The Distribution of Energy Within

Baryonic Sub-Atomic Particles.

[2]

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ABSTRACT.

The total energy within a Baryonic sub-atomic particle consists of three varieties, (i) matter energy - the matter energy of the three constituent quarks, (ii) the energy associated with the intrinsic angular momentum of the particle, and (iii) the energy associated with quark confinement.

The purpose of this paper is to determine the level of each type of energy within all Baryonic sub-atomic particles that possess intrinsic angular momenta of $J = 1/2\hbar$ and $J = 3/2\hbar$.

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REFERENCES.

1.0 Introduction.

The total energy content of all 75 Baryonic sub-atomic particles listed in [1] is made up of three varieties, (i) the matter energy of the three constituent quarks, (ii) the energy associated with intrinsic angular momentum - resonance energy and (iii) the energy associated with quark confinement.
The total energy of the majority these particles is known, firstly by the experimental measurement of mass as reported in [1] and [2], and secondly, for those particles whose mass is reported as unknown in [1] and [2], by virtue of the empirical determination of their mass in [3]. Also, the level of quark matter energy has been estimated sufficiently in [3] to enable [3] to be prepared, and is therefore considered acceptable for use here.
Consequently, in order to ascertain the apportionment of particle energy between (i), (ii) and (iii), it is only necessary to determine the level of either resonance energy or quark confinement energy, for each particle. With regard to the latter, the precise nature and source of this energy is unknown, and consequently there is no means by which the level of quark confinement energy within a Baryon can be independently determined. However, because Baryons exist with various levels of intrinsic angular momentum, this enables the levels of resonance energy within all Baryons to be easily obtained. This together with the particles total energy, and its quark matter energy, then enables the levels of quark confinement energy to also be obtained.

It should be noted that in this paper, energy will be represented as equivalent mass via the units MeV/c^2.

2.0 The Determination of the Resonance Energy Represented by One Unit of Intrinsic Angular Momentum.

There are 30 Baryonic Particles with an intrinsic angular momentum of $J = 1/2\hbar$, for which there also exists a resonance energy variant with intrinsic angular momentum of $J = 3/2\hbar$. It is reported, [1] and [2], that these particles and their variants contain the same constituent quarks. Because of this the quark matter energy level in each particle and its resonance energy variant will be identical. Also, because of this same quark constituency it is believed that their quark confinement energy levels will also be identical, an assumption which is later verified. Consequently, the simple subtraction of the total energy of each particle from that of its resonant energy variant, will produce a resonance energy level associated with one unit of intrinsic angular momentum for each particle/variant. This has been effected in the following table for the 60 subject particles.

$J = 1/2\hbar$ Particle	Particle Mass	$J = 3/2\hbar$ Particle	Particle Mass	Quark Content	$J = 1\hbar$ Resonance Energy	$J = 1/2\hbar$ Resonance Energy	$J = 3/2\hbar$ Resonance Energy
p^+	938.27	Δ^+	1232.00	uud	293.73	146.86	440.59
n^0	939.57	Δ^0	1232.00	udd	292.44	146.22	438.65
Σ^+	1189.37	Σ^{*+}	1382.80	uus	193.43	96.72	290.15
Σ^0	1192.64	Σ^{*0}	1383.70	uds	191.06	95.53	286.59
Σ^-	1197.45	Σ^{*-}	1387.20	dds	189.75	94.88	284.63
Ξ^0	1314.86	Ξ^{*0}	1531.80	uss	216.94	108.47	325.41
Ξ^-	1321.71	Ξ^{*-}	1535.00	dss	213.29	106.65	319.94
Σ^{++}_c	2453.98	Σ^{*++}_c	2518.00	uuc	64.02	32.01	96.03
Σ^{+}_c	2452.90	Σ^{*+}_c	2517.50	udc	64.60	32.30	96.90
Σ^{0}_c	2453.74	Σ^{*0}_c	2518.80	ddc	65.06	32.53	97.59
$\Xi^{\prime +}_c$	2575.63	Ξ^{*+}_c	2645.90	usc	70.30	35.15	105.45
$\Xi^{\prime 0}_c$	2577.90	Ξ^{*0}_c	2649.25	dsc	71.35	35.68	107.03
Ω^{0}_c	2695.20	Ω^{*0}_c	2765.90	ssc	70.70	35.35	106.05
Ξ^{++}_{cc}	3650.73	Ξ^{*++}_{cc}	3737.27	ucc	86.54	43.27	129.81
Ξ^{+}_{cc}	3653.16	Ξ^{*+}_{cc}	3739.66	dcc	86.50	43.25	129.74
Ω^{+}_{cc}	3752.22	Ω^{*+}_{cc}	3836.92	scc	84.71	42.35	127.06
Σ^{+}_b	5811.30	Σ^{*+}_b	5832.10	uub	20.80	10.40	31.20

