Baryon models in a circular extra space

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Abstract

Models of proton, neutron and other baryons were developed using a dual space concept. Charge, mass and spin of the models have its origin in a circular eigenspace fixed to the structure of each particle. Six partons (birotons) appear as structural components of a baryon model. The baryon charge is the sum of the parton charges, which are always integer elementary charges. The baryon spin is the sum of all parton spins, each parton carries a spin of the magnitude $\hbar/4$. The baryon mass is the sum of all parton masses. The masses of a parton determines also the relative magnetic moment of the parton, carrying an electromagnetic (em) charge. The magnetic moment of the baryon is the sum of all contributions from partons carrying em charges.

Examples are given for baryon models with $J^P = \frac{1}{2}^+$ and $\frac{3}{2}^+$. The numerical results of the models are usually within the measuring uncertainties of the observed values, except for the models of proton and neutron. Masses and relative magnetic moments of the proton and neutron models have six or seven decimals in agreement with the observed values.

The differences between the proposed model and the quark model are discussed.

A single biroton represents a lepton model, already described in a previous article (‘A joint model of particles and spacetime’). A single biroton has six dimensions, a baryon model consisting of six birotons (partons) has 26 dimensions. This represents the 'characteristic dimension' of mathematically consistent string theories, however the models discussed in this article don't contain strings.

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1 Introduction

The knowledge of the internal structures of proton and neutron is characterized by long-standing 'puzzles' and open questions. The authors of a review article describe this situation as follows [1]:

> "... One can never say any particle is well understood before its charge, mass and spin are successfully interpreted. The proton, which is the only stable hadron and directly involved into all of four fundamental interactions, has been investigated for a century. However, we still have very poor knowledge on its structure of charge, mass and spin."

In the Standard Model (SM), the charge of the baryon is per definitionem identical with the sum of the broken charges of the three quarks. However, this does not help to understand the charge distribution within a baryon [8].

The quark masses represent only a few percent of the baryon mass [2], the main part has to be considered as a result of gluon coupling, orbital motion of the quarks, and/or trace anomalies [4],[5]. An accepted decomposition of the proton mass does not exist. The Higgs mechanism, considered to be responsible for mass generation in the SM, can account only for the quark masses, about 1 percent of the proton mass. Nevertheless, the simulations of the processes beyond the Higgs mechanism using lattice QCD achieve results within a few percent difference to the baryon mass [3].

The baryon spin does not appear as the sum of the three quark spins. It has to be composed from four or more components in a very complicated manner, the 'spin puzzle' of the proton is unsolved for about 40 years. This situation persists despite the tremendous efforts to solve this puzzle by experiments and due to theoretical work [7].

The proton charge radius was the topic of a special puzzle for years, because the experiments gave different results depending on the applied method (e.g. using normal or myonic hydrogen) [10],[9].

This situation is unsatisfactory. Therefore in this article an attempt is made to construct models of proton, neutron and other baryons in a circular extra space, an 'eigenspace' fixed to the structure of the baryon. Strictly speaking, the models are living in two spaces at the same time: In spacetime they exist as relativistic structureless particles, and in the eigenspaces in form of composite, extended and highly structured entities. We use "basic space" as the general term for the entirety of all circular eigenspaces.

Such a dual space concept has been used in previous articles to develop models of leptons [11] and mesons [12]. An application of this concept for the development of baryon models could possibly solve some of the open questions in this field. We use the definitions and notations of the previous articles.

The mass of a particle is assumed to have two sources in the eigenspace:

The first source consists in the rotational energy of circulating mass quanta, this energy appears as main part of the invariant energy (rest energy) in spacetime. The circulating mass quanta build the 'skeleton' of the particle and contribute 95 to 98 % of the particle mass. The mass quantum in spacetime is of special importance:

$$m_Q = 3.252\,848\,5 \ MeV/c^2 \tag{1}$$

The second source of particle mass comes from the self-energy of circulating elementary charges. The self-energy is calculated as the Coulomb energy in a finite circular self-distance of a charge, such as the circumference of the circular motoin. Different types of circulation produce electromagnetic, weak and fluctuating charges which represent different interaction capabilities and form the 'dress' of the particle model.

2 The general structure of baryon models

2.1 A baryon model developed from eight muon models

A baryon model comprises 256 mass quanta, the same as eight single muon models. In order to become a baryon model, the eight single muons would have to undergo the following changes (see Fig 1):

Change of parton number: Two muons unite to a parton with a double number of mass quanta. This occurs twice per baryon model and leads to two 'legs' of the baryon model. Two legs means two partons with a double mass compared to 'arms', which retain the muonic number of 16 mass quanta per roton. Thus eight single muon models become six baryonic partons.

Change of spin: Eight single muons with parallel spins have a total spin of $4\hbar$. A baryonic parton has to have a spin of $\hbar/4$, this leads to a total spin of $\frac{3}{2}\hbar$ for six partons with parallel spins. If two of six partons have spins antiparallel to the baryon spin, one gets a total spin of $\hbar/2$ for the baryon. This picture is used for models of baryons with a half valued spin and positive parity, the signature $J^P = \frac{1}{2}^+$.
The unusual assumption of a parton spin of $\hbar/4$ is forced by the contribution of electromagnetically (em) charged partons to the relative magnetic moment μ/μ_N of the baryon.

Baryons with a total spin above 3/2 are not discussed in this article. We exclude in this study the combination of spin, produced in the eigenspace, and nonzero orbital angular momentum, produced in spacetime. The focus is on the circulation in basic space and we circumvent at the moment the discussion of complications by spin-orbit interactions. This does not mean, that baryon models cannot be constructed with a higher total spin $J > \frac{3}{2}$.

Enhancement of mass quanta: Single muons cannot create a binding between them. The mass quanta in baryonic partons are enhanced by charge clusters, this enables exchange processes between the partons and therefore the binding within the baryon. The amount of enhancement is smaller at light partons (enhanced by a cluster factor w_L^L) and higher at heavy partons (enhanced by a cluster factor w_H^H). We find empirically a general 5 : 3 relation between a heavy and a light mass block of spin 1/2 baryons. From the total of 256 rings per baryon the heavy block comprises 5 * 32 = 160 and the light block 3 * 32 = 96 rings. This assumption results in reasonable skeleton masses for the baryon families with spin 1/2.

The enhancement of mass quanta in baryonic partons is generally identical to the enhancement in partons and antipartons of meson models, see **??**. However, models of (anti)baryons consist exclusively of partons with positive(negative) masses, 'mixed matter' does not occur in (anti)baryon models. The masses of (mesonic and baryonic) antipartons in spacetime are always positive.

Change of dimensions: A single roton has an eigenspace with 3 + 1 dimensions equal to spacetime. The three spatial dimensions come from two dimensions defining the rotational area (of rotating masses and charges) and from one dimension representing the spin axis. A biroton has two mathematically separated rotational areas (two anti-commutative, two-dimensional vector spaces), a common direction for the two spin axes and a common time coordinate, in total six dimensions. Thus a lepton model, such as the model of a single muon, has six dimensons. In general, N rotons (N/2 birotons) have 2N + 2 dimensions.

$$D = 2N + 2 \tag{2}$$

The six partons (birotons) or antipartons of a baryon model have N = 12 rotons or 12 anti-rotons and therefore 2N + 2 = 26 dimensions. This is a remarkable reduction compared to the 8 x 6 = 48 dimensions of eight independent muon models.

Dress properties: The dresses of baryonic partons correspond to the dresses of leptons, adapted to the baryonic rotational parameters (ring parameter and radius). The symbols used for the self-energy factors of rotating charges are given in Fig. 2.

Table 1 contains an overview on the differences between models of leptons and of baryonic partons. Generally speaking, the birotons in baryons have radii, angular momenta and magnetic momenta divided by two, compared to the corresponding quantities of birotons in models of leptons and mesons.

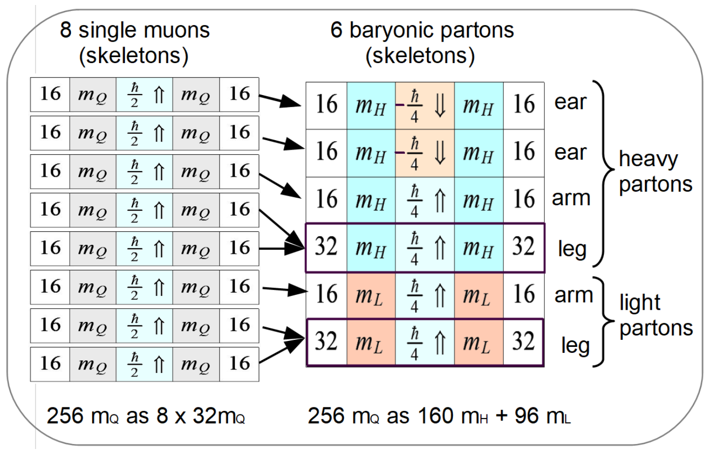

Figure 1: The symbolic origin of a baryon model from the models of eight single leptons. The six partons of a baryon differ from the structure of eight leptons by two properties: The formation of two 'legs', consisting of 32 instead of 16 mass quanta, and the enhancement of mass quanta in two different ways, producing heavy (H) and light (L) partons.

