International Journal of Advanced Research in Physical Science (IJARPS)
Volume 7, Issue 8, 2020, PP 6-10
ISSN No. (Online) 2349-7882
www.arcjournals.org

The Value of the Constant of the Fine Structure in the Outer Space of the Universe

Stanislav Konstantinov*

Department of Physical Electronics, Russian State Pedagogical University named after Herzen, St. Petersburg, Russia

Corresponding Author:** ***Stanislav Konstantinov, *Department of Physical Electronics, Russian State Pedagogical University named after Herzen, St. Petersburg, Russia .*

Abstract: *The article identifies the factors influencing the value of the fine structure of the baryonic and dark matter of the Universe in the process of its evolution. These include the temperature, pressure and polarization of dark matter under the influence of the fifth interaction in the direction (l, b) ~ (303º, - 27º).*

Keywords: *baryonic matter; dark matter; polarization; constants of fine structure; fifth fundamental interaction.*

PACS: *01.10.Fv, 04.50.-h, 12.10.Kt, 95.36.+x, 98.80.-k*

1. INTRODUCTION

The concept of fine structure was introduced into physics in the 20s of the 20th century by Arnold Sommerfeld to describe the energy sublevels discovered experimentally in the emission spectra of atoms. Since then, many other manifestations of the same constant relationship have been revealed in various phenomena associated with the interactions of elementary particles. In quantum electrodynamics, the fine structure constant is a measure of electromagnetism - one of the four fundamental forces in nature (others are gravity, weak nuclear force, and powerful nuclear force). Electromagnetic force holds electrons moving around the nucleus in the atom of the universe, otherwise all matter would be scattered into pieces. Until recently, it was believed that this is an invariable force in time and space. Currently, in quantum electrodynamics, the following value of the fine structure of elementary particles has been experimentally obtained:

$\alpha = 7.2973525376\ (50) \times 10^{-3} = 1 / 137.035999679$

$$\alpha = \frac{e^2}{\hbar c\ 4\pi\varepsilon_0} = \frac{e^2}{2\varepsilon_0 hc} \qquad (1)$$

Where e is the elementary electric charge,

$\hbar = h / 2\pi$ is the Dirac constant (or the reduced Planck constant),

c is the speed of light in vacuum,

ε_0 is the dielectric constant.

Until recently, it was believed that (α) this is an invariable magnitude in time and space. However, in an article published on April 27, 2020 in the journal Science Advances, scientists at the University of South Wales in Sydney reported that four new measurements of light emitted by a quasar 13 billion light-years from Earth confirm past research by Professor John Webb that found variations in the values of the fine structure (Figure: 1) [1, 2].

Figure1. *The light emitted by the quasar J1120 + 0641, 13 billion light years from Earth.*

Not only do universal constants appear to scientists to be variables at the outer edges of the cosmic universe, anomalies also only occur in one direction, which looks odd. Astrophysicists today continue to find hints that one of the cosmological constants, the fine structure, is not all that constant after all. Professor Webb stated: "We found a hint that this constant fine structure number was different in certain regions of the universe. Not only as a function of time, but actually in the direction of the universe, which is really strange if right. In the current study, a group of scientists studied the quasar, which allowed them to return to a time when the universe was only a billion years old, which has never happened before. Thus, the Universe cannot be isotropic from the point of view of the laws of physics, that is, it is statistically different in all directions. In fact, it may contain some directions or preferred directions in which the laws of physics change, but not in the perpendicular direction. In other words, the Universe in a sense has a dipole structure. "[1, 2]. A strong anisotropy of cosmological parameters was found at a level of ~5σ in the direction (l, b) ~ (303º, - 27º), which is in good agreement with the data of other cosmological probes [3].

In an earlier the article "Fundamental experiments on the detection of the anisotropy of physical space and their possible interpretation" 2015 Dr. Yu.A. Baurov, Yu.G. Sobolev, F. Meneguzzo presented a new interpretation of the global anisotropy of physical space of the Universe [4]. It is radically different from that in the standard cosmological model ΛCDM (Λ- Cold Dark Matter), the inflationary theory of anisotropy. In space anisotropy, Dr. Yu.Baurov exposed the cosmological vector potential - a new force of nature (fifth force), generated by the interaction of elementary particles of matter with dark matter [4]. In 2015, Dr. Attila Krasnahorkai and his colleagues at the Institute for Nuclear Research of the Hungarian Academy of Sciences (Debrecen) published an article in which they concluded that they had discovered the fifth interaction [5]. In 2019, Attila Kraznahorsky in new experiments with helium confirmed the discovery of the fifth interaction [6]. This experiment of the Hungarian researcher Dr. Attila Kraznahorsky interested Professor John Webb as a possible reason for the anisotropy of the value of the fine structure in a strictly defined direction of motion in the Universe (l, b) ~ (303º, −27º). A group of theoretical physicists led by Jonathan Fan from the University of California (Irvine, USA) decided to check the results of their Hungarian colleagues. Professor Yonotan Feng carefully studied the work of Dr. Attila Kraznahorsky and stated that the fifth interaction does not violate any laws of nature. The new scalar field may belong to a hypothetical dark matter particle - the protophobic X-boson, which, like the Higgs boson, creates a scalar field responsible for the fifth interaction between dark matter and ordinary (baryonic) matter. Dr. Jonathan Fehn of the University of California, Irvine, in a 2017 press release, said: "For decades, we have known about four fundamental forces: gravity, electromagnetism, and strong and weak nuclear forces. The discovery of a possible fifth force will completely change our understanding of the Universe, which will entail the unification of the fifth force and dark matter."[7]. In the light of the above, we can conclude that the value of the fine structure constant can depend on many factors. Below we will consider what exactly can influence the size of the fine structure.

