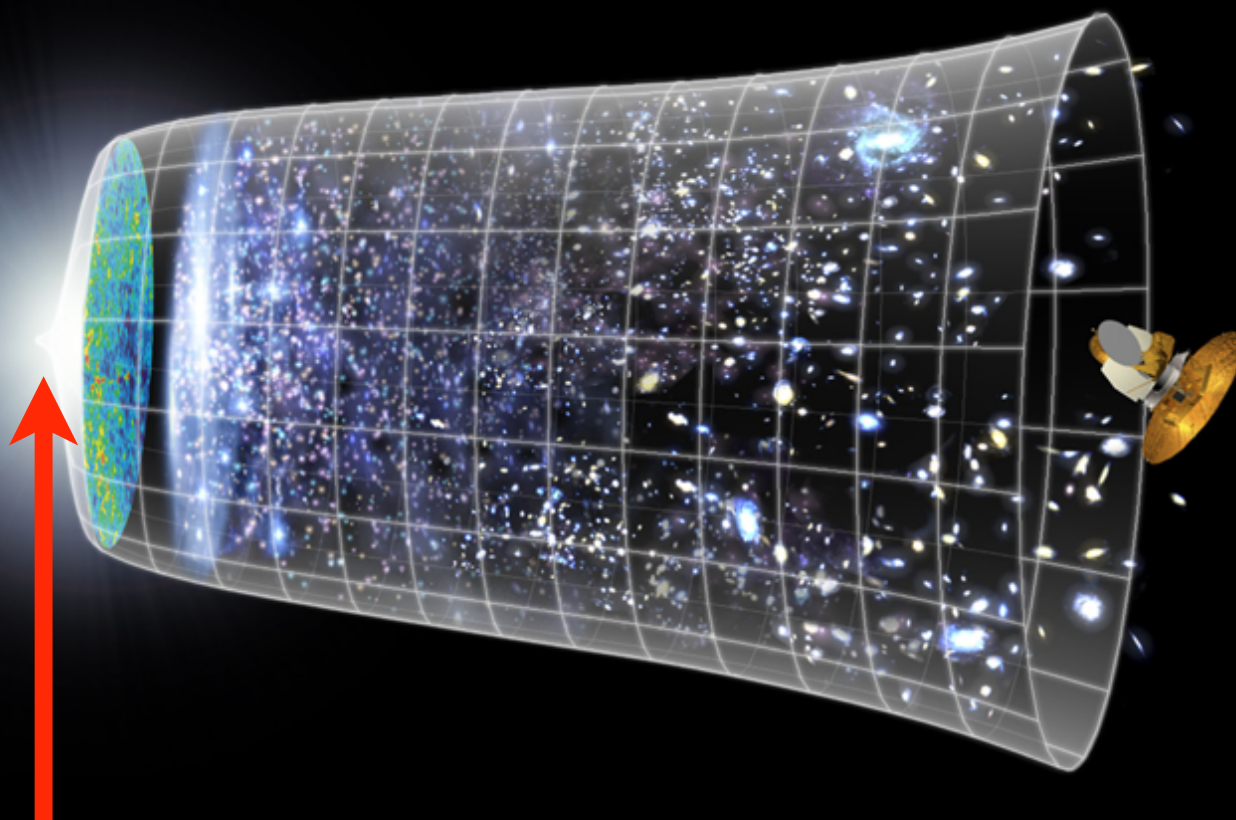


IN THE BEGINNING: INFLATION

MARK WYMAN

74TH COMPTON LECTURE SERIES



TODAY'S TOPIC

HOW DID THE UNIVERSE START?

ONE OF THREE KEY BREAKTHROUGHS OF
MODERN COSMOLOGY

PROBLEM, CA. 1980

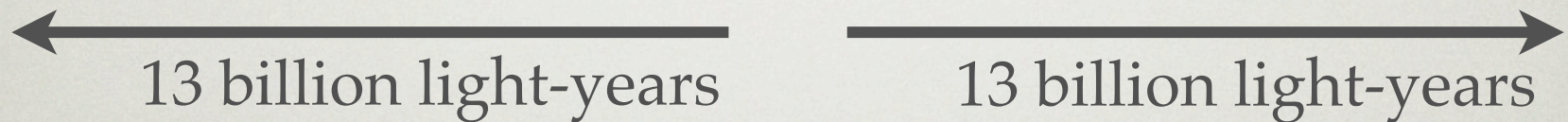


PROBLEM, CA. 1980



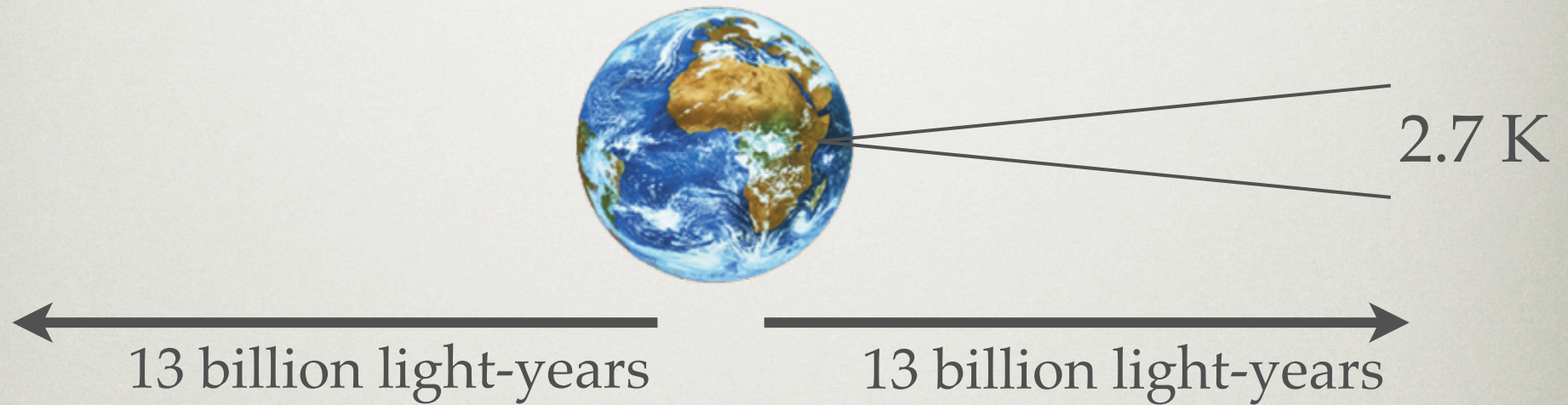
HE NEEDED A JOB

HORIZON PROBLEM



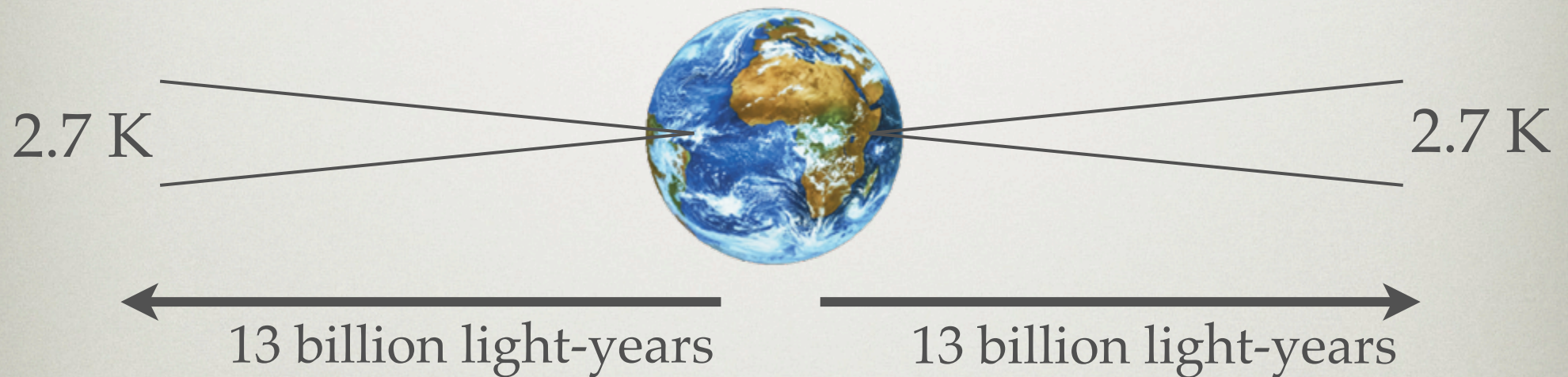
Universe: 13 billion years old. Total.

HORIZON PROBLEM



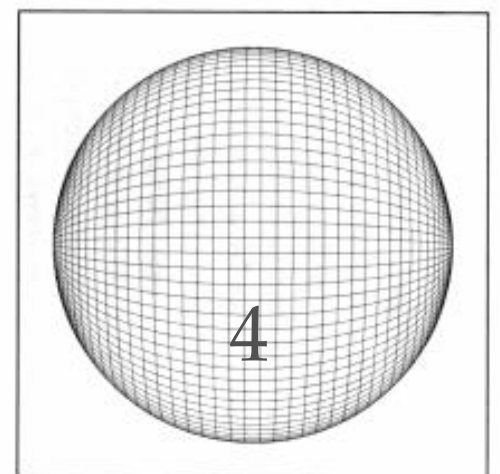
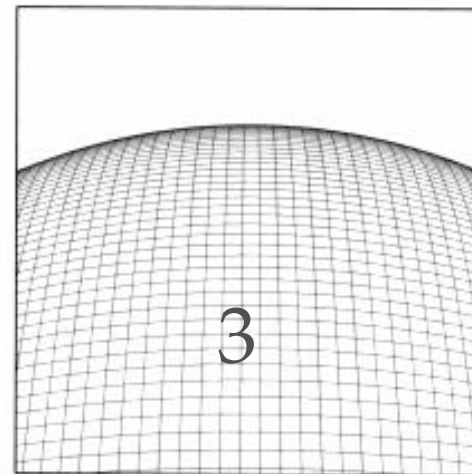
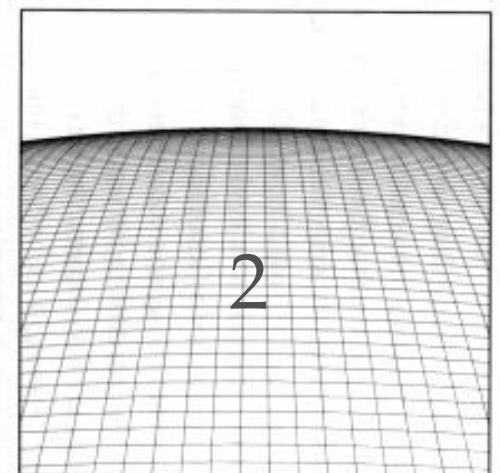
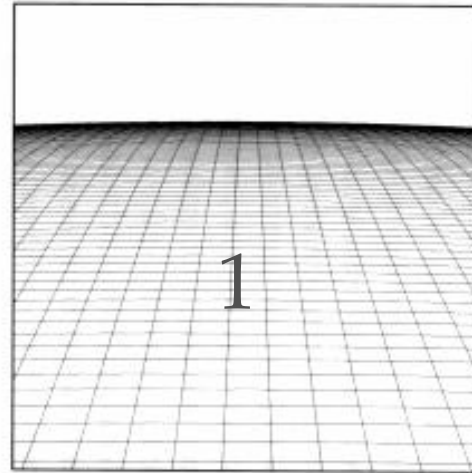
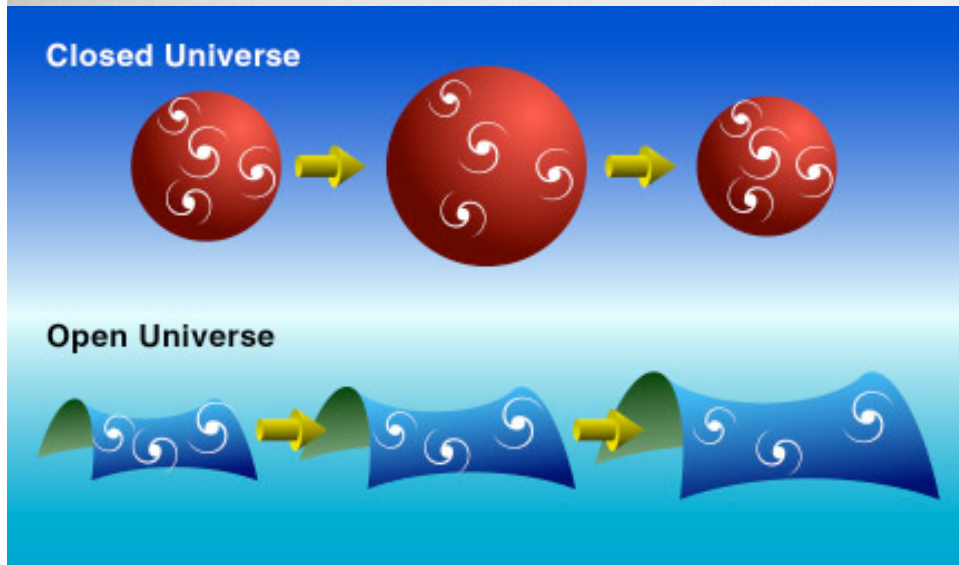
Universe: 13 billion years old. Total.

