

Title: Anthropic prediction for Lambda and the Q catastrophe

Date: Oct 25, 2005 01:00 PM

URL: <http://pirsa.org/05100046>

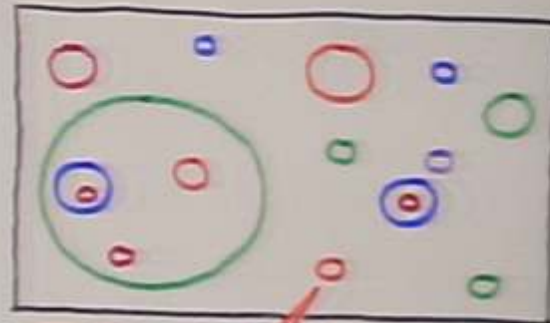
Abstract:

STRING THEORY \Rightarrow GOOGLES OF VACUA
WITH DIFFERENT CONSTANTS OF NATURE.



BOUSSO + POLCHINSKI: 00
SUSSKIND: 03
DOUGLAS: 03

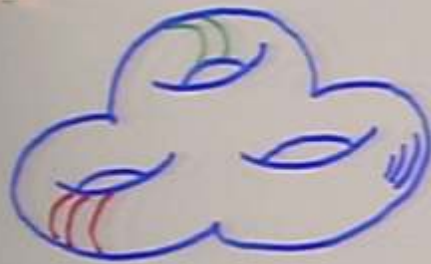
ETERNAL INFLATION
 \Rightarrow THE ENTIRE
LANDSCAPE WILL
BE EXPLORED.



WE ARE HERE

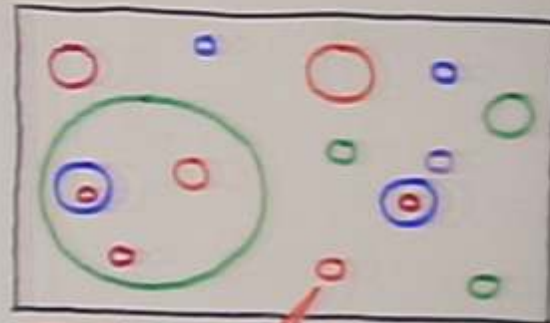
(ALL)
WE WILL NOT CALCULATE [^] THE CONSTANTS
FROM FIRST PRINCIPLES.

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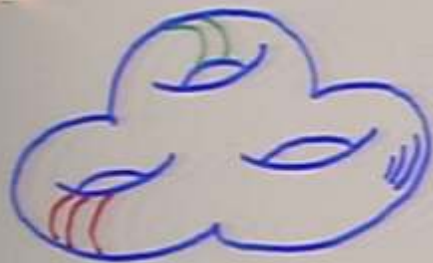
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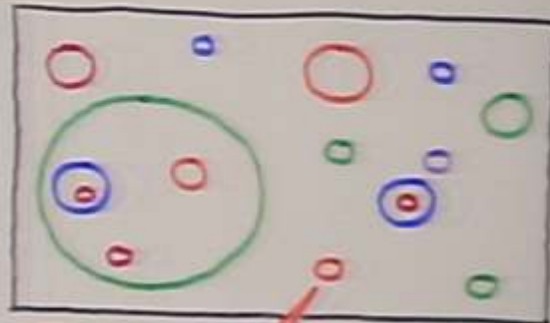
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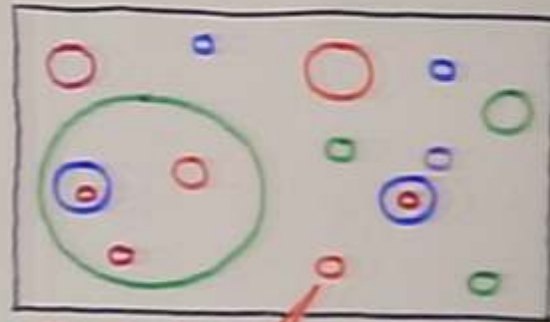
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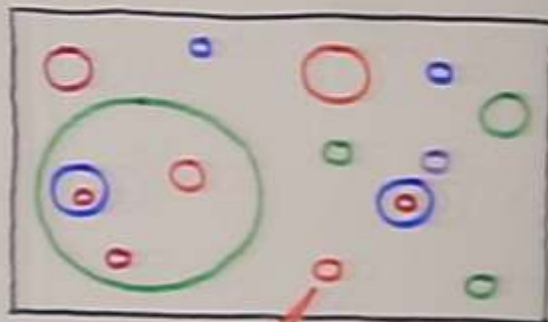
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KEY PROBLEM:

FIND THE PROBABILITY DISTRIBUTION
FOR THE CONSTANTS.

