62 MeV/c^2 which is comparable to the presently known value of 105.6583745 MeV/c^2.[10]

His calculated charged pion mass was 273.5$\mathbf{m_e}$ = 139.76 MeV/c^2 which compares with the known mass of 139.57018 MeV/c^2.[10] Browne's results were similar, while describing the orbits differently.[8] Except for the electrons' rest mass, the mass-energy of these resonances is due to relativistic energy rather than the rest mass-energy of the constituent particles.

4. Kaons: Pionium Resonances

The next heaviest unstable resonances are the kaons. If we investigate their decay modes, we find that the neutral kaon appears to consist of a positive and negative pion, while charged kaons appear to decay to a charged and neutral pion. Two factors make analysis of the kaons tricky. The neutral kaon has two different mean lifetimes designated as the K-short and K-long, and can also preferentially decay to either matter or antimatter decay products.

A neutral kaon can, however, be made of muons as well as pions. And, since the relativistic neutral pions combine in pairs with opposing spin, the additional electron and positron do not have a preferred direction of orbit when compared to two neutral pions rotating in opposite directions. Consequently, all four possible muon-pion combinations, when using a Sternglass muon, have the same mass-energy to several decimal places. This is best imagined by overlapping Figures 2 and 3 in your mind.

The muon-pion combination has an advantage in stability due to the extra electron-positron pair orbiting in the same direction as shown in Figures 2 and 3. These are the K-long kaons. The other two are the less stable K-short kaons. The four possible combinations are shown in Table 1. Note that the K-long kaons have a preferred decay mode to matter or antimatter as the muon part of a kaon is most likely to decay to a muon or its electron or positron. The decay modes of the K-short do not show a preference.

	Matter (K-Long only)	Antimatter (K-Long only)
K-long	$\mu^- + \pi^+$	$\mu^+ + \pi^-$
K-short	$\mu^- + \mu^+$	$\pi^- + \pi^+$

Table 1 The four types of neutral kaons.

It is also helpful to consider mass and mean lifetimes so Table 2 summarizes the masses and mean lifetimes of the pions and kaons.

	Mass (MeV/c^2)	Mean Lifetime (s)
$\mu^\pm$	105.6583745	2.1969811×10^{-6}
π^0	134.9766	8.4×10^{-17}
$\pi^\pm$	139.57018	2.6033×10^{-8}
$K^\pm$	493.677	1.2380×10^{-8}
K_S^0	497.614	8.594×10^{-11}
K_L^0	497.614	5.116×10^{-8}

Table 2 Masses and mean lifetimes of the pions and kaons.[13]

Note that the neutral pion has a much shorter mean lifetime than the charged pions, and it is also shorter than the kaons. This means that it is unlikely that a kaon could be composed of a neutral pion unless it is stabilized by the addition of an electron as we see with the charged pion. The charged kaon has approximately half the mean lifetime of the charged pion, which is consistent with the idea that it contains two charged pions orbiting a single electron or positron in what Browne called a trionium configuration.[8]

The trionium model best explains the charged kaon's decay modes and mean lifetime. A charged pion orbiting a neutral pion would not be as stable. We would expect the two orbiting pions to be oppositely charged so that they form a metastable onium orbit. But it is possible that they could have the same charge that is opposite from the inner charge. This model allows for two slightly different types of charged kaons.

When two charged pions and an electron are combined in a kaon, the unaccounted-for relativistic mass is 214.0 MeV/c^2. That is a little over a factor of $3/2\boldsymbol{\alpha}$, allowing for a small change in magnetic coupling energy. If we calculate the unaccounted-for relativistic mass of a neutral kaon containing two oppositely charged pions it is 218.5 MeV/c^2 which is also approximately a factor of $3/2\boldsymbol{\alpha}$. In both cases there are six electrons and positrons in relativistic orbit with three in each charged pion. Each electron or positron contributes a factor of ~35 MeV/c^2 ($\sim\mathbf{m}_e/2\boldsymbol{\alpha}$) to the mass-energy for a total of ~210 MeV/c^2.

The onium model also allows for a deexcited kaon (K_D) state where one pion is stationary and relativistically orbited by the other pion such that there is only ~105 MeV/c^2 in additional relativistic mass-energy. Its total mass-energy in the base state is approximately 384.14 MeV/c^2. And, while this does not apparently appear in the free state it does appear as a component in the K(892), tau, and D mesons.

5. Onium Model Outline

Given that introduction it is possible to understand an outline of the onium model. Increasingly heavier resonances typically decay to increasingly more pions. Additional pions in the decay products may be evidence that the resonance has an additional pion in its composition or it can be evidence that a quantum electron-positron pair interacts with the resonance during decay and gains enough energy to turn into a pion. Quantum electron-positron pairs can also separate during the decay process and contribute an electron and positron to the decay products. The latter is true with proton-antiproton quantum fluctuations given sufficient energy.

Two oppositely charged resonances form the most stable onium compounds and the most stable resonant pairs are typically equal in mass. Consequently, the base onium compounds contain 2, 4, 8, or 16 pions. 16 appears to be the limit of what is observable so far. To categorize these simplistically we can define groups based on the number of pions, such as Group 1 for the muons, pions, and Group 1 baryons, Group 2 for kaons and Group 2 baryons, and so on.

There are also trionium compounds. In the base trionium states, an electron or nucleon—proton or neutron—is orbited by a pair of resonances. If it has an electron in the center it will form a meson and if it contains a nucleon it will form a baryon. These can be thought of like a helium atom with a positive charge orbited by two negative charges, except that relativistic onium compounds often have opposite charges in orbit. Basic trionium compounds also progress in Groups of 2, 4, 8, and 16 total pions.

There are also trionium compounds with a single Group 1 resonance orbited by two mesons. These form Groups 3, 5, and 9. After that there are trionium states with a Group 2 meson or baryon orbited by two mesons. These form Group 4, 6, and 10 resonances. A Group 3 resonance can be orbited by two mesons to form Group 5, 7, and 9 resonances. The last of the known trionium compounds have a Group 4 meson or baryon orbited by two mesons. These can form Group 6, 8, and 12 resonances.

In some cases, mesons form “stacks” as predicted by Browne although “nested orbits” is better terminology.[8] A trionium compound may be orbited by two more mesons leading to different mass-energy subgroups in the groups already listed. Triple and quadruple nested compounds have been identified. Altogether, these compounds account for all known resonances and the onium model also does a great job at describing the numerous resonances that do not fit the quark model.

In the onium model the added relativistic mass-energy due to the onium orbit increases in steps of fractions of the fine structure constant times the number of particles. The steps proceed 0, $1/4\boldsymbol{\alpha}$, $1/2\boldsymbol{\alpha}$, and $1/\boldsymbol{\alpha}$ per particle with $1/4\boldsymbol{\alpha} = \sim\mathbf{m}_e/2\boldsymbol{\alpha}$, $1/2\boldsymbol{\alpha} = \sim\mathbf{m}_e/\boldsymbol{\alpha}$ and $3/4\boldsymbol{\alpha} = \sim\mathbf{m}_e 2/\boldsymbol{\alpha}$. Other energy steps may be possible. The 0 step is the non-relativistic onium. Kaons, for example, have $1/4\boldsymbol{\alpha}$ per particle relativistic mass-energy while D mesons have a $1/2\boldsymbol{\alpha}$ per particle relativistic mass-energy due to their orbits.

When two pions orbit they can have additional relativistic mass-energy of approximately 105, 210 or 420 MeV/c^2. Note that like a kaon containing a muon and pion, two resonances may have unequal energy states with one deexcited or excited relative to the other. This appears to be necessary to produce the most stable resonances in some cases, and it leads to some component resonances having more or less energy by factors of $\pm 1/4\boldsymbol{\alpha}$, $\pm 1/2\boldsymbol{\alpha}$, $\pm 3/4\boldsymbol{\alpha}$, or $\pm 1/\boldsymbol{\alpha}$.