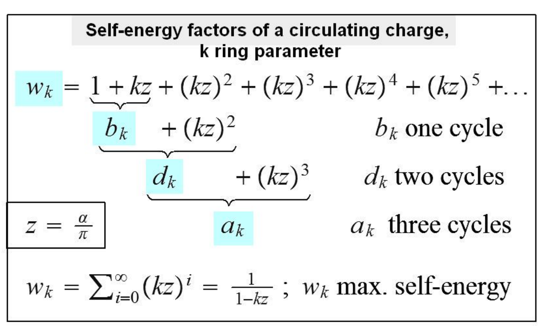

Figure 2: Self-energy factors of rotating charges. These factors, multiplied with the rotating mass, detemine the rotational energy of a biroton.

Table 1: Biroton properties in models of leptons and baryonic partons

(bi)roton	quantity	eigenspace formula		spacetime
		lepton	baryonic parton	
ext. roton	$\|\overrightarrow{r_1}\|$	$\frac{\hbar}{M_1 c}$	$\frac{\hbar}{2M_1 c}$	
	$\left\|\overrightarrow{L_1}\right\|$	$+\hbar$	$+\frac{\hbar}{2}$	$+\frac{\hbar}{2}$; *)
	$\|\overrightarrow{\mu_1}\|$	$\frac{\pm e\hbar}{2M_1}$	$\frac{\pm e\hbar}{4M_1}$	
int. roton	$\|\overrightarrow{r_2}\|$	$\frac{\hbar}{2M_2 c}$	$\frac{\hbar}{4M_2 c}$	
	$\left\|\overrightarrow{L_2}\right\|$	$-\frac{\hbar}{2}$	$-\frac{\hbar}{4}$	$-\frac{\hbar}{4}$; *)
	$\|\overrightarrow{\mu_2}\|$	0	0	
biroton	$\left\|\overrightarrow{L}\right\|$	$+\frac{\hbar}{2}$	$+\frac{\hbar}{4}$	$+\frac{\hbar}{4}$; *)
	M	$M_1 + M_2 = 2M_1$		$2m_{parton}$; **)
	$\|\overrightarrow{\mu}\|$	$\frac{\pm e\hbar}{M} = \frac{\pm e\hbar}{2M_1}$	$\frac{\pm e\hbar}{2M} = \frac{\pm e\hbar}{4M_1}$	$\frac{\pm e\hbar}{4m_{,parton}}$

*) Angular moments (partial spins) of rotons are identical in spacetime and in eigenspace, but not separately observable.

**) Parton masses in spacetime are one half the rotating masses in the eigenspace. Rotational energy (in eigenspace) is conserved as rest energy (in spacetime).

2.2 Summation of parton properties

The particle mass of a baryon model m_{baryon} is the sum of six parton masses:

$$m_{baryon} = \sum_{i=1}^{i=6} m_{parton,i} \tag{3}$$

Four of the six partons have a spin parallel to the particle spin, they are called 'arms' and 'legs'. Only arms and legs are able to carry electroweak charges. Electromagnetic (em) and weak charges do not rotate against the spin direction of the baryon model. Therefore, the birotons called "ears" with antiparallel spins are without electroweak charges in all cases.

The elektroweak charges of different partons of a baryon model rotate with four different radii to avoid collisions in the eigenspace. The four different radii are realized by the combination of the heavy / light and the arm / leg differences in the parton masses. A baryon structure cannot exist without these differences. This corresponds to the combination of three 'color-charges' in the quark model, where a baryon cannot exist without a 'color-neutral' combination of quarks.

The magnetic moment of a parton is zero, if it does not carry an em charge; for an arm or a leg carrying an em charge it amounts to

$$\mu_{parton} = \frac{\pm e\hbar}{4m_{,parton}} \tag{4}$$

(see Table 1). The nuclear magneton is defined as $\mu_N = \frac{e\hbar}{2m_p}$, where m_p means the proton mass. The relative magnetic moment of an em - carrying parton is therefore

$$\left(\frac{\mu_{parton}}{\mu_N}\right)_i = \pm\frac{m_p}{2m_{parton,i}} \tag{5}$$

The sign of the relative magnetic moment of a parton is given by the sign of its em charge. The relative magnetic moment of the baryon model is represented by the sum

$$\frac{\mu_{baryon}}{\mu_N} = \sum_{i=1}^{i=4}\left(\frac{\mu_{parton}}{\mu_N}\right)_i \tag{6}$$

The sum contains up to four terms, that means all arms and legs carrying an em charge in a certain baryon model.

2.3 Enhanced mass quanta in baryon models

The enhanced mass quanta $m_l = w_l^l m_Q$ such as $m_4,\ m_8,\ m_{12}$, and m_{16} are expressed as products of charge cluster factors w_l^l and the mass quantum m_Q. The mass quantum m_Q and the quantity w_l^l are already defined in a previous article, see **??**. One charge cluster may belong to several rings, so that for instance the single ring of the light block of the proton has the average energy factor $(\frac{1}{2}+\frac{1}{2}w_4^4)$. Only two rings of a block together possess one charge cluster with the energy factor w_4^4 and arrive at the average ring mass of
$m_{41} = \frac{1}{2}(w_4^4+1)m_Q = 3.314\,725\,7$ MeV.

The Table 2 contains the numerical values of the enhanced mass quanta occuring in baryon models. The maximum enhancement is reached with one charge cluster w_l^l per mass qatum m_Q, (rows $m_4,\ m_8,\ m_{12},\ and\ m_{16}$). The average enhancement can be lower than the maximum and only a fraction of one cluster per mass quantum is realized (such as $\frac{1}{2}$ or $\frac{7}{8}$). In particular charge clusters $w_{16}^{16} \approx 1.833$ belong to more than one ring in most cases.

Table 2: List of enhanced mass quanta

Enhanced mass quanta (MeV)	
m_Q	$3.252\,848\,5$
$m_{41} = \frac{1}{2}(w_4^4+1)m_Q$	$3.314\,725\,7$
$m_4 = w_4^4 m_Q$	$3.376\,602\,5$
$m_8 = w_8^8 m_Q$	$3.779\,494\,4$
$m_{127} = \frac{1}{8}(7w_{12}^{12}+1)m_Q$	$4.402\,374\,8$
$m_{12} = w_{12}^{12} m_Q$	$4.566\,592\,8$
$m_{164} = \frac{1}{8}(4w_{16}^{16}+4)m_Q$	$4.607\,718\,3$
$m_{165} = \frac{1}{8}(5w_{16}^{16}+3)m_Q$	$4.946\,435\,7$
$m_{166} = \frac{1}{8}(6w_{16}^{16}+2)m_Q$	$5.285\,153\,1$
$m_{167} = \frac{1}{8}(7w_{16}^{16}+1)m_Q$	$5.623\,870\,4$
$m_{16} = w_{16}^{16} m_Q$	$5.962\,587\,8$

Parton	p		n		Λ		Ξ^0		Ξ^-	
ear 1		m_8		m_8		m_{12}		m_{166}		m_{166}
ear 2		m_8		m_8		m_{12}		m_{166}		m_{166}
HA	⊖	m_8	⊖	m_8	⊕	m_{12}	⊖	m_{166}	⊖	m_{167}
HL		m_8	⊕	m_8		m_{12}	⊕	m_{166}	⊖	m_{167}
LA	⊕	m_{41}		m_4	⊖	m_8		m_{12}	⊕	m_{127}
LL	⊕	m_{41}		m_{41}		m_8		m_{12}		m_{127}

Figure 3: The heavy blocks (cyan) and the light blocks (orange) of ground state baryons. Only the type of enhancement of the mass quanta and the position of electromagnetic (em) charges are depicted. The em charges are always integer, elementary charges.

The skeleton of nucleons shows the geometry of the heavy and the light block as well as the two rotons per biroton (parton).

We remark, that the skeleton with mass quanta m_Q does not show any charges which would work as a coupling between the partons. A parton with the skeleton mass of $32m_Q = 104.15\ MeV$ represents the skeleton of the muon, a separated particle, see Fig. 1.

2.4 The 'body parts' of a baryon model

A realistic model of a baryon needs different radii for the partons carrying an electroweak charge. The first radius difference of a factor two is generated by the doubling of the ring number in 'legs" compared to 'arms'. The second radius difference comes from the combination of 'heavy' and 'light' partons, thus the partons in total belong either to the light or the heavy block. The mass relation light to heavy block equals approximately $3:5$. However, the number of partons have the relation $2:4$, because the light as well the heavy block contain one leg with twice the mass of an arm or an ear. Thus the partons carrying an electroweak charge are always distributed over four different radii, belonging to the partons named heavy arm (HA), heavy leg (HL), light arm (LA), and light leg (LL). The two partons with spins antiparallel to the baryon spin are dubbed ear 1 and ear 2. The 'ears' cannot carry an em or weak charge. Fig 3 shows the general structure and the distribution of em-charges in models of a nucleon, Λ - or Ξ - particle. The corresponding information of Σ - particles is given in Fig. 4.

