Primordial high-frequency perturbations in cosmology
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Citation for published version (APA):
Slagter, R. J. (1986). Primordial high-frequency perturbations in cosmology

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Summary

General relativistic cosmological models provide a framework for investigation of the evolution of the universe. A substantial fraction of our knowledge about solutions of the equations of general relativity has been obtained by linearizing Einstein's equations about some exact solution. Although the methods include many applications of physical interest, they do not cover all of them. In fact, most of the exact solutions we know today cannot be extended (with physically plausible sources) to asymptotically flat spacetimes or to closed cosmologies.

The purpose of this thesis is to investigate, with the help of the multiple-scale method, approximate solutions of the Einstein equations which are approximately periodic and can be interpreted as containing high-frequency waves. These primordial high-frequency perturbations will have a significant influence on the background metric (back-reaction) and formation of trapped surfaces. Detection and Fourier analysis of primordial gravitational waves could in principle be used to infer the spectrum of inhomogeneities in the very early epoch of the universe. Today, of course, one would expect the primordial radiation to be strongly redshifted and weakened, so its practical detection would be difficult. However, the timing measurements of the milli-second pulsars could uncover the features of the primordial gravitational background radiation spectrum.

Appreciable energy in the modes of very high angular momentum could be present, when non-isotropic background metrics are considered. The high-frequency gravitational waves of all modes are investigated on an anisotropic Bianchi IX background. Their frequencies are related to the eigenvalues of the Hamiltonian of the asymmetric rotor.

From the mathematical point of view, it is of interest to investigate if there would be a true asymptotic wave solution in a suitable topology. Numerical solutions could be helpful in this investigation.

The development of grand unified theories in connection to cosmology has revised the picture of the early universe dramatically. A point of particular interest is the introduction of a Higgs field coupled to gravity, leading to the inflationary models. In the non-linear approximation an approximate wave solution of order two can be constructed in this coupled system on a spherically symmetric background.
The initial situation of the universe may have been very irregular, i.e., anisotropic and inhomogeneous. So it seems appropriate to extend the investigations to inhomogeneous backgrounds. In the context of the exact solitary wave solutions found on the inhomogeneous Einstein-Rosen metric, a numerical solution is presented of the complete set of equations obtained from the non-linear approximation.

In section 1 an introduction is given to the subsequent sections. Some information is given about the background of this research and about related topics.

In section 2 I present some numerical solutions of the equations of Einstein in the high-frequency approximation and on the anisotropic Bianchi IX background. These uncover the characteristic features of such solutions.

In section 3 I apply the multiple-scale method to the coupled system of gravity and scalar field.