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IS THERE A POSSIBILITY OF A NEW ABELIAN GAUGE FORCE?

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A question is considered, whether there might exist a new Abelian vectorlike gauge force, stronger than the electromagnetic one, that could still be hidden from us in the structure of matter, more precisely, in the structure of quarks which would be then composite. The Abelian character of such a hypothetical force may open wide experimental perspectives. At low energies, the main consequence of this force would be a new magnetic-type spin-spin interaction of nucleons (stronger than the magnetic one) which could manifest itself (even macroscopically) in polarized nucleon systems.

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If the Sommerfeld constant α were larger than its actual value and the spontaneous magnetization of ferromagnets not so easy as it is, the electromagnetic phenomena would be less visible in our everyday life than they are, being hidden deeper in the structure of atoms, molecules and solids. In this note we consider a rather provocative question, whether there might exist in Nature a new Abelian vectorlike gauge force, stronger than the electromagnetic one, that could be still hidden from us in the structure of matter. Obviously, this question is intimately related to the problem of possible compositeness of the so-called elementary particles, first of all leptons and quarks [1, 2]. For the sake of convenience we shall call such a new hypothetical force the *ultraelectromagnetic force*[1].

The ultraelectromagnetic force would be transmitted through the *ultraelectromagnetic field* generated by a new Abelian charge — call it *ultracharge* — according to new Maxwell-type equations. The new massless gauge boson might be referred to as the *ultraphoton* Γ.

It is natural to assume that all presently known particles are neutral with respect to the hypothetical ultracharge. But, some of them may be composed of ultracharged subconstituents (preons) whose ultracharges are then mutually neutralized. Note, however, that

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[1] An alternative prefix "super" used previously in Ref. [3] (where this force was introduced) may be somewhat misleading as having nothing to do with supersymmetry. Besides, the present discussion is less model-dependent.

ultracharge-neutral fermions, if composed in this way, are expected to possess some nonzero *ultramagnetic moments* because of the Abelian character of ultraelectromagnetic force. So, even in the point-like limit, such fermions can interact with the part of ultraelectromagnetic field that may be called the *ultramagnetic field*, while the corresponding part of the ultraelectromagnetic force may be referred to as the *ultramagnetic force*. It follows that macroscopic polarized systems of composite fermions of this kind could be used to create and detect the ultramagnetic field in laboratory.

Since the ultraelectromagnetic constant α_u is presumed to be larger than the electromagnetic constant α, the generic ultramagnetic moments are expected to prevail over the magnetic moments of the same composite fermions. It may be reasonable to assume that leptons avoid possessing large ultramagnetic moments simply because they are elementary. On the other hand, assuming that quarks are composed of ultracharged preons, we must take into account the existence of quark ultramagnetic moments larger than the quark magnetic moments (but much smaller than the electron magnetic moments). In this case also nucleons, as being composed of quarks, should have ultramagnetic moments of considerable magnitudes. For instance if $\alpha < \alpha_u \leqslant 2$, the proton ultramagnetic moment is expected to be larger than the proton magnetic moment by a factor of the order of $1 < (\alpha_u/\alpha)^{1/2} \leqslant 16.6$, but smaller than the electron magnetic moment by a factor of the order of $0.000545 < (\alpha_u/\alpha)^{1/2}(m_e/m_p) \leqslant 0.00902$.

In nucleon systems, our new interaction of nuclear ultramagnetic moments with ultramagnetic field contributes a long-range part to the effective spin-spin interaction whose short-range part is provided by conventional meson exchanges. Another long-range parts is contributed by the magnetic spin-spin interaction (for nucleons, the ultramagnetic spin-spin interaction is expected to be stronger than the magnetic one but similar to it as far as the distance-dependence is concerned). Of course, in order to create and detect the ultramagnetic field in laboratory one needs macroscopic polarized nucleon systems. In principle, by measuring the mutual interaction between two such polarized systems one can test macroscopically the existence of the ultramagnetic force.

Due to the Abelian character of the ultraelectromagnetic force the ultracharged preons would not be confined (nor asymptotically free) within quarks, although their ultraelectromagnetic binding should be rather strong. The stronger this binding, the better description of hadronic phenomena is provided by the *effective QCD* operating with composite quarks (coupled to gluons assumed to be elementary). This description includes the effective confinement of quarks (and their asymptotic freedom) within hadrons below a high--energy threshold. However, the fundamental theory of hadron phenomena is provided by a union of the *basic QCD* operating with those of the ultracharged preons that carry also color (coupled to gluons), and the new Abelian *quantum ultraelectrodynamics*. Of course, the basic QCD implies the confinement of colored preons (and their asymptotic freedom) within hadrons or within other possible colorless composite systems that may arise in hadron collisions.

Thus, the vertical group structure of our theory is

$$SU_L(2) \otimes U_Y(1) \otimes SU_c(3) \otimes U_u(1). \tag{1}$$

where all electroweak bosons as well as gluons and ultraphoton are treated as elementary. Here, $U_u(1)$ denotes the gauge group of ultracharge. For ultracharge-neutral particles this group structure reduces to the standard model structure $SU_L(2) \otimes U_Y(1) \otimes SU_c(3)$, except for the interaction of quark ultramagnetic moments with the ultramagnetic field involved in the group factor $U_u(1)$ in Eq. (1).

But, at high enough energies the ultracharge-neutral quarks can split within hadrons into ultracharged preons, leading to splitting of hadrons into some ultracharged (though always colorless) debris, possibly accompanied by ultraphotons. Such a splitting may be called the *ultraionization* of hadrons. The ultracharged debris, if decelerated in matter, can also produce ultraphotons in the process that may be referred to as *ultrabremsstrahlung*.

