Magnetic Moments and Masses of Hyperons

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Abstract: Here within the lacking part of ultimate theory, i.e. the Everlasting Theory, I calculated the magnetic moments and rigorous masses of hyperons. The theoretical results overlap with experimental data or are very close to them.

1. Introduction

The lacking part of ultimate theory, i.e. the Everlasting Theory, is based on two fundamental axioms [1]. There are the phase transitions of the fundamental spacetime composed of the superluminal and gravitationally massless pieces of space (the tachyons). The phase transitions follow from the saturated interactions of the tachyons and lead to the superluminal binary systems of closed strings responsible for the entanglement, to the binary systems of neutrinos i.e. to the Einstein-spacetime components, to the cores of baryons and to the cosmic objects that appeared after the era of inflation but before the observed expansion of our Universe. The second axiom follows from the symmetrical decays of bosons that appear on the surface of the core of baryons. It leads to the Titius-Bode law for the strong interactions i.e. to the atom-like structure of baryons. Within such theory I calculated the relative magnetic moments of proton and neutron [1]: for proton is +2.79360 whereas for neutron –1.91343.

Internal structure of the hyperons is as follows [1] (the values of the approximate masses are in MeV)

$$m_{\Lambda} = m_{neutron} + M_{(o),k=0,d=2} = 1115.3, \qquad (1)$$

$$m_{\Sigma(+)} = m_{proton} + M_{(o),k=2,d=2} = 1189.6, \qquad (2)$$

$$m_{\Sigma(o)} = m_{neutron} + M_{(o),k=2,d=2} = 1190.9, \qquad (3)$$

$$m_{\Sigma(-)} = m_{neutron} + M_{(-),k=2,d=2} = 1196.9, \qquad (4)$$

$$m_{\Xi(o)} = m_{\Lambda} + M_{(o),k=1,d=2} = 1316.2, \qquad (5)$$

$$m_{\Xi(-)} = m_{\Lambda} + M_{(-),k=1,d=2} = 1322.2, \qquad (6)$$

$$m_{\Omega(-)} = m_{\Xi(-o)} + M_{(o-),k=3,d=2} = 1674.4. \qquad (7)$$

Following formula defines the masses $M_{(+-o),k,d}$ [1]

$$M_{(+-o),k,d=2} = m_{W(+-o),d=2} + \sum_{d=0,1,2,4}^{d<2^k} dE_W , \qquad (8)$$

where k = 0, 1, 2, 3 whereas E_W = 25.213 MeV. The k and d determine quantum state of particle having a mass $M_{(+-o),k,d}$. The mass of a hyperon is equal to the sum of the mass of a nucleon and of the masses calculated from (8). The $m_{W(+-o),d=2}$ is the relativistic mass of pion in the d = 2 state defined by the Titius-Bode law for the strong interactions ($m_{W(+-),d=2}$ = 181.704 MeV whereas $m_{W(o),d=2}$ = 175.709 MeV.

The Everlasting Theory [1] defines as well a probability that the y proton is composed of the charged core H^+ and relativistic neutral pion $W_{(o),d=1}$ and a probability that 1-y is composed of H^o and $W_{(+),d=1}$. From the Heisenberg uncertainty principle follows that the probabilities y and 1-y, which are associated with the lifetimes of protons in the above-mentioned states, are inversely proportional to the relativistic masses of the W pions

$$y = m_{pion(+-)}/(m_{pion(+-)} + m_{pion(o)}) = 0.5083856, \quad (9)$$

$$1 - y = m_{pion(o)}/(m_{pion(+-)} + m_{pion(o)}) = 0.4916144. \quad (10)$$

There is a probability that the x neutron is composed of H^+ and $W_{(-),d=1}$ and a probability that 1-x is composed of H^o, resting neutral pion and Z^o. The mass of the last particle is $m_{Z(o)}=m_{W(o),d=1}-m_{pion(o)}$. The probabilities are as follows

$$x = m_{pion(o)}/m_{W(-),d=1} = 0.6255371, \quad (11)$$

$$1 - x = 0.3744629. \quad (12)$$

2. Calculations

The relative magnetic moments are equal to the ratio of the mass of proton to mass of a charged component. For the charged core of baryons H^+ (mass is 727.44 MeV [1]) we obtain

X = 938.27/727.44 = +1.28983.

For $W_{(+-),d=1}$ (mass is 215.760 MeV [1]) is

Y = 938.27/215.760 = ±4.34868.

For $W_{(-),k=0,d=2}$ (mass is 181.704 MeV [1]) is

Z_1 = 938.27/181.704 = –5.16374.

For $W_{(-),k=1,d=2}$ (mass is 181.704 + 1·25.213 = 206.917 MeV) is

Z_2 = 938.27/206.917 = –4.53453.

For $W_{(-),k=2,d=2}$ (mass is 181.704 + 3·25.213 = 257.343 MeV) is

Z_3 = 938.27/257.343 = –3.64600.

For $W_{(-),k=3,d=2}$ (mass is 181.704 + 7·25.213 = 358.195 MeV) is

Z_4 = 938.27/358.195 = –2.61944.

Composition of the hyperon Λ is

$\Lambda = n + W_{(o),k=0,d=2} = H^+ + W_{(-),d=1} + W_{(o),k=0,d=2}$ or

$H^o + W_{(o),d=1} + W_{(o),k=0,d=2}$ or

$(H^o + e^+\nu_e) + (W_{(o),d=1} + e^-\nu_{e,anti}) + W_{(o),k=0,d=2}$.

The electric charges of the leptons are outside the hyperons so only the first composition gives contribution to the relative magnetic moment and it is the relative magnetic moment of neutron. Assume that probabilities for the all three compositions are the same so the relative magnetic moment R_Λ is

$R_\Lambda = R_{neutron}/3 \approx -0.64$.