A certain enhanced mass quantum can act as part of the light block in one baryon and as part of the heavy block in another type of baryon. An overview of the distribution of different enhanced mass quanta within the group of $\frac{1}{2}^+$ - baryons shows Fig. 5. The contributions to the heavy block are framed. Symbols for enhanced mass quanta with a reduced number of clusters are not used in Fig. 5, we write for instance

parton	Σ^+		Σ^0		$\Sigma^0_\pm$ *)		Σ^-	
ear 1		m_{16}		m_{16}		m_{16}		m_{167}
ear 2		m_{16}		m_{16}		m_{16}		m_{167}
HA	⊕	m_{164}	⊕	m_{164}	⊖	m_{164}	⊕	m_{167}
HL	⊕	m_{165}	⊖	m_{165}	⊖	m_{164}	⊖	m_{164}
LA		m_4		m_{41}	⊕	m_4	⊖	m_4
LL	⊖	m_4		m_4	⊕	m_4		m_4

*) model prediction, not observed

Figure 4: The heavy blocks (cyan) and the light blocks (orange) of ground state sigma particles. Only the type of enhancement of the mass quanta and the position of electromagnetic charges are depicted.. The em charges are always integer, elementary charges.

$2m_{41} = m_Q + w_4^4 m_Q = m_Q + m_4$.

The combination of number and sign of em charges with certain enhanced mass quanta will be discussed in the next paragraph.

2.5 The connection of cluster types and electromagnetic charges

The construction of basic space models of baryons reveals regularities concerning the relation of em charges and types of charge clusters. For instance a block containing the mass quanta m_4 carries always one or two positive em charges, a block containing the mass quanta m_{16} carries always one or two negative em charges. The combination of blocks carrying em charges with opposite sign is 'allowed', the combination of equal signs cannot be observed and is called 'forbidden'.

Fig. 6 shows the allowed combinations in models of proton, neutron and the Lambda particle.

In Fig. 7 we present the Σ particles which appear as 'allowed' according to the regularities. We find four particles instead of three. A second sigma-zero particle designated $\Sigma^0_\pm$, probably with properties very simalar to that of Σ^0 appears possible. Four em charges would occupy the four partons able to carry electroweak charges. The group of $\frac{1}{2}^+$ baryons would change from an octet to a nonet, similar to the meson nonets.

We remark, that the assumed existence of *four* possible charge carriers in a baryon model is in contradiction to the picture, that *three* quark colors are needed to produce a neutral, additive 'color mixing'. Possibly future experiments could decide whether or not the existence of a $\Sigma^0_\pm$ particle is realized in nature.

Particle	Number of mass quanta					Skel.mass
	m_Q	m_4	m_8	m_{12}	m_{16}	MeV
p	48	48	160			922.933
n	32	64	160			924.913
Λ	4		96	156		1088.23
Σ^+	48	96			112	1148.10
Σ^0	60	80			116	1156.96
Σ^-	44	96			116	1158.94
Ξ^0	48			84	124	1279.09
Ξ^-	44			84	128	1289.93

Figure 5: The numbers of enhanced mass quanta in baryon models. Numbers in the heavy blocks are bold framed. The number of mass quanta m_Q (without enhancement) shows the fact of a reduced cluster budget of some partons. The sum of completely enhanced quanta $m_l = w_l^l m_Q$ and of 'naked' mass quanta m_Q.is given in the table.

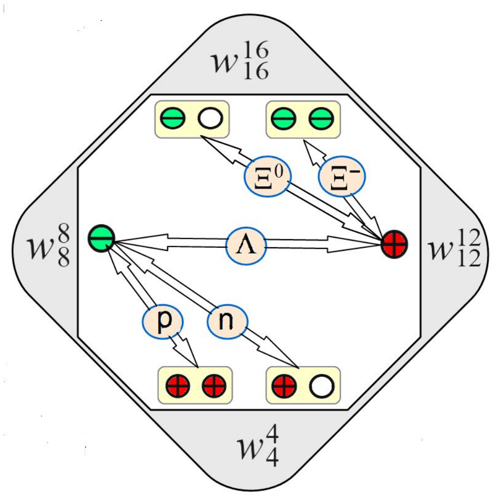

Figure 6: The combination of cluster type and em charge in the heavy and the light parts of n, p, and $\Lambda-$particles .

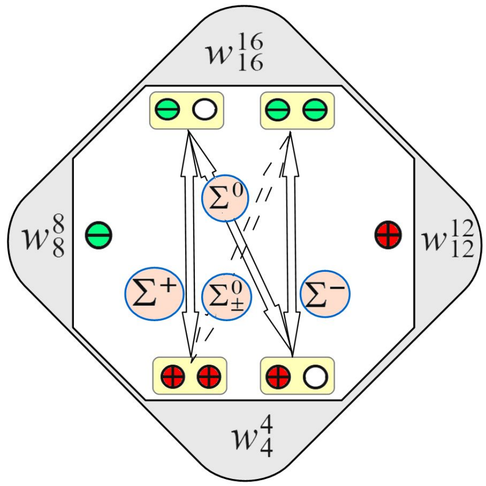

Figure 7: The combination of cluster type and em charge in the heavy and the light parts of sigma particles. The allowed combinations include a second Σ^0 particle containing two $\oplus$ and two $\ominus$ em charges. Possibly the two Σ^0 particles have nearly identical properties and cannot be separated experimentally.

3 Models of individual baryons

3.1 Models of p, n, and other baryons with $J^P = \frac{1}{2}^+$

The models of proton and neutron have the cluster types w^8_8 in the heavy block, and w^4_4 in the light block of partons. One negative em - charge is connected to the heavy block at the heavy arm, over-compensated by two positive em - charges in the light block of the proton model, see Fig. 8.
In spacetime one usually assumes the proton to have only one positive charge. Therefore one expects a constant charge radius. However, a proton with three charges would have a superposition of three fields, and the observed effective charge radius could depend on the distance of the observer. Different effective charge radii in different distances are expected (such as the size differences of normal hydrogen and μ-hydrogen). A 'charge radius puzzle' would not exist. Unfortunately we cannot calculate the range of effective charge radii in spacetime caused by the proton model in Fig. 8. The precise transformation of geometric data from the eigenspace into spacetime is currently not known.

The negative em - charge in the heavy block of the neutron model is exactly compensated to zero by one positive em-charge. However, this positive em - charge is not located in the light block as expected. We have to assume the heavy leg as the position of the positive charge, see Fig. 9. This is forced by the experimental value of μ/μ_N of the neutron.

The radii of the partons in the models of proton and neutron have a meaning

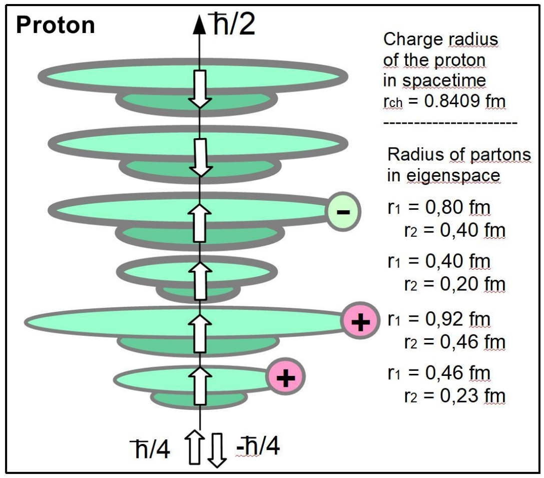

Figure 8: Geometric properties of the proton model. Four partons belong to the heavy block, they are bold framed. Two partons belong to the light block, framed with thin lines. The radii are calculated using the formulas given in Table 1, and are eigenspace-quantities.

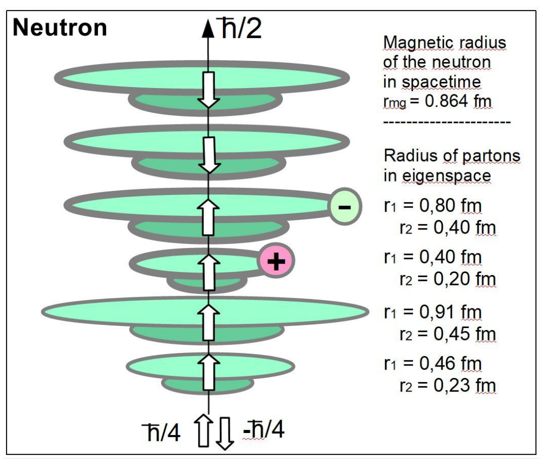

Figure 9: Geometric properties of the neutron model. Four partons belong to the heavy block, they are bold framed. Two partons belong to the light block, framed with thin lines. The radii are calculated using the formulas given in Table 1 and are eigenspace-quantities.

