ON THE COSMOLOGICAL CONSEQUENCES OF PROTON DECAY

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Recognizing identical dependence of both gravitational and electromagnetic forces from distance ($1/r^2$), as well as Maxwell's success with respect to his unification of electric and magnetic interactions in the theory of unified electromagnetic interaction, Einstein spent a great part of his lifetime studyind the possibility of unifying gravitational and electromagnetic interactions. Though most of physicists consider the basic idea of unification of all interactions should be the right one, it is more and more clear today that it was far from any success in Einstein's time, both because many of the important experimental data were unknown and, also, because the way to make it operable by further generalization of Einstein's theory of gravitation seems to be hardest one, if not impossible.

The contemporary fast progress of high-energy experimental physics, followed and preceeded by the fast development of the theory of elementary particles, opened a new way toward unification of interactions[1], which is fundamentally easier than Einstein's way, because it is within the scope of experimental checking. That way started with Weinberg-Salam unification of electromagnetic and weak interactions, which is supported by available experimental data, awaiting however final experimental tests in the discoveries of three bosons (W^+-and Z^0) at energy possibly as high as 300 GeV. Besides of this unification of electromagnetic and weak interactions within the quantum flavordynamics (QFD), the discovery of color-charge opened a way toward a new theory of strong interaction, so-called quantumchromodynamics (QCD), which is based on Gell-Mann's ideas. Giorgy and Glashow, however, tried to find a way for the unification of electromagnetic, weak and strong interactions, for which the first encouragment came from the experimental discovery of Υ boson at 9.46 GeV, as predicted for boson made of bottom quarks pair.

There are several groups candidating to be the basis for the theory of unified interactions. Simplest of them, SU(5) predicts the existance of 24 field bosons: photon, 3 W bosons, 8 gluons and 12 leptoquarks. The leptoquarks, however, possess a new remarkable property: they mediate the transformation of quarks into leptons. This resulted in a prediction that the proton may decay giving a positron and a neutral pion, the positron and pion coming out with roughly 500 MeV energy each.

The proton decay is theoretically predicted with $T_{1/2}$ as long as 10^{31} - 10^{34} years. The attempts are being made to detect this decay in the experiments involving the registration of corresponding coincident pulses from Cherenkov detectors observing an underground pool with several thousends tons of water. Such experiment is likely to detect proton decay in 1-2 years if $T_{1/2} \approx 10^{31}$ years; however, if $T_{1/2}$ is nearer to 10^{34} years we may wait a long period before this decay is proved in a direct experiment.

For that reason, it might be useful to investigate if there are some cosmological indications of the proton decay. From the contemporary cosmological theories and observations, one may take the data for the radius of universe $R \approx 3x10^{28}$ cm and the density of universe $\rho \approx 10^{-30 \pm 1}$ g/cm^3. What observable effects could result from 10^{45} - 10^{50} proton decays in the universe per year?

In general, the final result of proton decay is the slow increase of gamma radiation everywhere in the universe. This effect is, however, unobservable, though the general presence of gamma radiation within the universe, coming from other physical mechanisms, does not contraindicate the proton decay.

The simplest consequance of proton decay is the emission of high energy positrons from any cosmic object, which leaves that object negatively charged. However, the care must be taken that 500 MeV positrons do have a limited range in any material and only those positrons coming from the periphery of cosmic objects may be emitted toward the surrounding space. Also, the density distribution within any object may govern the existance of a gradient of charge density and the formation of electric field within such cosmic object. Here, the considerations are made for typical cosmic objects: a planet (Earth), a star (Sun), a galaxy (the Galaxy) and the universe as whole.

