# Elementary particle classification

brought forth by the period doubling mechanism from the Planck scale

Ari Lehto

Physics Foundations Society

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# Summary


Several well known natural phenomena can be explained by the period doubling phenomenon in nonlinear dynamical systems assuming there are internal degrees of freedom within the systems.

Each degree of freedom possesses its characteristic energy, which can be derived from the Planck energy by *period doubling*, or *energy halving*.

The analysis shown here is based on fusing the 3-degree of freedom (3d) mass energy structure and 4d electromagnetic energy structure into one 3d+4d=7-degree of freedom system.

Elementary particles arrange themselves into categories, when they are ordered according to the total number of period doublings. The categories are in complete agreement with the classification for the baryons and mesons given by the Standard Model of the elementary particles but now based, instead of quarks, on natural constants (the Planck scale) and the period doubling process.

The nucleon pair seems to be a special case and the light unflavoured pseudoscalar and vector mesons distinguish from the rest of the mesons.

# Introduction

The Standard Model (SM) of particles classifies particles according to their observed behavior in collision and decay processes. The classification can be explained by the hypothetical internal constituents of particles called quarks. Particles containing two quarks are called mesons, and those containing three quarks are called baryons respectively. Both together form the so-called hadrons. The quark model does not apply to the leptons. A drawback of the SM is that the physical properties of particles cannot be calculated, e.g. electron and proton rest energies, magnetic moments and the value of the elementary electric charge [1].

We have found earlier that the mass-energy system seems to have three internal degrees of freedom (3d) and electromagnetic (EM) system four (4d).

The electron and proton rest energies can be calculated from

$$E_{N,M} = \underbrace{\pi^{\frac{a}{3}} \cdot 2^{-\frac{N}{3}}}_{\text{3d (mass-energy)}} \cdot \underbrace{\pi^{\frac{b}{4}} \cdot 2^{-\frac{M}{4}}}_{\text{4d (EM-energy)}} \cdot E_{oo} \tag{1}$$

[Lehto 2009, 2014] where 'd' means an internal degree of freedom. The rotational-vibrational (rot-vib) states are represented by the powers of pi. $N$ is the total number of period doublings in the 3d system and $M$ in the 4d system. $a$ and $b$ are integers, $-3 \leq a \leq 3$, $-4 \leq b \leq 4$.

$E_{oo}$ ($2.64 \cdot 10^{25}$ MeV) is the generalized Planck energy containing both the Planck mass-energy and Planck charge Coulomb energy.

[1] These values can be accurately calculated from the Planck scale by period doubling, please see the references.

# Introduction

Our new interpretation of (1) is that there are three independent phase-spaces, namely:

1. combined periodic space with 3+4=7 degrees of freedom, observed as $2^{N/7}$
2. 3d rot-vib space observed as $\pi^{a/3}$ (mass-energy system)
3. 4d rot-vib space observed as $\pi^{b/4}$ (EM-energy system)

The roots are required to return the phase-space *volume* to the (perceived) *scalar* values [Lehto 2009, 2014] [1].

Equation (1) can now be written in the form

$$E_N = \underbrace{\pi^{\frac{a}{3}} \cdot \pi^{\frac{b}{4}} \cdot 2^{-\frac{N}{7}}} \cdot E_{oo} \qquad (2)$$

Product of independent phase-space volumes returned to the product of corresponding scalar values.

*N* is the total number of period doublings (or energy halvings) and (*a*,*b*) the rot-vib mode as before.

[1] Elementary particle analysis in [Lehto 2009] is now partly obsolete.

# Method

The total number $N$ of period doublings can be calculated from (2), if the particle rest energy $E_N$ is known:

$$N = -7 \cdot \frac{\log(E_N / (\pi^n \cdot E_{oo}))}{\log(2)} \qquad (3)$$

$n = a/3 + b/4$ in (3) is the combined power of pi in (2).

Different modes ($a$,$b$) yield different $N$-values, and the analysis is carried out by calculating the $N$-values for all different modes from $n$ =-2 ($a$=-3, $b$=-4) to $n$ =+2 ($a$=3, $b$=4) for each particle. Integer $N$'s are colored and written in a column in ascending order.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **reference=** | 2,64E+25 | MeV | base | **2,0** | dim. | **7** | | Partial table | | | | |
| | | | mode n and corresponding (a,b) | | | | | | | | | |
| | | **total** | (-3,-2) | (-2,-3) | (-1,-4) | (-3,-1) | (-2,-2) | (-1,-3) | (0,-4) | (-2,-1) | (-1,-2) | ($a$,$b$) |
| | | **periods** | -1,500 | -1,417 | -1,333 | -1,250 | -1,167 | -1,083 | -1,000 | -0,917 | -0,833 | $n$, ordered |
| **particle** | **E (MeV)** | **N** | | | | | | | | | | |
| Xi co | **2968,00** | 494 | 493,05 | 494,01 | 494,98 | 495,94 | 496,90 | 497,87 | 498,83 | 499,79 | 500,76 | all periods, integer $N$ chosen |
| Xi c+ | **2971,40** | 494 | 493,04 | 494,00 | 494,96 | 495,93 | 496,89 | 497,85 | 498,82 | 499,78 | 500,74 | |

The following tables show the results of the particle rest energy analyses using (3).

Particle rest energies are taken from the Particle Data Group 2014 particle listings.

# Table 1. Integer $N$–values for the baryons in ascending order from (3).

| Baryons | |
|---|---|
| Bottom | (blue) |
| Charmed | (light green) |
| u,d,s | (dark green) |

