

Referee report

Title: Primordial Black Holes as Dark Matter Candidates

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The article is a wonderful and very useful review on the topic of primordial black holes (PBHs). It is a revised version of an earlier review by the same authors [1]. Unlike the original review [1], these lectures are greatly simplified and made available for initial acquaintance with the topic. At the same time, they retain the completeness of the coverage. An extensive list of literature is of great value, which will allow one to orient yourself in the works on the PBHs.

The article undoubtedly deserves publication after the following small recommendatory additions.

1. It will be very useful for readers if the authors add to the historical part 1.1 a more detailed description of what was done in the work of Zeldovich and Novikov [3]. The article [3] was published five years earlier than Hawking's article [2] and contains the main elements of the PBH idea. It would be useful if the authors list them shortly:

A. For the first time, the possibility of gravitational collapse of density perturbations in the expanding early Universe (“gravitational self-closure” and “collapsed bodies”) is pointed out and an expression (4) for the collapse moment $t_c = GM_0/c^3$ is given. Thus, in my opinion, this can be considered as the birth of the PBHs hypothesis.

B. For the first time, the question of accretion on the PBH was raised and an estimate of PBH mass growth during the accretion in an expanding Universe was given (see equation (1) in [3] and the expression for ρ_r after this equation). In this regard, the remark of the authors of this article “However, this argument neglects the cosmic expansion...” is unclear and requires clarification. At the same time, Zeldovich and Novikov did not claim that the accretion on the PBH will necessarily be catastrophic. This is just a hypothesis (“if”) that requires “further calculations”. Zeldovich and Novikov understood that a more accurate calculation was required.

C. In the last lines of the article by Zeldovich and Novikov, for the first time, a limit was given on the fraction α of the collapsed mass of the Universe. In the reviewed article, this corresponds to the expression (1.5).

After these explanations, it will be easier for readers to understand who are the parents of the PBH hypothesis.

2. Small remarks on the structure of the article.

Eq. (1.5) does not explain what β is. It is desirable to repeat the explanation from the caption to Fig. 1 in the text.

On page 5, the fine tuning problem is mentioned, but it is not indicated that there is a solution to it, and that the solution will be described later in other chapter.

The article is written in good language, the material is balanced and qualitatively edited. I notice only the three typos:

page 19, first line. The M_{sun} expression can be replaced with M_{\odot} .

page 21. The M_{\odot} is missing in the Eq. (3.10).

page 22 .“y” \rightarrow “yr”.

This paper will become suitable for publication in the *SciPost Physics Lecture Notes* after these minor revisions.

References

- [1] B. Carr and F. Kühnel, “Primordial Black Holes as Dark Matter: Recent Developments”, *Ann. Rev. Nucl. Part. Sci.* 70, 355 (2020), doi:10.1146/annurev-nucl-050520-125911, 2006.02838.
- [2] S. Hawking, “Gravitationally collapsed objects of very low mass”, *Mon. Not. Roy. astron. Soc.* 152, 75 (1971).
- [3] Y. Zel’dovich and I. D. Novikov, “The Hypothesis of Cores Retarded during Expansion and the Hot Cosmological Model”, *Sov. astron.* 10, 602 (1967).