RESEARCH ARTICLE

The value of the fine structure and its anisotropy in the space and time of the Universe

Stanislav Konstantinov

1Department of Physical Electronics, Herzen State Pedagogical University, Saint Petersburg RSC”Energy”, Russia

Abstract

In the article, I pointed out the factors that determine the differences in the value of the fine structure as one of the fundamental constants in the space of the late Universe and during its evolutionary development. The dependence of the fine structure on temperature and pressure, as well as the anisotropy of cosmological parameters at a level of $\sim 5\sigma$ in the direction $(l, b) \sim (303^\circ, -27^\circ)$ in the late Universe, is associated with the discovery of large structural formations of dark matter and the fifth type of interaction (fifth by force).

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

Keywords: “quantum vacuum”, “dark matter”, “baryonic matter”, “polarization”, “fine structure constants”

1 | INTRODUCTION

In a paper published APRIL 27, 2020, in Science Advances, scientists from UNSW Sydney reported that four new measurements of light emitted from a quasar 13 billion light years from Earth away reaffirm Professor John Webb past studies that found tiny variations in the fine structure (Figure 1) [1].

Not only does the universal constants seem scientist variable at the outer borders of space the Universe, anomalies also arises in only one direction, which looks strange. Today, astrophysicists continue to find hints that one of the cosmological constants- the fine structure is, after all, not so constant. A team from the University of New South Wales, the University of Technology at Swinburne and the University of Cambridge presented on a report on the detection of changes in the fine structure constants $\alpha$ for publication in the journal Physical Review Letters [2]. A preliminary version of the paper is currently under peer review. Physicists are well aware of the experimental value of the fine structure constant of

FIGURE 1: Light emitted from a quasar J1120 + 0641 in 13 billion light years from Earth
elementary particles obtained in terrestrial conditions \( \alpha = 1/137.03552 \) or \( \alpha = 0.0072973 \). John Webb says that 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 every atom of the universe - without this, all matter would be scattered into pieces. Until recently, it was believed that this is an invariable force in time and space. Over the past two decades, Professor John Webb has noticed anomalies in the fine structure constant, as a result of which the electromagnetic force measured in one particular direction of the Universe seems a little different. If you can study the light in detail from distant quasars, you’re studying the properties of the universe as it was when it was in its infancy, only a billion years old. The universe then was very, very different. No galaxies existed, the early stars had formed but there was certainly not the same population of stars that we see today and there were no planets. The Planck mission observations 2013 which show the Universe isotropic when it was only 380,000 years old are considered the gold standard of cosmology (Figure 2).

**FIGURE 2:** Cosmic microwave radiation left over from the Big Bang. The Planck's mission

“So the late universe may not be isotropic in its laws of physics—one that is the same, statistically, in all directions”, Professor Webb says. “But in fact, there could be some preferred direction in one particular direction, we can look back 12 billion light years and measure electromagnetism when the universe was very young. Putting all the data together, we found that electromagnetism seems to increase in only one direction in space.” The argument that says these results is more than just a coincidence was confirmed by a team in the United States that works completely independently and is unknown to Professor Webb. A new study using NASA X-ray data from the Chandra Observatory and ESA XMM-Newton by Professor Konstantinos Migkas of Bonn University and his colleagues showed that the expansion rate of our universe (Hubble constant) seems to vary from region to region [3]. In the article “Probing cosmic isotropy with a new X-ray galaxy cluster sample through the LX–T scaling relation” K. Migkas, G. Schellenberger, T. H. Reiprich, F. Pacaud, M. E. Ramos-Ceja, L. Lovisari (Submitted 7 Apr 2020) scientists report that strong anisotropy of cosmological parameters was detected at a level of ~5\( \sigma \) in the direction (l, b) \( \sim (303^\circ, -27^\circ) \), which is in good agreement with other cosmological probes [3]. After reviewing the research results Dr. Konstantinos Migkas, the Professor Webb writes: “And they’re not testing the laws of physics, they’re testing the properties, the X-ray properties of galaxies and clusters of galaxies and cosmological distances from Earth. Dr. Konstantinos Migkas also found that the properties of the Universe are not isotropic and there’s a preferred direction. And lo and behold, their direction coincides with ours. Observations of the red shift \( z = 7.085 \) quasar J1120+0641 are used to search for variations of the fine structure constant, \( \alpha \), over the red shift range 5:5 to 7:1. Observations at \( z = 7:1 \) probe the physics of the universe at only 0.8 billion years old. These are the most distant direct measurements of \( \alpha \) to date and the first measurements using a near-IR spectrograph. A new AI analysis method is employed. Four measurements from the X-SHOOTER spectrograph on the Very Large Telescope (VLT) constrain changes in a relative to the terrestrial value \( (\alpha_0) \). The weighted mean electromagnetic force in this location in the universe deviates from the terrestrial value by \( \Delta \alpha/\alpha = (\alpha z - \alpha_0)/\alpha_0 = (-2:18 \pm 7:27) \times 10^{-3} \), consistent with no temporal change. Combining these measurements with existing data, we find a spatial variation is preferred over a no-variation model at the 3:9\( \sigma \) level.
Thus, what was considered an arbitrary random distribution of gas clouds, black holes, galaxies, quasars and planets - the Universe suddenly seemed to have north and south.” Later professor Webb said: “We found a hint that this fine structure constant number was different in certain areas of the universe. Not only as a function of time, but also actually in the direction of the universe, is which really is strange if is it right. In the current study, a team of scientists studied the quasar, which allowed them to return to the time when the universe was only a billion years old, which had never, happened before. Thus, the Universe may not be isotropic from the point of view of the laws of physics — that is, statistically different in all directions. In fact, it may contain some directions or preferred directions, where the laws of physics change, but not in the perpendicular direction. In other words, the Universe in a sense has a dipole structure.”