2. Dependence of the Magnitude of the Fine Structure on Temperature during ihe Evolution of the Universe.

When the vacuum is polarized and transformed into a substance, the change in the vacuum energy w can be represented as a sum [8]:

$w = w^p + w^e$ (2)

where w^p is the vacuum polarization, $w^p << E^2 / 8\pi$; (3)

w^e is the change in the energy of the substance at the production of particles

$w^e = eET\varkappa, \quad \varkappa = \frac{e^2E^2T}{4\pi^3}\exp(-\pi\frac{m^2}{\hbar E})$ (4)

The creation of particles is the main reason for the change in the energy of the vacuum. The small value of the reverse reaction w^p implies the limitation on the electric field E strength for the given time T ($\mathbf{E}s \approx 10^{16}$ [V × cm^{-1}] is the critical Schwinger's field) [9]. For an electromagnetic field, the polarization energy density of quantum vacuum can also be represented as the sum of two terms (2). Where is the first term w^p (w_0) quadratic in the electric and magnetic fields:

$$w_0 = \frac{\left(\mathbf{E}^2 + \mathbf{H}^2\right)}{8\pi} \quad (5)$$

determines the energy of a non-interacting electromagnetic field before critical values electric strengths Schwinger's field **E**s = 1.32 × 10^{16}[V × cm^{-1}] and magnetic field strength **H** = 10^{16} [Gs]. The second term w^e (w_1) describes the interaction of photons due to the production of electron-positron pairs [10]:

$$w_I = 2D\left[3\mathbf{E}^2\mathbf{E}^2 - \mathbf{H}^2\mathbf{H}^2 - \left(\mathbf{E}^2\mathbf{H}^2 + \mathbf{H}^2\mathbf{E}^2\right)\right] + 7D\left[\left(\mathbf{EH}\right)^2 + \left(\mathbf{HE}\right)^2\right] \quad (6)$$

The constant D can be calculated by the methods of quantum electrodynamics [10] and in Gaussian units

$$D \equiv \eta \frac{\hbar^3}{m^4c^5} \quad (7)$$

Where η is the dimensionless coefficient $\eta \equiv \frac{\alpha^2}{45\times(4\pi)^2} \approx 7.5 \times 10^{-9}$ (8)

α is the fine structure constant (1),

m is the mass of the electron,

c is speed of light.

It is convenient D to write the coefficient through the Compton wavelength of the electron $\lambda\!\!\!^{-} = \hbar/mc$ in the form [10]:

$$D = \eta \frac{\lambda\!\!\!^{-3}}{mc^2} \quad (9)$$

Experiments show that if an external field acts on the vacuum, then due to its energy, the production of real particles is possible [10]. Precisely because the vacuum is not virtual, but a real physical object (dark matter) and has a structure, the polarization of the vacuum leads not to virtual, but real radiation corrections to the laws of quantum electrodynamics [11]. The interaction of the electromagnetic field with the vacuum (dark matter) leads to a dependence of the speed of light propagation on the radiation temperature. Estimates show that in the modern era, even at very high temperatures, such as those that exist in the bowels of stars, the temperature-dependent correction to the speed of light is extremely small [10]:

$$\Delta\tilde{c} = \tilde{c} - c_0 \approx 10^{-5}\, cm/s \quad (10)$$

Where Δc is temperature-dependent correction to the speed of light,

c is speed of light in the interior of a star,

c_0 is speed of light in space vacuum.

