Measures and Eternal Inflation

Semi-classical picture of eternal inflation

Diverse regions w/ different properties.

2 questions:

1) How do we "map" this out?

2) How do we locate our universe and make predictions.

Making a Map

\[ P_p(x) \]: prob. to find an object p w/ properties \( x \).

Different objects p specify different maps, yielding different info.
For example:

How is volume distributed?

How many bubbles of each type are there?

How /which vacua are accessed on a single worldline?

How many transitions of a given type are there?

$p = \text{unit volume}$ Linde, Garriga others....

$p = \text{bubbles}$ Garriga, Vilenkin, others....

$p = \text{segment of a worldline}$ Bousso

$p = \text{transitions}$ Aguirre, Bath Johnson

In semi-classical picture: all maps are good

Quantum: Are all maps created equally?

Does the global description break down?

Do we understand how initial conditions work when necessary?
Making Predictions

\[ P_x (x) \propto p_p (x) \wedge p_{ix} (x) \]

\[ \wedge p_{ix} (x) \] connects map (prior) to what a randomly chosen object \( x \) sees.

Now, not all maps are useful.

1) The objects \( p \) must be appropriate for making anthropic predictions.

2) May need to specify initial conditions or gauge (w/ justification for doing so...)

3) Lots of infinities - how are they regulated?

4) Do they provide enough information to answer questions of interest?
Info. about vacua alone is insufficient!

Cosmological observables are history-dependent, so need a measure over histories.

Example:

A→B yields many e-folds

C→B yields few e-folds

Define a measure that counts transitions of a given type - along a worldline or globally.

- Can sum over all transitions into each vacuum to recover vacuum counting.

This measure may be more closely related to $\wedge_{x,p}(X)$ than one that counts vacua:

Entropy production or galaxy formation may be history-dependent.
Predictions:

**Cosmological Constant**

Priors determined by transition rates + other high-scale properties of the potential.

\[ \Rightarrow \text{No correlations systematically favoring particular } \Lambda. \]

Prior flat over anthropic window.

\( (i f \text{ enough low-c.e. vacua...}) \)

**# of inflationary e-Folds**

Transition-counting yields:

\[ \frac{P(c\rightarrow B)}{P(A\rightarrow B)} = e^{S_{E} - S_{CB}} \]

\( \ll \text{ or } \gg \)

Strong correlations between # of e-Folds and instanton action.

Wide anthropic window \( (N_e > 59-60) \)

\[ \Rightarrow \text{ Prior may dominate predictions!} \]
Do we actually live in a universe undergoing eternal inflation?

Possible test - Bubbles certainly collided with ours. Can we see them?

Perhaps, if a number of criteria are met:

1) Compatibility - At least 1 collision type admits our cosmology in its future light cone.

- Maybe possible if colliding bubble has a larger \( \Lambda \)

\[ \text{wall is expelled} \]
2) Probability - should be likely for us to observe collisions:

2 ways to see lots of collisions:

- go far from origin on const. density slice
  This is where most of the 3-volume is - we should expect to be here!

- wait a long time
  But, you only see a collision if $H_T < H_F \chi^{1/2}$
3) Observability - inflation should not dilute collision products away.

- Need a small # of eFolds (related to measure problem above)

What would the collisions look like?

Collisions can in principle affect discs of angular scale ψ

2-sphere surrounding observer portion of the wall in past LC the "Sky"

\[
\frac{dn}{d\psi \phi} \propto \Theta
\]

Bounded by values of H_I, H_F, \lambda unless H_F ≠ 0

Isotropic

Diverges like C^3 \psi

Anisotropic w/collisions in direction of wall

Late-time Collisions

Early-time Collisions