Empirical Formulas for the Masses of Subatomic Particles

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Abstract

A mathematical relationship between the masses of subatomic particles has been discovered. As a consequence, simple formulas are being proposed for the masses of 74 subatomic particles and even some heavy quarks. The reciprocal of the fine-constant occupies a major role in these formulas.

Report

After decades of intense study, the masses of subatomic particles have been measured in great detail, but there is no theory that can precisely explain why a subatomic particle has its own specific mass.

My approach towards solving this problem has been to search for common factors among the bewildering array of subatomic particle masses. Since the smallest, well-defined mass belongs to the electron, (0.51099891 MeV), I chose to use this value as the unit of measurement for this study. The initial step in the search consisted of converting the mass equivalent energies of a large number of subatomic particles to equivalent multiples of electron masses.

The next step was to try all types of dimensionless constants, pi, e, irrational numbers, square roots, fractions, exponential expressions, and even combinations of these values to see if they could explain the observed values. None were successful.

Only one constant, the reciprocal of the fine-structure constant, seemed to be involved. Throughout the remainder of this study the letter A will be used to represent the inverse fine-structure constant (137.03599914). The fine structure is a very reasonable choice because it relates mass energy to electrical energy and it occurs repeatedly in many physical phenomena.

The first indicator of the importance of the reciprocal of the fine structure constant is the charged pion. The mass of the charged pion is almost exactly twice the fine-structure constant minus one electron mass. The mass of the charged pion can be expressed as [2A-1] times the mass of the electron. The observed mass of the charged pion is 139.7018 MeV and the mass calculated by the formula is 139.5640 MeV, quite close, but not perfect.

A pair of particles, the charged kaon and the neutral kaon also seem to fit this pattern. The charged kaon can be expressed as (7A+7) m_e and the neutral kaon as (7A+14) m_e. The measured mass of the charged kaon is 493.677 MeV and the value calculated by the formula is 493.754 MeV; the measured mass of the neutral kaon is 497.614 MeV and the value calculated by the formula is 497.331 MeV. The values are quite close, but not perfect. What is amazing is that, other than the fine-structure constant, only integers are involved. Another point of interest is that the 7 and 14 are multiples of the integer factor of A. The formulas of these kaons can then be rewritten as [7(A+1)] and [7(A+2)] when measured in electron masses. These are remarkably simple formulas.

Applying these patterns to the neutral pion and the muon requires changes in the style of the formulas. The best formula for the neutral pion Is [2A-10] which provides a calculated value of 134.9905 MeV versus the measured value of 134.9766 MeV, still quite close. The muon provides a surprise. The best fit for the muon is [1.5A+1], where a half integer is used instead of a full integer, providing a calculated value of 105.549 MeV versus the measured value of 105.658 MeV. These formulas of [2A-10] and [1.5A+1] are still quite simple and provide calculated values that are quite close to the measured values. Formulas created for many other subatomic particles also involve half integers.

General Pattern for Formulas

Almost all of the 74 subatomic particles in this study can all be grouped under the following general formula:

$$[X(A+Y)+Z]m_e$$

A is the reciprocal of the fine-structure constant, X is the primary factor, Y is a multiple of the primary factor, and Z is a small number of electron masses needed to complete the formula. X can either be an integer or half-integer, Y and Z are either positive or negative integers or half integers, and m_e is the mass of the electron.

Tables of Formulas for Masses of Subatomic Particles

The following tables provide the formulas and masses of various groups of subatomic particles.

