The Origin of Jarlskog Invariant and Applications

Sylwester Kornowski

Abstract: The different size scales in Nature and CP violation lead to very simple our pre-Cosmos with left-handed polarization which has transformed into the left-handed internal helicity of the baryons - it solves the matter-antimatter asymmetry. The simplest grainy surface that can have internal helicity is the torus/charge/spin (or loop) with toroidal and poloidal speeds. Here we showed that the ratio of such speeds leads to both the Jarlskog invariant and a spilled half-jet in grainy spacetime (i.e. to an additional arrow of time) which is responsible for CP violation. The Jarlskog invariant allows you to calculate the lifetimes of the neutron and weakly decaying hyperons.

1. Introduction

The standard/orthodox Big-Bang model of cosmology is incomplete [1] so we do not understand fully the thermal history of our Cosmos and our Universe and growth of cosmic structures. According to the Scale-Symmetric Theory (SST), radius of our Cosmos is ~10,000 times bigger than the present-day radius of the Universe [2].

SST provides very different cosmological model which, contrary to the orthodox cosmology, leads to dark matter and dark energy [2]. The **different size scales** in Nature (i.e. the components of neutrinos, neutrinos, electrically charged fermions, and the cosmic structure that evolved into the Universe containing dark matter and dark energy), the **two-component spacetime** (i.e. the SST Higgs field and the Einstein spacetime (ES) composed of the neutrino-antineutrino pairs) and **CP violation** (**or an additional arrow of time which leads to T violation**) lead to very simple our pre-Cosmos (pre-inflation grainy object) with the left-handed external helicity (i.e. with the left-handed polarization) [2], [3], [4], [5].

The pre-inflation grainy object was built of the non-gravitating tachyons (they are the internally structureless bare balls) which initially were at rest one relative to the other i.e. the tachyonic kinetic and rotational energy had the pre-Cosmos as a whole [2], [3]. At the end of inflation, almost whole the left-handed polarization transformed into the left-handed internal helicity of the baryons – it solves the matter-antimatter asymmetry because anti-baryons have right-handed internal helicity [3]. The left-handed polarization could not be transformed into a surplus of left-handedness in the ground state of the ES because energy frozen inside each neutrino is $\sim 0.6 \cdot 10^{119}$ times higher than its kinetic energy – i.e. due to the tremendous frozen energy, number of left-handed neutrinos must be practically equal to number of right-handed neutrinos.

The initial inflation field transformed, due to a collision, into the ES and a remnant inflation field which is the SST Higgs field [2]. To obtain the experimental results from the SST initial conditions, we must assume that the linear speed of the SST tachyons is $v_{Linear} = 2.386343972 \cdot 10^{97}$ m/s and that the spin speed on equator of them is $v_{Spin} = 1.725741 \cdot 10^{70}$ m/s [3]. Values of the spin speed, inertial mass and radius of tachyons lead to conclusion that the inertial spin of the SST tachyons is infinitesimal [3]. The SST Higgs field is a scalar field but when we neglect the rotational energies of the tachyons then we are unable to describe the origin of the CP (or T) violation and the origin of the gravitational constant [3].

Denote the ratio v_{Spin}/v_{Linear} by F

$$F = v_{Spin}/v_{Linear} = 7.231736 \cdot 10^{-28} . \tag{1}$$

2. The Jarlskog invariant in SST

At the beginning of the SST inflation, most of the tachyons transformed into the superluminal binary systems of closed strings (entanglons) the neutrinos consist of [3]. Linear speed of them is about 29 orders of magnitude lower than tachyons so the ratio of the poloidal speed to toroidal one for the entanglons is practically equal to F.

In SST, spin of the different size-scale tori is classical and half-integral

$$Spin = M_{Torus}\, v_{Toroidal}\, R_{Torus,mean} = \hbar/2 , \tag{2}$$

and mass of torus is directly proportional to its squared radius: $M_{Torus} \sim R_{Torus,mean}^2$. Formula (2) leads to following conclusion

$$R_{Torus,mean} \sim 1 / v_{Toroidal}^{1/3} . \tag{3}$$

The circle on a torus with biggest radius we will call the equator of the torus. Acceleration on such equator is defined by formula (on assumption that G_i is defined)

$$a_i = G_i\, M_{Torus}/R_{Torus,equator}^2 \sim G_i\, R_{Torus,mean}^2/R_{Torus,equator}^2 = \text{const.} , \tag{4}$$

where G_i is a constant of interaction (it can be gravitational, electromagnetic, weak or strong interaction).