Baryons
Bottom
Charmed
u,d,s

| reference= | 2,6E+25 | MeV | dim. | 7 | base | 2 | (a,b) | | | | | (-3,0) | | | (-3,1) | (1,-4) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (-2,-4) | (-3,-2) | (-2,-3) | (-1,-4) | (-3,-1) | (-2,-2) | (-1,-3) | (0,-4) | (-2,-1) | (-1,-2) | (0,-3) | (-2,0) | (-1,-1) | (0,-2) | (-2,1) | (-1,0) | (0,-1) | (-2,2) | (-1,1) | (0,0) | (1,-1) | (2,-2) | (0,1) | (1,0) | (2,-1) | (3,-2) | (1,1) | (2,0) | (0,3) | (1,2) |
| Particle | E (MeV) | N | -1,667 | -1,500 | -1,417 | -1,333 | -1,250 | -1,167 | -1,083 | -1,000 | -0,917 | -0,833 | -0,750 | -0,667 | -0,583 | -0,500 | -0,417 | -0,333 | -0,250 | -0,167 | -0,083 | 0,000 | 0,083 | 0,167 | 0,250 | 0,333 | 0,417 | 0,500 | 0,583 | 0,667 | 0,750 | 0,833 |
| Xi b* | 5945,50 | 487 | 484,11 | 486,03 | 487,00 | 487,96 | 488,92 | 489,89 | 490,85 | 491,81 | 492,78 | 493,74 | 494,70 | 495,67 | 496,63 | 497,59 | 498,56 | 499,52 | 500,48 | 501,45 | 502,41 | 503,37 | 504,34 | 505,30 | 506,26 | 507,23 | 508,19 | 509,15 | 510,12 | 511,08 | 512,04 | 513,01 |
| | | 488 | | | | 488 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 489 | | | | | 489 | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 490 | | | | | | 490 | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 491 | | | | | | | 491 | | | | | | | | | | | | | | | | | | | | | | | |
| Sigma b*+ | 5829,00 | 492 | 484,31 | 486,23 | 487,20 | 488,16 | 489,12 | 490,09 | 491,05 | 492,01 | 492,98 | 493,94 | 494,90 | 495,87 | 496,83 | 497,79 | 498,76 | 499,72 | 500,68 | 501,65 | 502,61 | 503,57 | 504,54 | 505,50 | 506,46 | 507,43 | 508,39 | 509,35 | 510,32 | 511,28 | 512,24 | 513,21 |
| Sigma b*- | 5836,40 | 492 | 484,29 | 486,22 | 487,18 | 488,15 | 489,11 | 490,07 | 491,04 | 492,00 | 492,96 | 493,93 | 494,89 | 495,85 | 496,82 | 497,78 | 498,74 | 499,71 | 500,67 | 501,63 | 502,60 | 503,56 | 504,52 | 505,49 | 506,45 | 507,41 | 508,38 | 509,34 | 510,30 | 511,27 | 512,23 | 513,19 |
| Sigma b+ | 5807,80 | 493 | 484,34 | 486,27 | 487,23 | 488,20 | 489,16 | 490,12 | 491,09 | 492,05 | 493,01 | 493,98 | 494,94 | 495,90 | 496,87 | 497,83 | 498,79 | 499,76 | 500,72 | 501,68 | 502,65 | 503,61 | 504,57 | 505,54 | 506,50 | 507,46 | 508,43 | 509,39 | 510,35 | 511,32 | 512,28 | 513,24 |
| Sigmab- | 5815,20 | 493 | 484,33 | 486,26 | 487,22 | 488,18 | 489,15 | 490,11 | 491,07 | 492,04 | 493,00 | 493,96 | 494,93 | 495,89 | 496,85 | 497,82 | 498,78 | 499,74 | 500,71 | 501,67 | 502,63 | 503,60 | 504,56 | 505,52 | 506,49 | 507,45 | 508,41 | 509,38 | 510,34 | 511,30 | 512,27 | 513,23 |
| Xi co | 2968,00 | 494 | 491,12 | 493,05 | 494,01 | 494,98 | 495,94 | 496,90 | 497,87 | 498,83 | 499,79 | 500,76 | 501,72 | 502,68 | 503,65 | 504,61 | 505,57 | 506,54 | 507,50 | 508,46 | 509,43 | 510,39 | 511,35 | 512,32 | 513,28 | 514,24 | 515,21 | 516,17 | 517,13 | 518,10 | 519,06 | 520,02 |
| Xi c+ | 2971,40 | 494 | 491,11 | 493,04 | 494,00 | 494,96 | 495,93 | 496,89 | 497,85 | 498,82 | 499,78 | 500,74 | 501,71 | 502,67 | 503,63 | 504,60 | 505,56 | 506,52 | 507,49 | 508,45 | 509,41 | 510,38 | 511,34 | 512,30 | 513,27 | 514,23 | 515,19 | 516,16 | 517,12 | 518,08 | 519,05 | 520,01 |
| Xi b- | 5790,50 | 494 | 484,37 | 486,30 | 487,26 | 488,23 | 489,19 | 490,15 | 491,12 | 492,08 | 493,04 | 494,01 | 494,97 | 495,93 | 496,90 | 497,86 | 498,82 | 499,79 | 500,75 | 501,71 | 502,68 | 503,64 | 504,60 | 505,57 | 506,53 | 507,49 | 508,46 | 509,42 | 510,38 | 511,35 | 512,31 | 513,27 |
| | | 495 | | | | | | | | | | | 495 | | | | | | | | | | | | | | | | | | | |
| | | 496 | | | | | | | | | | | | 496 | | | | | | | | | | | | | | | | | | |
| Lam c+ | 2939,30 | 497 | 491,22 | 493,15 | 494,11 | 495,07 | 496,04 | 497,00 | 497,96 | 498,93 | 499,89 | 500,85 | 501,82 | 502,78 | 503,74 | 504,71 | 505,67 | 506,63 | 507,60 | 508,56 | 509,52 | 510,49 | 511,45 | 512,41 | 513,38 | 514,34 | 515,30 | 516,27 | 517,23 | 518,19 | 519,16 | 520,12 |
| | | 498 | | | | | | | 498 | | | | | | | | | | | | | | | | | | | | | | | |
| | | 499 | | | | | | | | 499 | | | | | | | | | | | | | | | | | | | | | | |
| Delta | 1232,00 | 500 | 500,00 | 501,93 | 502,89 | 503,85 | 504,82 | 505,78 | 506,75 | 507,71 | 508,67 | 509,64 | 510,60 | 511,56 | 512,53 | 513,49 | 514,45 | 515,42 | 516,38 | 517,34 | 518,31 | 519,27 | 520,23 | 521,20 | 522,16 | 523,12 | 524,09 | 525,05 | 526,01 | 526,98 | 527,94 | 528,90 |
