A Different Approach on Elementary Particles

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The Bohr Atom Model explains the basic light spectra of the hydrogen atom. The approach taken here is that this model contains most of the information in Quantum Theory and can be expanded to the study of elementary particles. The remainder of Quantum Theory adds some precision to the calculation of light spectra but adds little information about physics. Special Relativity Theory (SRT) is also recognized as a good descriptor of reality. But it is always of interest to press beyond the given description. That attitude has led to the rest of Quantum Mechanics (QM), but the same attitude hasn't been pressed as far for SRT. The Bohr model, the SRT model, combined with other models developed by the author, explain the light spectra of Protonium. Protonium is a proton and an anti-proton rotating about each other. In addition, these models provide for computer calculation of mass-energy states applicable to elementary particles.

Introduction

Several mathematical models are employed in this approach to elementary particles including the Bohr Atom model, the SRT model, the single-isolated 'photon' model, and models of neutral elementary particles involving constituent charged particles. While not describing the absolute physical nature of the elementary particles, the models are claimed to describe the paramount features for calculation of the mass-energy states of the particles. These models and some of their limitations are explained below. The main assumptions (or postulates) of this modeling are:

1. A single-isolated elementary particle is charged, can exist without a central force particle about which it must orbit, has an angular momentum of $\hbar$, and its circumference has a de Broglie wavelength of unity.
2. Bohr's assumption: the combined orbital angular momentums of two charged particles orbiting about a center-of-mass is equal to quantized values of $n\hbar$, where n is equal to 1, 2, 3, etc.

Simplicity Concept

Nature seems to have a tendency to do things the simple way. At the level of the subatomic particles, we might expect the most simple of construct of the elementary particles. Thus *one* particle is postulated to constitute a charged elementary particle. *Two* charged particles are postulated to constitute a neutral elementary particle. *Two* charged particles are postulated to constitute a neutral elementary particle. A two-charged particle system has its charged particles (of equal or different masses) orbiting around each other much like the way the proton and electron orbit around each other in the hydrogen atom (Bohr Atom). The two particle orbiting system provides the creative quantum states for the single charged elementary particle. A single 'seed' charged particle, the more massive of the two, provides a multitude of energy states for the creation of many different massive charged particles. It remains to calculate these mass-energy states of the two particles in the same manner as the mass-energy states of the hydrogen atom are calculated with Bohr theory.

Special Relativity (SRT) Model

The SRT model is employed. While the standard model of SRT excludes an ether, there exists interpretations of the null results of the Michel-Morley experiment [1] that include an ether, yet retain the concepts of length contraction and time dilation, the mathematics of which would work the same as for SRT.

The SRT model provides a mathematical basis for the masses associated with elementary particles. For instance, some of the masses of mesons range from 264.13 m_e to 5635.94 m_e. These masses may be composed mostly of kinetic energy according to the relativistic formula $m = \gamma m_o$, where $\gamma = 1/\sqrt{1 - v^2/c^2}$, m_o is the rest mass, v is the relative speed of the particle, and c is the speed of light. The author has shown that the electron and positron have a special place in the creation of matter because their mass is principally composed of potential energy [2]. Thus, the rest mass of the electron or positron, that can vary, constitutes the m_o in the relativistic formula for m. In order for the mass to have the high values associated with the meson, its velocity must be that approaching the speed of light c. Table 1 illustrates the mass obtainable when the mass m_e of an electron travels at speed approaching c differing from c by only a very small amount to create a multitude of high mass values.

