Essay

Pomeron and Odderon from TGD Viewpoint

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Abstract

Pomeron is part of low energy phenomenology of hadron physics and emerged already about half century ago in the so called Regge theory to explain the logarithmically rising (rather than decreasing) cross sections in proton-proton and proton-antiproton collisions. Odderon is a cousin of Pomeron. Since the charge parity (see `https://cutt.ly/ixd78aS`) is $C = 1$ for Pomeron $C = -1$ for Odderon, these states are analogous to pion with spin 0 and ρ meson with spin 1. Perturbative QCD cannot say much about these objects. In this article, these objects are discussed in the picture of low energy hadron physics provided by TGD.

1 Introduction

The following comments were inspired by a popular article telling about the empirical support for a particle christened Odderon (`https://cutt.ly/2xd7M7Y`). The article about Odderon by Csörgö et al is published in European Physics Journal C [1]. As the name tells, Odderon is not well-understood in QCD framework.

Odderon is a cousin of Pomeron which emerged already about half century ago in the so called Regge theory to explain the logarithmically rising (rather than decreasing) cross sections in proton-proton and proton-antiproton collisions. Pomeron is part of low energy phenomenology and perturbative QCD cannot say much about it. Since the charge parity (see `https://cutt.ly/ixd78aS`) is $C = 1$ for Pomeron $C = -1$ for Odderon, these states are analogous to pion with spin 0 and ρ meson with spin 1.

Pomeron and Odderon have not been in the interests of the frontier of theoretical physics: they represent for an M-theorist a totally uninteresting and primitive low energy phenomenology - as all that we used to call physics before the first superstring revolution -, and does not therefore deserve the attention of an ambitious superstring theorist more interested in the marvels of brane words, landscape, swampland, and multiverse.

I have written about Pomeron for years ago. The following is something different since the view about low energy strong interactions according to TGD [3] has developed considerably [5, 4].

One can go first to Wikipedia to learn about Pomeron [2] (`https://cutt.ly/Wxd5eFq`).

1. Pomeron exchange appearing in the t-channel in elastic scattering was postulated to explain the slowly (logarithmically) rising scattering cross sections in proton-proton and proton-antiproton collisions. For quarks and gluons the scattering cross sections fall down rather rapidly with energy (by dimensional argument like inverse $1/s$ of cm energy squared) so that something else would be in question.

2. The total cross sections do not depend on the charges of the colliding baryons. The usual shower of Cerenkov radiation was missing from Pomeron exchange events. The absence of pions usually present was interpreted as absence of color charge.

   This suggests that quarks and gluons do not participate the Pomeron events. There is often also a large rapidity gap in which no outgoing particles are observed.

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3. In the Regge theory which later was concretized in terms of the hadronic string model. Pomeron would correspond to a Regge trajectory for which the Reggeon would have quantum numbers of vacuum except for mass and angular momentum. Regge trajectory would satisfy the formula $M^2 = M_0^2 = \alpha(s)J$, M mass, J angular momentum. The exchange of the entire Regge trajectory would give rise to approximately constant cross section. Odderon would be Pomeron like state with an odd charge parity $C = -1$ instead of $C = 1$. Pomeron and Odderon could correspond $C = \pm 1$ parts of a Regge trajectory.

4. In the QCD picture Pomeron and Odderon are assumed to be associated with the gluonic exchanges, which should form Regge trajectories: this suggests a stringy picture and non-perturbative QCD. Pomeron *resp.* Odderon would be a many-gluon states with an even *resp.* odd number of gluons.

2 TGD view about Pomeron and Odderon

In the following the notion of many-sheeted space-time [3] is described first and then a model for Pomeron and Odderon relying on many-sheeted space-time and the notion of magnetic body is summarized.

2.1 The notion of many-sheeted space-time

In TGD framework space-times are 4-D surfaces in $H = M^4 \times CP_2$, where M^4 denotes empty Minkowski space and CP_2 denotes the complex projective space. Space-time as a 4-surface has M^4 projection whose dimension d can vary.

