Inherent QCD Difficulties with *pp* Scattering

(This is a section of an article.)

This work examines the presently available pre-LHC *pp* elastic cross section data (denoted by ECS). Claims stating that QCD is unable to provide an explanation for the *pp* cross section data have been published in the last decade [9]. Few specific reasons justifying these claims are listed below. The examples rely on QCD's main property where baryons consist of three valence quarks, gluons and possible pairs of quark-antiquark.

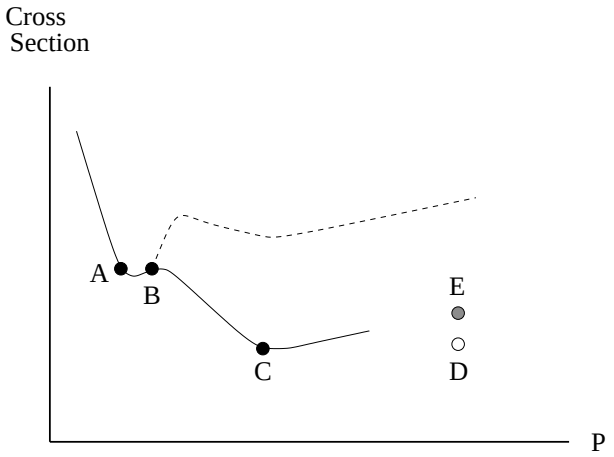

Figure 1: *A qualitative description of the pre-LHC proton-proton cross section versus the laboratory momentum P. Axes are drawn in a logarithmic scale. The solid line denotes elastic cross section and the broken line denotes total cross section. (The accurate figure can be found in [5]). Points A-E help the discussion (see text).*

- Deep inelastic *ep* scattering proves that for a very high energy, elastic events are very rare (see [7], p. 266). It means that an inelastic event is found for nearly every case where a quark is struck violently by an electron. On the other hand, fig. 1 proves that for high energy, elastic *pp* events take about 15% of the total events. Therefore, one wonders what is the proton's component that takes the heavy blow of a high energy *pp* collision and is able to leave the two

colliding protons intact? Moreover, why this component is not observed in the corresponding *ep* scattering?

- A QCD property called Asymptotic Freedom (see [10], p. 397) states that the interaction strength tends to zero at a very small vicinity of a QCD particle. Thus, at this region, a QCD interaction is certainly much weaker than the corresponding Coulomb-like interaction. Now, the general expression for the elastic scattering amplitude is (see [7], p. 186)

$$M_{if} = \int \psi_f^* V \psi_i d^3x, \tag{1}$$

where V represents the interaction. Evidently, for very high energy, the contribution of a very short distance between the colliding particles dominates the process. Therefore, if asymptotic freedom holds then the *pp* ECS line is expected to show a *steeper decrease* than that of the Coulomb interaction, which is seen on the left hand side of point A of fig. 1. The data represented in fig. 1 proves that for an energy which is greater than that of point C of fig. 1, the *pp* ECS line *increases*. Hence, the data completely contradict this QCD property.

- A general argument. At point C of fig. 1, the ECS graph changes its inclination. Here it stops decreasing and begins to increase. This effect proves that for this energy value, *something new shows up in the proton.* Now, QCD states that quarks and gluons are elementary particles that move quite freely inside the proton's volume. Therefore, one wonders how can QCD explain why a new effect shows up for this energy?

Each of these specific points illustrates the general statement of [9], concerning QCD's failure to describe the high energy *pp* cross section data.

References:

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