HORIZON PROBLEM

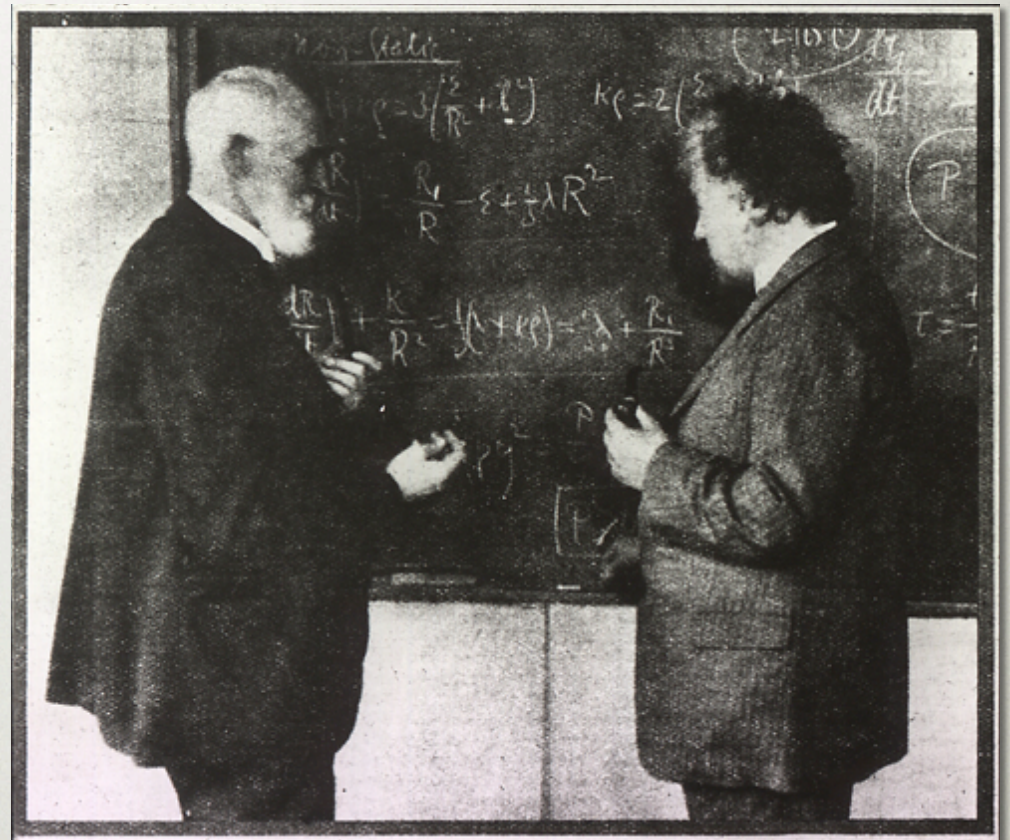
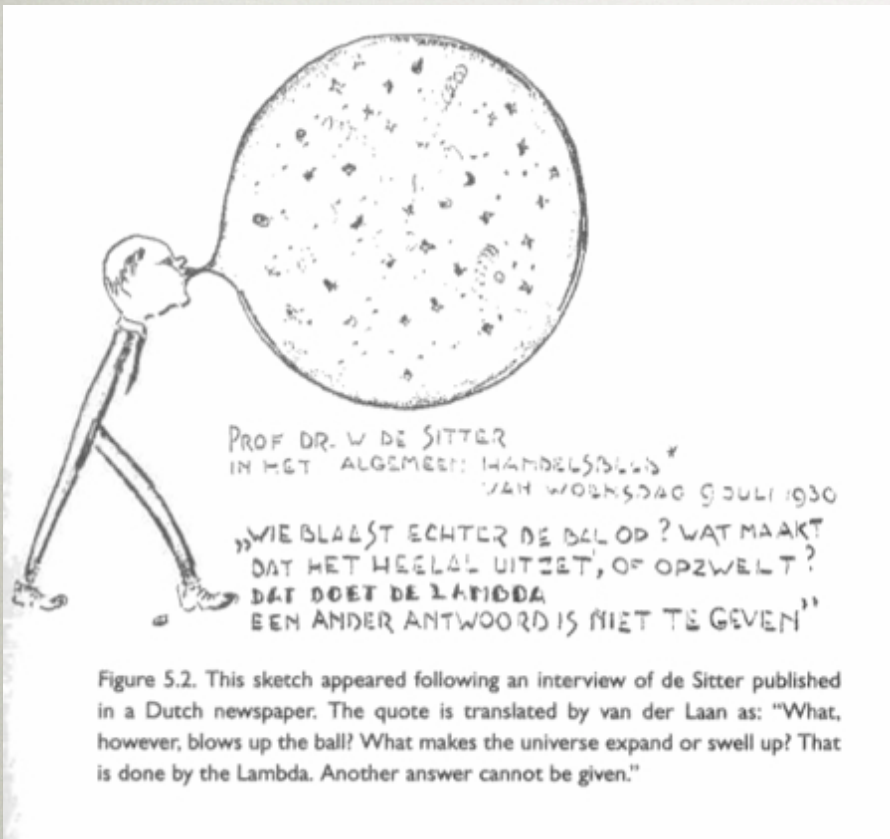


Universe: 13 billion years old. Total.

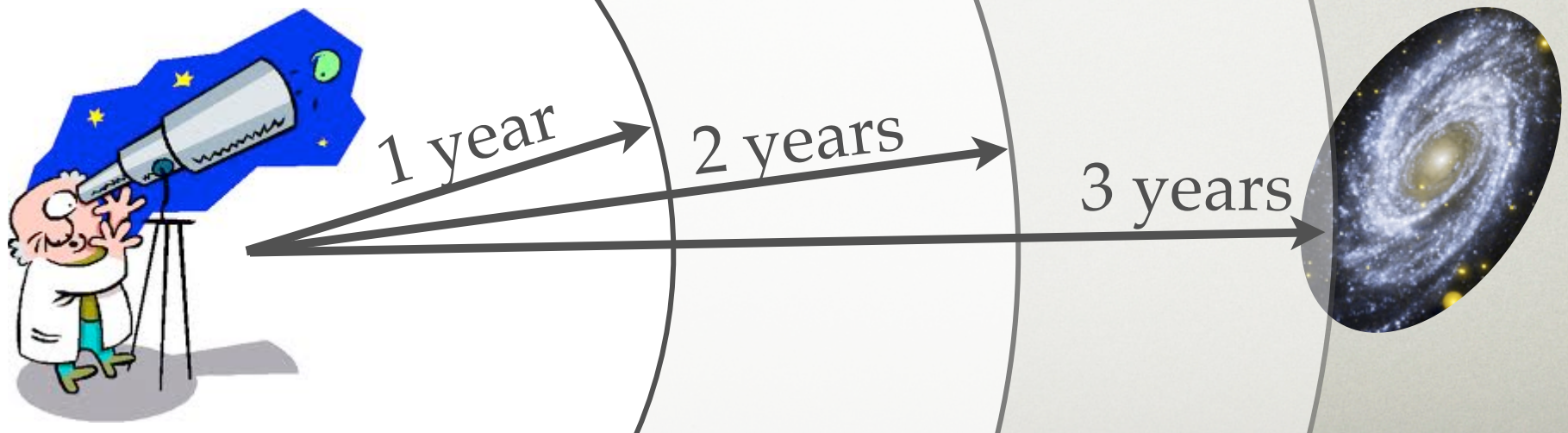
FLATNESS PROBLEM



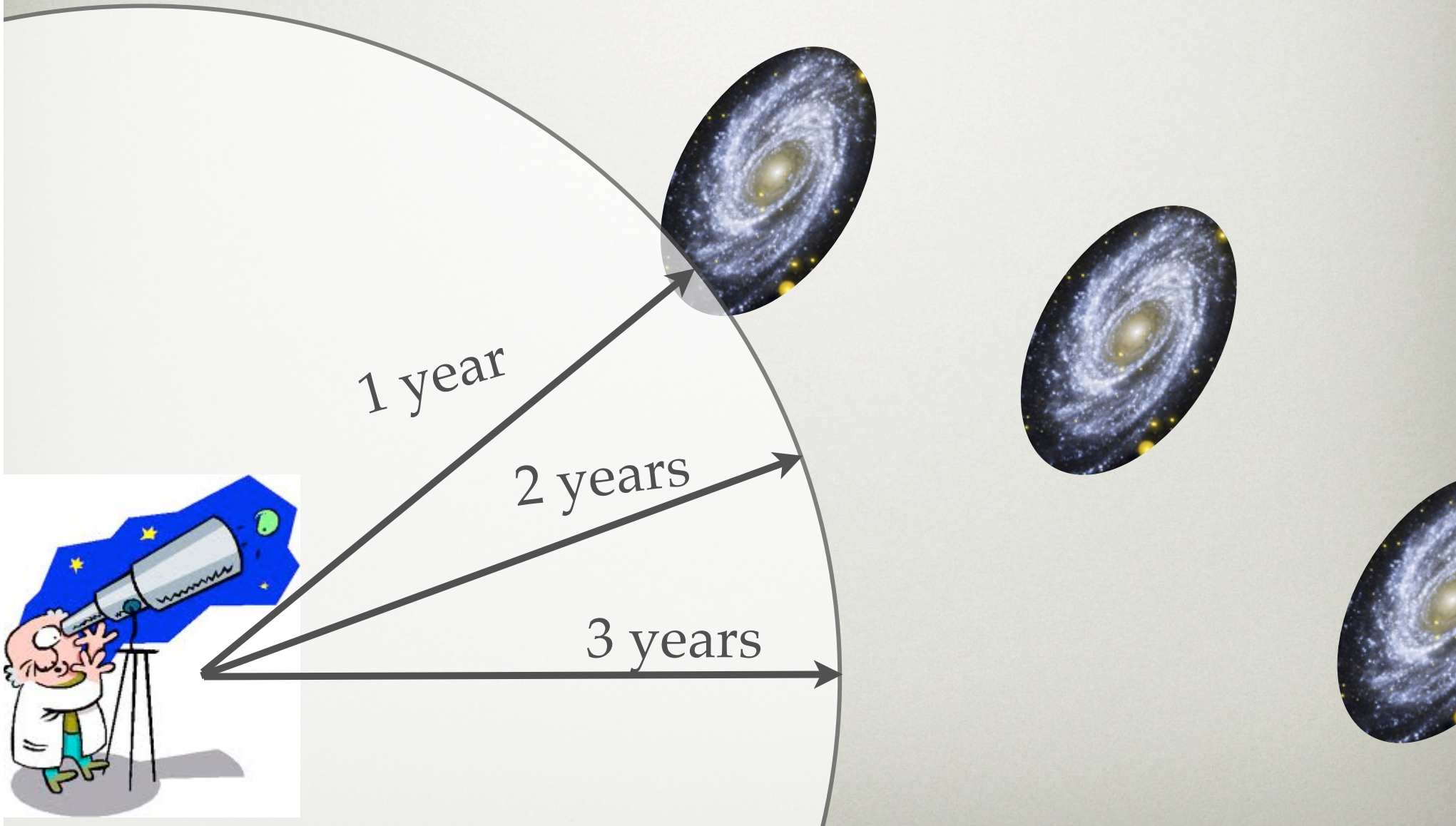
GUTH'S SOLUTION: INFLATION, OR "DE SITTER SPACE"



