The Origin of the Antiproton-to-Proton Ratio and the Proton Flux as a Function of Rigidity for Cosmic Rays

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Abstract: Here, within the Scale-Symmetric Theory that leads to the atom-like structure of baryons, the antiproton-to-proton ratio in the energy coordinates and some qualitative and partially quantitative description of proton flux as a function of rigidity are presented. Obtained results are consistent with the AMS data.

1. Introduction

Here, applying the Scale-Symmetric Theory (SST), [1], we described the antiproton-to-proton ratio, p^-/p^+, in the proton-energy coordinates, E_p [GeV], and proton Flux as a function of rigidity $R = pc/(Ze)$ [GV] (rigidity is directly proportional to the momentum/charge ratio). For a proton is $Z = 1$ so, for example, a 17 GeV proton has a rigidity of 17 GV. Obtained results are consistent with the AMS data [2].

The SST shows that inside proton are three very dense fields composed of the carriers of gluons. Most important in this paper is mass of one of the very dense fields – it is mass of the torus/charge of proton, $X = 318.2955$ MeV [1A]. This torus is responsible for the strong interactions (it is the black hole in respect of the strong interactions) – inside the torus are produced pions (here, most important is production of the $\pi^+\pi^-$ pairs). The torus behaves analogically to the electric charge of electron so its radiation energy is $E_{Radiation,X} = X\alpha_{Radiation(electron)} = 0.36913$ MeV, where $\alpha_{Radiation(electron)} \approx 0.0011597$ [1A]. This energy is responsible for the p^-p^+ pair production.

In centre of the torus is the second very dense field/condensate with a mass of $Y = 424.1245$ MeV – it is the black hole in respect of the weak interactions [1A]. The coupling constant of the weak interactions is $\alpha_{Weak(proton)} = 0.0187229$ [1A] The weak energy of the torus is $E_{Weak,X} = X\alpha_{Weak(proton)}$.

2. Calculations

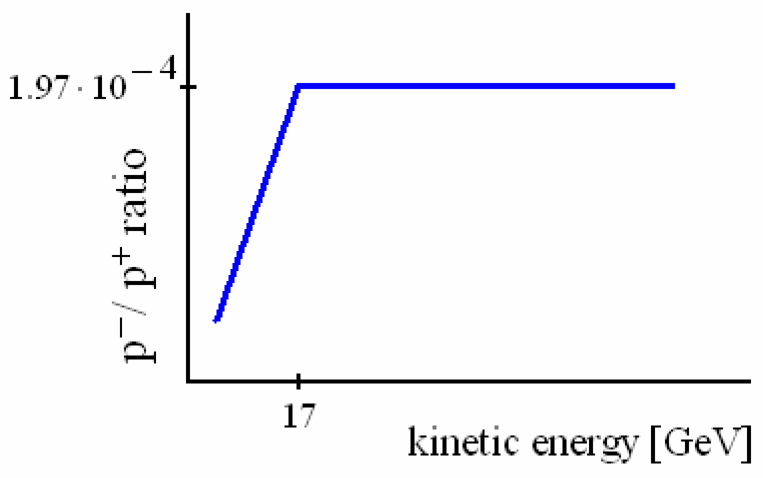
Outside the torus of relativistic proton are produced the relativistic proton-antiproton pairs/dipoles – in an approximation, there is the radial polarization of the axes of the p^-p^+ dipoles. Consider two p^-p^+ pairs polarized along the same direction. If the pairs are sufficiently close one to other then annihilation of inner proton and antiproton into two photons is possible. The emitted photons are moving along the direction of polarization so they collide with the external proton and antiproton i.e. it is the mechanism of separation of proton and antiproton. Notice that there can be involved more pairs so we have a cascade of annihilations of pairs and then the external proton and antiproton have higher kinetic energy. Such processes are possible, for example, inside and on surface of nucleonic plasma. The antiproton-to-proton ratio depends on number density of p^-p^+ pairs with separated constituents.

For lower temperature of nucleonic plasma, there are produced mostly the $\pi^-\pi^+$ pairs but when temperature increases, there appears more and more the X^-X^+ pairs which transform into the p^-p^+ pairs.

