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# The Key to the Puzzle "Effect PAMELA"

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**Abstract:** *The PAMELA effect has been a mystery to astrophysicists for 10 years. In connection with the discovery at CERN at the Large Hadron Collider of the effect of the dependence of the interaction constants and the mass of elementary particles on the energy at which measurements were made, it became possible to solve this riddle.*

**Keywords:** *vacuum; polarization; photon; electron; positron; proton; energy; range;*

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## 1. INTRODUCTION

The “PAMELA effect” consists in of an inexplicable increase in the number of positrons with respect to electrons in the total number of secondary electrons and positrons recorded by a PAMELA magnetic spectrometer, with an increase in the energy of cosmic radiation and relativistic protons starting from 5 GeV [1, 2]. The “PAMELA effect” is also observed in experiments on an Alpha-Magnetic Spectrometer (AMS-02) starting with an energy of 20 GeV [3]. The solution to the puzzle "The PAMELA Effect" is at the junction of three areas of physics: elementary particle physics, electrodynamics theory, and astrophysics. As possible explanations for the PAMELA effect, the emission of high-energy positrons by close pulsars was considered the highest priority [4]. Professor A. U. Abeysekara et al. (University of Utah, USA) using the HAWS Cherenkov telescope studied the extended gamma radiation of halo with energies of 8-40 TeV around the pulsars Geminga and PSRB0656 + 14. The hypothesis that this halo is created by the same the positron fluxes that produce the excess positrons observed by the PAMELA detector has not been confirmed. It turned out that the observed gamma-ray spectrum recorded much more positrons than could have reached near-Earth space, and the shape of the energy spectrum of high-energy positrons (peak formation) differs from the spectrum observed in the PAMELA detector (spectrum with an exponential degree) [4]. Thus, the researchers concluded that excess positrons must have a different source. Consider the experiments of PAMELA and AMC-02.

## 2. EXPERIMENTS

### 2.1. The Pamela Experiment

The PAMELA magnetic spectrometer was launched aboard the Resurs-DK satellite to an elliptical near-polar orbit with a height of 350-600 km to study the fluxes of particles and antiparticles of cosmic radiation in a wide energy range from tens of MeV to hundreds of GeV.

Since July 2006 to January 2016 continuous measurements of cosmic ray fluxes were carried out (Figure 1). The PAMELA device consists of a magnetic spectrometer based on a permanent magnet of ~ 0.4 Tl, surrounded by anti-coincidence detectors, an electromagnetic calorimeter, a time-of-flight system, scintillation counters and a neutron detector. The magnetic spectrometer has six silicon strip planes that measure the coordinates of the track with an accuracy of 3 mkm, which allows us to determine the sign of the charge of the particle and their stiffness by the deviation in the magnetic field. The electromagnetic calorimeter makes it possible to separate the electromagnetic and hadronic cascades and measure the energy of electrons and positrons with an accuracy of not worse than 10% from several GeV to hundreds of GeV. The time-of-flight system has a resolution of about 300 ps and makes it possible to separate low-energy protons from positrons up to 0.8-1 GeV. The authors of the

PAMELA device assert that “the use of a full set of criteria provides a proton-screening coefficient at the level of $10^{-5}$, which makes it possible to reliably isolate electrons and positrons against a background of protons.” [1,2]. We draw attention to the fact that up to an energy of 0.8-1 GeV, low-energy protons were separated from positrons by means of a time-of-flight system with a resolution of about 300 ps, and then the separation of positrons and relativistic protons is carried out using other systems based on the behavior of charged particles in a constant magnetic field of 0.4 Tl of the PAMELA spectrometer. It is from this moment on that the “PAMELA Effect” begins to appear (Figure 2).

