P3EWSB: High Precision Predictions to Probe the ElectroWeak-Symmetry Breaking

In 2012, a significant milestone was reached at the LHC with the discovery of the Higgs boson. This discovery completed the Standard Model of Particle Physics, a theoretical framework that describes the fundamental particles and forces that govern the universe. The Higgs boson is associated with the Higgs field, which is responsible for giving mass to other particles. The Higgs mechanism, which describes the process by which particles acquire mass through their interaction with the Higgs field, was confirmed by the discovery of the Higgs boson.

Despite this significant discovery, the dynamics of the Electroweak-Symmetry-Breaking (EWSB) mechanism, which is the process responsible for giving mass to the electroweak bosons (W- and Z-bosons), remains one of the most intriguing questions in particle physics. The EWSB mechanism is closely linked to several other fundamental questions, such as the structure of the early universe, the asymmetry between matter and antimatter, and the observed mass hierarchies of the known fermions.

Exploring the EWSB mechanism and the Higgs potential is a high-priority goal of the LHC physics programs and future colliders. One approach to studying the EWSB mechanism is to investigate the longitudinal polarisation state of the massive electroweak bosons. This polarisation state is connected through the Equivalence Theorem to the Nambu-Goldstone states of the Higgs field and, therefore, to the Higgs potential and dynamics.

At the LHC, it is possible to study the production of polarised bosons and probe their interactions by analysing (multi-)boson final states such as boson pair production (WW, WZ, ZZ), Higgs-bremsstrahlung processes (WH and ZH), vector-boson fusion, and vector-boson scattering processes. This approach requires high precision and accuracy experimentally and theoretically to test the scalar sector and the EWSB mechanism effectively.

The P3EWSB project aims to advance the precision of theory predictions for polarised cross-sections to the level required for these studies. This will be achieved by computing quantum corrections and investigating their impact on quantities measured at the LHC and future colliders. These precision predictions are essential to facilitate Standard Model precision measurements and to enlarge the reach of the search for new particles and new fundamental interactions. The ultimate goal is to understand better the EWSB mechanism and the Higgs potential, which will shed light on fundamental questions about the universe's structure and evolution.