- CAN BE USED TO MAKE PREDICTIONS
AT SPECIFIED CONFIDENCE LEVEL.

A MAJOR SUCCESS:

PREDICTION OF A NONZERO Λ .

Weinberg 87, Linde 87
Efstathiou 95, A.V. 95.

DOUBTS:

THE SUCCESSFUL PREDICTION MAY NOT
SURVIVE WHEN OTHER PARAMETERS,
SUCH AS Q , ARE ALSO ALLOWED TO VARY.

Banks, Dine + Gorbatorov 03
Graesser, Hsu, Jenkins + Wise 04

THIS TALK:

- PREDICTION FOR Λ
- THE LARGE Q CATASTROPHE (?)
- THE QUEST FOR THE PRIOR

VARIABLE Λ

STRUCTURE FORMATION STOPS
WHEN Λ STARTS DOMINATING.

\Rightarrow HIGH Λ MEANS NO GALAXIES.

ANTHROPIC RANGE:

$$\Lambda \lesssim 500 \rho_{m0}$$

Weinberg 87

$$\Lambda \gtrsim -\rho_{m0}$$

Barrow + Tipler 86

Kalosh + Linde 03

PROBABILITY DISTRIBUTION

$P(\Lambda) d\Lambda \propto$ # OF OBSERVERS WHO WILL
MEASURE Λ IN THE INTERVAL $d\Lambda$.

