On the System of Elementary Particles in View of Period Doubling

Rest energy and structure

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1. Summary

Summary

The period doubling model of physical structures and their properties has been further extended to include mass-independent Planck scale electromagnetic (EM) energy by using the Planck charge. The Planck energy is also slightly (≈ 0.1%) adjusted with the rest energy of the electron-positron pair (due to the relatively large inaccuracy of *G*).

In view of this model particles seem to originate by period doubling from a Planck scale object possessing Planck mass (3-d) and Planck charge (4-d). The perceived differences between particles are in the *number of period doublings* from the Planck scale and in the *mode* (vibration vs. rotation) of rest energy storage.

Particle		Mode	Mass			Mode	EM			
Name	**MeV**	***a***	***i***	***j***	***k***	***b***	***l***	***m***	***n***	***p***
ep-pair	1.022	**0**	32	64	128	**0**	1	2	4	32
proton	938.3	**0**	64	64	64	**-2**	1	2	4	32

mass-mode

3-d part

# of period doublings from the Planck mass-energy

EM-mode

4-d part

# of period doublings from the Planck EM-energy (defined by Planck charge)

The model seems to reveal a simple system in the particle structures and energies. Preliminary particle system is shown in this presentation. Example left: *ep*-pair and proton.

Summary

Particles are often created using high energy collisions between protons, which are (in this model) superstable particles. We therefore assume, that the 3-d part of the elementary particles is nearly the proton 3-d structure.

In this model *mass* and *charge* to the elementary particles are given by the *Planck mass* and *Planck charge* via the process of a multidimensional period doubling.

The most profound change in the present paradigm of charge, suggested in this model, concerns the uniqueness of the elementary electric charge. In this model the EM-energy of the elementary particles can get other values than the one corresponding to the elementary electric charge, which represents a superstable state of EM-energy.

Division of particles into leptons and hadrons seems rather arbitrary in view of this model. All particles obey the same logic: period doubling and two modes of internal energy storage (rotation, vibration).

2. Introduction

Introduction

In our opinion a mathematical model of a physical object must describe the measurable physical properties of the object to be modeled. In addition a model must have predictive power.

A particle model must therefore give an accurate description and numerical values for a particle of the rest energy, magnetic moment and electric charge, which are the directly measurable basic physical properties of particles. This also means that the value of the elementary electric charge must be modeled and calculated, not just taken as a natural constant.

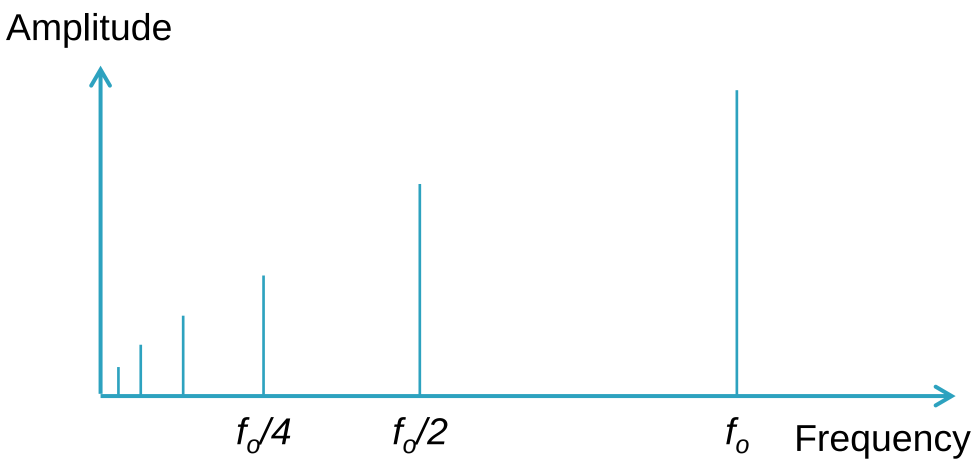
Great benefits for a model are conceptual and mathematical simplicity, solid physical foundation, predictive power and large applicability.

Our motivation for taking a different angle is in the inability of the Standard model to fulfill the above requirements (even for the electron and proton, which are the most important particles for the existence of matter).

The period doubling model is based on the universal behaviour of nonlinear dynamical systems. The characteristic feature is *period doubling*, here extended in multiple internal degrees of freedom.

Introduction

Period doubling can be illustrated with a one dimensional nonlinear oscillator. The frequency spectrum looks like this:



$$f_N = 2^{-N} \cdot f_o$$

$$t_N = 2^N \cdot t_o$$

$$E_N = hf_N = 2^{-N} \cdot E_o$$

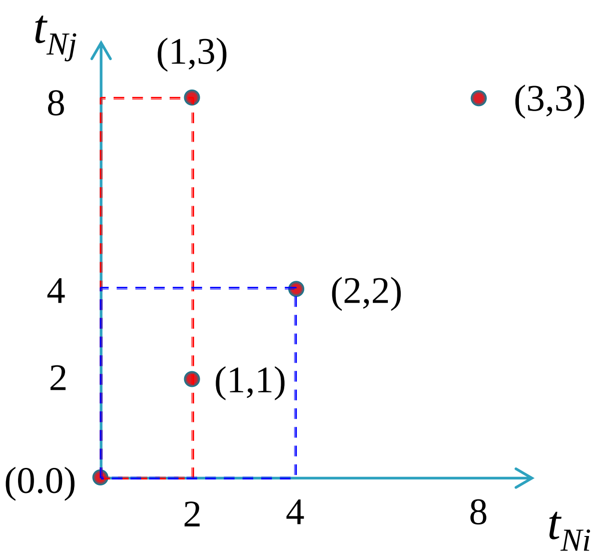
N = positive integer or zero.

f_o is the fundamental frequency. Halving frequencies mean period doubling. If the oscillator is linear, there would be only the fundamental frequency in the spectrum, i.e. the resonant frequency.

N is the number of doublings and t_N the N'th period. $E_o = hf_o$ is the reference energy .

Introduction

Let us now assume that our nonlinear oscillator has two dimensions, or degrees of freedom, t_{Ni} and t_{Nj}. In *period-space* the oscillator looks like this:



We can now assign shapes (N_i,N_j) to the oscillator. Periods (2,2) form a square and (1,3) a rectangle. The area of the (1,3)- rectangle in period-space is

$$A_{1,3} = t_1 t_3 = 2^1 t_o \cdot 2^3 t_o = 2^1 \cdot 2^3 \cdot t_o{}^2 = 2^4 t_o{}^2$$

But the area of the (2,2) square is the same!
The problem is that if we are only able to measure the area (=scalar), we loose all shape information.

The period-space area doubles every time one of the periods doubles.

