Decay of proton into Planck neutrinos at the Planck scale

D.L. Khokhlov

Sumy State University (Retired), R.-Korsakov St. 2
Sumy 40007 Ukraine
E-mail: dlkhokhl@rambler.ru

Abstract

Gravitational interaction is considered with use of the universal charge. Gravitational wave is defined as a tenzor electromagnetic like wave of the Planck mass called Planck field. Through the Planck field, the proton decays into the hypothetical Planck neutrinos. The lifetime of proton is decreasing with the energy of proton. The possibility of detection of the decay of proton at LHC is discussed.

In general relativity [1, 2] gravitational wave is considered within the framework of linearized theory in the flat background space. Canonical quantum gravity [3] starts with the Lagrangian of the Einstein theory

$$L = -\frac{1}{2k^2}\sqrt{-g}R \tag{1}$$

where k is the gravitational coupling in mass unit, $\hbar = c = 1$, $\hbar$ is the Planck constant, c is the speed of light. The metric is given by

$$g_{ik} = \eta_{ik} + kh_{ik} \tag{2}$$

where η_{ik} is the Minkowski metric, h_{ik} is a weak perturbation. Quantization of h_{ik} yields massless field of spin 2 propagating with the speed of light.

In [4] the concept of gravitational wave in the theory with the universal charge was considered. The Newton constant may be cast in the form

$$G = \frac{g^2}{m_{Pl}^2} \tag{3}$$

where $g = (\hbar c)^{1/2}$ is the universal charge, $m_{Pl} = (\hbar c/G)^{1/2}$ is the Planck mass. The electromagnetic charge e (charge of electron) and the charge g are related via the fine structure constant as $e^2 = \alpha g^2$. It is worth noting that the effective electromagnetic charge is a growing function of the transferred momentum q. Within the framework of quantum field theory [5] the representation of the Newton constant eq. (3) may be interpreted such that the gravitational interaction is governed by the universal charge at the Planck scale. The interaction occurs via the intermediate field of the Planck mass. We shall consider the theory of gravitation with the universal charge g. To this end, the concept of the universal charge g was under discussion, e.g. [8, 9] and references therein.

Assume that all fermions carry the universal charge g. Consider a toy model of proton consisting of positron and four hypothetical partons

$$p = e^{+}gggg \tag{4}$$

where g denotes the parton of the charge g and spin 1/2. Suppose that the total spin of four partons is equal zero and the total momentum of four partons in the frame of a proton is equal zero. It is worth noting that in the theory of strong interaction [5] proton is considered as a combination of three quarks. We shall not touch the question of the interplay of quarks and partons of charge g.

Consider interaction of four partons via the intermediate field of the Planck mass of spin 2. We shall consider the interaction of the partons separated by the Compton radius of proton, $r_c = \hbar/m_p c$ where m_p is the mass of proton. Since the total momentum of four partons in the frame of a proton is zero one can think of the intermediate field as a combination of two vector fields with the opposite momenta, with null total momentum of the intermediate field. That is one can interpret the intermediate field as a standing wave

$$Pl = \vec{A}_l \vec{A}^m (e^{ikr} + e^{-ikr})/\sqrt{2}. \tag{5}$$

At low energies $q^2 << m_{Pl}^2$, the propagator of the intermediate field reduces to

$$\frac{g^{\lambda\sigma} - q^\lambda q^\sigma / m_{Pl}^2}{q^2 - m_{Pl}^2} \to \frac{g^{\lambda\sigma}}{m_{Pl}^2}. \tag{6}$$

In view of eq. (6) the Lagrangian of interaction of four partons at the Compton radius of proton governed by the universal charge at the Planck scale may be cast in the form

$$L = \frac{g^2 m_p^3}{m_{Pl}^2} \Psi_2^\dagger \Psi_1 \Psi_4^\dagger \Psi_3 = G m_p^3 \Psi_2^\dagger \Psi_1 \Psi_4^\dagger \Psi_3 \tag{7}$$

where Ψ denotes the wave function of parton. The Lagrangian eq. (7) may describe self-gravity of proton. The interaction may be interpreted in terms of the effective charge $g m_p / m_{Pl}$. In the classical theory one can think of the Newtonian gravity as an interaction of the effective charges $g m_p / m_{Pl}$.