When two kaons are in orbit there are relativistic mass-energy steps of roughly 350-490 and 770-980 MeV/c^2. Due to deexcitation with one or both kaons in the K_D state, the relativistic mass-energy of the base resonances can be a lower than the base mass-energy of a 1/4**α** or 1/2**α** orbit. These orbits are "charmed" orbits in the quark model.

Including the kaon masses the "charmed" relativistic states typically add 1260-1400 MeV/c^2 and 1750-2100 MeV/c^2 respectively. The low energy range is where the hypothetical charm quark mass-energy of ~1275 MeV/c^2 comes from. The second energy range correlates with the D mesons and other "charmed" particles. In a trionium compound, the mass-energy of the inner particle or resonance must be added to get the total. The lower energy states occur when one or two K_D resonances are present.

When two D mesons, or other Group 4 mesons, orbit they have added mass-energy in steps of approximately 630-1050 and 1540-2100 MeV/c^2. These relativistic two D meson resonances are identified as "bottom" resonances. The "bottom" two D meson orbital mass-energies, including the mass-energy of the two D mesons, are approximately 4300-4800 MeV/c^2 and 5200-5800 MeV/c^2 respectively. The lower value is consistent with the hypothetical mass-energy of the bottom quark, while the upper range is consistent with the mass-energy of the B mesons. In many B mesons the D mesons are in a deexcited (D_D) state due to one of its kaons being stationary while the other orbits relativistically, thereby reducing the mass energy by ~490 MeV/c^2.

The onium model has the distinct advantage of being able to explain the mass-energy of all the resonances as relativistic mass-energy rather than as particles that acquire their mass due to unknown reasons.

The Sternglass style drawings make it clear that there are multiple combinations of spin, magnetic moment, and orbital states. Sternglass summed the particle spin and orbital angular momenta to derive the known spin state of the resonances. In order for this paper to be a relatively brief introduction to the onium model, no attempt is made to sort out all of the spin, magnetic moment, and orbital states of the resonances. This author has also shown in prior papers that particle spin arises from the quantum field polarization process, consequently, the traditional method of treating spin as a particle property is not appropriate anyway.[11]

With regard to Sternglass, he abandoned the simple onium model in his models for the kaons and more massive resonances, so only his muon and pions are considered to be part of this onium model. His heavier resonance models appear to be invalid.

6. More Pionium Resonances

The next resonances may fall into Groups 3 or 4 given that they have decay modes that include three or four pions. These resonances are listed in Table 3 with their masses and mean lifetimes.

	Mass (MeV/c^2)	Mean Lifetime (s)
η	547.862	5.0×10^{-19}
$\rho^{\pm}(770)$	775.11	4.5×10^{-24}
$\rho^{0}(770)$	775.26	4.5×10^{-24}
$\omega(782)$	782.65	7.75×10^{-23}
$K^{*}(892)^{\pm}$	891.66	3.26×10^{-23}
$K^{*}(892)^{0}$	895.81	$1.39 \text{ x } 10^{-23}$

Table 3 Masses and mean lifetimes of the next mesons by mass-energy.[13]

The eta most commonly decays to 2 gammas, 3 neutral pions, or two oppositely charged pions and a neutral pion. It has no known decay modes to a kaon of any kind so it is not an excited kaon. It is likely a trionium resonance with a neutral pion orbited by oppositely charged muons. The mean lifetime of the eta is consistent with it having a neutral pion in the center. Assuming the trionium model, the unaccounted-for relativistic mass after subtracting the masses of its components is 201.6 MeV/c^2. That is 33.6 MeV/c^2 per particle, so essentially a factor of 1/4**α**. That makes the eta the base state of the Group 3 trionium mesons. Note that 201.6 MeV/c^2 is insufficient energy to form a kaon during its decay.

In the quark model, Rho mesons are considered to be excited pions, but that is not what the decay products tell us. Rho mesons decay to two pions nearly 100% of the time, but are also known to decay to four pions. The charged rho can also decay to a charged pion and an eta. It does not decay to kaons, so they are not excited kaons either.

The lowest relativistic energy Group 4 resonance would be four neutral pions in nested orbits, but that would be highly unstable and have a mass-energy of approximately 560 MeV/c^2. The next more massive Group 4 meson is two nested pions and two pions in relativistic orbit which has the mass of two neutral pions plus a neutral kaon giving a total mass-energy of 767.57 MeV/c^2. This is the neutral rho and the charged rho has a charged pion in the center. Thus, the rho mesons appear to be the lowest mass-energy of the observable Group 4 mesons.

The omega meson's mass is very similar to the neutral rho. It can also decay into four pions including four charged pions, but its dominant decay mode is to a neutral pion and two charged pions. It does not decay to a kaon or a rho, but can decay to an eta. Based on the decay modes it appears to be either a Group 4 meson or an excitation state of the eta. If it is two oppositely charged pions in a non-relativistic orbit, orbited by two pions in a K-type orbit, its estimated mass-energy is 776.75 MeV/c^2. The omega is 234.8 MeV/c^2 more massive than the eta and 436.4 MeV/c^2 more massive than the sum of the masses of two muons and a neutral pion. This falls near the 1/2**α** per particle excitation energy of 420 MeV/c^2 meaning it could also be the higher energy relativistic excitation state of the eta. It is not clear which model is correct based on mass-energy alone but this author favors the Group 4 meson model presently.

K(892) vector kaons notated by the (*) decay predominantly to a kaon and a pion, but can also decay to a kaon and two oppositely charged pions making it appear to be a Group 4 meson rather than an excited Group 2 meson. We can model the neutral K(892) as a kaon in the K_D state relativistically orbited by two charged pions. The unaccounted-for mass-energy after subtracting the mass of a neutral kaon and two oppositely charge pions is 119.06 MeV/c^2 which is a ~1/4**α** orbit for a single pion. The K(892) mass-energy minus the neutral kaon mass-energy is 398.20 MeV/c^2 which is typical of the K_D. The charged kaon can similarly be modeled with a neutral K_D pion in the center.

Another meson in this energy range is the $f_0(500)$ formerly sigma (σ) meson. The $f_0(500)$ can decay to two neutral pions and there is a large spread in its suspected mass energy as it used to be called the $f_0(600)$. It could be either a three or four-pion nested orbit resonance with a mass-energy of either 420 MeV/c^2 or 560 MeV/c^2 respectively. Or it could be two neutral pion resonances in an onium orbit. All of those are not very stable due to the instability of the neutral pion, but they may be observable.

There is an additional suspected meson in this mass-energy range called the **κ** meson or K(800). Its mass-energy is close to the mass of two K_D resonances, so within the onium model, that is its likely composition.

7. Group 4 and 5 Mesons

Group 4 and 5 mesons shown in Table 4 often decay to four or five pions. There are both paired and nested kaonium resonances and Group 5 trionium resonances. The phi is the best known low-energy nested kaonium resonance, and the D mesons are the most prominent relativistic kaonium resonances. The eta prime appears to be a Group 5 meson.

	Mass (MeV/c^2)	Mean Lifetime (s)
η'(958)	957.78	3.32×10^{-21}
φ(1020)	1019.461	1.54×10^{-22}
$\tau^{\pm}$	1776.86	2.903×10^{-13}
$D^{\pm}$	1869.61	1.040×10^{-12}
D^0	1864.84	4.101×10^{-13}
$D_s^{\pm}$	1968.30	5.00×10^{-13}
$D^{*\pm}$	2010.26	7.89×10^{-21}
D^{*0}	2006.96	$>3.1 \times 10^{-22}$
$D_s^{*\pm}$	2112.1	$>3.4 \times 10^{-22}$

Table 4 Masses and mean lifetimes of the Group 4 and 5 mesons.[13]

The eta prime meson decays to an eta and two pions in two of its three predominant decay modes. That makes it appear to be a trionium compound with an eta orbited by a muon pair. This leaves an unaccounted-for mass-energy of 198.6 MeV/c^2, which is nearly the same energy as the base eta. So, the eta prime is a sort of double eta or nested eta. Like the eta, it does not decay to a kaon.