Introduction

We can define a *characteristic period t* for describing the area of the shapes:

$$t_{N_i,N_j} = \sqrt{A_{N_i,N_j}} = \sqrt{2^{N_i} 2^{N_j} t_o{}^2} = 2^{\frac{N_i+N_j}{2}} t_o$$

The characteristic period gives us magnitude information (=area) of the shape but no information about the edge lengths.

The characteristic period for the previous two areas is $2^2 t_o$.

If our oscillator were three dimensional, i.e. possessing three degrees of freedom, we would describe it as a *volume* in the period-space. Analogously the characteristic period would be

$$t_{N_i,N_j,N_k} = (V_{N_i,N_j,N_k})^{\frac{1}{3}} = (2^{N_i} 2^{N_j} 2^{N_k} t_o{}^3)^{\frac{1}{3}} = 2^{\frac{N_i+N_j+N_k}{3}} t_o$$

Introduction

Why are we dealing with periods like this? The reason is that energy is *scalar*. It is just a magnitude. If particles have *internal degrees of freedom*, or shapes, which can be characterized by periods, i.e. by frequencies and energies ($E=hf$) of each individual degree of freedom, we loose all structural information by measuring just the rest energy.

The period-space volume doubles each time any of the periods doubles. We can call this a volumetric doubling process.

The ratio of two 3-d characteristic periods (energies!) is always of the form

$$Ratio = 2^{\frac{\pm integer}{3}}$$

Note that the volume doubles, if the characteristic period is multiplied by $2^{1/3}$.

Introduction

For four dimensional objects the ratio of the characteristic periods is

$$Ratio = 2^{\frac{\pm integer}{4}}$$

Let us take two examples: the rest energy of the electron-positron pair and the elementary electric charge.

Let us define the Planck mass by $m_o = \sqrt{\frac{hc}{G}}$ and Planck energy by $E_o = m_o c^2$. We obtain $E_o = 3.06 \cdot 10^{22}$ MeV.

The ratio is: $$Ratio = \frac{E_o}{ep} = \frac{3.06 \cdot 10^{22} MeV}{1.022 MeV} = 2^{74.66} = 2^{\frac{224}{3}} = \frac{integer}{3}$$

Introduction

The Planck charge q_o is defined $q_o = \sqrt{4\pi\varepsilon_o hc}$, q_o=4.701·10^{-18} As.

The ratio of the Coulomb energies (periods!) corresponding to the Planck charge and the elementary electric charge is

$$Ratio = \frac{q_o^{\ 2}}{e^2} = (\frac{4.701\cdot 10^{-18}}{1.602\cdot 10^{-19}})^2 = 2^{9.750} = 2^{\frac{39}{4}} = \frac{integer}{4} \quad (1)$$

(Eq. (1) gives *e* with an inaccuracy of 30 ppm)

The examples suggest that the *ep*-pair structure has three internal degrees of freedom related to the Planck *mass-energy* and four related to the Planck charge *Coulomb energy* or EM-energy.

EM=electromagnetic

Introduction

We now assume that these two attributes are common to all elementary particles:

There are three internal degrees of freedom related to mass-energy and four related to the EM-energy.

The Planck energy is huge as seen from the elementary particle world. Period doubling offers a natural mechanism to obtain energies from the Planck energy that fit our particle world. Evidently a large number of doublings are needed for reducing the Planck energy to fit the known particle energies.

Some periods may be remarkably stable, others not so. In this model superstable periods mean periods, whose number of doublings is of the form 2^N, $N=2^n$, n=positive integer or zero. Example: number of doublings = 2^{64}, $64=2^6$.

Introduction

How do we obtain the shape, or structural information? The electron-positron pair production is the basic process in converting energy into matter. Both e^- and e^+ are also extremely stable, if not disturbed.

We therefore assume that the periods (energies) related to the *ep*-pair structure represent superstable periods.

The number of period doublings required for the mass-energy of the *ep*-pair can be written in superstable form in each of the three internal degrees of freedom:

$$E_{ep} = 2^{-\frac{224}{3}} E_o = 2^{-\frac{32+64+128}{3}} E_o = 1.021 MeV$$

One of the three periods has doubled 32 times, the others 64 and 128 times respectively. The shape is thus an elongated parallelepiped in the *period-space*.

Introduction

What about the shape of the EM-energy of the *ep*-pair?

$$Ratio = \frac{q_o^{\ 2}}{e^2} = (\frac{4.701\cdot 10^{-18}}{1.602\cdot 10^{-19}})^2 = 2^{9.750} = 2^{\frac{39}{4}} = 2^{\frac{1+2+4+32}{4}} \qquad (1)$$

We find that the EM-part has suffered from many fewer period doublings than the mass-energy part. The total number of doublings is only 39 vs. 224 for the *ep*-pair mass-energy. The shape is an elongated 4-d parallelepiped. Note that the total number of period doublings can be broken down into superstable components.

The previous model building is based on the period doubling phenomenon, which is common property of nonlinear dynamical systems. The gravitational and Coulomb potentials (and their gradients) are nonlinear. It is therefore plausible to assume that period doubling takes place in dynamical systems under these potentials.

Introduction

All periods (energies) can be accurately calculated, if the fundamental period is given. In practice we will use the Planck energy as the fundamental reference because the Planck scale is defined by the natural constants h, c, G and ε_o. Therefore the calculations yield absolute values for the physical properties of the system under study. The problem with G is that it is by far the most inaccurate of the constants.

Eq. (1) shows that the elementary electric charge squared (=energy=1/period) can be represented by superstable periods, which can be calculated from the Planck EM-energy. In this model *other charge states, up to the Planck charge, are likewise possible under non-equilibrium conditions* (like high energy collisions).

Four degrees of freedom are needed for the calculation, which means that the characteristic EM-energies have +/- polarity (fourth root), and likewise their gradients or forces.

Introduction

The mass-energy of the electron-positron pair also displays superstable periods, which can be calculated from the Planck mass-energy. Three degrees of freedom are needed. Three degrees of freedom mean mass unipolarity.

We could say in layman's words that our material world is three dimensional and the electromagnetic world four dimensional.

Period doubling is thus a multidimensional process, which can be interpreted as a three- and four dimensional volumetric doubling process. The three degrees of freedom related to mass seem to be independent of the four related to EM-energy, which means that for any values of i,j,k one can choose any values for l,m,n,p (see example, slide 3) keeping the sums $i+j+k$ and $l+m+n+p$ constant.

Introduction

In this seminar presentation we will show new results concerning model development and the system of the elementary particles.

As comes to particles the most fundamental changes, compared to previous versions of the model, concern the inclusion of the EM *Planck energy* and the apparent *modes* of energy storage.

