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About possibility of proton acceleration up to relativistic energies in the neutral layer of the interplanetary magnetic field (IMF)

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Abstract

The theoretical considerations concerning the acceleration of charged particles in general and, in particular, the process of acceleration of protons in neutral layer of outer space in the frames of Maxwell electro-magnetic theory are discussed briefly. A short historical overview of developments, indicating on the fact, that proton can be accelerated up to ultra-relativistic energies in the Neutral Layer of the Interplanetary Magnetic Field, which is confirmed by anomalous huge number of cosmic rays $\mu-$mesons, in lower layers of atmosphere, as well as in deep depths of underground and underwater, which in its turn, are generated by decay of protons through the decay of π- and κ-mesons.

1. Introduction

1.1. The problem of acceleration of the charged cosmic particles, first of all the essence of acceleration, stands on the agenda as far back as from Coulomb's epoch, when experimentally was shown that the charges of the same name are repelled to one another and the charges of different name are attracted to one another. The achievements of modern Quantum Electrodynamics which takes into account the exchange character of electromagnetic interactions proved to be insufficient for the close to final understanding of the complex mechanism of acceleration. This issue has become especially important as far as we received the first signals of proton acceleration in the neutral layers of cosmic space. In the interplanetary space, where the density of particles is only $10^{-15}\ g\cdot cm^{-3}$ and the neutral layer is formed as a result of reconnection of oppositely directed force lines of the magnetic field, the special conditions are created for acceleration of protons up to the high energies. We suppose that the induction mechanism of acceleration, may be serve as the fundamental factor, whose engineering analogue may be the ground-based induction accelerator, Betatron, which was built up in 1940 by Donald William Kerst. In the article briefly is described the theoretical considerations concerning to the acceleration of particles in general and specifically the peculiarities of proton acceleration process in the neutral layers of cosmic space, in the frame of Maxwell Theory. The short overview of historical events is reviewed, indicating that protons may speed up to ultra-relativistic energies in the neutral layers of the IMF. Moreover, the concise survey of historical events has been reviewed indicating that protons can gain momentum up to relativistic energies what is shown by anomalously high number of cosmic μ-mesons, which are generated by protons through the decay of π- and κ- mesons both at lower layers of atmosphere and at great depths of underground.

1.2. Back as in 1950 George and Evans [1] have been discovered anomalously great number of high energy μ-mesons using nuclear photo emulsion at great depths in the underground, at London subway station Holborn.

There was a poor knowledge on the Neutral Current Sheet of Interplanetary Magnetic Field for that time. Therefore, several propositions have been made relatively to the existence of supplementary channel which may be: direct generation of the μ-mesons by the muons; the decay of the heavy lepton L^0 which generates the muon by the scheme:

$$L^0 \rightarrow \mu^{\pm} + e^{\pm} + \nu_{\mu}. \qquad (1)$$

The above mentioned processes can be neglected, since the total cross section for generation of muon pairs by muons is four orders of magnitude less than the cross section for generation of electron pairs by muons.

As for the decay of heavy neutral leptons, such a lepton is still not detected in accelerators contrary to the allegation of Canadian physicists [2] on discovery of this particle in 1968. There were also unsuccessful attempts to connect an additional channels of muon production with individual discrete galactic sources as Cygnus X3, Hercules, etc.

2. Acceleration of charged particles in the electromagnetic field

2.1. First, close to the final, understanding of the complex mechanism of acceleration of charged particles can be regarded as an assumption of Maxwell that the alternating magnetic field creates a closed loop of superconducting vortex electric field, regardless of whether there is at this point, the conductor or not.

In other words, Maxwell made a great compilation, according to which the circulation of the electric field along an arbitrary closed contour is equal to the negative of the rate of change of magnetic flux through the surface bounded by this contour.

Therefore, in general, the Maxwell equation can be written as

$$\oint (E, dl) = -\frac{\partial \Phi_m}{\partial t} + \sum_{k=1}^{n} \varepsilon_k , \qquad (2)$$

where $\sum_{k=1}^{n} \varepsilon_k$ is the algebraic sum of the other possible electromotive force, E is the electric field intensity, Φ_m is the magnetic flux.

