THE 6TH INTERNATIONAL CONFERENCE ON PARTICLE PHYSICS AND ASTROPHYSICS

GRAVITY & COSMOLOGY

Compact extra dimensions as the source of primordial black holes

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Plan

- Motivation
- Multidimensional $f(R)$-gravity
- Domain walls and Primordial Black Holes
- Inflationary constraints
- Conclusion

Motivation

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OBSERVATION OF SUPER-EARLY (AT Z > 5) SUPERMASSIVE QUASARS

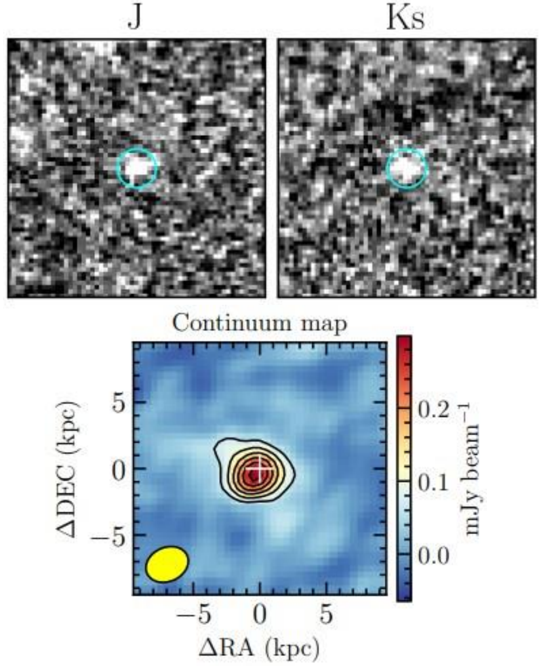

Fig. 1. Quasar J0313-1806 z = 7.64 (670 million years) $M \sim 10^{10} M_{\odot}$

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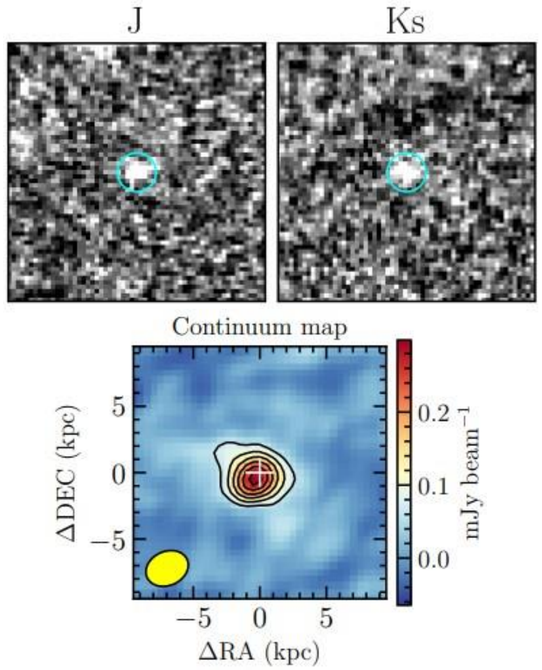

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DETECTION OF GRAVITATIONAL WAVES FROM BHS OF INTERMEDIATE MASSES

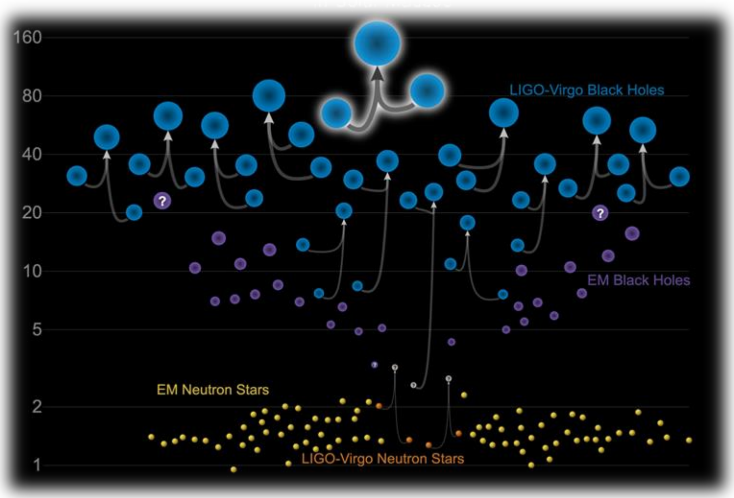

Fig. 2. Masses of BHs and neutron stars detected by LIGO and VIRGO.

