the general science journal

On the origin of fine structure constant and its derived expression in the BSM- Supergravitation Unified Theory

Stoyan Sarg Sargoytchev
World Institute for Scientific Exploration

Abstract: The fine structure constant appears in several fields of physics and its value is experimentally obtained with a high accuracy. Its physical origin however is unsolved long-standing problem. Richard Feynman expressed the idea that it could be similar to the natural irrational numbers, π, and *e*. Amongst the proposed theoretical expressions with values closer to the experimental one is the formula of I. Gorelik which is based on rotating dipole with two empirically suggested coefficients, while the physical origin is unknown. BSM-Supergravitation Unified Theory suggests a physical mechanism defining the fine structure constant. The mathematical expression is based on a spatial precession mode of vibrations in a tetrahedron of spheres with specific properties. The value from the derived expression differs from the CODATA 98 value by 0.000008% only. The conclusion is that the fine structure constant is a natural irrational number. While the irrational number π, is defined in a 2D space, the fine structure constant is related to a vibration property of a specific formation in a 3D space.

Keywords: *fine structure constant, spatially precessing dipole momentum, BSM-SG theory*

1. Introduction

The fine structure constant is one of the most fundamental physical constants. It appears in many physical phenomena in different fields, such as the particle physics, the Quantum Mechanics, the spectroscopy and so on. The experimental value of this constant is measured with very high accuracy. Finding a theoretical derivation of the fine structure constant, however, have been one of the most difficult problems in mathematical physics and it is still unresolved (see J. G. Gilson)[1]. In one of his book Feynman writes: *There is a most profound and beautiful question associated with the observed coupling constant, e the amplitude for a real electron to emit or absorb a real photon. It is a simple number that has been experimentally determined to be close to -0.08542455. (My physicist friends won't recognize this number, because they like to remember it as the inverse of its square: about 137.03597 with about an uncertainty of about 2 in the last decimal place. It has been a mystery ever since it was discovered more than fifty years ago, and all good theoretical physicists put this number up on their wall and worry about it.) Immediately you would like to know where this number for a coupling comes from: is it related to pi or perhaps to the base of natural logarithms? Nobody knows. It's one of the greatest damn mysteries of physics: a magic number that comes to us with no understanding by man.*

If investigating the cosmological variation of the fine structure constant, one may come to the idea that the deviation of α_c from the recommended value might be a result of such effect. Extensive studies about the cosmological variation of the fine structure constant have been published by (J. Webb et al., 2001)[3], (J. Webb et al. 2003)[4], (C. Gardner, 2003)[5]. For a red shift range of $0.2 \le z \le 3.7$, the measured variation of alpha is $\Delta\alpha/\alpha = (-0.57 \pm 0.10) \times 10^{-5}$. Based on the observed negative deviation, C. Gardner[5] concludes that "α is smaller in the past". It is interesting to note that the calculated value of alpha, using the Gorelik's (I. Gorelik[2])formula appears deviated in the same direction as the cosmological one and its fractional error is two orders smaller than the cosmological variation. In fact a few empirical formulae have been suggested, but without understanding what kind of physical mechanism is behind them. One of the formulae suggested by I. Gorelik[2] given by Eq. (1), provides pretty close value to the experimentally determined one recommended by CODATA 98.

$$\alpha = \frac{n_2}{\pi}\cos(\pi/n_1)\tan(\pi/n_1 n_2) = 7.297352532\times10^{-3} \qquad (1)$$

Where: $n_1 = 137$ and $n_2 = 29$ are two selected empirical parameters.

$$\alpha = 7.297352533\times10^{-3} \qquad \text{(CODATA 98)} \qquad (2)$$

The choice of the parameter $n_1 = 137$ in formula (1) is obvious, but the choice of $n_2 = 29$ is a selection.

