Victor Gorbenko, EPFL

Inflation:

A few developments in formal theory

1. Taming strong IR effects in I.

2. Non-perturbative gravitational (topology-changing) effects for I.

3. Dynamics of Electromagnetic fields during I.

4.* "Energy" basis for cosmological collider

1. Taming strong IR effects in I.

issue: perturbative calculations in inflation often lead to terms that grow with time, is it an instability?

solution: Starobinski explained how to deal with this growth back in the 80's, however the details of the formalism are still being worked out.

Gorbenko, Senatore '19

Gorbenko, Janssen, Senatore, Varrone, '25-?

conceptually it is by now clear that the only instability is "Eternal Inflation"

$$\langle \zeta^2 \rangle \sim O(1)$$

to do: Have a purely EFT way of thinking about long modes

Cohen, Green - ?

2. Non-perturbative gravitational (topology-changing) effects for Λ.

- Modern view on space-time is that it is emergent from degrees of freedom that do not have gravitational interactions. This is well-understood for $\Lambda < 0$ (AdS/CFT)

issue: Apart from some very recent works, there are no explicit examples in cosmology

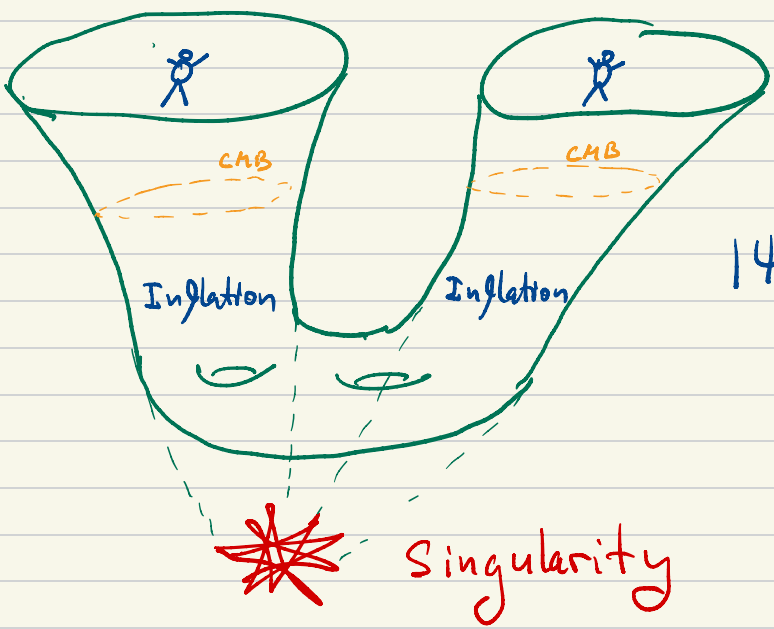
progress: There is an "intermediate" formalism — "Path integral" over metrics in which one includes topologically non-trivial space-times **wormholes**

Hartle-Hawking 80's, Maldacena et al '00-'20
review: 2006.06872

- The formalism was tested for Black Holes and sucessfully explains Hawking radiation. It is also applicable to 1D cosmology

Chen, Gorbenko, Maldacena '20
Fumagalli, Gorbenko, Kames-King '24

to do: Construct a realistic model in 3D

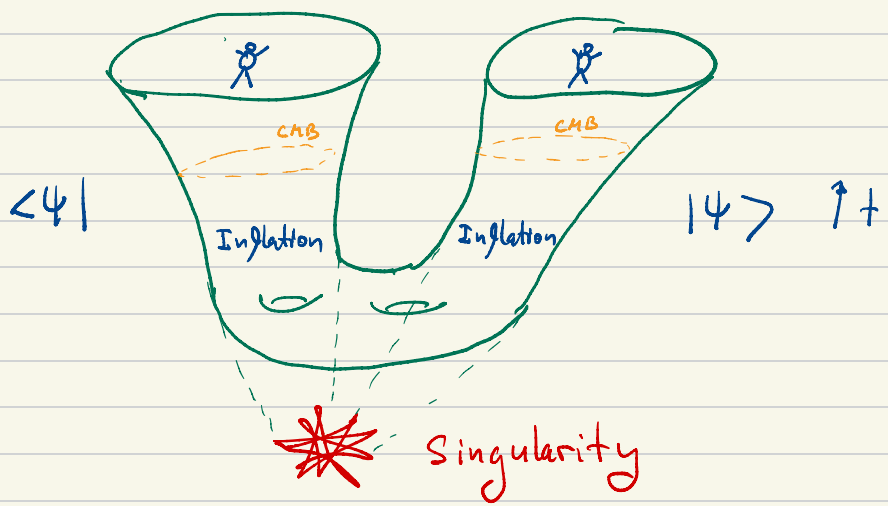


$\langle \psi |$ $|\psi\rangle$ $\uparrow t$

"Effective theory for initial conditions for I"

- If inflation did not last too long this may have observational consequences
  - → Spacial curvature
  - → Global spacial topology T^3, H^3, S^3, $S^2 \times S^1$
  - → Corrections to low-ℓ primordial spectrum

- If this theory is confirmed it is a very big shift of paradigm!



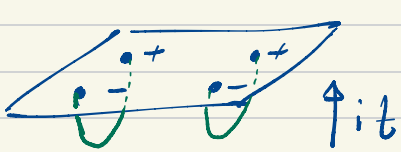
3. Dynamics of Electromagnetic fields during I.

- For me, this motivated purely as a theoretical construction of gauge invariant observables. Is there observational motivation ~ primordial magnetic field?

issue: charged objects are not well-defined in isolation ~ they have a "cloud" of EM field around them

solution: attach a very special de-Sitter invariant configuration of EM field to every charge ~ makes charged fields more similar to neutral (isocurvature) modes.

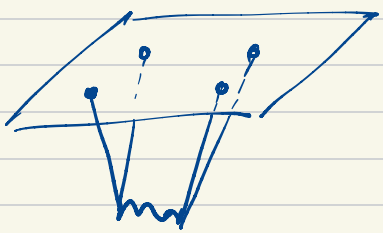
to do: applications?



Ankur, Di Pietro, Gorbenko, Komatsu, Sacchi '25 - '26

4.* "Energy" basis for cosmological collider

issue: Can we "Fourier" transform the cosmological collider oscillations?



Di Pietro, Gorbenko, Komatsu '21

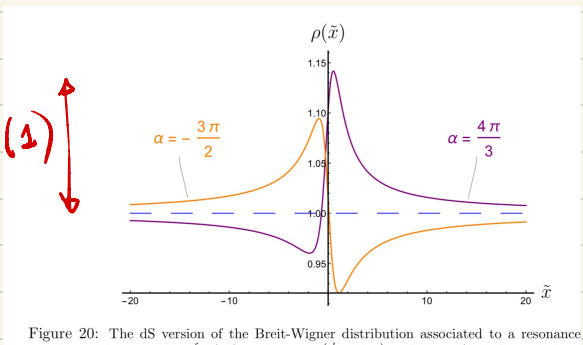


Figure 20: The dS version of the Breit-Wigner distribution associated to a resonance

$\tilde{x} \sim \frac{\nu}{\gamma}$

progress: In pure de Sitter, for a four-point function (tri-spectrum) there is a basis of Conformal partial waves

$$\langle \xi_1 \xi_2 \xi_3 \xi_4 \rangle = \sum_J \int_0^\infty d\nu \, \rho_J(\nu) \, F_{J,\nu}(\vec{k}_i)$$

$\rho_J \sim \frac{\gamma^2}{\nu^2+\gamma^2}$

to do: Work out Bi-spectrum in the absence of full dS isometry, useful for detection.