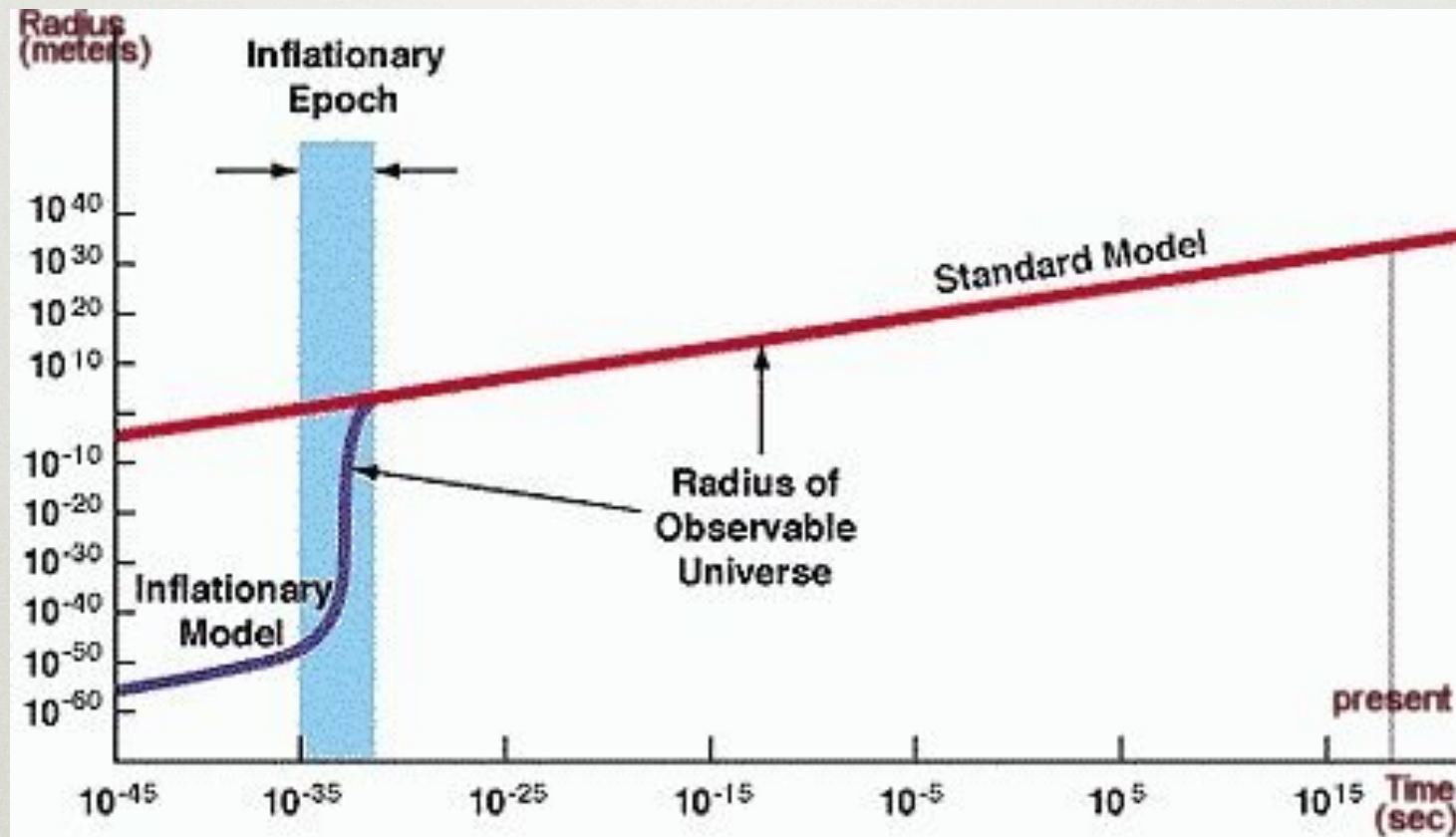
NORMAL EXPANSION RATE: SLOW COMPARED TO LIGHT

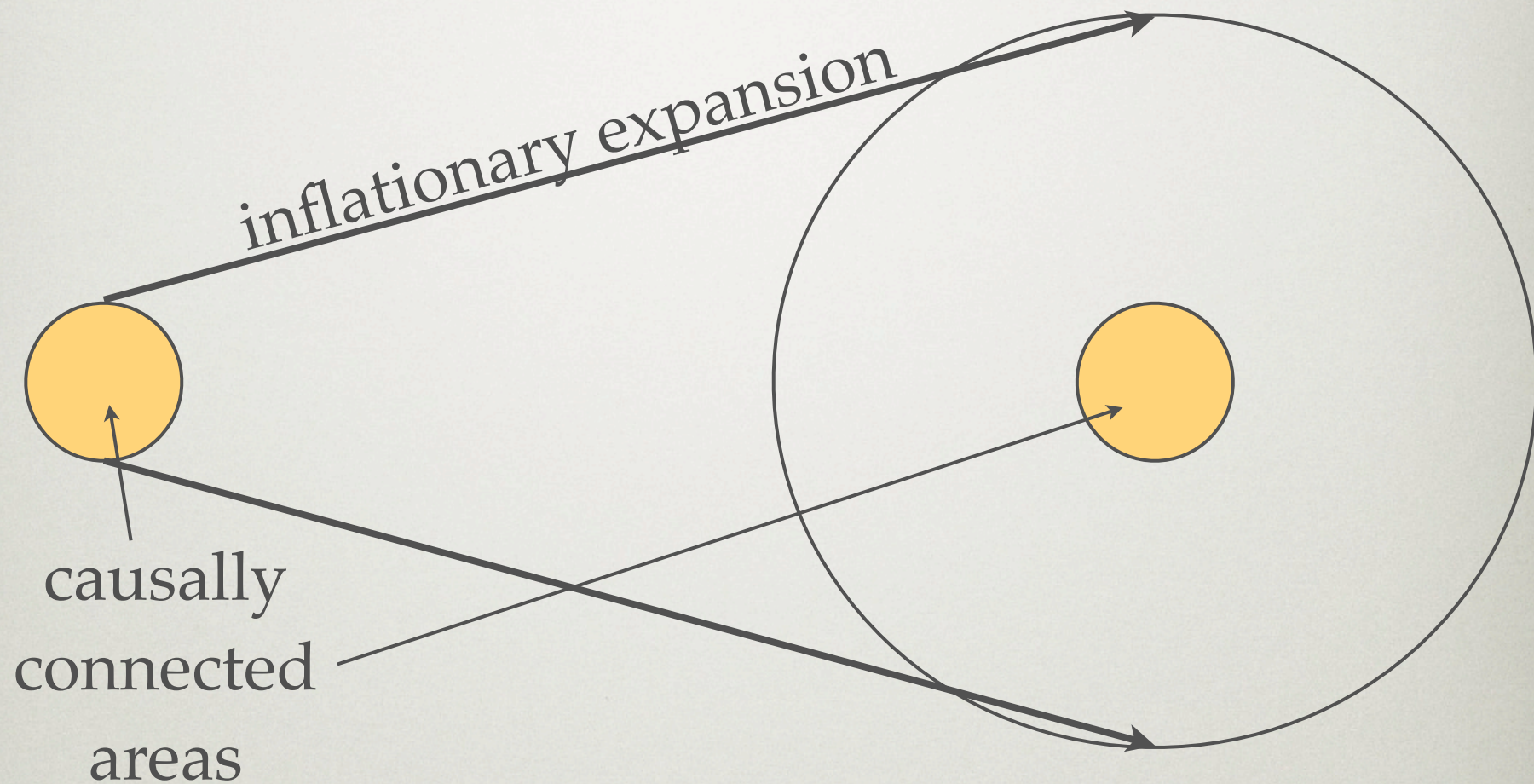


DE SITTER / INFLATIONARY EXPANSION: EXPANSION OUTRUNS LIGHT

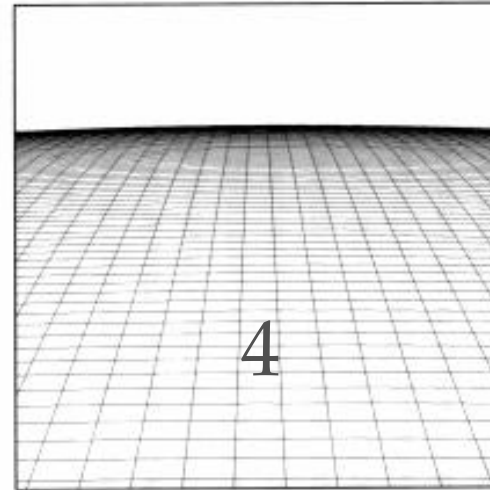
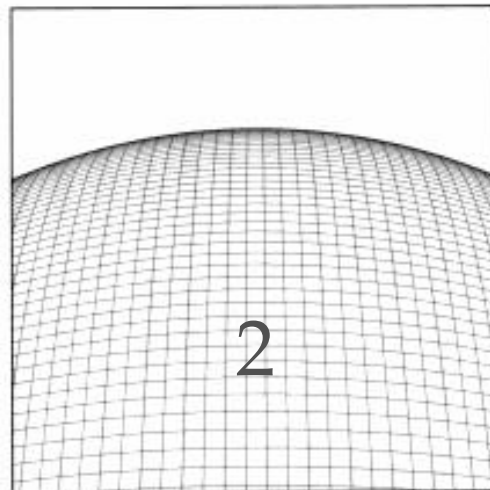
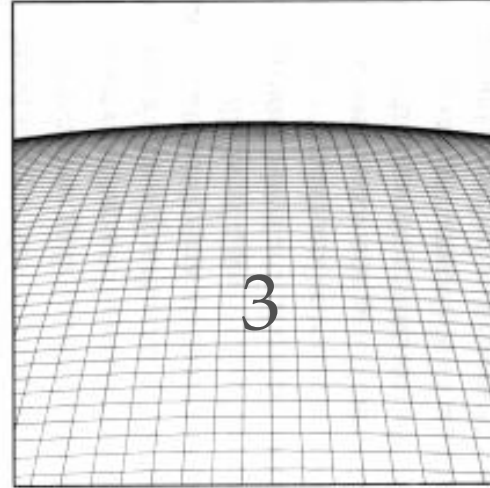
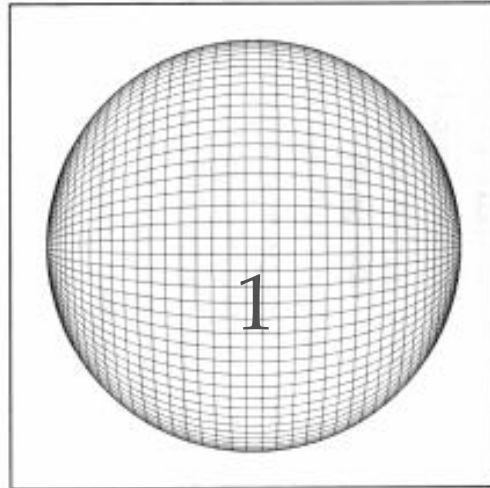


INFLATION SOLVES THE HORIZON PROBLEM





INFLATION FLATTENS SPACE OUT



WHAT INFLATES?

change in expansion rate $\propto -[\text{energy density}] - 3 \times [\text{pressure}]$

Dark Matter: pressure = 0

Radiation: pressure = $\frac{1}{3}$ (energy density)

WHAT INFLATES?