Σ^0_b	5731.82	Σ^{*0}_b	5820.27	udb	88.45	44.23	132.68
Σ^-_b	5815.50	Σ^{*-}_b	5835.10	ddb	19.60	9.80	29.40
$\Xi^{/0}_b$	5787.80	Ξ^{*0}_b	5945.50	usb	157.70	78.85	236.55
$\Xi^{/-}_b$	5791.10	Ξ^{*-}_b	5949.95	dsb	158.85	79.42	238.27
Ω^-_b	6071.00	Ω^{*-}_b	6078.47	ssb	7.47	3.73	11.20
$\Xi^{/+}_{cb}$	7487.11	Ξ^{*+}_{cb}	7639.61	ucb	152.50	76.25	228.75
$\Xi^{/0}_{cb}$	7490.72	Ξ^{*0}_{cb}	7643.41	dcb	152.69	76.34	229.03
$\Omega^{/0}_{cb}$	7638.11	Ω^{*0}_{cb}	7798.69	scb	160.58	80.29	240.87
Ω^+_{ccb}	9586.36	Ω^{*+}_{ccb}	9886.36	ccb	300.00	150.00	450.00
Ξ^0_{bb}	13381.23	Ξ^{*0}_{bb}	14130.57	ubb	749.34	374.67	1124.01
Ξ^-_{bb}	13386.84	Ξ^{*-}_{bb}	14137.04	dbb	750.20	375.10	1125.30
Ω^-_{bb}	13616.99	Ω^{*-}_{bb}	14401.61	sbb	784.62	392.31	1176.93
Ω^0_{cbb}	16669.09	Ω^{*0}_{cbb}	17984.05	cbb	1314.96	657.48	1972.44

Table 2.1 - Determination of the Resonance Energy Associated with One Unit of Intrinsic Angular Momentum.

In this table the particle mass for Ξ^+_{cc} as recorded in [1] and [2] is believed to be low, and so the calculated value from the empirical law of [3] has been used. The value in the table is shown in red.

3.0 The Determination of the Resonance and Quark Confinement Energies for All Baryonic Sub-Atomic Particles Possessing Intrinsic Angular Momenta of $J = 1/2\hbar$ and $J = 3/2\hbar$.

The final two columns of table 2.1 provide the levels of resonance energy associated with intrinsic angular momenta of particles with $J = 1/2\hbar$ and $J = 3/2\hbar$. These values could then, as discussed above, be used to determine the energy associated with quark confinement for the 60 particles listed in Table 2.1. However, prior to this, it is necessary to also cover the 15 particles not contained in this table. To effect this the values so obtained in Table 2.1 must accordingly be both suitably interpolated and extrapolated, by determination of a resonance energy empirical law. This is not possible for the complete range as in Table 2.1 because it is clear from this table, that resonance energy is not a straight function of either the particle mass, nor the sum of the quark masses. However, there is such a correlation apparent when considered in terms of quark content. This is shown in Appendix A, where the resonance energy equivalent to one unit of intrinsic angular momentum, (column 6 in Table 2.1), has been plotted against the sum of the applicable quark masses according to quark content, (i.e. uu + d, s, c, b etc). Curve fitting these plots enables preparation of Table 3.1, which shows the resulting empirical laws, (i.e. Weibull and MMF Models), and also the separate tables for each group of quark content in turn showing resonance energy, ($J = 1\hbar$), for their sum quark mass.

uu Quark Series Extrapolated		
Quark Content	Sum (Quark Mass)	Resonance Energy
u	7.20	297.75
d	9.55	293.72
s	104.80	193.42
c	1254.80	63.61
b	4304.80	24.00

dd Quark Series Interpolated		
Quark Content	Sum (Quark Mass)	Resonance Energy
u	11.90	292.43
d	14.25	287.72
s	109.50	189.73
c	1259.50	64.21
b	4309.50	26.14

ss Quark Series Interpolated		
Quark Content	Sum (Quark Mass)	Resonance Energy
u	202.40	215.28
d	204.75	214.83
s	300.00	194.52
c	1450.00	68.95
b	4500.00	17.32

Weibull Model: y=a-b*exp(-c*x^d)	
Coefficient Data:	
a =	303.89579
b =	338.84513
c =	10.265178
d =	-0.47608027

Weibull Model: y=a-b*exp(-c*x^d)	
Coefficient Data:	
a =	309.14699
b =	339.14953
c =	9.8108525
d =	-0.47713483

Weibull Model: y=a-b*exp(-c*x^d)	
Coefficient Data:	
a =	229.14359
b =	243.09587
c =	517.24794
d =	-0.978524

cc Quark Series Interpolated		
Quark Content	Sum (Quark Mass)	Resonance Energy
u	2502.40	83.66
d	2504.75	83.85
s	2600.00	91.32
c	3750.00	167.14
b	6800.00	297.09

MMF Model: y=(a*b+c*x^d)/(b+x^d)	
Coefficient Data:	
a =	-447.69533
b =	166.25552
c =	1122.7012
d =	0.56778255

bb Quark Series Extrapolated		
Quark Content	Sum (Quark Mass)	Resonance Energy
u	8602.40	746.60
d	8604.75	747.75
s	8700.00	794.14
c	9850.00	1314.93
b	12900.00	2425.85

MMF Model: y=(a*b+c*x^d)/(b+x^d)	
Coefficient Data:	
a =	-14097.234
b =	241.61231
c =	13062.233
d =	0.62628885

Three Quark Series		
Quark Content	Sum (Quark Mass)	Resonance Mass
uds	107.15	191.06
udc	1257.15	64.60
usc	1352.40	178.10
dsc	1354.75	178.37
udb	4307.15	88.45
usb	4402.40	157.70
dsb	4404.75	158.85
ucb	5552.40	152.50
dcb	5554.75	152.69
scb	5650.00	160.58

7th Degree Polynomial Fit: y=a+bx+cx^2+dx^3...	
Coefficient Data:	
a =	4514.7722
b =	-50.051709
c =	9.88E-02
d =	-8.06E-05
e =	3.27E-08
f =	-6.98E-12
g =	7.54E-16
h =	-3.25E-20

Table 3.1 - Interpolated and Extrapolated Values of Resonance Energy for an Intrinsic Angular Momentum of $J = 1\hbar$.