Assume that the proton may decay into some hypothetical field (call it Planck neutrino) via the intermediate field of the Planck mass

$$e^+ gggg \to e^+ + Pl \to e^+ + 4\nu_{Pl} \tag{8}$$

where ν_{Pl} is the Planck neutrino. The Lagrangian eq. (7) may describe the decay of partons into Planck neutrinos provided that the incoming wave functions denote partons, and the outgoing wave functions denote Planck neutrinos. We shall consider the theory at low energies, $q^2 << m_{Pl}^2$, thus handling the Planck field as a virtual one. We shall think of the Planck neutrino as a massless particle of spin 1/2 propagating with the speed of light. As known [5] the standard model regards three sorts of neutrinos being partners of three lepton such as electron, muon, tauon respectively thus forming three generations of leptons. Each sort of neutrino carries the quantum number labeling lepton generation which defines the corresponding current. It is natural to believe that the Planck neutrino carries the quantum number which distinguishes the Planck neutrino from the other three neutrinos, and this number defines the parton to Planck neutrino current. To this end, the decay of proton at the Planck scale was addressed in [10, 11].

In general relativity gravitational wave carries gravitational potential. In the theory with the universal charge one can define the tenzor electromagnetic like potential

$$\phi_{ik} = gk \frac{m}{m_{Pl}} \mathrm{e}_{ik} \tag{9}$$

where k is the wave vector, e_{ik} is the unity polarization tenzor. One can consider gravitational wave as a tenzor electromagnetic like wave carrying the potential ϕ_{ik}, with the energy-momentum tenzor of the wave

$$T_{\mu\nu} = \frac{1}{32\pi} \phi^{TT}_{jk,\ \mu} \phi^{TT}_{jk,\ \nu} \tag{10}$$

where $= \phi^{TT}_{jk}$ is the transverse traceless part of $\phi_{\mu\nu}$ which in TT gauge coincides with ϕ_{jk}.

Acceleration of the system of the charges g may generate the quadrupole emission at the Planck scale. When considering the quadrupole moment of the effective charge gm/m_{Pl} one can obtain the formula for quadrupole emission [4] the same as in the Einstein theory [1, 2]. It is worth noting that for the system of the charges g the dipole emission is absent as the charge to mass ratio is the same for all the charges.

One can identify the above described gravitational wave with the intermediate field of the Planck mass of spin 2. Owing to the foregoing reasoning one can use the quadrupole mechanism of generation of the electromagnetic like wave at the Planck scale. Within the Planck time the gravitational wave decays into four Planck neutrinos of spin 1/2. We come to the concept of gravitational radiation as Planck neutrinos. In the approach proposed the gravitational emission is defined as the quadrupole emission of the charge g at the Planck scale which is the same as the quadrupole gravitational emission in general relativity thus it is in accord with the observations of the binary radiopulsar PSR1913+16 [6]. Gravitational radiation as Planck neutrinos does not generate quadrupole oscillations when passing through the detector. Non-detection of gravitational waves in the LIGO and other projects [7] may be considered as an indirect evidence for the approach proposed.

The lifetime of proton relative to the decay into Planck neutrino is defined by the Lagrangian (7) as

$$t_p = t_{Pl} \left(\frac{m_{Pl}}{2m_p} \right)^5 \tag{11}$$

where the factor 2 is due to spin 2 of the Planck field. This yields the lifetime of proton, $t_p = 2.0 \times 10^{43}$ yr. For interacting relativistic protons in the collider, the lifetime of proton is a function of the energy of proton released in the interaction, $t_p \propto E_p^{-5}$. We shall estimate the probability to register the decay of proton in the LHC. The nominal energy of proton in the LHC is 7 TeV [12]. This yields the lifetime of proton, $t_p = 0.9 \times 10^{24}$ yr. Each proton beam at full intensity in the LHC [12] consists of 2808 bunches, each bunch contains 1.15×10^{11} protons, and the number of protons 3.2×10^{14} per beam. Hence, the probability to register the decay of proton in the LHC is 3.6×10^{-10} per year which is negligible.

In conclusion, we have considered gravitational wave in the theory with the universal charge $g = (\hbar c)^{1/2}$. Gravitational wave is defined as an intermediate field of the Planck mass (Planck field) under interaction of the partons of proton. The interaction may describe self-gravity of proton in terms of the effective charge gm_p/m_{Pl}. One can consider gravitational wave as a tenzor electromagnetic like wave carrying the potential gkm_p/m_{Pl}. Also, the interaction may describe the decay of the partons into the hypothetical Planck neutrinos which are identified as gravitational radiation. In the approach proposed the gravitational emission is the same as in general relativity thus it is in accord with the observations of the binary radiopulsar PSR1913+16 [6]. Gravitational radiation as Planck neutrinos may explain non-detection of gravitational waves in the LIGO and other projects [7].

The lifetime of proton relative to the decay into Planck neutrino is $t_p = 2.0 \times 10^{43}$ yr. For interacting relativistic protons in the collider, the lifetime of proton is a function of the energy of proton released in the interaction, $t_p \propto E_p^{-5}$. For the nominal energy of proton in the LHC 7 TeV, the lifetime of proton is $t_p = 0.9 \times 10^{24}$ yr. This yields the negligible probability to register the decay of proton in the LHC.

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