In fact I. Gorelik suggests a system of two simple equations (written in this way to show the separation of $1/\lambda$ into a whole and a fractional number):

$$n + k = 1/\alpha \qquad (3)$$

$$k(n+k) = \pi^2/2 \qquad (4)$$

where: *n* – is the whole number of the inverse fine structure constant, k – is the fractional part

Gorelik mentions that his formula is obtained by a rotation of an mathematical object like a spheroid with a constant step but does not provide a detailed description and discussion.

2. Physical model defining the fine structure constant based on the alternative spacetime concept of the Basic Structures of Matter – Supergravitation Unified Theory (BSM-SG)

The theory is based on an original alternative space-time concept that leads to a new vision of the micro-cosmos and Universe [7,8,9,10]. The successful relationship between the forces in Nature is unveiled by adopting the following framework: (1) Empty space without any physical properties and restrictions; (2) Two fundamental particles of superdense proto-matter with parameters associated with the Planck's scale; (3) A Fundamental law of Supergravitation (SG) with forces inverse proportional to the cube of distance in a pure empty space. An enormous abundance of these two particles, with vibrational energy beyond some critical level, can congregate into self-organized hierarchical levels of geometrical formations, governed by the fundamental SG law.

In BSM-Supergravitation unified theory the fundamental particles are two indestructible superdens balls of proto-matter (intrinsic matter). We may call them briefly primary balls. The ratio of their diameters is 2:3, while they have intrinsic matter density and stiffness that varies with the radius. This density variation permits the existence of vibrational mode and defines the intrinsic vibrational frequency of each fundamental particle. That frequency should be very high due the very small size and high density of the fundamental particles. We may expect that it is at the range of Plank's scale, where the vibration is associated with the Plank's frequency defined by the known physical constants

$$f_{PL} = \sqrt{\frac{2\pi c^5}{Gh}}$$

One important assumption that allows complex formations from both fundamental particles is that their size and intrinsic frequencies are different while vibration energies are equal. They interacts by Supergravitation forces which are inverse proportional to the cube of the distance in a pure empty space. (The Newtonian gravitation forces are inverse proportional of square of distance but in an Aether space, which is not empty). The different parameters between the two fundamental particles make their properties such that those of same proto-matter are stronger attracted than those of the different protomatter. The lowest level 3D formation of the fundamental particles of the same proto-matter is a tetrahedron, as shown in Fig. 1. (see Chapter 12 of BSM-SG).

The suggested physical concept of the fine structure constant in BSM-SG theory is similar to the mathematical model of rotating dipole suggested by I. Gorelik, while there is a well-defined 3D formation whose vibrational properties are described by a vector called the Spatial Precession Momentum (SPM).

Under SG law, the proto-matter is organized in hierarchical levels of 3D formations based on 3D geometry. Fig. 1, shows consecutive types of 3D formations at the lowest level of hierarchical order. They are denoted as Tetrahedron (TH), Quasipentagon (QP) and Quasiball (QB).

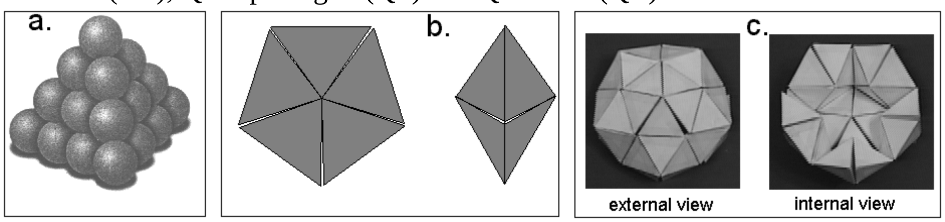

Fig. 1. Structures of lowest level. a. Primary tetrahedron (TH), b – Quasipentagon, c. – Quasiball (QB)

The Quasipentagone is formed of 5 tetrahedrons, and the Quasiball of 12 Quasipentagones. The gaps between the tetrahedrons is combined into one gap of 7.355 deg. This permits the Quasiball to be left-hand or right-hand twisted and this will be preserved in the next level of formation that are described in Chapter 12 of BSM-SG.