However, in the cosmological model of the hot Universe, in the first moments after the Big Bang, the temperature was so high that the speed of light was many orders of magnitude higher than the modern one. The effect of the dependence of the speed of light on temperature should be essential for understanding the early evolution of the Universe. As a result, the Dr. Yuri Poluektov obtained a dependence for the fine structure constant, recorded through the observed speed of light [10]:

$$\alpha_0 \equiv \frac{e^2}{\hbar\tilde{c}_0} \quad (11)$$

With the expansion of the Universe and its cooling, the speed of light decreased and in our era reached its value, almost equal to the speed of light at zero temperature. At Planck's temperature, Tp ≈1.42×10^{32}[K] ≈ 10^{19}[GeV] the speed of light $\tilde{c}_p$ would be much higher than the modern one:

$$\tilde{c}_p/\tilde{c}_0 \approx 0.8\cdot10^{17} \quad (12)$$

Dr. Yu. Poluektov in table 1 presented how the speed of light changed as the Universe cools in the first moments after the Big Bang [10].

Table 1

t, s	$T,\ GeV$	T, K	$\tau = T/T_0$	n, cm^{-3}	$\tilde{c}/\tilde{c}_0$
$5.4\cdot10^{-44}$	$1.2\cdot10^{19}$	$1.42\cdot10^{32}$	$4.9\cdot10^{22}$	$1.3\cdot10^{47}$	$0.8\cdot10^{17}$

10^{-39}	10^{16}	10^{29}	$3.5\cdot10^{19}$	$1.6\cdot10^{45}$	$2.3\cdot10^{14}$
10^{-11}	100	10^{15}	$3.5\cdot10^{5}$	$6.5\cdot10^{36}$	$1.5\cdot10^{3}$
10^{-5}	0.2	$2\cdot10^{12}$	$6.9\cdot10^{2}$	$1.4\cdot10^{35}$	10
10^{-2}	10^{-2}	$2\cdot10^{11}$	69	$2.5\cdot10^{34}$	1.9
1.5	$0.7\cdot10^{-3}$	$0.8\cdot10^{10}$	2.8	$4.9\cdot10^{30}$	1.00003

The reason for the large effect immediately after the birth of the universe during weak photon-photon interaction, as can be seen from the penultimate column of the table, is the extremely high density of photons at such temperatures [10].

3. Dependence of the Fine Structure Value on Pressure During Polarization of Quantum Vacuum (Dark Matter) in the Nucleus of a Hydrogen Atom and Neutron Stars

The CMS collaboration in experiments at the Large Hadron Collider in 2019 studied the distribution of reaction products in pp collisions with energies from 1 TeV to 13 TeV. It was found that a decrease in the mass of elementary particles obtained from data up to an energy of 13 TeV, as well as a decrease in the value of the interaction constants at a confidence level of 95% depend on the energy at which the measurements were made. This effect, explained by the polarization of the vacuum, was actually observed in experiments, in particular, a decrease in the mass of b- and c-quarks, as well as a changing in the strong interaction constant, were measured [12]. The vacuum polarization effect leads to charge screening at low energies. With increasing energy, fine structure magnitude (α) changing logarithmically:

$$\alpha(E) = \frac{\alpha_0}{1-\Delta\alpha(E)} \quad (13)$$

Where E is the electric field strength,

Δ α is the incremental value is calculated as part of QCD

In 2018. Professor Volker Burkert carried out a series of experiments at the CEBAF accelerator. After the collision of fast electrons with the mass of liquid hydrogen (the source of protons), the researchers registered the particles arising from their interaction - an electron, a proton and two photons. This allowed for the first time to measure the pressure at the center of the proton, bombarding the proton with electrons, the energy of which reached 100 MeV or more, which allowed the electron to penetrate into the structure of the proton (Figure 2) [13].

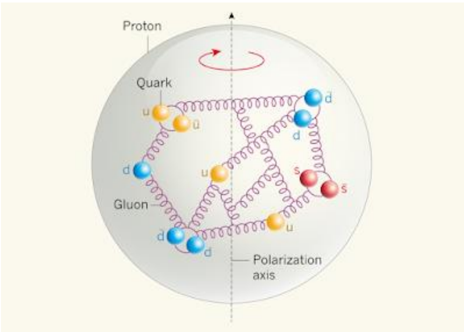

Figure2. *The structure of the proton, quarks and gluons*

Volker Berkert and his colleagues from Jefferson's laboratory found that the pressure in a proton can exceed 10^{35} Pascal [13]. It is known that at such a pressure polarization of the quantum vacuum is observed and, in accordance with formula (13), changing in the value of the fine structure constant.

Professor A.V. Rykov RAS, Institute of Physics of the Earth, relying on his theory of vacuum, as well as the energy of polarization of the vacuum and its electromagnetic parameters (ε_0, μ_0), calculated the value of the fine structure of the near-Earth quantum vacuum (dark matter) and intranuclear quantum vacuum. According to him, the fine structure of the near-Earth quantum vacuum α_e = 0.0072975 or (1/137) and the fine structure inside the hydrogen nucleus α_x = 0.00318157 (1/314) determine electromagnetism in the first case, and nuclear forces in the second case [14].The Professor A.V. Rykov determined the elastic deformation force in near-Earth quantum vacuum $F=1.155 \times10^{19}$ [kg / s^2] and inside the proton nucleus $F=5.211\times10^{26}$ [kg / s^2]. Thus, the elasticity of quantum vacuum inside the nucleus is 7 orders of magnitude higher than that of near-Earth quantum vacuum (dark matter) [14].

