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Non-linear Dynamics During Kination

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We investigate the effects of large scalar inhomogeneities during the kination epoch, a period in which the universe's dynamics are dominated by the kinetic energy of a scalar field, by fully evolving Einstein's equations using numerical relativity. By tracking the non-linear growth of scalar perturbations with both sub-horizon and super-horizon initial wavelengths, we are able to compare their evolution to perturbative results. Our key findings show that in the deep sub-horizon limit, the perturbative behaviour remains valid, whereas in the super-horizon regime, non-linear dynamics exhibit a much richer phenomenology. Finally, we discuss the possibility of primordial black hole formation from the collapse of such perturbations and assess whether this process could serve as a viable mechanism to reheat the universe in the post-inflationary era.

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