Proton	S	electroweak charges		roton 1		roton 2	
parton	$\frac{h}{4}$	em	weak	fluct. chrg.	skel.	skel.	fluct. chrg.
ear 1	$\Downarrow$			$16b_8$	$16m_8$	$16m_8$	$16b_8$
ear 2	$\Downarrow$			$16b_8$	$16m_8$	$16m_8$	$16b_8$
HA	$\Uparrow$	$\ominus$ $2w_8$	$2w_{16} + u_{32}$	$9b_8^2 + 2b_8$	$16m_8$	$16m_8$	$9b_8^2 + 2b_8$
HL	$\Uparrow$	0	$2w_{16} + u_{32}$	$5b_8^2 + 26b_8$	$32m_8$	$32m_8$	$4b_8^2 + 26b_8$
LA	$\Uparrow$	$\oplus$ $2w_4$	$2w_8 + u_{16}$	$12b_4$	$16m_{41}$	$16m_{41}$	$12b_4$
LL	$\Uparrow$	$\oplus$ $2w_4$	$2w_8 + u_{16}$	$7b_4^2 + 20b_4$	$32m_{41}$	$32m_{41}$	$7b_4^2 + 20b_4$

Neutron	S	electroweak charges		roton 1		roton 2	
parton	$\frac{h}{4}$	em	weak	fluct. chrg.	skel.	skel.	fluct. chrg.
ear 1	$\Downarrow$			$16b_8$	$16m_8$	$16m_8$	$16b_8$
ear 2	$\Downarrow$			$16b_8$	$16m_8$	$16m_8$	$16b_8$
HA	$\Uparrow$	$\ominus$ $2w_8$	$2w_{16} + u_{32}$	$b_8^2 + 12b_8$	$16m_8$	$16m_8$	$b_8^2 + 12b_8$
HL	$\Uparrow$	$\oplus$ $2w_8$	$w_{16}^2 + u_{32}$	$8b_8^2 + 18b_8$	$32m_8$	$32m_8$	$9b_8^2 + 18b_8$
LA	$\Uparrow$	0	$w_8^2 + u_{16}$	$14b_4$	$16m_4$	$16m_4$	$14b_4$
LL	$\Uparrow$	0	$w_8^2 + u_{16}$	$7b_4^2 + 20b_4$	$32m_{41}$	$32m_{41}$	$7b_4^2 + 20b_4$

Figure 10: Construction of the partons in models of proton and neutron. The different skeleton masses of arm / leg and heavy / light partons result in four 'colors' of the partons. The complete formulas of masses and magnetic moments of the partons are given in the appendix.

in basic space, not exactly in spacetime.

The overview on the construction details of the proton and the neutron models are given in Fig. 10, the complete formulas for masses and relative magnetic moments are contained in the appendix, Figs. 19 and 20.

The expressions for the masses of proton and neutron can be written as power expansion in $z = \alpha/\pi$. We used the definitions of the self-energy factors of the rotating charges, see Fig. 2. A third order approximation reads

$$m_p \approx 256 m_Q (1 + \frac{1599}{32} z + \frac{29\,591}{16} z^2 + 52\,533 z^3) = 938.24\ MeV \quad (7)$$

$$m_n \approx 256 m_Q (1 + \frac{1622}{32} z + \frac{29\,290}{16} z^2 + 51\,412 z^3) = 939.535\ MeV \quad (8)$$

The difference between neutron and proton mass amounts to

$$m_n - m_p \approx 256 m_Q (\frac{23}{32} z - \frac{301}{16} z^2 - 1121 z^3) = 1.294\ MeV \quad (9)$$

The masses of the baryon models depend on two parameters only: The mass quantum m_Q and the fine structure constant α.

The baryon models contain information on the skeleton masses of the partons, as well as on the interaction capabilities. Each of the interactions is governed by α, usually expressed as dependence on $z = \alpha/\pi$:

- The electromagnetic (em) interaction is proportional to $\alpha_{em.eff}(l) \sim w_l - 1 \sim \alpha$. Please note, that the factor $2w_l$ in Fig. 10 stands for a *single* em charge. The em self energy in the eigenspace is conserved in spacetime, while the mass quanta are halved. This causes a factor of two for the em self-energy in spacetime, see [11].

- The weak interaction is proprtional to $\alpha_{w,eff}(l) \sim 2(w_{2l} - 1) \sim 4\alpha$ or $w_{2l}^2 - 1 \sim 4\alpha$. The relation between the effective em and weak coupling capacity is approximately $\alpha_{em.eff}(l)/\alpha_{w,eff}(l) \sim \alpha/4\alpha = 1/4$. This corresponds to $\sin^2 \Theta_W$ in the Standard Model, where Θ_W means the Weinberg angle.

- The strong interaction is proportional to $\alpha_S \sim 1/w_l^l$, where w_l^l means the enhancement factor of mass quanta $m_l = w_l^l m_Q$. The strong interaction was discussed for mesons in more detail, see [12].

- The nuclear interaction generates the binding energy of nuclei and comes in quantized pieces proportional to $\alpha_N(l) \sim (b_l^2 - 1)m_l$. The particle energy $(b_l^2 - 1)m_l$ is lost during nuclear binding by losing one pair of fluctuating charges. In nucleons, the cluster parameter l has the two possible values $l = 4$ and $l = 8$ The discussion of the nuclear interaction needs a separate article.

The number of fluctuating charges N_f in the light and heavy blocks are very similar in the models of proton and neutron. We remark, that these charges appear always pairwise, and do not influence the electromagnetic properties of the parton.
An overview is given in Table 3, containing the numbers $N_f(R1)$, $N_f(R2)$,for the rotons R1 or R2 of all partons of a nucleon. We call R1 the rotons carrying the electroweak charges.

Table 3: Number of fluctuating charges N_f and skeleton data of the heavy (H) and light blocks (L) of p and n models.

Proton	$N_f(R1)$	skel.(R1+R2)	$N_f(R2)$	$N_f(p)$
H ⊖	86	$160m_8$	88	174
L ⊕⊕	46	$96m_{41}$	46	92
p (total)	132	$256m_Q$	134	266

Neutron	$N_f(R1)$	skel.(R1+R2)	$N_f(R2)$	$N_f(n)$
H ⊖⊕	80	$160m_8$	82	162
L	48	$32m_4 + 64m_{41}$	48	96
n (total)	128	$256m_Q$	130	258

The numerical results of the model construction for proton and neutron are in reasonable agreement with the observed values. The model values for mass and realative magnetic moment do not approximate the experimental values within

Λ particle	S	Electroweak charges		Roton 1		Roton 2	
parton	$\frac{\hbar}{4}$	em	weak	fluct. charges	skel.	skel.	fluct. charges
ear 1	$\Downarrow$			$16b_{12}$	$16m_{12}$	$16m_{12}$	$16b_{12}$
ear 2	$\Downarrow$			$16b_{12}$	$16m_{12}$	$16m_{12}$	$16b_{12}$
heavy arm	$\Uparrow$	$\oplus$ $2w_{12}$	$2w_{24}+u_{48}$	$2b_{12}^2+12b_{12}$	$16m_{127}$	$16m_{127}$	$2b_{12}^2+12b_{12}$
heavy leg	$\Uparrow$	0	$w_{24}^2+u_{48}$	$13b_{12}^2+16b_{12}$	$32m_{12}$	$32m_{12}$	$13b_{12}^2+16b_{12}$
light arm	$\Uparrow$	$\ominus$ $2w_8$	$2w_{16}+u_{32}$	$3b_8^2$	$16m_8$	$16m_8$	$3b_8^2$
light leg	$\Uparrow$	0	$w_{16}^2+u_{32}$	$5b_8^2+14b_8$	$32m_8$	$32m_8$	$5b_8^2+14b_8$

Figure 11: Construction details of the Λ−model. The complete formulas of masses and magnetic moments of the partons are given in the appendix.

the experimental uncertainties. However, they are well below the estimated relative uncertainty of the mass quantum m_Q of 10^{-6} (see Table 4).

Table 4: Comparison of model values and experimental values for the models of proton and neutron

Part.	quantity	model value	exp. value	rel. dev.
p	$m_p\ (MeV)$	938.272 129	938.272 088 16(29)	$4.3 * 10^{-8}$
p	μ/μ_N	2.792 846 96	2.7928473446(8)	$1.4 * 10^{-7}$
n	$m_n\ (MeV)$	939.565 367	939.565 420 52(54)	$6 * 10^{-8}$
n	μ/μ_N	−1.913 042	−1.9130427(5)	$3.6 * 10^{-7}$

The model of the Λ − particle has the cluster type w_8^8 in the light block and w_{12}^{12} in the partons of the heavy block. The negative em charge in the light block is compensated to a zero total charge by a posotive em - charge in the right block, as expected.

The construction details of the model are displayed in Fig. 11, the complete formulas are contained in the appendix, Fig. 21.

Models of the sigma family The sigma particles have the cluster type w_{16}^{16} in the heavy block and the type w_4^4 in the light block partons. The construction details of models of the Σ^+, Σ^o,and Σ^- particles are collected in Fig. 12. The relaive magnetic momenta are given in Fig. 13. The fourth particle $\Sigma^0_\pm$ has presumably a mass and a relative magnetic moment very similar to the known Σ^0 − particle and cannot be detected separately.