Multidimensional $f(R)$-gravity

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$$R = R_4 + R_n + P_k \,, \quad P_k = 2n\, \partial^2 \beta + n(n+1)(\partial\beta)^2 \,, \qquad (2)$$

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2. Integrating out coordinates of the extra space:

$$S = \frac{1}{2} \mathcal{V}[d_1]\, m_D^2 \int \sqrt{{}^4 g}\, d^4 x\ \mathrm{e}^{d_1 \beta} \left[f(R) + ... \right] \qquad (3)$$

$$m_D^2 = V_n e^{n\beta_m} f'(\phi_m); \quad V_n = \frac{2\pi^{\frac{n+1}{2}}}{\Gamma(\frac{n+1}{2})}.$$

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Effective 4-dim theory

3. Small extra dimensions and slow change approximation ($R_k \equiv \phi$):

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$$K(\phi) = \frac{1}{4\phi^2}\left[6\phi^2\left(\frac{f''}{f'}\right)^2 - 2n\phi\left(\frac{f''}{f'}\right) + \frac{n(n+2)}{2}\right] + \frac{c_1 + c_2}{f'\phi}$$

Domain walls in $f(R)$

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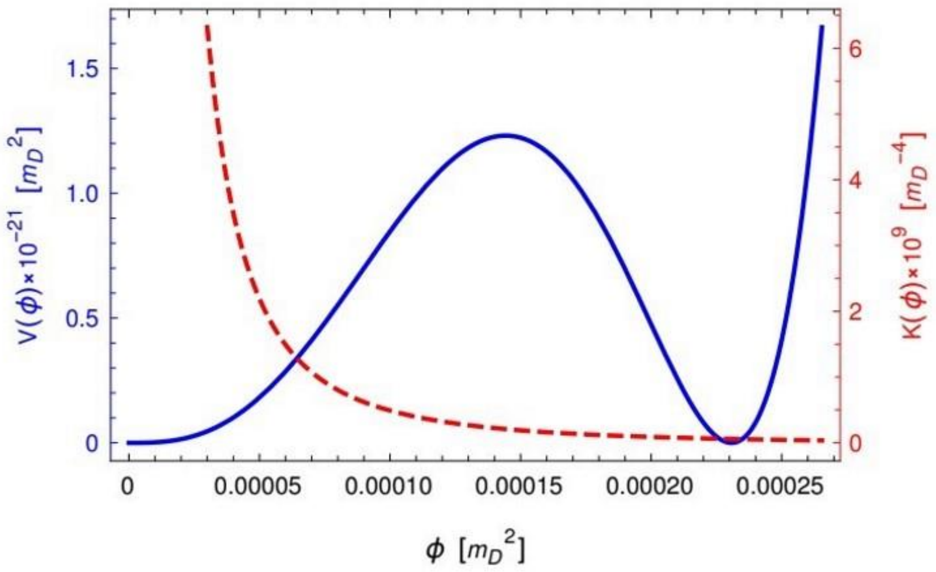