Incorporated in these tables, (shown in red), are the interpolated/extrapolated values for the five particles with three identical quarks, not included in Table 2.1, from which the resonance energy for the applicable $J = 3/2\hbar$ Baryons is obtained, (i.e. Δ^{++}, Δ^{-}, Ω^{-}, $\Omega^{++}{}_{ccc}$, and $\Omega^{-}{}_{bbb}$).

The ten particles identified in [3] as low confinement energy particles, are also not present in Table 2.1. Because resonance energy is, as shown above a function of quark content, the resonance energy in these particles will be the same as their higher energy counterparts.

Putting all the above together, the resonance energy of all 75 Baryons has now been determined and can be used to obtain the level of their quark confinement energy according to the simple relationship

$$m_c = m_p - M_q - m_r \qquad (3.1)$$

where

m_c = Quark confinement energy.
m_p = Total particle energy.
M_q = Sum of the quark content masses.
m_r = Resonance energy.

This has been effected in Table 3.2 below for particles with $J = 1/2\hbar$ and Table 3.3 for particles with $J = 3/2\hbar$.

Particle	Particle Mass	Quark Content	Quark Content Mass	Resonance Energy	Quark Confinement Energy
p^{+}	938.27	uud	9.55	146.87	781.86
n^{0}	939.57	udd	11.90	146.22	781.45
Σ^{+}	1189.37	uus	104.80	96.72	987.86
Λ^{0}	1115.68	uds	107.15	95.53	913.00
Σ^{0}	1192.64	uds	107.15	95.53	989.96
Σ^{-}	1197.45	dds	109.50	94.88	993.08
Ξ^{0}	1314.86	uss	202.40	108.47	1003.99
Ξ^{-}	1321.71	dss	204.75	106.65	1010.32
Σ^{++}_{c}	2453.98	uuc	1254.80	32.01	1167.17
Λ^{+}_{c}	2286.46	udc	1257.15	32.30	997.01
Σ^{+}_{c}	2452.90	udc	1257.15	32.30	1163.45
Σ^{0}_{c}	2453.74	ddc	1259.50	32.53	1161.71
Ξ^{+}_{c}	2467.80	usc	1352.40	35.15	1080.25
Ξ'^{+}_{c}	2575.60	usc	1352.40	35.15	1188.05
Ξ^{0}_{c}	2470.88	dsc	1354.75	35.68	1080.45
Ξ'^{0}_{c}	2577.90	dsc	1354.75	35.68	1187.47
Ω^{0}_{c}	2695.20	ssc	1450.00	35.35	1209.85
Ξ^{++}_{cc}	3650.73	ucc	2502.40	43.27	1105.06
Ξ^{+}_{cc}	3653.16	dcc	2504.75	43.25	1105.16
Ω^{+}_{cc}	3752.22	scc	2600.00	42.36	1109.86
Σ^{+}_{b}	5811.30	uub	4304.80	10.40	1496.10
Λ^{0}_{b}	5619.40	udb	4307.15	44.23	1268.03
Σ^{0}_{b}	5731.82	udb	4307.15	44.23	1380.44
Σ^{-}_{b}	5815.50	ddb	4309.50	9.80	1496.20
Ξ^{0}_{b}	5787.80	usb	4402.40	78.85	1306.55
Ξ'^{0}_{b}	5855.67	usb	4402.40	78.85	1374.42
Ξ^{-}_{b}	5791.10	dsb	4404.75	79.43	1306.93
Ξ'^{-}_{b}	5858.74	dsb	4404.75	79.43	1374.57
Ω^{-}_{b}	6071.00	ssb	4500.00	3.74	1567.27
Ξ^{+}_{cb}	7487.11	ucb	5552.40	76.25	1858.46
Ξ'^{+}_{cb}	7478.11	ucb	5552.40	76.25	1858.46
Ξ^{0}_{cb}	7490.72	dcb	5554.75	76.35	1859.63
Ξ'^{0}_{cb}	7490.72	dcb	5554.75	76.35	1859.63
Ω^{0}_{cb}	7638.11	scb	5650.00	80.29	1907.82
Ω'^{0}_{cb}	7638.11	scb	5650.00	80.29	1907.82
Ω^{+}_{ccb}	9586.36	ccb	6800.00	150.00	2636.36
Ξ^{0}_{bb}	13381.23	ubb	8602.40	374.67	4404.16
Ξ^{-}_{bb}	13386.84	dbb	8604.74	375.10	4407.00
Ω^{-}_{bb}	13616.99	sbb	8700.00	392.31	4524.68
Ω^{0}_{cbb}	16669.09	cbb	9850.00	657.48	6161.61

Table 3.2 Resonance Energy and Quark Confinement Energy for Particles with Intrinsic Angular Momentum $J = 1/2\hbar$.