The formulas for the calculation of masses and relative magnetic momenta of the partons of sigma models are given in the appendix, Figs. 22 to 24.

Contributions of charged partons to the relative magnetic momenta of sigma particles

Σ^+ particle	S	electroweak charges		roton 1		roton 2	
parton	$\frac{\hbar}{4}$	em	weak	fluct.charges	skel.	skel.	fluct.charges
ear 1	$\Downarrow$			$2b_{16}^2 + 8b_{16}$	$16m_{16}$	$16m_{16}$	$2b_{16}^2 + 8b_{16}$
ear 2	$\Downarrow$			$2b_{16}^2 + 8b_{16}$	$16m_{16}$	$16m_{16}$	$2b_{16}^2 + 8b_{16}$
heavy arm	$\Uparrow$	$\oplus$ $2w_{16}$	$2w_{32} + u_{64}$	$4b_{16}$	$16m_{164}$	$16m_{164}$	$4b_{16}$
heavy leg	$\Uparrow$	$\oplus$ $2w_{16}$	$2w_{32} + u_{64}$	$10b_{16}$	$32m_{165}$	$32m_{165}$	$8b_{16}$
light arm	$\Uparrow$		$2w_8 + u_{16}$	$13b_4^2$	$16m_4$	$16m_4$	$14b_4^2$
light leg	$\Uparrow$	$\ominus$ $2w_4$	$2w_8 + u_{16}$	$28b_4$	$32m_4$	$32m_4$	$28b_4$

Σ^0 particle	S	electroweak charges		roton 1		roton 2	
parton	$\frac{\hbar}{4}$	em	weak	fluct.charges	skel.	skel.	fluct.charges
ear 1	$\Downarrow$			$10b_{16}$	$16m_{16}$	$16m_{16}$	$10b_{16}$
ear 2	$\Downarrow$			$10b_{16}$	$16m_{16}$	$16m_{16}$	$10b_{16}$
heavy arm	$\Uparrow$	$\oplus$ $2w_{16}$	$2w_{32} + u_{64}$	$4b_{16}^2 + 8b_{16}$	$16m_{164}$	$16m_{164}$	$4b_{16}^2 + 10b_{16}$
heavy leg	$\Uparrow$	$\ominus$ $2w_{16}$	$2w_{32} + u_{64}$	$2b_{16}^2 + 18b_{16}$	$32m_{165}$	$32m_{165}$	$2b_{16}^2 + 18b_{16}$
light arm	$\Uparrow$		$2w_8 + u_{16}$	$b_4^2 + 2b_4$	$16m_{41}$	$16m_{41}$	$b_4^2 + 2b_4$
light leg	$\Uparrow$		$2w_8 + u_{16}$	$8b_4^2$	$32m_4$	$32m_4$	$9b_4^2$

Σ^- particle	S	Electroweak charges		Roton 1		Roton 2	
parton	$\frac{\hbar}{4}$	em	weak	fluct.charges	skel.	skel.	fluct.charges
ear 1	$\Downarrow$			$4b_{16}^2 + 12b_{16}$	$16m_{167}$	$16m_{167}$	$4b_{16}^2 + 12b_{16}$
ear 2	$\Downarrow$			$4b_{16}^2 + 12b_{16}$	$16m_{167}$	$16m_{167}$	$4b_{16}^2 + 12b_{16}$
heavy arm	$\Uparrow$	$\oplus$ $2w_{16}$	$2w_{32} + u_{64}$	$4b_{16}^2 + 6b_{16}$	$16m_{167}$	$16m_{167}$	$4b_{16}^2 + 6b_{16}$
heavy leg	$\Uparrow$	$\ominus$ $2w_{16}$	$2w_{32} + u_{64}$	$14b_{16}^2 + 6b_{16}$	$32m_{164}$	$32m_{164}$	$14b_{16}^2 + 6b_{16}$
light arm	$\Uparrow$		$2w_8 + u_{16}$	$8b_4^2 + 2b_4$	$16m_4$	$16m_4$	$8b_4^2 + 2b_4$
light leg	$\Uparrow$	$\ominus$ $2w_4$	$2w_8 + u_{16}$	$12b_4^2 + 8b_4$	$32m_4$	$32m_4$	$12b_4^2 + 8b_4$

Figure 12: Construction details of models of three $\Sigma-$particles The properties of the $\Sigma^0_\pm$ are not shown.

Parton	Σ^+		Σ^0		$\Sigma^0_\pm$ *)		Σ^-	
heavy arm	$\oplus$	3.1455	$\oplus$	3.0534	$\ominus$	-3.160	$\oplus$	2.5185
heavy leg	$\oplus$	1.4650	$\ominus$	-1.4433	$\ominus$	-1.585	$\ominus$	-1.5279
light arm					$\oplus$	4.269		
light leg	$\ominus$	-2.1528			$\oplus$	2.134	$\ominus$	-2.1502
μ/μ_N(mod)	2.4578		1.610		1.658		-1.1597	
μ/μ_N(exp)	2.458(10)		1.61(8)		*)		$-1.160(25)$	

*) $\Sigma^0_\pm$ is not observed as a particle separated from Σ^0

Figure 13: Relative magnetic moments of $\Sigma-$ models.

Ξ^0- particle	S	Electroweak charges		Roton 1		Roton 2	
parton	$\frac{h}{4}$	em	weak	fluct. charges	skeleton	skeleton	fluct. charges
ear 1	$\Downarrow$			$16b_{16}$	$16m_{166}$	$16m_{166}$	$16b_{16}$
ear 2	$\Downarrow$			$16b_{16}$	$16m_{166}$	$16m_{166}$	$16b_{16}$
heavy arm	$\Uparrow$	⊖ $2w_{16}$	$2w_{32}+u_{64}$	$10b_{16}^2+4b_{16}$	$16m_{166}$	$16m_{166}$	$10b_{16}^2+4b_{16}$
heavy leg	$\Uparrow$	⊕ $2w_{16}$	$2w_{32}+u_{64}$	$10b_{16}$	$32m_{166}$	$32m_{166}$	$10b_{16}$
light arm	$\Uparrow$		$2w_{24}+u_{48}$	$4b_{12}$	$16m_{12}$	$16m_{12}$	$4b_{12}$
light leg	$\Uparrow$		$2w_{24}+u_{48}$	$12b_{12}$	$32m_{12}$	$32m_{12}$	$12b_{12}$

Ξ^-- particle	S	Electroweak charges		Roton 1		Roton 2	
parton	$\frac{h}{4}$	em	weak	fluct. charges	skeleton	skeleton	fluct. charges
ear 1	$\Downarrow$			$16b_{16}$	$16m_{166}$	$16m_{166}$	$16b_{16}$
ear 2	$\Downarrow$			$16b_{16}$	$16m_{166}$	$16m_{166}$	$16b_{16}$
heavy arm	$\Uparrow$	⊖ $2w_{16}$	$2w_{32}+u_{64}$	$2b_{16}$	$16m_{167}$	$16m_{167}$	$2b_{16}$
heavy leg	$\Uparrow$	⊖ $2w_{16}$	$2w_{32}+u_{64}$	$4b_{16}$	$32m_{166}$	$32m_{166}$	$4b_{16}$
light arm	$\Uparrow$	⊕ $2w_{12}$	$2w_{24}+u_{48}$	$2b_{12}^2+12b_{12}$	$16m_{127}$	$16m_{127}$	$2b_{12}^2+12b_{12}$
light leg	$\Uparrow$		$2w_{24}+u_{48}$	$4b_{12}$	$32m_{127}$	$32m_{127}$	$4b_{12}$

Figure 14: Construction details of models of $\Xi-$ particles. The different skeleton masses of arm / leg and heavy / light partons result in four 'colors' of the partons. The complete formulas of masses and magnetic moments of the partons are given in the appendix.

Models of Ξ - particles The Ξ - particles have the cluster type w_{16}^{16} in the heavy block and the type w_{12}^{12} in the light block partons. The construction details of models of the Ξ - particles are collected in Fig. 14.

The relative magnetic moments are given in Fig. 15. The model of the Ξ^- appears as the counterpart of the proton, concerning the number and distribution of em - charges. Correspondingly, the Ξ^0 is the counterpart of the neutron. Complete formulas of masses and relative magnetic moments of Ξ - particles are given in the appendix, Figs. 25 and 26.

The model data are within the measuring uncertainty of the observed data, except for the proton and neutron data. In Table 3 the data of proton and neutron are given including the deviation of the model data from the experiment. Table 5 contains this comparison for the other baryons, however without

Parton	p		n		Λ		Ξ^0		Ξ^-	
heavy arm	⊖	−3.7905	⊖	−3.8126	⊕	3.2343	⊖	−2.6198	⊖	−2.6679
heavy leg			⊕	1.89959			⊕	1.3695	⊖	−1.2721
light arm	⊕	4.3898			⊖	−3.8474			⊕	3.2895
light leg	⊕	2.1936								
μ/μ_N(mod)	2.79284632		−1.9130420		−0.6131		−1.2503		−0.6506	
μ/μ_N(exp)	2.79284734		−1.9130427		−0.613(4)		−1.250(14)		−0.6507(25)	

Figure 15: Relative magnetic moments of models of proton, neutron, $\Lambda-$ and $\Xi-$particles. The formulas are given in the appendix.

deviation.