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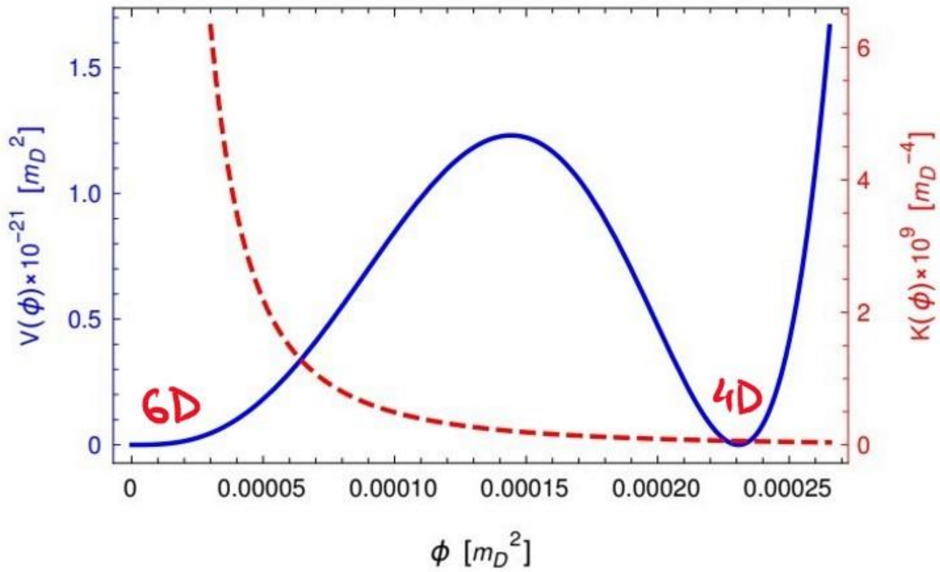

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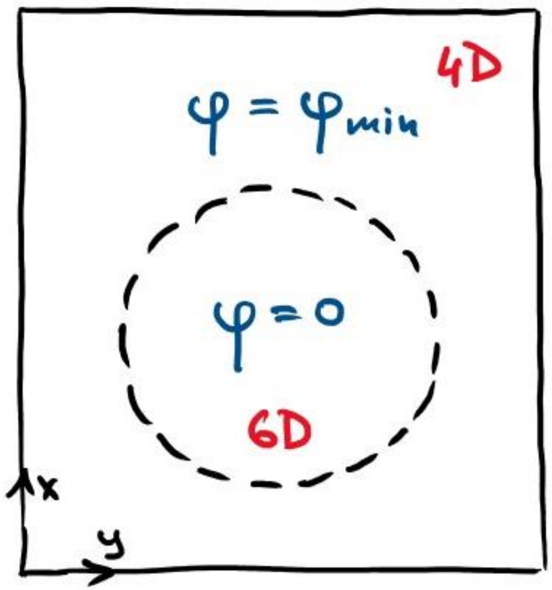

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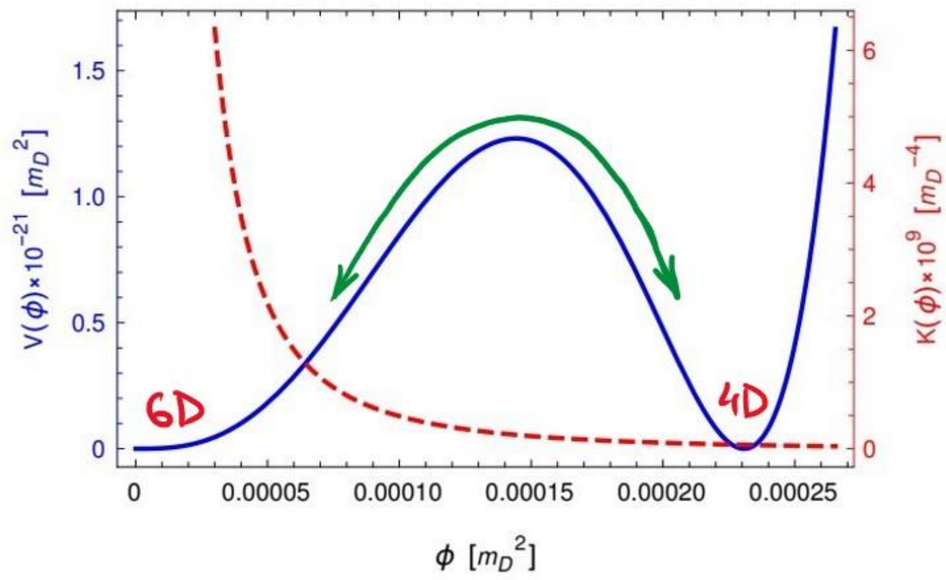