Calculate kinetic energy of emitted protons, $E_{Threshold(proton)}$, for which number density of p^-p^+ pairs with separated constituents reaches its upper limit (at first there appears a condensate with an energy of $E_{Threshold(proton(X))}\alpha_{Weak(proton)}$ which transforms into the torus with a mass of X)

$$E_{Threshold(proton(X))} = X / \alpha_{Weak(proton)} = 17\ \mathrm{GeV}. \qquad (1)$$

We can see that due to the weak interactions, there is a resonance between the kinetic energy of proton equal to 17 GeV and the mass of torus equal to $X \approx 318.3$ MeV which leads to the p^-p^+ pairs with separated constituents.



Antiproton-to-proton ratio.

Calculate the upper limit for the antiproton-to-proton ratio, $(p^-/p^+)_{upper\text{-}limit}$, – there appears the asymptote for the energy of protons higher than the threshold energy 17 GeV (the asymptote is parallel to the axis of the kinetic energy of protons). For one thermal proton in nucleonic plasma we obtain (there is one portion of radiation energy whereas an p^-p^+ pair has mass of two protons)

$$(p^- / p^+)_{upper\text{-}limit} =$$

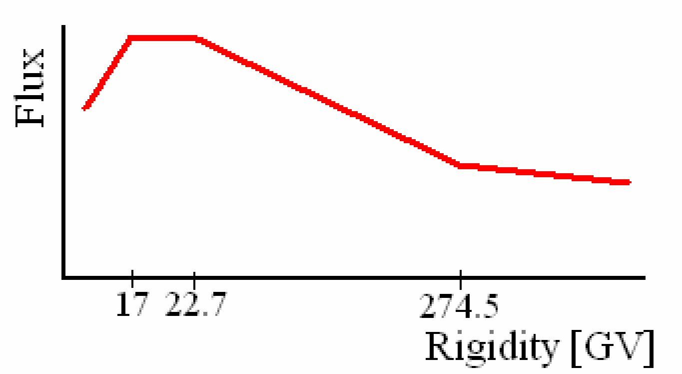
$$= fraction\text{-}of\text{-}separated\text{-}pairs / (1 + fraction\text{-}of\text{-}separated\text{-}pairs) =$$

$$= \{E_{Radiation,X} / (2\ m_{proton})\} / \{1 + E_{Radiation,X} / (2\ m_{proton})\} =$$

$$= 1.97 \cdot 10^{-4}. \qquad (2)$$

Above rigidity of proton equal to $R_{Threshold(proton(Y))} = Y_R / \alpha_{Weak(proton)} = 22.7$ GV there are produced from the radiation energy the p^+p^- pairs and more and more the condensates with a mass of Y – it decreases the proton flux (there is less p^-p^+ pairs with separated constituents). But above rigidity of proton equal to $R_{Radiation,X} = X_R / \alpha_{Radiation(electron)} = 274.5$ GV, once more there increases number density of the X^-X^+ pairs that transform into the p^-p^+ pairs – separation of the constituents of the pairs significantly reduces the rate of the decrease in the proton flux.

Notice that in nuclei of helium atoms there are two protons so instead 17 GV we obtain 34 GV whereas instead 22.7 GV is 45.4 GV so the flat part of the $Flux = f(R)$ curve for helium is for the interval (34, 45.4) GV. Probably due to the two protons, for rigidity higher than a few hundred GV, instead the slow decrease in flux, as it is for protons, there is an increase in flux.



Proton flux as a function of rigidity.

3. Summary

In this paper we showed that the AMS data lead to the atom-like structure of baryons described within the Scale-Symmetric Theory.

References

[1] Sylwester Kornowski (2015). *Scale-Symmetric Theory*
[1A]: http://vixra.org/abs/1511.0188 (Particle Physics)
[1B]: http://vixra.org/abs/1511.0223 (Cosmology)
[1C]: http://vixra.org/abs/1511.0284 (Chaos Theory)
[1D]: http://vixra.org/abs/1512.0020 (Reformulated QCD)
[2] AMS Collaboration, CERN, Geneva (15 April 2015).
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