We have previously [1] used the Planck mass m_o and elementary electric charge e for defining the Planck energy E_o

and $$E_{NM} = 2^{-\frac{N}{3}} \cdot 2^{-\frac{M}{4}} \cdot E_o \qquad (2)$$ for energy calculations.

[1] See eg. The Baryons, presentation at Physics Foundations Society Seminar, August 17, 2010.

Introduction

Electron-positron pair rest-energy E_{ep} =1.021 MeV (previously)

$$E_{ep} = 2^{-\frac{32+64+128}{3}} \cdot 2^{-\frac{0+0+0+0}{4}} \cdot E_o \qquad (3)$$

Mass-energy (1.021 MeV), 3 degrees of freedom.

No period doublings in the EM-energy because reference charge is assumed = ***e***.

We now modify (3) such that the EM-energy associated with the pair is defined using the *Planck charge* q_o as reference.

This modification can be accomplished by multiplying the EM-part of (3) by the ratio of corresponding EM-energies to obtain the new reference energy E_{oo}:

$$E_{oo} = E_o \cdot \left(\frac{q_o}{e}\right)^2 \qquad (4)$$

Introduction

The *ep*-pair (1.021 MeV) now becomes:

$$E_{ep} = 2^{-\frac{32+64+128}{3}} \cdot 2^{-\frac{1+2+4+32}{4}} \cdot E_{oo} \qquad (5)$$

Mass-energy period doublings, same as before.

Period doublings from the Planck scale EM-energy required for the EM-energy of the elementary elecric charge.

$$e^2 = 2^{-\frac{1+2+4+32}{4}} \cdot q_o{}^2$$

… and a finally a small adjustment …

Introduction

Because the gravitational constant G is by far the most inaccurate of all natural constants, we make a small correction (≈ 0.1%) to E_{oo} by calculating its value from the rest energy of the electron-positron pair [1]. We obtain

$$E_{oo} = 2.63875 \cdot 10^{25}\ \text{MeV} \qquad (6)$$

The value of E_{oo} in (6) will be used in the calculations from this on. Eq. (4) will now yield 1.022 MeV for the *ep*-pair instead of 1.021 MeV.

The equation for the particle rest energies is then:

$N = i + j + k$
$M = l + m + n + p$

$$E_{NM} = 2^{-\frac{i+j+k}{3}} \cdot 2^{-\frac{l+m+n+p}{4}} \cdot E_{oo} \qquad (7)$$

[1] Eq. (1) gives the elementary charge correctly, so the small difference in the *ep*-pair energy (1.021 MeV vs. 1.022 MeV) is likely due to the 3-d mass part, i.e. The Planck mass and G.

Introduction

Confined energy can be stored in both *rotational* and *vibrational* modes in all of the system degrees of freedom. In thermodynamic equilibrium all modes have the same energy (equipartition principle), but under non-equilibrium conditions energy can be distributed unevenly between the modes.

In this model a rotational mode characterized by period (=circumference) is converted into a vibrational one by division by π (circumference to diameter, or circular to linear motion). Multiplication by π turns a vibrational mode (diameter) into a rotational one (circumference).

Eq. (7) becomes:

$$E_{NM} = (\pi^{a_i} 2^{-i} \cdot \pi^{a_j} 2^{-j} \cdot \pi^{a_k} 2^{-k})^{\frac{1}{3}} \cdot (\pi^{b_l} 2^{-l} \cdot \pi^{b_m} 2^{-m} \cdot \pi^{b_n} 2^{-n} \cdot \pi^{b_p} 2^{-p})^{\frac{1}{4}} E_{oo} \quad (8)$$

rot or *vib* mode of the the mass-energy degrees of freedom …

… and in the 4-d EM-part

$$a_{i,j,k}, b_{l,m,n,p} = 0, \pm 1$$

Notation

Eq. (8) simplified

$$E_{NM} = \underbrace{\pi^{a/3} 2^{-\frac{i+j+k}{3}}}_{\text{Mass-energy (mode and period doublings)}} \cdot \underbrace{\pi^{b/4} 2^{-\frac{l+m+n+p}{4}}}_{\text{EM-energy (mode and period doublings)}} \cdot E_{oo} \qquad (9)$$

Short for Eq. (9): $\underbrace{(a,b)}_{\text{group by modes}}\underbrace{(i, j, k; l, m, n, p)}_{\text{period doublings}}$

$a = a_i + a_j + a_k$
$b = b_l + b_m + b_n + b_p$

$N = i + j + k$
$M = l + m + n + p$

3. Particle analysis

by Eq. (9)

Leptons

$$e^2 = 2^{-\frac{1+2+4+32}{4}} \cdot q_o{}^2$$

Table 1		Mode	Mass			Mode	EM				Remark
Name	**MeV**	***a***	***i***	***j***	***k***	***b***	***l***	***m***	***n***	***p***	
e^+e^-	1.022	**0**	32	64	128	**0**	**1**	**2**	**4**	**32**	Present mass and EM ground state
$\mu^+\mu^-$	211.3	**2**	68	68	68	**-2**	1	1	2	32	EM-excitation by $2^{3/4}$ (*m*,*n*)
$\tau^+\tau^-$	3554	**2**	64	65	65	**1**	1	1	4	32	EM-excitation by $2^{1/4}$ (*m*)

Number of period doublings from the Planck mass-energy. (columns *i*, *j*, *k*)

Number of period doublings from the Planck EM-energy. (columns *l*, *m*, *n*, *p*)

$$Inaccuracy = \frac{E_{measured} - E_{model}}{E_{measured}} \cdot 100\%$$

Name	MeV meas.	MeV model	Inaccuracy %
e^+e^-	1.022	1.022	Accurate by def'n
$\mu^+\mu^-$	211.32	211.32	0.003
$\tau^+\tau^-$	3553.64	3554.02	0.01

Changing reference

The tables to follow may be more easily read by adopting (for notation purposes) the (0,0)(64,64,64;1,2,4,32) energy level 1661.3 MeV for reference.

