The Reformulated Asymptotic Freedom

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Abstract: Within the Everlasting Theory I calculated the running coupling for the strong interactions applying three different methods. They lead to the same or very close theoretical results. At very high energy there appears asymptote for 0.1139. When we add to the strong running coupling calculated within the Everlasting Theory the correction that follows from the weak interactions associated with the parton-shower production then we obtain theoretical results consistent with experimental data for the “strong” interactions. The difference between the Standard Model and the Everlasting Theory follows from the fact that within the Standard Model it is very difficult to describe correctly the parton-shower production. The asymptotic freedom described within the QCD is consistent with experimental data only because within this theory the weak interactions associated with the parton-shower production are not extracted from the strong interactions.

1. Introduction

Many experimental results lead to conclusion that inside baryons is a core. The Everlasting Theory [1] shows that due to the phase transitions of the modified Higgs field there appear the torus and ball in its centre both composed of the Einstein spacetime components. The torus is the black hole in respect of the strong interactions whereas the ball is the black hole in respect of the weak interactions.

Define energy of collision per nucleon as $E_N[\mathrm{GeV}] = nm_N = m_N/\beta$ i.e. $\beta = m_N/E_N$, where $m_N = 0.939$ GeV. Then, the two formulae derived in the Everlasting Theory [1] for the upper and lower limits for the running coupling for the strong-weak interactions we can rewrite as follows:

$$\alpha_{sw} = \alpha_{sw,\text{central-value}} \pm \Delta\alpha_{sw}\ , \tag{1}$$

$$\alpha_{sw} = \{\alpha_{w(proton)}\beta^2 + b\beta + c\} \pm (b - b_l)\beta, \tag{2}$$

$\alpha_{w(proton)} = 0.0187229$,
$b = 0.36255$,
$c = 0.1139$,
$b - b_l = 0.04415$.

We can see that at very high energy there is asymptote $\alpha_{sw} = c = 0.1139$. The formula (2) follows from the internal structure of the core of baryons (the torus + ball), the law of conservation of spin and the uncertainty principle.

For $E_N \rightarrow \infty$ is $\alpha_{sw} = 0.1139$, for $E_N = 2.76$ GeV is 0.1140, for 91.19 GeV is 0.1176 ± 0.0005, for 20 GeV is 0.1309 ± 0.0021, for 10 GeV is 0.1481 ± 0.0041, for 5 GeV is 0.1827 ± 0.0083, for 2 GeV is 0.2882 ± 0.0207 and for 1 GeV is 0.4708 ± 0.0415.

The running coupling in 1-, 2-, 3- and 4-loop approximation for QCD scale $\Lambda = 0.22$ GeV and $\alpha_s(M_Z) = 0.119$ is for $E_N = 2.76$ GeV in approximation 0.08 [2]. This value differs very much from the result obtained from formula (2) i.e. 0.114. We can use this significant difference to test the Everlasting Theory.

2. Calculations

On surface of the torus inside the core of baryons appear the gluon balls. Their energy M[GeV] we can calculate from formulae (214)-(216) presented here [1]. We can rewrite these formulae as follows

$$M[\mathrm{GeV}] = (C/E_N[\mathrm{GeV}] + D)^{10}, \tag{3}$$

$C = 0.52294$,
$D = 0.96868$.

Calculate following derivative $\partial M/\partial E_N$:

$$\partial M/\partial E_N = -10C(C/E_N + D)^9/E_N^2, \tag{4}$$

For $C/E_N << D$ i.e. for $E_N >> C/D = 0.54$, we obtain

$$\partial M/\partial E_N = -F/E_N^2, \tag{5}$$

$F = 3.927$.

The value F is for the strongly interacting torus which mass is $X = 318.3$ MeV [1]. This torus produces gluons which energy m_g is the one fourth of the mass of the bound neutral pion (134.9661 MeV) [1]. The change of the X onto m_g changes the value of the F: $F' = Fm_g/X \approx 0.42$. So, we can rewrite the formula (5) as follows

$$\partial M/\partial E_N = -F'/E_N^2, \tag{6}$$

$F' = 0.42$.

Integrate the equation (6). There appears the integration constant H which we can interpret as the ratio of the mass of the torus X to the mass of nucleon m_N : $H = X/m_N$. We obtain

$$M = F'/E_N + H, \tag{7}$$

$H = 0.339$.

We can define running coupling α_{sw} as follows $\alpha_{sw} = M^2$. It leads to following formula

$$\alpha_{sw} = (F'/E_N + H)^2, \tag{8}$$

For $E_N \rightarrow \infty$ is $\alpha_{sw} = 0.115$, for $E_N = 2.76$ GeV is 0.115, for 91.19 GeV is 0.118, for 20 GeV is 0.13, for 10 GeV is 0.15, for 5 GeV is 0.18, for 2 GeV is 0.30 and for 1 GeV is 0.58. We can see that only for 1 GeV the obtained result from formula (8) is not close to the central value obtained from formula (2).