The phi, on the other hand, decays most commonly to two charged kaons or two neutral kaons, but it does not have enough additional energy for it to be two kaons in relativistic orbit. So, it appears to be a nested onium compound with one kaon orbited by 2 pions. That leaves an unaccounted-for relativistic mass-energy of 242.7 MeV/c^2 which is a 1/4**α** per particle K-type orbit.

The higher-energy subgroup includes the tau and D mesons. Tau particles decay most frequently to two pions, but have 8 known decay modes to two kaons and approximately 30 decay modes to a total of 4 pions. So, while physicists have classified it as a lepton, the decay modes tell us that it is a resonance composed of a total of two kaon-like resonances and an electron. Note that this author previously attempted to incorrectly model the tau as a relativistic electron-pion resonance.

If we consider a tau composed of two charged kaons relativistically orbiting an electron in a trionium form, the tau has an unaccounted-for relativistic mass-energy of 789.0 MeV/c^2. The base relativistic mass-energy for 14 particles in a $1/2\boldsymbol{\alpha}$ per particle orbit is 980.35 MeV/c^2. So, the two kaons are deexcited by a little less than a factor of $3/4\boldsymbol{\alpha}$ making them K_D kaons which have a mass-energy of 398.20 MeV/c^2 in the K(892). The result of 2 x 398.20 + 980.35 = 1776.75 MeV/c^2 which is almost precisely the mass-energy of the tau.

The base D meson is 92.75 MeV/c^2 heavier than the tau or a little less than a factor of $3/4\boldsymbol{\alpha}$. This means that one kaon-like component is now in the base kaon state. Note that 398.20 + 493.677 + 980.35 = 1872.23 MeV/c^2 which matches the mass-energy of the charged D meson. The neutral D is similar. These are $1/2\boldsymbol{\alpha}$ per particle D-type orbital energies.

The strange D meson is 98.69 MeV/c^2 more massive than the base D meson. So once again here appears a factor of a little less than $3/4\boldsymbol{\alpha}$. The strange D meson is known to decay into two kaons, so both kaons are clearly in their stable kaon state or they would not have enough energy to predominantly decay into two stable kaons. If we calculate 2 x 493.677 + 980.35 + .511 we get 1968.21 MeV/c^2 as its mass-energy, a near perfect match. Again, we have a factor of $1/2\boldsymbol{\alpha}$ per particle in a D-type orbit.

In the base D mesons, one of the kaons is in a deexcited state. As such, it seldom decays cleanly to two kaons. Because one of the kaons is in the deexcited state in the base D mesons, those D mesons decay preferentially to one kaon or the other. This gives the neutral D meson the appearance of decaying preferentially to matter or antimatter, depending on if the negative kaon or positive kaon is in the base state.

Vector D mesons are a factor of slightly greater than $1/\boldsymbol{\alpha}$ heavier than the base D mesons and strange D meson respectively so they could be either Group 4 or 5 mesons. Given there is no other Group 5 meson with this energy they probably are Group 5 mesons with a pion orbited by two kaons. Adding the mass of a pion to the base D meson mass-energies yields accurate mass estimates.

The remaining D meson excitation states can almost certainly be modeled with an onium model. That includes the $D^*_{s0}(2317)^\pm$, $D^*_o(2400)^0$, $D^*_o(2400)^\pm$, $D^*_1(2420)^0$, $D^*_1(2420)^\pm$, $D^*_1(2430)^0$, $D^*_2(2460)^0$, $D^*_2(2460)^\pm$, $D_{s1}(2460)^\pm$, $D_{s1}(2536)^\pm$, $D(2550)^0$, $D_{s2}(2573)$, D(2600), $D^*(2640)^\pm$, $D^*_{s1}(2700)^\pm$, D(2750), $D^*_{sJ}(2860)^\pm$, and $D_{sJ}(3040)^\pm$. These D mesons have extra pions in their decay modes which could be excited quantum fluctuations or they could be Group 5 or greater mesons.

There are additional lower-energy mesons that do not fit the quark model that are known to decay to a total of four pions including the $f_0(980)$, $a_0(980)$, $a_1(1260)$, $f_0(1370)$, $K_1(1270)$, $K_1(1400)$, $K^*(1410)$, $K_2^*(1430)$, $K^*(1680)$, etc. The $f_0(980)$ and $a_0(980)$ in particular are known to decay to two kaons and may be a kaon orbited by two pions in nested orbits like the phi.

There are other resonances including the $b_1(1235)$, $f_2(1270)$, $f_1(1285)$, $\eta(1295)$, $a_2(1320)$, $h_1(1380)$, $\eta(1405)$, $f_1(1420)$, $K_2^*(1780)$, $K_2(1820)$, and $K^*(1780)$, which decay to 5 total pions that could be in Group 4 or greater. The $K_4^*(2045)$ can decay to a phi and a $K^*(892)$ indicating that it may be a $K^*(892)$ orbited by two pions plus two more pions in stacked orbits. That would leave 591 MeV/c^2 in relativistic mass-energy indicating one $1/2\boldsymbol{\alpha}$ pion pair orbit and one $1/4\boldsymbol{\alpha}$ pion pair orbit. There are many resonances in this mass-energy range that are not well explained by the quark model that can be better modeled with the onium model.

8. Group 8 to 13 Mesons

Next are the mesons in Groups 8 to 13, which based on their decay modes can decay into a total of 8 to 13 pions. The best-known examples are listed in Table 5 with their masses and mean lifetimes.

Symbol	Mass (MeV/c^2)	Mean Life-time (s)
$\eta_c(1S)$	2983.6	2.04×10^{-23}
J/Ψ	3096.916	7.09×10^{-21}
$B^\pm$	5279.26	1.638×10^{-12}
B^0	5279.58	1.519×10^{-12}
B_s^0	5366.77	1.512×10^{-12}
$B^{*\pm}$	5325.2	Unknown
B^{*0}	5325.2	Unknown
B_s^{*0}	5415.4	Unknown
$B_c^\pm$	6275.6	Unknown

Table 5 Masses and mean lifetimes of the Group 8 to 12 mesons.[13]

The charmed eta gets identified as an eta because one of its major decay modes is to an eta prime and two pions. But it also decays to two phi mesons, a phi and two kaons, and has many decay modes to nine total pions. Assuming it is a true Group 9 eta it must be a trionium resonance with an eta prime like resonance orbited by two kaons.

While the J/Psi has decay modes to 9 total pions, some are limited to 8. It is known to decay to a phi and two kaons, but is much longer lived than a phi while only a factor of two longer lived than an eta prime, so it is likely an eta prime-like resonance with two kaons in relativistic orbit. The sum of the masses of a neutral pion, two neutral kaons, and two charged kaons in a 980.35 MeV/c2 orbit is 3097.91 MeV/c^2 thus confirming the model.

The charmed eta is 113.3 MeV/c^2 less massive than the J/Psi, a deexcitation factor of ~3/4$\boldsymbol{\alpha}$. If one kaon is in the base K_D state we can sum the mass of a neutral pion, two neutral kaons, a charged kaon, a 384.14 MeV/c^2 kaon, and 980.35 MeV/c^2 in relativistic orbital energy to get 2988.37 MeV/c^2.

There are a many J/Psi excitation states claimed to be excited states of charmonium that are instead likely Group 9 mesons and excitation states with two kaons in 1/2$\boldsymbol{\alpha}$ orbits. Their symbols are: $X_{c0}(1P)$, $X_{c1}(1P)$, $h_c(1P)$, $X_{c2}(1P)$, $\eta_c(2S)$, $\Psi(2S)$, $X_{c0}(2P)$, X(4260), X(4360) and X(4660). The lightest of these is the $X_{c0}(1P)$ with a mass-energy of 3414.75 MeV/c^2.

Some additional resonances currently classified as charmonium preferentially decay to two D mesons. Their symbols are: X(3872), $X(3900)^{\pm}$, $X_{c2}(2P)$, $\Psi(4040)$, $\Psi(4160)$, and $\Psi(4415)$. These could be composed of D meson orbited by two kaons in a D-type orbit as the mass of two D mesons is 3739.22 MeV/c^2. Some of the other charmonium mesons could be as well.

