What can we learn/expect *on elastic and diffractive scattering* from the LHC experiments ?

- contribution to the discussion session.

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Diffraction is the last frontier in the effort to harness the standard model under a computational framework that includes non-perturbative quantum electrodynamics (npQCD). Despite the success of lattice calculations in predicting the hadron mass spectrum, predictions for diffraction are still based on phenomenological models. The transition from phenomenology to theory will benefit from the larger rapidity and transverse momentum that will become available at the Large Hadron Collider (LHC). The aim should be twofold: unveil the QCD basis of diffraction, and use diffraction as a tool to discover new physics either within (dark energy?) or beyond the standard model (supersymmetry?).

1 Introduction

The goal of conducting studies of elastic and diffractive scattering at hadron colliders should be twofold: unveil the QCD nature of the diffractive exchange, which historically is referred to as the *Pomeron*, and use diffraction as a tool in searching for new physics [1]. A general QCD process involves a color transfer by gluons and/or quarks. Due to color-confinement, this is a short-range interaction. In diffraction, the exchange is a color-singlet combination of gluons and/or quarks carrying the quantum numbers of the vacuum. As no color is transferred, the process can be viewed as *pseudo-deconfinement*, where the prefix *pseudo* is used because the exchange has an imaginary mass and the process can proceed only if there is enough energy transferred to produce a pion. This is not unlike photon emission, in which a photon can only *deconfine* itself from the proton by interacting with an electromagnetic field, as for example in passing through matter. However, the difference is that the photon is massless, while the quantum of the strong force, the pion, has mass.

Figure 1 illustrates the final-state event topologies of non-diffractive (ND) and single-diffractive (SD) pp interactions. An event with a central pseudorapidity gap from double diffraction dissociation (both protons dissociate) is illustrated in Fig. 2, which is a photograph taken at a New Year's midnight celebration fireworks display show in New York's Central Park. Apparently, the fireworks designer had taken some physics and designed two *fireballs* with a trigger that threw them into opposite directions before they exploded.

An interesting question arises: what happens if the emitted Pomeron has such low energy that it cannot produce a pion upon absorption by a nearby proton? Will it keep going in search of another hadron, or more precisely in search of a quark and be trapped in the Universe as a large wave length energy bundle in the process of being exchanged? Such an energy bundle will correspond to an imaginary mass, which brings up the next question: what are the gravitational

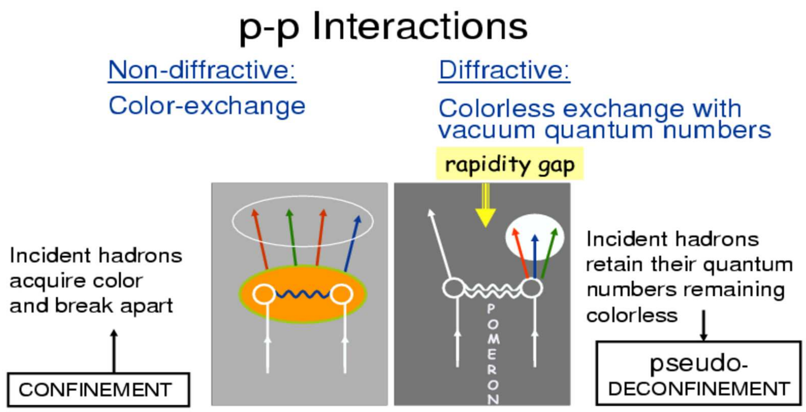

Figure 1: Non-diffractive and diffractive pp interactions.

consequence of this imaginary energy trapped in the Universe?

The dependence of the diffractive cross section on the size of the rapidity gap may be a clue that provides the answer. As displayed in Fig. 3, in writing the differential diffractive cross section in terms of the rapidity gap Δy instead of the forward momentum loss fraction ξ using $\Delta y = -\ln \xi$, the term 2ϵ, where ϵ is the excess above unity of the intercept of the Pomeron trajectory, appears formally as a negative particle density. Does this signify a gravitational repulsion caused by this unrealized energy permeating the Universe? If yes, can one relate the value of ϵ with the rate of gravitational expansion?