On the other hand, for the radial acceleration on the equator is

$$a_i \sim \Delta R / \Delta t^2 = \text{const.} . \tag{5}$$

From (3) and (5) is

$$\Delta t_{Toroidal} \sim 1 / v_{Toroidal}^{1/6} . \tag{6}$$

From constancy of the **F** it results that the poloidal time depends on the $v_{Poloidal}$ in the same way as the $t_{Toroidal}$ on $v_{Toroidal}$.

The relation (6) leads to following formula

$$\Delta t_{Toroidal} / \Delta t_{Poloidal} = (v_{Poloidal} / v_{Toroidal})^{1/6} = F^{1/6} = 2.996 \cdot 10^{-5} = J\,, \qquad (7)$$

where J is the SST Jarlskog invariant. We can see that poloidal time is going the J times slower than toroidal one i.e., for example, $\Delta t_{Poloidal} = 1$ s corresponds to $\Delta t_{Toroidal} = J$ second.

In SST, the Jarlskog invariant concerns the nuclear weak interactions because they are associated with the decays parallel to the axis of rotation of the baryon torus i.e. concerns the poloidal speed. In SST, the strong and electromagnetic interactions concern the toroidal motions i.e. motions in the plane of the torus equator. Notice that phase shift between the weak interactions and the strong interactions (or electromagnetic interactions) is $\pi/2$ radian but because the half-jet is spilled so the phase shift is broadened. The poloidal motions do not concern the plane of the torus equator so CP (or T) is not violated in nuclear strong and electromagnetic interactions [6].

The SST values in the CKM matrix are very close to the values in the standard CKM matrix but their interpretation is very different and follows from the atom-like structure of baryons [7]. In all mixing angles appears the mass of the torus in the core of baryons $X = 318.2955$ MeV.

Emphasize that lifetime of a particle does not correspond directly to Δt in formula (7) because particles which appear in decays, generally, are not in central part of the particle – in centre of hyperons and baryonic resonances is, generally, nucleon only [3]. Generally, lifetimes depend directly proportional on distances of pions from centre of baryons [3].

In the Wolfenstein parameterization of V_{CKM}, the Jarlskog invariance is [1]

$$J_{CKM} \approx \lambda\, A\, \eta = 3.18^{+0.27}_{-0.24} \cdot 10^{-5}\,. \qquad (8)$$

We calculated it in the simplest way by using the three parameters $\lambda = 0.22453(44)$, $A = 0.836(15)$, and $\eta = 0.355^{+0.012}_{-0.011}$ from [1].

3. CP violation (or time-reversal T violation) from SST

SST shows that time-reversal violation is linked with CP violation through the CPT=1 (charge-conjugation + parity-transformation + time-reversal) theorem, which states that under the simultaneous transformations, physical laws are symmetrical [5].

The CP (or T) violation is a result of creation of a spilled half-jet in the grainy Einstein spacetime (i.e. of an additional arrow of time) because of the poloidal speed of a torus/charge/spin – time in such a jet is going slower and is defined by the Jarlskog invariant. Below we showed that such an invariant determines lifetimes of hyperons decaying weakly and lifetime of neutron.

In reality, due to the dynamic viscosity of the tachyons and entanglons, there are created whirls around the torus in such a way that they are going via the torus hole. It leads to conclusion that weak interactions can take place in whole volume of baryons.

Time reversal means that we change direction of the half-jet in relation to spin.

In the Wu experiment [8], spin of the atomic nucleus of cobalt is 5 and all nucleons are left-handed so such nucleus produces a strong half-jet along the direction of the resultant spin but the half-jet is antiparallel to the resultant spin. Such half-jet carries the electrons which appear due to the decays of the cobalt nuclei. Assume that we polarized the spins of the cobalt nuclei by placing them in a magnetic field. Then, due to the half-jets, most of the electrons should favour a direction of motion opposite to that of the nuclear spin – it is consistent with the experiment carried out by Wu. On the other hand, the direction of spins of the emitted electrons follows from the internal structure of neutrons.

Notice that equatorial radii of tori of the electron, muon, and proton are different and in particles can be two or more such tori and/or loops with both toroidal and poloidal speeds so there are many different CP asymmetries concerning the weak interactions. Mathematical descriptions of such CP violations are very complicated but they all are the result of creation of the half-jets i.e. of the additional arrows of time.