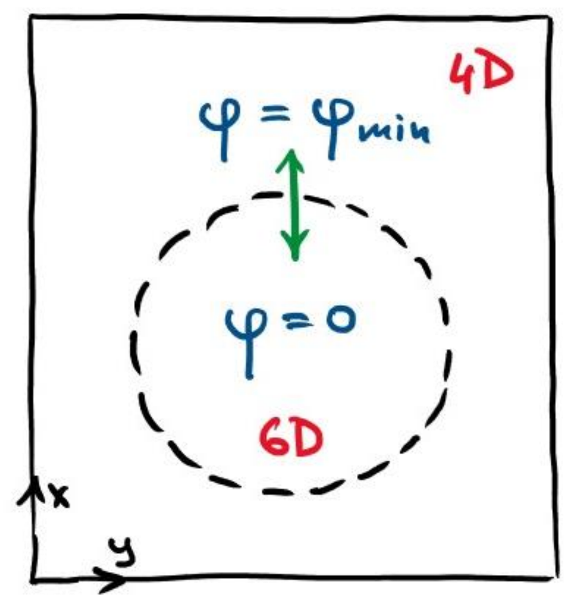

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Primordial black holes

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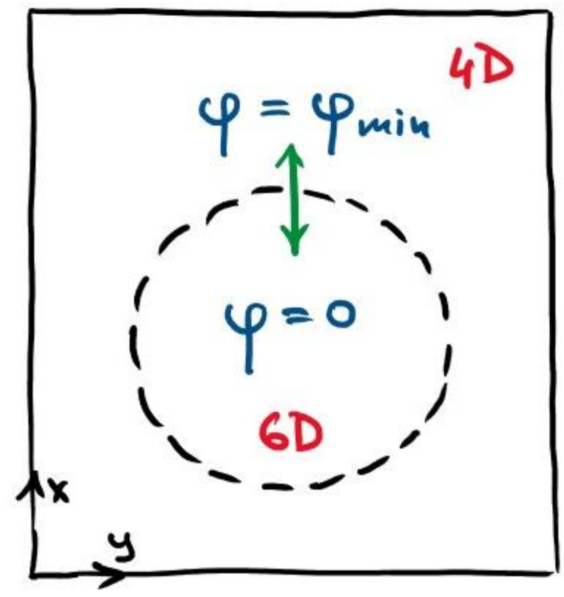

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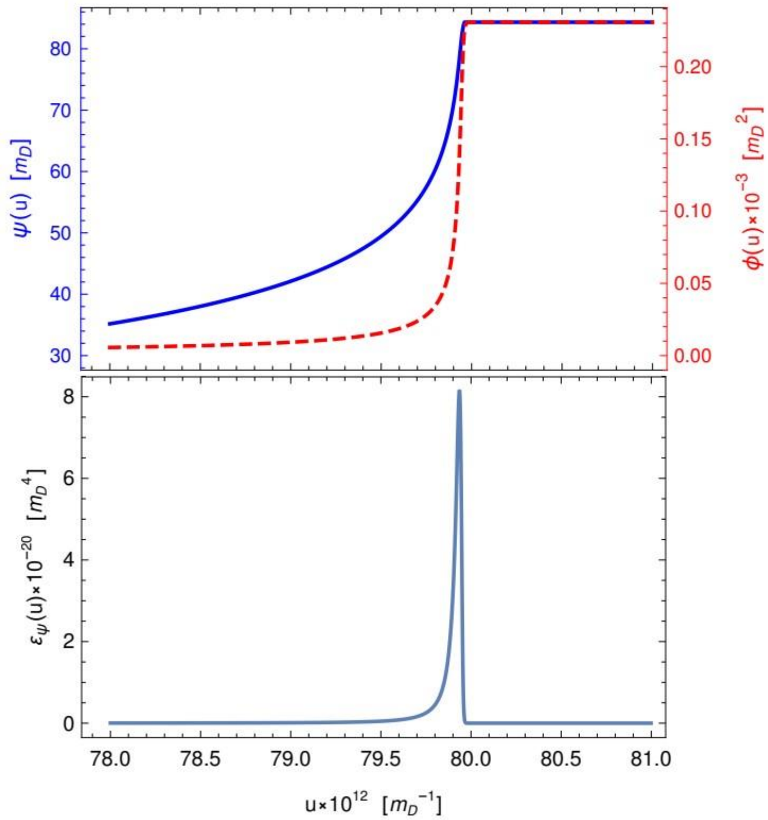

Fig. 5. Top - the value of the field when moving through the wall. Bottom - energy density when moving through the wall.

