Mini Review

Pamela effect

Abstract

The "PAMELA effect" is a mystery for astrophysicists for 10 years, since its discovery. The article assumes that the effect may be due to imperfections in the equipment of detectors. The creators of the cosmic detectors PAMELA and AMS–02 were guided in their calculations by classical electrodynamics, which differs from of the real electrodynamics of the behavior of relativistic protons in of the magnetic spectrometers of detectors.

Keywords: vacuum, polarization, photon, electron, positron, proton, energy, range

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Introduction

The "PAMELA effect" consists in an inexplicable increase in the number of positrons with respect to electrons detected by the PAMELA magnetic spectrometer, with an increase in the energy of cosmic radiation and relativistic protons starting from 5GeV.[1,2] The same effect is observed in the registration of the electron–positron ratio in AMS–02 and FERMI–LAT but at higher energy values.[3,4] Primary high–energy electrons and protons in cosmic rays are formed during acceleration in supernova remnants. Secondary electrons and positrons are generated in the cosmic medium by relativistic protons and cosmic radiation and are within the boundaries of the Earth's magnetosphere, which is assumed to be 25,000km. The generation of secondary particles under the action of relativistic protons is almost 100 times higher than from of cosmic radiation, and the energy spectrum of secondary positrons and electrons is very "soft" with a sharp drop above 100MeV.[1] It was established that the generation of secondary particles increases with increasing altitude (by decreasing the magnetic field B below 0.215 G). The results obtained are difficult to explain in the framework of the model of inelastic interactions of the protons of the radiation belt with atomic nuclei of the residual atmosphere.[1] Another mechanism for the formation of secondary electron–positron pairs can be the collision of protons with protons and nuclei of the interstellar medium. In these collisions, pions and kaons are formed, which eventually decay into leptons.[3] The formation of electron–positron pairs excludes the PAMELA effect. However, an analysis of the results of observations shows that in the range 20–200GeV, the electron spectrum decreases with increasing energy faster than the positron spectrum, that is, the electron spectrum is softer. This may indicate the primary nature of positron origin, which is difficult to explain in the framework of the traditional model of diffusion propagation of cosmic rays. The solution of the puzzle "PAMELA Effect" is at the intersection of three areas of physics: elementary particle physics, electrodynamics and astrophysics. As possible explanations of the Pamela effect, the emission of positrons of high energies by close pulsars was considered the most priority version. A.U. Abeysekara and others (University of Utah USA)[5] with the help of the Cherenkov telescope HAWS investigated extended halo gamma radiation with energies of 8–40TeV around pulsars Geminga and PSRB0656+14. The hypothesis that this halo is produced by the same positron fluxes that produce excess positrons observed by the Pamela detector has not been confirmed. It turned out that much more positrons are registered in the observed gamma–radiation spectrum than the Earth could reach and the form of the energy spectrum of high energy positrons (peak formation) differs from the spectrum observed in the Pamela detector (of spectrum with exponent of degree). Thus, researchers came to the conclusion that excess positrons should have a different source.[5] Let's consider physical features of registration of elementary particles by magnetic spectrometer PAMELA and AMS–02.

Experiments

The pamela experiment

The PAMELA magnetic spectrometer was launched aboard the Resurs–DK satellite to an elliptical near–polar orbit with a height of 350–600km 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 July2006 to January 2016 continuous measurements of cosmic ray fluxes were carried out. 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 km, 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 0.8–1GeV. 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 0.8–1GeV, low–energy protons were separated from positrons by means of a time–of–flight system with a resolution of about 300ps, 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 1).
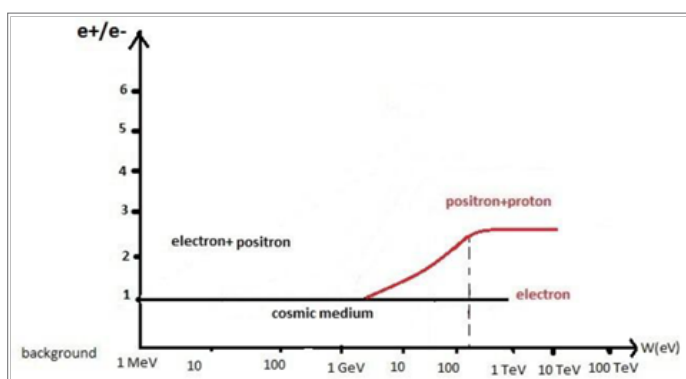
Figure 1 Graph of measurement of positron–electron ratio (e+/e–) in PAMELA and AMS experiments.

