# The E- and B-Modes in the CMB

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**Abstract:** Here, on base of the lacking part of ultimate theory, i.e. the Scale-Symmetric Theory, we described the production of the E- and B-modes in the CMB. The obtained result 0.22 for the ratio of amplitudes of the B-modes to E-modes (i.e. the tensor-to-scalar ratio) for the beginning of expansion of the very early Universe, for multipole moment equal to 384, is close to the central value in the BICEP2 data. The tensor-to-scalar ratio depends on density of the Einstein-spacetime and is higher for higher densities. The calculated energies carried by the Einstein-spacetime components the spreading condensates were built of (such condensates produced the B-modes in the CMB), were in approximation the sixteen powers of ten of GeV.

## 1. Introduction

The General Relativity leads to the non-gravitating Higgs field composed of tachyons [1A]. On the other hand, the Scale-Symmetric Theory (SST) shows that the succeeding phase transitions of such Higgs field lead to the different scales of sizes [1A]. Due to the saturation of interactions via the Higgs field and due to the law of conservation of the half-integral spin that is obligatory for all scales, there consequently appear the superluminal binary systems of closed strings (entanglons) responsible for the quantum entanglement, stable neutrinos and luminal neutrino-antineutrino pairs which are the components of the luminal Einstein spacetime (it is the Planck scale), cores of baryons, and the cosmic structures (protoworlds) that evolution leads to the dark matter, dark energy and expanding universes [1A], [1B]. The non-gravitating tachyons have infinitesimal spin so all listed structures have internal helicity (helicities) which distinguishes particles from their antiparticles [1A].

During the inflation, the liquid-like inflation field (the non-gravitating superluminal Higgs field) transformed partially into the luminal gravitating Einstein spacetime (it is the Higgs mechanism) [1A]. In our Cosmos, the two-component spacetime is surrounded by timeless wall – it causes that the fundamental constants are invariant [1A], [1B].

Due to the symmetrical decays of bosons on the equator of the core of baryons, there appears the atom-like structure of baryons described by the Titius-Bode orbits for the nuclear strong interactions [1A].

SST shows that the beginning of the expansion of the Universe (the "soft" big bang) was separated in time from the inflation (the big bang) [1A], [1B]. It leads to conclusion that the observed $E$-modes and $B$-modes concern the "soft" big bang".

SST shows that the three fundamental fields inside our Universe (i.e. the luminal gravitating Einstein spacetime, the dark matter and dark energy) consist of the same particles i.e. of the neutrino-antineutrino pairs [1A]. The neutrino-antineutrino pairs in the Einstein spacetime that fills whole inner Cosmos (the Cosmos consists of universes [1B]), are "free" i.e. they interact gravitationally only so their motions are chaotic. The dark energy consists of the additional Einstein-spacetime components (i.e. they are "free" as well) that fill our Universe and cause its expansion. The dark matter consists of entangled neutrino-antineutrino pairs (i.e. they are not "free") – generally, they are the cosmic loops that interact via leptons with baryonic matter so there is an advection that can lead to the untypical motions (i.e. there are some departures from the theory of gravity) of stars in rotating galaxies [1A].

SST shows also that some very small changes in density of the Einstein spacetime (about $1$ part in $40{,}363$ parts) cause that there appears the confinement of the neutrino-antineutrino pairs that leads to production of the condensates [1A].

In the Einstein spacetime can appear flows that, due to the confinement of the Einstein-spacetime components, can produce condensates. Condensates are the very unstable objects so they spread very quickly. Condensates are less unstable when the spins of the Einstein-spacetime components are polarized. There are three possibilities:

**1.1**

The spins of the Einstein-spacetime components are aligned and parallel i.e. the condensates look as magnetic domains. When resultant spin of such condensate rotates and the condensate is spreading then it produces the $B$-modes in the CMB. They are produced by the tensor perturbations (by the spin curls).

**1.2**

The spins of the Einstein-spacetime components are tangent to concentric circles. The resultant spin is equal to zero. When such condensate is spreading then it produces the $E$-modes in the CMB. They are produced by the scalar perturbations.

**1.3**

The spins of the Einstein-spacetime components are tangent to radial directions (which are divergent). The resultant spin is equal to zero. When such condensate is spreading then it produces the $E$-modes as well. They are produced by the scalar perturbations. But since distances between the radial directions are changing so such condensate is more unstable.

To create less unstable condensates at higher and higher energies there is needed higher ordering. It leads to conclusion that at very high energies we should observe the $B$-modes only.