1. For $d = 4$, space-time surface can be locally regarded as a many-sheeted covering of M^4. Space-time surface is topologically non-trivial in all scales and one must give up the simple view of special and general relativities about space-time. For instance, macroscopic objects correspond to space-time sheets glued to larger space-time sheets. The notion of many-sheeted space-time summarizes this picture.

2. The union of space-time sheets with the same M^4 projection replaces superposition of classical fields do that only their effects sum up.

3. At quantum field theory (QFT) limit the sheets are replaced with a single region of M^4 endowed with a slightly curved metric and gauge potentials. Gauge potentials are sums of gauge potentials at various sheets identifiable as components of the induced spinor connection. The deformation of the metric from the Minkowski metric is expressible as a sum of the deviations of the induced metric from the M^4 metric for various space-time sheets.

4. This description loses all information about many-sheetedness, and one expects that QFT approach cannot satisfactorily describe the situations in which many-sheetedness becomes important. Low energy limit of hadron physics could be such a situation.

2.2 TGD based model for hadron and low energy hadron interactions

In the many-sheeted space-time of TGD [3], hadron is a many-sheeted object [4] and has a color magnetic body (MB) consisting of flux tubes having approximate description as strings. The reconnections of flux tubes of MBs replace the QFT description of low energy hadron interactions as meson exchanges.

1. There is a hadronic space-time sheet and quark and gluon space-time sheets are glued at this. There is a magnetic body (MB) of hadron having a layered structure. In particular, there are em/color/weak MBs consisting of flux tubes and "tentacles", which are U-shaped flux tubes.

Low energy hadron physics would be described in terms of reconnections of these tentacles. This is a rather new element in the picture. In a reasonable approximation, flux tubes are strings and the reconnection of closed strings appears as a basic reaction vertex for closed strings. This gives a connection with the hadronic string model. TGD indeed emerged as a generalization of the hadronic string model 43 years ago (and also as a solution of the energy problem of GRT).

2. Most of the energy of hadron is assumed to be carried by color MB: quarks and gluons carry only a small part of energy. In QCD space-time dynamics is not present and the analog of hadron as space-time surfaces would be a gluon condensate of some kind.

3. Low energy hadron reactions would consist of reconnections of the U-shaped flux tubes of the colliding color MBs. Besides this there are also the collisions of quarks and gluons having approximate description in terms of QCD. The already mentioned connection with hadronic string model suggests a connection with Regge and string model descriptions of Pomeron/Odderon.

4. Hadrons have U-shaped flux tubes acting like tentacles and reconnect to form a bridge of two flux tubes between colliding hadrons. This topological interaction mechanism would be universal and occur in all scales. In biology the ability of reacting biomolecules to magically find each other in the dense molecular soup would rely on this mechanism. It would be also a mechanism of high Tc - and biological superconductivity.

2.3 How to understand Pomeron and Odderon?

Could the proposed picture explain the basic properties of the Pomeron?

1. Charge independence and the absence of pion emission assignable to quark-gluon reactions can be understood. Gluons and quarks of colliding hadrons would not meet each other at all. The two colliding hadrons would just touch each other with their "tentacles" which would transfer some momentum between them in elastic collisions. This would explain the rapidity gap.

2. What about the slow dependence on collision energy? Why the cross section describing the probability of the formation of reconnection would not depend on collision energy?

   (a) One could visualize the cross section in cm frame geometrically as the area of a 2-D surface cylinder parallel to the line connecting the colliding particles. The area of this cylinder would tell the probability for the formations of reconnection. If I try to touch some object in darkness, its area tells how probable the success is.

   (b) In elastic scattering the t-channel momentum exchange would be orthogonal to this cylinder and have vanishing energy component. It would not change in Lorentz boosts increasing the cm collision energy. If the contribution to the cross section depends only on t, it would be independent of collision energy.

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