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RELATIVISTIC RAPPROCHEMENT OF WEAK AND STRONG INTERACTIONS

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Based on the Lienard-Wiechert potential and the relativistic Yukawa one for pion and quark fields it has been found early [1] that the corresponding interactions increase differently with growing energy (the electromagnetic one increases more rapidly). According to the estimates, at distances of the «action radius» of nuclear forces (μ^{-1}) the interaction potentials of electromagnetic and nuclear (quark) fields are compared at $\gamma \cong 960$, where γ is the Lorentz-factor. However, it is more right to compare the interaction energy. As a result we have $\gamma \cong 2 \cdot 10^6$ instead of the previous value.

Remind that according to contemporary representations, hadrons consist of quarks, which interact between themselves by gluon exchange, and so just quarks define in fact the behaviour of the «boundary region» of hadrons*. Taking into account an effective growth of transversal sizes of moving hadrons allows one to explain the known increase of interaction cross sections at high energies [2]. For the spinor field the Yukawa relativistic potential takes the form

$$\phi_q = g_q \frac{\sqrt{u^0+1}\,\exp(-\mu_q u^i R_i)}{\sqrt{2}\,u^i R_i}\,. \tag{1}$$

Here μ_q is the mass of constituent quark; u^i, the 4-velocity of hadrons ($u^0 \equiv \gamma$); R^i, the 4-vector of retarded distance; $h = c = 1$. Below we assume for simplicity that $g_q \approx g_\pi$ and $\mu_q \approx 2\mu$.

According to the modern electroweak theory, weak interactions are conditioned by the exchange of $W^{\pm}$- and Z^0-bosons just as electromagnetic ones are due to photon exchange. For this the weakness and a small radius of weak interaction is explained by that W- and Z-bosons are very heavy particles (m_w, $m_z \sim 80$, 90 GeV). The time component of the relativistic (vector) Yukawa potential [3] of weak interaction is

$$\phi_w = g_w \frac{u^0 \exp(-m_w u^i R_i)}{u^i R_i}\,. \tag{2}$$

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*The pions, as one considers, are produced as a result of hadronization only at the very «boundary» of hadrons. As, on the other hand, for constituent quarks $\lambda_q \approx 0.7F$ (compare with $\lambda_\pi \approx 1.4F$), then exactly quarks — these are to some extent «hidden parameters» — might mainly define the short-range action of nuclear forces.

Here a «weak charge» is defined by equality $g_w^2 = G_F M^2$, where G_F is the Fermi constant and the proton mass.

Leaning upon eqs. (1) and (2), we obtain for the interaction energy the ratio

$$a_q^w = U_w/U_s \cong (g_w^2/g_\pi^2)\sqrt{2\gamma}\ \exp\left[-m_w R(1-\beta\cos\theta)\gamma\right], \qquad (3)$$

where β is the velocity of a field source; θ, the angle between vectors **R** and β. In the "forward" direction, where the effect is maximum, taking into account that $\beta \cong 1$ and $m_w \cong 600\mu$, we have

$$a_q^w \cong 10^{-6}\sqrt{\gamma}\ exp(-300\mu R/\gamma)\ . \qquad (4)$$

Based on (4), we conclude that the rapprochement of weak and strong interactions must occur at $\gamma \cong 10^{12}$*. For nucleons this answers an energy of $E_{ws} \cong 10^9$ TeV which is considerably greater than E_{es}, but all the same smaller than the energy in the model of «grand unification». Note also that at E_{ws} for the ratio analogous to (4) we obtain $a_s^e \cong 700$, i.e., the electromagnetic interaction and strong one charge their places (compare $a_e^s(\gamma = 1) \cong 300$)). The calculation results of the energy ratio of the weak and strong interactions (for quark and pion field) are listed in Table 1. The analogous ratio for the electromagnetic and strong interaction energies are presented in Table 2.

Table 1

γ	1	10^3	10^4	10^5	10^6	10^8	10^{10}	10^{12}
a_q^w	0	$3\cdot10^{-5}$	10^{-4}	$3\cdot10^{-4}$	10^{-3}	10^{-2}	0.1	1
a_π^w	0	10^{-3}	10^{-2}	0.1	1			

Table 2

γ	1	$2\cdot10^3$	10^4	10^5	$2\cdot10^6$
a_q^e	$4\cdot10^{-3}$	$3\cdot10^{-2}$	$7\cdot10^{-2}$	0.2	1
a_π^e	10^{-3}	1			

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*We should have $\gamma \cong 10^6$ for the pion field.

It is interesting to mark that for $\gamma \cong 10^6$ at a distance ~1Å the weak interaction reaches the quantity of the «static» electromagnetic one. As a result, the production of «weak» hydrogen atom (with neutron instead of proton) becomes in principle possible.

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