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 Krasznahorkay and colleagues from the Institute for Nuclear Research of the Hungarian Academy of Sciences (Debrecen) published an article in the ArXiv preprint database where they concluded that they discovered the fifth interaction [5]. In January 2016, their article on this was published in the journal Physical Review Letters. Both publications were not noticed by the scientific community, with the exception of a group of theoretical physicists led by Jonathan Feng from the University of California (Irwin, USA), who decided to check the results of Hungarian colleagues. Professor Jonotan Feng carefully studied the work of Dr. Attila Krasznahorky and announced that the fifth interaction does not violate any laws of nature. In 2019, Attila Krasznahoroky in new experiments with helium confirmed the discovery of the fifth interaction [6]. This experiment of a Hungarian researcher Dr.Attila Kraznahorsky interested professors John Webb as a possible cause of anisotropy in the value of the fine structure in a strictly defined direction of motion in the Universe (l, b) ~ (303°, -27°). The new scalar field may belong to a hypothetical particle of dark matter the protophobic X boson, which, like the Higgs boson, creates the scalar field responsible for the fifth interaction between dark matter and ordinary (baryonic) matter. Dr. Jonathan Feng from the University of California, Irvine, in a press release in 2017 said: “For decades, we’ve known of four fundamental forces: gravitation, electromagnetism, and the strong and weak nuclear forces. Discovery of a possible fifth force would completely change our understanding of the universe, with consequences for the unification of fifth force and dark matter. The protophobic X boson of dark matter makes it possible to explain a number of experiments in which the anomalous magnetic moment of the muon is observed and is associated with the fifth interaction”[7]. In June 2020, the Dr.Lior Shamir from Michigan Technological University analyzed observational data on more than 200 thousand spiral galaxies collected in the SDSS and Pan-STARRS surveys, and received unexpected results. The difference in the number of left-handed and right-handed stellar systems indicates the rotation of the Universe by the action of the fifth force (Figure 3). Moreover, this asymmetry increases with distance from the Earth, that is, when observing an ever earlier Universe. But the point is not only that there are different numbers of them. They are also complexly distributed across the sky. According to the expert’s calculations, this distribution has a quadrupole (four-pole) structure. “If the Universe has an axis, then this is not just a single axis, like a carousel,” says Shamir. “This is a complex alignment of several axes, which, in addition, has a certain drift.” The researcher announced his results at the 236th symposium of the American Astronomical Society (236th American Astronomical Society meeting) in June 2020.