The phenomenon of the space induced electric field under the influence of an alternating magnetic field was used to create an induction accelerator betatron.The idea of this method for accelerating electrons was made by the Norwegian particle physicist Rolf Widerøe, and later was developed by Soviet Physicist Terletsky Yakov Petrovich (30.VI.1912 – 15.XI.1993)

2.2. The first betatron was built in 1940 by Donald William Kerst at the University of Illinois. In subsequent years, accelerator technology developed rapid pace.In the initial stage of particle accelerator technology development, the charged particles trajectory has been close to a straight line, i.e. each particle passed only once through the electrostatic field, whereas in cyclic accelerators, the trajectory has the form of circle or helix.

The Proton Cyclotron (Synchro-Phazotron) in which by the coordinated reduction of frequency of accelerating electric field and increase in an induction of a magnetic field, it has appeared possible to achieve such condition at which accelerated protons started to move on a circular orbit of constant radius was the most powerful accelerator of protons. Values of the maximum energy got by protons in these accelerators were the little more than 30 GeV, and radii of orbits approximately 30 meters.

2.3. Progress of ideas in Engineering, Technology and Experimental Physics have led to fact that energies exceeding tens of TeV are achieved in colliding-beam modern accelerators. (1 TeV=10^{12} eV). There is a perception that it is not possible to specify an upper limit of accelerating energy. But such an assumption will sooner or later comes into conflict with

relativity. All currently known experimental research and theoretical evidence suggests that charge accelerated particles do not depend on the speed, so the relative dependence of specific charge from the speed can only be explained by the fact that mass accelerated particles increases with increasing speed by law:

$$m = m_0 / \sqrt{1-(v/c)^2} \ , \qquad (3)$$

where m_0 is the mass of resting particles. This formula is true to the findings of the theory of relativity and at low values of the velocity $(v << c)$, when the kinetic energy of a particle have being accelerated is not great and almost equal to m_0. Therefore, as it is evident from the above presented formula the rotation period is constant and the condition of synchronism is easy to realize by means of corresponding selection of rotation period T_0 or magnetic field.induction B.

However, with increased speed to levels commensurate with the speed of light is affected by the change in mass. Period T of circulation increases and cease to be equal to T_0. Synchronism condition is violated and the process of continuous acceleration will eventually cease. Despite the above mentioned successes, the achieved energies on accelerators have been built on Earth by humans cannot compete with accelerators created in Space by Nature since the energy of Space Natural accelerators exceeds the energy of artificial accelerators created by Humans at least by the value 10^8-10^{10} eV and more.

Admiration ahead of possibilities of accelerators with difficulties of research have relegated the elaboration of uneasy theory of mechanism of acceleration in the background,

2.4. Creation of the largest unique installation – laboratory for research interactions in cosmic rays is roughly the same cost as one large experiment on an existing accelerator. But unfortunately, is often forgotten about it.

According to classical electrodynamics [3], the charge undergoing acceleration a during the time period dt radiates energy

$$dE = \frac{2}{3} \cdot \frac{q^2 Z^2}{c^3} \cdot |a|^2 \, dt \ , \qquad (4)$$

where q and Z are charges for accelerated particles and particles which create field for acceleration. Since then the acceleration $\vec{a} = \vec{F} / m$ then $dE \sim 1/m^2$ and the radiation losses will be significant only for the lightest particles.

A quantum calculation carried out by Bethe and Heitler allows us to find the electron energy loss on the bremsstrahlung:

$$\left(-\frac{dE}{dx} \right)_{rad} = 4n\alpha Z_n^2 r_0^2 \, ln(183 Z_n^{1/3}) E \ , \qquad (5)$$

where $\alpha = e^2/\hbar c \approx 1/137$ is the fine structure constant, $r_0 = e^2 / m_e c^2$ is the classical radius for electron, Z_n is the atomic number of nucleon, n is the number of atoms in each 1cm^3 volume of matter, and E is the total energy emitted by an electron.

