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Role of Bardeen potential in PBH formation in the subhorizon k-space

We describe the dynamical origin of the primordial black hole (PBH) in the sub horizon k space of inflation and the role of the Bardeen potential in the formation of PBHs. In our study, we find large negative peaks of Bardeen potential in the k space which indicates the gravitational collapse, which is responsible for the PBH formation in the radiation dominated era at a small conformal time, η^{-12}. In the present study, we have solved self-consistently three nonlinear coupled differential equations in the large k regime and have shown that cosmological perturbation breaks down in the small scale region. We have also shown that in the large k ($\sim 10^{13} Mpc^{-1}$) limit, the perturbative part of the potential $V(k)$ and inflaton field $\phi(k)$ shoots up and the density contrast exceeds the value of the 0.41 which is necessary for PBH formation. We use here, the spatially flat gauge to incorporate the role of the inflaton field as, in this case, $\delta\phi \neq 0$. We have calculated various properties of PBHs such as mass, evaporation time, Hawking temperature, $\sigma(M)$, $\beta(M)$ and f_{PBH}. The calculated f_{PBH} is consistent with the LISA, WD, NS, DECIGO/AI, FL, SIGWS forecasts.

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