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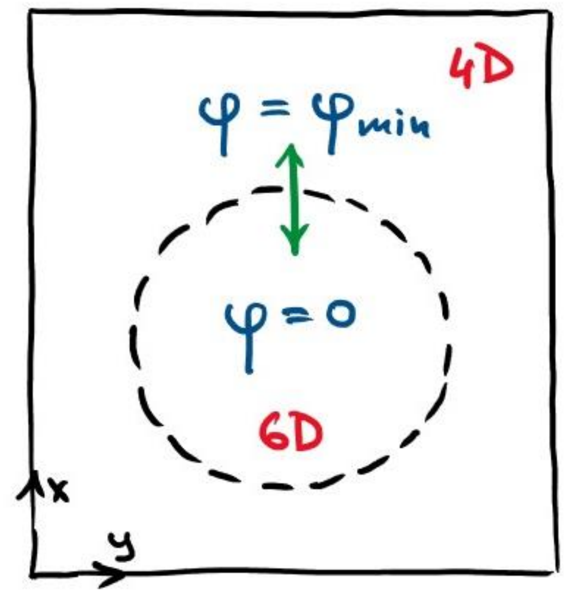
$$\psi_{uu} + \frac{2\psi_u}{u} - \tilde{V}'(\psi) = 0 \,, \tag{9}$$



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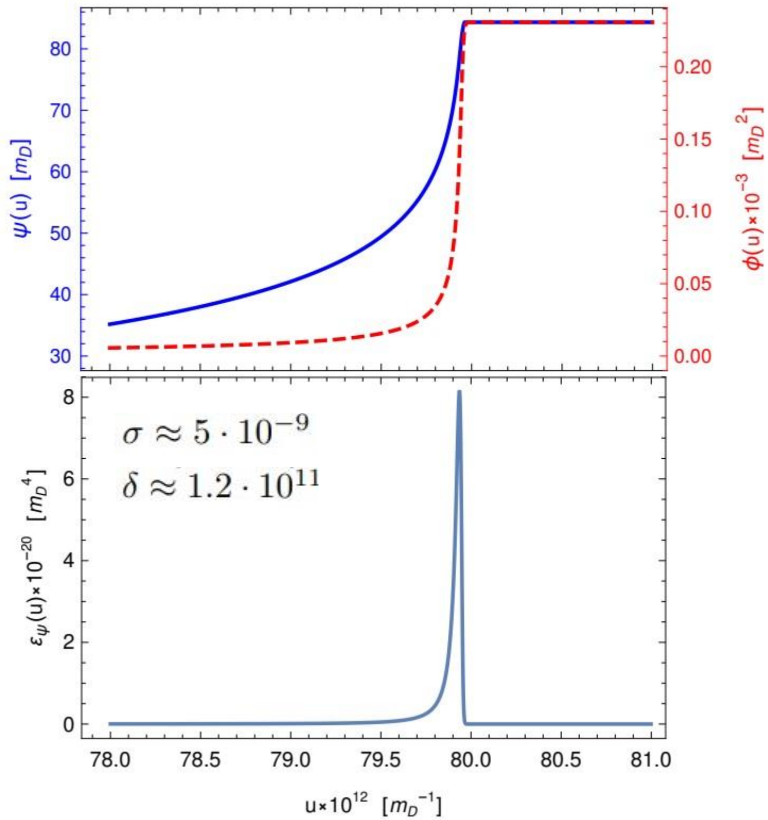