$\mu^+\mu^-$	211.3	**2**	68	68	68	**-2**	1	1	2	32	EM-excitation by $2^{3/4}$ (*m*,*n*)
$\tau^+\tau^-$	3554	**2**	64	65	65	**1**	1	1	4	32	EM-excitation by $2^{1/4}$ (*m*)

$\mu^+\mu^-$	211.3	**2**	4	4	4	**-2**	0	-1	-2	0	EM-excitation by $2^{3/4}$ (*m*,*n*)
$\tau^+\tau^-$	3554	**2**	0	1	1	**1**	0	-1	0	0	EM-excitation by $2^{1/4}$ (*m*)

Change from (64,64,64)-reference

Change from (1,2,4,32)-reference correspondingly

Mesons

Table 2-1		Mode	Mass			Mode	EM				Remark
Name	**MeV**	***a***	***i***	***j***	***k***	***b***	***l***	***m***	***n***	***p***	
π^o	135	**-1**	2	2	3	**-3**	0	0	-2	0	
$\pi^+\pi^-$	279	**0**	1	1	2	**-3**	0	0	0	0	See K^o below
K^+K^-	987	**0**	1	1	1	**0**	0	-1	0	0	Basic group (0,0)
K^o	498	**0**	1	1	1	**-3**	0	0	-2	0	$K_o = \pi^{0.583} \cdot 2^{-0.666} \cdot (3\pi^o)$, $K^o{}_L$?
K^o	498	**2**	3	4	4	**2**	0	0	0	0	$K_o = 2^{0.833} \cdot (\pi^+ \pi^-)$, mode, $K^o{}_S$?
D^o	1865	**0**	0	0	1	**0**	0	0	-2	0	$D^o = 2^{1.916} \cdot K^+$
D^+	1870	**0**	-1	0	0	**-1**	0	-1	0	0	$D^+ = \pi^{-0.25} \cdot 2^{2.333} K^+$
η_c	2980	**0**	-2	-2	-1	**-3**	0	-1	-2	0	$\eta_c = \pi^{0.083} \cdot 2^{1.50} \eta'$
h_c	3525	**0**	-1	-1	-1	**-1**	0	0	-2	0	$h_c = \pi^{0.5} \cdot 2^{-0.583} \eta_c$

Mesons

Table 2-2		Mode	Mass			Mode	EM				Remark
Name	**MeV**	***a***	***i***	***j***	***k***	***b***	***l***	***m***	***n***	***p***	
B^+	5279	**0**	-2	-2	-1	**0**	0	0	0	0	
B^o	5280	**0**	-2	-2	-1	**0**	0	0	0	0	
B^*	5325	**-3**	-4	-3	-3	**0**	0	0	0	0	
$B^o{}_s$	5366	**-3**	-5	-4	-4	**-3**	0	-1	0	0	
$B^*{}_s$	5415	**-1**	-3	-2	-2	**-2**	-1	-2	0	0	
B_1	5723	**-1**	-2	-2	-2	**-1**	-1	-2	0	0	
$B_2{}^*$	5743	**-1**	-3	-3	-2	**-2**	-1	-1	0	0	$2^{0.083}B^*{}_s$, excited state of $B^*{}_s$
B_{s1}	5829	**-2**	-2	-2	-2	**1**	0	0	-2	0	
$B_{s2}{}^*$	5840	**-2**	-3	-3	-2	**0**	0	-1	0	0	
B_c	6277	**0**	-2	-2	-1	**0**	0	-1	0	0	$2^{0.25}\cdot B^o$, excited state of B^o

Khi-mesons

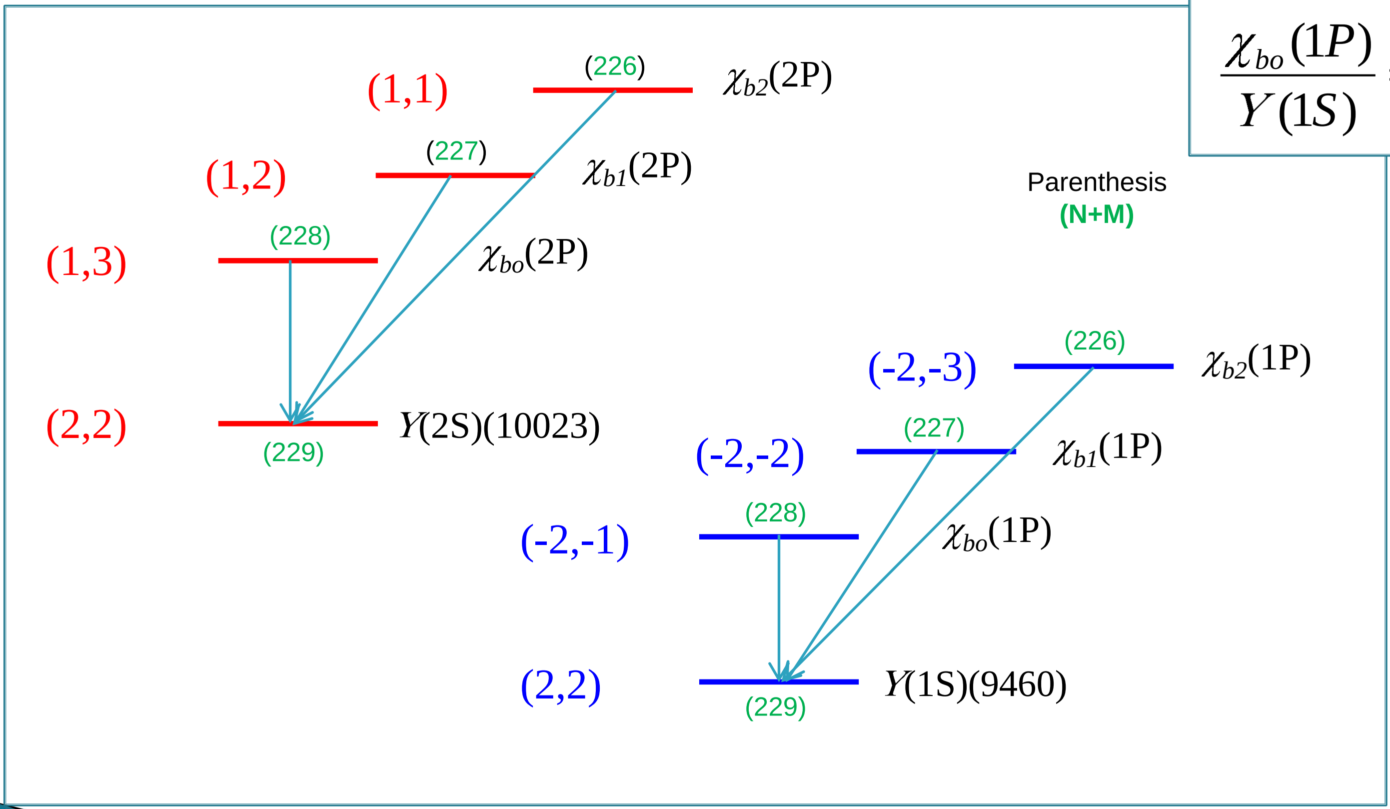
Table 3		Mode	Mass			Mode	EM				Remark
Name	**MeV**	***a***	***i***	***j***	***k***	***b***	***l***	***m***	***n***	***p***	
χ_{co}	3415	**-1**	-2	-2	-1	**-2**	-1	-2	0	0	Structures by best fit to experimental values.
χ_{c1}	3511	**-2**	-3	-3	-2	**-3**	-1	-2	0	0	
χ_{c2}	3556	**-3**	-2	-2	-2	**0**	-1	-2	0	0	
χ (3872)	3872	**1**	-1	0	0	**-1**	0	-1	-2	0	χ (4260)=$\pi^{0.083}\cdot$ χ (3872)
χ (4260)	4263	**2**	-1	0	0	**-2**	0	-1	-2	0	Identical 3-d and 4-d parts
χ_{bo}	9859	**-2**	-4	-3	-3	**-1**	0	-1	-2	0	3-d step=$2^{-2/3}$, 4-d step=$2^{1/4}$
χ_{b1}	9893	**-2**	-4	-4	-4	**-2**	0	0	-2	0	
χ_{b2}	9912	**-2**	-5	-5	-4	**-1**	0	-1	0	0	
χ_{bo}	10233	**1**	-1	0	0	**3**	0	0	-2	0	3-d step=$2^{-2/3}$, 4-d step=$2^{1/4}$
χ_{b1}	10255	**1**	-1	-1	-1	**2**	0	-1	0	0	
χ_{b2}	10269	**1**	-2	-2	-1	**1**	0	0	0	0	