B mesons predominantly decay to two D mesons or equivalent. The masses of these Donium resonances are approximately equal to two D mesons plus their relativistic orbital energy. B mesons are not likely made of tau resonances since they are too short lived to explain the mean lifetime of the base B mesons.

The unaccounted-for relativistic mass-energy of a charged B meson composed of an electron and two charged D mesons is 1539.5 MeV/c^2. Similarly, the unaccounted-for mass-energy of a neutral B meson composed of two charged D mesons is 1540.4 MeV/c^2. These are B-type orbits. If we divide those figures by two, we get ~770 MeV/c^2 which is the energy of a D-type orbit. So, like the D mesons, the B meson's additional orbital mass-energy is a factor of 1/2$\boldsymbol{\alpha}$ per particle but in a deexcited state.

Multiplying $30\mathbf{m_e}/\boldsymbol{\alpha}$ we get the full orbital energy of 2100.75 MeV/c^2. Assuming a D meson is deexcited in the D_D that decreases the total orbital energy by ~490 MeV/c^2. Then there is a remaining factor of ~70 MeV/c^2 in energy reduction that must be accounted-for with the ~1540 MeV/c^2 B-type orbits.

The B mesons are similar as a group to the D mesons in that the base mesons appear to have one resonance of the D meson pair in a deexcited state and one in the base state. This leads to the B mesons decaying preferentially to one or the other giving the neutral B meson the appearance of having both matter and antimatter versions while containing an equal number of matter and antimatter particles.

The strange B mesons and vector B mesons are excitation states of the base B mesons. Other known B mesons include the $B_1(5721)^0$, $B^*_2(5747)^0$, $B_{s1}(5830)^0$, and $B^*_{s2}(5840)^0$ which are known to decay to a lower energy B meson and a pion for the first two and a B Meson and a kaon for the second two. They have enough additional energy that they could be Group 9 and 10 mesons respectively with a pion and kaon respectively orbited by two D mesons. The $B^*_{s2}(5840)^0$ might be an excitation state of the base B mesons since the mass of two charged D mesons and the maximum 2100.75 MeV/c^2 in orbital energy is 5839.97 MeV/c^2.

The charmed B meson is the heaviest of the B mesons with a mass of 6275.6 MeV/c^2. It does not decay to two D mesons a significant percentage of the time, but rather, it is known to decay to a J/Psi and a D meson, or a J/Psi and two kaons. This means that it is a Group 13 meson rather than Group 8. By working through some possible combinations, we find it is likely a trionium configuration of an eta prime orbited by two D mesons. The sum of the mass of an eta prime and a neutral B meson in 6237.4 MeV/c^2. which is within a factor of 1/4$\boldsymbol{\alpha}$.

There are also lower energy resonances such as the $f_2(2010)$, $\varphi(2170)$, $f_2(2300)$, $f_2(2340)$, etc., which appear to fit in Group 8 since they are known to decay to eight total pions. The lower energy ones appear to be trionium resonances with a Group 4 meson orbited by two Group 2 mesons in a nested orbit. The quark model is not flexible enough to accommodate all of the Group 8 to 13 mesons into a self-consistent model, while the onium model can do so easily.

9. Group 16 Mesons

If we study the decay modes of the “bottomonium” resonances their composition is not obvious from the upsilon and bottom eta. The mass energy is almost twice that of the base B mesons suggesting B mesons in nested orbits. The decay modes of the X_{b0}(1P), X_{b1}(1P), and X_{b2}(1P) include a 90% confidence that each of these resonances can decay to two J/Psi mesons, a J/Psi and Ψ(2S), or two Ψ(2S) resonances. But the mass-energy of two J/Psi mesons in an 18 particle, factor of $1/2\boldsymbol{\alpha}$ per particle orbit, is not sufficient to account for their mass. This is a strong indication that these so-called bottomonium resonances are actually forms of Bonium. The lightest two resonances are the bottom eta and upsilon listed in Table 6.

Symbol	Mass (MeV/c^2)	Mean Lifetime (s)
η_b	9398.0	Unknown
Y(1S)	9460.30	1.22×10^{-20}

Table 6 Masses and mean lifetimes of the Group 16 mesons.[13]

The unaccounted-for mass-energies of the bottom eta and upsilon, after subtracting the mass-energy of four D mesons, are 1919.56 MeV/c^2 and 1981.86 MeV/c^2 respectively. Dividing by two to get the energy per Group 8 resonance of 990.93 MeV/c^2 for the upsilon. 2100.75 MeV/c^2 is the maximum for two $1/4\boldsymbol{\alpha}$ per particle orbits indicating that one of the D mesons is deexcited by a factor of $3/4\boldsymbol{\alpha}$.

Other “bottomonium” resonances that appear to be Y(1S) Donium excitation states are: X_{b0}(1P), X_{b1}(1P), h_{b1}(1P), X_{b2}(1P), *Y*(2S), *Y*(1D), X_{b0}(2P), X_{b1}(2P), X_{b2}(2P), *Y*(3S), X_b(3P), and *Y*(11020). The *Y*(4S) (formerly *Y*(10580)) and *Y*(10860) “bottomonium” resonances have dominant decay modes to two B mesons. They have sufficient mass energy to be two B mesons in stacked $1/2\boldsymbol{\alpha}$ per particle orbits.

10. Meson Mass Table

Based on the suggested calculations and working from the masses of the component particles and resonances, and adding the relativistic mass-energy of the relativistic outer orbit, we can compute the mass-energies of the best-known mesons. They can be compared with the known mass-energy and the relative error calculated as shown in Table 7.

Symbols	Mass (MeV/c^2)	Calculated (MeV/c^2)	% Error
μ^-, μ^+	105.6583745	105.8	0.13
π^0	134.9766	134.7	0.20
π^+, π^-	139.57018	140.0	0.31
K^+, K^-	493.677	489.65	0.82
K^0	497.614	489.14	1.70
η	547.862	556.29	1.54
ρ^+, ρ^-	775.11	772.16	0.38
ρ^0	775.26	767.57	0.99
ω	782.65	766.29	2.09
K^{*+}, K^{*-}	891.66	877.16	1.63
K^{*0}	895.81	881.75	1.57
η'	957.78	969.18	1.19
φ	1019.461	1030.23	1.05
τ^-, τ^+	1776.86	1776.75	<0.01
D^+, D^-	1869.61	1872.23	0.14
D^0	1864.84	1868.08	0.22
D_S^+, D_S^-	1968.30	1968.21	<0.01
D^{*+}, D^{*-}	2010.26	2004.41	0.29
D^{*0}	2006.96	2009.18	0.11
D_S^{*+}, D_S^{*-}	2112.1	2103.28	0.42
η_c	2983.6	2988.37	0.16
J/Ψ	3096.916	3097.91	0.03
B^+, B^-	5279.26	5279.73	<0.01
B^0	5279.58	5279.22	<0.01
B^{*+}, B^{*-}	5325.2	5314.72	0.17
B^{*0}	5325.2	5314.22	0.21
B_S^0	5366.77	5384.22	0.32
B_S^{*0}	5415.4	5419.22	0.07
B_C^+, B_C^-	6275.6	6237.4	0.61
η_b	9398.0	9403.44	0.06
Y	9460.30	9473.44	0.13

Table 7 Mass calculation comparison of the best-known mesons.

The table shows how well the known mass-energies can be derived using the onium model. In-depth analysis of orbit, spin, and magnetic effects should lead to even better fits.

11. Group 1 Baryons

Baryons contain a nucleon—proton or neutron—that does not orbit at relativistic velocity, for if it did, the total mass-energy would be >64 GeV/c^2 = $\boldsymbol{m_p}/2\boldsymbol{\alpha}$. Consequently, baryons have a nucleon in the center with one or more pions, or other mesons orbiting it. Group 1 baryons have one nucleon and one pion in an onium compound as is readily identified from their decay products. The Group 1 baryons are listed in Table 8. Note that the base onium compounds can be identified by their longer mean lifetimes.