Table 5: Comparison of model and experimental values for baryons (without proton and neutron)

Particle	Mass in MeV		μ/μ_N	
	model	experiment	model	experiment
Λ	1115. 683 2	1115.683(6)	-0.613	$-0.613(4)$
Σ^+	1189. 354	1189.37(7)	2. 458	2.458(10)
Σ^0	1192. 641 8	1192.642(24)	1.610	1.61(8)
Σ^-	1197. 453 8	1197.449(30)	-1.160	$-1.160(25)$
Ξ^0	1314. 873	1314.86(20)	-1.2503	$-1.250(14)$
Ξ^-	1321. 78	1321.71(7)	-0.6506	$-0.6507(25)$
Ω^-	1672. 45	1672.43(32)	-2.02	$-2.02(5)$

The Ω^-- particle, included in Table 5, will be discussed in the following section.

3.2 Baryon models with the signature $J^P = \frac{3}{2}^+$

The partons called 'ears' can change their spins ($\frac{\hbar}{4}$) from antiparallel into parallel to the particle spin. This needs additional energy, coming from a higher number of rings. We assume again six partons, the same as in models of baryons with $J^P = \frac{1}{2}^+$, however $256 + 64 = 320$ mass quanta instead of 256. The additional 64 mass quanta correspond in most cases to a doubling of the mass of the ears due to the spin flip. The increase of the skeleton masses of baryons due to the spin flip of the ears is estimated in Table 6.

Table 6: Estimation of skeleton masses of $\frac{3}{2}^+$- baryons

J^P	Skel.mass	J^P	Exp. mass	Skeleton mass
$\frac{1}{2}^+$	MeV	$\frac{3}{2}^+$	MeV	MeV
n	924.913	$\Delta(1232)$	1232	$924.9 + 64m_{12} = 1217.2$
Λ	1088. 23			$160m_{126} + 160m_4 = 1218.4$
Σ^+	1148.10	$\Sigma(1385)^+$	1382.8	$1148.1 + 64m_4 = 1364.2$
Σ^0	1156.96	$\Sigma(1385)^0$	1383.7	$1156.1 + 64m_4 = 1372.2$
Σ^-	1158.94	$\Sigma(1385)^-$	1387.2	$1158.9 + 64m_4 = 1375.0$
Ξ^0	1279.09	$\Xi(1530)^0$	1531.8	$1279.09 + 64m_8 = 1521$
Ξ^-	1289.93	$\Xi(1530)^-$	1535.0	$1289.93 + 64m_8 = 1531.8$
Ξ^-	1289.93	$\Omega^-(1672)$	1672.4	$1289.93 + 64m_{167} = 1649.9$

The number of dimensions of the baryon models remains unchanged. We have to assume 4 dimensions per parton, added to 24 dimensions for six partons, plus a common spin axis and a time coordinate. The total number of dimensions of a baryon model in its eigenspace amounts to 26 dimensions.

As an example, the details of the Ω^- $-$model are given in Fig. 16, for the complete formulas see Fig. 27 in the appendix. The relative magnetic moment could be measured for the Ω^-- particle, not so for the other $\frac{3}{2}^+$- baryons. One

Ω^- - particle	S	Electroweak charges		Roton 1		Roton 2	
parton	$\frac{h}{4}$	em	weak	fluct. charges	skeleton	skeleton	fluct. charges
ear 1	$\Uparrow$			$32b_{16}$	$32m_{166}$	$32m_{166}$	$32b_{16}$
ear 2	$\Uparrow$			$32b_{16}$	$32m_{166}$	$32m_{166}$	$32b_{16}$
heavy arm	$\Uparrow$	$\oplus$ $2w_{16}$	$2w_{32} + u_{64}$	$8b_{16}$	$16m_{167}$	$16m_{167}$	$8b_{16}$
heavy leg	$\Uparrow$	$\ominus$ $2w_{16}$	$2w_{32} + u_{64}$	$14b_{16} + 7b_{16}^2$	$32m_{167}$	$32m_{167}$	$14b_{16} + 7b_{16}^2$
light arm	$\Uparrow$	$\ominus$ $2w_{12}$	$2w_{24} + u_{48}$	$2b_{12}$	$16m_{127}$	$16m_{127}$	$2b_{12}$
light leg	$\Uparrow$		$2w_{24} + u_{48}$	$4b_{12} + 2b_{12}^2$	$32m_{127}$	$32m_{127}$	$6b_{12} + 2b_{12}^2$

Figure 16: Model of the Ω^-- particle with construction details. The spins of the six partons are parallel to the particle spin (column S, green color). The higher energy comes from the doubling of the mass of two partons called 'ears', the skeleton masses of the ears are red framed.

would have many degrees of freedom during model construction, if the mass were the only observed data. Therefore we did not develop models of the other baryons.

4 Comparison of the dual space model and the quark model

According to the Standard Model of particles, the baryons are composed of three elementary quarks, and of gluons. The quark model has been developed about 50 years ago and describes processes between several particles elegantly and successfully. All quarks of one flavor are identical, they have the same mass and the same broken charge. However, within the quark model it is difficult or even impossible to calculate masses and magnetic moments of particles. An accepted decomposition of charge, spin, and mass of baryons does not exist.

Quark flavors

Two types (flavors) of quarks are necessary for quark-models of proton and neutron: up-quarks and down-quarks. The basic space models need two types of charge clusters, thus in the case of nucleons their seems to be a similarity between u- and d- quarks at the one hand and w_4^4- and w_8^8 - clusters at the other.

The quark models of the Λ and of heavier particles contain the up-, down-, and strange quarks. The basic space models need two types of charge clusters per particle family, in total four types, namely w_4^4, w_8^8, w_{12}^{12}, and w_{16}^{16}. In general, the 'flavor physics' of the both models is different. The role of clusters with higher cluster parameters up to the unstable cluster w_{48}^{48} was discussed in [12].

Quark masses

The three quarks in the quark-model of a baryon contribute only 1 to 2 percent to the baryons mass, the rest of the mass is produced by the dynamical processes of the strong interaction between quarks and gluons. In contrast, the

Quark assignments					Tentative 'quark equivalents'		
Particle		u	d	s	u*	d*	s*
p	uud	$+\frac{2}{3}; +\frac{2}{3}$	$-\frac{1}{3}$		$\oplus_4$ $\oplus_4$	$\ominus_8$	
n	udd	$+\frac{2}{3}$	$-\frac{1}{3}; -\frac{1}{3}$		$\oplus_8$	$\ominus_8$ $\bigcirc$	
Λ	uds	$+\frac{2}{3}$	$-\frac{1}{3}$	$-\frac{1}{3}$	$\bigcirc$	$\ominus_8$	$\oplus_{12}$
Ξ^0	uss	$+\frac{2}{3}$		$-\frac{1}{3}; -\frac{1}{3}$	$\oplus_{16}$		$\ominus_{16}$ $\bigcirc$
Ξ^-	dss		$-\frac{1}{3}$	$-\frac{1}{3}; -\frac{1}{3}$		$\oplus_{12}$	$\ominus_{16}$ $\ominus_{16}$
Σ^+	uus	$+\frac{2}{3}; +\frac{2}{3}$		$-\frac{1}{3}$	$\ominus_4$ $\oplus_{16}$		$\oplus_{16}$
Σ^0	uds	$+\frac{2}{3}$	$-\frac{1}{3}$	$-\frac{1}{3}$	$\oplus_{16}$	$\bigcirc$	$\ominus_{16}$
$\Sigma^0_\pm$	uss	$+\frac{2}{3}$		$-\frac{1}{3}; -\frac{1}{3}$	$\oplus_4$	$\oplus_4$	$\ominus_{16}$ $\ominus_{16}$
Σ^-	dds		$-\frac{1}{3}; -\frac{1}{3}$	$-\frac{1}{3}$		$\ominus_4$ $\ominus_{16}$	$\oplus_{16}$
avg. charge		$+\frac{2}{3}$	$-\frac{1}{3}$	$-\frac{1}{3}$	$\frac{+7-1}{9} = \frac{2}{3}$	$\frac{-5+2}{9} = -\frac{1}{3}$	$\frac{-6+3}{9} = -\frac{1}{3}$

$\oplus_4$ means a positive elementary charge attached to m_4 ; $\ominus_4$ a negative charge

Figure 17: Comparison of charges of quarks and baryonic partons. The attempt to define 'quark equivalents' in basic space - models leads to different charge states of a certain quark equivalent. However the average charge taken over the nonet of $\frac{1}{2}^+$−baryons provides broken values equal to the quark charges.

partons in a basic space model are structured in skeleton and dress, the sum of parton masses provides the baryon mass to 100 %. The mass equivalents of internal coupling processes are included in the parton mass.

