The electromagnetic origin of the 3 GeV peak in the flux profiles of Cosmic Rays protons.

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Abstract:

In two recent publications we developed a field theoretical model in which the origin of baryons is associated with the stabilization of charge vortices from vacuum. According to this model the vortices should condense from a state 2.7 GeV higher in energy than the proton rest energy. In support of such a picture, all number- flux and energy-flux profiles taken from protons cosmic rays (CR) display a peak in the range between 2.5 and 4 GeV(the form of this peak may suffer the influence on particles of the Sun magnetic field). In the present work we demonstrate through a simple calculation that the observed peak at ~ 3 GeV would correspond to the "elastic" limit of a vortex-proton structure. Any excess energy should then be released through radiation to avoid "melting" of the vortices, so that particles mostly concentrate at values of energy lower than 3 GeV.

Introduction.

In recent years we have worked extensively on heuristic models for baryons, which resulted in three publications [1-3]. In the two most recent publications[1,2] we developed a fieldtheoretical model which supplemented the essentially phenomenological treatment initially presented [3]. The model in [3] actually extends similar work of Barut[4] and Post[5] on the subject, reobtaining Barut's main final results which relate mass of baryons to the inverse of the alpha-constant [4]. In particular, Barut's *n* (a number of action quanta from the Bohr-Sommerfeld conditions) reappears in our treatment as a number of magnetic flux-quanta [1-3].

Perhaps the truly original (and surprising!) result of this work has been the realization that baryons should be the result of a process of stabilization(or condensation) of vortices of charge, generated from a parent state located at 3.7 GeV[1]. Such state might be associated with the EM vacuum and the baryons would come as a result of instabilities of EM origin taking place in that vacuum. Support for such an explanation comes from the energy distribution of protons and other particles in cosmic rays (CR)[6], which peak in the range 2.5-4 GeV, indicating a heavy concentration of particles below the peak energy. The purpose of the present paper is to supplement the brief analysis of this experimental observation advanced in [2]. As we show below the association of the peak position with the limiting "elastic" strength of a vortex of charge can be done from simple arguments, as well as it is possible to show that at the 3.7 GeV level some form of melting might indeed happen as energy increases.

Strained charge vortices.

At some point in their history particles in CR were subject to extreme electric and magnetic forces, and the measured flux distributions we detect now were established under the influence of such forces. Let´s concentrate on the case of protons, which represent by far the majority of the contents of CR. Protons are composed of entangled constituents of different charge values, and probably different topological properties associated with these charge values[5]. Under extreme electromagnetic forces, the proton structure is subject to huge internal stresses to avoid breakdown. We now argue that the observed peak at 3GeV energy in the spectra of CR directly probes the proton structure elastic response to such forces.

It is well known that a spring-mass oscillating system of mass *m* and elastic spring constant *k* will spontaneously oscillate at its fundamental frequency $\omega = (k/m)^{1/2}$ when subject to a constant force *F* along the spring- mass direction. Let´s assume that the peak kinetic energy of 3 GeV corresponds to the ground state energy of a 3DIM quantum harmonic oscillator, so that $3/2\hbar\omega \approx 3$ GeV.

The proton has three(major) constituents of mass ~ m/3, with *m* the proton mass. From classical mechanics there would be several natural modes of vibration and torsion. We take a representative natural frequency of this structure from the formula $\hbar\omega = \hbar\,(3k/m)^{1/2} = 2$ GeV= $3.2\text{x}\,10^{-10}$ J, giving $\omega = 3.1\text{x}10^{24}$ rad/s (we recognize that since the proton is a multi-component system other normal modes theoretically exist, but we will concentrate on the most conspicuous one, that at about 3 GeV).

The intense forces mentioned in the previous paragraphs would excite the vibration mode of frequency ω, and the internal consituents of the proton would acquire additional oscillating displacements as a result. The maximum amplitude δ related to such additional oscilating motion is given by the maximum elastic energy expression (*m* is the proton mass) :

$$3/2\,(m/3)\omega^2\delta^2 = 3/2\,\hbar\omega \qquad (1)$$

One immediately obtains $\delta = 2.4\text{x}10^{-16}$ m= 0.24 fm. This is the magnitude of the vibrational displacements(here considered elastic) of the proton inner constituents when excited 3 GeV above the rest state. It remains to be discussed whether the elastic regime is still applicable, since this might imply the possibility of destruction of the structure. The value for δ is indeed deeply revealing as far as the process taking place at 3.7 GeV is concerned, as we discuss below.

Analysis and Conclusions.

As argued in ref. [2], protons of energy around 3 GeV in theory reach their stability limits and lose the energy advantage over the parent state at 3.7 GeV. One might speculate that the proton would then "melt" into its parent phase.

In the previous section we have calculated the value for the displacements δ, which will be used to put such rather abstract concept of melting into a quantitative form. A practical way of doing this is through the Lindemann criterion (LC) for the melting of a solid.

According to the LC a solid loses cohesion towards a disordered ("molten") phase when atomic oscillations reach about 5 to 10% of the interatomic distance. Here we must replace the term interatomic by "inter-constituent" spacings. One might immediately evaluate if this is the case with the protons in CR. The radius of a proton is estimated from about 0.6 fm (from the calculated profile of charge distribution) up to 0.9 fm. The inter-constituent spacing cannot be greater than the size of the particle itself, of 1.2 to 1.8 fm It is possible to conclude then that the amplitude δ = 0.24 fm is about 13 to 20 % of the experimental inter-constituent spacing. The Lindemann criterion for melting(if applicable in its usual form here) is therefore just exceeded at such high kinetic energies.

From other similar cases in Physics the peak in a distribution exists because it indicates that at a particular energy an abrupt(or continuous) physical change takes place, which might be structural or in properties related to the structure, like mechanical strength, or electrical conductivity, among others. Is there any actual indication that protons disappear into vacuum or break apart at 3 GeV(like in a meltdown process)? In fact, there exists ample evidence that protons profusely radiate electromagnetic energy as their speed increases in accellerators, so that energy is released, thus avoiding breakdown(decay!). This is widely explored in synchrotron accellerators. The result in this case is the observed concentration of CR protons up to and below about 3 GeV energies. It seems energy is released until strains come back to the full elastic regime and the structure is stable. Such threshold can be regarded also as a fingerprint of the importance of electromagnetic forces in the formation of complex particles like the proton(see [1]).

The same explanation might be attempted to the electron case, in which inner topological features [5] might play the role of the baryon constituents in the analysis.

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