| Xi c | 2645,90 | 501 | 492,28 | 494,21 | 495,17 | 496,14 | 497,10 | 498,06 | 499,03 | 499,99 | 500,95 | 501,92 | 502,88 | 503,84 | 504,81 | 505,77 | 506,73 | 507,70 | 508,66 | 509,62 | 510,59 | 511,55 | 512,51 | 513,48 | 514,44 | 515,40 | 516,37 | 517,33 | 518,29 | 519,26 | 520,22 | 521,18 |
| Lam | 1115,68 | 501 | 501,00 | 502,93 | 503,89 | 504,86 | 505,82 | 506,78 | 507,75 | 508,71 | 509,67 | 510,64 | 511,60 | 512,56 | 513,53 | 514,49 | 515,45 | 516,42 | 517,38 | 518,34 | 519,31 | 520,27 | 521,23 | 522,20 | 523,16 | 524,12 | 525,09 | 526,05 | 527,01 | 527,98 | 528,94 | 529,90 |
| Lam c+ | 2628,10 | 501 | 492,35 | 494,28 | 495,24 | 496,20 | 497,17 | 498,13 | 499,09 | 500,06 | 501,02 | 501,98 | 502,95 | 503,91 | 504,87 | 505,84 | 506,80 | 507,76 | 508,73 | 509,69 | 510,65 | 511,62 | 512,58 | 513,54 | 514,51 | 515,47 | 516,43 | 517,40 | 518,36 | 519,32 | 520,29 | 521,25 |
| Lam c+ | 2881,53 | 502 | 491,42 | 493,35 | 494,31 | 495,27 | 496,24 | 497,20 | 498,16 | 499,13 | 500,09 | 501,05 | 502,02 | 502,98 | 503,94 | 504,91 | 505,87 | 506,83 | 507,80 | 508,76 | 509,72 | 510,69 | 511,65 | 512,61 | 513,58 | 514,54 | 515,50 | 516,47 | 517,43 | 518,40 | 519,36 | 520,32 |
| Lambda bo | 5620,20 | 502 | 484,67 | 486,60 | 487,56 | 488,53 | 489,49 | 490,45 | 491,42 | 492,38 | 493,34 | 494,31 | 495,27 | 496,23 | 497,20 | 498,16 | 499,12 | 500,09 | 501,05 | 502,01 | 502,98 | 503,94 | 504,90 | 505,87 | 506,83 | 507,80 | 508,76 | 509,72 | 510,69 | 511,65 | 512,61 | 513,58 |
| | | 503 | | | | | | | | | | | | 503 | | | | | | | | | | | | | | | | | | |
| | | 504 | | | | | | | | | | | | | 504 | | | | | | | | | | | | | | | | | |
| Lam c+ | 2595,40 | 505 | 492,48 | 494,40 | 495,37 | 496,33 | 497,29 | 498,26 | 499,22 | 500,18 | 501,15 | 502,11 | 503,07 | 504,04 | 505,00 | 505,96 | 506,93 | 507,89 | 508,85 | 509,82 | 510,78 | 511,74 | 512,71 | 513,67 | 514,63 | 515,60 | 516,56 | 517,52 | 518,49 | 519,45 | 520,41 | 521,38 |
| | | 506 | | | | | | | | | | | | | | 506 | | | | | | | | | | | | | | | | |
| Xi - | 1321,71 | 507 | 499,29 | 501,22 | 502,18 | 503,15 | 504,11 | 505,07 | 506,04 | 507,00 | 507,96 | 508,93 | 509,89 | 510,85 | 511,82 | 512,78 | 513,74 | 514,71 | 515,67 | 516,63 | 517,60 | 518,56 | 519,52 | 520,49 | 521,45 | 522,41 | 523,38 | 524,34 | 525,30 | 526,27 | 527,23 | 528,19 |
| Xi c'+ | 2575,60 | 507 | 492,55 | 494,48 | 495,44 | 496,41 | 497,37 | 498,33 | 499,30 | 500,26 | 501,22 | 502,19 | 503,15 | 504,11 | 505,08 | 506,04 | 507,00 | 507,97 | 508,93 | 509,89 | 510,86 | 511,82 | 512,78 | 513,75 | 514,71 | 515,68 | 516,64 | 517,60 | 518,57 | 519,53 | 520,49 | 521,46 |
| Xi c'o | 2577,90 | 507 | 492,55 | 494,47 | 495,44 | 496,40 | 497,36 | 498,33 | 499,29 | 500,25 | 501,22 | 502,18 | 503,14 | 504,11 | 505,07 | 506,03 | 507,00 | 507,96 | 508,92 | 509,89 | 510,85 | 511,81 | 512,78 | 513,74 | 514,70 | 515,67 | 516,63 | 517,59 | 518,56 | 519,52 | 520,48 | 521,45 |
| Sigma- | 1197,45 | 508 | 500,29 | 502,22 | 503,18 | 504,14 | 505,11 | 506,07 | 507,03 | 508,00 | 508,96 | 509,92 | 510,89 | 511,85 | 512,81 | 513,78 | 514,74 | 515,70 | 516,67 | 517,63 | 518,59 | 519,56 | 520,52 | 521,48 | 522,45 | 523,41 | 524,37 | 525,34 | 526,30 | 527,26 | 528,23 | 529,19 |
| Xi o | 1314,86 | 508 | 499,34 | 501,27 | 502,23 | 503,20 | 504,16 | 505,12 | 506,09 | 507,05 | 508,01 | 508,98 | 509,94 | 510,90 | 511,87 | 512,83 | 513,79 | 514,76 | 515,72 | 516,68 | 517,65 | 518,61 | 519,57 | 520,54 | 521,50 | 522,47 | 523,43 | 524,39 | 525,36 | 526,32 | 527,28 | 528,25 |
| Xi co | 2819,60 | 508 | 491,64 | 493,57 | 494,53 | 495,49 | 496,46 | 497,42 | 498,38 | 499,35 | 500,31 | 501,27 | 502,24 | 503,20 | 504,16 | 505,13 | 506,09 | 507,05 | 508,02 | 508,98 | 509,94 | 510,91 | 511,87 | 512,83 | 513,80 | 514,76 | 515,72 | 516,69 | 517,65 | 518,61 | 519,58 | 520,54 |
| Sigma o | 1192,64 | 509 | 500,33 | 502,26 | 503,22 | 504,18 | 505,15 | 506,11 | 507,07 | 508,04 | 509,00 | 509,96 | 510,93 | 511,89 | 512,85 | 513,82 | 514,78 | 515,74 | 516,71 | 517,67 | 518,63 | 519,60 | 520,56 | 521,52 | 522,49 | 523,45 | 524,41 | 525,38 | 526,34 | 527,30 | 528,27 | 529,23 |