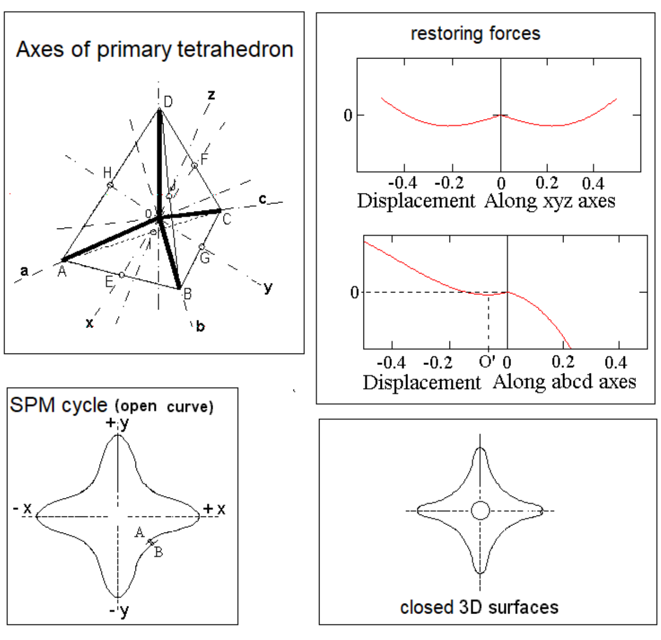

Fig. 2

In order to preserve the balance between intrinsic energy the formations of other type of fundamentally particles will be with an opposing handedness. The association of the fine structure constant with the vibrational properties of the Primary tetrahedron is presented in section 12.A.5.3 of BSM-SG theory.

Now let us consider the vibrational mode of the primary tetrahedron. It is known that the tetrahedron has two sets of axes: 4 axes denoted as *abcd* passing through apexes at angle of 109.45 deg between them and 3 orthogonal axes denoted as *xyz*. Both set of axes have a common origin O, but their mutual symmetry is different. The stiffness along *abcd* axes is larger than in *xyz* axes due to different numbers of aligned spheres. The SPM vector describes the partial deformations and restoration forces under SG law. Fig. 2 shows the restoration forces and the position of the tip of SPM vector under SG law. The different mutual symmetry of both sets of axes will cause a spatial precession of the SPM vector describing the vibrational mode. The magnitude of the SPM vector depends on the number of aligned spheres, so it is greater along the *abcd* axes and smaller along the *xyz* axes. The origin of the

SPM vector is fixed, while its tip performs a motion with a small helical step. In this process an energy momentum is involved. Figure 4 illustrates the dynamical behavior of the suggested SPM vector.

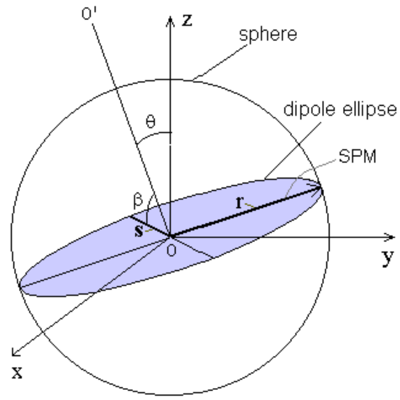

Fig. 4. Spatially precessing dipole momentum expressed by SPM vector. R – major semiaxis, s – minor semiaxis

Let suppose that the origin of the SPM vector is always fixed at the origin O of a coordinate system XYZ, while having a freedom to rotate. Due to asymmetry of restoring forces show in Fig. 3 after one cycle of rotation the tip of SPM vector will not pass through the same point but through a point closer to the previous one, so the distance between them is much smaller than the trace of the vector's tip. We may call this a *quasicycle*. After many quasicycles, however, the tip of the SPM vector will pass exactly through the same initial point. This cycle we may call a *full cycle*. Then the full cycle will contain many quasicycles, but their number may not be an integer.