Interestingly, astronomers have previously observed global asymmetry in the Universe associated with the distribution of the relict background radiation. Among experiments confirming the anisotropy of
THE VALUE OF THE FINE STRUCTURE AND ITS ANISOTROPY IN THE SPACE AND TIME OF THE UNIVERSE

FIGURE 3: Comparison of the rotating disks of galaxies in the far and near Universe. Dark matter in galaxies

physical space, known the work of NASA, carried out in 1989 - 1992 years using Using spacecraft Cosmic Background Explorer (COBE) to detect the anisotropy of the relic background radiation, discovered in 1965. A. Penzias and Robert Wilson [8]. In my article “Anisotropy of the Late Universe” of April 15, 2020, based on an analysis of experimental data accumulated by astrophysics over thirty years of observations using satellites and radio telescopes, it is approved [9]. The Universe is a dynamic system that continuously generates baryonic masses of matter and dark matter and regulates their density, expanding its boundaries. Today, new independent methods for reliable verification of space isotropy are crucial. The same thought sounds as a referent in the article of the John Webb dated April 27, 2020. Perhaps the expansion rate of our universe, as well as the fundamental physical constants, can vary both throughout the evolution of the universe and the direction of motion. My the article is supposed to give a physical justification for this fact, depending on the anisotropy of the density of quantum vacuum (dark energy and dark matter) in various regions of the Universe and the presence of a new fundamental interaction (fifth force) between dark matter and ordinary (baryonic) matter [10].

2 | THE DEPENDENCE OF THE VALUE OF THE FINE STRUCTURE ON TEMPERATURE DURING THE EVOLUTION OF THE UNIVERSE

Consider the features of the electromagnetic field in a vacuum from the point of view of classical electrodynamics. First of all, this is a medium with absolute dielectric and magnetic permeability’s \((\varepsilon_0, \mu_0)\) equal to the dielectric and magnetic constants \((\varepsilon, \mu)\):

\[
\varepsilon_0 = \varepsilon_0 = 1/(36\pi) \times 10^{-9} \text{ [F/m]} \quad (4)
\]

\[
\mu_0 = \mu_0 = 4\pi \times 10^{-7} \text{ [Gn/m]} \]

The electric strength of this medium should be infinitely high, due to the lack of charge carriers. This means that the electric field \(E\) and the magnetic field \(H\), as well as the electromagnetic energy density determined by them in a vacuum, can be infinitely large. Such a conclusion, obtained from the position of the theory of classical electrodynamics, in the high-energy region, was not consistent [11]. In quantum electrodynamics, the instability of vacuum in external fields was experimentally established for electric field strengths \(E_s = 1.32 \times 10^{16} \text{[V/cm]}\) (Schwinger’s characteristic quantum electrodynamics field) and magnetic field strength \(H = 10^{16} \text{[T]}\), caused by the creation of electron-positron pairs in a vacuum (polarization effect of the vacuum) due to which the vacuum itself becomes unstable. With the polarization of vacuum and its transformation into the matter, the change in vacuum energy \(w\) can be represented as the sum:

\[
w = w^p + w^e \quad (5)
\]

where \(w^p\) is the vacuum polarization,

\[
w^p = E^2 / 8\pi \quad (6)
\]

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

\[
w^e = e^2 E^2 T \quad (7)
\]

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 \(T\) \((E_s \approx 10^{16} \text{[V/cm]}\) is the critical Schwinger’s field) [12]. Niels Bohr was right when he stated 80 years ago the statement “about the impossibility of achieving the strength of the order of \(E_s\) for a field
generating electron-positron pairs”. \[ (E_s = m^2 / e = 1.32 \times 10^{16} [V \times \text{cm}^{-1}], \text{sauter’s characteristic quantum electrodynamics field}) \] [11]. For an electromagnetic field, the polarization energy density of quantum vacuum can also be represented as the sum of two terms (5). Where is the first term \( w^p (w_0) \) quadratic in the electric and magnetic fields:

\[
     w_0 = \frac{(E^2 + H^2)}{8\pi} \quad (8)
\]

determines the energy of a non-interacting electromagnetic field before critical values electric strengths schwinger’s field \( E_s = 1.32 \times 10^{16} [V \times \text{cm}^{-1}] \) and magnetic field strength \( H = 10^{16} \text{[Gs]} \). The second term \( w^e (w_1) \) describes the interaction of photons due to the production of electron-positron pairs [13]:

\[
     w_1 = 2D \left[ \left(E'H - H'E \right)^2 - \left(E'H - H'E \right)^2 \right] + 7D \left[ \left(E'H \right)^2 - \left(H'E \right)^2 \right] \quad (9)
\]

The constant \( D \) can be calculated by the methods of quantum electrodynamics [13] and in Gaussian units, where the dimensionless coefficient, \( \alpha \) is the fine structure constant, \( m \) 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 in the form [13]. Experiments show that if an external field acts on the vacuum, then due to its energy, the production of real particles is possible [11,13]. 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 [14]. The interaction of the electromagnetic field with the vacuum of the electron-positron field 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. 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:

\[
     \alpha_0 = \frac{\alpha^2}{\hbar c} \quad (10)
\]

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, \( T_p \approx 1.42 \times 10^{32}[K] \approx 10^{19}[\text{GeV}] \) the speed of light would be much higher than the modern one:

\[
     \frac{c_p}{c_0} \approx 0.8 \times 10^{17} \quad (11)
\]

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 [13].