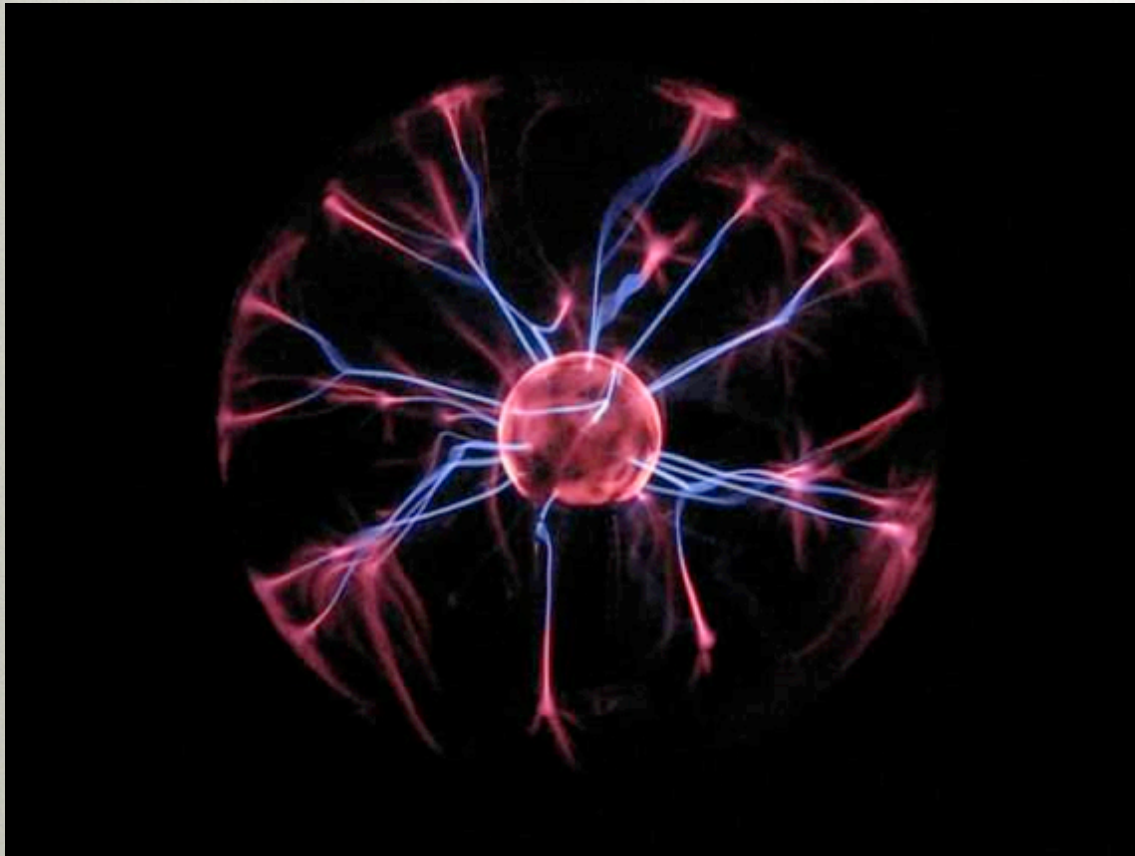
change in expansion rate $\propto -[\text{energy density}] - 3 \times [\text{pressure}]$

Dark Matter: pressure = 0

Radiation: pressure = $\frac{1}{3}$ (energy density)

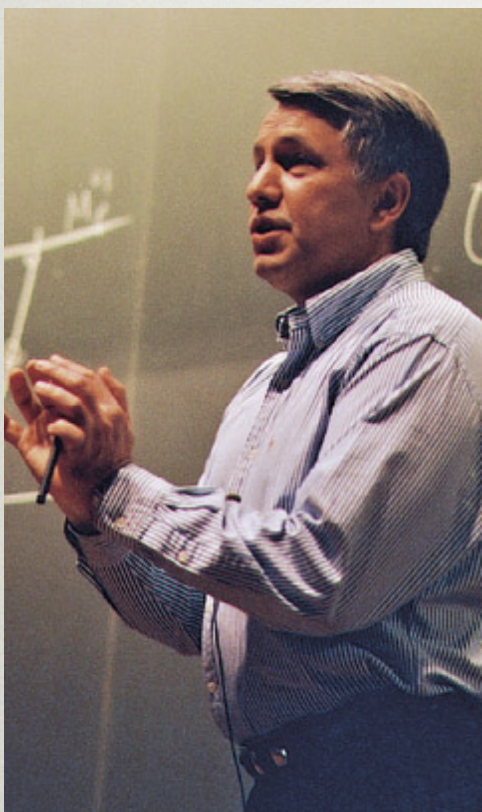
“vacuum energy:” pressure = $-[\text{energy density}]$

WHAT IS “VACUUM ENERGY”?



PROBLEM: GUTH'S INFLATION THEORY DIDN'T QUITE WORK

So these guys fixed it.