At some high energies there is also another possibility of destroying the quark structure of hadrons by a rearrangement of ultracharged and coloured preons within hadrons, resulting into some excited hadronic *isomers* without their prompt splitting into any debris. Energies needed to produce hadronic isomers may be considerably lower than the hadron ultraionization energies.

The above general picture of ultracharge-neutral quarks composed of ultracharged preons bound by ultraelectromagnetic attraction may be exemplified in the following model. Assume that in Nature, beside the usual elementary leptons of $N \geqslant 3$ generations, $\nu^{(n)}$ and $e^{(n)}$ ($n = 1, \ldots, N$), there are elementary colorless spin-1/2 *ultraleptons* $U^{(n)}$ and $D^{(n)}$ ($n = 1, \ldots, N$) with charges 1 and 0, respectively, carrying additionally the ultracharge -1. Assume further that there exists also an elementary color triplet of spin-0 bosons Φ with the charge $-1/3$, possessing additionally the ultracharge 1. Then, the colorless preons $U^{(n)}$ and $D^{(n)}$ can be bound with the colored preons Φ into up and down quarks of $N \geqslant 3$ generations,

$$u^{(n)} = \Phi U^{(n)}, \quad d^{(n)} = \Phi D^{(n)} \tag{2}$$

by means of the ultraelectromagnetic attraction[2].

In this model, the intrinsic quantum numbers of leptons and preons can be listed as follows:

	spin	Q	L	B	color	ultracharge	$I_3^{(L)}$	Y
$\nu^{(n)}_{L,R}$	1/2	0	1	0	**1**	0	1/2, 0	−1, 0
$e^{(n)}_{L,R}$	1/2	−1	1	0	**1**	0	−1/2, 0	−1, −2
$U^{(n)}_{L,R}$	1/2	1	−1	0	**1**	−1	1/2, 0	1, 2
$D^{(n)}_{L,R}$	1/2	0	−1	0	**1**	−1	−1/2, 0	1, 0
Φ	0	−1/3	1	1/3	**3**	1	0	−2/3.

Here,

$$Q = I_3^{(L)} + \tfrac{1}{2} Y, \quad \tfrac{1}{2} Y = I_3^{(R)} + \tfrac{1}{2}(B - L) \tag{3}$$

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[2] The hypothesis that quarks can be factorized into a flavored part of spin 1/2 and a colored part of spin 0 was put forward already in Ref. [4]. Cf. also Refs [1, 2].

with the obvious values of $I_3^{(R)}$. Notice that the model is anomaly free since leptons and ultraleptons have opposite hypercharges Y, while the lefthanded ultraleptons and lefthanded antiultraleptons form a real (reducible) representation of the vectorlike group $U_u(1)$.

To set in this particular model an example of ultraionization of hadrons at some high energies we may consider the process

$$p+p \to p+\Phi(\Phi U)(\Phi D)+U, \tag{4}$$

where colliding protons have the structure $p = (\Phi U)(\Phi U)(\Phi D)$ with U and D denoting the ultraleptons of the first generation $n = 1$. The ultralepton U, if decelerated in matter, can produce an ultraphoton Γ that may in turn cause the ultraionization of a target nucleon, for example

$$\Gamma+p \to \Phi(\Phi U)(\Phi D)+U. \tag{5}$$

In our model, the proton $p = (\Phi U)(\Phi U)(\Phi D)$ and the neutron $n = (\Phi D)(\Phi D)(\Phi U)$ may be excited at some high energies to the isomeric states

$$p^* = (\Phi\Phi\Phi)UUD, \quad n^* = (\Phi\Phi\Phi)DDU, \tag{6}$$

where a colorless core $(\Phi\Phi\Phi)$ is surrounded by three colorless ultraleptons bound by ultra-electromagnetic attraction. Of course, the wave function of the colorless configuration $(\Phi\Phi\Phi)$ of three color-triplet bosons Φ ought to include a fully antisymmetrical orbital factor $f(\vec{r}_1, \vec{r}_2, \vec{r}_3)$ built up of two relative coordinates $\vec{r} = \vec{r}_1 - \vec{r}_2$ and $\vec{\varrho} = \vec{r}_3 - \frac{1}{2}(\vec{r}_1 + \vec{r}_2)$. In the case of spin-0 ground state of $(\Phi\Phi\Phi)$ one can try the ansatz

$$f(\hat{r}_1, \hat{r}_2, \hat{r}_3) = P_1(\hat{r} \cdot \hat{\varrho})R(r, \varrho)$$
$$+ \text{ two cyclic permutations of } \vec{r}_1, \vec{r}_2, \vec{r}_3, \tag{7}$$

where $\hat{r} = \vec{r}/r$ and $\hat{\varrho} = \vec{\varrho}/\varrho$, whilst $P_1(x)$ is the Legendre polynomial of the order 1 that is the lowest possible odd order (here, $\vec{L}f = 0$ with $\vec{L}$ being the total orbital angular momentum of $(\Phi\Phi\Phi)$).

Note finally that the high-energy interaction between a nucleon and a nucleon isomer (appearing e.g. in intermediate states in high-energy nucleon collisions) is dominated by the ultramagnetic force since the constituents of p and n are ultracharge neutral, while the constituents of p^* and n^* are colorless (but in both cases the fermionic constituents carry ultramagnetic moments). It is natural to expect that the important part of this force is an ultramagnetic spin-orbit interaction because the constituents of p^* and n^* carry ultracharges and so can have orbital ultramagnetic moments. The above mechanism enhances the role of spin-dependent part of nucleon-nucleon elastic cross-section, especially above the threshold for production of a real nucleon isomer in intermediate states.

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