hep-ex/9908053 16 Aug 1999

DISCLOSURE of NEW STABLE HEAVY CHARGED PARTICLES in COSMIC RAYS

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ABSTRACT

A telescope of two coaxial scintillation detectors (an upper thin CsJ crystal of Ø63x0,35mm^2 and a lower thick NaJ crystal of Ø150x100 mm^2) located vertically on the surface of the Earth was used to have during T=106 hours 20 events registered with increased specific ionization in each detector that turned out to exceed 10 times the specific ionization caused by cosmic rays. All the events excluding three background events are within two standard deviations from a curve calculated for non-relativistic single charged particles with mass M_E=(175 ± 25)GeV/C^2, flying vertically along the telescope. Based upon the condition of being non-relativistic and the limitations on the dimentions of the experimental set-up, it follows that their life-time t_E >1,5× 10^{-9} s. Their intensity in cosmic rays on the Earth surface is J_E=(1,8 ± 0,4)× 10^{-6} cm^{-2} ster^{-1} s^{-1} (at E_E < 6 GeV, P_E<50 GeV/C). The events disclosed are in full correspondence with our phenomenological predictions, with previous experimental results in the course of searching them for, and with the predictions of the "mirror model" which interpreters a possibility of existing hypothetical stable heavy hadrons (*Erzions*).

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INTRODUCTION

A hypothesis on existence of new stable heavy penetrating hadrons [1,2] was developed for explanation of anomalously sloping shape of energy spectra of cosmic muons [3,4,5]. Many characteristics of these hypothetical hadrons were predicted phenomenologically (mass, charge, life time, intensity, nuclear character of interaction, track lengths in interaction and absorbtion) for the sake of bringing in conformity a large totality of anomalous and regular results in experiments with cosmic rays. Later on there were undertaken experimental attempts to disclose them[6-11] as well as theoretical attempts to create a model that would give a possibility to justify their long life time ($t > 1.5 * 10^5$ c) given so high mass ($M > 30$ GeV/C^2) first based on supersymmetrical model [12] and then more cucessfully based upon "mirror model" $U(1)xSU_l(2)xSU_r(2)xSU(3)$ [13-14]. The existing standart models [15] do not explain such a long life time of that heavy elementary particles by means of weak interaction. Theoretical ideas about the structure of hypothetic heavy hadrons let it possible to design and plan experiments for disclosing those hadrons because of better understanding the character of their interaction. The

experimental set up was organized at the underground facility of the Research Institute of Nuclear Physics of the Moscow State University (40 meter water equivalent depth m.w.e.,SW ~10^3 cm^2 ster), that was created specially to keep searching for hypothetical hadorns. It consists of overall vertical magnetic spectrometer (P_{max}=700 GeV/C) and six rows of large area (S=2 * 10^4 cm^2) plastic scintillators located beneath the spectrometer and serving as the detector of particle stops. During the period of time T@ 200 hours three suitable evidences of the particles under search were detected (J_e @ 4 * 10^4 cm^{-2} $ster^{-1}$ c^{-1}), which were supposed at that time to be background events [8-9].

EXPERIMENT

In the course of experiments using set-ups of the second and third generations [10-11] that were cheaper and simpler in use, we failed to gain positive results because of various reasons. In this work we have realized a version of the fourth generation installation intended to search for stopped heavy charged particles of cosmic rays. This version of experimental set-up is the simplest out of all the previous versions.

The experimental set-up consists of vertical telescope of two scintillation detectors (SD) working on coincidences (Fig.1). The upper SD1 - is a thin CsJ crystal (Ø 63x0,35 mm^2) coupled with a photomultiplier PM-110, the lower SD2 is a thick monocrystal NaJ(Ø 150x100 mm^2) coupled with a potomultiplier PM -49. High voltage power supply was provided by a power supply unit HVPS for PH-110 and by spectrometric chip SBS-50M for PM -49 (Fig.1).