$$P(\Lambda) = P_{\text{prior}}(\Lambda) n_{\text{obs}}(\Lambda)$$

VOLUME FRACTION

OF OBSERVERS
PER UNIT VOLUME

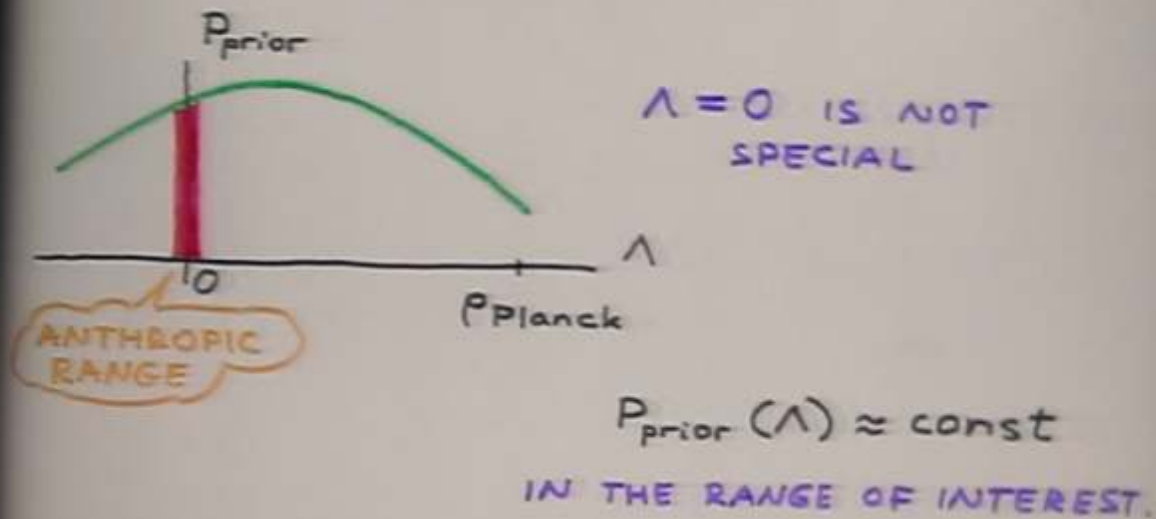
P_{prior} - FROM FUNDAMENTAL PHYSICS

$$n_{\text{obs}} \propto f_G(\Lambda)$$

FRACTION OF MATTER
CLUSTERED IN GALAXIES

$$n_{\text{obs}} \propto f_G(\Lambda)$$

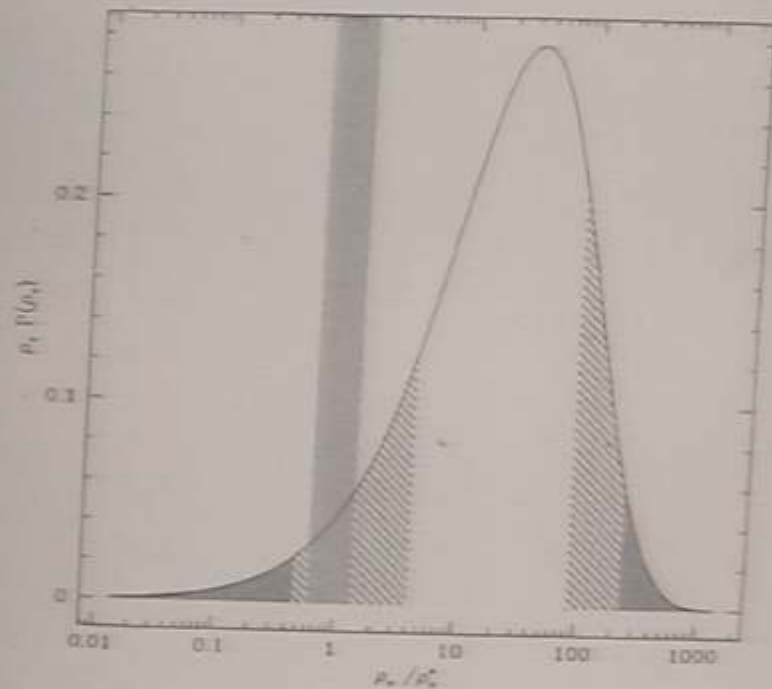
WHAT DO WE USE FOR PRIOR?



$$\Rightarrow dP(\Lambda) \propto f_G(\Lambda) d\Lambda$$

$$P(\Lambda) \propto \text{erfc}(y^{1/3}),$$

$$y = C\Lambda/Q^3$$
$$C = \text{const}$$
$$Q = 10^{-5} - \text{fixed}$$



Martel, Shapiro + Weinberg 98
Garriga + A.V. 03

VARIABLE Q AND Λ

$$P_{\text{prior}}(\Lambda, Q) \Rightarrow P_{\text{prior}}(Q) \quad \left\{ \begin{array}{l} \text{ANALOG OF} \\ \text{FLAT PRIOR} \\ \text{FOR } \Lambda. \end{array} \right.$$

$$dP(\Lambda, Q) \propto P_{\text{prior}}(Q) \operatorname{erfc}(y^{1/3}) d\Lambda dQ$$

$$y = C\Lambda/Q^3$$

$$dP(y, Q) \propto Q^3 P_{\text{prior}}(Q) dQ \cdot \operatorname{erfc}(y^{1/3}) dy$$

PREDICTION FOR y
IS UNCHANGED!