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 160ps. 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. Precision data of AMS–02 confirmed that at high energies the ratio of positrons to electrons increases with increasing energy, i.e. the presence of the "PAMELA effect". However, we draw attention to the fact that the time resolution of the time–of–flight system of the detector AMS–02 is almost twice as high as that of the time–of–flight system of the PAMELA detector (160ps versus 300ps). This made it possible to use a time–of–flight system in the AMS–02 detector to separate the relativistic protons from the secondary positrons to higher proton energies than in the PAMELA detector and thereby push the boundary of the appearance of the PAMELA effect to higher energies (20–30GeV).[4]

The relativistic coulomb's law and reduction of lorentz's force

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 by the errors of experiments; however such a system error may exist, since all detectors are based on general physical principles, which ignore of the deformation of the electric field of a moving charge (relativistic Coulomb's law). The article proposes to consider the probability that in the role of positrons in the PAMELA effect, relativistic protons can appear that are mistakenly summed in the PAMELA and AMS–02 detector with positrons. This can also be confirmed by the fact that the

spectrum of secondary positrons becomes more rigid with increasing energy, while the spectrum of electrons varies little.[4] The mechanism of acceleration of cosmic rays in expanding non relativistic shock waves during a supernova explosion predicts a law of spectrum with exponent of degree γ with cutoff at high energies for the energy spectra of protons:[3]

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

It exactly corresponds to the spectrum of the "source" of primary positrons in the PAMELA effect in the energy range 20–200GeV.[3] The spectral index γ is usually 2, although with great uncertainty. This fact confirms that together with positrons the detectors PAMELA and AMS–02 fix relativistic protons. Consider a possible mechanism for the failure of space detector equipment. One of the reasons may be the effect of retarded potentials and charge deformation at ultra relativistic proton velocities. True, the Italian physicists in Frascati recently published the results of experiments indicating a possible presence of a rigid connection between the Coulomb field and the electron charge in a short beam of ultra relativistic electrons,[6] but there are many of works that speak of the effect of retarded potentials and charge deformation for ultra relativistic particles.[7,8]

We consider the problem of the interaction of the cosmic medium (dark matter) with the electromagnetic energy of a moving charge. The initial energy of the electric field of a stationary charge is reduced when driving this charge in the amount of energy detected magnetic field, ie the magnetic energy in the environment around a moving charge does not appear, as is commonly believed, and extracted from it. The initial energy of the electric field of a stationary charge $\mathbf{W}_{E_0}$ decreases when moving this charge an amount equal to the complete energy of the detected magnetic field $\mathbf{Í}\, \mathbf{c} = (v / c)\mathbf{Å}$. Interaction of electric charge e and the electric field $\mathbf{E}_0$ is, given the retarded potentials and distortion of the electric field $\mathbf{E}$ of the moving charge, It is described by the dependence:

$$F = E_0 q\sqrt{1 - v^2 / c^2} \tag{2}$$

Taking into account the mass of the charge and acceleration α, the dependence (2) can be written in the form:

$$F = E_0 q\sqrt{1 - v^2 / c^2} = m_v \alpha = \frac{m_0 \alpha}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{3}$$

However, equation (2) is an expression of the relativistic Coulomb's law. The left–hand side of equation (3) would be relativistic–invariant if the expression $\sqrt{1 - v^2 / c^2}$ were in the denominator as in right–hand side. The developers of the PAMELA detector in their calculations used classical electrodynamics, in which the Coulomb's law (the Gauss's theorem is one of Maxwell's equations) is valid only for stationary charges. The proposed changes in one of the equations in the Maxwell's system will lead to the fact that the electric and magnetic fields of the modified Maxwell's equations cease to correspond to the transformations of Einstein's theory of relativity, which will also need to be changed.[8] But no one returned to this problem when analyzing the results of the PAMELA experiment,

although it is now quite clear that of Maxwell's electrodynamics is not always a true theory[9] and today the requirement of invariance with respect to Lorentz transformations is not entirely reasonable.[10]