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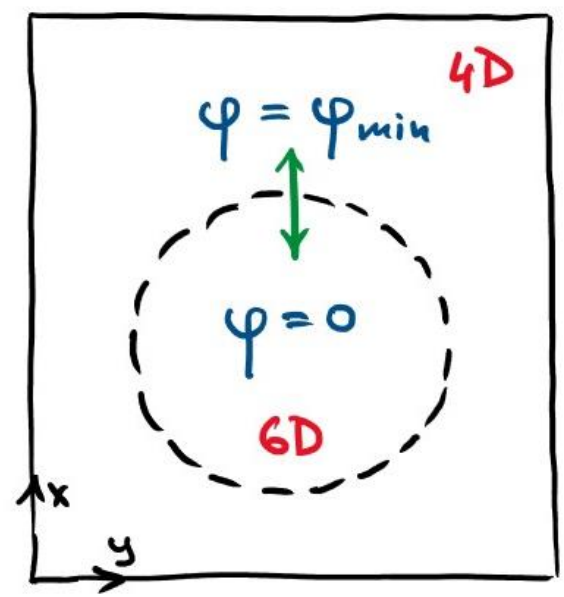

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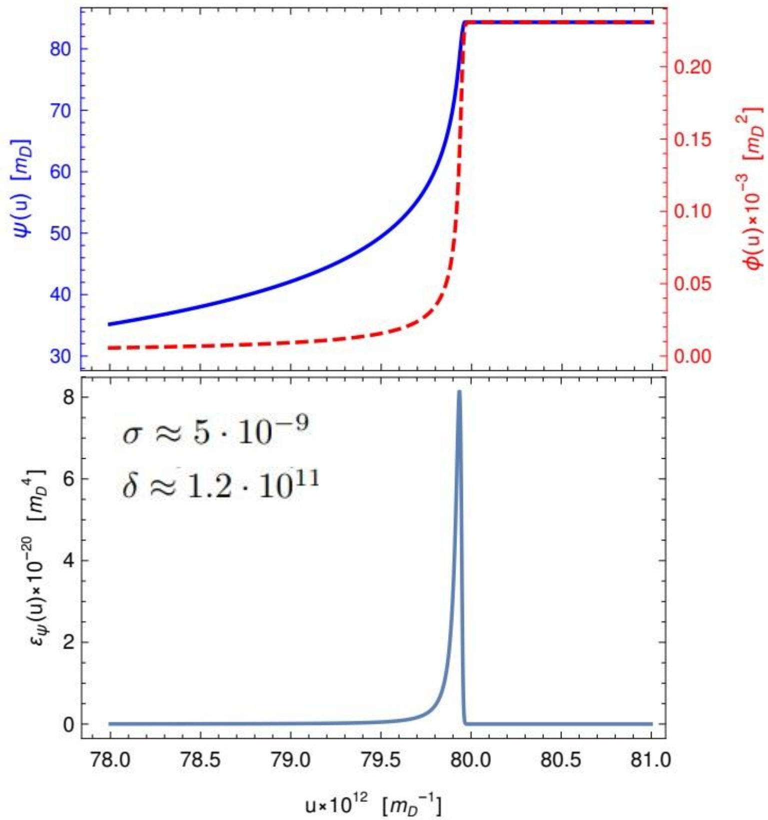

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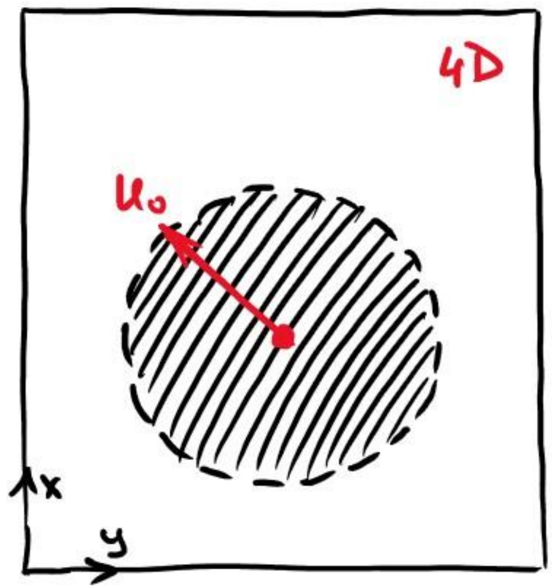

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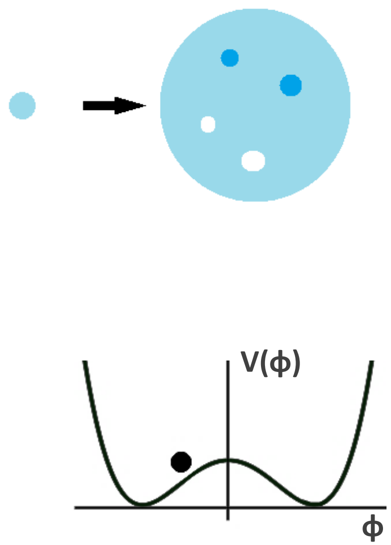

Fig.6. The gradual formation[2] of a critical region, which will be further surrounded by a domain wall as a result of repeated fluctuations on a background of the expanding Universe (at the inflationary stage).