| Xi c+ | 2816,60 | 509 | 491,65 | 493,58 | 494,54 | 495,50 | 496,47 | 497,43 | 498,39 | 499,36 | 500,32 | 501,28 | 502,25 | 503,21 | 504,17 | 505,14 | 506,10 | 507,06 | 508,03 | 508,99 | 509,95 | 510,92 | 511,88 | 512,84 | 513,81 | 514,77 | 515,74 | 516,70 | 517,66 | 518,63 | 519,59 | 520,55 |
| Sigma+ | 1189,37 | 510 | 500,36 | 502,28 | 503,25 | 504,21 | 505,17 | 506,14 | 507,10 | 508,06 | 509,03 | 509,99 | 510,95 | 511,92 | 512,88 | 513,84 | 514,81 | 515,77 | 516,73 | 517,70 | 518,66 | 519,62 | 520,59 | 521,55 | 522,51 | 523,48 | 524,44 | 525,40 | 526,37 | 527,33 | 528,29 | 529,26 |
| Xi co | 3079,90 | 510 | 490,75 | 492,68 | 493,64 | 494,60 | 495,57 | 496,53 | 497,49 | 498,46 | 499,42 | 500,38 | 501,35 | 502,31 | 503,27 | 504,24 | 505,20 | 506,16 | 507,13 | 508,09 | 509,05 | 510,02 | 510,98 | 511,94 | 512,91 | 513,87 | 514,83 | 515,80 | 516,76 | 517,72 | 518,69 | 519,65 |
| Xi c+ | 2789,10 | 511 | 491,75 | 493,68 | 494,64 | 495,60 | 496,57 | 497,53 | 498,49 | 499,46 | 500,42 | 501,38 | 502,35 | 503,31 | 504,27 | 505,24 | 506,20 | 507,16 | 508,13 | 509,09 | 510,05 | 511,02 | 511,98 | 512,94 | 513,91 | 514,87 | 515,83 | 516,80 | 517,76 | 518,72 | 519,69 | 520,65 |
| Xi co | 2791,80 | 511 | 491,74 | 493,67 | 494,63 | 495,59 | 496,56 | 497,52 | 498,48 | 499,45 | 500,41 | 501,37 | 502,34 | 503,30 | 504,26 | 505,23 | 506,19 | 507,15 | 508,12 | 509,08 | 510,04 | 511,01 | 511,97 | 512,93 | 513,90 | 514,86 | 515,82 | 516,79 | 517,75 | 518,71 | 519,68 | 520,64 |
| Xi c+ | 3077,00 | 511 | 490,76 | 492,68 | 493,65 | 494,61 | 495,57 | 496,54 | 497,50 | 498,46 | 499,43 | 500,39 | 501,35 | 502,32 | 503,28 | 504,25 | 505,21 | 506,17 | 507,14 | 508,10 | 509,06 | 510,03 | 510,99 | 511,95 | 512,92 | 513,88 | 514,84 | 515,81 | 516,77 | 517,73 | 518,70 | 519,66 |
| | | 512 | | | | | | | | | | | | | | | | | | | | | 512 | | | | | | | | | |
| Omega co | 3695,20 | 513 | 488,91 | 490,84 | 491,80 | 492,76 | 493,73 | 494,69 | 495,65 | 496,62 | 497,58 | 498,54 | 499,51 | 500,47 | 501,43 | 502,40 | 503,36 | 504,32 | 505,29 | 506,25 | 507,21 | 508,18 | 509,14 | 510,10 | 511,07 | 512,03 | 512,99 | 513,96 | 514,92 | 515,88 | 516,85 | 517,81 |
| Sigma c+ | 2517,50 | 513 | 492,78 | 494,71 | 495,67 | 496,64 | 497,60 | 498,56 | 499,53 | 500,49 | 501,45 | 502,42 | 503,38 | 504,34 | 505,31 | 506,27 | 507,24 | 508,20 | 509,16 | 510,13 | 511,09 | 512,05 | 513,02 | 513,98 | 514,94 | 515,91 | 516,87 | 517,83 | 518,80 | 519,76 | 520,72 | 521,69 |
| Sigmaco | 2518,00 | 513 | 492,78 | 494,71 | 495,67 | 496,64 | 497,60 | 498,56 | 499,53 | 500,49 | 501,45 | 502,42 | 503,38 | 504,34 | 505,31 | 506,27 | 507,23 | 508,20 | 509,16 | 510,12 | 511,09 | 512,05 | 513,01 | 513,98 | 514,94 | 515,90 | 516,87 | 517,83 | 518,79 | 519,76 | 520,72 | 521,68 |
| Sigma c++ | 2518,40 | 513 | 492,78 | 494,71 | 495,67 | 496,63 | 497,60 | 498,56 | 499,52 | 500,49 | 501,45 | 502,41 | 503,38 | 504,34 | 505,30 | 506,27 | 507,23 | 508,19 | 509,16 | 510,12 | 511,08 | 512,05 | 513,01 | 513,98 | 514,94 | 515,90 | 516,87 | 517,83 | 518,79 | 519,76 | 520,72 | 521,68 |
| Lam c+ | 2286,46 | 514 | 493,76 | 495,68 | 496,65 | 497,61 | 498,57 | 499,54 | 500,50 | 501,46 | 502,43 | 503,39 | 504,35 | 505,32 | 506,28 | 507,24 | 508,21 | 509,17 | 510,13 | 511,10 | 512,06 | 513,02 | 513,99 | 514,95 | 515,91 | 516,88 | 517,84 | 518,80 | 519,77 | 520,73 | 521,69 | 522,66 |
| Omega co | 2765,90 | 514 | 491,83 | 493,76 | 494,72 | 495,69 | 496,65 | 497,61 | 498,58 | 499,54 | 500,50 | 501,47 | 502,43 | 503,39 | 504,36 | 505,32 | 506,28 | 507,25 | 508,21 | 509,17 | 510,14 | 511,10 | 512,07 | 513,03 | 513,99 | 514,96 | 515,92 | 516,88 | 517,85 | 518,81 | 519,77 | 520,74 |
| | | 515 | | | | | | | | | | | | | | | | | | | | | | | | 515 | | | | | | |
| Lam | 1405,10 | 516 | 498,67 | 500,60 | 501,56 | 502,53 | 503,49 | 504,45 | 505,42 | 506,38 | 507,34 | 508,31 | 509,27 | 510,23 | 511,20 | 512,16 | 513,12 | 514,09 | 515,05 | 516,01 | 516,98 | 517,94 | 518,90 | 519,87 | 520,83 | 521,79 | 522,76 | 523,72 | 524,68 | 525,65 | 526,61 | 527,57 |
| | | 517 | | | | | | | | | | | | | | | | | | | | | | | | | | 517 | | | | |
| Xi - | 1535,00 | 518 | 497,78 | 499,71 | 500,67 | 501,63 | 502,60 | 503,56 | 504,52 | 505,49 | 506,45 | 507,41 | 508,38 | 509,34 | 510,30 | 511,27 | 512,23 | 513,19 | 514,16 | 515,12 | 516,08 | 517,05 | 518,01 | 518,97 | 519,94 | 520,90 | 521,87 | 522,83 | 523,79 | 524,76 | 525,72 | 526,68 |