The most common instruments for the accurate measurement of the energy spectrum of constant and pulsed beams of charged particles are magnetic spectrometers. This method is based on the dependence of the radius of the cyclotron orbit on the kinetic energy of the particle. The equality of the Lorentz's force and the centrifugal force when the particle moves around the circumference in a homogeneous magnetic field leads to the equation:

$$qvB = \frac{mv^2}{r} \qquad (4)$$

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:

$$W = m_o c^2 \left\{ \sqrt{\frac{q^2 \mathbf{B}^2 \mathbf{r}^2}{\left(m_0 c^2\right)^2} + 1} - 1 \right\} \qquad (5)$$

In modern spectrometers, an approximate relation is used to estimate the kinetic energy of ultra relativistic charged particles in a magnetic field when $qBr >> m_o c^2$.[11]

$$W \approx q\mathbf{B}r \qquad (6)$$

where q is the particle charge, $\boldsymbol{B}$ is the induction of a homogeneous magnetic field, r is the radius of a circle described by a particle.

This may indicate the general physical principles inherent in all magnetic spectrometers and the general possible systemic errors of space detectors PAMELA and AMS. As the velocity of the particle increases and it approximates the speed of light, the efficiency of the action of the magnetic field on the charged relativistic particle decreases. With the help of the magnetic deflection method alone, the relativistic increase in mass (energy) is not measured. To estimate this gain, it is necessary to isolate this energy, to turn it into other forms – and this requires the interaction of a fast particle not with fields, but with matter. The first honest measurements of the brake losses of fast particles – in proportional counters[12] and photographic emulsions[13] showed: the energy of the particle does not grow into relativistic infinity, but goes to saturation. The final clarification of this question was made by the Chinese physicist Fan Liangjia in 2010 after three experiments on a linear accelerator at the Shanghai University each of them clearly indicates the absence of relativistic growth in fast electrons.[14] Particularly impressive is the fact that when the accelerating voltage increases several times the radius of curvature of the trajectory of a relativistic electron in a magnetic field instead of increasing remains constant. This indicates a complete inapplicability of the magnetic spectrometer in the region of relativistic measurements. Thus, the reliability of the conclusions about the complete elimination of relativistic protons from the flux of secondary electrons and positrons in the PAMELA magnetic spectrometer is doubtful. An experiment capable of confirming or refuting the assertion made

in the article about the absence of the "PAMELA Effect" and the presence of a constructive error in the PAMELA and AMS detectors detection equipment requires the elimination of relativistic protons at the detector input. This is easy to do since PAMELA and AMS–02 can work as gamma telescopes.

The results of this experiment could completely eliminate the assumption of a hardware error in the detection of the "PAMELA effect" associated with incomplete screening of protons.

Conclusion

As already noted in the preface to the article, the solution to the puzzle the "Pamela Effect" is at the intersection of three areas of physics: elementary particle physics, the theory of electrodynamics and astrophysics. What has brought each of these disciplines?

The physics of elementary particles and quantum electrodynamics (QED) allowed us to point to a new source of secondary electron–positron pairs in near–Earth space in the PAMELA and AMS–02 experiments associated with the polarization of the vacuum (dark matter). This source, undeservedly circumvented by the attention of researchers, can make a decisive contribution to the overall flux of electron–positron pairs formed in the vacuum (dark matter) under the action of relativistic protons, cosmic gamma radiation and the Earth's magnetic field. The creation of secondary electron–positron pairs in vacuum is a chain reaction that continues up to up to the moment of complete loss of energy by photons and charged particles. This is very reminiscent of the extensive atmospheric showers generated by cosmic particles. They are called S–cascades (from the English shower – a shower). In this case, the formation of pairs of particles and antiparticles excludes the conditions for the appearance of the "PAMELA effect".