A- Pseudo Scalar Mesons
B- Vector Mesons
C- Baryons Spin 1/2
D- Baryons Spin 3/2
E- Leptons

Table A- Pseudo Scalar Mesons

particle	measured mass (MeV)	calculated mass (MeV)	proposed formula (m_e)	condensed equation (m_e)
pion: +	139.7018	139.5640	2A-1	2A-1
pion: 0	134.9766	134.9905	2A-10	2A-10
eta: 0	547.862	547.938	8(A-3)	8A-24
eta prime: 0	957.78	957.87	14(A-3)-2	14A-44
charmed eta: 0	2983.6	2983.5	42(A+2)-1	42A+83
bottom eta: 0	9398.0	9398.1	10 protons +30 electrons	$10p^+ + 30e^-$
kaon: +	493.677	493.754	7(A+1)	7A+7
kaon: 0	497.614	497.331	7(A+2)	7A+14
D meson: +	1869.61	1869.48	27(A-1.5)-1	27A-41.5
D meson: 0	1864.84	1864.88	27(A-2)+3.5	27A-50.5
D meson strange: +	1968.30	1968.37	28(A+0.5)+1	28A+15
B meson: +	5279.26	5279.25	76(A-1)-7.5	76A-83.5
B meson: 0	5279.58	5279.51	76(A-1)-7	76A-83
B meson strange: 0	5366.77	5366.62	75.5(A+2)+5	75.5A+156
B meson charmed: +	6275.6	6275.7	89(A+1)-4	89A+85

continued				
particle	measured mass (MeV)	calculated mass (MeV)	proposed formula (m_e)	condensed equation (m_e)
rho: +	775.11	775.13	11(A+1)-1.5	11A+9.5
rho: 0	775.26	775.39	11(A+1)-1	11A+10
omega: 0	782.65	782.54	11(A+2)+2	11A+24
phi: 0	1019.461	1019.463	15(A-4)-0.5	15A-60.5
J/psi: 0	3096.916	3096.934	43(A+4)-4	43A+168
upsilon: 0	9460.30	9460.27	A(A-2)+8.5	A^2-2A+8.5
kaon*: +	891.66	891.68	13(A-3)+2.5	13A+41.5
kaon*: 0	895.81	895.76	13(A-2)-2.5	13A-28.5
D*: +	2010.26	2010.6	28.5(A+1)	28.5A+28.5
D*: 0	2006.96	2006.96	28.5(A+1)-6.5	28.5A+22
strange D*: +	2112.1	2112.0	29.5(A+3)+2	29.5A+90.5
B*: +	5325.2	5325.2	75(A+2)-6.5	75A+143.5
B*: 0	5325.2	5325.2	75(A+2)-6.5	75A+143.5
strange B*: 0	5415.4	5415.6	76.5(A+1.5)	76.5A+114.75

Table C- Baryons- spin ½

particle	measured mass (MeV)	calculated mass (MeV)	proposed formula (m_e)	condensed equation (m_e)
proton: +	938.272046	938.1869	13.5(A-1)-0.5	13.5A-14
neutron: 0	939.565379	939.4644	13.5(A-1)+2	13.5A-11.5
lambda: 0	1115.81	1115.81	16(A-0.5)-1	16A-9
charmed lambda: +	2286.46	2286.56	33(A-1.5)+2	33A-47.5
bottom lambda: 0	5619.4	5619.4	80(A+0.5)-6	80A+34
sigma: +	1189.37	1189.41	17A-2	17A-2
sigma: 0	1192.642	1192.473	17A+4	17A+4
sigma: -	1197.449	1197.583	17(A+1)-3	17A+14
charmed sigma: ++	2453.98	2453.95	35A+6	35A+6
charmed sigma: +	2452.9	2452.9	35A+4	35A+4
charmed sigma: 0	2453.74	2453.69	35A+5.5	35A+5.5
bottom sigma: +	5811.3	5811.3	83A-1.5	83A-1.5
bottom sigma: -	5815.5	5815.4	83A+6.5	83A+6.5

Baryons-spin ½ continued

particle	measured mass (MeV)	calculated mass (MeV)	proposed formula (m_e)	condensed equation (m_e)
Xi: 0	1314.86	1314.89	18.5(A+2)+1	18.5A+38
Xi: -	1321.71	1321.79	19(A-1)+2	19A-17
charmed Xi: +	2467.8	2467.75	35(A+1)-2	35A+33
charmed Xi: 0	2470.88	2470.81	35(A+1)+4	35A+39
charmed Xi prime: +	2575.6	2575.6	36(A+3)+2	36A+109
charmed Xi prime: 0	2577.9	2577.9	36(A+3)+3.5	36A+111.5
double charmed Xi: +	3518.9	3518.9	49.5(A+2)+4	49.5A+103
bottom Xi: 0	5787.8	5787.8	81.5(A+2)-5	81.5A+158
bottom Xi: 0	5791.1	5791.1	81.5(A+2)+1.5	81.5A+244.5
charmed omega: 0	2695.2	2695.2	38(A-2)-9	38A-67
bottom omega: -	6071	6071	87(A-0.5)+2	87A-41.5