**Figure1.** *“PAMELA” in a container on the Resurs-DK satellite*

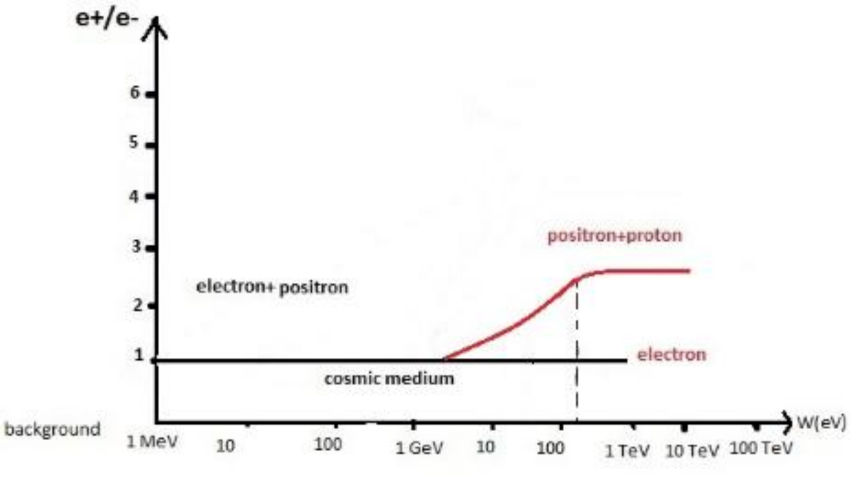

**Figure2.** *Graph of positron-electron relations (e + / e-) in PAMELA experiments*

## 2.2. Experiment AMS-02

Alpha-magnetic spectrometer AMS-02 is designed to measure high-energy charged particles with a set of large statistics (an average of 2-3 orders of magnitude more than the “standard” measurements in cosmic rays). The magnitude of the electric charge in the AMS-02 detector is measured independently by a coordinate detector (Tracker), a Cerenkov detector (RICH), a flight time counter (TOF) with a time resolution of 160 ps. A charge sign and a particle pulse are measured along a trajectory in a magnet using nine planes of a two-way coordinate silicon detector. The particle velocity is measured by a time-of-flight system (TOF), a transition radiation detector (TRD) and a Cerenkov detector (RICH). The energy of electromagnetic particles is measured in a calorimeter (ECAL) [3]. The detector AMS-02 was placed on the International Space Station (ISS) and during 2011-2015, it carried out a wide range of studies of cosmic radiation in the near-Earth environment (Figure 3).

