

The Origin of Jarlskog Invariant and Applications

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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 $\sim 10,000$ 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 $v_{\text{Linear}} = 2.386343972 \cdot 10^{97}$ m/s and that the spin speed on equator of them is $v_{\text{Spin}} = 1.725741 \cdot 10^{70}$ 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 $v_{\text{Spin}}/v_{\text{Linear}}$ by F

$$F = v_{\text{Spin}}/v_{\text{Linear}} = 7.231736 \cdot 10^{-28} . \quad (1)$$

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

$$\text{Spin} = M_{\text{Torus}} v_{\text{Toroidal}} R_{\text{Torus,mean}} = \hbar/2 , \quad (2)$$

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

$$R_{\text{Torus,mean}} \sim 1 / v_{\text{Toroidal}}^{1/3} . \quad (3)$$

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)

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

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

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

From (3) and (5) is

$$\Delta t_{\text{Toroidal}} \sim 1 / v_{\text{Toroidal}}^{1/6} . \quad (6)$$

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

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

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, $\Delta t_{\text{Poloidal}} = 1$ s corresponds to $\Delta t_{\text{Toroidal}} = J$ 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]

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

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 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 $\Sigma^0 \rightarrow \Lambda \gamma$ there appears photon and strangeness is conserved so it is the electromagnetic decay. The photon is emitted from the $d = 1$ state – see Paragraph “*Black body spectrum*” in [2] – so the SST lifetime is

$$\tau_{em,\Sigma(0)} = (A + B) / (\alpha_{em}^2 c) = 7.51 \cdot 10^{-20} \text{ s} . \quad (9)$$

The experimental value is $\tau_{\Sigma(0)} = (7.4 \pm 0.7) \cdot 10^{-20} \text{ s}$ [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 $\Delta(1232) 3/2^+ \rightarrow p + \pi^0$, 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])

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

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

Lifetime is directly proportional to distance R of emitted particle from the centre of a baryon: $\tau \sim R$. In paragraph 2 we showed that $R \sim 1 / v_{\text{Poloidal}}^{1/3} \sim 1 / J^2$ so $\tau \sim 1 / J^2$ but it is valid only for weak interactions which follow from the poloidal motions.

In the decay of the sigma hyperon $\Sigma^+ \rightarrow p + \pi^0$ 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

$$\tau_{w,\Sigma(+)} = R / (J^2 \alpha_w^2 c) = \lambda_{\pi(0),d=2} / (J^2 \alpha_{w(\text{proton})}^2 c) = 0.75 \cdot 10^{-10} \text{ s} , \quad (11)$$

where $\lambda_{\pi(0),d=2} = 2\pi\hbar / (m_{\pi(0),d=2}c) = 7.056 \text{ fm}$ is the de Broglie length of wave, $m_{\pi(0),d=2} = 175.709 \text{ MeV}$, and $\alpha_{w(\text{proton})} = 0.0187229$ [3].

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

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

5. Lifetime of the neutron

The transitions from neutron to proton and vice versa, cause that around the torus in the core of baryons with a mass of $X = 318.2955 \text{ MeV}$ [3] there appears virtual field [10] (such a field we can consider as a specific condensate) composed of the pairs of quanta and each such quantum carries energy $\Delta m = (n - p) = 1.29333 \text{ MeV}$ [1] – such quanta, contrary to the holes in ES, have positive energy. Such virtual field increases number density of particles and decreases lifetime of neutron according to following relation – see relation (12) in [3]

$$\eta_{s,SST} = \tau_o^* / \tau_o = \{m / (m + 2\Delta m)\}^4 = \{X / [X + 2(n - p)]\}^4 = 0.96814 . \quad (12)$$

Notice that the same value has the scalar spectral index in cosmology: $\eta_s = 0.968(6)$ [1]. It, probably, has a deeper meaning.

Assume that before the weak decay of neutron, the electron, which is in neutron in distance $2\pi(2A/3)$ from the centre of neutron [3], transits to the first atomic orbit in hydrogen. By an analogy we have $2\pi(2A/3) \rightarrow R^* = 2\pi(2r_B/3) = 2.21661 \cdot 10^{-10} \text{ m}$, where $r_B = 0.529177 \cdot 10^{-10} \text{ m}$.

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

Applying formula (11) we obtain

$$\tau_{\text{neutron},SST} = \eta_s R / (J^2 \alpha_w^2 c) = \eta_{s,SST} R^* / (J^2 \alpha_{w(\text{electron-muon})}^2 c) = 881.58 \text{ s} . \quad (13)$$

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

6. 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 $\sim 6.7 \cdot 10^{-67} \text{ kg}$. 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.

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