Inflation Without a Beginning

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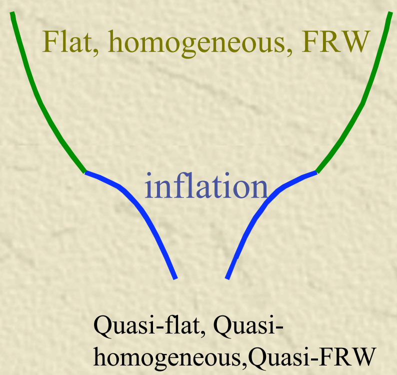
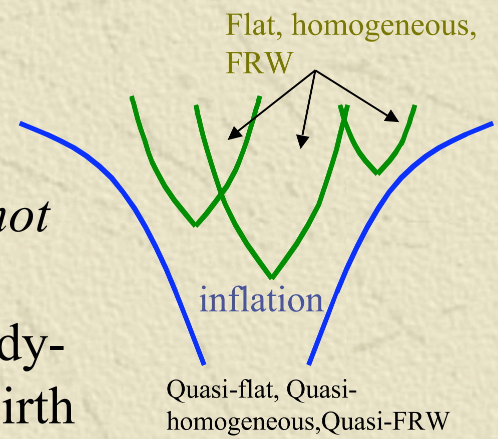
Inflation and Eternal Inflation

- **Inflation:** exponential phase inserted to produce FRW cosmology from "more general" initial condition.



- **Semi-eternal Inflation:** but generically, inflation *does not end!* It keeps going, ⇨ "steady-state", giving birth to FRW-regions.



Can we have truly (past- and future-) eternal inflation, and avoid an initial singularity/beginning of time? Apparently not!

Several theorems ⇨ eternally inflating space- times must contain "singularities":

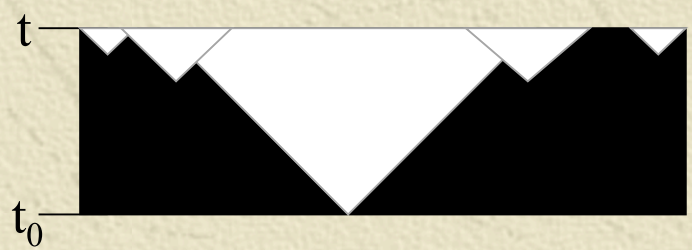
- Requiring weak energy condition (Borde & Vilenkin 1996).
- Requiring "local Hubble const." $H > H_{min} > 0$ (Borde, Guth & Vilenkin 2001).

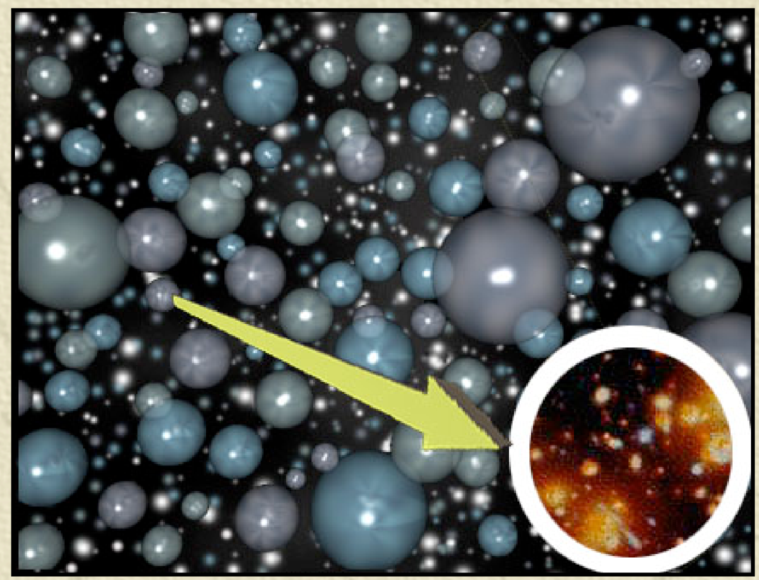
Steady-State eternal inflation

Let's try anyway!

Strategy: make state *approached* by semi-eternal inflation *exact*:

- Flat spatial sections.
- Consider bubbles formed between t_0 and t. Send t_0 □ □ .
- Inflation endures; bubbles & inflating region make cosmological fractal (see Vilenkin 1992).





