Erratum

First-order quantum-gravitational correction to Friedmannian cosmology from covariant, holomorphic spinfoam cosmology

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The imaginary unit on the right-hand side of Eq. (15) should not be there, namely the product $\alpha\beta$ has to be real-valued,

$$\alpha\beta = -\frac{3t}{16\pi\gamma G} \in \mathbb{R},$$

for real values of the Barbero–Immirzi parameter γ . As a consequence, and for $dR/dT \neq 0$, the first-order quantum Friedmann Hamiltonian constraint (16) becomes

$$\frac{dR}{dT} - \frac{4\pi i l_P^2}{R^2} = 0.$$

(Note that for $dR/dT = 0$, one immediately finds both $H_{\text{Cl.}} = 0$ and $H_{\text{Qu.}} = 0$ (cf. Eq. (13)), leading to the solution $R = \text{const.}$ from which one concludes that in this case no quantum correction to the classical scale factor exists.) Since there is no unique way to select a proper cosmological time T for the formal parameterization of the scale factor R from the covariant approach, the canonical parameter choices for the cosmological time are discussed.

First, consider a real-valued cosmological time $T \in \mathbb{R}_{\geq 0}$. The solution of the first-order quantum Friedmann Hamiltonian constraint is easily found by separation of variables and integration with respect to the cosmological time T , yielding the solution

$$R(T) = (12\pi i l_P^2 T + \lambda_0)^{1/3} \in \mathbb{C},$$

where λ_0 denotes a constant. This complex-valued solution is unphysical because a meaningful scale factor is a positive real-valued function and, thus, this solution has to be disregarded. For the remaining, imaginary choices of the cosmological time $T = \pm i\mathcal{T} \in \mathbb{C}$ with $\mathcal{T} \in \mathbb{R}_{\geq 0}$, the corresponding first-order quantum Friedmann Hamiltonian constraints are given by the differential equations

$$\frac{dR}{d\mathcal{T}} \pm \frac{4\pi l_{\text{P}}^2}{R^2} = 0,$$

which can be solved by the same method as in the previous case. These solutions read

$$R(\mathcal{T}) = (\mp 12\pi l_{\text{P}}^2 \mathcal{T} + \lambda_0)^{1/3},$$

describing either growing universes with small decelerating expansions of the order $l_{\text{P}}^{2/3}$ (positive solution) or shrinking universes with accelerating contractions of the same order (negative solution) with initial values at $R = \lambda_0^{2/3}$ and cutoffs for the shrinking universe solutions at $R = 0$. It is sufficient to study only the expanding universe scenario because the shrinking universe scenario can be obtained by a discrete time reflexion transformation $\mathcal{T} \mapsto -\mathcal{T}$ applied to the latter. Thus, the computations presented in Secs. 3 and 4 are still valid, however, one has to keep in mind that the imaginary cosmological time parametrization $T = -i\mathcal{T}$ was used, i.e., the scale factor and the derivatives (operator and dot notations) refer to the time parameter $\mathcal{T}$.