<table>
<thead>
<tr>
<th>( t, s )</th>
<th>( T_\gamma ), ( \text{GeV} )</th>
<th>( T, K )</th>
<th>( \tau = T / T_\gamma )</th>
<th>( n, \text{cm}^{-3} )</th>
<th>( \xi / \ell )</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.4 \times 10^{-16}</td>
<td>1.0 \times 10^{10}</td>
<td>1.2 \times 10^{10}</td>
<td>4.0 \times 10^{10}</td>
<td>1.3 \times 10^{10}</td>
<td>0.8 \times 10^{10}</td>
</tr>
<tr>
<td>1.0 \times 10^{-16}</td>
<td>1.0 \times 10^{10}</td>
<td>1.0 \times 10^{10}</td>
<td>5.5 \times 10^{10}</td>
<td>2.3 \times 10^{10}</td>
<td>1.0</td>
</tr>
<tr>
<td>1.0 \times 10^{-15}</td>
<td>1.0 \times 10^{10}</td>
<td>6.9 \times 10^{10}</td>
<td>1.4 \times 10^{10}</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>1.0 \times 10^{-14}</td>
<td>2.1 \times 10^{10}</td>
<td>2.5 \times 10^{10}</td>
<td>1.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.0 \times 10^{-13}</td>
<td>1.0 \times 10^{10}</td>
<td>4.9 \times 10^{10}</td>
<td>1.00003</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The reason for the large effect at short times 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 [13].

### 3 | Dependence of the Fine Structure Value on Pressure during Polarization of Quantum Vacuum (Dark Matter) in the Hydrogen Core and Neutron Stars

In quantum electrodynamics (QED), polarization of quantum vacuum (dark matter) is accompanied by the production of pairs of particles and antiparticles, and in quantum chromodynamics (QCD) polarization of quantum vacuum is accompanied by the production of mesons. The vacuum polarization effect leads to screening of the charge at low energies. With increasing energy, \( \alpha \) grows logarithmically:

\[
     \alpha(E) = \frac{\alpha_0}{1 - \alpha(E)} \quad (12)
\]
THE VALUE OF THE FINE STRUCTURE AND ITS ANISOTROPY IN THE SPACE AND TIME OF THE UNIVERSE

Where $E$ is the electric field strength, $\Delta \alpha$ is the incremental value is calculated as part of QCD.

Photons act as exchange particles in the electromagnetic interaction with vacuum in QED. Recall the most famous Feynman diagram for the interaction of two electrons [14]. Their trajectory of mutual approach and repulsion (the latter occurs according to the Coulomb law) is determined in QED by the interaction of charges, which in this case exchange virtual photons. In our concept, where there is a quantum vacuum structure, the use of the concept of an exchange photon is not necessary, since the process of polarization (deformation) of a vacuum can be energetically represented by formula (5) [15].

The CMS collaboration in the experiment at the Large Hadron Collider in 2019 for the first time demonstrated a decrease in the t-quark mass with increasing energy [16]. They studied the distribution of reaction products in $pp$ collisions with an energy from of 1 [TeV] to of 13 [TeV]. It was found the decrease in the of elementary particles mass obtained from data up to an energy of 13 [TeV], as well as a decrease in the magnitude of the interaction constants at a confidence level of 95%, depend on the energy at which measurements are made. This effect, explained by vacuum polarization, was indeed observed in experiments in particular, the decrease of the mass of b and c quarks was measured, as well as the decrease of the strong interaction constant [16]. Quantum vacuum is involved in all fundamental interactions, but if the polarization of vacuum in electromagnetic interactions is accompanied by the formation of electron-positron pairs with the participation of exchangeable virtual photons, then during strong nuclear interaction the polarization of quantum vacuum is accompanied by the formation of three unstable $\pi$-mesons ($\pi^0$, $\pi^+$, $\pi^-$) with the participation of virtual exchange pions and the subsequent birth of short-lived protons and antiprotons. At the same time, the energy spectrum of the production of new particles and antiparticles changes, which indicates a change in the structure of a quantum vacuum when it is included in the nuclei of atoms. Such a design means that in quantum vacuum in the process of polarization (deformation) is formed dipoles and, in macroscopic terms, is a polarizing medium [17].

