Generation of PBH Spin

Dependence on FOPT Parameters

< 口 > < 同 >

Spinning Primordial Black Holes from First Order Phase Transitions

Indra Kumar Banerjee

IISER Berhampur

20/12/2023

PHOENIX 2023

Based on Spinning Primordial Black Holes from First Order Phase Transition, IKB, U.

K. Dey, arXiv: 2311.03406

Indra Kumar Banerjee

Spinning Primordial Black Holes from First Order Phase Transitions

< 口 > < 同 >

Introduction

- 2 Creation Mechanism
- **3** Generation of PBH Spin
- **4** Dependence on FOPT Parameters
- 6 Future Scope

IISER Berhampur

Indra Kumar Banerjee

- **2** Creation Mechanism
- **3** Generation of PBH Spin
- **4** Dependence on FOPT Parameters
- **6** Future Scope

- * ロ > * @ > * 注 > * 注 > 「注 = シッペ

Indra Kumar Banerjee



• PBHs were proposed as compact objects, more precisely, black holes formed in the early universe.

< 17 ►

Indra Kumar Banerjee



- PBHs were proposed as compact objects, more precisely, black holes formed in the early universe.
- They can partially or completely play the role of dark matter in the standard cosmology.



- PBHs were proposed as compact objects, more precisely, black holes formed in the early universe.
- They can partially or completely play the role of dark matter in the standard cosmology.
- Many theoretical predictions, such as Hawking evaporation or superradiant instability, can be verified from PBHs.



- PBHs were proposed as compact objects, more precisely, black holes formed in the early universe.
- They can partially or completely play the role of dark matter in the standard cosmology.
- Many theoretical predictions, such as Hawking evaporation or superradiant instability, can be verified from PBHs.
- PBHs can originate from inflation, cosmic strings, first-order phase transitions (FOPT), etc

< 口 > < 同 >

2 Creation Mechanism

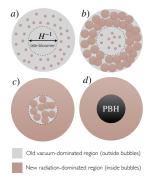
- **3** Generation of PBH Spin
- **④** Dependence on FOPT Parameters
- **5** Future Scope

- * ロ * * 個 * * 声 * * 声 * うくぐ

Indra Kumar Banerjee



• In this study, we consider the delayed vacuum decay during a FOPT as the mechanism that creates PBH.



(taken from arXiv: 2305.04942)

< 口 > < 同 >

- **2** Creation Mechanism
- **3** Generation of PBH Spin
- **4** Dependence on FOPT Parameters
- **5** Future Scope

- * ロ * * 個 * * 声 * * 声 * うくぐ

Indra Kumar Banerjee

Spinning Primordial Black Holes from First Order Phase Transitions



• The spectral moments:

$$\sigma_n^2 = \int \frac{dk}{k} k^{2n} \mathcal{P}_{\zeta}(k)$$

• The fraction that collapses:

$$\beta_0 = \sqrt{\frac{2}{\pi}} \frac{2}{5} \frac{\sigma_h}{\delta_{\rm H,th}} \exp\left[-\frac{25}{8} \left(\frac{\sigma_h}{\delta_{\rm H,th}}\right)^2\right]$$

Indra Kumar Banerjee

IISER Berhampur

Image: A math a math



• Mass of the PBHs:

$$M_{\rm PBH} = 9.23 \times 10^{31} \left(\frac{T}{{
m GeV}}
ight)^{-2} {
m g}$$

Abundance:

$$f_{\rm PBH} = 1.26 \times 10^{26} \beta_0 \left(\frac{M_{\rm PBH}}{\rm g}\right)^{-1/2}$$

• Spin:

$$\langle a_*^2 \rangle^{1/2} = \frac{\mathcal{A}\sqrt{1-\gamma^2}}{\left(1 + 0.036 \left[21 - 2\log_{10}\left(\frac{f_{\rm PBH}}{10^{-7}}\right) - \log_{10}\left(\frac{M_{\rm PBH}}{10^{15}{\rm g}}\right)\right]\right)}$$