It is apparent that the dipole momentum of SPM vector could be expressed by an ellipse lying in the equivalent plane. We may call it a "*dipole ellipse*". The rotational axis OO` will be perpendicular to the major semiaxis ***r*** of the dipole ellipse, but not perpendicular to the minor semiaxis. In other words the plane of the dipole ellipse will be rotating with a small pitch angle $(\pi/2-\beta)$ defined by the helical motion of the SPM vector. **Then for one quasicycle, the dipole ellipse will sweep a volume of an oblate spheroid with a magor semiaxis *r* and a minor semiaxis defined by the product:** $s\cos\beta$ **.**

In every quasicycle, the dipole ellipse will sweep the same volume, while the initial angle θ (arbitrary selected) will change with one and a same step. This angle is shown for reference only. It could be defined for any one of the orthogonal axes. The rate of θ change will define the number of completed quasicycles within one full cycle. The latter, however, may not contain an exact number of quasicycles but a whole number plus a fraction, so we have:

Full cycle = n + k

Where: *n* – is the number of completed quasicycles contained in one full cycle, *k* – is a fraction of a quasicycle

Our goal is to express the fraction parameter (k) as a function of the whole number (n) using the defined model. We will derive expression using the relation between the volume of the circumscribed sphere and the volume of the oblate spheroid.

The volume of the circumscribed sphere is: $V_{SP}=(4/3)\pi r^3$ If the full cycle contains a large number of quasicycles, then: $\cos\beta <<$ 1. We may associate this with the fractional part of $1/\alpha$, (keeping in mind the Gorelik system of equations (3) and (4)), so we may write: $\cos\beta = k$. Due to the pitch from the helical step the quasicycle will sweep a volume that we may associate with an oblate spheroid. Then, the volume of the oblate spheroid is:

$$V_{os} = (4/3)\pi r^2 s\cos\beta = V_{os} = (4/3)\pi r^3 sk \qquad (6)$$

The tip of the SPM vector is associated with the point of interception of the dipole ellipse with the major semiaxis. This means that for a full cycle of the SPM vector the volume of the oblate spheroid, swept by the rotating dipole ellipse. The oblate spheroid will sweep the total volume of the spheroid for $(n+k)$. Then the expression for the volume equality is

$$(4/3)\pi r^2 sk(n+k) = (4/3)\pi r^3 \qquad (7)$$

Using a normalized parameter $s_r = s/r$ then $s = s_r k$ and simplifying the expression (7) we arrive to:

$$s_r k(n+k) = 1 \qquad (8)$$

We may look for a possible reasonable value of the product $(s_r k)$, while trying to relate the parameter s_r with π. Knowing that (n+k) is equal to $1/\alpha$,) according to Eq. (3), we should have

$$s_r k \approx \alpha \text{ , so } s_r = \frac{\alpha}{k} \qquad (9)$$

To determine k we will use the reciprocal value $1/\alpha =$ of fine structure constant given by CODATA 98.

$$1/\alpha = 137.03599977$$

The guess is that the full cycles of the oblate spheroid is $n = 137$, while the fractional cycle is $k = 0.03599977$

Then from Eq. (9) we obtain $s_r = 0.20270553$. This value is very close to $2/\pi^2 = 0.20264237$. The difference between them is only 0.03%, so we may accept:

$$s_r = 2/\pi^2 \qquad (10)$$

The idea to relate the parameter s_r to π is reasonable if examining the more accurate formula (1), where π participates**.**

Substituting (10) in (8) we obtain a quadratic equation of k

$$k^2 + nk - \frac{\pi^2}{2} = 0 \qquad (11)$$

Only one of its roots leads to a correct expression for alpha.

$$k = -0.5[(n^2 + 2\pi^2)^{1/2} + n] \qquad (12)$$

Using the solution (12) and combining with the expression $(n+k) = 1/\alpha$ **we get the explicit theoretical expression for the fine structure constant (denoted as α_{th}).**

$$\alpha_{th} = 2/[(n^2 + 2\pi^2)^{1/2} + n] \qquad (13)$$

For n = 137 the theoretical value of α_{th} is:

$$\alpha_{th} = 7.29735194 \times 10^{-3}$$

The parameter n = 137 is also obvious from the plot of Eq. (13) shown in Fig. 3. For any other number of *n* the deviation of α_{th} from the CODATA value is significant.