Professor John Webb in his studies (published April 27, 2020) anisotropy of fine structure drew attention that the Universe in a sense has a dipole structure and priority directions for accelerated expansion [2]. In our time, in the presence of near-Earth satellites, space radio telescopes and the Large Hadron Collider new discoveries made, which allowed me to propose a new cosmological model of superfluid dark matter and present in this article some experiments that allow us to obtain the numerical values of the fine structure for formations of quantum vacuum (dark matter) in the near-Earth environment and inside the nuclei of atoms, where the pressure reaches huge values comparable to the pressure inside neutron stars [10]. After Volker Burkert and his colleagues from the Jefferson laboratory found that in the of the proton the pressure could exceed $10^{35}$ Pascal [18], it became clear at what pressure the quantum vacuum is located inside the hydrogen nucleus.

![FIGURE 4: The structure of the proton, quarks and gluons](image)

According to modern views the proton consists of three quarks - two u-quarks (upper quarks fro) and one d-quark (the bottom quark), hence the designation uud. The gluons bind quarks in a single particle (Fig. 4). The maximum repulsion between quarks is observed at a distance of $6 \times 10^{-13}$ [m], with the pressure reaching $10^{35}$ Pascal [18].

Professor A.V. Rykov, Russian Academy of Sciences, Institute of Physics of the Earth, relying on his “Fundamentals of the theory of ether” [19], as well as the polarization energy of vacuum and its electromagnetic parameters ($\varepsilon_0$, $\mu_0$), calculated the value of the fine structure of near-Earth quantum
vacuum (dark matter) and intranuclear quantum vacuum. According to him, the fine structure of the near-Earth quantum vacuum \( \alpha = 0.0072975 \) or \( (1/137) \) and the fine structure inside the hydrogen nucleus \( \alpha x = 0.00318157 \) \( (1/314) \) determine in the first case electromagnetism, in the second case, nuclear forces. The Professor A.V. Rykov determined the elastic deformation force in near-Earth quantum vacuum \( F = 1.155 \times 10^{19} \) [kg / s^2] and inside the proton nucleus \( F = 5.211 \times 10^{26} \) [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) [19]. From this we can conclude that the extreme pressure existing inside neutron stars and in the nuclei of protons affects the value of the fine structure constant. With the first detection of gravitational waves from the binary system of neutron stars GW170817, Astrophysicists at the Goethe University in Frankfurt have opened a new window to study the properties of matter at and above nuclear-saturation density. Reaching densities a few times that of nuclear matter and temperatures up to 100 MeV, such mergers also represent potential sites for a phase transition (PT) from confined hadronic matter to deconfined quark matter [20]. Professor Luciano Rezzolla regards that thanks to the simulation, a new signature was discovered, and if it passes again in the model in gravitational waves, science will receive important evidence of the creation of a quark-gluon plasma in the modern Universe [20]. At the same time, in an article by astrophysicists from Finland published on June 1 says that “the matter in the interior of maximally massive stable neutron stars interpret as evidence for the presence of quark-matter cores in which the speed of sound almost reaches that of light” [21]. It is believed that a certain form of this strange substance, called quark-gluon plasma, filled the newborn universe about 20 microseconds after the Big Bang. She behaved like an extremely hot liquid, which then cooled to a state of “ordinary” substance, which today fills the universe. Currently, the only place in the Universe where quark matter can still be found is 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 / s^2].

4 | CONCLUSION

In the article I present views on the physical essence of the concept of the fine structure of elementary particles and dark matter, which is based on an experimental physical basis. This is a new look at understanding the physical nature of the fine structure, which covers not only “ordinary” matter in terrestrial conditions and the quark-gluon plasma of neutron stars, but also the galactic structure of quantum vacuum (dark matter), and this is its relevance.

5 | REFERENCES

1. Lachlan Gilbert, “New findings suggest laws of nature ’downright weird,’ not as constant as previously thought”, University of New South Wales, (April 27, 2020)


THE VALUE OF THE FINE STRUCTURE AND ITS ANISOTROPY IN THE SPACE AND TIME OF THE UNIVERSE


13. 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


How to cite this article: S.K. The value of the fine structure and its anisotropy in the space and time of the Universe. Academy of Social Science Journals. 2020;1729–1736. https://doi.org/10.15520/assj.v5i8.2628