Particle	Particle Mass	Quark Content	Quark Content Mass	Resonance Energy	Quark Confinement Energy
Δ^{++}	1232.00	uuu	7.20	446.63	778.18
Δ^{+}	1232.00	uud	9.55	440.60	781.86
Δ^{0}	1232.00	udd	11.90	438.66	781.44
Δ^{-}	1232.00	ddd	14.25	431.58	786.17
Σ^{*+}	1382.80	uus	104.80	290.15	987.86
Σ^{*0}	1383.70	uds	107.15	286.59	989.96
Σ^{*-}	1387.20	dds	109.50	284.63	993.08
Ξ^{*0}	1531.80	uss	202.40	325.41	1003.99
Ξ^{*-}	1535.00	dss	204.75	319.94	1010.32
Ω^{-}	1672.45	sss	300.00	291.78	1080.67
$\Sigma^{*+}{}_{c}$	2517.50	udc	1257.15	96.90	1163.05
$\Sigma^{*++}{}_{c}$	2518.00	uuc	1254.80	96.03	1167.17
$\Sigma^{*0}{}_{c}$	2518.80	ddc	1259.50	97.59	1161.71
$\Xi^{*+}{}_{c}$	2645.90	usc	1352.40	105.45	1188.05
$\Xi^{*0}{}_{c}$	2649.25	dsc	1354.75	107.03	1187.47
$\Omega^{*0}{}_{c}$	2765.90	ssc	1450.00	106.05	1209.85
$\Xi^{*++}{}_{cc}$	3737.27	ucc	2502.40	129.81	1105.06
$\Xi^{*+}{}_{cc}$	3739.66	dcc	2504.75	129.75	1105.16
$\Omega^{*+}{}_{cc}$	3836.92	scc	2600.00	127.07	1109.86
$\Omega^{++}{}_{ccc}$	5116.89	ccc	3750.00	250.71	1116.18
$\Sigma^{*+}{}_{b}$	5832.10	uub	4304.80	31.20	1496.10
$\Sigma^{*0}{}_{b}$	5820.27	udb	4307.15	132.69	1380.43
$\Sigma^{*-}{}_{b}$	5835.10	ddb	4309.50	29.40	1496.20
$\Xi^{*0}{}_{b}$	5945.50	usb	4402.40	236.55	1306.55
$\Xi^{*-}{}_{b}$	5949.95	dsb	4404.75	238.28	1306.93
$\Omega^{*-}{}_{b}$	6078.47	ssb	4500.00	11.21	1567.27
$\Xi^{*+}{}_{cb}$	7639.61	ucb	5552.40	228.75	1858.46
$\Xi^{*0}{}_{cb}$	7643.41	dcb	5554.75	229.04	1859.63
$\Omega^{*0}{}_{cb}$	7798.69	scb	5650.00	240.87	1907.82
$\Omega^{*+}{}_{ccb}$	9886.36	ccb	6800.00	450.00	2636.36
$\Xi^{*0}{}_{bb}$	14130.57	ubb	8602.40	1124.01	4404.16
$\Xi^{*-}{}_{bb}$	14137.04	dbb	8604.75	1125.30	4406.99
$\Omega^{*-}{}_{bb}$	14401.61	sbb	8700.00	1176.93	4524.68
$\Omega^{*0}{}_{cbb}$	17984.05	cbb	9850.00	1972.40	6161.66
$\Omega^{-}{}_{bbb}$	32177.71	bbb	12900.00	3638.78	15638.94

Table 3.3 Resonance Energy and Quark Confinement Energy for Particles with Intrinsic Angular Momentum $J = 3/2\hbar$.

From these tables it is clear that the level of quark confinement energy is identical for the two groups of particles contained in Table 2.1. For those particles the maximum difference between Tables 3.2 and 3.3 being 0.05MeV/c^2 between $\Omega^0{}_{cbb}$ and $\Omega^{*0}{}_{cbb}$ with the majority of the others being identical to two decimal places. This verifies the assumption made in Section 2.0.
It is also apparent that Δ^+ is a resonance variant of p^+, and Δ^0 is a resonance variant of n^0.
For the ten particles, ($J = 1/2\hbar$), that have low confinement energy variants, correlation of their quark confinement energy with their resonance energy variants appears in two groups. This is detailed in the following table.

