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Foamy Interior Geometry of Schwarzschild Black Holes in Quantum Gravity

The Hawking-Wheeler conjecture that the spacetime has a foamy structure at Planckian scales is an attractive feature to be captured in any theory of Quantum Gravity. While Loop Quantum Gravity predicts a discrete geometry at such fundamental scales, String Theory begins with the assumption of stringy nature of all fundamental particles. Both these fundamental theories of Quantum Gravity have been applied to study the quantum nature of the black hole spacetime.

In this work, we study the quantum nature of Schwarzschild black hole spacetimes in yet another well-formulated theory of Quantum Gravity, namely, the Wheeler-DeWitt quantization scheme. We solve the Wheeler-DeWitt equation $\hat{H}\Psi = 0$ in the minisuperspace approximation with the spherically symmetric metric $ds^2 = -N^2dt^2 + u^2dr^2 + v^2(d\theta^2 + \sin^2\theta\, d\phi^2)$, the metric coefficients being treated as functions of both r and t.

The corresponding eigen value problem reduces to Bessel's equation. The black hole interior (exterior) solution is Bessel (modified Bessel) function of imaginary order with real argument, both being determined by the metric coefficients. Applying restriction on the wave function coming from boundary conditions, we obtain legitimate forms of the metric coefficients that encode the foamy interior geometry of the black hole. Our results are in close resemblance with those obtained via Loop Quantum Gravity.

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