Table D- Baryons- spin 3/2

particle	measured mass (MeV)	calculated mass (MeV)	proposed formula (m_e)	condensed equation (m_e)
delta: ++	1232	1231.8	18(A-3)-2	18A-56
delta: +	1232	1231.8	18(A-3)-2	18A-56
delta: 0	1232	1231.8	18(A-3)-2	18A-56
delta: -	1232	1231.8	18(A-3)-2	18A-56
sigma*: +	1382.8	1382.87	19.5(A+2)-5	19.5A+34
sigma*: 0	1383.7	1383.89	19.5(A+2)-3	19.5A+36
sigma*: -	1387.2	1387.47	19.5(A+2)+4	19.5A+43
charmed sigma*: ++	2517.9	2517.8	36A-6	36A-6
charmed sigma*: +	2517.5	2517.3	36A-7	36A-7
charmed sigma*: 0	2518.8	2518.87	36A-4	36A-4
bottom sigma*: +	5832.1	5832.05	84.5(A-2)+2.5	84.5A-166.5
bottom sigma*: -	5835.1	5835.12	84.5(A-2)+8.5	84.5A-160.5
Xi*: 0	1531.80	1531.87	22(A-1)+5	22A-17
Xi*: -	1535.0	1534.93	22(A-0.5)	22A-11
charmed Xi*: +	2645.9	2645.88	37.5(A+1)+1.5	37.5A+39
charmed Xi*: 0	2645.9	26.45.88	37.5(A+1)+1.5	37.5A+39
bottom Xi*: 0	5945.5	5945.51	85.5(A-1)+4	85.5A-81.5
omega: -	1672.45	1672.42	23.5(A+2)+5.5	23.5A+52.5
charmed omega*: 0	2765.9	2765.73	39(A+2)-10	39A+68

Table E- Leptons

particle	measured mass (MeV)	calculated mass (MeV)	proposed formula (m_e)	condensed equation (m_e)
Electron: -	0.510998946	same	1	1
Muon: -	105.658	105.549	1.5A+1	1.5A+1
Tau: -	1776.84	1776.69	25(A+2)+1	25A+51

Quarks

Surprisingly, the proposed masses of the heavier quarks can also be expressed utilizing the fine structure constant (A) and the mass of the electron (m_e).

quark	suspected mass (MeV)	calculated mass (MeV)	proposed formula (m_e)	condensed equation (m_e)
strange (s)	70 to 130	70.0 to 140	A to 2A	A to 2A
charm (c)	1160 to 1340	1159.3 to 1296	$A^{1.5}(2)^{0.5}$ to $A^{1.5}(2.5)^{0.5}$	(1.41421) $A^{1.5}$ (1.58114) $A^{1.5}$
bottom (b)	4130 to 4370	4131 to 4377	59A to 62.5A	59A to 62.5A

Conclusion

The proposed formulas for the masses of subatomic particles do not in themselves provide an answer to why each particle has its own specific mass. Instead, it establishes a mathematical connection between the masses. The next step is to discover what the integers and half integers represent within these equations.

This problem is analogous to the explanation of the Rydberg constant. The Rydberg constant is an empirical physical constant relating to atomic spectra, discovered by Johannes Rydberg in 1890. It took 23 years more for a derivation of the Rydberg constant to be created by Neils Bohr in 1923. Hopefully, in using these new formulas it will not that long to explain the observed patterns of subatomic masses.

Speculations

The proposed formulas probably describe stable structures within each particle and the bonds that connect these structures.

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