| Xi co | 2470,88 | 518 | 492,97 | 494,90 | 495,86 | 496,83 | 497,79 | 498,75 | 499,72 | 500,68 | 501,64 | 502,61 | 503,57 | 504,53 | 505,50 | 506,46 | 507,42 | 508,39 | 509,35 | 510,31 | 511,28 | 512,24 | 513,20 | 514,17 | 515,13 | 516,09 | 517,06 | 518,02 | 518,98 | 519,95 | 520,91 | 521,87 |
| Xi o | 1531,80 | 519 | 497,80 | 499,73 | 500,69 | 501,66 | 502,62 | 503,58 | 504,55 | 505,51 | 506,47 | 507,44 | 508,40 | 509,36 | 510,33 | 511,29 | 512,25 | 513,22 | 514,18 | 515,14 | 516,11 | 517,07 | 518,03 | 519,00 | 519,96 | 520,92 | 521,89 | 522,85 | 523,81 | 524,78 | 525,74 | 526,70 |
| Xi c+ | 2467,80 | 519 | 492,99 | 494,91 | 495,88 | 496,84 | 497,80 | 498,77 | 499,73 | 500,69 | 501,66 | 502,62 | 503,58 | 504,55 | 505,51 | 506,47 | 507,44 | 508,40 | 509,36 | 510,33 | 511,29 | 512,25 | 513,22 | 514,18 | 515,14 | 516,11 | 517,07 | 518,03 | 519,00 | 519,96 | 520,92 | 521,89 |
| Sigma - | 1387,20 | 520 | 498,80 | 500,73 | 501,69 | 502,66 | 503,62 | 504,58 | 505,55 | 506,51 | 507,47 | 508,44 | 509,40 | 510,36 | 511,33 | 512,29 | 513,25 | 514,22 | 515,18 | 516,14 | 517,11 | 518,07 | 519,03 | 520,00 | 520,96 | 521,92 | 522,89 | 523,85 | 524,81 | 525,78 | 526,74 | 527,70 |
| Sigma c+ | 2452,90 | 520 | 493,05 | 494,97 | 495,94 | 496,90 | 497,86 | 498,83 | 499,79 | 500,75 | 501,72 | 502,68 | 503,64 | 504,61 | 505,57 | 506,53 | 507,50 | 508,46 | 509,42 | 510,39 | 511,35 | 512,31 | 513,28 | 514,24 | 515,20 | 516,17 | 517,13 | 518,09 | 519,06 | 520,02 | 520,98 | 521,95 |
| Sigmaco | 2453,76 | 520 | 493,04 | 494,97 | 495,93 | 496,90 | 497,86 | 498,82 | 499,79 | 500,75 | 501,71 | 502,68 | 503,64 | 504,60 | 505,57 | 506,53 | 507,49 | 508,46 | 509,42 | 510,38 | 511,35 | 512,31 | 513,27 | 514,24 | 515,20 | 516,16 | 517,13 | 518,09 | 519,05 | 520,02 | 520,98 | 521,94 |
| Sigma c++ | 2454,20 | 520 | 493,04 | 494,97 | 495,93 | 496,90 | 497,86 | 498,82 | 499,79 | 500,75 | 501,71 | 502,68 | 503,64 | 504,60 | 505,57 | 506,53 | 507,49 | 508,46 | 509,42 | 510,38 | 511,35 | 512,31 | 513,27 | 514,24 | 515,20 | 516,16 | 517,13 | 518,09 | 519,05 | 520,02 | 520,98 | 521,94 |
| Lam | 1519,50 | 521 | 497,88 | 499,81 | 500,77 | 501,74 | 502,70 | 503,66 | 504,63 | 505,59 | 506,55 | 507,52 | 508,48 | 509,44 | 510,41 | 511,37 | 512,33 | 513,30 | 514,26 | 515,22 | 516,19 | 517,15 | 518,11 | 519,08 | 520,04 | 521,00 | 521,97 | 522,93 | 523,89 | 524,86 | 525,82 | 526,78 |
| Omega - | 1672,45 | 521 | 496,91 | 498,84 | 499,80 | 500,77 | 501,73 | 502,69 | 503,66 | 504,62 | 505,59 | 506,55 | 507,51 | 508,48 | 509,44 | 510,40 | 511,37 | 512,33 | 513,29 | 514,26 | 515,22 | 516,18 | 517,15 | 518,11 | 519,07 | 520,04 | 521,00 | 521,96 | 522,93 | 523,89 | 524,85 | 525,82 |
| [illegible]ga co | 2695,20 | 521 | 492,10 | 494,02 | 494,99 | 495,95 | 496,91 | 497,88 | 498,84 | 499,80 | 500,77 | 501,73 | 502,69 | 503,66 | 504,62 | 505,58 | 506,55 | 507,51 | 508,47 | 509,44 | 510,40 | 511,36 | 512,33 | 513,29 | 514,25 | 515,22 | 516,18 | 517,14 | 518,11 | 519,07 | 520,03 | 521,00 |
| [illegible] | [illegible] | 521 | 498,84 | 500,76 | 501,73 | 502,69 | 503,65 | 504,62 | 505,58 | 506,54 | 507,51 | 508,47 | 509,43 | 510,40 | 511,36 | 512,32 | 513,29 | 514,25 | 515,21 | 516,18 | 517,14 | 518,10 | 519,07 | 520,03 | 520,99 | 521,96 | 522,92 | 523,88 | 524,85 | 525,81 | 526,77 | 527,74 |
| Sigma o | [illegible] | [illegible] | 498,83 | 500,76 | 501,72 | 502,68 | 503,65 | 504,61 | 505,57 | 506,54 | 507,50 | 508,46 | 509,43 | 510,39 | 511,35 | 512,32 | 513,28 | 514,24 | 515,21 | 516,17 | 517,13 | 518,10 | 519,06 | 520,02 | 520,99 | 521,95 | 522,91 | 523,88 | 524,84 | 525,80 | 526,77 | 527,73 |
| Proton | 938,27 | [illegible] | [illegible] | [illegible] | 505,64 | 506,61 | 507,57 | 508,53 | 509,50 | 510,46 | 511,42 | 512,39 | 513,35 | 514,31 | 515,28 | 516,24 | 517,20 | 518,17 | 519,13 | 520,09 | 521,06 | 522,02 | 522,98 | 523,95 | 524,91 | 525,87 | 526,84 | 527,80 | 528,76 | 529,73 | 530,69 | 531,65 |
| Neutron | 939,58 | 522 | [illegible] | [illegible] | [illegible] | [illegible] | 507,55 | 508,52 | 509,48 | 510,44 | 511,41 | 512,37 | 513,33 | 514,30 | 515,26 | 516,23 | 517,19 | 518,15 | 519,12 | 520,08 | 521,04 | 522,01 | 522,97 | 523,93 | 524,90 | 525,86 | 526,82 | 527,79 | 528,75 | 529,71 | 530,68 | 531,64 |