2 What to do at the LHC

goal	· understand the QCD basis of diffraction and discover new physics
exploit	· large $\sqrt{s} \Rightarrow$ large σ, $\Delta\eta$, E_T
TEV2LHC	· from Tevatron to LHC: confirm, extend, discover...
	$\Rightarrow$ confirm Tevatron results and extend them into the new kinematic domain
specifics	· elastic diffractive, total cross sections, and ρ-value
	$\Rightarrow$ diffractive structure function: dijets vs. W-boson, ...
	$\Rightarrow$ multi-gap configurations
	$\Rightarrow$ jet·gap·jet: $d\sigma/d\Delta\eta$ vs. $E_T^{\rm jet} \Rightarrow$ BFKL, Mueller-Navelet jets

References

[1] V.A. Khoze, A.B. Kaidalov, A.D. Martin, M.G. Ryskin, W.J. Stirling, *Diffractive processes as a tool for searching for new physics,* arXiv:hep-ph/0507040.

[2] Konstantin Goulianos, *Factorization Breaking in Diffraction*, in these Proceedings.

[3] Konstantin Goulianos, *Diffractive and Total pp Cross Sections at LHC*, in these Proceedings.

[4] Konstantin Goulianos, *The Forward Detectors of CDF and DØ*, in these Proceedings.

Figure 2: Rapidity gaps in fireworks: double diffraction dissociation with a central large rapidity gap in a fireworks display in New York's Central Park.

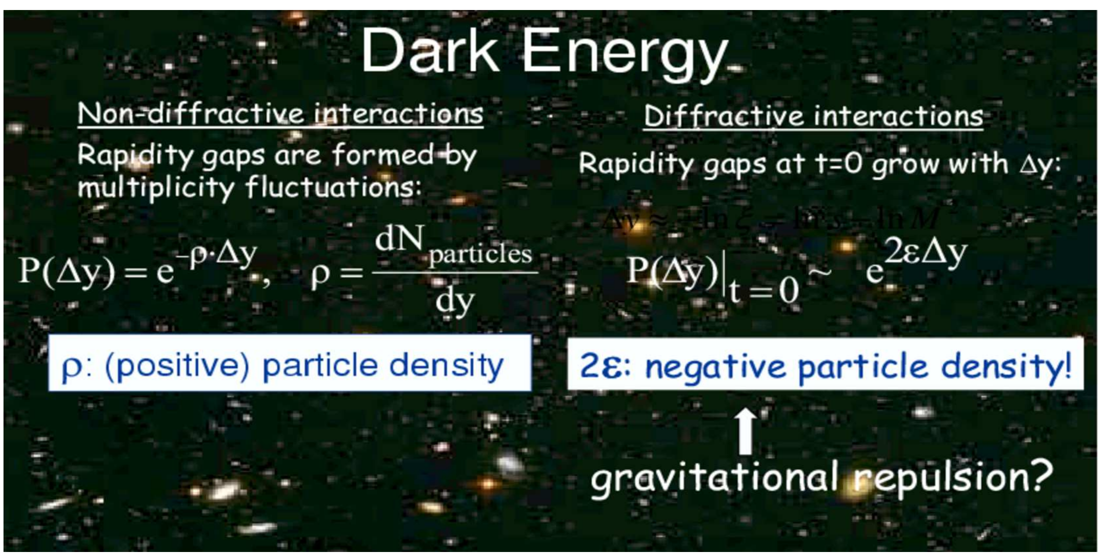

Figure 3: (left) In non-diffractive interactions the probability $P(\Delta y)$ for forming a gap Δy is exponentially suppressed as $\exp[-\rho \cdot \Delta y]$, where ρ is the final state particle density per unit rapidity; (right) in diffractive interactions, $P(\Delta y)$ at $|t| = 0$ increases with Δy, which corresponds to a *negative* particle density $\rho' = -2\epsilon$. Does this lead to gravitational repulsion?