<div align="center">

Table 1.

v = factor x c, $m = \gamma m_o$, $\gamma = 1/\sqrt{1 - v^2/c^2}$

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Factor	γ	Mass (m_e)
0.999999990	7071.1	7071.1
0.999999950	3162.3	3162.3
0.999999900	2236.1	2236.1
0.999999500	1000.0	1000.0
0.999999000	707.1	707.1
0.999995000	316.2	316.2
0.999990000	223.6	223.6
0.999950000	100.0	100.0
0.999900000	70.7	70.7
0.999500000	31.6	31.6

Such a particle orbiting around another particle at near speed c would have very high centripetal acceleration or very high 'centrifugal force',quantified by the classical formula:

$$f_c = \frac{mv^2}{r} \tag{1}$$

Where m is the inertial mass, v is the tangential speed of the particle which is rotating at radius r from a central point. It is important to emphasize here that m includes not only the rest mass of the particle, but the mass increase due to its kinetic energy.

The force between two orbiting particles must be high to hold a massive particle orbiting at a velocity near c. Again SRT provides the force for this formula [3]:

$$f_{12} = \frac{r_{12}kq_1q_2/r^3}{\gamma^2\left[1 - \left(v^2/c^2\right)\sin^2\theta\right]^{\frac{3}{2}}} \tag{2}$$

f_{12} is the force vector between charges q_1 and q_2 and is in a direction of the radial vector r_{12} joining q_1 and q_2. θ is the angle between the relative velocity vector v of the two charges and the vector r_{12}. γ is defined as above and $k = 1/4\pi\varepsilon_o$, where ε_o is the permittivity of free space. Eq. (2) is taken quite literally by the author to be good for all γ s and all speeds up to c. It is assumed there are no time delays in the force interaction. Since we are considering two large particle speeds with at least one approaching c, then we must employ the SRT formula [4] for velocity addition to determine the relative speed v and the γ in (2):

$$\gamma = \gamma_1\gamma_2\left(1 + |v_1||v_2|/c^2\right) \tag{3}$$

γ_1, γ_2, v_1, and v_2 are the gammas and velocities of q_1 and q_2 with respect to the center-of-mass (CM) of the two orbiting charged particles.

Eq. (2) becomes:

$$f_{12} = \frac{\gamma E_k R_k r_{12}}{r^3} \tag{4}$$

Eq. (4) uses the new constants, E_k and R_k, for Coulomb's Law when the charge values are e [2]. $E_k \equiv 2m_ec^2 = 1.637452944\text{x}10^{-13}$ J. $R_k \equiv ke^2/2m_ec^2 = 1.4089695\text{x}10^{-15}$ m. For two orbiting particles, $\theta = 90^o$. The γ in (4) must be calculated with (3).

Bohr Model

A very important assumption Bohr made for his analysis of the spectral content of the hydrogen atom (Bohr atom) is that the *total* orbital angular momentum of the orbiting masses is quantized by Plank's constant, h [5]. For the case of two charged masses orbiting around each other this assumption is expressed mathematically by:

$$m_1v_1r_1 + m_2v_2r_2 = n\hbar$$
$$m_2v_2r_2a = n\hbar \tag{5}$$
$$a = 1 + m_2/m_1$$

$n = 1, 2, 3$, etc., $\hbar = h/2\pi$. The r's are the radii of the respective orbits about the CM. The mass m_2 in the computer program that follows is taken to be smaller than or equal to m_1. When v_2 is near c, the quantized mass-energy states of m_2 may be approximated by the formula:

$$m_2 = \frac{n\hbar}{cr_2a} \tag{6}$$

If the rest mass of m_2 is larger than the rest mass of the electron m_e and v_2 is less than c the following formula may be employed:

$$v_2 = \frac{n\hbar}{m_2r_2a} \tag{7}$$

The classical formulae related to two charged particles orbiting about each other and their CM are employed as necessary:

$$m_1r_1 = m_2r_2$$
$$m_1v_1 = m_2v_2 \tag{8}$$

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New Concept: Rest Mass Varies