Symbol	Mass (MeV/c^2)	Mean Lifetime (s)
Λ^0	1115.683	2.632×10^{-10}
Σ^+	1189.37	8.018×10^{-11}
Σ^0	1192.642	7.4×10^{-20}
Σ^-	1197.449	1.479×10^{-10}
$\Delta^+(1232)$	1232	5.63×10^{-24}
$\Delta^0(1232)$	1232	5.63×10^{-24}
$\Delta^-(1232)$	1232	5.63×10^{-24}
$\Delta^{++}(1232)$	1232	5.63×10^{-24}

Table 8 Masses and mean lifetimes of the Group 1 baryons.[14]

The lowest energy neutral baryons, the lambda and sigma, are composed of a proton and a negative muon or pion, or a possibly a neutron orbited by an electron-positron pair. If we take the mass of the lambda and subtract the mass of a proton and muon, the unaccounted-for relativistic mass is 71.8 MeV/c^2, a factor of ~1/2**α**. The neutron with an orbiting electron-positron pair model, like Browne's muon, best explains the energy and stability of the lambda. The reason for the extra mass-energy needs to be determined. Perhaps instead of a neutron there is a proton orbited by an electron with the additional orbital energy.

Assuming the neutral sigma has a proton and pion, its unaccounted-for relativistic mass-energy is 114.8 MeV/c^2 or ~1/4**α** per particle for three particles indicating a negative pion relativistically orbiting the proton. The neutral sigma decays to a lambda plus a gamma photon, as it does not have enough extra energy to produce a pion in the decay process. The neutral sigma has a much shorter mean lifetime than the lambda, so it can in some way be thought of as an unstable excitation state of the lambda.

The positive sigma is likely a proton and a neutral pion, which is its most common decay mode. The rest of the time it decays to a neutron and a positive pion, which could easily happen if a quantum electron-positron pair is captured during the decay process. Its unaccounted-for mass is 116.1 MeV/c^2.

The two most likely proton and neutral pion combinations are analogous to a positive muon and pion. The positive sigma is most likely a Sternglass muon-like compound with the proton orbiting in the same direction as the inner neutral pion.

In the onium model there is also a positive baryon with a proton orbited by an electron-positron pair. It has the configuration and mass-energy of a positive lambda. It appears inside some heavier resonances, but is not listed as a particle in the standard model. This resonance needs to be investigated.

The negative sigma decays to a neutron and a negative pion, so that is almost certainly what it is. The unaccounted-for relativistic mass is 118.3 MeV/c^2, which is indicative of a 1/4**α** per particle relativistic orbit which is similar to the other sigmas and the K_D resonance.

Delta baryons are the last Group 1 baryons. Based on their decay products, three are composed of a proton and one of three pions ($\pi^\pm$, π^0). The negative delta must almost certainly be a neutron and a negative pion. They are only a factor of 1/4**α** more massive than the base sigma baryons. These are likely excitation states that are different from the sigmas like pions are different from muons.

There are more than 90 known or suspected resonances classified as nucleons (N), deltas, lambdas, or sigmas. While the nucleons and deltas are considered to be excitation states of the nucleons, they all decay to one or more pions plus the nucleon. The higher mass-energy resonances decay to a nucleon and two pions indicating that some of those excitation states may be Group 2 or greater baryons.

The lambda Λ(1405) has an extra pion in its decay that might be a product of the decay process or part of the resonance. If the Λ(1405), contains a neutron, muon, and pion, it has an unaccounted-for relativistic mass-energy of 220.3 MeV/c^2 indicating the muon and pion are in a K-type orbit and making the Λ(1405) a Group 2 baryon.

The quark model alone is not adequate to explain the 90+ additional excitation states, so we presently consider them to be spin and angular momentum excitation states. The onium model is a more straightforward approach to explaining these baryon resonances as will be seen in some examples that follow.

12. Group 2 Baryons

The Group 2 baryons are trionium compounds with a nucleon orbited by two pions. The lowest energy Group 2 baryons are listed in Table 9 with their masses and mean lifetimes.

Symbol	Mass (MeV/c^2)	Mean Lifetime (s)
Ξ^0	1314.86	2.90×10^{-10}
Ξ^-	1321.71	1.639×10^{-10}
$\Sigma^{*+}(1385)$	1382.8	1.839×10^{-23}
$\Sigma^{*0}(1385)$	1383.7	1.83×10^{-23}
$\Sigma^{*-}(1385)$	1387.2	1.671×10^{-23}

Table 9 Masses and mean lifetimes of the Group 2 baryons.[14]

There are two important clues that the Xi baryons belong in Group 2 instead of Group 1. The first is the decay mode, as the Xi baryons' dominant decay mode is to a lambda and a pion, indicating it contains two pions. The second is that the neutral Xi has a longer mean lifetime than the lambda and the negative Xi has a longer mean lifetime than the negative sigma. That means it is impossible for the Xi baryons to be excited states of a lambda or sigma. The Xi baryons must have an onium state that is even more stable than the base Group 1 onium compounds.

The neutral Xi may be a neutron orbited by oppositely charged muons or pions, or nested orbits of two electron-positron pairs. The unaccounted-for relativistic mass-energy of the neutral Xi after subtracting the mass of a lambda and a neutral pion is 64.2 MeV/c^2. The unaccounted-for mass-energy for the negative Xi is 71.0 MeV/c^2. This is a factor of $1/2\boldsymbol{\alpha}$ like the lambda, and probably has the same origin.

In the quark model, the Σ(1385) sigmas are said to have the same composition as the base sigmas but have different spin and angular momentum. When they decay, they decay to the base resonance and a pion. Their masses are in the range of 1385 MeV/c^2 which is approximately 200 MeV/c^2 heavier than the base sigmas, a total factor of almost $3/2\boldsymbol{\alpha}$.

In the onium model there are necessarily resonances with a muon-pion pair or two pions orbiting a nucleon. The Σ(1385)s are the only baryons that fit this energy and composition. The sum of the masses of a neutron, muon, pion and 210 MeV/c^2 in orbital energy is 1394.79 MeV/c^2. This is close to the known neutral Σ(1385) mass. The other two are similar. All three of the Σ(1385) sigmas are Group 2 baryons.

The higher mass-energy Ξ(1530) baryons decay to a base Xi baryon and a pion and are Group 3 baryons discussed in the next section. The Ξ(1690), Ξ(1820), Ξ(1950), and Ξ(2030) Xi baryons decay frequently to a lambda or sigma and a kaon. The Ξ(1690) has the right mass-energy to be a Group 3 baryon with a sigma orbited by two pions in a $1/4\boldsymbol{\alpha}$ orbit. The Ξ(1820) appears to be a Xi orbited by two pions in a $1/4\boldsymbol{\alpha}$ orbit while the Ξ(2030) has the $1/2\boldsymbol{\alpha}$ orbit. The Ξ(1950) is ~420 MeV/c^2 more massive than the Ξ(1530) and decays to a lambda and a kaon so it may be an excited Ξ(1530).

As mentioned previously, there are other baryon resonances that are not well defined in terms of quark composition that may be Group 2 or greater baryons based on their decay products. That list includes: N(1440), N(1520), N(1535), N(1675), N(1680), N(1700), N(1710), N(1720), N(1875), N(1900), N(2190), N(2220), Δ(1600), Δ(1620), Δ(1700), Δ(1905), Δ(1910), Δ(1920), Δ(1930), Δ(1950), Λ(1520), Λ(1600), Λ(1670), Λ(1690), Λ(1800), Λ(1810), Λ(1820), Λ(1830), Λ(1890), Λ(2100), Λ(2110), Σ(1660), Σ(1670), Σ(1750), Σ(1775), Σ(1915), and Σ(1940). The actual group determinations will need to be made on a cases-by-case basis, but they can certainly be more easily explained with an onium model than the quark model.

13. Group 3 Baryons

Group 3 baryons include the omega baryon and the Ξ(1530) baryons. Their masses and mean lifetimes are shown in Table 10.