Quark Content	$J = 1/2\hbar$.		$J = 3/2\hbar$.	$J = 3/2\hbar$. to $J = 1/2\hbar$. Confinement Energy Correlation.
	Low Confinement Energy Particle	**High Confinement Energy Particle**	**Resonance Energy Variant**	
uds	Λ^{0}	Σ^{0}	Σ^{*0}	Σ^{0}
udc	Λ^{+}_{c}	Σ^{+}_{c}	Σ^{*+}_{c}	Σ^{+}_{c}
usc	Ξ^{+}_{c}	$\Xi^{\prime +}_{c}$	Ξ^{*+}_{c}	$\Xi^{\prime +}_{c}$
dsc	Ξ^{0}_{c}	$\Xi^{\prime 0}_{c}$	Ξ^{*0}_{c}	$\Xi^{\prime 0}_{c}$
udb	Λ^{0}_{b}	Σ^{0}_{b}	Σ^{*0}_{b}	Σ^{0}_{b}
usb	Ξ^{0}_{b}	$\Xi^{\prime 0}_{b}$	Ξ^{*0}_{b}	Ξ^{0}_{b}
dsb	Ξ^{-}_{b}	$\Xi^{\prime -}_{b}$	Ξ^{*-}_{b}	Ξ^{-}_{b}
ucb	Ξ^{+}_{cb} (1)	$\Xi^{\prime +}_{cb}$ (1)	Ξ^{*+}_{cb}	Ξ^{+}_{cb}
dcb	Ξ^{0}_{cb} (2)	$\Xi^{\prime 0}_{cb}$ (2)	Ξ^{*0}_{cb}	Ξ^{0}_{cb}
scb	Ω^{0}_{cb} (3)	$\Omega^{\prime 0}_{cb}$ (3)	Ω^{*0}_{cb}	Ω^{0}_{cb}

Table 3.4 - Quark Confinement Energy Correlation of Particle Variants.

Thus for the first five particles in Table 2.5, correlation of quark confinement energy occurs between the resonance energy variant and the high confinement energy particle. Whereas for the second five, it occurs with the low confinement energy particle. The reason for this variation is unclear.

For particles annotated (1), their mass was reported as unknown in [1] and [2] and was therefore evaluated via the empirical law of [3]. Their mass was therefore calculated to be identical which led to identical quark confinement energies. As the mass and quark confinement energy of the primed particle should be higher, it would be expected that correlation of quark confinement energy would occur between the resonance variant and the un-primed $J = 1/2\hbar$ particle as has been reflected in the above table. This discussion also applies to particles annotated (2) and (3).

4.0 An Empirical Law for Quark Confinement Energy.

The fact that quark confinement energy is identical for particles with $J = 1/2\hbar$ and $J = 3/2\hbar$ indicates that it is not a direct function of, nor directly affected by, the particles intrinsic angular momentum. Therefore it is concluded that it must be a function of some other aspect of the quark content. Plotting quark confinement energy against the sum of the constituent quark mass, from either Table 2.3 or 2.4 produces the figure shown in Appendix B. However, curve fitting this plot produces an empirical law that exhibits errors which range from +5.56% to -8.40%. Consequently it is only useful as an indication or guide. The above errors are primarily due to the use of resonance energy in determining quark confinement energy via Eq.(3.1), and it was shown, Table 3.1, that resonance energy is not a direct function of the sum of the quark masses but only as dictated by quark content. It is therefore expected that empirical laws for quark confinement energy should be based upon the same premise. This has been effected and is shown in Table 4.1.

uu Quark Series			
Quark Mass	Confinement Energy		% Error
	Actual	Empirical Calculation	
2.40	778.18	7.77E+02	0.11742995%
4.75	781.86	7.83E+02	-0.12005249%
100.00	987.86	9.88E+02	0.00253382%
1250.00	1167.17	1.17E+03	-0.00001380%
4300.00	1496.10	1.50E+03	0.00001223%

3rd degree Polynomial Fit: y=a+bx+cx^2+dx^3	
Coefficient Data:	
a =	771.59204
b =	2.3692777
c =	-0.002105548
d =	3.71E-07

dd Quark Series			
	Confinement Energy		% Error
Quark Mass	Actual	Empirical Calculation	
2.40	781.45	7.81E+02	0.05388994%
4.75	786.17	7.87E+02	-0.05502122%
100.00	993.08	9.93E+02	0.00116108%
1250.00	1161.71	1.16E+03	-0.00001496%
4300.00	1496.20	1.50E+03	-0.00003146%

3rd degree Polynomial Fit: y=a+bx+cx^2+dx^3	
Coefficient Data:	
a =	775.31233
b =	2.3870094
c =	-0.00213206
d =	3.76E-07

ss Quark Series			
	Confinement Energy		% Error
Quark Mass	Actual	Empirical Calculation	
2.40	1003.99	1.01E+03	-0.21537092%
4.75	1010.32	1.01E+03	0.21984478%
100.00	1080.67	1.08E+03	-0.00547599%
1250.00	1209.85	1.21E+03	0.00004469%
4300.00	1567.27	1.57E+03	0.00000810%

3rd degree Polynomial Fit: y=a+bx+cx^2+dx^3	
Coefficient Data:	
a =	1004.1565
b =	0.83323308
c =	-0.000687247
d =	1.22E-07

cc Quark Series			
Quark Mass	Confinement Energy		% Error
	Actual	Empirical Calculation	
2.40	1105.06	1.11E+03	1.5011E-3%
4.75	1105.16	1.11E+03	-1.550E-3%
100.00	1109.86	1.11E+03	3.678E-5%
1250.00	1116.18	1.12E+03	-4.56E-6%
4300.00	2636.36	2.64E+03	-1.23E-6%