The quark picture for light baryons is somewhat different as for mesons, where above the charm threshold the Standard Model contains constituent quarks as well (charm, bottom, and top quarks).

Quark charges

Quarks of a certain flavor are identical, they have the same mass and the same broken charge. In contrast, the partons in baryon models have different masses depending on the baryon family and on the 'body part' within each particle. The charge per parton is always integer and can change between the charge states -e, 0 , and +e. Therefore it is not useful to speak of 'quark equivalents' in basic space models. The comparison in Fig. 17 shows, that the tentative quark equivalents would have broken charge values only in the statistical average, similar to the quark charges. This justifies the hypothesis, that the success of the quark model is caused by a description of charge states which are correct in the *average* of possible different realizations of a process.

The charge concepts of the two models are different. The hypothesis of the character of the broken quark charges as an 'average number' can be illustrated using the three particles Δ^{++}, Δ^-,and Ω^-,consisting of three identical quarks, see Fig. 18.

Quark colors and confinement

In the quark model, a baryon consists of *three* quarks with three different 'color-charges'. A baryon cannot exist without a 'color-neutral' combination of quarks. In contrast, in baryon models with partons carrying em charges *four*

		Quark assignments			Tentative 'quark equivalents'		
particle		u	d	s	u*	d*	s*
Δ^{++}	uuu	$+\frac{2}{3}; +\frac{2}{3}; +\frac{2}{3}$			$\oplus_4\ \oplus_4\ \bigcirc$		
Δ^{-}	ddd		$-\frac{1}{3}; -\frac{1}{3}; -\frac{1}{3}$			$\ominus_8\ \bigcirc\ \bigcirc$	
Ω^{-}	sss			$-\frac{1}{3}; -\frac{1}{3}; -\frac{1}{3}$			$\oplus_{12}\ \ominus_{16}\ \ominus_{16}$
avg. charge		$+\frac{2}{3}$	$-\frac{1}{3}$	$-\frac{1}{3}$	$+\frac{2}{3}$	$-\frac{1}{3}$	$\frac{+1-2}{3} = -\frac{1}{3}$

Figure 18: Comparison of charges in the quark model and the basic space models of $\frac{3}{2}^{+}-$baryons. Only the average charge of the 'quark equivalents' equals the broken values of the quark charges.

different radii exist. This is realized by the combination of the heavy / light and the arm / leg differences in the parton masses and -radii. A baryon structure cannot exist without these differences. The mass- and radius- differences of partons correspond to the color differences of quarks. Instead of a picture from optics (colors in additive mixing) we could use a mechanical and geometrical picture: The four 'cogs in a machine' can function only in the combination of four different radii.

Quark compositeness

Many attempts have been made to describe quarks as consisting of some simpler entities (preons, rishons...), however, these proposals were not accepted by the community of particle physicists. Quarks have obviously no internal structure in space-time. The dual space concept proposed in this article allows to realize compositeness of fundamental particles in an extra space while avoiding compositeness in spacetime.

5 Conclusions

The decomposition of proton, neutron and other baryons was tested by constructing models in a circular extra space.

A baryon model is extended and composite in its circular eigenspace and consists of six partons ('birotons'). A biroton resembles a lepton model, already described in a previous article, see [11].

Masses and relative magnetic moments μ/μ_N of proton, neutron, and other ground state baryons are reproduced using models living in a circular extra space with 26 dimensions. The model values of proton and neutron agree with the observed values within six or seven decimals. The numerical values of $\Lambda-, \Sigma-$,and Ξ- models are within the measuring uncertainties of the observed values.

Some baryon models carry more than one em charge, for instance the proton model has three charged partons. In such cases the effective charge radius of the baryon model depends on the distance in spacetime and does not represent a constant quantity. A 'charge radius puzzle' does not exist. The other 'puzzles' in describing the internal structure of proton and neutron concerning mass and spin are absent as well. The price for this result would be the acceptance of

Parton	Parton mass formula	Mass, MeV
E 1	$32b_8m_8$	123. 191 264
E 2	$32b_8m_8$	123. 191 264
HA ⊖	$(32+16(b_8^2-1)+6(b_8-1)+(2w_8+2w_{16}+u_{32}-5))m_8$	123. 768 288
HL	$(64+18(b_8^2-1)+42(b_8-1)+(2w_{16}+u_{32}-3))m_8$	247. 380 899
LA ⊕	$(32+4(b_4^2-1)+16(b_4-1)+(2w_4+2w_8+u_{16}-5))m_{41}$	106. 871 624
LL ⊕	$(64+11(b_4^2-1)+32(b_4-1)+(2w_4+2w_8+u_{16}-5))m_{41}$	213. 868 790
proton	exp.: m_p = 938. 272 088 MeV	938. 272 129

Parton	Parton μ/μ_N calculation	μ/μ_N(mod)
HA ⊖	$-m_p/(2m_{HA}(p_{\mathrm{mod}})) = -m_p/(2*123.768288)$	− 3. 790 438 18
LA ⊕	$+m_p/(2m_{LA}(p_{\mathrm{mod}})) = +m_p/(2*106.871624)$	4. 389 715 68
LL ⊕	$+m_p/(2m_{LL}(p_{\mathrm{mod}})) = +m_p/(2*213.868790)$	2. 193 569 45
proton	μ/μ_N(exp) = 2. 792 847 34	2. 792 846 96

Figure 19: Model of the proton

an extra space, not accessible to direct experiments, and the abandoning of the quark model.

The main properties of the quark model and the dual space model are compared. Both concepts are very different, the broken charge of a quark seems to be a statistical average of the possible different integer charge states of a corresponding parton. The quark picture is suitable to describe processes in spacetime, however it seems to be insufficient to describe the internal structure of baryons. Probably it is justified to use two models in parallel, one within a well defined level of reality.

6 Declarations

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7 Appendix

The appendix contains formal expressions for masses and relative magnetic moments of selected baryon models. We use the abbreviations according to the 'body parts' nomenclature of the six partons:

Ears (E1 and E2), heavy arm (HA), heavy leg (HL), light arm (LA), and light leg (LL). Each parton represents a biroton in the eigenspace of the particle.

Parton	Parton mass formula	Mass, MeV
E 1	$32b_8m_8$	123. 191 264
E 2	$32b_8m_8$	123. 191 264
HA $\ominus$	$(32+24(b_8-1)+2(b_8^2-1)+(2w_8+2w_{16}+u_{32}-5))m_8$	123. 047 690
HL $\oplus$	$(64+36(b_8-1)+17(b_8^2-1)+(2w_8+w_{16}^2+u_{32}-4))m_8$	246. 966 488
LA	$(32+28(b_4-1)+(w_8^2+u_{16}-2))m_4$	108. 928 825
LL	$(64+40(b_4-1)+14(b_4^2-1)+(w_8^2+u_{16}-2))m_{41}$	214. 239 836
neutron	exp. m_n = 939. 565 421 MeV	939. 565 367

Parton	Parton μ/μ_N calculation	μ/μ_N(mod)
HA $\ominus$	$-m_p/(2m_{HA}(n_{\text{mod}})) = -m_p/(2*123.04769)$	– 3. 812 635 9
HL $\oplus$	$+m_p/(2m_{HL}(n_{\text{mod}})) = +m_p/(2*246.966488)$	+ 1. 899 593 9
neutron	μ/μ_N(exp) = – 1. 913 042 7	–1. 913 042

Figure 20: Model of the neutron

Parton	Parton mass formula	Mass, MeV
ear 1	$32b_{12}m_{12}$	150. 204 2
ear 2	$32b_{12}m_{12}$	150. 204 2
HA $\oplus$	$(32+4(b_{12}^2-1)+24(b_{12}-1)+(2w_{12}+2w_{24}+u_{48}-5))m_{127}$	145. 049 84
HL	$(64+26(b_{12}^2-1)+32(b_{12}-1)+(2w_{24}+u_{48}-3))m_{12}$	303. 026 66
LA $\ominus$	$(32+6(b_8^2-1)+(2w_8+w_{16}^2+u_{32}-4))m_8$	121. 934 82
LL	$(64+10(b_8^2-1)+28(b_8-1)+(2w_{16}+u_{32}-3))m_8$	245. 263 48
Λ particle	exp.: m_Λ = 1115. 683(6) MeV	1115. 683 2

Parton	Parton μ/μ_N calculation	μ/μ_N(mod)
HA $\oplus$	$+m_p/(2m_{HA}(\Lambda_{\text{mod}})) = +m_p/(2*145.04984)$	+ 3. 234 3
LA $\ominus$	$-m_p/(2m_{LA}(\Lambda_{\text{mod}})) = -m_p/(2*121.93482)$	– 3. 847 4
Λ particle	μ/μ_N(exp) = – 0. 613(4)	– 0. 613