The crystals were located coaxial at the distance of d@ 50mm between them. So, the light capacity of such a telescope is SW @ 30cm^2 ster . The hopes for success when using a telescope with a low light capacity are based upon the hypothesis [1,2] according to which their intensity at the sea level J(P_E/ 100 GeV/C)» 10^{-6} cm^{-2} $ster^{-1}$ s^{-1}. If the mass of hypothetical *Erzions* [13,14] M_E / 100 GeV/C^2 they can be relativistic at such high intensity which is very important for the proposed method of their disclosure [7]. On the other hand, at all the previous generations of the experimental set-ups they were located at pretty little depths (40 m.w.e.) with the aim of reducing cosmic rays background. Nevertheless, this thickness of soil should noticeably absorb *Erzions* at the expence of ionization losses in non-relativistic region (at M_E = 200 GeV/C^2 approximately 10 fold) in spite of the fact that *Erzions*

are actually penetrating hadrons with track length of L=100 m.w.e. till absorption because of their nuclear interaction with soil. So, the remarkable novelty of this experiment is placement of the set-up on the Earth surface which made it possible to increase the effect to great extent despite the likely increase in background.

The upper thin SD1 is intended to measure specific ionization (dE/dx) of charged particles at the entrance of SD2 while the thick SD2 measures full energy release: $E= (dE/dx)_{med}$ h. The crystal SD2 is thick enough

(p * h = 36 g * cm^{-2} ~ 4 radiation units) and electromagnetic cascades effectively develop in it that probably makes worse the background conditions. Nevertheless, such large thickness was chosen on purpose so that in such a crystal stopping of the particles of interest could occur effectively and hence noticeable changes in specific ionization could take place on the residual run. Registration of SD pulses (Fig. 1) is fulfilled with a two-beam memory oscilloscope C8-17. In addition to provide continuous control after normal functioning of the set-up as well as while adjusting it the registration of SD pulses was also done using multichennal (8192 channels) analyzer SBS-50M ("Greenstar" make) and also using a multichennal analyzer AÈ-1024.

The calculation of the expected distributions of pulse amplitudes from SD1 (A_1) and SD2 (A_2) was done using the Bethe-Blox and Bragg curves and run length-energy functions derived for single-charged particles of various masses (10, 150, 200, 1000 GeV/C^2) based upon the analogous curves for protons in various media [16,17,18]. The magnitudes of A_1 and A_2 have been represented in a normalized form in terms of the units of the amplitudes of the most probable magnitudes in differential spectra of amplitudes from separate relativistic cosmic muons for each of the SD's (m_1, m_2).

RESULTS and ANALYSIS

In the course of 100 hours of experiment beginning 07/06/99 and till 07/30/99 given the threshold of selecting events A_1/ 11m_1 and A_2/ 11m_2 twenty (A_1, A_2)-coincidence events were registered. They are shown in Fig. 2 coupled with a theoretical curve for non-relativistic protons and for hypothetical heavy single-charged particles with masses of 10, 150, 200, and 1000 GeV/C^2. When calculating it was assumed that such non-relativistic hadrons loose their energy just for ionization and their nuclear interactions could be neglected like leptons. The fact is also essential that in scintillation crystals CsJ and NaJ at such high specific ionization the effect of light putting out is practically absent while it is real in organic crystals and plastic scintillators [17].

Following the criterion of accordance [17] almost all the experimental points, excluding three of them, are within the band of confidence of the calculated curves for heavy single-charged particles with M = (150 200) GeV/C^2. Availability of the experimental points on the falling portion of the curve is very essential. Those points correspond to the particle stops inside SD2 and allow to estimate the mass of the particle of interest in a reliable way. Based upon the condition of particles being non-relativistic ones (V <0.3 * C) and taking into consideration the dimensions of the set-up (l = d + h = 15 cm) it follows that their life time t should be longer than the duration of their flight all along the set-up (t = l/v) and hence t >1.5 * 10^{-9} s.

In the result of the experiment in the course of 106 hr long measurements 20 particles of interest were detected, the mass of the particles being equal to M_E = (175± 25) GeV/C^2, the particles demonstrating increased ionization A>10m (E_E £ 6 GeV,, P_E £ 50 GeV/C) with intensity

J = N/SW T@ 20/(106 * 3600 * 30) = (1.8± 0.4) * 10^6 [cm^{-2} $ster^{-1}$ s^{-1}]

which is in good accordance with expected intensity [1,2] and does not contradict to the three "suitable" events registered before when experimenting underground at the depth of 40 m.w.e. (see above given explanations). By the way, all three "suitable" events demonstrated negative charge according to the readings of the magnetic spectrometer used as it follows from the Erzion model of the hypothetical particles [13,14].