3rd degree Polynomial Fit: y=a+bx+cx^2+dx^3	
Coefficient Data:	
a =	1104.9059
b =	0.057496102
c =	-8.31E-05
d =	3.55E-08

bb Quark Series			
Quark Mass	Confinement Energy		% Error
	Actual	Empirical Calculation	
2.40	4404.16	4.40E+03	5.009E-4%
4.75	4407.00	4.41E+03	-5.157E-4%
100.00	4524.68	4.52E+03	1.268E-5%
1250.00	6161.61	6.16E+03	-6.3E-7%
4300.00	15636.94	1.56E+04	-3.1E-7%

3rd degree Polynomial Fit: y=a+bx+cx^2+dx^3	
Coefficient Data:	
a =	4401.1926
b =	1.2270498
c =	7.24E-05
d =	5.81E-08

Three Quark Series				
Quark Content	Sum (Quark Mass)	Confinement Energy		% Error
		Actual	Empirical Calculation	
uds	107.15	913.00	9.13E+02	-1.82E-6%
udc	1257.15	997.01	9.97E+02	-1.532E-4%
usc	1352.40	1026.35	1.03E+03	5.774E-3%
dsc	1354.75	1026.95	1.03E+03	-5.559E-3%
udb	4307.15	1223.80	1.22E+03	2.493E-3%
usb	4402.40	1306.55	1.31E+03	-5.66E-2%
dsb	4404.75	1306.93	1.31E+03	5.889E-2%
ucb	5552.40	1858.46	1.86E+03	-6.529E-2%
dcb	5554.75	1859.63	1.86E+03	7.19E-2%
scb	5650.00	2046.87	2.05E+03	1.418E-3%

6th Degree Polynomial Fit: y=a+bx+cx^2+dx^3...	
Coefficient Data:	
a =	1367.4722
b =	-5.1802251
c =	0.009447151
d =	-6.62E-06
e =	2.12E-09
f =	-3.12E-13
g =	1.73E-17

Table 4.1 - Quark Confinement Energy Plus Empirical Law Calculations and Error Levels.

The maximum error range here is in the ss quark series, +0.219845% to -0.215372%. The empirical law relationships for both resonance energy and quark confinement energy are shown in Appendix C.

5.0 Conclusions.

In view of the uncertainty with which the quark masses are "known", [3], it is concluded that the results derived here exhibit an excellent level of accuracy. This conclusion is based upon the following three factors -

(i) The excellent agreement on the values of quark confinement energy between applicable particles with intrinsic angular momenta of $J = 1/2\hbar$ and those with $J = 3/2\hbar$.

(ii) The regularity and accuracy with which the empirical laws for particle resonance energy have been derived.

(iii) The regularity and accuracy with which the empirical laws for quark confinement energy have been derived.

Despite this, the method adopted here cannot, as it stands, be applied to Baryons in general. This is because there are many other variants in [1] and [2], with various levels of resonance energy, to which the empirical laws derived here do not exactly apply. It is believed that this is because there are many other levels of quark confinement energy which Baryons can exhibit, and the precise nature of the variation of this parameter needs to be determined, in order that the method used here can be extended such that it can be applied globally to all Baryons, whatever their resonance and quark confinement energy levels.

Finally, for the particular particles studied here, the results will now enable the determination of the distribution of the three varieties of particle energy, between their three constituent quarks, which will in turn illustrate the energy transitions that occur during their decay.

APPENDIX A - Fig.A.1.

