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Numerical analysis of the volume operator in loop quantum gravity

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In loop quantum gravity (LQG), the volume operator plays a crucial role in the study of quantum geometry and quantum dynamics. However, the effect of the volume operator is studied only for some simple cases. In this talk, we introduce a numerical algorithm that can give the matrix elements of the volume operator on arbitrary valent gauge-variant and gauge-invariant spin network states and their corresponding coherent states. Moreover, we propose an improved version of the Giesel-Thiemann semiclassical perturbation theory of the volume operator, which gives the correct semiclassical approximation to the matrix elements and the gauge invariant expectation values. Our numerical algorithm verifies the result and links the full quantum evaluation to the semiclassical results. Based on this analysis, we implement an algorithm for the computation of the matrix elements of the Hamiltonian operator with the Lorentzian term on arbitrary spin network states and for the computation of its semiclassical expectation value on the corresponding coherent states. This opens the possibility to study the genuine full quantum dynamics in LQG.

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