**We must emphasize that with increasing energy of the Einstein spacetime, the ratio of the amplitudes of the $B$-modes to the $E$-modes increases as well and we can assume that at energy about $10^{16}$ GeV (see formula (1)) the condensates produce the $B$-modes only**.

This leads to conclusion that the observed $E$-modes in the CMB were not produced by spreading condensates. They were produced due to the energy released in the beta decays of the neutrons in the activated protogalaxies (activated by the flows of the dark matter and dark energy) our double cosmic loop (the very early Universe) was built of [1B]. At the beginning of expansion of the very early Universe there was the radial polarization of the magnetic axes of the protogalaxies.

We can see that density perturbations (for example, the swelling protogalaxies) produce the $E$-mode polarization only, whereas the spreading condensates produced in the Einstein spacetime can produce both the $E$-mode polarization and the $B$-mode polarization.

Here, we will show that the energy-density of fluctuations that can be produced by the condensates that produced the $B$-modes is about $10^{16}$ GeV. This energy does not concern the period of inflation. We calculated also for the CMB the ratio of the tensor amplitude to the scalar amplitude i.e. the tensor-to-scalar ratio.

The observed differences in temperature in the CMB (about one part in $10^5$), is close to the coupling constant for the electron-proton interactions, [1A], so such fluctuations appeared due to the activation of the protogalaxies by the inflowing dark matter and dark energy.

In the Einstein spacetime are possible gravitational flows (not gravitational waves) which produce the fluctuations, condensates and particles. SST shows that gravitational fields are the gradients produced by masses in the superluminal non-gravitating Higgs field so creation of the postulated gravitational waves is impossible.

The electrons that appeared in the beta decays, produced condensates which masses were the same as the condensate in centre of electron (0.2552 MeV [1A]) whereas due to rotational energies of the Einstein-spacetime components, the energies of such condensates can be tremendous. Such condensates should produce the $B$-modes in the CMB.

On the other hand, here [2] is the conclusion that the BICEP2 collaboration found indirect sign of gravitational waves. They claim that the observed $B$-modes (curls) in the CMB are due to rippling gravitational waves. They rejected some other alternative explanations as, for example, polarization caused by more distant galaxies. But the explanation has one very important weak point. Just, due to the mainstream theories of inflation, the $B$-modes should be much weaker than the observed. It leads to conclusions that probably the mainstream description of creation of our Cosmos is incorrect.

## 2. Calculations

### 2.1 Energy characteristic for the period of the $B$-modes production

Applying SST, we can calculate the rotational energies of the Einstein-spacetime components in the period of the $B$-modes production at beginning of the expansion of the very early Universe (existence of the $B$-modes suggests that there were the gravitational flows in spacetime but it is not direct evidence that gravitational waves exist).

SST shows that range of bosons of energy about $E_{boson}$ = 0.7503 GeV is about $B$ = $0.5018 \cdot 10^{-15}$ m [1A] On the other hand, during the activation of the protogalaxies by the inflows of the dark matter and dark energy, instead the gravitational interactions between the Einstein-spacetime components there dominated the confinement characteristic for condensates [1A]. According to the SST, range of the confinement of the Einstein-spacetime components is about $R_C = 3.926 \cdot 10^{-32}$ m. Since energy is inversely proportional to range so energy $E_C$ of the Einstein-spacetime components, during the period of the $B$-modes production, was

$$E_C = E_{boson} B / R_C = 0.959 \cdot 10^{16} \text{ GeV}. \tag{1}$$

This energy is characteristic for the beginning of the expansion of the very early Universe.

**2.2 E-modes in the CMB**

Due to the Thomson polarization theory, there appeared the $E$ photons. At first there appears anisotropy power maximum (i.e. maximum for density fluctuation of the dark matter and temperature fluctuation), followed by the maximum for density of ionized matter and then the maximum for the $E$ polarization. The CMB polarization was highest when the produced velocity gradient was at its highest (i.e. the modified neutron black holes (MNBHs) swelled due to the inflows of the dark matter [1B]). The velocity gradient, i.e. the polarization spectrum, is out of phase with the density spectrum, i.e. with the temperature anisotropy.

The most energetic early photons had energy of about 8.79 MeV – it is the mean binding energy of the nucleons inside iron. The characteristic energy for the beta decays is 0.7815 MeV. Furthermore, the maximum temperature fluctuations for the scalar $E$-mode polarization should be approximately 8.79 / 0.7815 = 11.25 times lower than the maximum temperature fluctuations for the densest matter i.e. 72.06 / 11.25 = 6.4 μK [1B]. The maximum anisotropy power associated with the scalar $E$-mode polarization should be approximately 41 $\mu K^2$. This was for the multipole moment $I = 384$ because the density of ionized matter was at its lowest then [1B]. The obtained value is only a rough estimate.