The deviation of α_{th} from the CODATA 98 value is only 0.000008%.

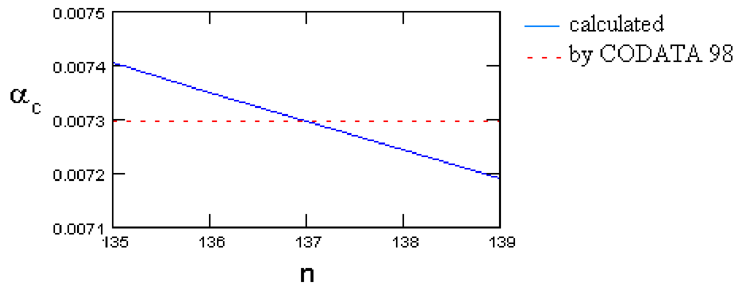

Fig. 3. Plot of Eq. (11) (blue line) and CODATA 98 value (red dashed line) vs number of full cycles

Conclusions:

(1) The theoretical derived formulae (11) of the fine structure constant provides very close value to the experimentally determined one. The small difference results from the approximation of the spatial shape of oscillation with a swiping ellipsoid.

(2) The theoretical formula of α_{th} provides a value little bit smaller than the CODATA 98 value but does not need a selection of other number than the obvious one n = 137.

The suggested method of using a spatially presesing dipole momentum (represented by a SPM vector), provides a simplified mathematical formulation of the fine structure constant. The obtained accuracy and involvement of the number π leads to the conclusion that the fine structure constant is also a natural irrational number. While π is defined in a 2D space, the fine structure constant is defined in a 3D space.

Further mathematical developments based on the proposed physical mechanism could lead to unveiling of additional parameters of the fundamental particles (stiffness, radial density. and their number in the primary tetrahedron. This is a complex mathematical task that could be eventually solved by a mathematician acquainted with the BSM-SG unified theory.

References:

1. J. G. Gilson, Fine structure constant, http://www.btinternet.com/~ugah174
2. I. Gorelik, Formula for fine structure constant, (2001) www.geocities.com/Area51/Nebula/3735/fine.html
3. J. K. Webb et al. Phys. Rev. Lett. , **87**, 091301 (2001). ArXive: Astro-ph/0012539
4. J. K. Webb et al., Does the fine structure constant vary? A third quasar absorption sample consistent with varying α , Astrophys. J. Supp. **283**, 565 (2003), arXiv: astro-ph/0210531 v1 24 Oct 2002
5. C. L. Gardner, Cosmological Variation of the Fine Structure Constant from an Ultra_Light Scalar Field: The Effect of Mass, arXiv: astro-ph/0305080 v1. 6 May 2003.
6. 14. S. Sarg, Basic Structures of Matter (first edition 2002, second edition, 2002) electronic archives, National Library of Canada
7. Stoyan Sarg, *Basic Structures of Matter – Supergravitation Unified Theory*, Trafford Publishing, Canada, 2006, ISBN 141208387-7 (www.trafford.com/06-01421), amazon.com
8. S. Sarg, New approach for building of unified theory, http://lanl.arxiv.org/abs/physics/0205052 (May 2002)
9. S. Sarg © 2001, Atlas of Atomic Nuclear Structures, monograph, http://www.nlc-bnc.ca/amicus/index-e.html (April, 2002), (AMICUS No. 27106037); Canadiana: 2002007655X; ISBN: 0973051515, LC Class: QC794.6*; Dewey: 530.14/2 2110. Stoyan Sarg
10. Stoyan Sarg, *Beyond the Visible Universe, from e new space-time concept of the Physical vacuum*, Helical-structures Press, 2004, ISBN 09730,51531
11. Books reviews in Physics in Canada / La Physique au Canada, Vol, 62, No. 4, July/August 2006