The marked decrease of protons flux in cosmic rays beyond 3 GeV kinetic energy analyzed through a vortex model for the proton.

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Abstract:

We analyze available data for cosmic rays protons below 10 GeV and find evidence for instability of these particles as their kinetic energy increases beyond about 3 GeV, as expected from our recent model [1] which proposes the existence of a parent state at about 3.7 GeV, from which protons would condense in the form of flux-confining vortices. According to the model, above 2.7 GeV kinetic energy such vortex states become unstable compared to the parent, and thus protons of higher energy become very rare in cosmic rays, as confirmed by the data.

1. Analysis of cosmic rays data in the light of the vortex model for baryons.

Theoretical justification of the approach.

We have recently developed a field-theoretical model for baryons in which such particles are modelled as vortices confining magnetic flux, which would "condense" from a parent state at about 3.7 GeV, under the effect of electromagnetic instabilities of such a state[1,2]. This model has been shown to reproduce the dependence of mass of baryons with their magnetic moments (through an amount of confined magnetic flux) in a consistent, quantitative way. We here concentrate on the case of protons. Since the particles are assumed to be the result of the creation of states stabilized from a higher energy level, it should be expected that the number of protons will markedly decrease in cosmic rays for excessive kinetic energies. This is what we investigate and verify in this short note.

Application to cosmic rays data.

In Figure 1 we show data for the *number* flux of protons plotted as E (dN/dE) against kinetic energy E in GeV, from cosmic rays below 10 GeV kinetic energy, taken from the upper left corner of Figure 1.1 of ref. [3]. Below about 2 GeV kinetic energy there is an approximate plateau. From 2 GeV on, a marked decrease in the flux of protons is observed. We have obtained the actual functional relations in the original double-log plot, to calculate the number N of particles in units of $(\mathrm{m}^2\ \mathrm{sr\ s})^{-1}$ for several energy intervals. Assuming the plateau in E (dN/dE) extends from 0.1 GeV up to 3 GeV, we obtain N= 6800 by integration in this interval. Beyond 3 GeV the ordinate decays as $E^{-3/2}$. Therefore, one obtains by integration N= 1100 between 3 and 10 GeV, and a very small N= 204 between 10 and 100 GeV. That is, well over 80% of the protons have energies below about 3 GeV, and the numbers beyond 10 GeV are negligible in absolute terms in spite of the great interest around them from the high-energy physics standpoint.

According to our model in ref [1] , protons accelerated beyond 2.7 GeV kinetic energy (which comes from the difference between the parent level at 3.7 GeV and the proton rest mass of about 1 GeV, i.e., the "energy advantage") should become unstable since they lose the energy advantage acquired by settling in the lower energy vortex state. A related effect breaks Cooper pairs in superconductors if their kinetic energy gets greater than the pairing interaction provided by phonon-intermediated coupling.

Figure 2 shows a plot of the estimated (from collected data) *energy* distribution for the interstellar flux of protons [3], which peaks exactly at 2.7 GeV. In view of the gigantic values of E beyond the peak one realizes the minute amount of very energetic particles to the right of the peak. That is, once more one concludes that protons are essentially unstable above 2.7 GeV kinetic energy.

2. Conclusion

This short note analyzes data collected for the flow of protons in cosmic rays in the light of a recently proposed model in which protons are modelled as vortices in an energy state 2.7 GeV below a parent state from which they would have condensed[1]. We have found evidence for a critical kinetic energy of 2.7 GeV in both the number distribution of protons and in their energy distribution. Although It is clear that 2.7 GeV represents a critical value for the energies of protons in cosmic rays, a very small (“tail”) population of particles is detected at high energies. The expected question is why do these particles exist. In fact the vortex model completely neglects the recognized internal structure of the baryons. The survival of some particles to high energies is certainly related to internal short-range forces between constituents, not considered in the model. The good results of the vortex model of [1] however suggest that the effects of the proton constituents become more relevant at distances shorter than L/π, with L the size of the vortex in [1], which is on the order of 10^{-16} m.