Symbol	Mass (MeV/c^2)	Mean Lifetime (s)
$\Xi^{*0}(1530)$	1531.80	7.23×10^{-23}
$\Xi^{*-}(1530)$	1535.0	6.6×10^{-23}
Ω^-	1672.45	8.21×10^{-11}

Table 10 Masses and mean lifetimes of the Group 3 baryons.[14]

The omega baryon is the most stable Group 3 baryon. It decays most commonly to a lambda and a kaon, but also decays to either base Xi baryon and a pion. In order to achieve the proper negative charge, the simplest stable trionium Group 3 baryon compound is a positive sigma orbited by two negative pions. An omega baryon composed of a sigma and two pions has extra relativistic mass-energy of 203.9 MeV/c^2. This is very close to a factor of $3/2\boldsymbol{\alpha}$ due to the orbiting pions which is a K-type orbit.

The Ξ(1530) baryons decay to a base Xi baryon and a pion. The extra pion could be part of the resonance or an excited quantum fluctuation. That said, electron-positron orbits do not appear to have 280 MeV/c^2 excitation states, as there is no known 280 MeV/c^2 neutral pion. That means the Ξ(1530) baryons are more likely to be Group 3 baryons. The mass energy of a neutron orbited by an electron-positron pair orbited by two pions in a K-type orbit is 1534.36 MeV/c^2 which is a good match for the Ξ(1530) baryons.

Some baryon resonances with mass-energies of ~1600 MeV/c^2 or greater may be Group 3 baryons. For example, N(1650), N(1710), N(1720), N(1875), N(1900), N(2190), Δ(1910), Δ(1920), Δ(1950), Λ(1670), Λ(1690), Λ(1800), Λ(2100), Λ(2110), Σ(1750), Ξ(1820), and Ξ(1950) are known to decay to a lambda or sigma and two total pions. They, and similarly massive resonances listed in the last section, could possibly be Group 3 baryons rather than excited Group 2 baryons. Each must be investigated further to make this determination.

14. Group 4 Baryons

Group 4 baryons are trionium compounds with a nucleon orbited by two Group 2 mesons or a Group 2 baryon orbited by two pions. The best-known Group 4 baryons are shown in Table 11 along with their masses and mean lifetimes.

Symbol	Mass (MeV/c^2)	Mean Lifetime (s)
Λ_C^+	2286.46	2.00×10^{-13}
Σ_C^+	2452.9	2.91 x 10^{-22}
Σ_C^0	2453.74	>1.43 x 10^{-22}
Σ_C^{++}	2453.98	3.05×10^{-22}
$\Sigma_C^{*+}(2520)$	2517.5	>3.87 x 10^{-23}
$\Sigma_C^{*0}(2520)$	2518.8	4.54 x 10^{-23}
$\Sigma_C^{*++}(2520)$	2517.9	4.42 x 10^{-23}

Table 11 Masses and mean lifetimes of the Group 4 baryons.[14]

The charmed lambda is the principle example of the first subgroup. The decay mode that hints at its composition includes a proton and two oppositely charged kaons. The other Group 4 charmed baryons commonly decay to a charmed lambda and one or more pions.

Given a charmed lambda composed of a proton and two kaons, they have an unaccounted-for relativistic mass-energy of 360.8 MeV/c^2. This is approximately half the increase we see with the tau and D meson "charmed" mesons, so it is a deexcited orbit with a factor of 1/4$\boldsymbol{\alpha}$ per particle instead of 1/2$\boldsymbol{\alpha}$. The maximum energy for this orbit is 490 MeV/c^2 (14 x 35), so it is deexcited by ~140 MeV/c^2 which means one K_D resonance.

The charmed positive sigma is 166.4 MeV/c^2 more massive than the charmed lambda, which is also positively charged. It appears to be the lambda with the maximum orbital energy plus a factor of 1/4$\boldsymbol{\alpha}$. The other charmed sigmas appear to be a neutron orbited by oppositely charge kaons and two positive kaons respectively with the maximum orbital energy plus the factor of 1/4$\boldsymbol{\alpha}$.

The charmed $\Sigma_C(2520)$ baryons are only a factor of ~1/2$\boldsymbol{\alpha}$ more massive than the base charmed sigmas indicating that they are excitation states with the same composition and only a small change in energy rather than being Group 5 baryons.

The $\Omega(2250)^-$ has 580 MeV/c^2 greater mass-energy than the omega baryon so it does not appear to be a Group 3 baryon, but rather, it appears to be a base state Group 4 charmed baryon given its similar mass-energy to the charmed lambda. It makes sense that there is a negatively charged baryon resonance at this energy that is composed of a proton orbited by two negative kaons. The Σ(2250) baryon could also account for a base state neutral resonance in the charmed baryon group.

More Group 4 Baryons should exist as trionium compounds with a Group 2 baryon (Xi) orbited by two pions like the Ξ(1820) and Ξ(2030). The minimum mass-energies are ~1800 MeV/c^2 and ~2000 MeV/c^2 for the 1/4$\boldsymbol{\alpha}$ and 1/2$\boldsymbol{\alpha}$ per particle orbits. Resonances that could fall in this group include: N(1875), N(1900), N(2190), N(2220), Δ(1905), Δ(1910), Δ(1920), Δ(1930), Δ(1950), Λ(1800), Λ(1810), Λ(1820), Λ(1830), Λ(1890), Σ(1915), Σ(1940), Σ(2030), and Ξ(1950). The Σ(2030) in particular is known to decay to a Xi and kaon and has the same mass as the Ξ(2030). Again, the onium model is a much better than the quark model at explaining the known resonances that do not fit the quark model.

15. Group 5 Charmed Baryons

Group 5 baryons are trionium compounds with a Group 1 baryon orbited by two Group 2 mesons or a Group 3 baryon orbited by two pions. The commonly known ones are charmed Xi baryons in the first subgroup. The neutral charmed Xi is a lambda and two oppositely charged kaons and the positive charmed Xi is the positive resonance that is similar to the lambda and two negative kaons. The Group 5 Xi baryons are shown in Table 12.

Given the above, a neutral charmed Xi has an unaccounted-for relativistic mass-energy of 367.8 MeV/c^2. The relativistic mass-energy of the positive Xi baryon is 363.5 MeV/c^2. These are 1/4**α** per particle orbits which are the same as the charmed lambda.

Symbol	Mass (MeV/c^2)	Mean Life-time (s)
Ξ_C^+	2467.87	4.42 x 10^{-13}
Ξ_C^0	2470.87	1.12 × 10^{-13}
$\Xi'_C{}^+$	2575.6	Unknown
$\Xi'_C{}^0$	2577.9	Unknown
Ξ_C^{*+}(2645)	2645.9	2.1 x 10^{-22}
Ξ_C^{*0}(2645)	2645.9	1.2 x 10^{-22}

Table 12 Masses and mean lifetimes of the Group 5 Xi baryons.[14]

The Xi prime charmed baryons are approximately 3/4**α** more massive than the base charmed Xi baryons. This indicates the kaon pair is in a higher energy orbit closer to the 490 MeV/c^2 maximum for a 1/4**α** two-kaon orbit. The Ξ_C(2645) charmed Xi baryons decay to a base Xi and a pion. These appear to be sigmas orbited by two kaons instead of lambdas orbited by two kaons.

There are additional charmed Xi baryons, the Ξ_C(2790), Ξ_C(2815), Ξ_C(2970), Ξ_C(3055), and Ξ_C(3080). The Ξ_C(2790)s may be Σ(1385)s and two kaons. The Ξ_C(3055) and Ξ_C(3080) decay to a lambda and a D meson so they likely have D-type orbits.

The base example of the second type of Group 5 baryons would be a Group 3 omega baryon orbited by two pions with either 1/4**α** or 1/2**α** orbits. Their minimum mass would be ~2150 MeV/c^2 and ~2350 MeV/c^2 respectively. The Λ(2350) is a possible Group 5 baryon of this type based on its mass-energy and the Λ(2100) and Λ(2110) may be the lower energy state.

