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Qualitative and numerical analysis of a cosmological modely based on a classical massive scalar field

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Abstract

On the basis of a qualitative analysis of the set of differential equations of the standard cosmological model it is shown that in the case of zero cosmological constant Λ this set has a stable center corresponding to zero values of the potential and its derivative at infinity. Thus the model based on a single massive classical scalar field would give a flat Universe in the infinite future. A numerical simulation of the dynamic system corresponding to the set of Einstein-Klein-Gordon equations has shown that at late times of the evolution the invariant cosmological acceleration has an oscillating nature and changes from −2 (braking), to +1 (acceleration). The average value of the cosmological acceleration is negative and is equal to −1/2. Oscillations of the cosmological acceleration happen in the background of a rapidly falling Hubble parameter. In the case of a nonzero value of Λ, depending on its value, three various qualitative behavior types of the dynamic system on the 2D plane (Φ, Φ·) are possible, which correspond either to a zero attractive focus or to a stable attractive knot with zero values of the potential and its derivative. Herewith, the system asymptotically enters a secondary inflation. Numerical simulations have shown that with Λ < 3 × 10−8 m2, the macroscopic value of the cosmological acceleration behaves similarly to the case Λ = 0, i.e. in the course of the cosmological evolution there appears a lasting stage on which this value is close to −1/2, which corresponds to a non-relativistic equation of state.

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