The rest mass, m_o, of a charged particle in a two unlike charge particle system varies according to the following formula [2]:

$$m_o = m_{o(r=\infty)} - \frac{m_e R_k}{r} \tag{9}$$

For larger mass particles, where the value of the charge of the particle is the same as the value for the electron, the rest mass (for unlike charge system) varies according to (9). For example, the rest mass of the proton is given by:

$$m_{po} = m_p - \frac{m_e R_k}{r} \tag{10}$$

Argument for 'Photon' Particles

The 'photon' particle is hypothesized and defined as follows [6,7,8]:

$$m_{(particle)} c r_{(particle)} = \hbar \tag{11}$$

It exists and spins about itself in a circle of circumference equal to on de Broglie wavelength, without a central force (contrarily, the electron in the hydrogen atom has to have the proton as a central force to keep them together). It is induced that protons and many more massive elementary particles exist independently outside of atoms in the 'photon' state. Also, this single-isolated elementary particle has a charge of e.

The author demonstrated in an article [2] the equivalence of the following for Coulomb's Law for charges of value e:

$$\frac{ke^2}{r_t^2} = \frac{E_k R_k}{r_t^2} \tag{12}$$

where r_t is the distance between the two charged particles. Substituting the definition for $E_k \equiv 2 m_e c^2$ into the right side of (12), Coulomb's Law is now:

$$\frac{ke^2}{r_t^2} = \frac{2 m_e c^2 R_k}{r_t^2} = \left(\frac{2 R_k m_e c}{\alpha} \right) (\alpha * c) \left(\frac{1}{r_t^2} \right) \tag{13}$$

where α is the fine structure constant. The following formula has been found to be numerically true:

$$\frac{2 R_k m_e c}{\alpha} = \hbar \tag{14}$$

Eq. (14) may be substituted into (13) in the following way:

$$\frac{ke^2}{r_t^2} = \left(\frac{\hbar}{2} + \frac{\hbar}{2} \right) (\alpha * c) \left(\frac{1}{r_t^2} \right) \tag{15}$$

The spin angular momentum of the electron L_{se} and the spin angular momentum of the proton L_{sp} appears to be the defining contributors to the force in Coulomb's Law and each has a charge e. Thus:

$$L_{se} = m_e c r_e = L_{sp} = m_p c r_p = \hbar \tag{16}$$

where r_e and r_p are the respective radii of the electron and proton. The factor of ½ in the left parentheses of (15) can be accounted for by spin tilt of the electon and proton as they rotate about each other in the hydrogen atom. We may conclude that the electron and proton, because of their appearance in Coulomb's Law, are 'photon' particles. Their

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masses are revolving at their respective radi at velocity *c*. By extension, we can hypothesis that other 'photon' particles with different masses exist and they are defined by (11). Also, it can be seen, that according to this theory, all matter is composed of light energy because the matter is traveling at velocity near or approaching *c*.

According to (16) the radius of the electron is 3.8615937x10^{-13} m and the radius of the proton is 2.10x10^{-16} m. This agrees with Mitsopoulos's interpretation of the 'photon' proton [9]. Also, it follows from (11) and (16) that the wavelength of the

electron is
$$\lambda_e = 2\pi r_e = \frac{h}{m_e c} = \frac{h}{\rho_e} \qquad (17)$$

Generalizing for all single particles including photons, (17) becomes the de Broglie wave

equation:
$$\lambda = \frac{h}{\rho} \qquad (18)$$

From (11) and (17), the equation for energy of the electron is:
$$K_{se} = E_e = m_e c^2 = \frac{hc}{\lambda_e} \qquad (19)$$

Generalizing for all single particles and photons, (19) becomes:
$$E = \frac{hc}{\lambda} \qquad (20)$$

If the time for one orbit of revolution is considered, $T = \lambda / c$, then (20) becomes:
$$ET = h \qquad (21)$$

which resembles one form of the uncertainty principle. From (18), (19), (20), and (21), it can be seen how 'photon' particles have the characteristics of photons.