Khi$_b$-system, mode (a,b) and decay

Observation: $$\frac{\chi_{bo}(2P)}{\chi_{bo}(1P)}=\frac{\chi_{b1}}{\chi_{b1}}=\frac{\chi_{b2}}{\chi_{b2}}=\pi^{\frac{1}{3}}\cdot 2^{-\frac{2}{4}}$$

$$\frac{\chi_{bo}(2P)}{Y(2S)}=\pi^{-\frac{1}{3}+\frac{1}{4}}2^{\frac{2}{3}}$$

$$\frac{\chi_{bo}(1P)}{Y(1S)}=\pi^{-\frac{2}{3}+\frac{2}{4}}2^{\frac{1}{3}}$$



(N+M)= total number of period doublings. See also appendix.

Baryons

Table 4		Mode	Mass			Mode	EM				Remark
Name	**MeV**	***a***	***i***	***j***	***k***	***b***	***l***	***m***	***n***	***p***	Decay
p	938.3	**0**	0	0	0	**-2**	0	0	0	0	Cube, EM ground state (chg=e)
n	939.6	**0**	0	0	1	**-3**	0	-1	0	0	Decays to p
Λ^o	1116	**0**	0	0	0	**-2**	0	-1	0	0	$\Lambda^o = 2^{0.25} \cdot p$, same group as p
Λ_c^+	2286	**-1**	-2	-2	-2	**-3**	0	-1	0	0	$\Lambda^+_c = \pi^{-0.583} \cdot 2^{2.25} \cdot p$
Λ_b^o	5620	**0**	-3	-2	-2	**-2**	0	-1	0	0	$\Lambda^o_b = \pi^{0.583} \cdot 2^{0.33} \cdot \Lambda_c^+ = 2^{2.333} \cdot \Lambda^o$
Σ^+	1189	**-3**	-2	-1	-1	**-1**	0	-1	0	0	$\Sigma^+ = \pi^{-0.75} \cdot 2^{1.583}\ p$
Σ^o	1193	**-3**	-1	-1	-1	**-2**	0	0	0	0	$\Sigma^o = \pi^{-1.00} \cdot 2^{1.75} \Lambda^o$
Σ^-	1197	**-3**	-2	-2	-1	**-3**	0	-1	0	0	$\Sigma^- = \pi^{-1.00} \cdot 2^{2.00}\ n$
Σ_c^+	2453	**-2**	-1	-1	0	**1**	0	-1	0	0	$\Sigma_c^+ = \pi^{0.666} \cdot 2^{-1.00} \Lambda_c^+$
Σ_c^o	2454	**-2**	-1	-1	-1	**1**	0	-1	0	0	$\Sigma_c^o = \pi^{0.666} \cdot 2^{-1.00} \Lambda_c^+$
Σ_c^{++}	2454	**-2**	-1	-1	-1	**1**	0	-1	0	0	$\Sigma_c^o = \pi^{0.666} \cdot 2^{-1.00} \Lambda_c^+$
Σ_b^+	5808	**1**	-2	-2	-1	**-1**	0	0	0	0	(not far from (-2,1)-group)
Σ_b^-	5815	**-2**	-2	-1	-1	**2**	0	-1	-2	0	$\Sigma_b^- = \pi^{0.333} \cdot 2^{-0.5} \cdot \Lambda_b^o$

Source also Wikipedia, List_of_Baryons

Baryons

Table 4 cont'd		Mode	Mass			Mode	EM				Remark
Name	**MeV**	***a***	***i***	***j***	***k***	***b***	***l***	***m***	***n***	***p***	Decay
Δ	1232	**-2**	-1	0	0	**-1**	0	-1	-2	0	$\Delta = \pi^{-0.166} \cdot 2^{0.666}\, n$
Ξ^o	1315	**0**	1	1	1	**1**	0	-1	0	0	$\Xi^0 = \pi^{0.75} \cdot 2^{-1.00}\, \Lambda^o$
Ξ^-	1322	**0**	0	1	1	**-1**	0	-1	-2	0	$\Xi^- = \pi^{0.25} \cdot 2^{-0.166}\, \Lambda^o$
Ξ_c^+	2468	**-2**	-2	-1	-1	**-1**	0	-1	-2	0	$\Xi_c^+ = \pi^{-0.417} \cdot 2^{1.833}\, \Lambda^o$
Ξ_c^o	2471	**-2**	-2	-2	-2	**-2**	0	0	-2	0	$\Xi_c^o = \pi^{-0.666} \cdot 2^{2.25}\, \Lambda^o$
Ξ'^+_c	2576	**1**	-3	-2	-2	**-4**	0	-1	-2	0	$\Xi_c'^+ = \pi^{-0.416} \cdot 2^{0.75}\, \Xi_c^+$
Ξ'^o_c	2578	**1**	-3	-2	-2	**-4**	0	-1	-2	0	$\Xi_c'^o = \pi^{-0.416} \cdot 2^{0.75}\, \Xi_c^o$
Ξ_b^-	5791	**1**	-1	-1	-1	**0**	0	-1	-2	0	$\Xi_b^- = \pi^{0.833} \cdot 2^{1.00}\, \Lambda^o$
Ω^-	1673	**0**	-1	0	0	**-2**	0	0	-2	0	$\Omega^- = 2^{0.583}\, \Lambda^o$
Ω_c^o	2695	**-1**	-1	-1	-1	**0**	0	-1	0	0	$\Omega_c^o = \pi^{0.416} \cdot 2^{0.00}\, \Omega^-$
Ω_b^-	6165	**-2**	-2	-2	-1	**2**	0	0	-2	0	$\Omega_b^- = \pi^{0.333} \cdot 2^{1.333}\, \Omega^-$

Particles of historical importance

Table 5			Mass				EM				Remark
Name	**MeV**	***a***	***i***	***j***	***k***	***b***	***l***	***m***	***n***	***p***	
J/ψ	3097	**-2**	-2	-2	-2	**0**	0	0	0	0	Charm experiment,Ting, Richter. Nobel 1976
W^+	80399	**-3**	-7	-7	-7	**0**	0	-1	0	0	*W, Z* (electroweak) theory, Glashow,Weinberg, Salam. Nobel 1979
Z^o	91188	**-1**	-6	-6	-5	**1**	0	-1	0	0	Experiment, Rubbia, van der Meer. Nobel 1984

These particles do not differ conceptually from one another or other particles.