16. Group 6 Baryons

Group 6 baryons are trionium compounds with either a Group 2 baryon orbited by two Group 2 mesons or a Group 4 baryon orbited by two pions. The charmed omega baryon is the base example of the first subtype. Its decay modes indicate that it is composed of a neutral Xi and two oppositely charged kaons. The masses and mean lifetimes of the best-known Group 6 baryons are shown in Table 13.

If the omega baryon contains a neutral Xi and two kaons, the unaccounted-for relativistic mass-energy is 393.0 MeV/c^2. This is a 1/4**α** per particle relativistic orbit. The Ω_C(2770) baryon decays to the base charmed omega and a gamma photon and has additional mass-energy of a factor of 1/2**α**, which indicates that it is probably an excitation state with a higher energy orbit like the Xi prime baryons.

Symbol	Mass (MeV/c^2)	Mean Life-time (s)
Ω_C^0	2695.2	6.9 x 10^{-14}
Ω_C^{*0}(2770)	2765.9	Unknown

Table 13 Masses and mean lifetimes of the Group 6 baryons.[14]

Another Group 6 baryon subgroup has a Group 4 baryon orbited by two pions. If a charmed lambda is orbited by two charged pions with 210 MeV/c^2 relativistic orbital energy, the total mass-energy is 2775.6 MeV/c^2. Consequently, there should be another baryon with similar mass-energy as the Ω_C(2770).

17. Group 8 and Greater Baryons

Group 8, 9, and 10 baryons listed in Table 14 are trionium compounds with a nucleon or baryon orbited by two mesons. The bottom baryons are the largest subgroup, and based on their decay products they have two D mesons in orbit. The less massive subgroups are the double charmed baryons and the exotic baryons.

The bottom lambda is the lowest energy bottom baryon. In order for it to be electrically neutral it must be a neutron orbited by two oppositely charged D mesons. The unaccounted-for relativistic mass-energy is 940.6 MeV/c^2. This is consistent with other resonances with 1/4**α** per particle added relativistic energy. It is deexcited by a factor of 3/4**α** given the maximum 1050 MeV/c^2 1/4**α** per particle two-D-meson orbit.

Symbol	Mass (MeV/c^2)	Mean Lifetime (s)
Ξ_{CC}^{++}	3621.40	Unknown
Ξ_{CC}^{+}	Unknown	Unknown
$P_C(4380)^+$	4380	Unknown
$P_C(4450)^+$	4449.8	Unknown
Λ_b^0	5619.4	1.429×10^{-12}
Ξ_b^0	5787.8	Unknown
Ξ_b^-	5791.1	1.56×10^{-12}
Σ_b^+	5811.3	6.8×10^{-23}
Σ_b^-	5815.5	1.34×10^{-22}
Σ_b^{*+}	5832.1	5.7×10^{-23}
Σ_b^{*-}	5835.1	8.8×10^{-23}
Ξ_b^{*0}	5949.8	3.1×10^{-22}
Ω_b^-	6046.1	1.13×10^{-12}

Table 14 Masses and mean lifetimes of the Group 8, 9, 10, and 11 baryons.[14]

The bottom sigmas and the spin 3/2 bottom sigmas have dominant decay modes to a bottom lambda and a pion. The positive charmed sigma is likely composed of a positive sigma and two oppositely charged D mesons, while the negative bottom sigma is likely composed of a negative sigma orbited by two negative D mesons. The unaccounted-for relativistic mass-energy of the lightest two are 882.7 MeV/c^2 and 878.8 MeV/c^2 respectively. These are deexcited 1/4$\boldsymbol{\alpha}$ per particle orbits.

The spin 3/2 (*) bottom sigmas appear be excitation states as they are ~20 MeV/c^2 more massive. There is an expected resonance that is 35 MeV/c^2 more massive similar to the difference between a muon and pion for the inner sigma's orbital energy. The spin 3/2 bottom sigmas appear to fit that void in the onium model.

The bottom Xi baryons' mean lifetimes and mass-energies match up best with a lambda orbited by two D mesons making them Group 9 baryons. As a base state, the negative bottom Xi is composed of the positive lambda-like resonance orbited by two negative D mesons and a neutral bottom Xi is a lambda orbited by two oppositely charged D mesons. The unaccounted-for relativistic mass-energies are is 937.5 MeV/c^2 and 932.9 MeV/c^2 respectively. Those numbers are consistent with the bottom lambda.

The bottom omega is so stable that it must necessarily be a base state of the next group, Group 10. If we assume it is a negative Xi orbited by two D mesons the unaccounted-for relativistic mass is 985.17 MeV/c^2. This is again a 1/4$\boldsymbol{\alpha}$ per particle orbit.

There have been other bottom lambda and bottom Xi baryons observed, the $\Lambda_b(5912)^0$, $\Lambda_b(5920)^0$, $\Xi_b(5935)^-$, $\Xi_b(5945)^0$, and $\Xi_b(5955)^-$. The $\Xi_b(5935)^-$, $\Xi_b(5945)^0$, and $\Xi_b(5955)^-$ actually appear to be Group 10 or 11 baryons with a Xi orbited by two D mesons, much like the bottom omega but with a lower energy orbit. The bottom lambdas are a factor of ~2/$\boldsymbol{\alpha}$ heavier than the base bottom lambda. Their mass-energies match with what we would expect from a $\Sigma(1385)$ orbited by two D mesons.

The lowest mass-energy Group 8 subgroup is the double charmed Xi baryons.[12] The double charmed Xi decay modes point to them being Group 6 or 8 baryons but the decay to a charmed lambda plus a kaon and two pions indicating that it belongs in Group 8. If we add the mass of the charmed lambda, two charged kaons, and 350 MeV/c^2 in relativistic orbital energy, we get 3623.81 MeV/c^2, thus confirming the model.

Exotic baryons decay to a J/Psi and a proton and as such are clearly Group 9 baryons. That means the exotic baryons are likely a trionium compound with a lambda orbited by two kaons, and then two more kaons in nested orbits. That means they are like a charmed Xi orbited by two kaons.

Being positively charged, the two exotic baryons may be a positive charmed Xi orbited by oppositely charged kaons. In that case, the unaccounted-for mass of the $P_C(4380)^+$ is 924.8 MeV/c^2. And the unaccounted-for mass-energy of the $P_C(4450)^+$ is 994.6 MeV/c^2. That means the outer kaons are in a 1/2$\boldsymbol{\alpha}$ per particle D-type orbit and the two exotic baryons likely have the same composition with the $P_C(4380)^+$ in a deexcited stated while the $P_C(4450)^+$ has the maximum orbital energy of ~980 MeV/c^2.

There should be other baryon resonances with a 1/2$\boldsymbol{\alpha}$ internal kaon orbit giving them ~400 MeV/c^2 more mass-energy. There may be additional Group 8 or greater baryons where the outer D mesons are in a 1/2$\boldsymbol{\alpha}$ per particle relativistic orbit making them ~940 MeV/c^2 more massive than those listed in Table 14.

18. Baryon Mass Table

Like with the mesons, the baryon mass computations based on the onium model can be tabulated as shown in Table 15.