Andrei
Linde



Andy
Albrecht



Paul
Steinhardt

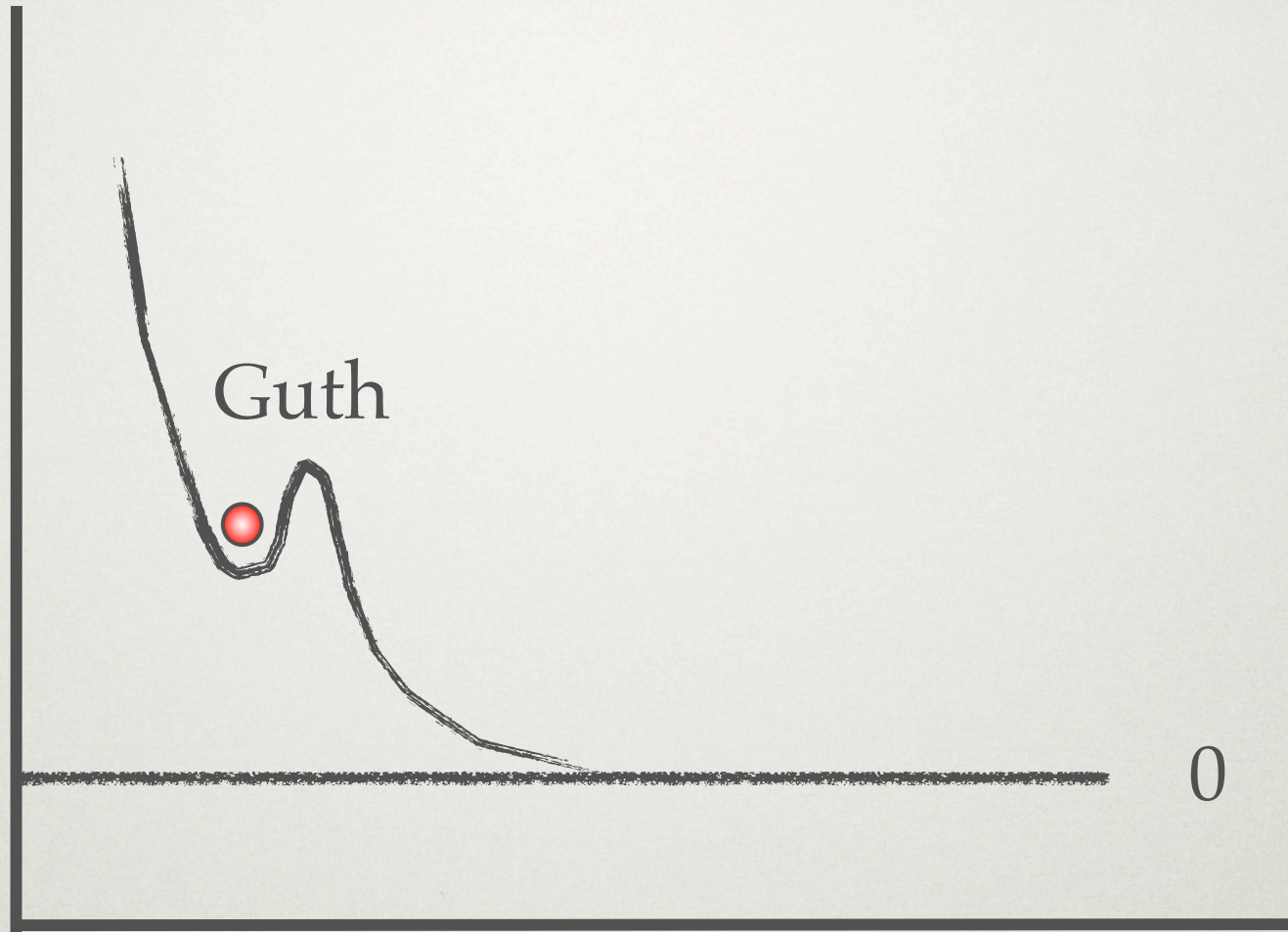
potential
energy

Guth



0

field value



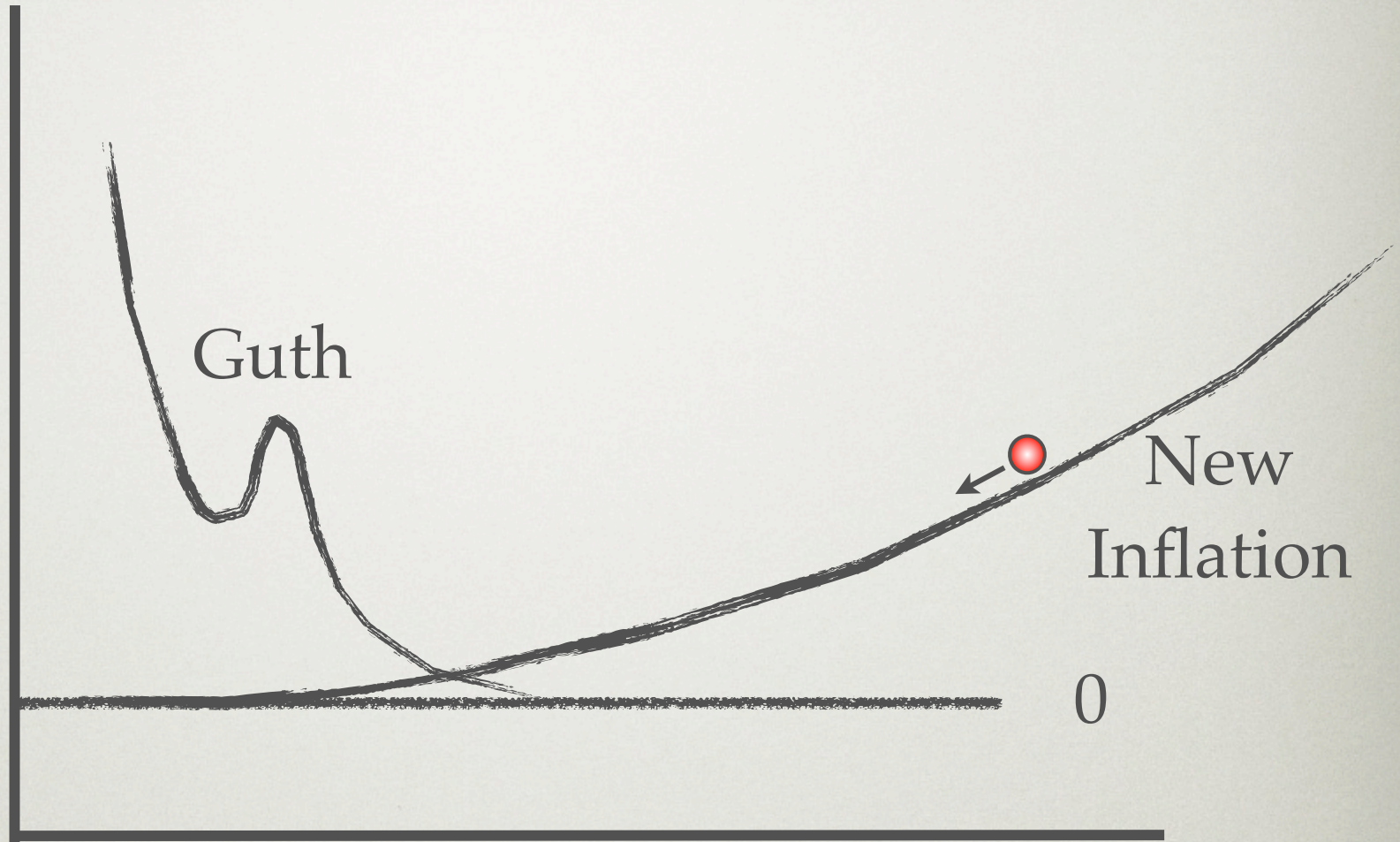
potential
energy

Guth

New
Inflation

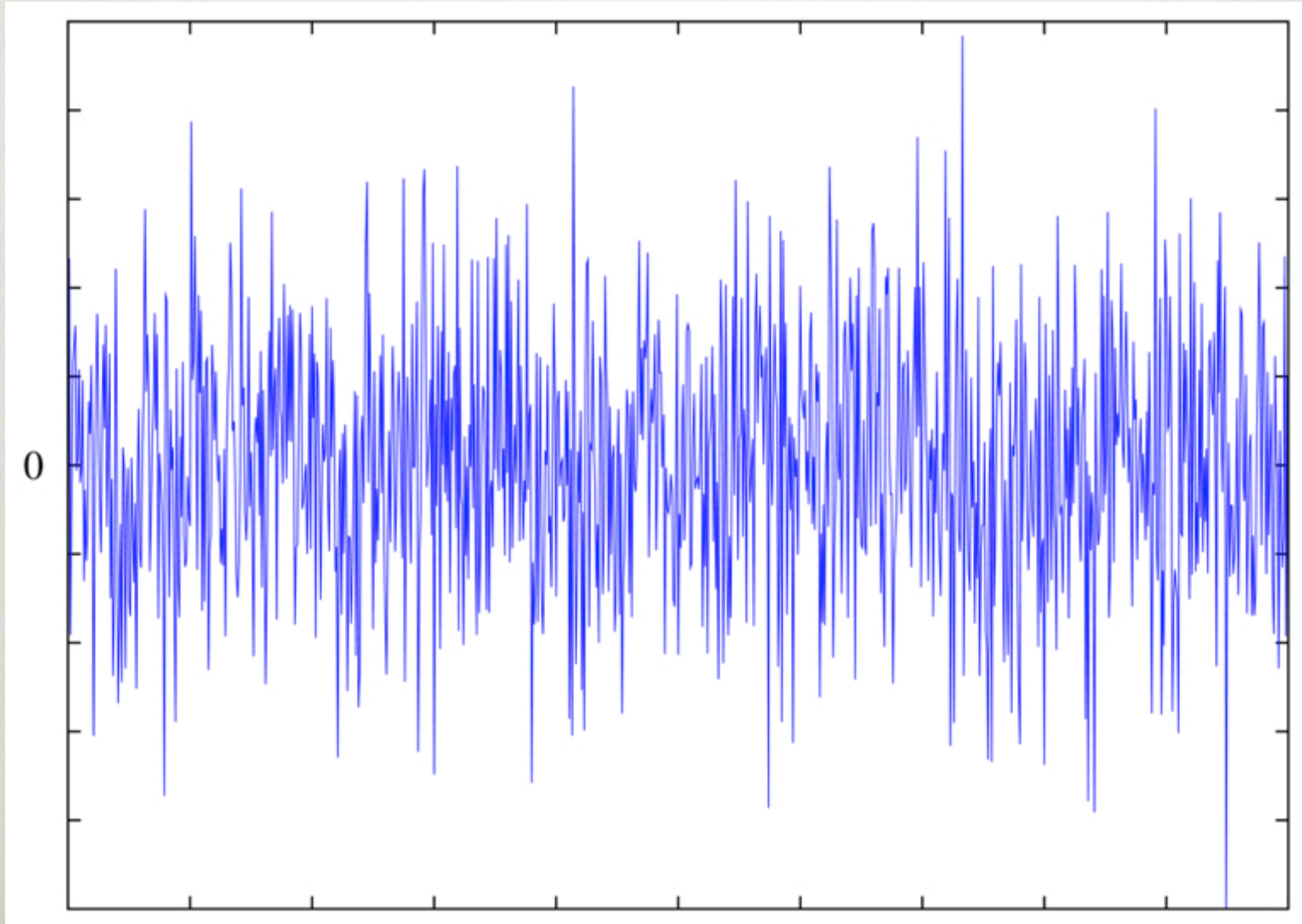
0

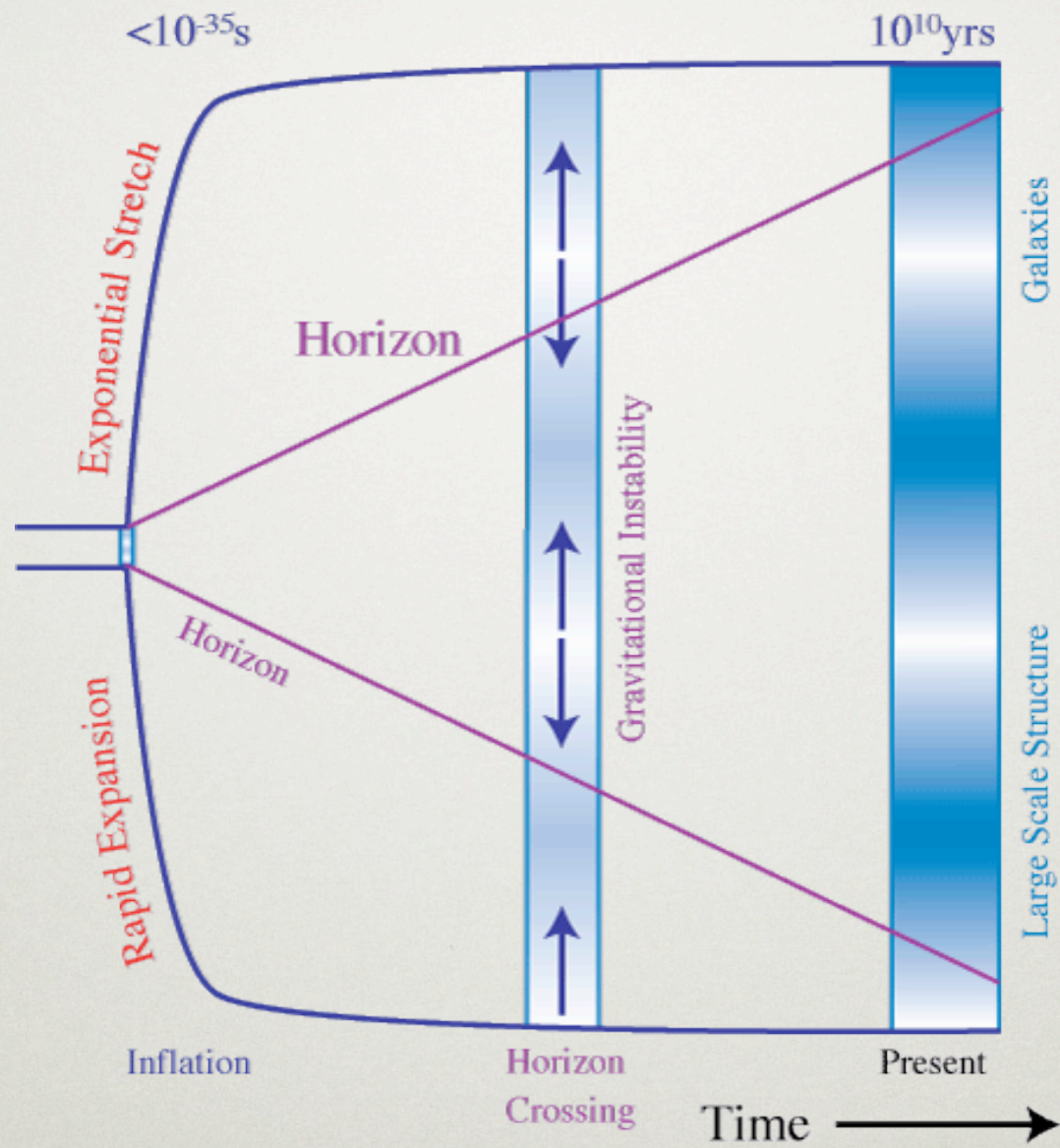
field value



SUCCESS

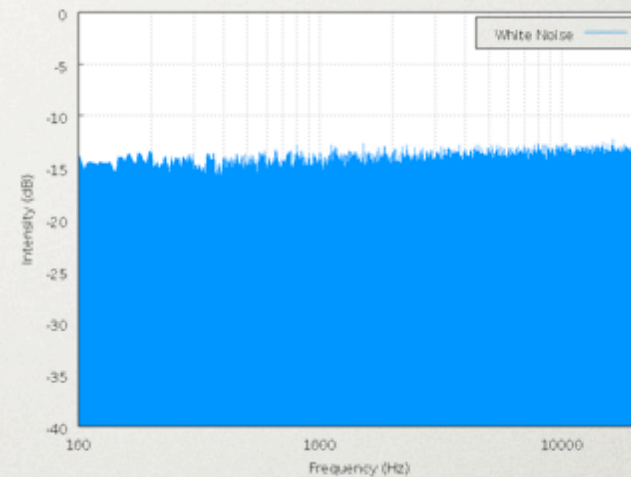
INFLATION PRODUCES QUANTUM PERTURBATIONS



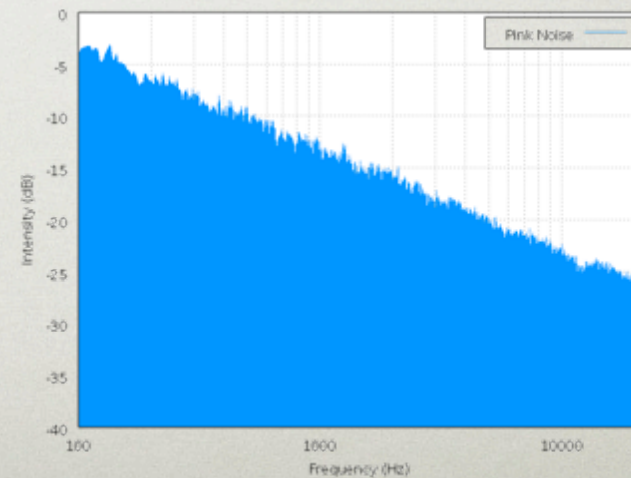


WHAT COLOR IS THE INFLATIONARY NOISE?

white noise

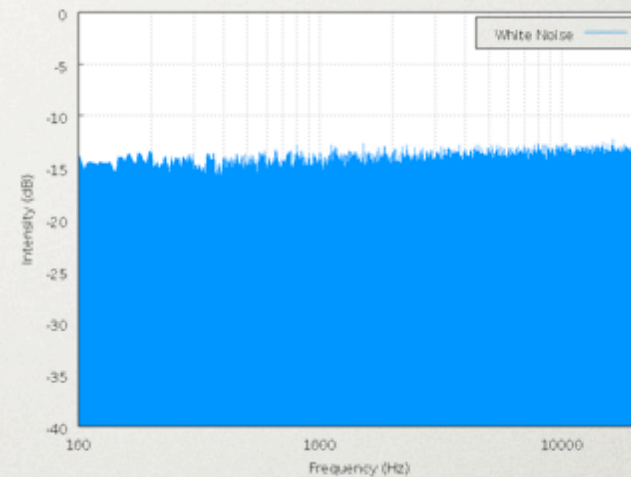


pink noise

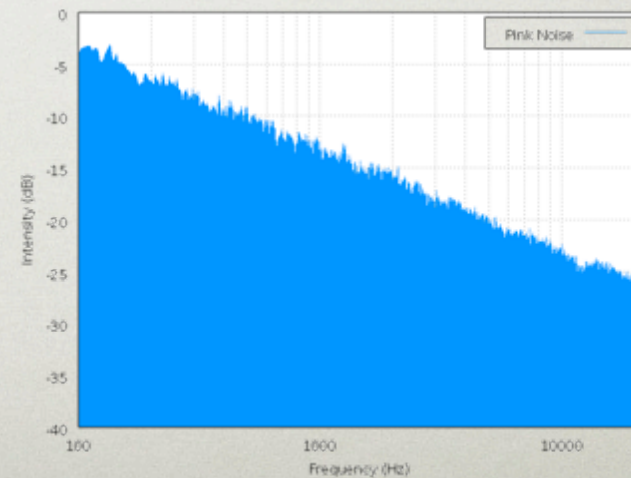


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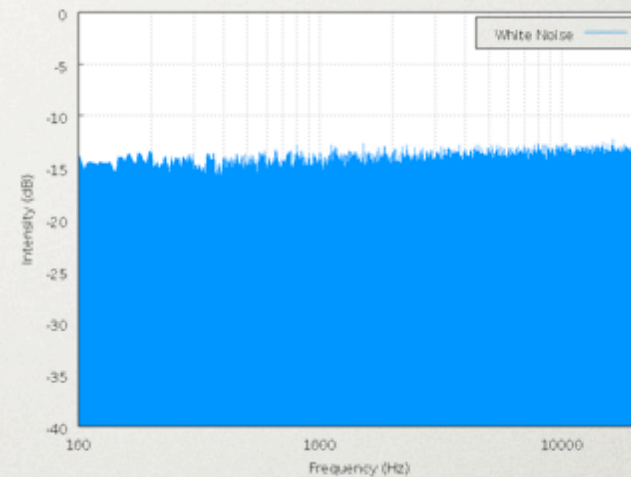


pink noise

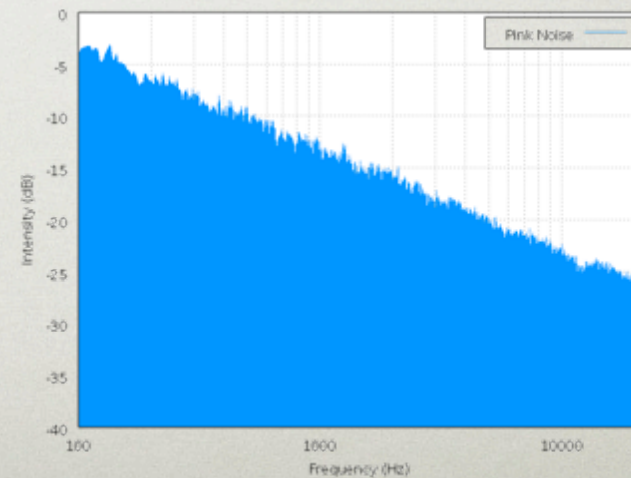


WHAT COLOR IS THE INFLATIONARY NOISE?