Basic relations

$$n, p = \pi^{0.00} 2^{2.75} \cdot \pi^{\pm}$$

Δ=0.00 Δ=0.25

$$\Lambda^{o} = \pi^{0.00} 2^{3.00} \cdot \pi^{\pm}$$

$$\Sigma^{+} = \pi^{-0.50} 2^{3.916} \cdot \pi^{+}$$

Δ=-0.25 Δ=0.416

$$\Sigma^{o} = \pi^{-0.75} 2^{4.33} \cdot \pi^{+}$$

Δ=-2*0.25 Δ=2*0.416

$$\Sigma^{-} = \pi^{-1.25} 2^{5.166} \cdot \pi^{+}$$

$$K^{\pm} = \pi^{0.75} 2^{0.583} \cdot \pi^{\pm}$$

$$\Xi^{o} = \pi^{-0.916} 2^{4.75} \cdot \pi^{+}$$

Δ=-0.25 Δ=0.416

$$a_2 = \pi^{-1.166} 2^{5.166} \cdot \pi^{+}$$

Δ=-0.25 Δ=0.416

$$\Xi^{-} = \pi^{-1.416} 2^{5.583} \cdot \pi^{+}$$

$$\Omega^{-} = \pi^{-1.166} 2^{-0.166} \cdot K^{-}$$

$$\Omega^{-} = \pi^{0.00} 2^{3.583} \cdot \pi^{-}$$

Please note that these relations concern the energies (or structures) only.

4. Discussion

Discussion

The three and four degrees of freedom mean that the object under study can be given *period-space* shape and size by the number of period doublings in each dimension. Because energy and period are closely related ($E=h/t$), one also obtains shape and size in *energy-space*.

By considering energy as scalar, as is normally the case, one loses the structural information of the object now possible to obtain with this model (by using Eq. (9), slide 23).

Previous particle analysis is carried out according to the grouping given by the Standard model. The period doubling model obviously gives order within the groups, although there are differences in the logic within a group.

The total number of doublings , i.e. sums $N=i+j+k$ and $M=l+m+n+p$ together with the modes determine the magnitude (i.e. the rest energy of particles). The individual choice of i, j, k and l, m, n, p , maintaining the sum, determines the structure (or shape) of the object. The selection principle used is to assign a superstable value for each doubling in the 4-d EM-part and to maintain a cubical (or nearly so) shape in the 3-d mass part.

Discussion

As stated earlier the electron-positron pair represents superstable periods. The model value for the *ep*-pair rest energy is accurate by definition (see Introduction) and the value of the elementary electric charge is correct without any adjustments. The model rest energies of the muon and tau are practically accurate, too (Table 1). Muon and tau belong to the same group a=2. No tuning of model energies is possible as soon as the reference energy E_{oo} is fixed.

The 3-d mass-energy part of the proton is superstable (64, 64, 64) structure and the EM-part same superstable as the *ep*-pair (Table 2). Proton also balances the 4-d EM-energy part by having two vibrational and two rotational modes. The model value of proton rest energy is 937.24 MeV, which is 1.022 short of the measured rest energy. This means that the proton structure is accompanied by the *ep*-pair structure, which has a 64-period in the mass part and the same EM-part (resonance condition). The sum energy is 938.27 MeV.

Lambda particle's internal structure seems to be the first excited EM-state of the proton structure ($938.27 \cdot 2^{1/4}$ MeV = 1115.8 MeV).

Discussion

The Sigma triplet represents particles with same mass-mode a =-3 and consequent EM-modes b = -1, -2, -3. Their decay into nucleons and lambda follows the logic of the model. The rest energies of the charmed sigmas are nearly the same, so we have placed them in the same group.

The Ksi dublet also represents particles with same mass-mode a = 0 and EM-modes b = -1,1 as if a particle with b =0 were missing (actually meson a_2 (1320) fills this gap[1]).

The Ω^- -particle belongs to the same (0,-2)-group as Λ^o (and proton) and can be described as a mass- and EM-excited state of Λ^o.

The χ_b –particles fit the model in a logical way (slides 29, 30).

The recently discovered 10539 MeV χ_{bo}-particle belongs to the basic (0,0) group.

The "Remark" column shows the common decay route of the particle.

[1] Please note that in this model all particles are conceptually same.

Discussion

Problems with the model

The measured rest energy of the particles does not contain any *shape* information, it only gives $N+M$, the total number of period doublings and the mode (a,b). Therefore the i, j, k and l, m, n, p values are ambiguous. The number of doublings has been chosen to keep the mass-part near the superstable $i=j=k=64$ and EM-part in the ground state or nearly so.

Another problem is related to the choice of the modes. Because the theoretical density of states is high, there are close by energy values that could have been chosen as well to represent the particle. High theoretical density of states is needed, however, because the experimental energy values are dense, too. Values for a, b, N and M giving energies nearest to the measured ones have been chosen.

Measurement inaccuracy may also lead to a wrong choice of the group.

Future studies of the decay of particles is likely to reveal proper choices for the shapes (i.e. how shapes transform from one another in the simplest way).

Thank you!