In the third state of the hyperon Λ, the sum of the masses of H^o and $e^+\nu_e$ is equal to the mass of H^+ whereas of $W_{(o),d=1}$ and $e^-\nu_{e,anti}$ is equal to the mass of $W_{(-),d=1}$.

Composition of the hyperon Σ^+ that gives a contribution to the relative magnetic moment is

$\Sigma^+ = H^+ + W_{(o),d=1} + W_{(o),k=2,d=2}$ or

$H^o + W_{(o),d=1} + W_{(+),k=2,d=2}$

so the relative magnetic moment $R_{\Sigma(+)}$ is

$R_{\Sigma(+)} = yX + (1 - y)(-Z_3) = +2.4482$.

Composition of the hyperon Σ^o is similar to hyperon Λ but instead the $W_{(o),k=0,d=2}$ there is the $W_{(o),k=2,d=2}$. This difference does not change the relative magnetic moment so the relative magnetic moment $R_{\Sigma(o)}$ is

$R_{\Sigma(o)} = R_\Lambda \approx -0.64$.

Composition of the hyperon Σ^- that gives a contribution to the relative magnetic moment is (it is the only one possible charged state so the probability is 1)

$\Sigma^- = H^+ + (W_{(o),d=1} + e^-\nu_{e,anti}) + W_{(-),k=2,d=2}$ or

$H^+ + W_{(o),d=1} + e^-\nu_{e,anti} + W_{(-),k=2,d=2}$.

When there are two negatively charged W particles then the closer one to the core of baryon decays into the neutral W particle and the pair $e\nu_e$. We can see that the relative magnetic moment $R_{\Sigma(-)}$ is

$R_{\Sigma(-)} = F(X + Z_3) = –1.1781$.

The mass of the $e^-\nu_{e,anti}$ in the second mass state of the hyperon Σ^-, written without the brackets, is 0.511 MeV.

There are the two states of neutron, the charged and uncharged. The uncharged state does not give a contribution to the mean relative magnetic moment (it is the mean magnetic moment in the nuclear magneton). Assume that probabilities of these two states for hyperons are the same so there appears the factor F = 1/2. Contributions to the relative total magnetic moments are only from the charged constituents. From formula (11) follows that when there is the relativistic charged pion $W_{(-),d}$ then the probability is x whereas for the $W_{(-),d}$ interacting with the vector boson E_W is 1 - x (for greater mass probability is lower; 1 - x < x).

Composition of the hyperon Ξ^o that gives a contribution to the relative magnetic moment is

$\Xi^o = H^+ + W_{(o),d=1} + W_{(-),k=0,d=2} + W_{(o),k=1,d=2}$

so the relative magnetic moment $R_{\Xi(o)}$ is

$R_{\Xi(o)} = Fx(X + Z_1) = –1.2116$.

Composition of the hyperon Ξ^- that gives a contribution to the relative magnetic moment is

$\Xi^- = H^+ + W_{(o),d=1} + e^-\nu_{e,anti} + W_{(o),k=0,d=2} + W_{(-),k=1,d=2}$

so the relative magnetic moment $R_{\Xi(-)}$ is

$R_{\Xi(-)} = F(1 – x)(X + Z_2) = –0.6075$.

Composition of the hyperon Ω^- that gives a contribution to the relative magnetic moment is

$\Omega^- = \Xi^o + W_{(-),k=3,d=2}$

so the relative magnetic moment $R_{\Omega(-)}$ is

$R_{\Omega(-)} = Fx(X + Z_1 + Z_4) = –2.0309$.

3. Summary

Here within the lacking part of ultimate theory, i.e. the Everlasting Theory, I calculated the magnetic moments of hyperons. The theoretical results overlap with experimental data or are very close to them.

Table 1 *Relative magnetic moments*

Nucleon or Hyperon	**Relative magnetic moment PDG [2]**	**Relative magnetic moment Everlasting Theory**
Proton p	+2.792847356(23)	+2.79360 [1]
Neutron n	–1.9130427(5)	–1.91343 [1]
Hyperon Λ	–0.613 ± 0.004	–0.64
Hyperon Σ^+	+2.458 ± 0.010	+2.4482
Hyperon Σ^o	?	–0.64
Hyperon Σ^-	–1.160 ± 0.025	–1.18
Hyperon Ξ^o	–1.250 ± 0.014	–1.21
Hyperon Ξ^-	–0.6507 ± 0.0025	–0.61
Hyperon Ω^-	–2.02 ± 0.05	–2.03

On base of the relative magnetic moments of hyperons we can calculate the rigorous masses. The obtained results are very good as well and are collected in Table 2.

Table 1 *Rigorous mass of hyperons*

Particle	**Experimental mass PDG [2]**	**Rigorous theoretical mass Everlasting Theory**
Hyperon Λ	1115.683 ± 0.006	1115.649 MeV
Hyperon Σ^+	1189.37 ± 0.07	1189.069 MeV
Hyperon Σ^o	1192.642 ± 0.024	1191.288 MeV
Hyperon Σ^-	1197.449 ± 0.030	1197.240 MeV
Hyperon Ξ^o	1314.86 ± 0.20	1314.380 MeV
Hyperon Ξ^-	1321.71 ± 0.07	1320.936 MeV
Hyperon Ω^-	1672.45 ± 0.29	1672.856 MeV

References

[1] S. Kornowski (3 December 2012). “The Everlasting Theory and Special Number Theory”.
http://www.rxiv.org/abs/1203.0021 [v2].
[2] K. Nakamura *et al.* (Particle Data Group), J. Phys. G **37**, 075021 (2010) and 2011 partial update for the 2012 edition.