**2.3 Ratios of amplitudes of the $B$-modes to the $E$-modes**

SST shows that due to the Thomson polarization theory, the CMB should be polarized with amplitude of a few μK with upper limit for $E$-mode 6.4 μK. This $E$-mode is associated with energies produced in the beta decays of neutrons. The CMB polarization was highest when the produced velocity gradient was at its highest (i.e. the modified neutron black holes swelled due to the inflows of the dark matter and dark energy). The velocity gradient, i.e. the polarization spectrum, is out of phase with the density spectrum, i.e. with temperature anisotropy.

The electrons that appeared due to the beta decays, at very high energy produced condensates composed of the Einstein-spacetime components. Their gravitational mass $\Delta m$ is the same as the condensate in centres of the electrons i.e. is equal to the half of the mass of bare electron $\Delta m = m_{bare(electron)} / 2 = 0.2552$ MeV [1A]. These condensates are less unstable when the spins of the Einstein-spacetime components are polarized in a manner similar to magnetic domains. At very high densities, the resultant spins of the condensates rotated. Such curling and spreading condensates produced the $B$-modes.

SST shows that when the early Universe (the cosmic double loop) transformed into expanding ball, there was the radial polarization of the magnetic axes of the protogalaxies – it follows from the conservation of spins of nucleons. It leads to the $E$ polarization perpendicular to the radial directions so we can see the maximum effect. There is some difference for the $B$-modes. The fine structure constant, which concerns the $E$-modes, is 1/137.036 i.e. about $10^{-2}$ whereas the coupling constants for the weak interactions of the electron condensates are much lower – for the weak electron-muon interactions is about $10^{-6}$ whereas for the weak electron-proton interactions is about $10^{-5}$. It leads to conclusion that the orientation of the resultant spins of the condensates can be arbitrary. Since there are the three orthogonal/perpendicular directions so for the $B$-modes we can see the 2/3 of the maximum effect i.e. $2\Delta m/3$.

For multipole moment $I = 384$, the calculated temperature fluctuation which results from energy released in the beta decays, is for the $E$-modes 6.4 μK. This temperature fluctuation is associated with the energy $\Delta E = m_{neutron} - m_{proton} - m_{electron} \approx 0.7815$ MeV released by decaying neutrons in the activated protogalaxies.

Calculate for the $I = 384$ the ratio $r_A$ of amplitudes of the $B$-modes to the $E$-modes

$$r_A = 2\Delta m / (3\Delta E) \approx 0.22. \quad (2)$$

This result is very close to the central value in the BICEP data [2].

When rotational energy of a spreading condensate is equal to zero then it does not produce the $B$-modes so $r = 0$. In the regions with the higher densities of the Einstein spacetime (it was during the inflows of the dark matter and dark energy into the very early Universe) there dominated the spin polarization of the condensates characteristic for the magnetized ferromagnetic substances i.e. the spreading and curling condensates produced the $B$-modes. But there can be spreading condensates in which the spins are tangent to the radial directions or in which the spins are tangent to concentric circles with increasing radius. Then observed resultant spin of spreading condensate is equal to zero so it behaves as scalar which produces the $E$-modes. There should be some density at which the energies of the $E$- and $B$-modes associated with spreading condensates are the same. Calculate the ratio $r_h$ for such spreading region at the beginning of expansion of the very early Universe

$$r_h = (\Delta m / 3) / (\Delta E + \Delta m / 3) \approx 0.10. \quad (3)$$

**3. Summary**

Here we described the production of the $E$- and $B$-modes in the CMB. The obtained result about $0.22$ for the ratio of amplitudes of the $B$-modes to $E$-modes (i.e. the tensor-to-scalar ratio) for the beginning of expansion of the very early Universe, for multipole moment equal to $384$, is close to the central value in the BICEP2 data. The tensor-to-scalar ratio depends on density of the Einstein-spacetime and is higher for higher densities. The calculated energies carried by the Einstein-spacetime components the spreading condensates were built of (such condensates produced the $B$-modes in the CMB), were about $10^{16}$ GeV.

The $E$- and $B$-modes production is not directly associated with the period of inflation. It is associated with the phenomena at the beginning of expansion of the very early Universe, respectively, with the swelling protogalaxies composed of the modified neutron black holes (it was caused by inflows of the dark matter) and with the spreading curling condensates in which the spins of the Einstein-spacetime components were aligned and parallel. The condensates behaved as curling magnetized ferromagnetic.

There are not in existence the gravitational waves because gravitational fields are the gradients produced in the superluminal non-gravitating Higgs field.

**References**

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