3. References

1. O.F.Schilling, Progress in Physics, **15(**3**)**, 185 (2019). Correction: In eq. 7 one should include "+ m_p^2 c^2" between the curly brackets.
   http://www.ptep-online.com/2019/PP-58-08.PDF
   See also previous work by the author in vixra.org
2. O.F.Schilling, Annales de la Fondation Louis de Broglie, **43**-1, 1 (2018).
3. T.K.Gaisser, R. Engel and E. Resconi, Cosmic Rays and Particle Physics, Cambridge, 2016.

Figure 1: Reproduction of the upper left part of the double-log plots in Figure 1.1 of ref.[3] (linearized scales are adopted here). The *number* flux of protons in 10^3 m^{-2} $(sr.\ s)^{-1}$ units is plotted against the protons kinetic energy in GeV. The vertical line is placed at the value of K that corresponds to total loss of the vortex energy advantage compared to the vacuum parent state(see [1]). Integration shows that 80% of *N* concentrates below 3 GeV energies. The solid line is a guide.

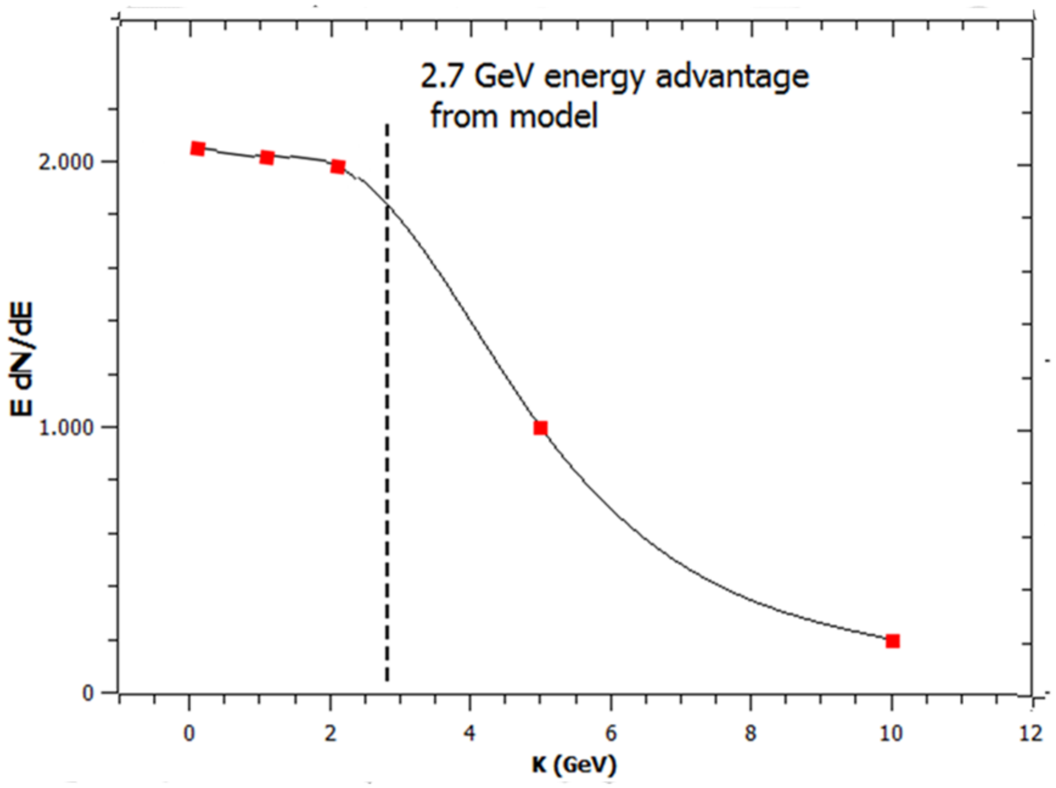

Figure 2: Estimated *energy* flux distribution of interstellar protons in cosmic rays, which peaks at exactly K= 2.7 GeV[3].