Work continues …

Appendix

Additional info and puzzle

Particle data

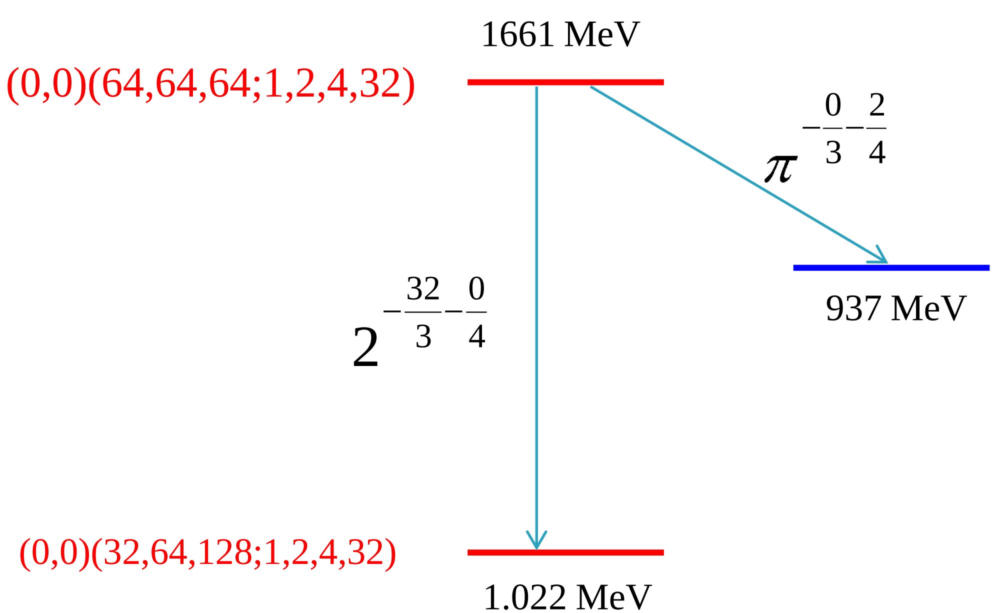
Table 6 Source: Particle Data Group, http://pdg.lbl.gov/

e-	0,511	Pi1(1400)	1354,00	Pi(1800)	1816,00	Khi co	3414,80	Khi bo	10233,00
Muon	105,66	K1(1400)	1403,00	K2(1820)	1816,00	Khi c1	3510,70	Khi b1	10255,00
Pion o	134,98	Eta(1405)	1409,80	Phi3(1850)	1854,00	hc	3525,40	Khi b2	10269,00
Pion+	139,57	K*(1410)	1414,00	Do	1864,80	Khi c2	3556,20	Ypsilon	10355,00
Ko	497,61	Ko*(1430)	1425,00	D+	1869,60	Eta c	3637,00	Ypsilon	10579,00
K+	493,68	K2*(1430)	1425,60	Pi2(1880)	1895,00	Psi	3686,00	Ypsilon	10865,00
Eta o	547,90	f1(1420)	1426,40	f2(1950)	1944,00	Psi	3770,00	Ypsilon	11019,00
Rho(770)	775,50	Rho(1450)	1465,00	D+s	1968,50	Khi(3872)	3871,60	W+	80399,00
Ome(782)	782,70	ao(1450)	1474,00	a4(2040)	2001,00	Psi(4040)	4039,00	Zo	91188,00
K*(892)	891,70	Eta(1475)	1476,00	D*(2007)	2007,00	Psi(4160)	4153,00		
Proton	938,27	3K	1484,95	D*(2010)	2010,30	Khi(4260)	4263,00		
Neutron	939,58	fo(1500)	1505,00	f2(2010)	2011,00	Psi(4415)	4421,00		
Eta'(958)	957,80	f2'(1525)	1525,00	f4(2050)	2018,00	B+	5279,20		
fo-ao(980)	980,00	Eta2(1645)	1617,00	K4*(2045)	2045,00	Bo	5279,50		
Phi(1020)	1019,50	Pi1(1600)	1662,00	D*s+	2112,30	B*	5325,10		
Lambda	1115,60	Ome3(1670)	1667,00	Phi(2170)	2175,00	Bos	5366,30		
Sigma+	1189,37	Ome(1650)	1670,00	Lambda+c	2286,46	B*s	5415,40		
Sigma o	1192,64	Pi2(1670)	1672,40	f2(2300)	2297,00	B1(5721)	5723,40		
Sigma-	1197,45	Omega -	1672,50	D*so(2317)	2317,80	B2*(5747)	5743,00		
b1(1235)	1229,50	Phi(1680)	1680,00	Do*(2400)	2318,00	Bs1(5830)	5829,40		
Delta	1232,00	Rho3(1690)	1688,80	f2(2340)	2339,00	B*s2(5840)	5839,70		
K1(1280)	1272,00	K*(1680)	1717,00	D1(2420)	2422,00	Bc	6277,00		
f2(1270)	1275,10	Rho(1700)	1720,00	Ds1(2460)	2459,50	Ypsilon	9460,30		
f1(1285)	1281,80	Phio(1710)	1720,00	D2*(2460)	2462,80	Khi bo	9859,40		
Eta(1295)	1294,00	K2(1770)	1773,00	Ds1(2536)	2535,30	Khi b1	9892,80		
Xi o	1314,90	K3*(1780)	1776,00	D*s2(2573)	2572,60	Khi b2	9912,20		
a2(1320)	1318,30	Eta c	2980,30	Eta c	2980,30				
Xi -	1321,70	Tau	1776,82	J/Psi	3096,90	Ypsilon	10023,00		

Source also Wikipedia, List_of_Baryons

Origin of *ep*-pair and proton

$$e^2 = 2^{-\frac{1+2+4+32}{4}} \cdot q_o^{\ 2}$$



(0,-2)(64,64,64;1,2,4,32)