Mass of an Isolated, Charged, Single Particle Concept
As can be seen from (11) the *m* and *r* of the particle can vary together to provide an infinite number of different masses. The particle has a charge *e* equal to that of the electron. Since (11) also is a defining characteristic of a photon, does it then also have a charge of *e*? The main difference between a photon and a "photon particle" is that the photon is traveling linearly in a straight line at velocity *c* and the 'photon particle' can exist in a stationary state. The isolated-charged-single particle is created in a two-particle system. On being separated from another particle about which it rotated, it continues to exists independently, possessing the same amount of energy it had in a two-particle quantum energy state. Also, the circumference of its self rotation is equal to a de-Broglie wavelength of *unity*. For example, an electron of mass 1 (m_e units) may be accelerated up to near the speed of light and all its energy ($\gamma m_e c^2$) may be stored in a "photon" particle of mass, for example, 273.144, a charged pion. An energy quantum state of two orbiting charged particles, one particle equivalent to that mass, must exist for its energy to be stored in the "photon" state with circumference of one wavelength and $v = c$. This hypothesis is supported by the famous equation: $E = mc^2$.

Also, it is hypothesized that the masses of all charged particles begin with a potential energy rest mass equal to that of the electron. A charged particle with mass greater than that of the electron has in addition only relativistic mass. The masses of the computed elementary particles in this paper are of this type. Once a mass is in the photon state, it is treated mathematically as a point. The electron is treated mathematically as a

point without being in a photon state. This is in the manner of Dirac who employed mathematical points.

Protonium Spectral Terms

Using the above formulae, a computer program was written to calculate the spectra of protonium, a proton and anti-proton orbiting about each other. An internet search produced some measurement confirmation [10]. See Table 2.

Table 2. Calculated and Measured Protonium Spectral Terms

$n_1 - n_2$ transition	Calculated Value (kev)	Measured Value (kev)
3-2	1.735	1.74
Infinity-2	----	3.12
20-2	3.092	----

While these results are not precise, they do indicate the formulae and methodology employed are "in the ballpark".

Calculated Mass-Energy States of Elementary Particles

The mass-energy states of the hydrogen atom are closely related to its spectra states. This appears to be so with elementary particles. The above formulae are employed to write a computer program to calculate the mass-energy states of elementary particles. The following partial pascal program listing is the 'core' of the program. N is mass-energy state. M1 and M1i are initialized to equal the sum of the mass of a proton and the mass of the neutral kaon particle. R2 is initialized to $2 \times R_k$. The fac (factor) is initialized to a value of 1.0. M2 and M2i are initialized to equal m_e. An 'a' is initialized accordingly. Most of the variables are self-explanatory. K2 is equal to R_k.

```
For N := 1 to Number do
   Begin
     For J := 1 to 10 do
       Begin
         If M2 > (1.0*M1) then goto Endloop;
         r1 := r2*M2/M1;
         M2 := N*hbar/(a*fac*c*r2);
         V1 := V2*r1/r2;
        M2o := M2i*(1-K2/(a*r2));
         G2 := M2/M2o;
         G1 := 1.0/sqrt(1.0-(sqr(V1)/(c*c)));
         ft := 1.0 + V1/c;
         Gt := G1*G2*ft;
        M1o := M1i-K2*Me/(a*r2);
         M1 := G1*M1o;
          a := 1+M2/M1;
         r2 := Gt*2.0*Me*K2/(sqr(a)*M2);
         fac:= sqrt(1.0-1.0/sqr(G2));
   End;

  Mb[N] := M1/Me;
```

```
    Ms[N] := M2/Me;
    Mt[N] := (M1 + M2)/Me;

    Writeln(N:2,'  ',Mt[N]:7:1,'  ',Mb[N]:7:1,'  ',Ms[N]:7:1,'  ',v1:10,
      '  ',r1:10,'  ',r2:10,'  ',Gt:8:4);
```

