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Renormalization Group in Six-derivative Quantum Gravity

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The exact one-loop beta functions for the four-derivative terms (Weyl tensor squared, Ricci scalar squared, and the Gauss-Bonnet) are derived for the minimal six-derivative quantum gravity (QG) theory in four spacetime dimensions. The calculation is performed by means of the Barvinsky and Vilkovisky generalized Schwinger-DeWitt technique. With this result we gain, for the first time, the full set of the relevant beta functions in a super-renormalizable model of QG. The complete set of renormalization group (RG) equations, including also these for the Newton and the cosmological constant, is solved explicitly in the general case and for the six-derivative Lee-Wick (LW) quantum gravity proposed in a previous paper by two of the authors. In the ultraviolet regime, the minimal theory is shown to be asymptotically free and describes free gravitons in Minkowski or (anti-) de Sitter ((A)dS) backgrounds, depending on the initial conditions for the RG equations. The ghost-like states appear in complex conjugate pairs at any energy scale consistently with the LW prescription. However, owing to the running, these ghosts may become tachyons. We argue that an extension of the theory that involves operators cubic in Riemann tensor may change the beta functions and hence be capable of overcoming this problem.

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