Starting with a star (Sun), it is easily seen that 500 Mev positrons coming from the Sun surface are not bound by gravitation-however they would become bound by the negative Sun charge after some 200 milion years of positron emision, if this would be the only physical effect at the surface. However, a continual compensation of Sun's negative sharge is made by the emision of low energy electrons from the Sun surface. The destiny of these low energy electrons is to be trapped within the inter-planetary dust, what is inevitable if one takes into account the data for this dust: the density about $4\cdot10^{-22}$ g/cm^3, with dust particles mostly between 10^{-8} - 10^{-5} g, with a maximum around $3\cdot10^{-7}$ g, i.e. 30-60μm. Therefore, a gradual negative charging of the space around the Sun would take place, with this negative cloud going far beyond the Pluto, resulting in continuation of situation for positron being unbound by Solar system, at least within the known age of the last. Other physical effects, as the emission of protons from Sun's surface or photoeffect on dust particles are being automatically taken care by trapping too and by compensation of emission from Sun's surface. In order to check the negative charging of dust, there is, in principle, a possibility of collecting the dust by a specially devised "catcher" on board of a space ship. With $T_{1/2}$ for proton decay being 10^{31}-10^{35} years, one may expect 10^{-37} - 10^{-34} coulombs/cm^3 in interplanetary space carried by dust particles and catching 10^{-13} - 10^{-17} Coulombs per year by a "catcher" with 10 m diameter.

Concerning the Earth, it is easily seen that the decay of protons from its surface layer results in Earth's negative charging of about 10^{-13} coulombs per second. This is much less than negative charging of about 10^{-9} coulombs per second which the Earth would gain in the role of a great "catcher" of the negatively charged interplanetary dust. This last effect would make Earth to become a kind of low-energy accelerator for protons from the Solar wind, causing only about 10^{-10} - 10^{-8} variation in proton flux around Earth, which, is practically unobservable. Therefore, the best possible experiment on Earth or its near vicinity is nothing but the mentioned experiment with direct observation of proton decay with Cherenkov detectors around an underground pool.

In the case of the Galaxy, taking into account that its negative charge is the sum of negative charges of all stars (each of them having the same mechanism mentioned earlier for the Sun) and for proton $T_{1/2} = 10^{31}$ years, the present charge of the Galaxy might be about $4 \cdot 10^{20}$ coulombs. However, after Galaxy's negative charging of about $3 \cdot 10^{19}$ coulombs, the 500 Mev positron becomes bound with the Galaxy and this limits the charge of the Galaxy. It seems interesting to point here that, in an earlier paper[3], I have shown that the experimentally detected[2] annihilation gamma protons, which are accelerated in a weak galactic central electric field, if one assumes the negative charge of the Galaxy being higher than $6\cdot10^{18}$ coulombs. This charge should have been produced if the proton decays with $T_{1/2}\leq 7\cdot10^{32}$ years. Therefore, the experimentally detected 511 keV gamma rays coming from center of the Galaxy are the first experimental indirect indication of proton decay with $T_{1/2}\leq 7\cdot10^{32}$ years. Also, the direct observation of proton decay in experiments on Earth with $T_{1/2}\leq 7\cdot10^{32}$ years will directly prove the assumption on the existance of weak galactic electric field.

Concerning the universe as whole, any consideration depends on the cosmological model used. Since the estimate of universe density is based mostly on the observation of visible matter, and this one is made mostly from galaxies, it seems reasonable to consider a cosmological model, let us call it "realistic" one, made out of galaxies and in the state of experimentally observed expansion with known Hubble constant. In such an universe, 500 MeV positrons should be bound until the expansion comes to a state with radius of (relativistic)universe higher than about 10^{34} cm, which is far higher than presently estimated value. Therefore, in the present universe, the positrons, coming from proton decay are bound within the universe, which is, consequently, uncharged (Q=0) The galaxies could happen to be charged negatively with $6\cdot10^{18}\leq Q_{gal}\leq 3\cdot10^{19}$ coulombs, while the high energy positrons could be travelling through the intergalactic space. The whole picture is interestingly recalling Thomson's model of atom, with positive cloud (made of positrons) and galaxies as negatively charged agglomerations in a bound (closed) cosmological model.

REFERENCES:

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