(日)、<日)、<</p>

Indra Kumar Banerjee

IISER Berhampur

- **2** Creation Mechanism
- **③** Generation of PBH Spin
- Opendence on FOPT Parameters
- **6** Future Scope

Indra Kumar Banerjee

Spinning Primordial Black Holes from First Order Phase Transitions

IISER Berhampur

Image: A mathematical states and a mathem



• The curvature power spectrum:(arXiv:2208.14086)

$$\mathcal{P}_{\zeta}(k) = 34.5[\sigma_H(\alpha, \beta/H)]^2 (k/\mathcal{H})^3$$

• Spin:

$$\langle a_*^2 \rangle^{1/2} = \frac{\mathcal{A}\sqrt{1-\gamma^2}}{\left(1+0.036\left[21-2\log_{10}\left(\frac{f_{\rm PBH}}{10^{-7}}\right) - \log_{10}\left(\frac{M_{\rm PBH}}{10^{15}{\rm g}}\right)\right]\right)}$$

- Narrow power spectrum (arXiv: 2011.00710): $\mathcal{A} = 4.01 \times 10^{-3}$
- The power spectrum due to FOPT (arXiv: 2311.03406) $\mathcal{A}=2.5\times 10^{-2}$

Indra Kumar Banerjee

Spinning Primordial Black Holes from First Order Phase Transitions

troduction Creation Mechanism Genera 0 00 000

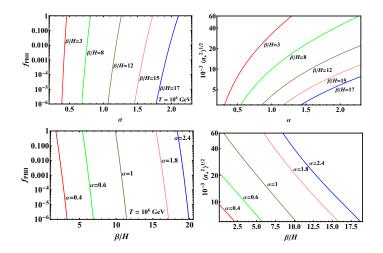
eneration of PBH Spin

Dependence on FOPT Parameters

Image: A math a math

Future Scope

Dependence on FOPT parameters

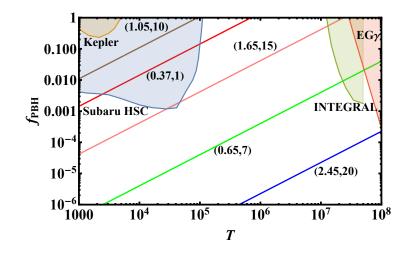


Indra Kumar Banerjee

IISER Berhampur

Introduction Creation Mechanism Generation of PBH Spin Dependence on FOPT Parameters Future S 00 00 000 000 000 000 000 000

Dependence on FOPT parameters



Indra Kumar Banerjee

IISER Berhampur



- PBH mass depends on the transition temperature, whereas the PBH abundance and spin depend on the strength of the FOPT (α), the inverse time scale of the FOPT (β), and the transition temperature.
- { $T, \alpha, \beta/H$ } \rightarrow { $M_{\text{PBH}}(g), f_{\text{PBH}}, 10^{-3} \langle a_* \rangle^{1/2}$ } { $10^8 \text{ GeV}, 3.22, 22$ } \rightarrow { $9.23 \times 10^{15}, 0.00025, 4.74$ } { $10^6 \text{ GeV}, 2.1, 17$ } \rightarrow { $9.23 \times 10^{19}, 0.918, 6.48$ } {100 GeV, 2.7, 18} \rightarrow { $9.23 \times 10^{27}, 0.0176, 8.79$ } {26 GeV, 1.4, 12} \rightarrow { $1.36 \times 10^{29}, 0.0161, 8.04$ }

- **2** Creation Mechanism
- **3** Generation of PBH Spin
- **4** Dependence on FOPT Parameters
- 6 Future Scope

- <ロ> <四> <ヨ> <ヨ> (日>)

Indra Kumar Banerjee



- Supercooled cases, for which the order of the nucleation and the percolation temperatures are different than that of the critical temperature, might give rise to different temperature dependence.
- FOPTs in Non-standard cosmology, such as some early matter-dominated era, may give rise to PBH with high initial spin, which has implications in Hawking evaporation superradiant instability, gravitational waves, etc.

Thanks!

- ・ロト・西ト・西ト・西・ つくぐ

Indra Kumar Banerjee