SAME AS BEFORE

Garriga, Livio + A.V. 99

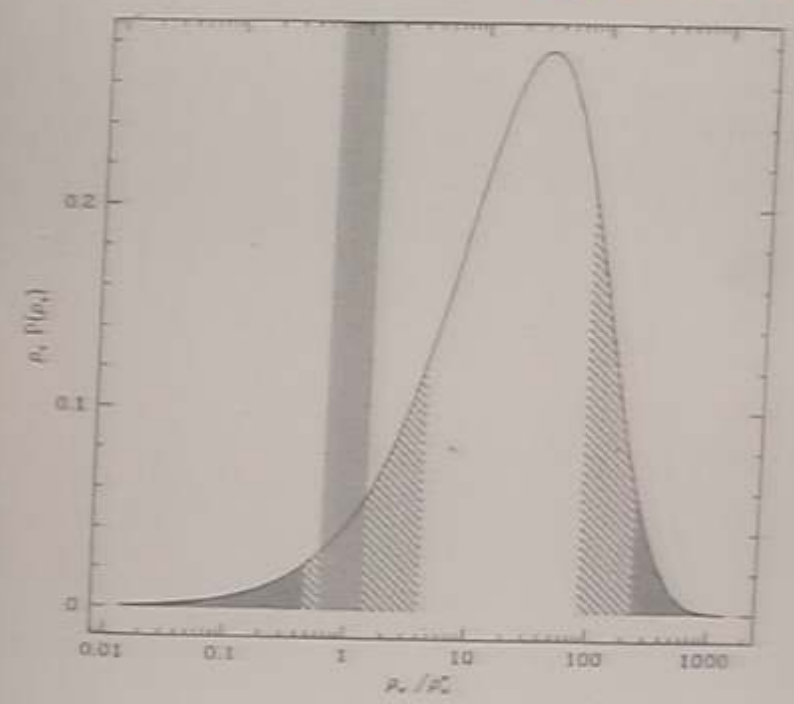
Press & Schechter 74

$$\rho_g(\Lambda) \propto \text{erfc}(y^{1/3}),$$

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A PRIOR FOR Q

Graesser et al. 04

ASSUME INFLATIONARY POTENTIAL

$$V(\varphi) = \lambda \varphi^n \Rightarrow Q \propto \frac{V^{3/2}}{V'} \propto \lambda^{1/2}$$

ANTHROPIC RANGE FOR Q:

$$10^{-6} \lesssim Q \lesssim 10^{-4}$$

Tegmark + Rees

$$\Rightarrow 10^{-14} \lesssim \lambda \lesssim 10^{-12}$$

BY THE SAME LOGIC WE USED FOR Λ ,

$$P_{\text{prior}}(\lambda) = \text{const} \Rightarrow P_{\text{prior}}(Q) \propto d\lambda/dQ \propto Q.$$

$$P(Q) \propto Q^3 P_{\text{prior}}(Q) \propto Q^4.$$

STRONGLY FAVORS LARGE Q

\Rightarrow THE Q CATASTROPHE.

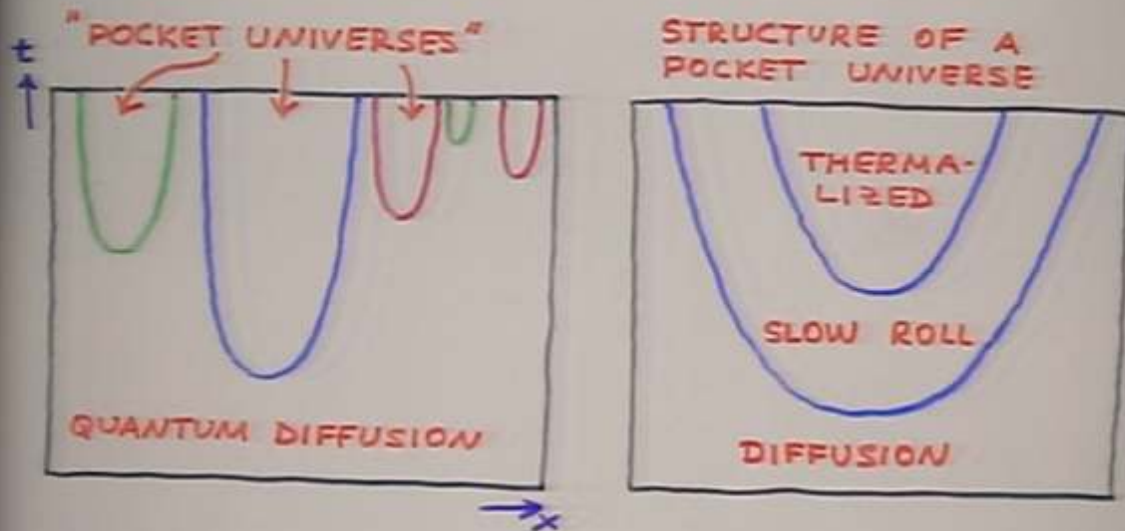
BUT: λ AFFECTS NOT ONLY Q,
BUT ALSO THE DYNAMICS OF INFLATION.
 \Rightarrow THE FLAT PRIOR ASSUMPTION
IS NOT JUSTIFIED.

HOW CAN WE FIND $P_{\text{prior}}(Q)$?