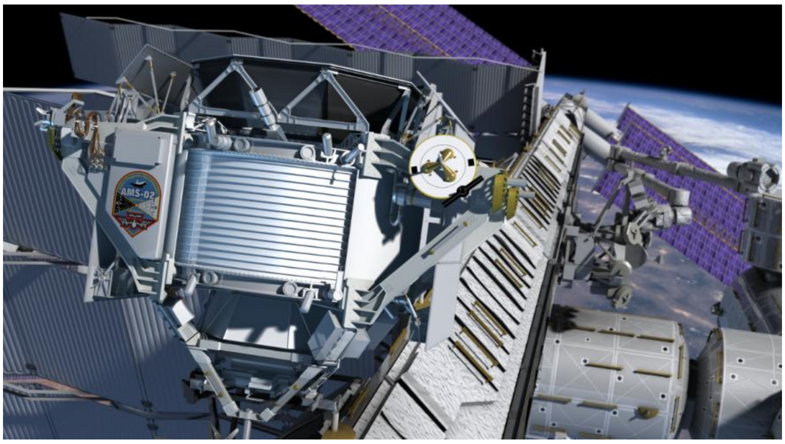

**Figure3.** *AMS-02 detector at the International Space Station (ISS)*

Analyzing the results of studies, an employee of the Massachusetts Institute of Technology Yu.V. Galaktionov notes that "neither the electronic nor the positron spectra can be described by a power-law with a single exponent in the entire studied energy range. The AMC-02 precision data confirmed that at high energies of relativistic protons in the range of 20-200 GeV, the electron spectrum decreases with decreasing energy faster than the positron spectrum, i.e. the electron spectrum is softer. This may indicate either the primary nature of the origin of positrons or the secondary nature of the origin of electrons "[3]. Thus, in the energy range 20-200 GeV, the ratio of the number of positrons to electrons increases with increasing proton energy, i.e. the PAMELA effect takes place. However, let us pay attention to the fact that the time resolution of the time-of-flight system of the AMS-02 detector is almost two times higher than that of the time-of-flight system of the PAMELA detector (160ps versus 300ps) and AMS-2 has the largest track magnetic spectrometer (with an area of 6.7 $m^2$), built for space research. This made it possible to use the time-of-flight system in the AMS-02 detector for separating relativistic protons from secondary positrons to higher proton energies than in the PAMELA detector and thereby move the detection boundary of the PAMELA effect from 5 GeV to 20 GeV. The most remarkable thing is that, according to AMS-02, it was possible to fix the presence of an extremum (resonance maximum) in the total spectrum of electrons and positrons at the energy of external radiation and relativistic protons $W_p \approx 15\text{-}20$ GeV Fig.16,21,22 [3]. This may indicate the generation of secondary electron-positron pairs in the near-Earth space environment (dark matter). According to Yu.V. Galaktionov, "one of the most important goals of the AMS-02 physical research program was to detect dark matter in the near-Earth environment in its non-gravitational manifestations." One of such non-gravitational manifestations could be the resonant generation of secondary electron-positron pairs during polarization of quantum vacuum (dark matter) under the influence of cosmic radiation and relativistic protons [5].

## 3. THE KEY TO SOLVING OF THE "PAMELA EFFECT"

Today there appeared a large number of works explaining the growth of positrons in the PAMELA effect, their number exceeded several hundred. The very number indicates that there is still no convincing explanation. At the same time, researchers completely exclude the explanation of positron growth as experimental errors, however, such a system error may exist, since all detectors are based on general physical principles that ignore the latest data from CERN. In experiments at the Large Hadron Collider in November 2019, it was found with a 95% probability that the magnitude of the interaction constants and the mass of elementary particles can be "traveling", i.e. depend on the energy at which measurements are made. This effect is explained by the polarization of vacuum and can relate not only to strong interactions but also to electromagnetic interactions [6]. Maxwell mistakenly applied the Ostrogradsky-Gauss theorem not only for resting charges but also for moving ones (the Gauss theorem is one of Maxwell's equations). As a result of this arbitrary assumption, the dynamic state of moving electric charges is simply replaced by their static state. In this regard, the article proposes to consider the likelihood that relativistic protons can appear in the role of positrons in the PAMELA effect, which are mistakenly summed in the PAMELA and AMC-02 detector with positrons. This can also be confirmed by the fact that the spectrum of secondary positrons becomes more rigid with increasing energy, and the spectrum of electrons changes little. According to Yu.V. Galaktionov, "the mechanism of cosmic-ray acceleration in expanding non-relativistic shock waves arising from supernova explosions predicts a power-law cutoff at high energies for the proton energy spectrum that exactly corresponds to the spectrum of the“ source ”of primary positrons in the PAMELA effect in the range energies of 20-200 GeV ” (1) [3].

$$\Phi = C \left(\frac{E}{E_0}\right)^{-\gamma} \exp\left(-\frac{E}{E_0}\right) \quad , \tag{1}$$

The spectral index $\gamma$ is usually 2, although with great uncertainty. Conclusion Yu.V. Galaktionova may indicate that together with positrons the PAMELA and AMS-02 space detectors fix relativistic protons. The reason for this should be sought in the method of measuring the energy of charged particles in a magnetic spectrometer Magnetic spectrometers are used to measure the energy spectrum of constant and pulsed beams of charged particles and their separation in a constant magnetic field. The device is based on the dependence of the radius of the cyclotron orbit on the kinetic energy of the particle. The equality of the Lorentz force and centrifugal force when the particle moves around a circle in a uniform magnetic field leads to the equation:

$$qvB = \frac{mv^2}{r} \tag{2}$$

where q is the particle charge, v is its velocity, B is the magnetic field induction,

r is the radius of the cyclotron orbit, $m = m_o / \sqrt{1 - v^2 / c^2}$, $m_o$ = rest mass,

c is the speed of light.