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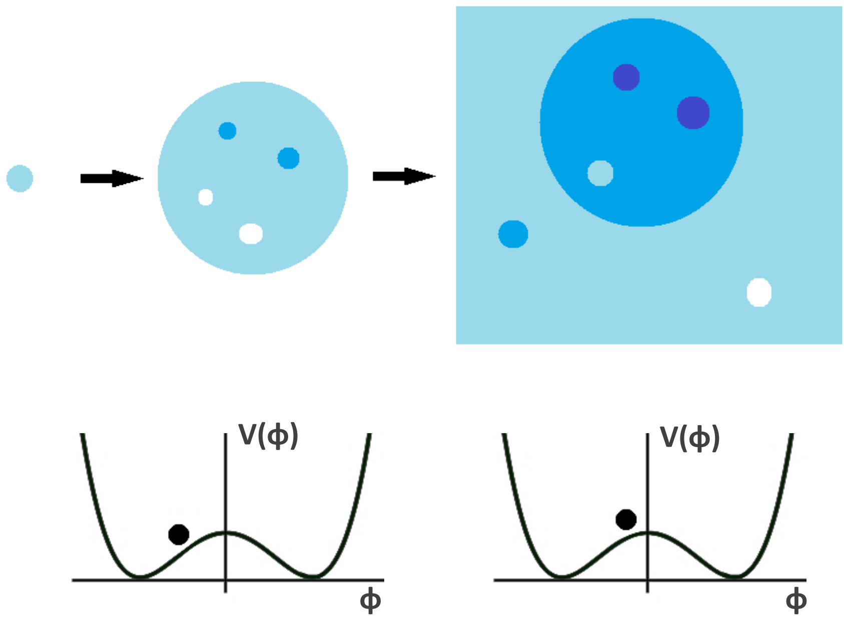

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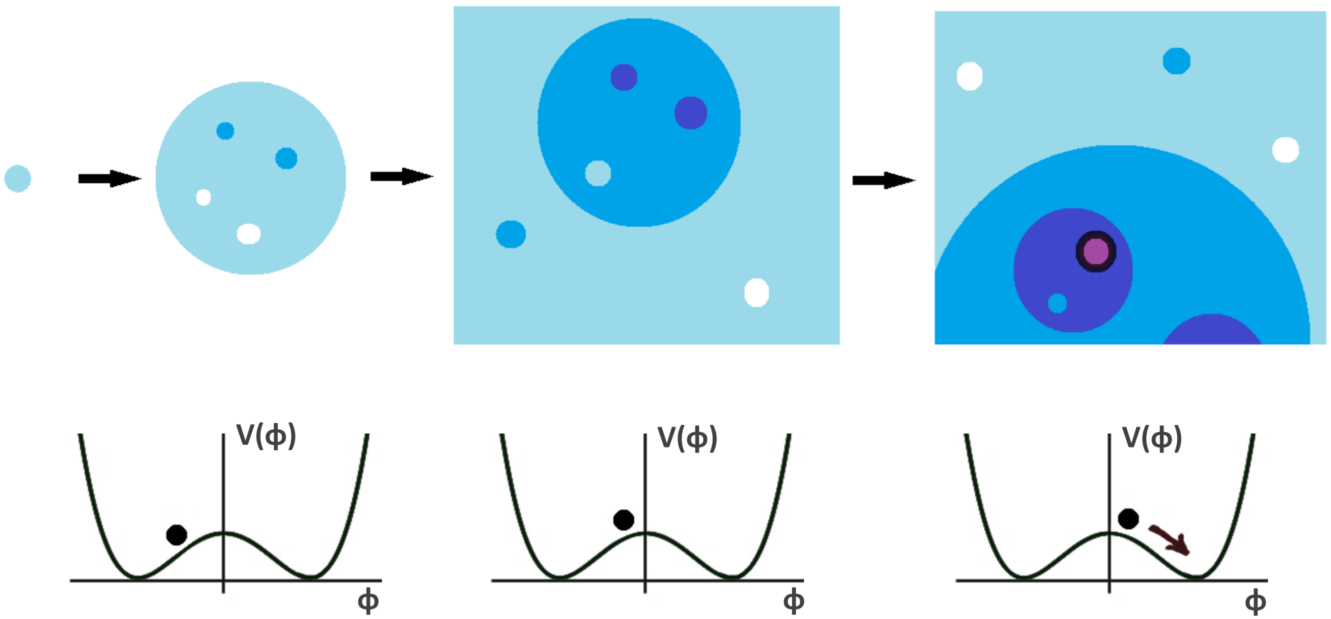