Neutron decays into a proton, electron and electron-antineutrino. The all four particles have internal helicities respectively left, left, right and left but the inertia of internal helicity increases with mass of particle so the left-handedness of the nucleons dominates. It leads to an excess of the left-handedness in the Universe.

It is not true that to explain the matter-antimatter asymmetry we must assume that physical laws have acted differently for matter and antimatter. Just the left-handedness of the pre-Cosmos leads to the matter-antimatter asymmetry.

SST shows that the misunderstanding of violation of CP symmetry or T symmetry in the weak interactions only results from neglecting the internal structure of bare fermions and loops, in particular their internal helicity which results from the initial conditions for the inflation field described in SST.

4. Lifetimes of particles

According to SST, there are two types of particles i.e. the fermions containing a dominating torus in their centres and the condensates of fields which can be scalars or vector particles. Formulae for their lifetimes are different.

Consider the condensates or fields which behave as condensates. To them we can use the theory of stars [3]. Their lifetime is inversely proportional to four powers of their mass or to coupling constant: $\tau \sim 1 / m^4 \sim 1 / \alpha_i$ – see relations (12) and (16) in [3]. When neutron decays then very near and inside the dominating torus in the baryons (its mass is $X = 318.2955$ MeV [3]) there are produced virtual pairs of quanta with the positive mass of each component equal to $\Delta m = n - p = 1.29333$ MeV [1] (there simultaneously are created in the ES the “holes” with negative mass [10]). Such virtual field we can consider as a specific condensate so it decreases lifetime of the neutron when electron is placed very near or inside the dominating torus – SST shows that it is true [3]. On the assumption that there is one virtual pair per decaying neutron, we obtain

$$\tau / \tau_o = \{m_o / (m_o + 2\Delta m)\}^4 = \{X / (X + 2\Delta m)\}^4 = 0.96814 . \qquad (9)$$

SST shows that our very early Universe was the binary system of loops composed of the SST neutron black holes which initially transformed into 50% of protons and 50% of nuclei of helium so we can assume that the ratio $n_{s,SST,n\text{-}p} = \tau / \tau_o = 0.96814$ is the scalar spectral index in cosmology – the observed value is $\eta_s = 0.968(6)$ [1] so both results are consistent. Notice as well that initially there was about 2/3 of protons and 1/3 of neutrons. On the other hand, there are three different pions i.e. two charged and one neutral. If in the initial strong interactions, number densities of them were the same then there was 2/3 of charged pions and 1/3 of neutral pions – it means that their percentage abundances were the same as respectively protons and neutrons. The mean mass of the pions was $m_{\pi,mean} = 138.04$ MeV. SST shows that the coupling constant for the nuclear weak interactions is $\alpha_{w(proton)} = 0.0187229$ [3] so weak mass of $m_{\pi,mean}$ is $m_{\pi,mean,weak} = \alpha_{w(proton)}\, m_{\pi,mean} = 2.5845$ MeV $\approx 2\Delta m$. When we assume that there is or was one virtual pion per nucleon then applying formula (9) we obtain

$$n_{s,SST,\pi,mean} = \{X / (X + m_{\pi,mean,weak})\}^4 = 0.96817 . \qquad (10)$$

The mean value of the scalar spectral index calculated within SST is $n_{s,SST} = 0.9682$. We will use this value to calculate the lifetime of neutron.

Emphasize that the weak condensates do not interact electromagnetically and strongly so the lifetime correction from the scalar spectral index concerns the weak interactions. Moreover, such a model is valid for products of decay that initially were inside the core of baryons.

Consider the fermions. There are three different possibilities.

*__The A type__: In the toroidal motions of particles outside the dominating torus, for coupling constants $\alpha_i \leq 1$, because of the interactions, the wave length of a particle increases ($\lambda = \lambda_o / \alpha_i$) while the speed of the particle decreases ($v = c\,\alpha_i$). This leads to following formula for lifetime: $\tau = \lambda / v = \lambda_o / (\alpha_i^2\, c)$. But there are two possibilities. In the nuclear strong interactions and electromagnetic interactions, the particles/loops overlap with the allowed orbits around the dominating torus, i.e. centres of the particles/loops are in the centre of the dominating torus and the loops lie on the plane of its equator. Then lengths of wave are equal to radii of the loops i.e. $\lambda_o = R$ so formula for lifetime in nuclear strong decays and electromagnetic decays of baryons looks as follows: $\tau = R / (\alpha_i^2\, c)$.

