Report on JCAP_026P_0524

Date: December 3, 2024

Author(s): E. J. Barroso, L. F. Demétrio, S. D. P. Vitenti, Xuan Ye

Title: Primordial Black Hole Formation in a Dust Bouncing Model

Received: 2024-05-06 17:42:20.0

Editor report

I thank the author's thorough response. I understand that problems of both quantum cosmology and bouncing cosmology are quite involved and it's not realistic to resolve all of them in a single paper which focus on the PBH formation. I also agree that some of the problems can be left to future studies by the authors. Nonetheless, I believe that the following problems deserve to be carefully addressed since they're relevant for the PBH formation scenario.

- In my point 2.(c) of the previous report, the problem of $\bar{\rho} + \bar{p} = 0$ at the bouncing point $H = 0$ is discussed. I thank the author to address the ghost instability problem and clarify that the perturbation remains valid near the bouncing point. However, there is actually one additional associated problem, which the authors seems missing. When $\bar{\rho} + \bar{p} = 0$, the density contrast, defined by $\delta = \delta\rho/(\bar{\rho} + \bar{p} = 0)$ as Eq. (3.5) in the revised manuscript, also diverges. Hence, I asked whether the definition of density contrast, but unfortunately the authors seems not noticed this question.

  The density contrast is highly relevant to the author's formalism. If δ is no longer valid again, then Sec. 4 and App. A in the revised manuscript are potentially in danger. Thus, I would like the authors to clarify whether δ can be defined in the above way and used as a criteria for PBH formation near the bouncing point.

  Also, in Eq. (A.27) the authors define the density contrast in another way: $\delta = \delta\rho/\bar{\rho}$. Which one is the correct one that the authors intended to use, and throughout this manuscript, do the authors use a consistent definition of δ to conduct their analysis?

- I thank the authors to discuss whether the classical cosmological perturbation theory is applicable in the cosmic history, especially near the bouncing point where quantum effect becomes relevant. I feel sorry that I might not express my concern clearly and such confusions are made. So, please allow me to state the question in a more explicit way.

  The authors adopt the paradigm of PBH formation via the gravitational collapse of a local overdensed region. However, in the classical gravitational collapse paradigm, the background and perturbation must be classical. Otherwise, there will be no overdensed region but only quantum fluctuations. If I understand correctly, the authors in the reply say the the background and perturbation are in a superposition of Gaussian states and is naturally quantum. In this case, we can at best have virtual particles. Gravitational collapse will not take place in this scenario and concepts like the Jeans length may not be valid.

  So, the point is, if the PBH is formed near the bouncing phase, then it's important to clarify whether the background and perturbations are classical in that epoch. If both of them are classical then it's fine, and one can safely use the classical cosmological perturbation theory and the gravitational collapse of over-dense region. If they are quantum then one needs to rethink the viability of the above concepts, since Sec. 4 which is based on the classical gravitational collapse are potentially in danger. While I understand that this is a difficult task to finish, this point shall at least be discussed carefully, and the technical details are suggested to be left to future works.