Particle grouping is in agreement with the Standard Model classification.

K.A. Olive et al. (Particle Data Group), Chin. Phys. C38, 090001 (2014)

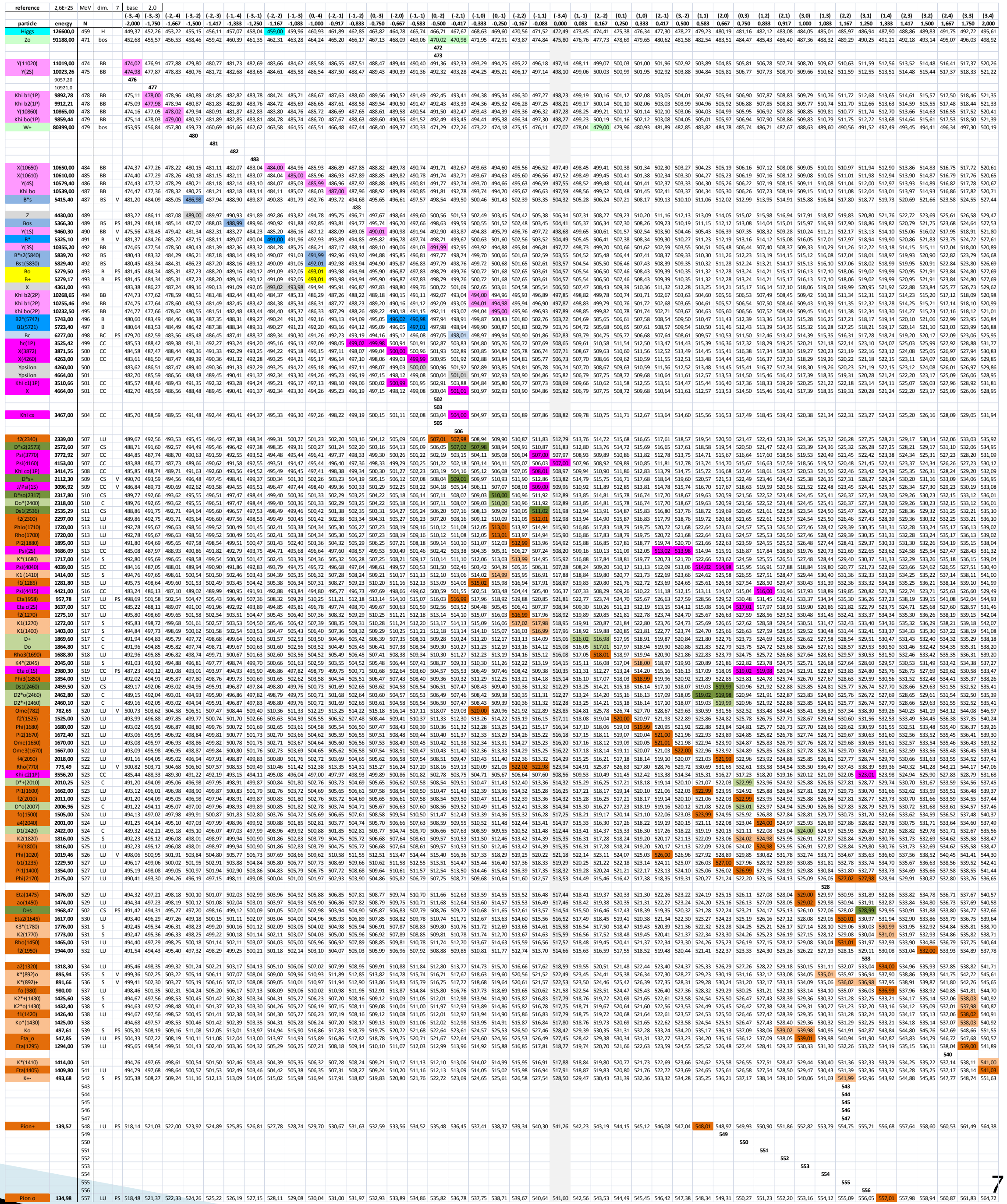
Nucleons are at (0,0)

# Table 2. Integer *N*–values for the mesons from (3) in ascending order.

| | | | |
|---|---|---|---|
| Higgs | H | | |
| G-boson | GB | | |
| Double bottom | BB | bb | |
| Bottom, charmed mesons | BC | cb | |
| Bottom, strange mesons | BS | sb | |
| B/Bo/Bso admixture | MIX | | |
| Bottom mesons | B | ub, db | |
| Double charmed | CC | cc | |
| Charmed, strange mesons | CS | sc | |
| Charmed mesons | C | uc, dc | |
| Strange mesons | S | us, ds | |
| Light unflavored mesons | LU | ud | |
| Confirmed, not listed yet | | | |
| Pseudoscalar | PS | | |
| Vector | V | | |

Particle grouping is in agreement with the Standard Model classification.

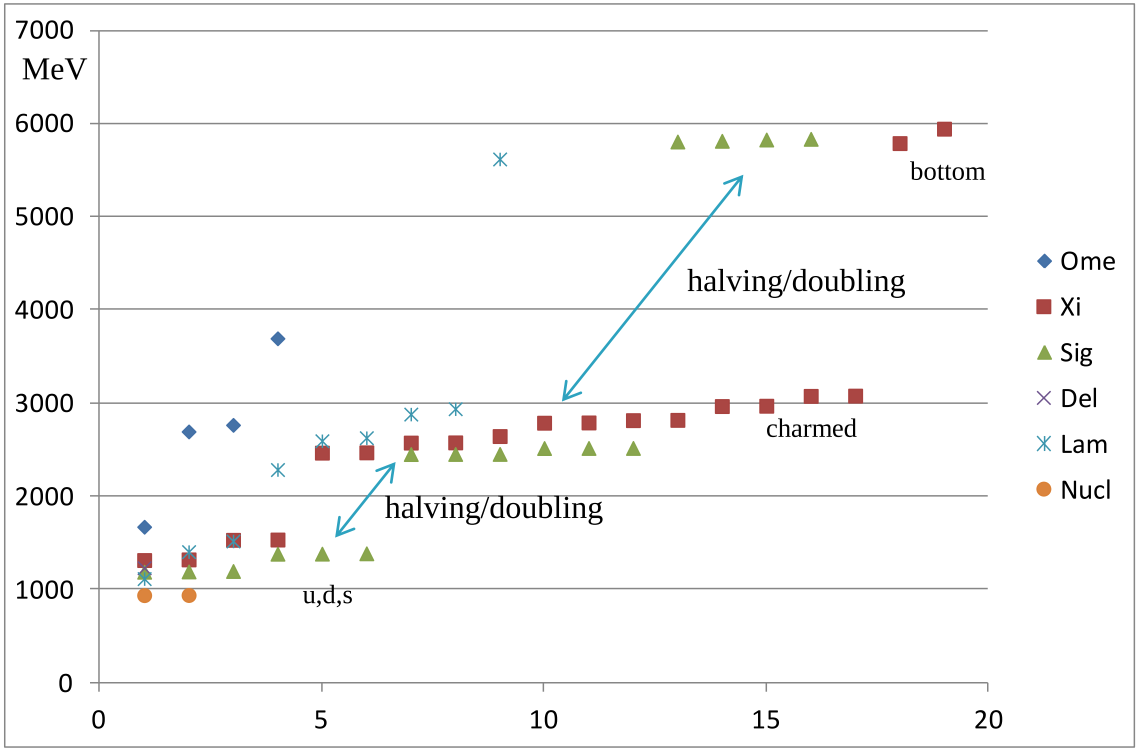
Light unflavoured vector and pseudoscalar mesons separate .