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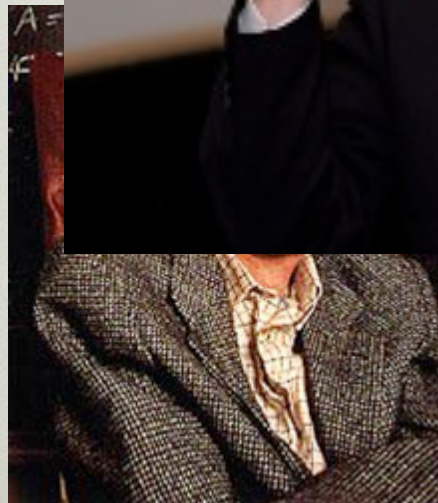
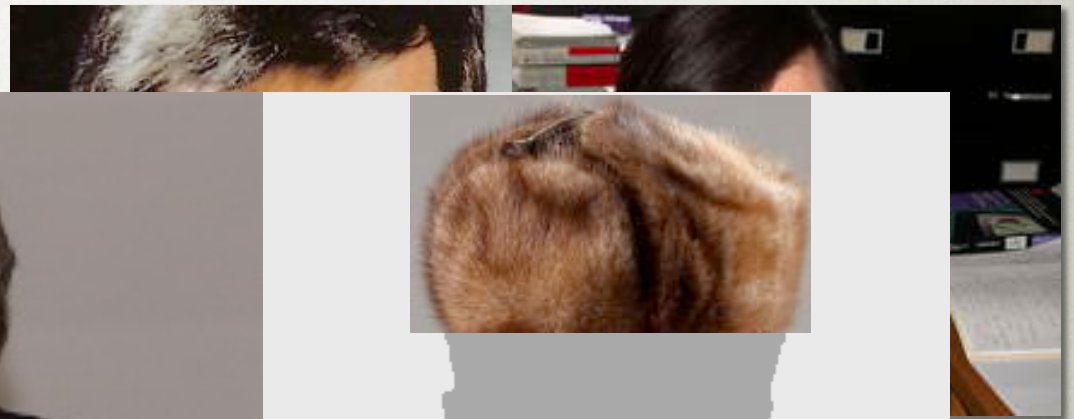
pink noise



