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12 The Hypothesis of Unity of the Higgs Field With the Coulomb Field

E.G. Dmitrieff *

29 88 Postyshev bvd., Irkutsk, Russia

Abstract. In this discussion we propose a hypothesis about the physical unity of the Coulomb field and the Higgs field, which leads to the concept of physical vacuum with the periodic domain structure. Estimating the domain radius and the thickness of cross-domain wall in the spheric approximation, we find them both about 10^{-21} m.

Povzetek. V diskusiji avtor obravnava hipotezo fizikalne povezanosti Coulombskega in Higgsovega polja, kar vodi k fizikalnemu vakuumu s periodično strukturo domen. Za radij domene in debelino sten med domenami dobi oceno reda 10^{-21} m.

12.1 Introduction

Developing the model of vacuum and fundamental particles, that is based either on boolean algebra objects or spatial polyhedral tessellations, we were looking for a physical structure in the Nature, which would behave like a discrete field of binary digits, or as a foam with electrically charged near-to-polyhedral cells. Combining the ideas of vacuum domains [1], Kelvin problem of minimal-surfaced foam [2] and its best solution [3], and specific alteration of electric charges in our model [4], we supposed the following model of the physical vacuum.

12.2 United Higgs - Coulomb field

We suppose that scalar Higgs field and field of Coulomb scalar potential are the same physical entity. Also we suppose that the complex phase of Higgs field is limited to 0 and π (like angle in sphere S_0), forming just real values, positive and negative. In this case, the only possibility to get from positive to negative value and back, is to go through zero value.

The space, being in average electrically neutral, in this case would be either structureless 'empty space' with $\varphi = 0$ everywhere (may be, with fluctuations), or the mixture of pieces, or domains [1], having different and alternating values of this field.

Following the effective energy density of Higgs field as

$$V(\varphi) = \lambda^2(\varphi^2 - \eta^2)^2, \tag{12.1}$$

* eliadmitrieff@gmail.com

in empty space phase it would be positive: $V = \lambda^2\eta^4$.

Inside domains, where the potential keeps near $\pm\varphi$, the electrical field and energy density is about zero.

Near the walls between domains, the potential changes from positive to negative value – or back – through zero. So the walls will have extra energy, since zero potential corresponds to local maximum of effective energy density.

The electric charge in this case will be distributed mostly along the walls, causing pieces to be charged.

12.3 Evaluation of characteristic structure sizes

Equating the expression of potential for the charged sphere with radius r to the vacuum expectation value [5]:

$$\frac{q}{4\pi\varepsilon_0 r} = \eta \approx 246\text{GeV}, \tag{12.2}$$

we estimate the domain size:

$$r = \frac{q}{4\pi\varepsilon_0\eta} = \frac{qc^2}{10^7\eta} = \frac{ec^2}{6\cdot 10^7\eta}; \tag{12.3}$$

$$r = \frac{1.602\cdot 10^{-19}\cdot 2.998^2\cdot 10^{16}}{6\cdot 10^7\cdot 246\cdot 10^9} = 9.755\cdot 10^{-22} \approx 10^{-21}\text{m}. \tag{12.4}$$

As the value of charge q we use $\frac{1}{6}e$ since it is the charge carried by one b-type bit in our 8-bit model.

The wall between pieces can be treated as a charged capacitor. Equating the capacity of the spherical capacitor with the charge to potential ratio:

$$C = \frac{q}{\eta} = \frac{4\pi\varepsilon_0 r^2}{d} = \frac{10^7 r^2}{dc^2} = \frac{q^2c^2}{10^7 d\eta^2}, \tag{12.5}$$

we express d to estimate the wall width, which occurs equal to r:

$$d = \frac{qc^2}{10^7\eta} = r \tag{12.6}$$

12.4 Spontaneous origination of the structure

Probably, the Coulomb character of field causes the instability of domains with radius larger than r: being charged, the different parts of any domain would experience the Coulomb repulsion from each other, so the domain would trend to split into smaller parts. Since this process increases the specific square of inter-domain walls surface, it also leads to increased Higgs energy. So the fragmentation must stop when the Higgs energy equals to Coulomb one.

In this case, the model is supposed to be isomorphic with the solution of the Kelvin problem [2], that is about of the minimal-surfaced foam of bubbles with equal volume. The 'air' phase corresponds to volumes, and 'liquid' phase corresponds to walls.

Because of equality of the estimated cell radius to the wall width, the potential is probably changes smoothly in a function close to a sine wave, forming no sharp walls.

The best known solution of Kelvin problem is the foam with Weaire-Phelan structure [3]. We found that this structure has two variants of optimal charge alterations, with different handedness. This providing possibility for the asymmetric baryogenesis.

12.5 Beyond the Standard Model

According to our models [4] and the assumptions noted above, vacuum probably has a structure of periodic Weaire-Phelan foam with alternating positive and negative charged cells, and the single or multiple anti-structure defects in it are experimentally observed as fundamental particles. Their properties are determined by the defect count and structure.

We also suppose that the vacuum structure may experience distortion and wave processes, that are relevant to the phenomena of gravity.

References

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