# Fig. 1.Baryon rest energy halving/doubling

Baryon rest energies in MeV

| | Ome | Xi | Sig | Del | Lam | Nucl |
|---|---|---|---|---|---|---|
| 1 | 1672,5 | 1314,9 | 1189,4 | 1232,0 | 1115,7 | 938,3 |
| 2 | 2695,2 | 1321,7 | 1192,6 | | 1405,1 | 939,6 |
| 3 | 2765,9 | 1531,8 | 1197,5 | | 1519,5 | |
| 4 | 3695,2 | 1535,0 | 1382,8 | | 2286,5 | |
| 5 | | 2467,8 | 1383,7 | | 2595,4 | |
| 6 | | 2470,9 | 1387,2 | | 2628,1 | |
| 7 | | 2575,6 | 2452,9 | | 2881,5 | |
| 8 | | 2577,9 | 2453,8 | | 2939,3 | |
| 9 | | 2645,9 | 2454,2 | | 5620,2 | |
| 10 | | 2789,1 | 2517,5 | | | |
| 11 | | 2791,8 | 2518,0 | | | |
| 12 | | 2816,6 | 2518,4 | | | |
| 13 | | 2819,6 | 5807,8 | | | |
| 14 | | 2968,0 | 5815,2 | | | |
| 15 | | 2971,4 | 5829,0 | | | |
| 16 | | 3077,0 | 5836,4 | | | |
| 17 | | 3079,9 | | | | |
| 18 | | 5790,5 | | | | |
| 19 | | 5945,5 | | | | |




$$E_N = \underbrace{\pi^{\frac{a}{3}} \cdot \pi^{\frac{b}{4}}}_{\text{rot-vib }(a,b)} \cdot \underbrace{2^{-\frac{N}{7}} \cdot E_{oo}}_{N\text{ period doublings from the Planck time}}$$

rot-vib ($a$,$b$)

$N$ period doublings from the Planck time

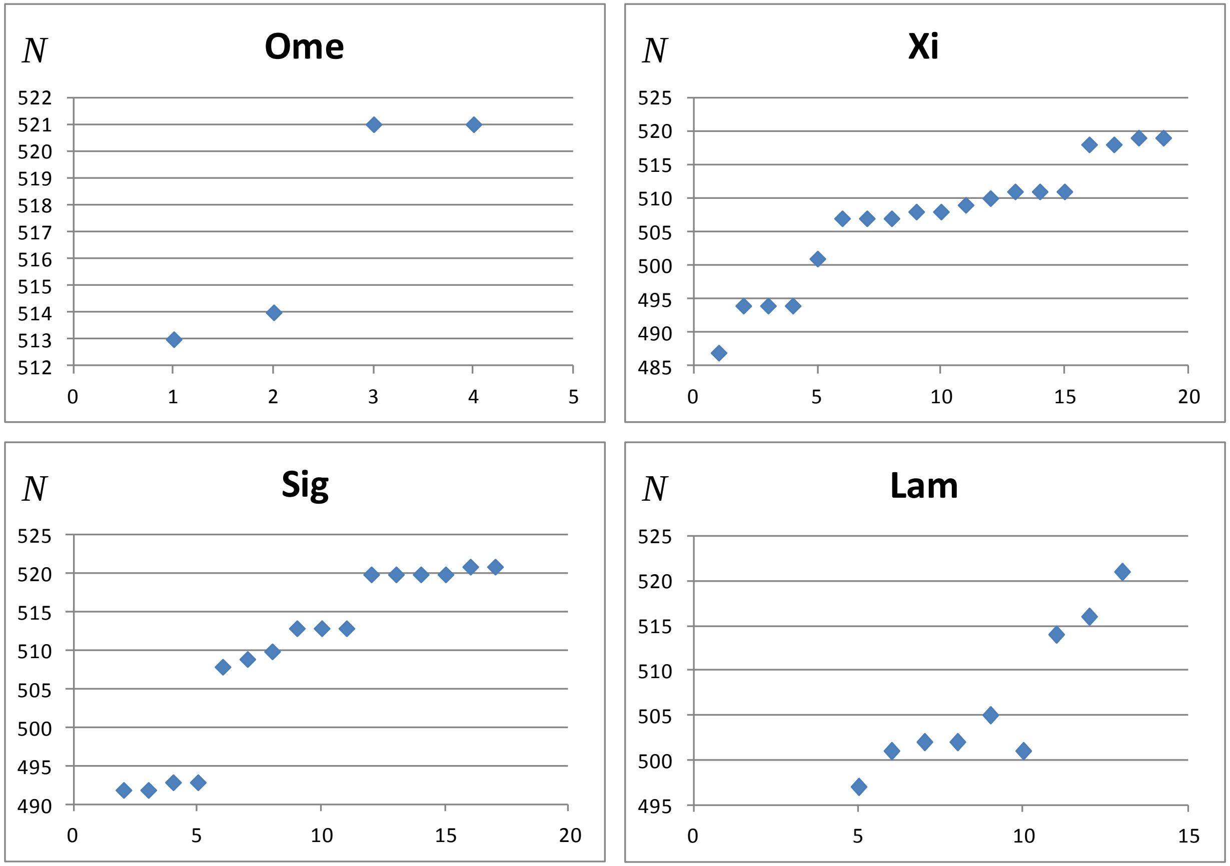
Figure 1 shows the doubling/halving of the observed rest energy. $N$ can change by 1 for any degree of freedom, but the mode ($a$,$b$) changes correspondingly in such a way in (2) that $E_N$ doubles/halves (depending on which direction $N$ goes).

The doubling/halving process explains why the ’charm’ and ’bottom’ quarks had to be introduced in the Standard Model.

# Fig. 2. Baryon *N*–values

Figure 1 shows that the rest energy halves/doubles. Figure 2 in turn shows that there are many more *N*-levels than the three energy levels in Fig.1. This is not a discrepancy, however, because it is the total energy (2), which obeys the period doubling behaviour ($E=hf=h/\tau$).

The figures also show that $\Delta N \approx 7$ , except for the lambda particle. $\Delta N = 7$ means that all 7 degrees of freedom in the periodic part halve/double together.




*N* is the total number of period doublings from (3).

# Discussion

Period doubling in nonlinear dynamical systems means that in addition to the fundamental period $\tau_o$ (here the Planck time), periods $2\tau_o$, $4\tau_o$, $8\tau_o$, $16\tau_o$, $32\tau_o$ etc. are generated within the system. If the system has internal degrees of freedom (or dimensions), then each one undergoes the doubling process independently. Rotational and vibrational states can be distinguished by a factor of pi (circumference to diameter and vice versa) separately for each degree of freedom.

Equation (2) is the new version of (1), where the 3d and 4d parts are dealt with as independent entities. Equation (1) is found to apply to the electron and proton properties[1], Hydrogen 21 cm wavelength, 3K microwave radiation (CBR) and the quantized galaxy redshifts. The Solar system seems to be a pure 3d mass system with quantized orbits and orbital velocities.

Equation (2) combines the periodic parts into a single 3d+4d=7 degree of freedom system modified by the rot-vib states of the particles, which seems to apply to the artificial elementary particles.