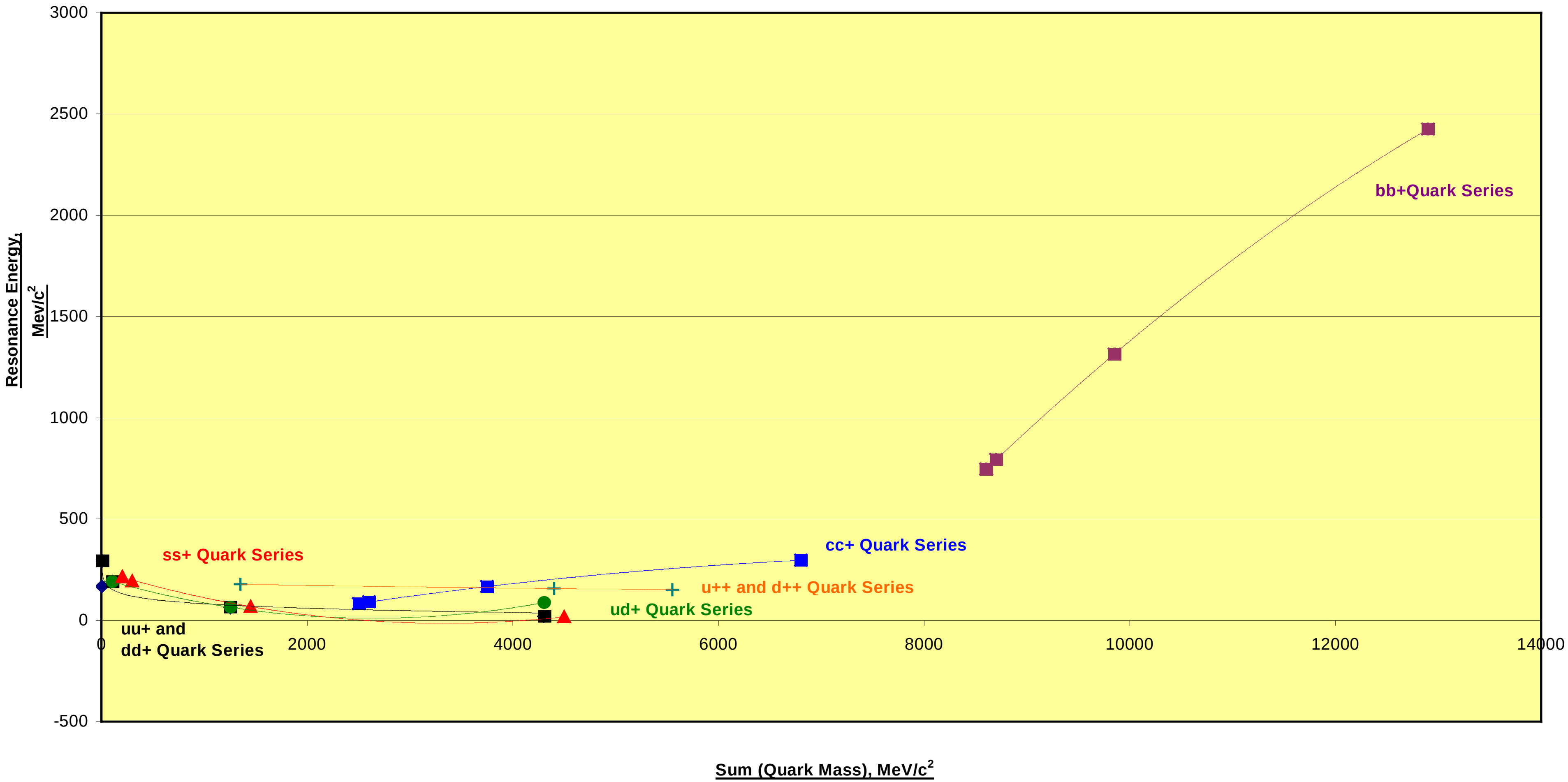

Fig.A.1 - Plots of Particle Resonance Energy as a Function of Sum Quark Masses by Quark Content.

APPENDIX B - Fig.B.1.