At first glance, the simplest explanation of such events could be showers with the number of charged particles N >10, given the energy of each particle being E >100 MeV and the cross-dimension r~ 1 cm at the level of SD1 detector location. But such explanation contradicts the points located on the falling portion of the curve in Fig. 2. Moreover, if these cascades are nuclear ones initiated by protons in the matter of the lower part of photomultiplier PM-110 (d ~ 1 g/cm^2) they should have intensity of J_k £ 10^{-9} cm^{-2} $ster^{-1}$ s^{-1} [18-21] which is much less than the intensity of the registered events (nuclear showers initiated in the upper part of the photomultiplier will have cross diminution R>>1 cm). The probability of protin interactions (run length l_p@ 100 g * cm^{-2} before interaction) should be $W_p = d_p/l_p$ ~ 0.01. Nuclear showers with the number of charged particles N >10 can be caused only by protons with energies E_p >100 GeV intensity of which in cosmic rays J_p >10^{-7} cm^{-2} $ster^{-1}$ s^{-1}. Based upon the fact that $J_k = J_h$ *W it follows that the statement J_k £ 10^{-9} cm^{-2} $ster^{-1}$ s^{-1} is true.

The most noticeable two events located on the falling portion of the calculated curve can not be interpreted by either trivial process. If, for example, one assumes that they are caused by relativistic nuclei Be (A_1~ 16) that released in SD2 additional energy of 2 MeV (say, in the process of scattering) and thus provided the pulse amplitude in

SD2 $A_2 \sim 36$, as well as the two events under interpretation had, then their intensity should be $J = J_{Be}$. $W_{Be} = 10^{-8} * 10^{-2} = 10^{-10}$ which is three orders of magnitude below the intensity of the events under interpretation.

Three background points on the curve can be interpreted as the events of relativistic nuclei ^{4}Be ($A_1 @ A_2 @ 16$) and ^{7}N ($A_1 @ A_2 @ 49$). One of these points is located in this refion ($A_1 = 42$, $A_2 = 53$). Two other points are located above the calculated curve of ionization losses for multicharged particles that can be explained by additional release of energy in the crystal SD1 because of nuclear interaction in this crystal.

The probability of nuclear events to be located on the calculated curve of ionization losses is approximately equal to the probability of them being located above this curve as the run length till nuclear interaction is comparable to the thickness of crystal SD1 (l @ p*h). The intensity of these three events $J \sim 10^{-7}$ cm^{-2} ster^{-1} s^{-1} corresponds exactly to the intensity of relativistic nuclei in cosmic rays at the sea level.

CONCLUSION

The author consideres that because of the absense of trivial explanations of the registered events he has disclosed new stable heavy charged particles in cosmic rays (*Erzions*) with the following parameters:

Mass $M_E = (175 \pm 25)$ GeV/C^2

Intensity in cosmic rays on the surface of the Earth

$J_E = (1.8 \pm .4) * 10^{-6}$ cm^{-2} ster^{-1} s^{-1}

(at $E_E \pounds$ 6 GeV, $P_E \pounds$ 50 GeV/C)

Life time $t_E > 1.5\ 10^{-9}$ s.

The events disclosed are in full correspondence with our phenomenological predictions, with previous experimental results in searchinh them for and with prediction of the mirror model that interpretes the possibility of existing hypothetical stable heavy hadrons Erzions.

ACKNOWLEDGEMENT

Author appreciates all those giving continuous help and support, in person: L.A.Mikaelyan, V.S.Murzin, L.G.Sapogin, A.F.Perekalski, N.I.Khochlov, S.N.Yashin, D.S.Baranov, V.P.Koretsky, V.G.Marchenko, and those persons who helped the author to get this article prepared for publication: E.V.Pletnikov, V.G.Grishin, A.M.Frolov, Sh.A.Shakarbekov, and I.V.Goryachev.

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