General Relativity and Quantum Cosmology

Viscous Quark-Gluon Plasma in the Early Universe

A. Tawfik (ECTP & Mti U.), M. Wahba (ECTP & Mti U.), H. Mansour (Cairo U.), T. Harko (Hong Kong U.)

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We consider the evolution of a flat, isotropic and homogeneous Friedmann-Robertson-Walker Universe, filled with a causal bulk viscous cosmological fluid, that can be characterized by an ultra-relativistic equation of state and bulk viscosity coefficient obtained from recent lattice QCD calculations. The basic equation for the Hubble parameter is derived under the assumption that the total energy in the Universe is conserved. By assuming a power law dependence of bulk viscosity coefficient, temperature and relaxation time on energy density, an approximate solution of the field equations has been obtained, in which we utilized equations of state from recent lattice QCD simulations QCD and heavy-ion collisions to derive an evolution equation. In this treatment for the viscous cosmology, we found no evidence for singularity. For example, both Hubble parameter and scale factor are finite at $t=0$, t is the comoving time. Furthermore, their time evolution essentially differs from the one associated with non-viscous and ideal gas. Also thermodynamic quantities, like temperature, energy density and bulk pressure remain finite as well. In order to prove that the free parameter in our model does influence the final results, qualitatively, we checked out other articular solutions.

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