From the known q, r, B, we can calculate the kinetic energy of a particle:

$$W = m_o c^2 \left\{ \sqrt{\frac{q^2 \mathbf{B}^2 \mathbf{r}^2}{(m_o c^2)^2} + 1} - 1 \right\} \tag{3}$$

In modern spectrometers, an approximate relation is used to estimate the kinetic energy of ultrarelativistic charged particles in a magnetic field when $qBr \gg m_o c^2$ [7].

$$W \approx q\mathbf{B}r \tag{4}$$

where q is the particle charge,

**B** is the induction of a homogeneous magnetic field,

r is the radius of a circle described by a particle.

In classical and quantum electrodynamics, the energy of a relativistic charged particle in a magnetic field (4) does not depend on the particle velocity at which measurements are made. However, as the particle velocity approaches the speed of light, the effect of the magnetic field on the charged relativistic particle decreases [6]. This effect leads to the fact that the radius of the cyclotron orbit of the relativistic proton in the spectrometer can be close to the radius of the positron (Figure 4). As a result, the declared proton screening coefficient at the level of $10^{-5}$ [1] is not fulfilled, which does not allow reliably highlight positrons from the background of protons.

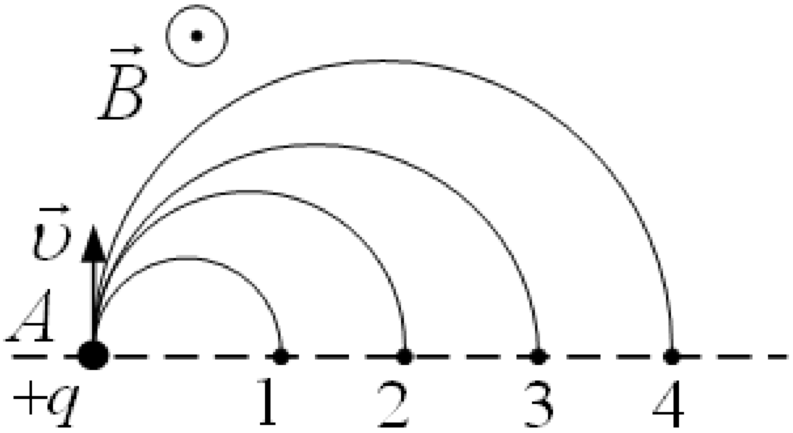

**Figure4.** *The radii of the trajectories of positrons and protons in a magnetic spectrometer*

## 4. CONCLUSION

Thus, the reliability of the conclusions about the presence of the PAMELA effect and the complete separation of ultrarelativistic protons from secondary positrons, both according to the data of the PAMELA detector and the data of the AMS-02 detector, is doubtful. This can also be confirmed by the fact that the spectrum of secondary positrons becomes more rigid with increasing energy, while the spectrum of secondary electrons changes little, which indirectly suggests the summation of a certain number of ultrarelativistic protons with secondary positrons. According to the latest data, it turned out that in the PAMELA detector both the calorimeter information and the magnetic spectrometer information are not enough to completely remove the proton background. [8]. An experiment capable of confirming or refuting the statement made in the article about the absence of the “PAMELA Effect” and the presence of a constructive error in the registration equipment of the PAMELA and AMC detectors requires the exclusion of relativistic protons at the detector input. In this case, the generation of secondary electron-positron pairs should be realized only by photons of cosmic radiation. This is easy to do and PAMELA and AMC-02 can work as gamma-ray telescopes. If the upper counter is included in anticoincidence, protons are completely excluded, and electron-positron pairs from photons are recorded. The results of this experiment could completely eliminate the assumption of a hardware error in detecting the "PAMELA Effect" associated with the incomplete screening of protons.

Of course, the opinion presented in the article requires careful verification, since it expresses the rejection of the use of magnetic spectrometers in experiments related to measuring the energy spectrum of constant and pulsed beams of ultrarelativistic charged particles and their separation in a constant magnetic field.

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