General Relativity and Quantum Cosmology

# Quantum Cosmology Close to the Classical Big Bang Singularity and in the Semiclassical Limit

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We investigate a cosmological model whose energy content is described by a Chaplygin gas represented by a scalar field $\phi$ with an associated potential producing a big bang singularity such that for vanishing scale factor, $a\to 0$, one has $|\phi|\to \infty$. The classical version of the model is discussed in detail, however, our main interest lies in its quantization. Upon quantization of this model in the Schr\"odinger picture, we get the Wheeler--DeWitt equation which can be solved exactly in the two limits $a\to 0$ and $a\to\infty$, respectively. Employing the DeWitt criterium that the wave function should vanish at the classical singularity in order to avoid the big bang, we show that a solution to the Wheeler-DeWitt equation fulfilling this condition can indeed be found. In addition to DeWitt's initial condition at the big bang, we postulate an asymptotic condition to be imposed on the wave function which guarantees that the quantum wave function is strongly peaked at the classical field configurations in the semiclassical limit. We also investigate a universe filled with dust (describing baryonic and dark matter) and show that in this case there exists an exact solution to the Wheeler-DeWitt equation which describes the evolution of the universe during its whole history. Also for this model one can construct a wave packet which avoids the big bang singularity at small scale factors and is strongly peaked at the classical field in the far future of the universe. Finally, we discuss the significance of our treatment of the Wheeler-DeWitt equation and mention some open problems.

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