Inflating background is **eternal**.

Each bubble is an open FRW cosmology; one could be ours.

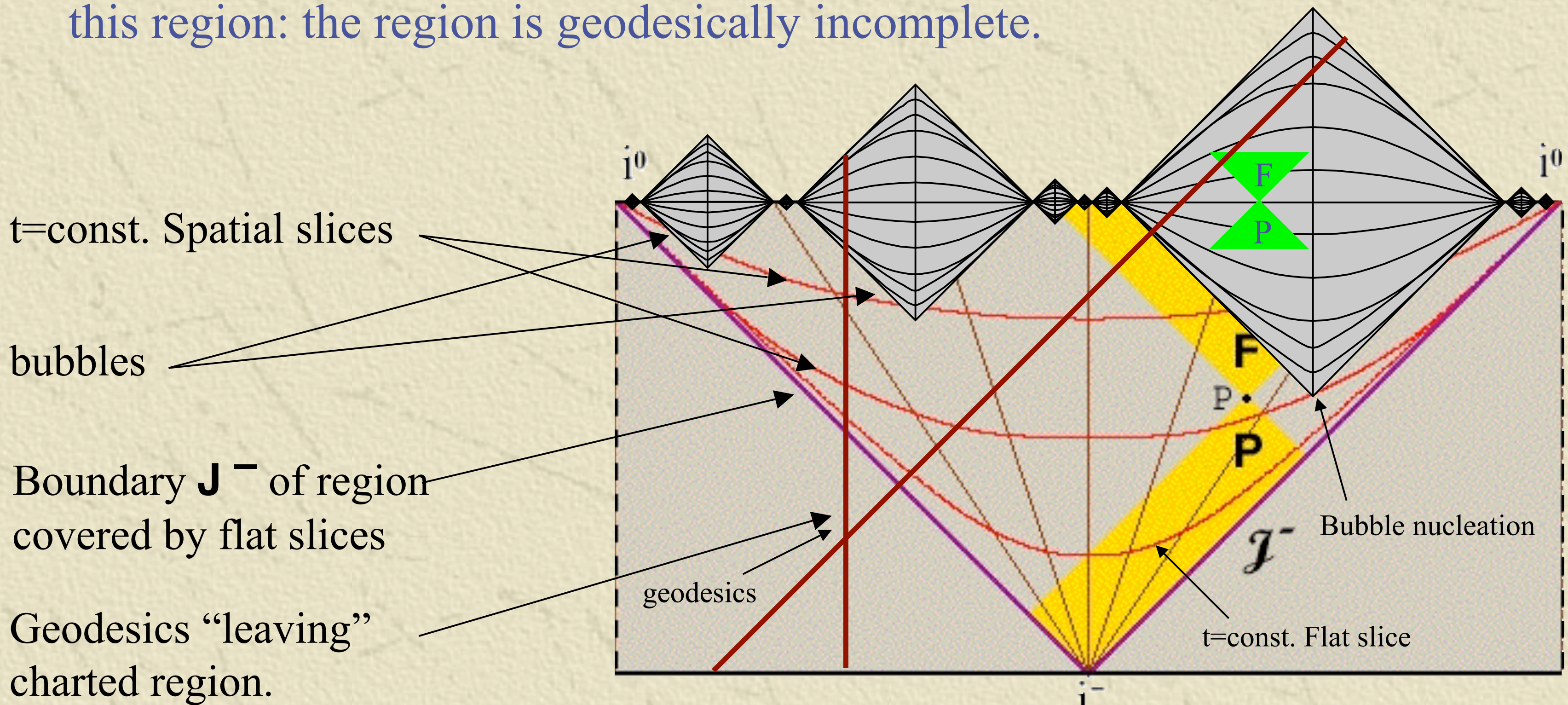
Bubble distribution is a "steady-state" with no preferred or initial time.

So what about the singularity theorems?

Analysis of “singularity”

For □ $< t <$ the flat spatial sections we have used in defining the background comprise only 1/2 of de Sitter space.

All null and “most” timelike geodesics have only finite proper time within this region: the region is geodesically incomplete.