The formula (8) we can derive in different way. The gluon balls produced from the energy of collision of a nucleon look similarly to the ball in the centre of torus. Due to the confinement [1], the all gluon balls have the same radius as the ball in centre of torus. When energy of a gluon ball increases then increases the rotational energy of the carriers of the gluons the ball consists of. This energy does not increase mass density of the ball so it still is the black hole in respect of the weak interactions. For a rotating gluon ball is E_b v r = const. i.e. $E_b \sim 1/v$, where v is the spin speed of the rotating components of the Einstein spacetime i.e. of the carriers of gluons. The relative mass R_{sw} responsible for asymptotic freedom, we can separate into two parts. The first part concerns the strong interactions of the torus that is the black hole in respect of the strong interactions. The R_strong should be R_strong = X/m_N, where X = 0.3183 GeV is the rest mass of the torus. The second part concerns the weak interactions of the created gluon balls. They are the black holes in respect of the weak interactions. Due to the relation $E_b \sim 1/v$, the intensity of weak interactions of the gluon balls decreases when energy increases. It leads to conclusion that the second part R_weak should be R_weak = Y/E_N, where Y = 0.4241 GeV is the rest mass of the ball in centre of the torus.

The above description leads to following formula

$$R_{sw} = R\_weak + R\_strong = Y/E_N + X/m_N. \tag{9}$$

Similar as previously we can define the running coupling as R^2 so we obtain

$$\alpha_{sw} = (Y/E_N + X/m_N)^2. \tag{10}$$

This formula is correct for $E_N >> E_o = Ym_N/X = 1.25$ GeV. Due to the quadrupole symmetry for the weak interactions, the lower limit for the E_N should be $4E_o = 5$ GeV and such value is in the old asymptotic freedom.

3. Comparison of theoretical results with experimental data

Within the Standard Model the parton shower (PS) is not good understood so the phenomena associated with the PS can change the experimental data concerning the running coupling for the strong interactions.

In the Everlasting Theory, PS is produced due to the weak decays of condensates composed of the carriers of gluons and photons i.e. of the Einstein-spacetime components [1]. Partons are the Einstein-spacetime components and each parton has three internal helicities [1]. The internal structure of partons is important in the strong fields whereas is not important in electromagnetic fields. It is because the strong fields have internal helicity whereas electromagnetic have not [1]. It leads to conclusion that there are 8 types of gluons and only one of photons [1]. We can see also that on the edge of the strong fields the gluons transform into photons [1]. It causes that photon emission is so similar to gluon emission.

In the collisions of nucleons there are produced the Z bosons and their weak decays into parton shower weakens the weak interactions of the colliding nucleons. It is due to the holes produced in the Einstein spacetime in the places of decays of the Z bosons. Energy E of a condensate composed of weakly interacting partons is directly proportional to volume i.e. $E \sim r^3$, where r is the radius of the condensate. On the other hand, the coupling constant for weak interactions is directly proportional to the radius of a condensate $\alpha_{W,proton,Z\text{-}production} \sim r$ ([1] – see formula (54)). Since for E = 0 is $\alpha_{W,proton,Z\text{-}production} = \alpha_{W,proton} = 0.018723$ [1] whereas for E = M_Z = 91.2 GeV is $\alpha_{W,proton,Z\text{-}production} = 0$ so we obtain following formula

$$\alpha_{W,proton,Z\text{-}production} = \alpha_{W,proton}[1 - (E/M_Z)^{1/3}]. \tag{11}$$

We can assume that the phenomena leading to the parton-shower production that lead to formula (11) are not eliminated in the Standard Model from the phenomena responsible for the strong interactions. It follows from the fact that such phenomena are not good understood within the Standard Model so generally they are neglected.

It leads to following formula that ties the experimental data for the "strong" running coupling $\alpha_{S,experiment}$ (in reality, it is the sum of coupling constants for strong and weak interactions) with the real strong running coupling α_{sw} described in this paper by formula (2)

$$\alpha_{ET} = \alpha_{S,experiment} = \alpha_{sw} + \alpha_{W,proton}[1 - (E/M_Z)^{1/3}]. \qquad (12)$$

Calculate a few results that follow from formula (12) – they are collected in Table 1. We can see that they are consistent with experimental data [5]. The "strong" coupling $\alpha_{ET}(E=Q)$ is a function of the momentum transfer Q [GeV].

Table 1

Q [GeV]	**$\alpha_{ET}(E=Q)$**
2,000	0.080
1,000	0.091
91.2	0.1176 ± 0.0005
50	0.1241 ± 0.0008
20	0.1316 ± 0.0021
10	0.1579 ± 0.0041
5	0.1943 ± 0.0083
1	0.4854 ± 0.0415

4. Summary

I described the "asymptotic freedom" applying three different methods. They lead to the same or very close theoretical results. When we add to the strong running coupling calculated within the Everlasting Theory the correction that follows from the weak interactions associated with the parton-shower production then we obtain theoretical results consistent with experimental data. The difference between the Standard Model and the Everlasting Theory follows from the fact that within the Standard Model it is very difficult to describe correctly the parton-shower production.

The asymptotic freedom described within the old QCD [3], [4] is consistent with experimental data only because within this theory we do not eliminate the weak interactions associated with the parton-shower production from the strong interactions.

The experimental results indirectly lead to the core of baryons composed of the torus and ball in its centre. Within the Everlasting Theory I derived the internal structure of the core of baryons on base of the phase transitions of the modified Higgs field which I refer to as the Newtonian spacetime as well. This spacetime consists of internally structureless tachyons that carry the inertial mass only. The modified Higgs field is the gravitationally massless field. The mean spin of the tachyons is in approximation 10^{67} times lower than the reduced Planck constant.

References

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