Figure 21: Model of the Λ-particle

Parton	Σ^+ Parton mass formula	Mass, MeV
ear 1	$(32+16(b_{16}-1)+4(b_{16}^2-1))m_{16}$	196. 154 2
ear 2	$(32+16(b_{16}-1)+4(b_{16}^2-1))m_{16}$	196. 154 2
HA $\oplus$	$(32+8(b_{16}-1)+(2w_{16}+2w_{32}+u_{64}-5))m_{164}$	149. 142 9
HL $\oplus$	$(64+18(b_{16}-1)+(2w_{16}+2w_{32}+u_{64}-5))m_{165}$	320. 230 8
LA	$(32+27(b_4^2-1)+(2w_8+u_{16}-3))m_4$	109. 751 2
LL $\ominus$	$(64+56(b_4-1)+(2w_4+2w_8+u_{16}-5))m_4$	217. 920 7
Σ^+ particle	exp.: m_{Σ^+} = 1189. 37(7) *MeV*	1189. 354

Parton	Parton μ/μ_N calculation	μ/μ_N(mod)
HA $\oplus$	$+m_p/(2m_{HA}(\Sigma^+)) = +m_p/(2*149.1429)$	3. 145 5
HL $\oplus$	$+m_p/(2m_{HL}(\Sigma^+)) = +m_p/(2*320.2308)$	1. 4650
LL $\ominus$	$-m_p/(2m_{LL}(\Sigma^+)) = -m_p/(2*217.9207)$	– 2. 152 8
Σ^+ particle	μ/μ_N(exp) = 2. 458(10)	2. 457 8

Figure 22: Model of the Σ^+particle

Parton	Σ^0 Parton mass formula	Mass, MeV
ear 1	$(32+20(b_{16}-1))m_{16}$	195. 234 8
ear 2	$(32+20(b_{16}-1))m_{16}$	195. 234 8
HA $\oplus$	$(32+18(b_{16}-1)+8(b_{16}^2-1)+(2w_{16}+2w_{32}+u_{64}-5))m_{164}$	153. 646 2
HL $\ominus$	$(64+36(b_{16}-1)+4(b_{16}^2-1)+(2w_{16}+2w_{32}+u_{64}-5))m_{165}$	325. 037 8
LA	$(32+4(b_4-1)+2(b_4^2-1)+(2w_8+u_{16}-3))m_{41}$	106. 316 1
LL	$(64+17(b_4^2-1)+(2w_8+u_{16}-3))m_4$	217. 172 1
Σ^0 particle	exp.: $m_{\Sigma^0}=1192.642(24)$ MeV	1192. 642

Parton	Parton μ/μ_N calculation	μ/μ_N(mod)
HA $\oplus$	$+m_p/(2m_{HA}(\Sigma^0)) = +m_p/(2*153.646176)$	3. 053
HL $\ominus$	$-m_p/(2m_{HL}(\Sigma^0)) = -m_p/(2*325.037802)$	– 1. 443
Σ^0 particle	μ/μ_N(exp) = 1.61(8)	1. 610

Figure 23: Model of the Σ^0- particle

Parton	Σ^- Parton mass formula	Mass, MeV
ear 1	$(32+24(b_{16}-1)+8(b_{16}^2-1))m_{167}$	188. 386 467
ear 2	$(32+24(b_{16}-1)+8(b_{16}^2-1))m_{167}$	188. 386 467
HA $\oplus$	$(32+8(b_{16}^2-1)+12(b_{16}-1)+(2w_{16}+2w_{32}+u_{64}-5))m_{167}$	186. 276 096
HL $\ominus$	$(64+28(b_{16}^2-1)+12(b_{16}-1)+(2w_{16}+2w_{32}+u_{64}-5))m_{164}$	307. 042 826
LA	$(32+16(b_4^2-1)+4(b_4-1)+(2w_8+u_{16}-3))m_4$	109. 183 262
LL $\ominus$	$(64+24(b_4^2-1)+16(b_4-1)+(2w_4+2w_8+u_{16}-5))m_4$	218. 178 652
Σ^- particle	exp.: $m_{\Sigma^-}=1197.449(30)$ *MeV*	1197. 453 77

Parton	Parton μ/μ_N calculation	μ/μ_N(mod)
HA $\oplus$	$+m_p/(2m_{HA}(\Sigma^-)) = +m_p/(2*186.2761)$	2. 518 5
HL $\ominus$	$-m_p/(2m_{HL}(\Sigma^-)) = -m_p/(2*307.0428)$	– 1. 527 9
LL $\ominus$	$-m_p/(2m_{LL}(\Sigma^-)) = -m_p/(2*218.1787)$	– 2. 150 2
Σ^- particle	μ/μ_N(exp) = $-1.160(25)$	– 1. 160

Figure 24: Model of the Σ^--particle

Parton	Parton mass formula	Mass, MeV
E 1	$32b_{16}m_{166}$	175. 410
E 2	$32b_{16}m_{166}$	175. 410
HA $\ominus$	$(32+20(b_{16}^2-1)+8(b_{16}-1)+(2w_{16}+2w_{32}+u_{64}-5))m_{166}$	179. 073
HL $\oplus$	$(64+20(b_{16}-1)+(2w_{16}+2w_{32}+u_{64}-5))m_{166}$	342. 552
LA	$(32+8(b_{12}-1)+(2w_{24}+u_{48}-3))m_{12}$	147. 129
LL	$(64+24(b_{12}-1)+(2w_{24}+u_{48}-3))m_{12}$	295. 297
Ξ^0 particle	exp. 1314.86(20) *MeV*	1314. 873

Parton	Parton μ/μ_N calculation	μ/μ_N(mod)
HA $\ominus$	$+m_p/(2m_{HA}(\Xi^0_{\mathrm{mod}})) = -m_p/(2*179.073033)$	– 2. 619 8
HL $\oplus$	$-m_p/(2m_{HL}(\Xi^0_{\mathrm{mod}})) = +m_p/(2*342.552077)$	1. 369 5
Ξ^0 particle	μ/μ_N(exp) = $-1.250(14)$	–1. 250 3

Figure 25: Model of the Ξ^0- particle

Parton	Parton mass formula	Mass, MeV
E 1	$32b_{16}m_{166}$	175. 410 45
E 2	$32b_{16}m_{166}$	175. 410 45
HA $\ominus$	$(32+4(b_{16}-1)+(2w_{16}+2w_{32}+u_{64}-5))m_{167}$	181. 197 68
HL $\ominus$	$(64+8(b_{16}-1)+(2w_{16}+2w_{32}+u_{64}-5))m_{167}$	361. 997 58
LA $\oplus$	$(32+24(b_{12}-1)+4(b_{12}^2-1)+(2w_{12}+2w_{24}+u_{48}-5))m_{127}$	145. 049 84
LL	$(64+8(b_{12}-1)+0(b_{12}^2-1)+(2w_{24}+u_{48}-3))m_{127}$	282. 714 63
Ξ^-particle	exp.1321. 71(7) MeV	1321. 780 6

Parton	Parton μ/μ_N calculation	μ/μ_N(mod)
HA $\ominus$	$-m_p/(2m_{HA}(\Xi^-_{\text{mod}})) \;\; = -m_p/(2*181.\,197\,68)$	–2. 667 93
HL $\ominus$	$-m_p/(2m_{HL}(\Xi^-_{\text{mod}})) \;\; = +m_p/(2*361.\,997\,58)$	–1. 272 16
LA $\oplus$	$+m_p/(2m_{LA}(\Xi^-_{\text{mod}})) \;\; = +m_p/(2*145.\,049\,84)$	3. 289 46
Ξ^- particle	$\mu/\mu_N(\text{exp}) = -0.6507(25)$	–0. 650 63

Figure 26: Model of the Ξ^--particle

Parton	Ω^- Parton mass formula	Mass, MeV
ear 1	$64b_{16}m_{166}$	350. 821
ear 2	$64b_{16}m_{166}$	350. 821
HA $\oplus$	$(32+16(b_{16}-1)+(2w_{16}+2w_{32}+u_{64}-5))m_{167}$	183. 706
HL $\ominus$	$(64+28(b_{16}-1)+14(b_{16}^2-1)+(2w_{16}+2w_{32}+u_{64}-5))m_{167}$	372. 139
LA $\ominus$	$(32+4(b_{12}-1)+(2w_{12}+2w_{24}+u_{48}-5))m_{127}$	141. 600
LL	$(64+10(b_{12}-1)+4(b_{12}^2-1)+(2w_{24}+u_{48}-3))m_{126}$	273. 363
Ω^- particle	exp.: $m_{\Omega^-} = 1672.43(32)$ *MeV*	1672. 45

Parton	Parton μ/μ_N calculation	μ/μ_N(mod)
HA $\oplus$	$+m_p/(2m_{HA}(\Omega^-)) \;\; = +m_p/(2*183.\,706)$	2. 553 7
HL $\ominus$	$-m_p/(2m_{HL}(\Omega^-)) \;\; = -m_p/(2*372.\,139)$	–1. 260 6
LA $\ominus$	$-m_p/(2m_{LA}(\Omega^-)) \;\; = -m_p/(2*141.\,600)$	–3. 313 1
Ω^- particle	$\mu/\mu_N(\text{exp}) = -2.02(5)$	–2. 02

Figure 27: Model of the Ω^-- particle

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