Conformal diagram

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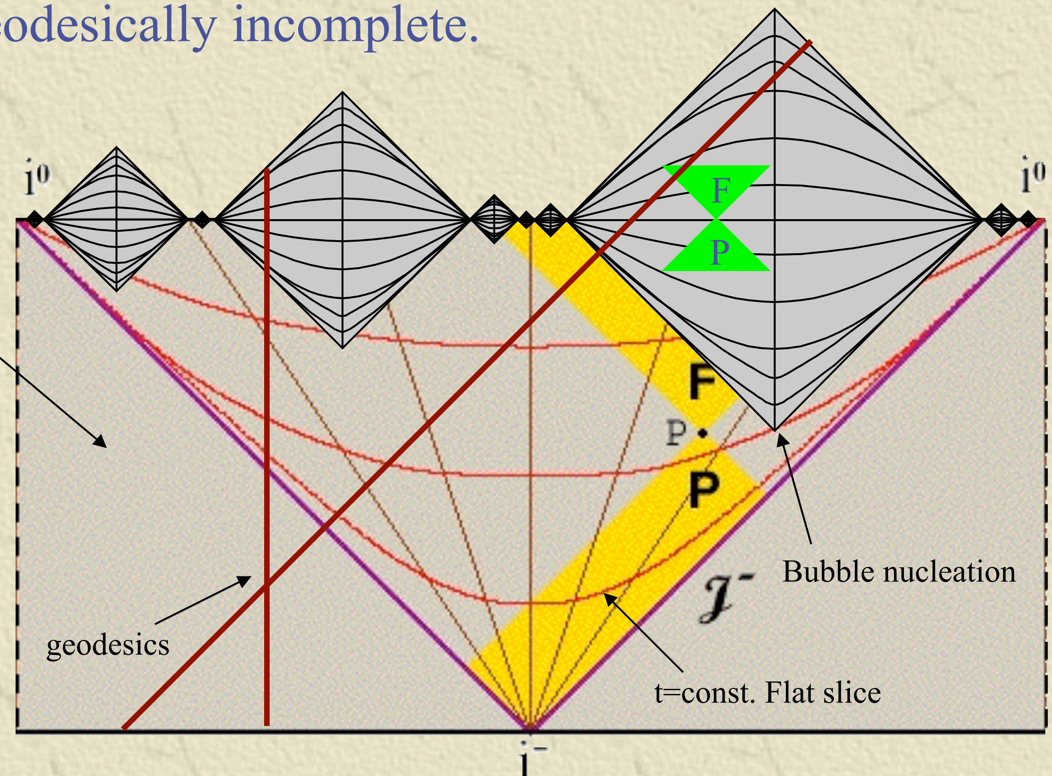
What is in the uncharted region?

Consider:

As t_0 □ □ , all geodesics enter false vacuum.

Continuity of fields then ⇨ **J**$^{-}$ = pure false vacuum.



Conformal diagram

Boundary conditions for eternal inflation

J⁻ is a boundary value surface for fields in both region one and two (it fills the light cone of any point).

(semi)classically, **J**⁻ is pure de Sitter space (no bubbles pass through it)

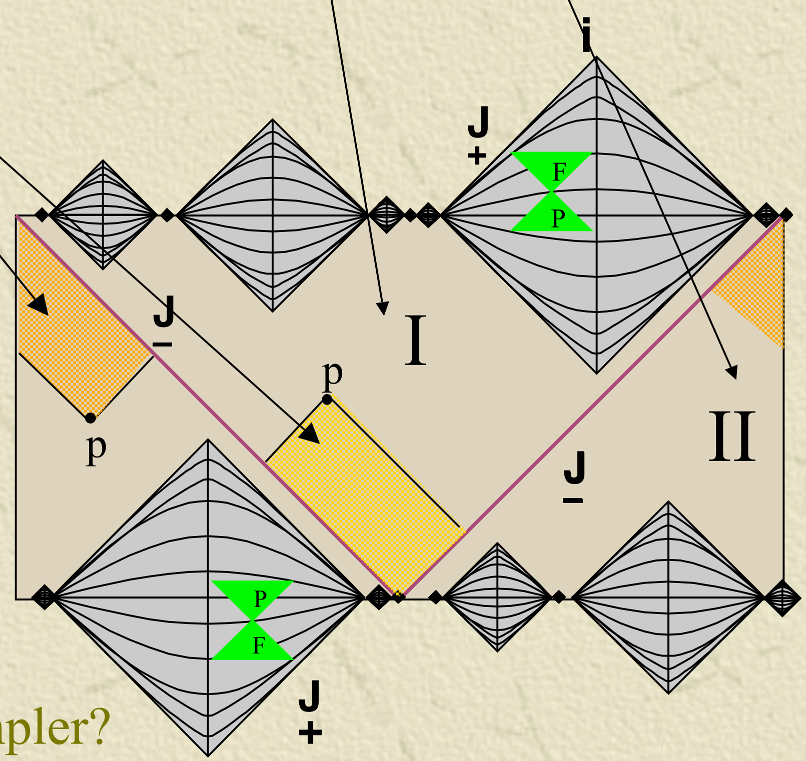
⇨ Classically, region II is just de Sitter.

