РОССИЙСКАЯ АКАДЕМИЯ НАУК

ПИСЬМА В ЖУРНАЛ ЭКСПЕРИМЕНТАЛЬНОЙ И ТЕОРЕТИЧЕСКОЙ ФИЗИКИ

ОСНОВАН В 1965 ГОДУ — *ТОМ 66, ВЫПУСК 8*
ВЫХОДИТ 24 РАЗА В ГОД — *25 ОКТЯБРЯ, 1997*

Pis'ma v ZhETF, vol.66, iss.8, pp.513 - 514 © 1997 October 25

ON THE THICKNESS OF THE SKIN LAYER FOR THE SCREENING OF LEPTONIC CHARGE OF A BODY

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Submitted 15 September 1997

The problem of the skin layer for the screening of leptonic charge of a body by condensed bosons is considered.

PACS: 11.15.-q, 67.90.+z

The authors of papers [1-3] have considered the possible existence of leptonic (electronic) photon for a range of values of leptonic charge. They discussed the possibility that light stable scalar bosons may, in contrast to fermions (antineutrinos), neutralize the electron repulsion in condensed bodies. For this purpose in ref.[3] the problem of the skin layer for bosons was compared with that for the fermions. According to [3] the thickness of the skin is of the order of the Compton wave length of the boson. As we will argue this statement cannot be corret in all cases. In fact, this thickness should depend on the leptonic coupling constant(α_l), the density of electrons in the condensed body (n) and the mass of the boson (m) in the combination we are going to discuss in this paper.

Let us follow the paper[3] and consider condensed bosons near a surface of a solid body. They are described by the field Φ. This field $\Phi = e^{-iEt}\phi$ and the leptostatic potential A_0 are the solutions of field equations

$$(E + gA_0)^2\phi + \Delta\phi = m^2\phi, \tag{1}$$

$$-\Delta A_0 = gn - g2(E + gA_0)\phi^2. \tag{2}$$

Here $g = \sqrt{4\pi\alpha_l}$, E is the lowest energy of the bosons. Let $A_0 = 0$ inside the body, so A_0 outside the body will represent the jump of the potential across the skin layer. In what follows we will consider two cases: nonrelativistic and relativistic approximations for eqs.(1),(2). As we will see the approximation depends on the value of the dimensionless parameter $\gamma = (\alpha_l n/m^3)^{1/3}$.

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First, let us consider the case when $gA_0 << m, E = m+\delta E, \delta E << m$ (nonrelativistic approximation). Then we get from eq.(1)

$$\delta E\phi \approx (-\frac{\Delta}{2m} - gA_0)\phi \tag{3}$$

and from eq.(2)

$$-\Delta A_0 \approx gn - g2m\phi^2. \tag{4}$$

Using only dimensional considerations we can determine from above equations the dependence of the thickness of the transition region d and the jump of the potential energy of the boson gA_0 on the parameters of the model:

$$d \sim (\alpha_l nm)^{-1/4}, gA_0 \sim (\alpha_l n/m)^{1/2}. \tag{5}$$

Our approximation $gA_0/m << 1$ means that $\gamma = (\alpha_l n/m^3)^{1/3} << 1$. Then, $1/md \sim$ $\sim (\alpha_l n/m^3)^{1/4}$ and $d >> 1/m$, contrary to ref.[3].

Second, let us consider the case $m \to 0$ ($m << (\alpha_l n)^{1/3}, \gamma >> 1$). Neglecting m in eqs.(1),(2) we get the following formulae for d and gA_0 (we do not consider here the problem of the existence of the solution; in one special case[4] the solution was found numerically):

$$d \sim (\alpha_l n)^{-1/3} << 1/m, gA_0 \sim (\alpha_l n)^{1/3}. \tag{6}$$

Looking at the expressions for d (5),(6) in two limiting cases we see that $d \sim$ $\sim \gamma^{1/4}(\alpha_l n)^{-1/3}$ (nonrelativistic case, $\gamma << 1$) and therefore $d \sim (\alpha_l n)^{-1/3}$ (relativistic case) is the largest possible value of the thickness of the skin layer for all m. Let us compare it with the critical size of the grain with unscreened electrons [3] $r_c \sim \alpha/\alpha_l^{1/2} n^{1/3}$

$$d/r_c \sim \alpha_l^{1/6}/\alpha. \tag{7}$$

We see that for $\alpha_l < 10^{-12}$ $d < r_c$ and the skin layer is stable against the process of "peeling" [3].

In conclusion, using only dimensional arguments we have estimated the size of the skin layer of leptonically charged body screened by hypothetical light bosons. It seems reasonable that the thickness of the skin layer is smaller than $(\alpha_l n)^{-1/3}$ and the "peeling" of the surface of the body does not occur for $\alpha_l < 10^{-12}$. It is obvious that the problem needs further investigations from the point of the existence of solutions for eqs.(1),(2).

The author acknowledges the stimulating discussions with L.B.Okun and critical remarks by M.B.Voloshin.

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