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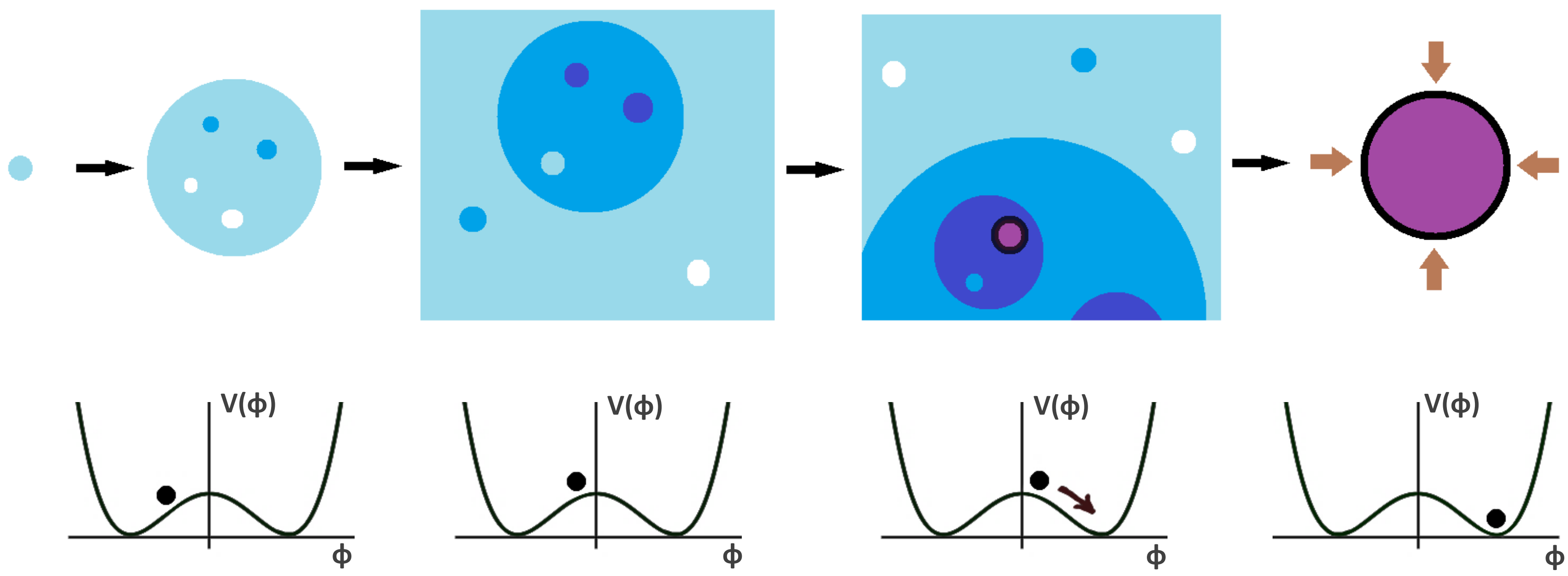

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$$H^J \gtrsim 10^{13}\ [\mathrm{GeV}] \tag{13}$$

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arXiv:2204.06360
10.3389/fspas.2022.927144

Thank you
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QUESTIONS?