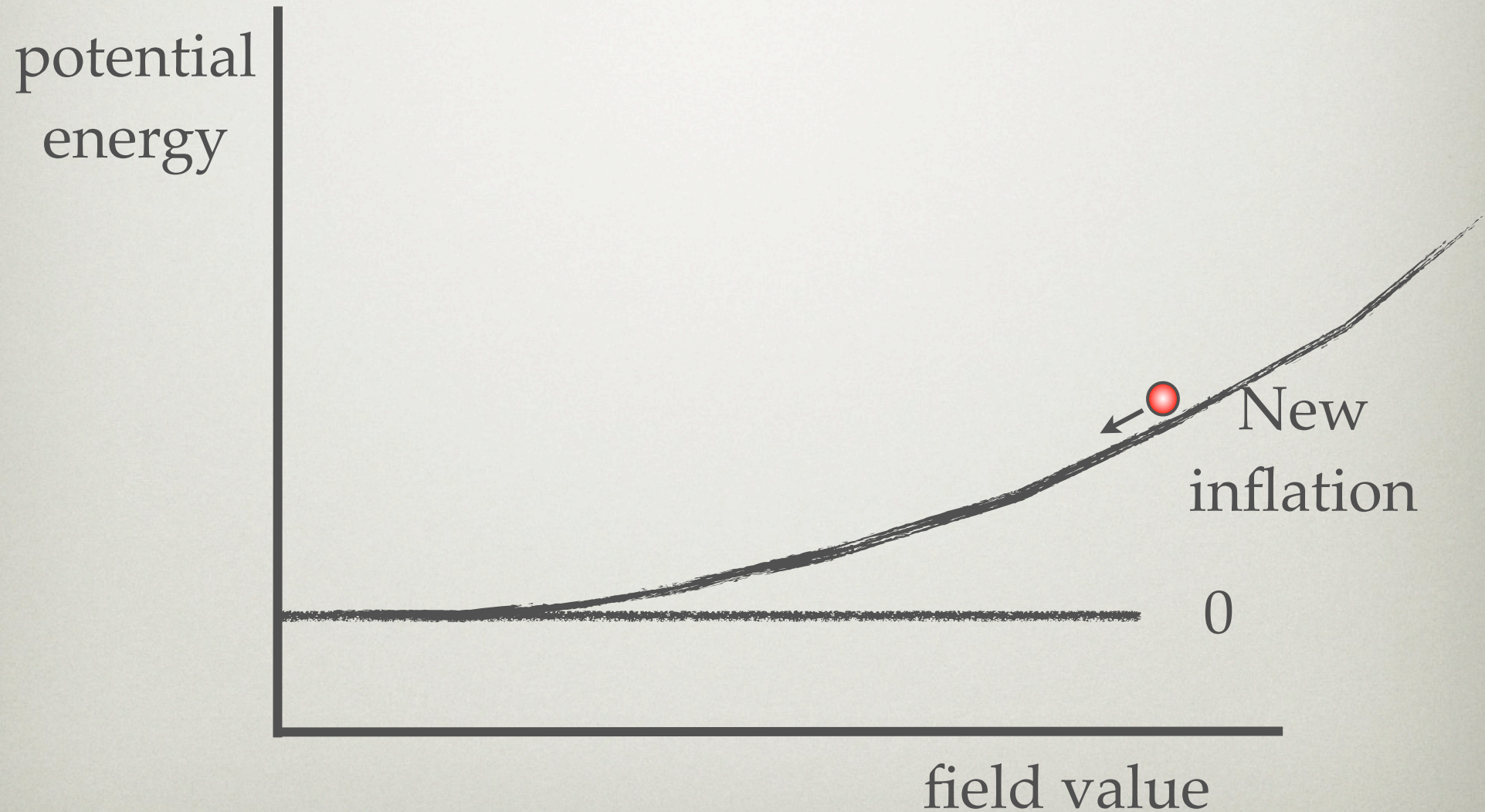
1982 NUFFIELD WORKSHOP



1982 NUFFIELD WORKSHOP

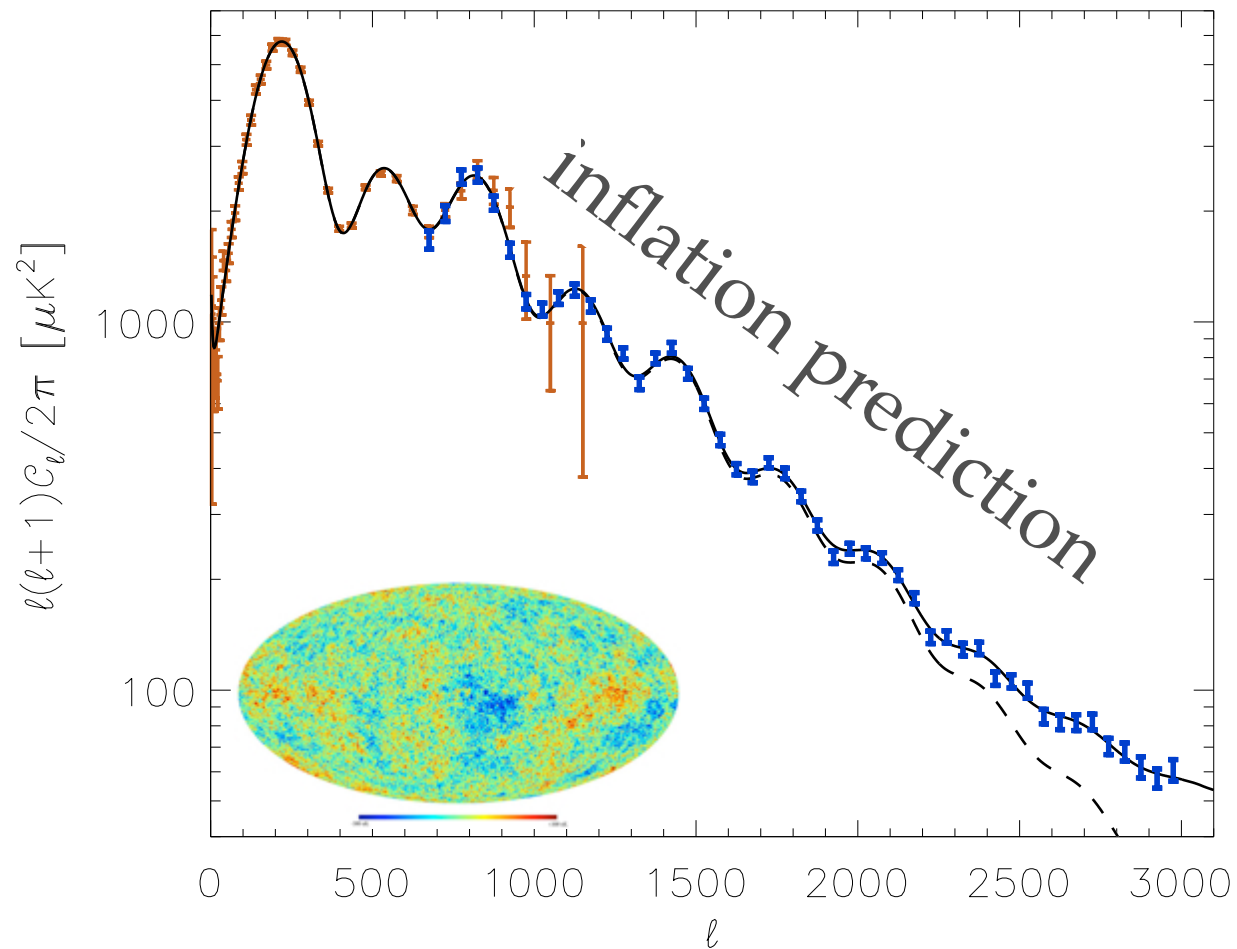


NEW INFLATION THEORY SAYS: ALMOST WHITE NOISE, JUST A BIT PINK



THE PATTERN IN THE CMB

almost white noise, just a bit pink



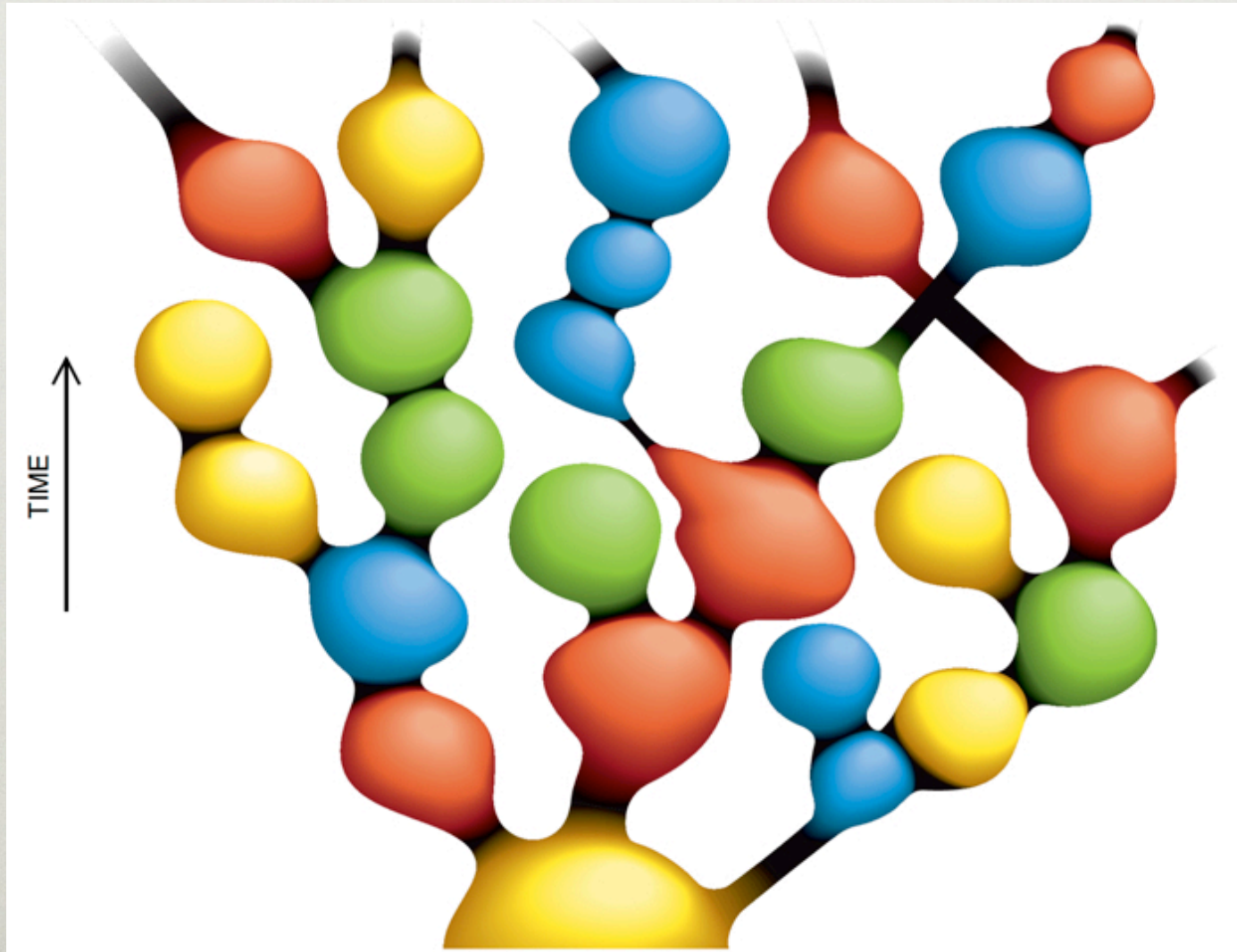
~2001

CONTROVERSY

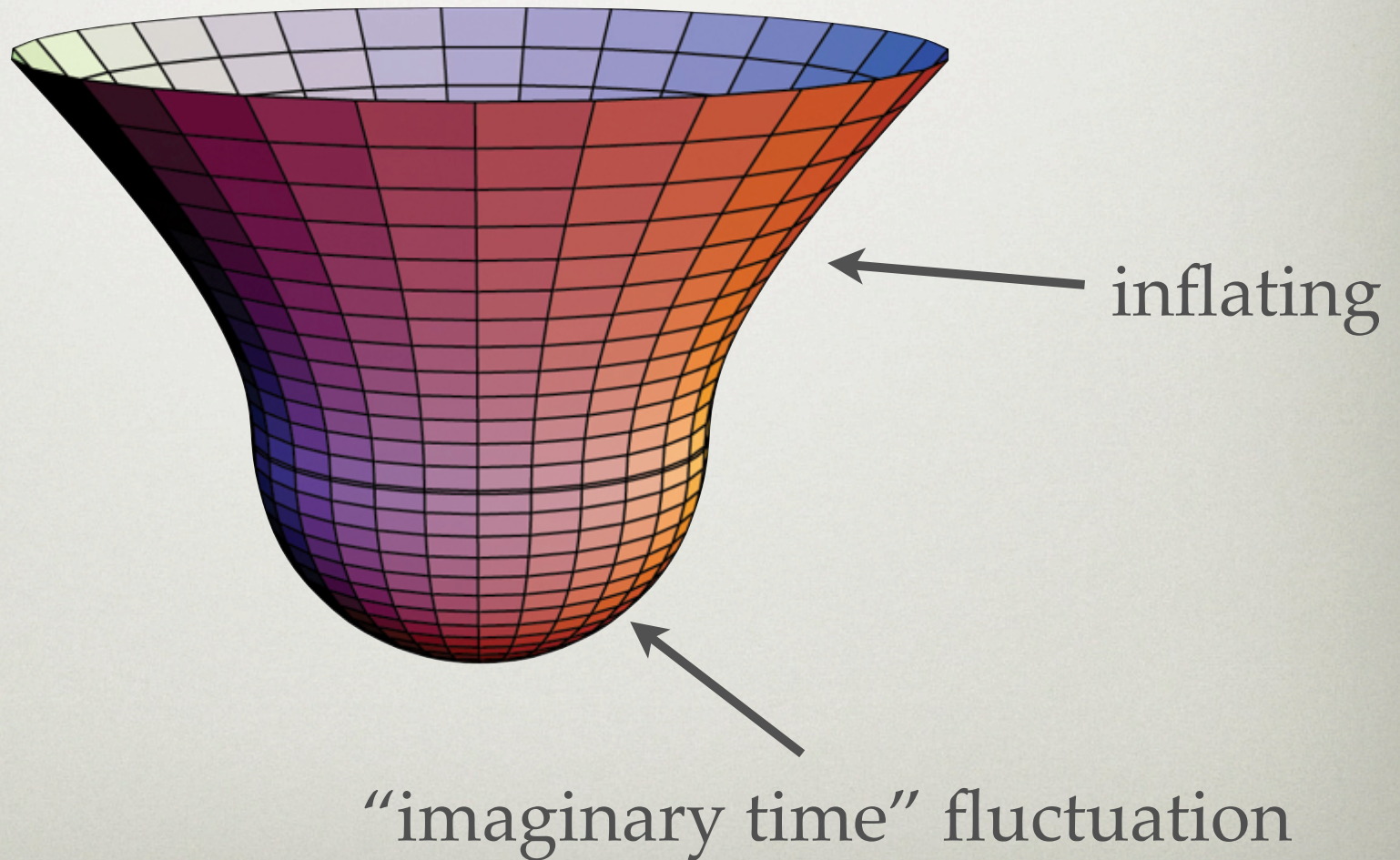
INITIAL CONDITIONS?



MANY UNIVERSES AND AN INFINITE PAST?

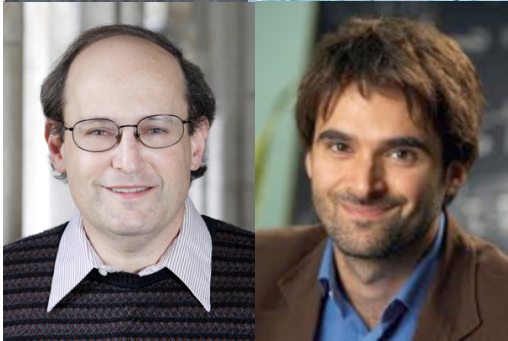


HARTLE-HAWKING UNIVERSE

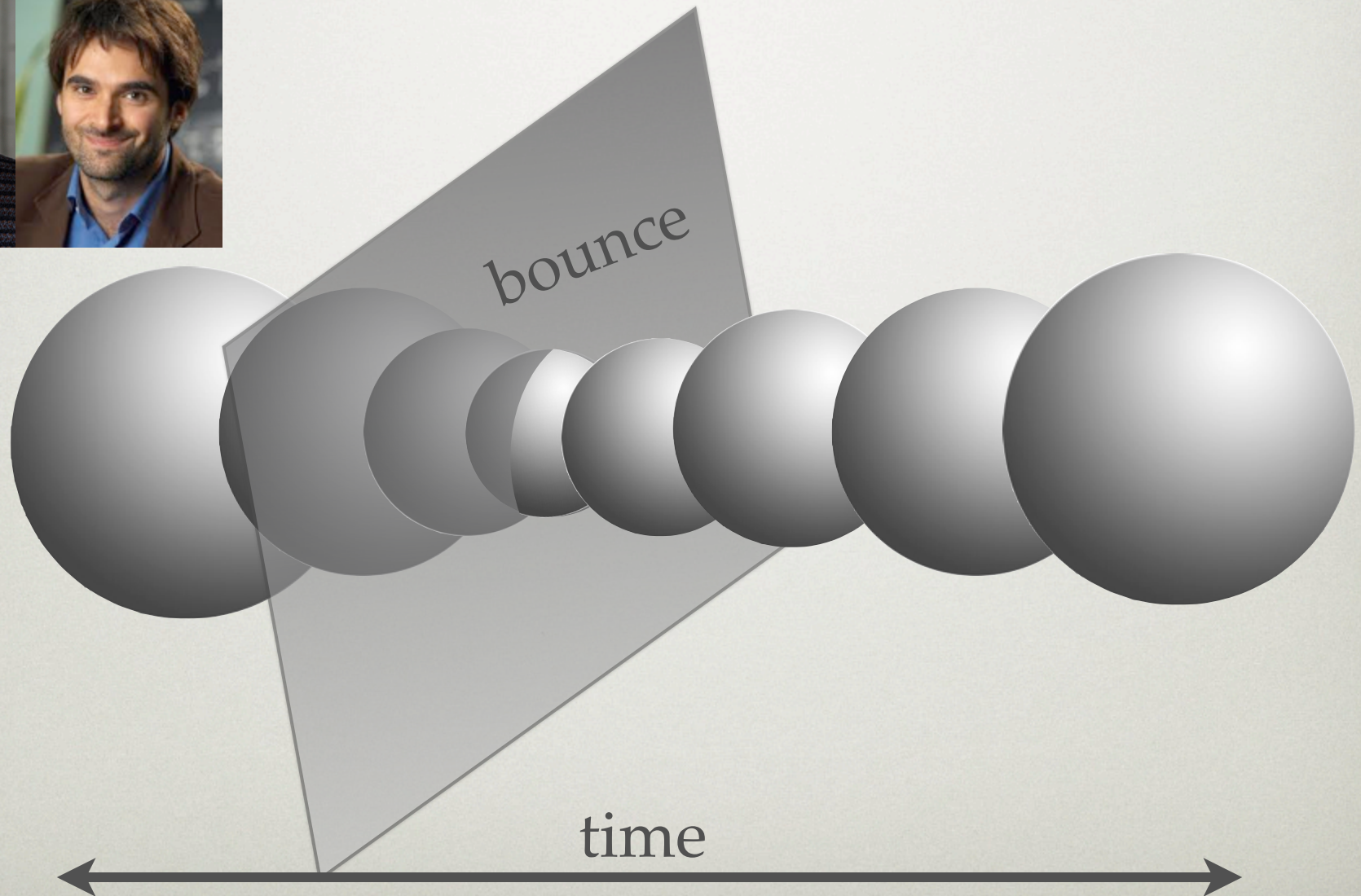


?

