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Forward-backward and charge asymmetries at Tevatron and the LHC [1]

Johann H. Kühn

Institut für Theoretische Teilchenphysik, Karlsruher Institut für Technologie, D-76133, Karlsruhe, GERMANY

Germán Rodrigo

Instituto de Física Corpuscular, Universitat de València - Consejo Superior de Investigaciones Cientìficas, Parc Científic, E-46980 Paterna, Valencia, SPAIN

We provide a qualitative and quantitative unified picture of the charge asymmetry in top quark pair production at hadron colliders in the SM and summarise the most recent experimental measurements.

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1 Introduction

An interesting property in top quark pair production in hadronic collisions is the charge asymmetry, namely a difference in the angular distribution of the top quarks with respect to that of the antiquarks, due to higher order corrections in the Standard Model (SM). Since 2007, sizeable differences have been observed between theory predictions [?, ?, ?] and measurements by the CDF [?, ?, ?, ?, ?, ?] and the D0 [?, ?, ?] collaborations at the Tevatron. This discrepancy was particularly pronounced for the subsample of $t\bar{t}$ pairs with large invariant mass, $m_{t\bar{t}} > 450$ GeV, and the asymmetry defined in the $t\bar{t}$ rest-frame, where a 3σ effect was advocated [?]. These anomalies triggered a large number of theoretical investigations speculating about possible new physics contributions [?, ?, ?, ?, ?, ?, ?]. Recent analysis, however, lower this discrepancy, particularly at D0 [?]. Also, measurements at the LHC [?, ?, ?, ?, ?, ?, ?] are in good agreement with the SM prediction.

The $t\bar{t}$ asymmetry is often called forward–backward asymmetry at the Tevatron and charge asymmetry at the LHC, but in fact, although the kinematical configurations of the two machines are different the physical origin of the asymmetry in both cases is the same. In this talk, we provide a qualitative and quantitative unified picture of this property in the SM and summarize the experimental measurements.

2 The charge asymmetry in the SM

The dominant contribution to the charge asymmetry originates from $q\bar{q}$ annihilation [?] due to the interference between the Born amplitudes for $q\bar{q} \to t\bar{t}$ and the one-loop amplitudes, which are antisymmetric under the exchange of the heavy quark and antiquark (box and crossed box). To compensate the infrared divergences, these virtual corrections are combined with the interference between initial and final state radiation. Diagrams with the triple gluon coupling in both real and virtual corrections give rise to symmetric amplitudes and can be ignored. A second contribution to the asymmetry from quark-gluon scattering ("flavour excitation") hardly contributes to the asymmetry at the Tevatron. At the LHC, it enhances the asymmetry in suitable chosen kinematical regions [?]. CP violation arising from electric or chromoelectric dipole moments of the top quark do not contribute to the asymmetry.

The inclusive charge asymmetry is proportional to the symmetric colour factor $d_{abc}^2 = 40/3$, and positive, namely the top quarks are preferentially emitted in the direction of the incoming quarks at the partonic level [?]. The colour factor can be understood from the different behaviour under charge conjugation of the scattering amplitudes with the top and antitop quark pair in a colour singlet or colour octet state. The positivity of the inclusive asymmetry is a consequence of the fact that the system will be less perturbed, and will require less energy, if the outgoing colour