Following the program is a listing of the output produced. Masses are in units of m_e.
Speeds are in units of m/sec. Orbits radii are in units of m. Gt is the total relativistic
gamma factor, γ. The central mass can be initialized with any value, but the one
initialized for this output listing produces a large number of elementary particles.

```
Rmv2a   04/02/02     w = N      2810.18

 N     Mt       Mb        Ms        v1          r1          r2         Gt

 1    2902.6   2811.3      91.3   9.7E+0006   1.3E-0016   4.1E-0015   141.4716
 2    2998.2   2815.8     182.5   1.9E+0007   2.6E-0016   4.0E-0015   291.8333
 3    3096.3   2823.1     273.2   2.9E+0007   3.7E-0016   3.9E-0015   450.8985
 4    3196.7   2833.3     363.4   3.8E+0007   4.8E-0016   3.8E-0015   618.4557
 5    3299.0   2846.1     452.9   4.8E+0007   5.9E-0016   3.7E-0015   794.1865
 6    3403.0   2861.5     541.5   5.7E+0007   6.8E-0016   3.6E-0015   977.7105
 7    3508.5   2879.4     629.0   6.6E+0007   7.7E-0016   3.5E-0015  1168.6028
 8    3615.0   2899.6     715.5   7.4E+0007   8.5E-0016   3.5E-0015  1366.4097
 9    3722.5   2921.9     800.6   8.2E+0007   9.3E-0016   3.4E-0015  1570.6598
10    3830.6   2946.1     884.5   9.0E+0007   1.0E-0015   3.4E-0015  1780.8736
11    3939.1   2972.2     966.9   9.8E+0007   1.1E-0015   3.3E-0015  1996.5688
12    4047.9   3000.0    1047.9   1.1E+0008   1.1E-0015   3.3E-0015  2217.2627
13    4156.7   3029.3    1127.4   1.1E+0008   1.2E-0015   3.2E-0015  2442.4712
14    4265.4   3060.1    1205.3   1.2E+0008   1.3E-0015   3.2E-0015  2671.7085
15    4373.8   3092.2    1281.5   1.3E+0008   1.3E-0015   3.2E-0015  2904.4876
16    4481.7   3125.7    1356.0   1.3E+0008   1.4E-0015   3.2E-0015  3140.3288
17    4589.2   3160.5    1428.7   1.4E+0008   1.4E-0015   3.2E-0015  3378.7852
18    4696.2   3196.7    1499.5   1.4E+0008   1.5E-0015   3.2E-0015  3619.5031
19    4802.7   3234.5    1568.2   1.5E+0008   1.5E-0015   3.1E-0015  3862.3636
20    4909.0   3274.4    1634.6   1.5E+0008   1.6E-0015   3.2E-0015  4107.8127
21    5016.1   3317.3    1698.7   1.6E+0008   1.7E-0015   3.2E-0015  4357.6690
22    5125.9   3365.3    1760.6   1.6E+0008   1.7E-0015   3.2E-0015  4617.1982
23    5243.9   3422.9    1821.0   1.7E+0008   1.8E-0015   3.2E-0015  4900.8305
24    5384.3   3500.6    1883.6   1.8E+0008   1.8E-0015   3.3E-0015  5249.4921
25    5589.2   3628.4    1960.8   1.9E+0008   1.9E-0015   3.5E-0015  5791.2321
26    6009.0   3912.9    2096.2   2.1E+0008   2.0E-0015   4.0E-0015  7013.4742
27    7504.2   5068.2    2436.0   2.5E+0008   1.9E-0015   6.3E-0015 12001.3627

Mt[ 4]:  3196.66     P[30]: 3195.66
Mt[ 6]:  3403.02     P[34]: 3405.05
Mt[16]:  4481.75     P[50]: 4481.36
Mt[17]:  4589.23     P[51]: 4588.99
Mt[22]:  5125.92     P[56]: 5127.14

Mb[18]:  3196.70     P[30]: 3195.66
Mb[23]:  3422.86     P[35]: 3420.70

Ms[ 3]:   273.22     P[ 2]:  273.15
Ms[11]:   966.94     P[ 3]:  966.37
Ms[24]:  1883.62     P[12]: 1882.56

Mt[19]:  4802.67     b[52]: 4804.25

Mb[ 7]:  2879.42     b[13]: 2876.68
Mb[11]:  2972.19     b[14]: 2970.61
Mb[11]:  2972.19     b[15]: 2974.52
```

```
Mb[12]:    2999.95      b[18]: 3001.53
Mb[20]:    3274.41      b[24]: 3272.76
Mb[23]:    3422.86      b[30]: 3424.62
```