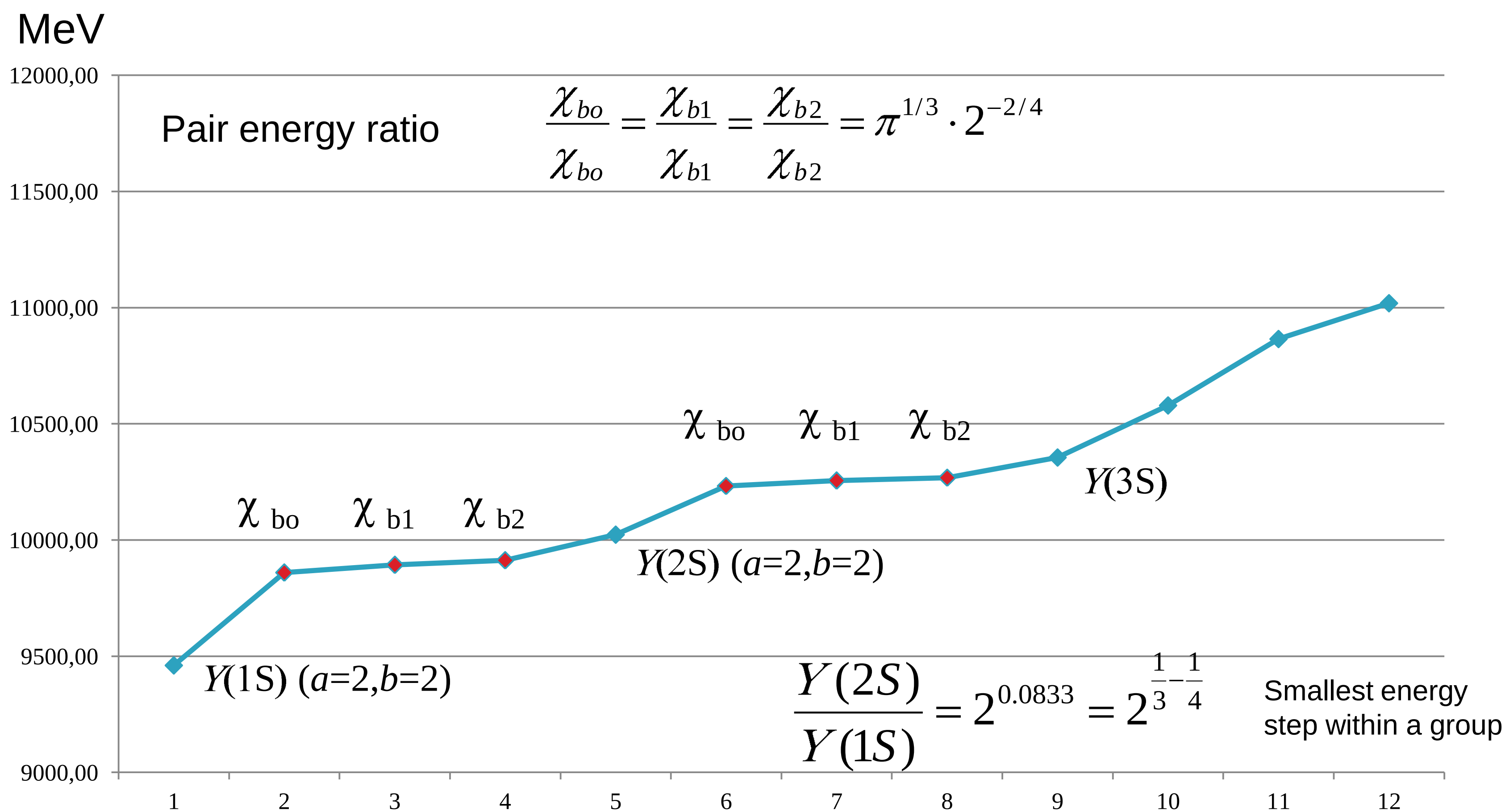
Proton basic structure
Mode change, same total number of period doublings.

Electron-positron pair
32=2⁵ more period doublings in the 3-d mass part.

$$p - e^+e^- = \pi^{-\frac{2}{4}} 2^{-73.75002} E_{oo}$$

There is also an interesting (2,2) 938.9 MeV structure. We'll return to this in a later seminar.

Finding *Khi*$_b$-system



Decimal exponents

The reader may have wondered what the decimal parts in the powers of π (mode, a,b) and 2 (doubling) mean in fractions. Here they are in common fractions (for the 3-d part and 4-d part).

$$E_{NM} = \pi^{a/3} 2^{-\frac{i+j+k}{3}} \cdot \pi^{b/4} 2^{-\frac{l+m+n+p}{4}} \cdot E_{oo}$$

$$\frac{proton}{E_{oo}} = \pi^{-0.50} 2^{-73.75} = \pi^{\frac{0}{3}-\frac{2}{4}} \cdot 2^{-\frac{192}{3}-\frac{39}{4}}$$

(0,-2)(64,64,64;1,2,4,32)

as calculated from (9)

3-d 4-d			3-d 4-d		
-3/3-4/4	=	-2,000	1/3-1/4	=	0,083
-3/3-3/4		-1,750	2/3-2/4		0,167
-2/3-4/4		-1,667	0/3+1/4		0,250
-3/3-2/4		-1,500	1/3+0/4		0,333
-2/3-3/4		-1,417	2/3-1/4		0,417
-1/3-4/4		-1,333	0/3+2/4		0,500
-3/3-1/4		-1,250	1/3+1/4		0,583
-2/3-2/4		-1,167	2/3+0/4		0,667
-1/3-3/4		-1,083	0/3+3/4		0,750
-3/3-0/4		-1,000	1/3+2/4		0,833
-2/3-1/4		-0,917	2/3+1/4		0,917
-1/3-2/4		-0,833	3/3+0/4		1,000
0/3-3/4		-0,750	1/3+3/4		1,083
-2/3-0/4		-0,667	2/3+2/4		1,167
-1/3-1/4		-0,583	3/3+1/4		1,250
0/3-2/4		-0,500	1/3+4/4		1,333
-2/3+1/4		-0,417	2/3+3/4		1,417
-1/3-0/4		-0,333	3/3+2/4		1,500
0/3-1/4		-0,250	2/3+4/4		1,667
-2/3+2/4		-0,167	3/3+3/4		1,750
-1/3+1/4		-0,083	3/3+4/4		2,000
		0,000			

Can be also written -0/3-4/4 and 0/3+4/4 respectively

About ongoing work

Do S-states decay into S-states, which is forbidden in electronic transitions (allowed by phonons)?

Name	MeV	*a*	*i*	*j*	*k*	*b*	*l*	*m*	*n*	*p*	Decay
Ψ(2S)	3686	**-2**	62	62	62	**0**	1	**1**	4	32	60 % to J/ψ
J/ψ(1S)	3097	**-2**	62	62	62	**0**	0	**2**	4	32	3-d cube

Both particles belong to the same (-2,0)-group and their 3-d structures are identical. The *Ψ(2S)* is the first EM-excited state of *J/ψ*(1S). In atomic physics *Ψ(2S)* would be considered as a *P*-state.

Name	MeV	*a*	*i*	*j*	*k*	*b*	*l*	*m*	*n*	*p*	Decay
Υ(2S)	10023	**0**	63	**63**	64	**-3**	1	**2**	4	32	18 % to *Υ*(1S) and pions
Υ(1S)	9460	**0**	63	**64**	64	**-3**	1	**1**	4	32	

Both particles belong to the same mode (0,-3). Here the transition takes place in both 3-d and 4-d parts.).

How about *P* to *S*? And other details …

About ongoing work

CERN has recently announced the discovery of a new 10539 MeV χ_{bo}(3P)-particle (ATLAS collaboration 2011, http://arxiv.org/abs/1112.5154)

Name	MeV	*a*	*i*	*j*	*k*	*b*	*l*	*m*	*n*	*p*	Remark
χ_{bo}	10539	**0**	-3	-3	-2	**0**	0	0	0	0	$\chi_{bo}=\pi^{0.166}\cdot 2^{-0.25}\,\Upsilon$(10355), note group (0,0)

This particle belongs to the basic (0,0)-group together with K^+, D^o and B^o. Ground state EM-part. One would expect this particle to decay into Υ(3S) (10355).

The hint given by the proton (combination of basic structure and *ep*-pair) will be further studied including other particles.