⇨ Semi-classically, bubbles must form in region II; but they must point "down".

Region II is a copy of region I!

In short:

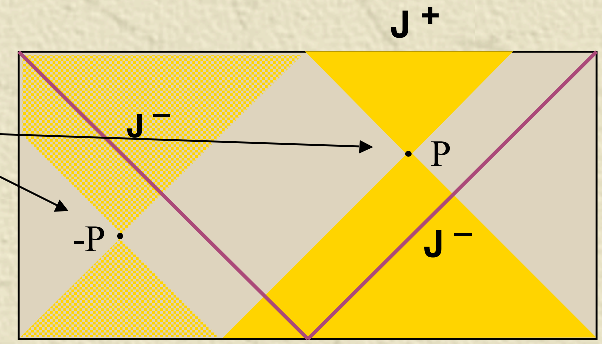
We specify that all fields are homogeneous and in (false or true) vacuum states on an infinite null surface in dS.



We get eternal inflation. What could be simpler?

The antipodal identification

Are the two "duplicate" regions really distinct?

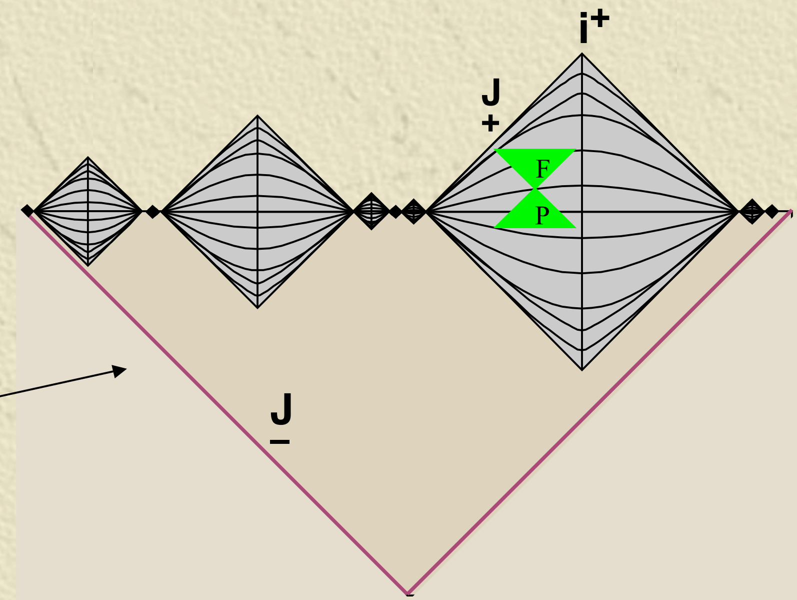


Old idea (Schrodinger 1957): identify **antipodal points** in de Sitter space.

Then region I = region II, $\mathcal{J}^-$ maps onto itself.

Features of antipodally identified de Sitter:

- No horizons.
- No closed time-like curves.
- (but non-time-orientable.)
- Only one spacelike infinity (interesting for dS/CFT conjecture).
- With it, eternal inflation is more "economical", and $\mathcal{J}^-$ is just a "surface" of infinite past time.



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For some details see: astro-ph/0111191.

A follow-up work will appear soon.