The output listings at the bottom represent matches of calculated masses with masses of known elementary particles. The matches are within 0.1 percent. P[x] are masses of known meson particles [11]. Known bayron masses are represented by b[x]. The values on the left are calculated values. The most spectacular of the calculated results are the masses of the charged pion (273.22), the charged kaon (966.94), and the meson of mass 1883.62. The fact that these are computed *together* in one program adds to the probability and support of this theory of elementary particles. These results show how these particles may be created in a mass-energy state associated with a heavier particle. Most of the other masses of the known mesons and bayrons may be similarly matched by initializing the center mass, M1, to different values. All this implies that it takes a heavy 'seed' particle to create the elementary particles.

Note that r2 remains fairly constant and is in the range of measured nuclear sizes. When r2 starts getting larger due to increase in energy state N, the program becomes unstable and "kicks" out of the loop. This implies an upper limit to N.

No regard was given to matches according to the charge of the particle except in the case of the charged pion and the charged kaon.

The Role of the Electron

According to this model and analysis, the electron plays a major role in the creation of all elementary particles. In the above computer model the mass M_2 must be initiated with the mass m_e of the electron. From that mass all charged elementary masses are created. Charged elementary masses are created when the electron, supplied with additional energy, interacts with a central particle that is heavy and charged. Neutral masses are created from two of these charged elementary masses. This model emphasizes the flexibility of the electron. For instance, it exists at the Bohr orbit A with a wavelength of *unity*. It exists in an isolated self-orbit with a wavelength of *unity*. There are wave solutions at the nuclear level where it exists with mass much greater than m_e and with wavelengths *unity* and greater.

The Neutron

As an example, a detailed description a wave-particle solution resembling the neutron is presented. When M1 is initiated with a mass of a K* (1745.77 m_e) and M2 is initiated with a mass of m_e, the mass of an electron, the program produces a neutral particle with a total mass of 1839.1 m_e. The mass of the neutron is given to be 1838.63 m_e. The electron is orbiting the K* with a mass of 91.3 m_e at a velocity near c at a radius of 4.0×10^{-15} m and at a quantum state of n =1 with the K*. The K* is orbiting around the CM at a radius of 2.1×10^{-16}. It has a mass of 1747.8 m_e and a velocity of 2.1×10^7 m/s.

Discussion

Slight variations in the values of numbers initiated in the above pascal program causes variations in the programs output matches. For instance if the number of times the particles' masses are calculated is varied, say from J = 10 maximum to J = 20 maximum, then some of the matches (within 0.1 %) are dropped and some new ones are added. This suggests that the program is just a 'number generator' and matches (in probability theory)

are to be found. This argument may be countered by recognizing that the large numbers of the measured mass-energy states for elementary particles must be produced by the existence of a large number of mass-energy states. Also, the program output is not exactly precise and parallels the output of Bohr Atom theory for circular orbits before the full development of quantum mechanics. Circular orbits are employed instead of elliptical orbits and probability theory is not employed at all. Perhaps the most significance of the program results is that it shows there are *stable* mass-energy states at the nuclear level very similar to mass-energy atomic states of the hydrogen atom.

Conclusions

This approach to the calculation of the mass of elementary particles produces abundant matches of calculated masses to known masses. Those matches suggest that this approach has merit and should be pursued. As presented in this paper, it describes a partial and broad outline for a model of elementary particles. Further work on this approach would include descriptions of magnetic moments, angular momentums, the assignment of charge, and specific quantum states.

This study supports the theory of "photon" particles. Also, it shows how the Coulomb force acting between charges of *e* can be attributed to the spin of the relating particles.

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