Quasinormal modes of an effective loop quantum black hole

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We investigate the quasinormal modes (QNMs) of a solution for a Schwarzschild black hole (BH) modified by Loop Quantum Gravity (LQG) corrections. This modified spacetime is regular everywhere and features a global structure consistent with a black bounce, where the bounce radius is governed by an LQG parameter. Our analysis centers on massless scalar field perturbations within this modified spacetime. We compute the QNMs using both the Wentzel-Kramers-Brillouin (WKB) approximation and the continued fraction method. For modes with multipole number $l = 0$ and overtone number $n > 0$, we find that the QNM frequency orbits form self-intersecting, spiraling paths in the complex plane, which converge to a fixed complex value representative of the QNMs in the extremal case. Our results indicate that for small values of the LQG parameter, the damping of QNMs decreases with increasing LQG parameter. Additionally, the QNM spectrum of the LQG-corrected BH displays an oscillatory pattern, suggesting the potential existence of QNMs with vanishing real parts. This pattern implies that the limit $n \to \infty$ for the real part of QNMs is not well-defined, contrasting with the behavior in the classical Schwarzschild case. Furthermore, we examine the time-domain profiles of scalar field perturbations and show that the LQG correction does not affect the Schwarzschild power-law tail. We extract the fundamental mode from the time profile using the Prony method, achieving excellent consistency with the frequencies obtained from both the WKB and continued fraction methods.