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Inhomogeneous Initial Conditions and the Start of Inflation

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The robustness of inflation to inhomogeneous initial conditions for matter fields and the spacetime metric is under investigation. If inflationary expansion fails to begin under sufficiently inhomogeneous initial conditions, such that inflation requires fine-tuning of its initial state to occur, then its naturalness is challenged. I will present results for the range of initial conditions which give rise to inflation, based on numerical calculations which evolve the equations of motion of the scale factor and the inflaton field coupled to its quantum fluctuations and metric perturbations through a well-defined set of nonlinear interactions in the Hartree approximation. These results address to what extent inflation can occur under inhomogeneous initial conditions for a few standard slow-roll single-field inflationary models, in calculations which include effects of back-reaction of perturbations on the background dynamics and on the perturbations themselves, and which have wide applications beyond the inflationary models I will present. We have found that significantly inhomogeneous initial conditions can have nontrivial effects on the number of efolds of inflation. In particular, the initial inhomogeneities can shift the regions of phase space that support sufficient inflation, compared to the case in which one neglects all perturbations. But we also find that there seems to be no reduction in the overall volume of phase space that yields sufficient inflation, thereby providing an interesting measure of robustness. Our findings are consistent with recent simulations involving full (3+1) numerical relativity. However, by relying on certain well-studied approximations, our numerical approach can be applied more efficiently to a wide range of models, and can track the evolution of perturbations across a wide range of scales, thereby complementing the recent numerical-relativity simulations.

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