

Abstract

This thesis presents a comprehensive overview of an alternative diagrammatic approach based on holomorphic cutting rules for the computation of reaction rates in quantum field theory. The focus is placed on applications to physics beyond the Standard Model, especially matter–antimatter asymmetry and dark matter production in the early universe. To set the stage, the work first reviews the dynamics of a radiation-dominated universe, the Friedmann equation for cosmic expansion, and the Boltzmann equation for particle number densities, connecting macroscopic cosmology with microscopic quantum processes. A brief overview of the quantum field theory relevant for computing the collision term of the Boltzmann equation is provided. The holomorphic cutting approach is then developed and demonstrated, showing how it naturally streamlines the extraction of CP asymmetries, the enforcement of unitarity constraints, and the systematic cancellation of divergences. Moreover, anomalous thresholds are shown to give rise to thermal masses, while a simple cylindrical winding procedure incorporates quantum-statistical effects. Both thermal-mass and quantum-statistical effects are incorporated while remaining entirely within the familiar framework of zero-temperature Feynman rules.

Keywords: Early Universe, Dark Matter, Beyond Standard Model Physics, Leptogenesis, Baryogenesis