*__The B type__: On the other hand, in the weak interactions, the centres of particles are moving along the orbits in a quantum way [10] so lengths of wave are equal to the de Broglie wavelength $\lambda_o = \lambda_{de\text{-}B}$. Moreover, in the weak decays there dominate the poloidal motions so there is an additional decrease in lifetime which depends on the Jarlskog invariant J. Lifetime is directly proportional to distance R of emitted particle from the centre of the dominating torus: $\tau \sim R$. In paragraph **2** we showed that $R \sim 1/v_{Poloidal}^{1/3} \sim 1/J^2$ so $\tau \sim 1/J^2$. This leads to following formula for lifetime in weak interactions: $\tau = \lambda_{de\text{-}B} / (J^2\, \alpha_{w,i}^2\, c)$.

*__The C type__: It is the **B** type extended due to the scalar spectral index – it concerns the decays of neutrons: $\tau = n_{s,SST}\, \lambda_{de\text{-}B} / (J^2\, \alpha_{w,i}^2\, c)$.

4.1 Lifetimes of baryons

In the cases considered here, the lifetime of some decay is proportional to the inverse square of the coupling constant between the initial and final products.

In the decay of the neutral sigma hyperon $\Sigma^o \rightarrow \Lambda\gamma$ there appears photon and strangeness is conserved so it is the electromagnetic decay ($\alpha_{em} = 1/137.036$ [3]). The photon is emitted from the $d = 1$ state – see Paragraph "*Black body spectrum*" in [2] – so the SST lifetime is (it is the A type)

$$\tau_{em,\Sigma(o)} = (A + B) / (\alpha_{em}^2\, c) = 7.51 \cdot 10^{-20}\ \text{s} , \qquad (11)$$

where $A = 0.6974425$ fm and $B = 0.5018395$ fm [3].

The experimental value is $\tau_{\Sigma(o)} = (7.4 \pm 0.7) \cdot 10^{-20}$ s [1].

We can compare the nuclear strong and weak interactions in decays which yield the same final particles – below they are the proton and neutral pion.

In the decay of the delta resonance $\Delta(1232)\ 3/2^+ \rightarrow p + \pi^o$, strangeness is conserved so it is the nuclear strong decay. The pre-neutral-pion (as a spin~2 loop) is in the $d = 2$ state [3] so the SST lifetime is ($\alpha_s = 1$ [3]) – it is the A type

$$\tau_{s,\Delta(1232),3/2(+)} = (A + 2B) / (\alpha_s^2 c) = 5.67 \cdot 10^{-24} \text{ s} . \qquad (12)$$

The Breit-Wigner full width (mixed charges) $\Gamma \approx 117 \pm 3$ MeV [9] i.e. $\tau_{\Delta(1232),3/2(+)} = (5.63 \pm 0.14) \cdot 10^{-24}$ s (there is $\tau = \hbar / \Gamma$).

In the decay of the sigma hyperon $\Sigma^+ \rightarrow p + \pi^o$ strangeness is not conserved so it is the nuclear weak decay. The neutral pion as a relativistic pion is in the $d = 2$ state [3] so the SST lifetime is (it is the **B** type)

$$\tau_{w,\Sigma(+)} = \lambda_{de\text{-}B} / (J^2 \alpha_{w,i}^2 c) = \lambda_{\pi(o),d=2} / (J^2 \alpha_{w(proton)}^2 c) = 0.75 \cdot 10^{-10} \text{ s} , \qquad (13)$$

where $\lambda_{\pi(o),d=2} = 2\pi\hbar/(m_{\pi(o),d=2} c) = 7.056$ fm is the de Broglie length of wave, $m_{\pi(o),d=2} = 175.709$ MeV, and $\alpha_{w(proton)} = 0.0187229$ [3].

The experimental value is $\tau_{\Sigma(+)} = (0.8018 \pm 0.0026) \cdot 10^{-10}$ s [1].

We calculated lifetimes of the hyperons and other particles in a different way also [11], [12], [13], [3].