Electrodynamics involving the relativistic Coulomb's law and of Leo Sapogin's Unitary Quantum Theory (UQT)[15] allow us to point out the source of the "primary" positrons in the PAMELA and AMS–02 experiments. The flux of "primary" positrons is formed in PAMELA and AMS detectors from secondary positrons with a soft energy spectrum and ultra relativistic protons possessing a rigid spectrum, since their trajectories in a magnetic spectrometer are close and they are difficult to distinguish from each other. The reason for this is that the classical Maxwell's electrodynamics and quantum electrodynamics (QED), which are the basis for the development of the PAMELA and AMS detector equipment, do not take into account the effect of retarded potentials and the deformation of the electric field of a moving charge. As a result, the spectrum of "primary" positrons becomes hard, and their number exceeds the number of secondary electrons.

Astrophysics made it possible to exclude pulsars from the sources of electrons and positrons in PAMELA and AMS experiments and compare the spectrum of electrons and protons in cosmic rays generated by supernova explosions with the spectrum of "primary" positrons.[5] It turned out that the energy spectra of ultra relativistic protons are identical to the spectra of "primary" positrons.[3] This can serve as evidence that relativistic protons are part of the "primary" positron flux in the PAMELA and AMS experiments.

Acknowledgments

Conflict of interest

Author declares there is no conflict of interest.

References

1. Mikhailov VV, Adriani O, Bazilevskaya GA. Secondary electrons and positrons in the near Earth space in the PAMELA experiment. *Bulletin of the Russian Academy of Sciences Physics.* 2017;81(2):203–205.

2. Mikhailov VV, Adriani O, Bazilevskaya GA. Modulation of electrons and positrons in 2006–2015 on the PAMELA experiment. *Bulletin of the Russian Academy of Sciences: Physics.* 2017;81(2):154–156.

3. Galaktionov YV. Search for antimatter and dark matter, precision studies of the cosmic rays fluxes on the international space station. AMS experiment. Results of four year exposure. *Physics–Uspekhi.* 2017;60(1):45–64.

4. Eroshenko YN. Physics news on the Internet (based on electronic preprints). *Physics–Uspekhi.* 2014;57(11).

5. Abeysekara AU, Albert A, Alfaro R. Extended gamma–ray sources around pulsars constrain the origin of the positron flux at Earth. *Science.* 2017;358(6365):911–914.

6. De Sangro R, Finocchiaro G, Patteri P, et al. Measuring propagation speed of Coulomb fields. *The European Physical Journal C.* 2015;73:137.

7. Ageev IM, Shishkin GG. *Of longitudinal waves.* Russia: MAI; 2014.

8. Sapogin LG, Dzhanibekov VA, Мокulsky MA, et al. About the Conflicts between the Unitary Quantum Theory and the Special and General Relativity Theories. *Journal of Modern Physics.* 2015;6(6):780–785.

9. Konstantinov SI. Tokomaks, Accelerators, Colliders and Maxwell's Electrodynamics. *Global Journal of Science Frontier Research: A Physics and Space Science.* 2016;16(7):85–97.

10. Sapogin LG, Ryabov YA. The Mass Spectrum of Elementary Particles in Unitary Quantum Theory and Standard Model. *Global Journal of Science Frontier Research: A Physics and Space Science.* 2016;16(2):1–15.

11. Kudasov YB. *Electrophysical measurements.* Russia: Fizmatlit; 2010.

12. Deich M, Kofed–Hansen O. *Experimental nuclear physics.* In: Segre E, editor. USA: Publishing house of foreign literature; 1961.

13. Barashenkov VS, Toneev V. *Interaction of high–energy particles and atomic nuclei with nuclei.* Russia: Atomizdat; 1972.

14. Liangzao Fan. *Three experiments challenging Einstein's relativistic mechanics and the traditional electromagnetic acceleration theory.* Russia: Electrosad; 2010.

15. Sapogin LG, Ryabov YA, Boichenko VA. *The Unitary Quantum Theory and a New Source of Energy.* USA: Science Publishing Group; 2015.