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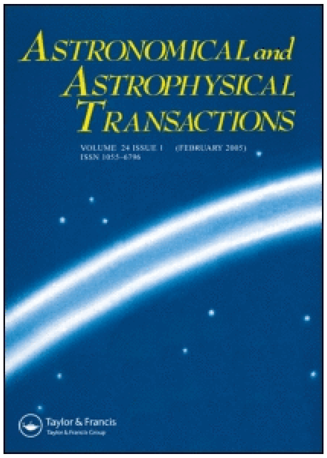

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Lorentzian wormholes in the higher-derivative gravity and the weak-energy condition

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LORENTZIAN WORMHOLES IN THE HIGHER-DERIVATIVE GRAVITY AND THE WEAK-ENERGY CONDITION

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(16 December 1992)

The possibility of the existence of a traversible wormhole is examined in a gravitational theory with R^2 term.

KEY WORDS Wormhole, Lorentzian, R^2.

The traversible wormhole solution which does not break the weak energy condition is examined in a higher-derivative theory of gravity,

$$f(R) = R - \omega R^2.$$

Since the wormhole configuration is not compatible with the WEC (Weak-Energy Condition) in the case of the Einstein gravity exotic matter or some quantum effect, which could provide negative energy density, is necessary near the wormhole throat for the existence of a stable traversible wormhole. If the size of such a wormhold throat is small, the curvature becomes very large near the throat. Then we could expect that the R^2-term plays an important role in the Einstein equation near the throat. Here we studied the gravitational theory with the lagrangian, $L_G = \sqrt{g}(R - \omega R^2)$, in order to see whether and how the higher curvatures could overcome the above incompatibility. In the negative region of ω, the classical equation of our theory is equivalent to the Einstein gravity with a normal scalar field, which is constructed by the metric. Then the incompatibility of a wormhole and the WEC can be shown in terms of a conformally transformed equation. So we concentrated our attention to the case of positive ω, where the conformally transformed equation loses its meaning.

Whatever the sign of ω is, we can prove the breaking of the WEC on the wormhole if the right-hand side of inequality (2.9) is bounded from below by some sufficiently small negative number. Since such a bound does not exist except for the case of very small value of $|\omega|$, we studied directly the equation of motion by assuming a spherically symmetric wormhole configuration. Two examples for such configurations are considered by introducing a few parameters. We restricted the range of the parameters by imposing the WEC at the wormhole throat, and we tried to find a wormhole configuration which is compatible with the WEC in all the region of the wormhole. However we could not find such a configuration, and we concluded that the wormhole is not compatible in the case of the theory with the R^2-term.

Details can be found in *Phys. Rev.* **D46** (1992) 1507.