The total number $N$ of period doublings (=energy halvings) must be an integer, because period doubling is exact. The rest energy of a particle depends on both $N$ and the mode $(a,b)$. Therefore ordered $N$'s do not yield ordered energies. Only for (0,0) particles the two orders are the same, because $N$ alone would determine the rest energy.

[1] accurate values for the mass, magnetic moment and charge from the Planck scale.

# Discussion

The nucleons seem to have the fundamental structure where the mode is (0,0). The light unflavoured pseudoscalar and vector mesons separate from the rest of the mesons.

Particles are missing from some $N$-values in the tables. It is possible to calculate the rest energy for any $N$ and all modes ($a$,$b$) using (2).

The groupings for the baryons and mesons are analogous, determined by $N$ and the rot-vib mode ($a$,$b$).

Figure 1 shows that particle rest energies group in levels separated by a factor of $\approx 2$ characteristic to the doubling process. This also explains why ’charm’ and ’bottom’ quarks had to be introduced in the Standard Model.

Figure 2 tells that the mode ($a$,$b$) compensates the $N$-change such that the total energy remains in or close to the halving/doubling sequence.

The Planck energy reference connects the particles directly to the natural constants in both (1) and (2).

Appendix 1 shows an $N$-distribution for random numbers.

# References

Lehto A., ”On the Planck Scale and Properties of Matter”, Nonlinear Dynamics, 55, 3, 279-298, 2009

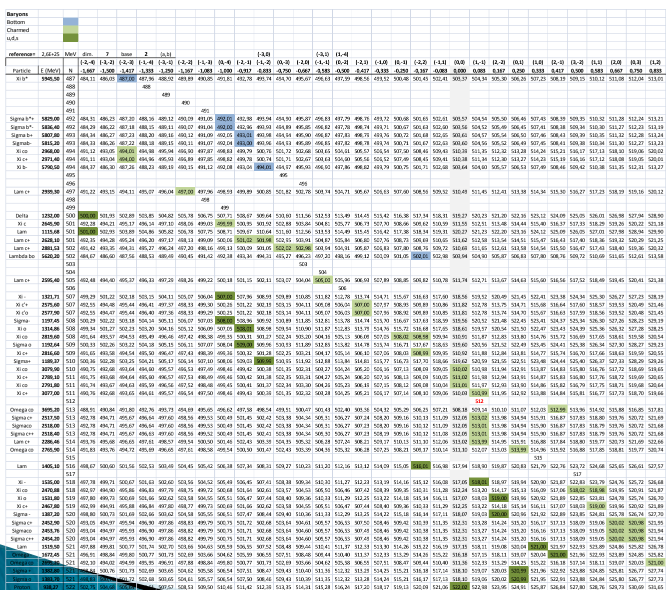
Lehto A., “On the Planck Scale and Properties of Matter”, International Journal of Astrophysics and Space Science, Vol. 2, Issue Number 6-1, December 2014

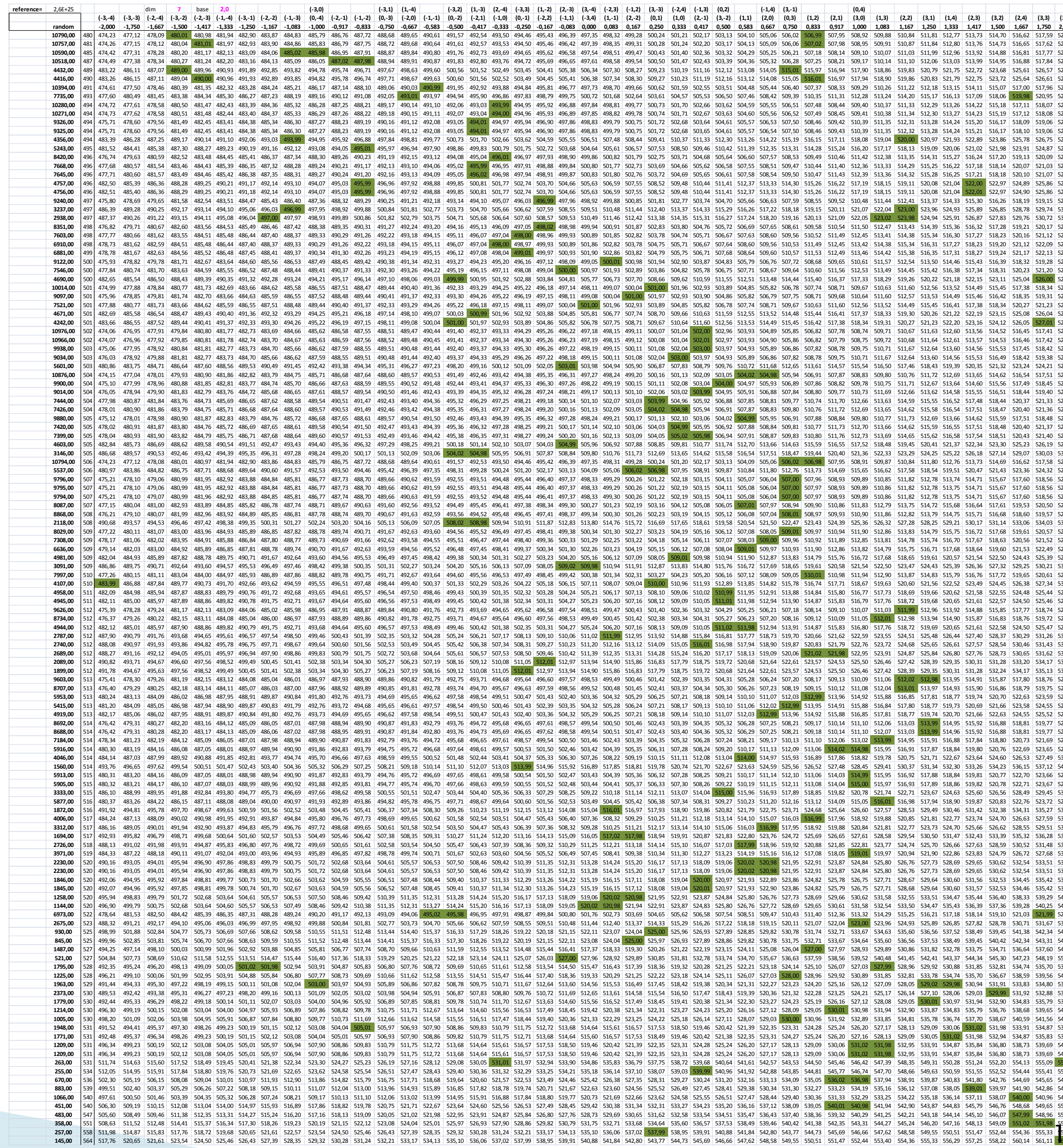
# Appendix 1. *N*–values for random numbers.

Random numbers, range 10000-100

integer

For comparison: the baryons





# THANK YOU!