Abstract

Canonical loop quantum gravity (LQG) is a canonical quantization of general relativity in its Hamiltonian formulation, which has successfully completed the construction of a kinematical Hilbert space and the implementation of the Gauss constraints and the spatial diffeomorphism constraints.

In the first part of this thesis I give a general introduction to the Ashtekar–Barbero Hamiltonian formulation of general relativity and a detailed overview of the LQG program.

In the second part, I present a new approach for quantizing the Hamiltonians in various LQG models. The result allows to make a step forward toward improving the status of the dynamics in the theory. The construction is based on novel regularization procedures of the classical functionals, starting with the construction of a new geometrical operator, the curvature operator, related to the three–dimensional Ricci curvature. This new approach eventually leads to a diffeomorphism covariant scalar constraint operator in vacuum LQG with an anomaly–free constraints algebra. Moreover, thanks to the new prescription, it is possible to construct eligible symmetric extensions with the perspective to obtain self–adjoint extensions.

In the third part, I expose how the new regularization is used to implement symmetric Hamiltonian operators in the context of two particular LQG deparametrized models, completing the quantization of the two models with a full quantum gravity sector. Finally, I present an approximation method based on time–independent perturbation theory, which was applied to the Hamiltonian operators in those deparametrized models and where the perturbation parameter depends on the Barbero–Immirzi parameter.