In an article by astrophysicists from Finland, published on June 1, 2020, it is said that “the matter inside the most massive stable neutron stars is interpreted as evidence of the presence of quark matter nuclei, in which the speed of sound almost reaches the speed of light” [15]. It is believed that a form of this strange substance, called quark-gluon plasma, filled the newborn universe about 20 microseconds after the Big Bang. It behaved like an extremely hot liquid, which then cooled to the state of "ordinary" matter that fills the universe today. Currently, the only place in the universe where quark matter can still be found is at the epicenter of particle collisions at the Large Hadron Collider and possibly the heart of a neutron star. It is in neutron stars that nuclear forces determine the value of the fine structure equal to $\alpha_x = 0.00318157$ (1/314). Moreover, the force holding quarks in the neutron star’s core is $F = 5.211 \times 10^{26}$ [kg / s²].

4. Conclusion

Thus, the meaning of the fine structure is determined by five fundamental interactions: electromagnetic, gravitational, strong and weak nuclear interactions and the fifth interaction between baryonic matter and quantum vacuum (dark matter) and their derivatives: temperature and pressure.

References

[1] Wilczynska M. R. et al. “Four direct measurements of the fine structure constant 13 billion years ago”, Science Advances, (2020),DOI: 10.1126 / sciadv.aay9672

[2] Lachlan Gilbert, “New findings suggest laws of nature 'downright weird,' not as constant as previously thought”, University of New South Wales, (April 27, 2020)

[3] Migkas, K. et al., “Probing cosmic isotropy with a new X-ray galaxy cluster sample through the LX−T scaling relation” Journal reference:A&A 636, A15, (April 2020) Press releases from NASA/Chandra, ESA, Uni. of Bonn. DOI:10.1051/0004-6361/201936602

[4] Baurov Yu.A. and Sobolev Yu.G. and Meneguzzo F. “Fundamental Experiments for Revealing Physical Space Anisotropy and Their Possible Interpretation”, Bulletin of the Russian Academy of Sciences: Physics, Vol.79, No.7, pp.935-939 (2015) DOI: 10.3103/S1062873815040048

[5] Krasznahorkay Attila et al., “Observation of Anomalous Internal Pair Creation in ^{8}Be: A Possible Signature of a Light, Neutral Boson”, Phys. Rev. Lett., 116, 042501, (2016)

[6] Physics news on the Internet, “Particle X17”, Physics–Uspekhi, 63 (1), p.112 (2020)

[7] Feng Jonathan L., “Protophobic Fifth Force Interpretation of the Observed Anomaly in ^{8}Be Nuclear Transitions”, arXiv: 1604.07411v2 [hep-ph], (15 Aug. 2016)

[8] Adornov T.K., et al., “Peculiarities of the production of particle pairs in a peak electric field”, Russian Physics Journal, Vol. 60, N3, (2017)

[9] Gitman D.M. and Gavrilov S.P., “Description of processes in strong external fields within the framework of quantum field theory”, Russian Physics Journal, Vol. 59, N11, (2016).

[10] Poluektov Yu.M., “On the dependence of the equilibrium light speed on the temperature”, National Science Center “Kharkov Institute of Physics and Technology”, (2019), PACS numbers: 05.10.-a, 05.30.-d, 11.10.Wx, 12.20.-m, 14.70.Bh, 42.25.-p, 42.50.-p, 42.65.-k, 98.80.-k

[11] Konstantinov Stanislav, “Polarization of Vacuum”, Open Access Journal of Physics, Volume 2, Issue 3, pp. 15-24, (2018)

[12] Physics news, “Running mass of a τ-quark”, Physics–Uspekhi, 62 (11), p.1172, (2019), DOI: 10.3367/UFNe.2019.10.038675

[13] Burkert V.D. and Elouadrhiri L. and Girod F.X., “The pressure inside the proton” Nature, 557:396–399, (2018)

[14] A.V. Rykov, “Fundamentals of the theory of ether”, Moscow: Russian Academy of Sciences, Institute of Physics of the Earth, (2000).

[15] Eemeli Annala, and et al., “Evidence for quark-matter cores in massive neutron stars”, Nature Physics, (01 June 2020)

Citation: *Stanislav Konstantinov, (2020). The Value of the Constant of the Fine Structure in the Outer Space of the Universe. International Journal of Advanced Research in Physical Science (IJARPS) 7(8), pp. 6-10, 2020.*