4.2 Lifetime of the neutron

Assume that before the weak decay of neutron, the electron, which is in neutron on the loop with radius $2A/3$ (i.e. its length is $2\pi(2A/3)$ [3], transits in such a way that A is replaced by r_B, where r_B is the radius of the first atomic orbit in hydrogen – emphasize that the electron is not on the first hydrogen orbit. By an analogy we have $2\pi(2A/3) \rightarrow \lambda_{de\text{-}B}{}^* = 2\pi(2r_B/3) = 2.21661 \cdot 10^{-10}$ m, where $r_B = 0.529177 \cdot 10^{-10}$ m.

The neutron decays due to the weak interactions of electron so the coupling constant for the weak interactions is $\alpha_{w(electron\text{-}muon)} = 0.9511082 \cdot 10^{-6}$ – see formula (82) in [3].

The decay of the neutron is of the **C** type

$$\tau_{neutron,SST} = \eta_{s,SST} \lambda_{de\text{-}B}{}^* / (J^2 \alpha_{w(electron\text{-}muon)}^2 c) = 881.6 \text{ s} . \qquad (14)$$

We can compare this value with the mean experimental result $\tau_{neutron} = 880.2 \pm 1$ s [1].

5. Summary

There is only one direct way for future probes of inflation – we should measure density of the ground state of the Einstein spacetime – to do it, we must measure mass with accuracy higher than $\sim 6.7 \cdot 10^{-67}$ kg. Other evidences are indirect only.

The left-handedness of the pre-Cosmos leads to the matter-antimatter asymmetry. Physical laws are the same for matter and antimatter.

The misunderstanding of violation of CP symmetry or T symmetry in the weak interactions only follows from neglecting the internal structure of bare fermions and loops, in particular their internal helicity which results from the initial conditions for the inflation field described in SST.

The CP (or T) violation is a result of creation of a spilled half-jet (it represents an additional arrow of time) and whirls in the grainy Einstein spacetime because of the poloidal speed of torus/charge/spin.

Time in the half-jet is going slower and is defined by the Jarlskog invariant.

Here we used the Jarlskog invariant to determine lifetimes of neutron and hyperon Σ^+ in weak interactions.

Time reversal means that we change direction of the half-jet in relation to spin.

We showed that the scalar spectral index follows from the neutron→proton transitions – calculated here value is $n_{s,SST} = 0.9682$.

References

[1] M. Tanabashi *et al.* (Particle Data Group).
Phys. Rev. D **98**, 030001 (2018)
[2] Sylwester Kornowski (29 June 2016). “Foundations of the Scale-Symmetric Physics (Main Article No 2: Cosmology)”
http://vixra.org/abs/1511.0223
[3] Sylwester Kornowski (23 February 2018). “Foundations of the Scale-Symmetric Physics (Main Article No 1: Particle Physics)”
http://vixra.org/abs/1511.0188
[4] Sylwester Kornowski (15 November 2017). “Two-Component Spacetime as a Mixture of Non-Locality and Locality: A Conceptual Error about Gravitational Waves, the Different Theories of Gravitation and the Matter-Antimatter Asymmetry”
http://vixra.org/abs/1711.0324
[5] Sylwester Kornowski (28 December 2015). “CPT Symmetry and Symmetry-Breaking in the Scale-Symmetric Theory”
http://vixra.org/abs/1303.0188
[6] Sylwester Kornowski (4 September 2016). “The Strong CP Problem and the Transition from Linearity to Non-Linearity”
http://vixra.org/abs/1609.0038
[7] Sylwester Kornowski (17 August 2016). “The CKM Quark-Mixing Matrix in the Scale-Symmetric Theory”
http://vixra.org/abs/1608.0154
[8] Wu C. S. *et al.* (February 1957). “Experimental Test of Parity Conservation in Beta Decay”
Physical Review, **105** (4); 1413-1415
[9] K. A. Olive *et al.* (Particle Data Group).
Chin. Phys. C38, 090001 (2014)
http://pdg.lbl.gov
[10] Sylwester Kornowski (1. January 2019). “Classical Interpretation of Quantum Mechanics”
http://vixra.org/abs/1812.0408
[11] Sylwester Kornowski (26 February 2018). “Lifetimes of the Muon, Hyperons and Tau Lepton”
http://vixra.org/abs/1802.0378
[12] Sylwester Kornowski (24 February 2018). “Lifetime of the Neutron”
http://vixra.org/abs/1802.0178
[13] Sylwester Kornowski (20 January 2016). “Lifetimes of Higgs, W and Z Bosons in the Scale-Symmetric Physics”
http://vixra.org/abs/1503.0212