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Abstract

QCD outcomes in electron-positron collision

Quantum chromodynamics (QCD) explains how quarks and gluons, known as partons, bind together to form hadrons via the strong interaction. The interaction of partons can be observed in high-energy collisions, the simplest way of producing a partonic outcome being when an electron and a positron collide. The produced photon propagator can scatter into various outcomes, including a quark-antiquark pair.

The same initial annihilation of an electron and a positron can also produce a lepton pair, making it possible to compare the different final state results. By calculating the processes' cross sections and taking the ratio between the two, we obtain a result that differs from one. This indicates that the strong force contains coefficients that are not applicable to a leptonic process. The coefficients arise from the property of partons called color.

The binding of partons is called color confinement. The confinement has an asymptotic nature, which means that the strong force between particles increases as the distance between them grows. In the pre-hadronic state of the collision the force is weak and the partons can be observed as almost free particles.

Since the final partonic state resulting from the collision includes not only the quark-antiquark pair but also a series of possible combinations of partons, the partonic cross section is calculated up to next-to-leading order (NLO). The leading order (LO) contains the simplest Feynman graph of a 2-to-2 particle process, while the NLO result includes both virtual and real corrections, with the real correction involving a 2-to-3 particle process. The cross section calculations include modern loop integration techniques and the Passarino-Veltman procedure, and the total cross section is calculated perturbatively, summing the next orders with the leading order cross section.

The ratio of the different outcomes in electron-positron collision is one of the proofs of strong interaction and its effects. Observing the partons on a small perturbative scale gives us information about their properties, such as asymptotic freedom.

The partonic outcome can be calculated further, but considering the characteristics of the confinement, the first corrective order, NLO, should give us the biggest correction term, making it the most important of the orders.