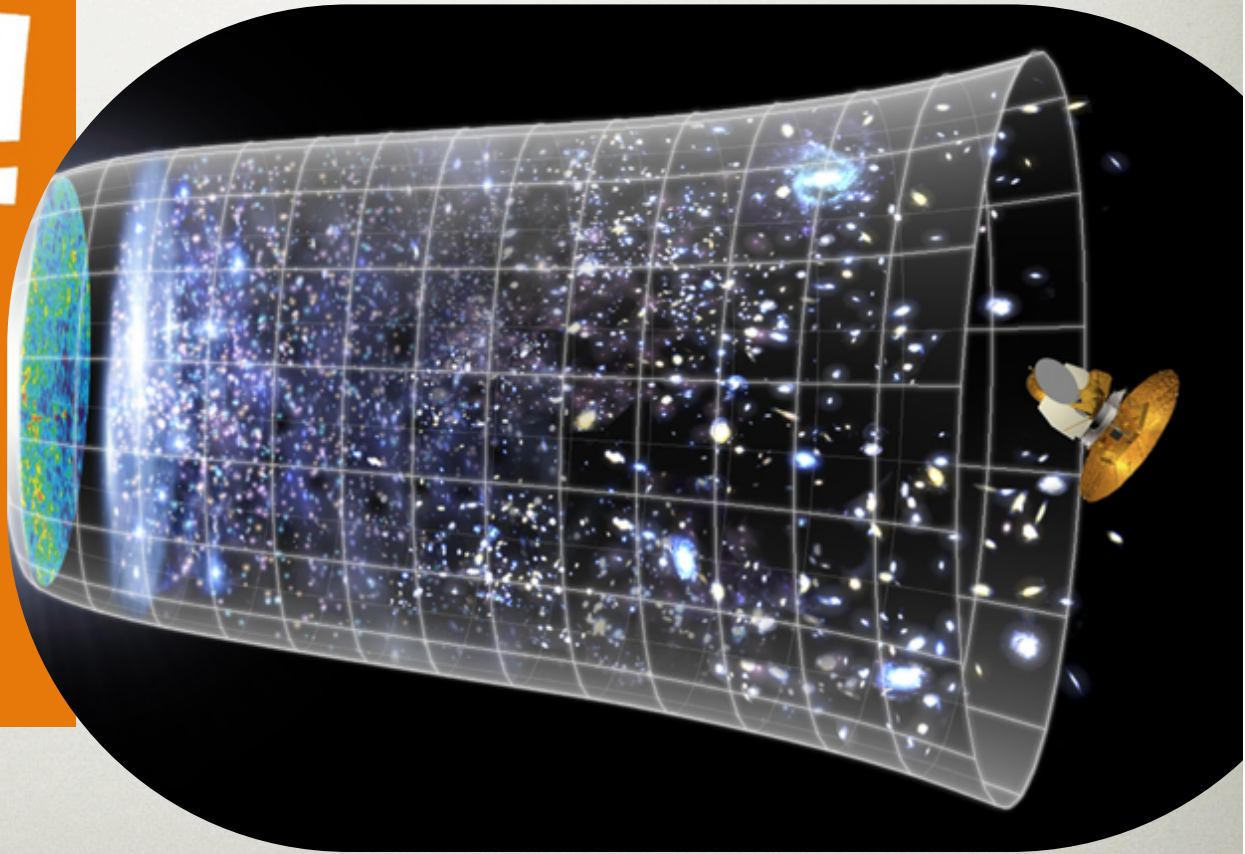
ALTERNATIVES?



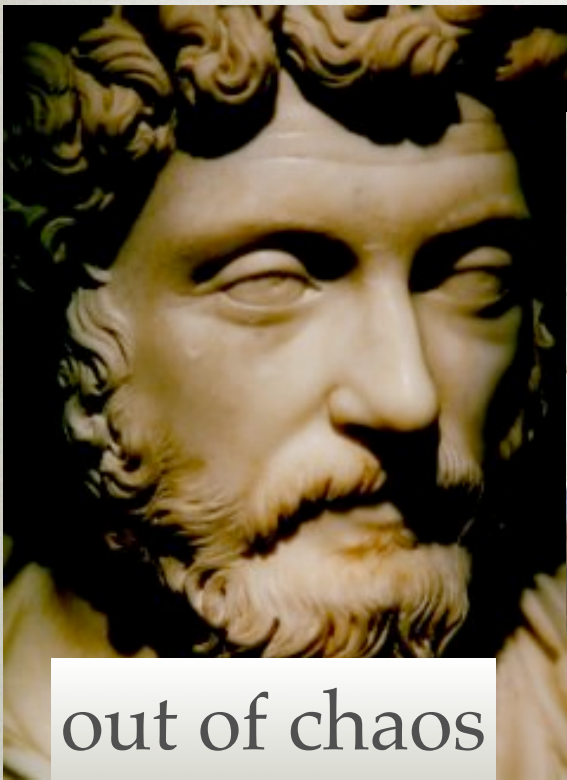
CYCLIC CONTRACTION



NO INFLATION?



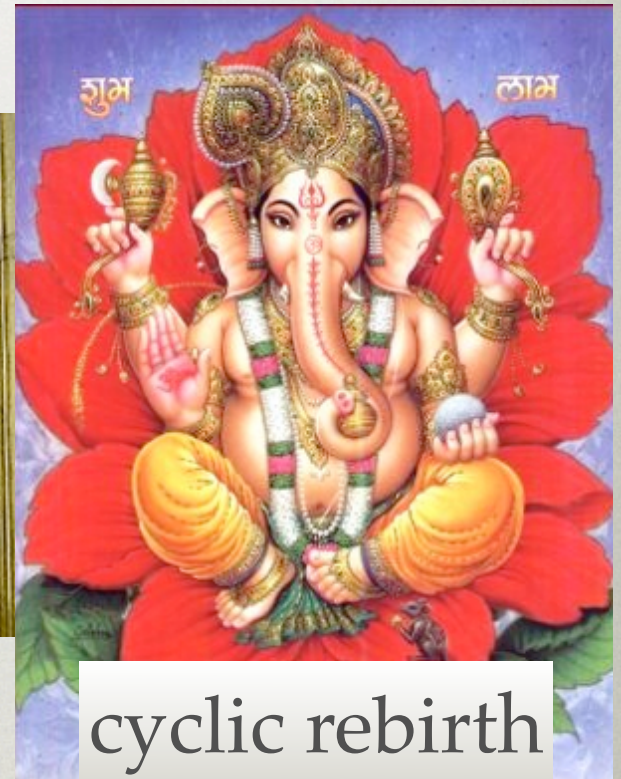
NOTHING NEW UNDER THE SUN?



out of chaos



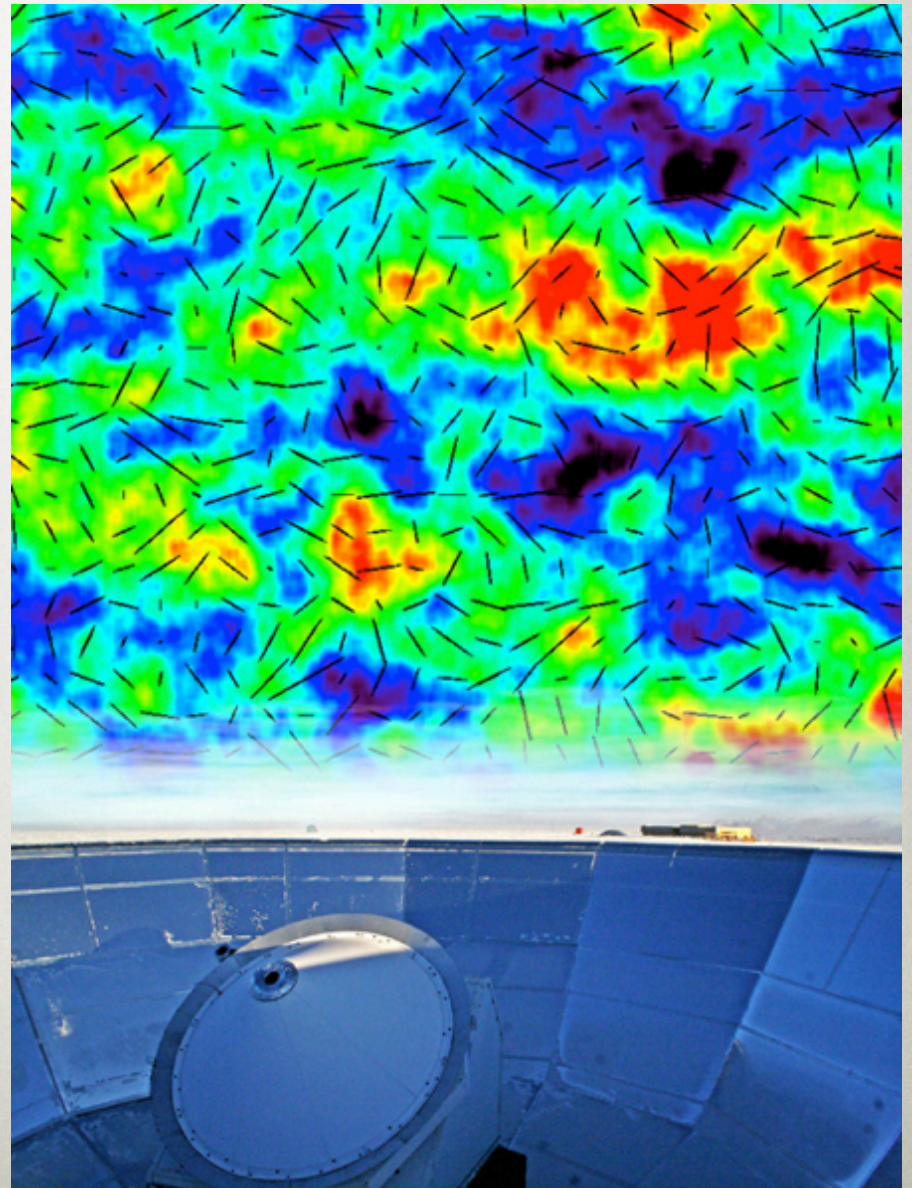
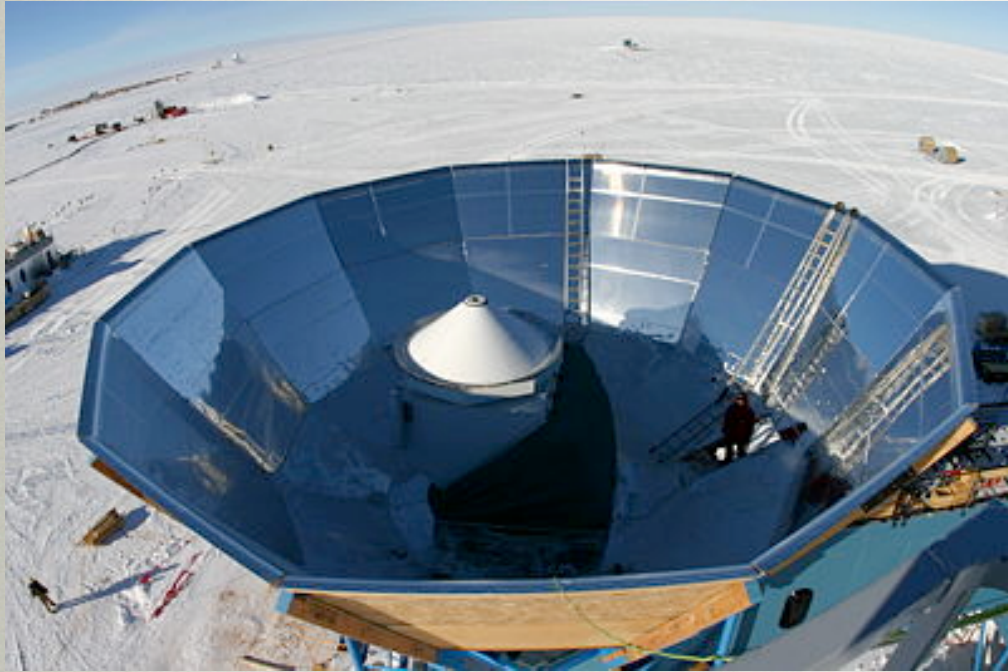
out of nothing



cyclic rebirth

HOW OBSERVATIONS
(MIGHT)
SAVE THE DAY

INFLATION MAY MAKE OBSERVABLE GRAVITATIONAL WAVES



ANOTHER “UNIVERSE” MIGHT BUMP INTO OURS!