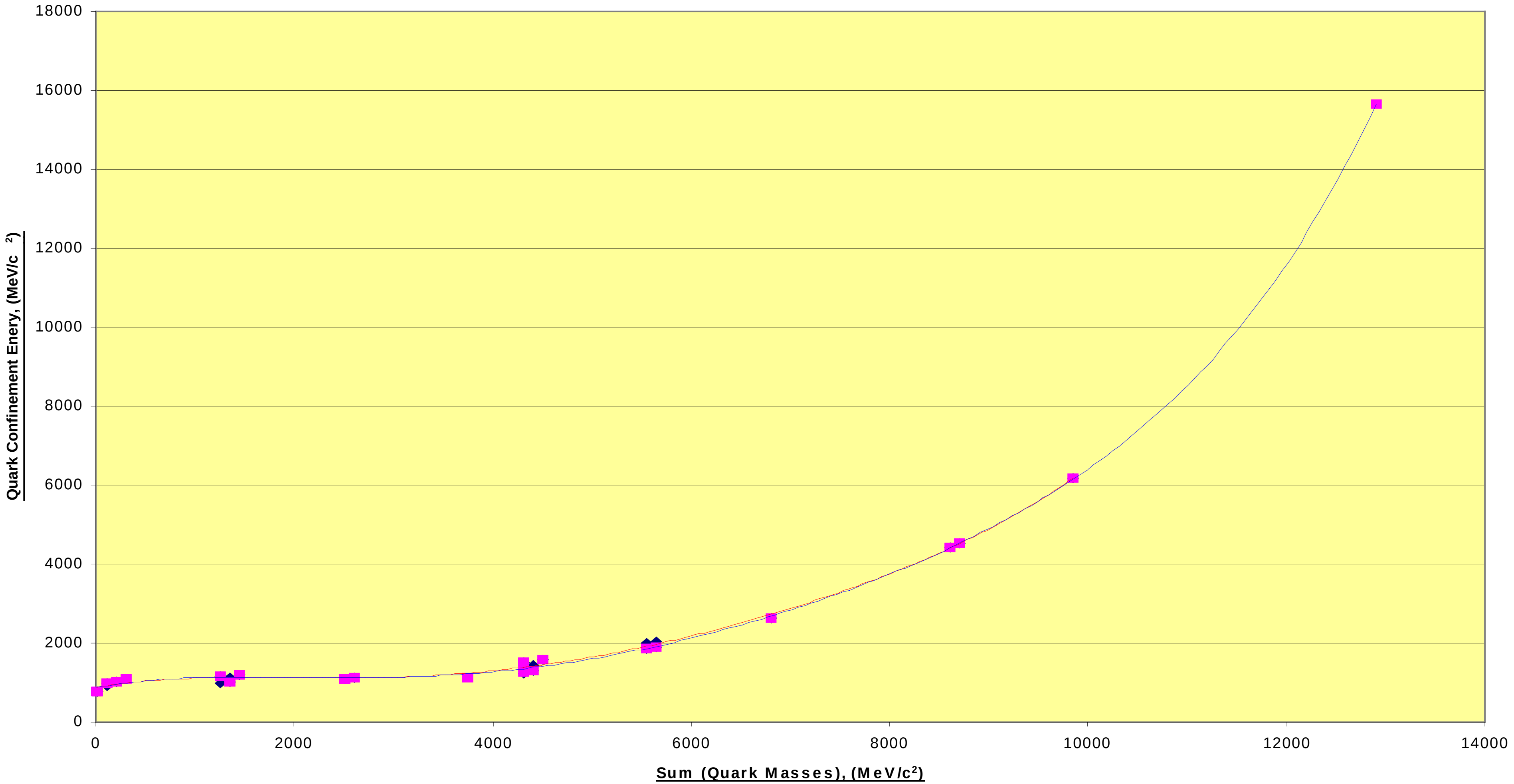

Fig.B.1 - Plot of Quark Confinement Energy as a Function of Sum Quark Masses.

Appendix C.

Empirical Law Relationships for Resonance and Quark Confinement Energies.

In the relationships below, the following definitions apply.

m_p = Total Particle Energy, (Equivalent Mass).

m_r = Particle Resonance Energy, (Equivalent Mass).

m_c = Particle Quark Confinement Energy, (Equivalent Mass).

M_q = Sum of the Energy of Applicable Constituent Quarks, (Equivalent Mass).

C.1 Resonance Energy Empirical Laws, (From Table 3.1).

These equations are for one unit of intrinsic angular momentum. For particles with $J = 1/2\hbar$, multiply the RHS by 1/2. For particles with $J = 3/2\hbar$ multiply the RHS by 3/2.

(i) The uu Quark Series, (Weibull Model).

$$m_r = 303.89579 - 338.84513 EXP\left[-10.265171 M_q^{-0.47608027}\right] \tag{C.1}$$

(ii) The dd Quark Series, (Weibull Model).

$$m_r = 309.14699 - 339.14953 EXP\left[-9.8108525 M_q^{-0.47703483}\right] \tag{C.2}$$

(iii) The ss Quark Series, (Weibull Model).

$$m_r = 229.14359 - 243.09587 EXP\left[-517.24794 M_q^{-0.978524}\right] \tag{C.3}$$

(iv) The cc Quark Series, (MMF Model).

$$m_r = \frac{-447.69533 x 166.25552 + 1192.7012 M_q^{-0.56778255}}{166.25552 + M_q^{0.56778255}} \tag{C.4}$$

(v) The bb Quark Series, (MMF Model).

$$m_r = \frac{-14097.234 x 241.61231 + 13062.233 M_q^{-0.62628885}}{241.61231 + M_q^{-0.62628885}} \tag{C.5}$$

(vi) The Three Quark Series, (7th Degree Polynomial Model).

$$\begin{aligned} m_r = &(-3.25E-20)M_q^7 + (7.54E-16)M_q^6 - (6.98E-12)M_q^5 + (3.27E-8)M_q^4 \\ &-(8.06E-5)M_q^3 + (9.8797991E-2)M_q^2 - 50.051709 M_q + 4514.7722 \end{aligned} \tag{C.6}$$

C.2 Particle Quark Confinement Energy Empirical Laws, (From Table 4.1).

(i) The uu Quark Series, (3rd Degree Polynomial Model).

$$m_c = (3.71E-7)m_q^3 - (2.105548E-3)m_q^2 + 2.3692777m_q + 771.59204 \quad \text{(C.7)}$$

(ii) The dd Quark Series, (3rd Degree Polynomial Model).

$$m_c = (3.76E-7)m_q^3 - (2.132016E-3)m_q^2 + 2.3870094m_q + 775.31233 \quad \text{(C.8)}$$

(iii) The ss Quark Series, (3rd Degree Polynomial Model).

$$m_c = (1.22E-7)m_q^3 - (6.87247E-3)m_q^2 + 0.83323308m_q + 1004.1565 \quad \text{(C.9)}$$

(iv) The cc Quark Series, (3rd Degree Polynomial Model).

$$m_c = (3.55E-8)m_q^3 - (8.31E-5)m_q^2 + 5.7496102m_q + 1104.9059 \quad \text{(C.10)}$$

(v) The bb Quark Series, (3rd Degree Polynomial Model).

$$m_c = (5.81E-8)m_q^3 + (7.24E-5)m_q^2 + 1.2270498m_q + 4401.1926 \quad \text{(C.11)}$$

(vi) The Three Quark Series, (6th Degree Polynomial Model).

$$\begin{aligned} m_c = (1.73E-17)M_q^6 - (3.12E-13)M_q^5 + (2.12E-9)M_q^4 - (6.62E-6)M_q^3 \\ + (9.447151E-3)M_q^2 - 5.1802251M_q + 1367.41722 \end{aligned} \quad \text{(C.12)}$$

REFERENCES.

[1] Wikipedia, *List of Baryons*, en.wikipedia.org.

[2] Particle Data Group, *Particle Listings*, pdg.lbl.gov.

[3] P.G.Bass, *Derivation of Empirical Laws for the Mass of Sub-Atomic Baryonic Particles*, www.relativitydomains.com.