As it is well known, during passage of distance between charged particles or potential difference in 1 Volt, the work in 1 eV is committed by the forces of electric field. Thus the particle gets kinetic energy or in other words is accelerated and, on the contrary [4], if the charged particle is braked,. then it returns energy which has been received. If this energy q^2 / r to connect with the mass, then the lost energy will be appeared inversely proportional to the square of its mass, that is in good agreement with experiment. From the point of view

of quantum electrodynamics and if want, unified field theory, these processes are inseparable from each other, they are proceeding simultaneously!

2.5. In the classical mechanics well-known the principle of independence of movement according to which the particle possesses weight and thrown at an angle to horizon with identical success participates both in uniform, and in equally accelerated movement (in free falling).Something similar is had and in case of the charged particle, electro-magnetic interaction of the charged particle can be considered in approach of an one-photon exchange. However virtual photons or γ-quanta don't give an unambiguous answer as accelerating or brake forces are provided. What is the ratio of space-like and time-like photons, transferring electromagnetic forces in a spectrum. Although in Muller and Baba experiments in the early seventies were registered time-like photons, which have been transferring only the energy, and space-like photons which have been transferring only momentum. But their relationship and even more so, changing with the growth of energy has not been defined.

3. Conclusion

Therefore, as we are regarding, during approximation of oppositely directed magnetic field lines of Interplanetary Magnetic Field (IMF), the process of reconnection of magnetic field lines takes place. Protons are colliding, which rotate around magnetic force lines together with electrons. As a result of the collision, the protons from the opposite magnetic field lines are scattering; they no longer can perform rotational movement that leads to destruction of magnetic field lines; “frozen condition" disappears. Lightweight electrons are moving towards protons, emitting electro-magnetic waves, including the high-frequency, thanks to which the part of the protons are accelerated up to high energies. A special role can be played by the fact that the particle density in the space is very low -10^{15}cm^3.

Hence the accelerated particle is deprived possibility of fast loss of energy because of interaction with the limited number of the charged particles especially if energy it has received at the expense of Maxwell’s vortex field. All this allows us to assume that protons in the neutral layer quickly accumulating energy and then slowly relinquish it.

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О возможности ускорения протонов до сверхвысоких энергий в нейтральном слое межпланетного магнитного поля (ММП)

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Резюме

В статье кратко рассматриваются теоретические соображения, касающиеся процесса ускорения заряженных частиц, вообще, и, в частности, особенности процесса

ускорения протонов в нейтральных слоях космического пространства, в рамках электро-магнитной теории Максвелла. Дается краткий исторический обзор событий, указывающих на то, что в нейтральном слое (ММП) протоны могут разгоняться до ультра-релятивистских энергий, о чем свидетельствует аномально высокое число космических $\mu-$мезонов, родителями которых являются протоны, через распад π- и κ-мезонов как в нижних слоях атмосферы, так и на больших глубинах грунта.

ზემაღალ ენერგიებამდე პროტონების აჩქარების შესაძლებლობის შესახებ საპლანეტათაშორისო მაგნიტური ველის (სმვ) ნეიტრალურ ფენაში

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რეზიუმე

ნაშრომში მოკლედ განხილულია თეორიული მოსაზრებები, რომლებიც ეხება დამუხტული ნაწილაკების აჩქარების პროცესს ზოგადად და, კერძოდ, პროტონების აჩქარების პროცესს კოსმოსური სივრცის ნეიტრალურ შრეებში მაქსველის ელექტრო-მაგნიტური ველის თეორიის ჩარჩოებში. მოცემულია მოვლენათა მოკლე ისტორიული მიმოხილვა, რომელიც მიგვანიშნებს იმ ფაქტზე, რომ საპლანეტთაშორისო მაგნიტური ველის (სმვ) ნეიტრალურ ფენაში პროტონები შეძლება იქნენ აჩქარებულნი ულტრა-რელატივისტურ ენერგიებამდე, რასაც ადასტურებს კოსმოსური სხივების μ-მეზონების ანომალურად მაღალი რიცხვი როგორც ატმოსფეროს ქვედა ფენებში, ასევე გრუნტის დიდ სიღრმეებში, რომელთა დაბადება ხდება პროტონებიდან, ამ უკანასკნელთა π- და κ-მეზონებად დაშლის შემდეგ.