Symbols	Mass (MeV/c^2)	Calculated (MeV/c^2)	% Error
Λ^0	1115.683	1108.248	0.67
Σ^+	1189.37	1178.249	0.94
Σ^0	1192.642	1183.930	0.73
Σ^-	1197.449	1185.223	1.02
$\Delta^{++}(1232)$	1232	1217.7	1.16
$\Delta^+(1232)$	1232	1213.2	1.53
$\Delta^0(1232)$	1232	1218.9	1.03
$\Delta^-(1232)$	1232	1220.2	0.96
Ξ^0	1314.86	1320.66	0.44
Ξ^-	1321.71	1319.37	0.17
$\Sigma^{*+}(1385)$	1382.8	1393.50	0.77
$\Sigma^{*0}(1385)$	1383.7	1394.79	0.80
$\Sigma^{*-}(1385)$	1387.2	1393.50	0.45
$\Xi^{*0}(1530)$	1531.80	1534.36	0.16
$\Xi^{*-}(1530)$	1535.0	1533.07	0.13
Ω^-	1672.45	1686.98	0.87
Λ_C^0	2286.46	2275.63	0.47
Σ_C^+	2452.9	2450.6	0.09
Σ_C^0	2453.74	2451.9	0.07
Σ_C^{++}	2453.98	2451.9	0.08
Ξ_C^+	2467.8	2451.74	0.65
Ξ_C^0	2470.88	2453.04	0.72
$\Sigma_C^{*+}(2520)$	2517.5	2520.6	0.12
$\Sigma_C^{*++}(2520)$	2517.9	2521.9	0.16
$\Sigma_C^{*0}(2520)$	2518.8	2521.9	0.12
$\Xi'_C{}^+$	2575.6	2591.74	0.62
$\Xi'_C{}^0$	2577.9	2593.04	0.59
$\Xi_C^{*+}(2645)$	2645.9	2666.7	0.78
$\Xi_C^{*0}(2645)$	2645.9	2670.0	0.91
Ω_C^0	2695.2	2687.2	0.30
$\Omega_C^{*0}(2770)$	2765.9	2792.2	0.95
Ξ_{CC}^{++}	3621.40	3623.81	0.07
Λ_b^0	5619.4	5623.8	0.08
Ξ_b^0	5787.8	5799.9	0.21
Ξ_b^-	5791.1	5798.6	0.12
Σ_b^+	5811.3	5827.5	0.28
Σ_b^-	5815.5	5827.5	0.21
Σ_b^{*+}	5832.1	5862.5	0.52
Σ_b^{*-}	5835.1	5862.5	0.47
Ξ_b^{*0}	5949.8	5938.8	0.18
Ω_b^-	6046.1	6040.9	0.09

Table 15 Mass calculation comparison of the best-known baryons.

This table shows how a simple onium model can explain the mass-energies of the best-known baryons as relativistic mass-energy while being consistent with the known decay products. An even better fit can undoubtedly be achieved for most resonances by taking into account orbit, spin, and magnetic effects.

19. Relativistic Protonium

The remaining resonances have masses of 80 GeV/c^2 or greater. The known ones are presently identified as the W, Z, Higgs, and top. They are all produced in proton or proton-antiproton accelerators and are suspected protonium resonances. They are listed in Table 16 with their masses.

Name	Symbol	Mass (GeV/c^2)
W	W^+, W^-	80.379
Z	Z^0	91.1876
Higgs	H	125.18
Top quark	t	173.0

Table 16 Masses of the known resonances in the protonium energy range.

Given the existence of relativistic positronium there must be protonium resonances with one or more relativistic protons. A single relativistic proton in an onium orbit has a mass-energy of approximately $1/2\boldsymbol{\alpha}$ or $1/\boldsymbol{\alpha}$ times the mass of the proton for 64.3 GeV/c^2 or 128.5 GeV/c^2. If we use Sternglass' factor of $263\mathbf{m}_e/2$ per particle and substitute the mass of the proton, we get 123.4 GeV/c^2. This is comparable to the Higgs.

The W and Z masses may be somewhat lower in a similar fashion to a muon's mass being lower than a pion's. The Higgs mass minus a factor of 1/4 is 93.9 GeV/c^2. This is comparable to the mass-energy of a Z resonance, so its mass-energy can be explained by a relativistic onium compound containing a relativistic proton and a negative pion.

Because the W is about 10.8 GeV/c^2 less massive than a Z, it is more of a puzzle. Within the onium model a W could be an onium compound with a relativistic proton orbiting a neutral pion. If the proton orbits in the same orbital direction as the neutral pion, like a positron in a positive Sternglass muon, it could be about 3/4ths the mass-energy of a resonance where the proton orbits the other way. But, the real mass ratio of the W to Higgs is closer to 2/3rds than 3/4ths.

We can consider that there are pion and muon equivalent states of protonium composed entirely of protons and antiprotons instead of electrons and positrons. In the first approximation we can estimate their masses by multiplying the known muon and pion masses by the proton to electron mass ratio. These estimates are shown in Table 17.

Name	Symbol	Mass (GeV/c^2)
Protuon	M^+, M^-	196.9 or 170.9
Neutral Protion	Π^0	247.8
Charged Protion	Π^+, Π^-	256.3

Table 17 Masses of some hypothetical protonium resonances.

"Protuon" is suggested as the name of the muon-like protonion with a capital mu ($M^{\pm}$) for the symbol. Similarly, "protion" is suggested as the name for the pion-like form with capitol pi (Π^0, $\Pi^{\pm}$) as its symbol. We could also use "pruons" as the name for resonances containing a single relativistic proton with masses equivalent to the W, Z, and Higgs.

Note that two possible masses are given for the protuon. The first mass of 196.9 GeV/c^2 is based on the 3/4ths muon to pion mass ratio and the second, 170.9 GeV/c^2, is based on the 2/3rds W to Higgs mass ratio. So, if it turns out that the proper ratio is 2/3rds, that ratio applies to both the W and top.

Since two pions in orbit form 1/2**α** per particle orbits we might think that the same energy can apply to a proton and pion in orbit. There must also be cases where the entire pion experiences relativistic mass increase, rather than just its component particles. If we sum the masses of a proton and negative pion and multiply by 1/2**α** we get 73.9 GeV/c^2 which is closer to the mass-energy of the W resonance. But the error is still large when compared to all the other onium models.

It is also important to note that the sum of the W and Z masses is 171.6 GeV/c^2. Assuming the top is a protonion resonance, it makes sense that there is some simple relationship between the mass-energies as they must have the same underlying cause. The top is also known to decay predominantly to a W, which is consistent with the relativistic protonium model and their mass-energy being due to relativistic protons. Further research is needed to refine the models of the W and top to better match their mass-energies.

There may be additional protonium resonances that follow the meson model, such as kaon-like resonances. These may be observable in higher energy accelerators if they exist for long enough to be observed. Given the short mean lifetimes of the W and top those resonances may not be observable.

20. Conclusion

Mesons, baryons, and protonions follow a distinct pattern of decay products and mass-energy increases that is readily explained by a relativistic onium model with only electrons and protons as elementary particles. An electron and proton may combine to form a neutron in some baryon and protonium resonances with the neutron treated as a special case, separate from the onium model.

There are non-relativistic and relativistic resonances in onium, and trionium compounds. And, there are orbital energy states in steps of roughly 0, 1/4**α**, 1/2**α**, 3/4**α**, and 1/**α** per particle. There may be even higher energy steps. There are additional spin and orbital excitation states that occur in increments of ±1/4**α**, ±1/2**α**, ±3/4**α**, and ±1/**α** along with smaller correction terms that need to be determined on a case-by-case basis. All mass-energy beyond the rest masses of the electrons, protons, and neutrons is relativistic.

The quark model is unnecessary to understand any particle or resonance. The above analysis even points to many mistakes in the current quark model and all the resonances that do not fit the quark model are better explained with the onium model. The standard particle model strongly relies on onium modeling with spin and orbital excitation states already, so scientifically speaking it is not a big leap to eliminate the quark model entirely.

As shown here, it is a straightforward exercise to construct an onium model of the unstable resonances that explains them in a self-consistent way. Most of the models suggested here are best first estimates based on their decay products and mass-energy and will certainly need to further refinement when analyzed in greater detail.

Given the general success of the onium model it is clear that relativistic onium compounds exist. It is possible for all known resonances to be described as compounds consisting only of electrons and protons with all their mass explained as relativistic mass-energy. If it is possible it is likely true, as it is the simplest possible particle theory. That statement is particularly true if the electron and proton are different states of a single elementary particle.

Sternglass and Browne deserve much of the credit for the onium model as Sternglass popularized the relativistic positronium model and Browne predicted the pattern of onium and trionium compounds.

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All particle data not otherwise cited is from the Lawrence Berkeley National Laboratory Particle Data Group.

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