CALCULATION OF P_{prior}

J. Garriga, D. Perlov, A.V. + S. Witlitzki
(hep-th/0509184)

SPACETIME STRUCTURE OF AN ETERNALLY INFLATING UNIVERSE:



$$P_j \propto P_j Z_j^3$$

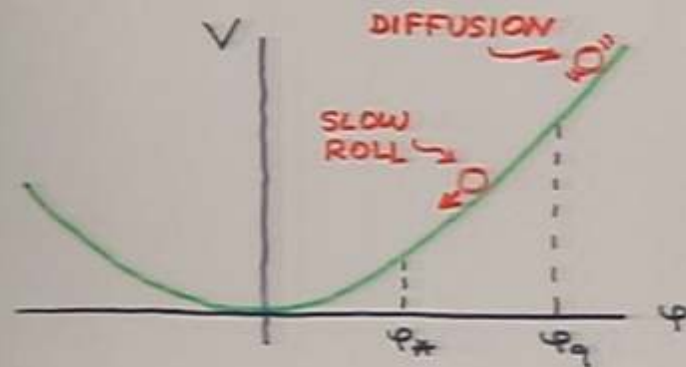
"j" LABELS DIFFERENT TYPES OF POCKETS.

"DENSITY" OF j-TYPE POCKETS AT \mathcal{H}^+

EXPANSION FACTOR DURING SLOW ROLL

AN EXAMPLE

$$V_j(\varphi) = \frac{1}{2} m_j^2 \varphi^2$$



$$\varphi_q \sim (2m_j)^{-1/2}$$

$$\varphi_* \sim 1/6$$

$$Z_j = \exp \left[8\pi \int_{\varphi_*}^{\varphi_q} \frac{V}{V'} d\varphi \right] \approx \exp \left(\frac{\pi}{m_j} \right)$$

DENSITY FLUCTUATIONS: $Q \sim m_j$

$$\Rightarrow P_\delta(Q) \propto Z^3(Q) \propto \exp \left(\frac{\text{const}}{Q} \right).$$

SMALL Q ARE EXPONENTIALLY FAVORED.

Garriga + A.V. 05

Feldstein, Hall + Watari 05

QUANTUM FLUCTUATIONS OF THE INFLATON
ARE NOT LIKELY TO BE THE SOURCE
OF THE OBSERVED Q .

⇒ NEED SOME OTHER MECHANISM
(e.g. CURVATON)

(OR MAYBE INFLATON MODELS WITH
MORE COMPLICATED POTENTIALS.)

CURVATON-TYPE MODELS

IS GENERATED BY FIELDS χ_a
OTHER THAN THE INFLATON.

$$m \ll H$$

$$V(\chi) = \frac{1}{2} m^2 \chi^2, \quad \chi^2 = \sum_{a=1}^N \chi_a^2.$$

$$Q \sim \frac{\delta \chi}{\chi} \sim \frac{H}{\chi}.$$

$$dP_{\text{prior}} \propto Q^3 \chi^{N-1} d\chi \\ \propto Q^{2-N} dQ.$$

Linde + Mukhanov 96
Lyth + Wands 01
Dvali, Gruzinov
+ Zaldarriaga 03

$$\text{FOR } N=3: \quad dP_{\text{prior}}(Q) \propto \frac{dQ}{Q}.$$

SINGLE-FIELD MODELS WITH MORE
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CONCLUSIONS

- VARIABLE Q DOES NOT AFFECT THE SUCCESSFUL PREDICTION FOR $y \propto \Lambda / Q^3$.
- Q DUE TO THE INFLATON TENDS TO BE EXPONENTIALLY SUPPRESSED.
- THE OBSERVED Q IS LIKELY TO BE DUE TO SOME OTHER MECHANISM (E.G. CURVATON).
- ANTHROPIC MODELS CAN BE FALSIFIED OR CONFIRMED AT A SPECIFIED CONFIDENCE LEVEL.

CAVEATS:

"ATTRACTORS" - INFINITE ACCUMULATIONS
OF VACUA IN THE LANDSCAPE

Dvali + AV 04
Dvali 04
Denef + Douglas 05

"COSMIC NATURAL SELECTION"

Smolin 92

⇒ A SINGLE VACUUM IS SELECTED.

BUT: MOST VACUA ARE NOT BIO-FRIENDLY.

HOW DID WE GET SO LUCKY?

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