Title: Battle of the Big Bang: The New Tales of Our Cosmic Origins

Speakers: Niayesh Afshordi

Collection/Series: Public Lecture Series

Date: June 04, 2025 - 7:00 PM

URL: https://pirsa.org/25060061

Abstract:

Title
Battle of the Big Bang: The New Tales of Our Cosmic Origins
Abstract
The story of the universe’s origins is one of the greatest mysteries in science. From the explosive birth of the cosmos to the enigmatic nature of time and space, we are continually challenged by paradoxes that defy current understanding. In this public talk, we shall explore the triumphs and debates that shape modern cosmology, and the novel quests to uncover our cosmic origins. I will also highlight the pioneering contributions of my friend and colleague, Lee Smolin. His groundbreaking ideas on quantum gravity, the nature of time, and cosmological evolution have sparked new directions in the search for a deeper theory of the universe. Together, we will journey through the frontiers of physics, exploring how new theories and astronomical observations might offer clues to the next great paradigm shift. Whether you’re a science enthusiast or just curious about the cosmos, join us for a conversation on the past, present, and future of our understanding of the universe.
About the Speaker

Niayesh Afshordi is a theoretical astrophysicist and professor at the University of Waterloo and Perimeter Institute for Theoretical Physics. His research explores the frontiers of cosmology, gravity, and quantum physics, with a focus on black holes and the origins of the universe. He is the co-author of the forthcoming popular science book Battle of the Big Bang: The New Tales of Our Cosmic Origins (University of Chicago Press, 2025), which reexamines the history and future of the cosmos through the lens of cutting-edge theory and observation.

Battle of the Big Bang

The New Tales of Our Cosmic Origins

Niayesh Afshordi

UNIVERSITY OF WATERLOO

WATERLOO CENTRE FOR ASTROPHYSICS

PERIMETER INSTITUTE FOR THEORETICAL PHYSICS

What is the oldest thing you can remember?

From: phillip halper <skydancephil@hotmail.co.uk>
Sent: 11 June 2018 15:08
To: nafshordi@perimeterinstitute.ca
Subject: Cosmology film series, VSl, interview request.

HI Dr Ashfordi

I am the producer of a series of educational not for profit films made for youtube exploring competing models of the early universe.

All Shorts Videos Unwatched Watched Recently uploaded Live Playlists Filters

Before the Big Bang 8: Varying Speed Of Light Cosmology (VSL)

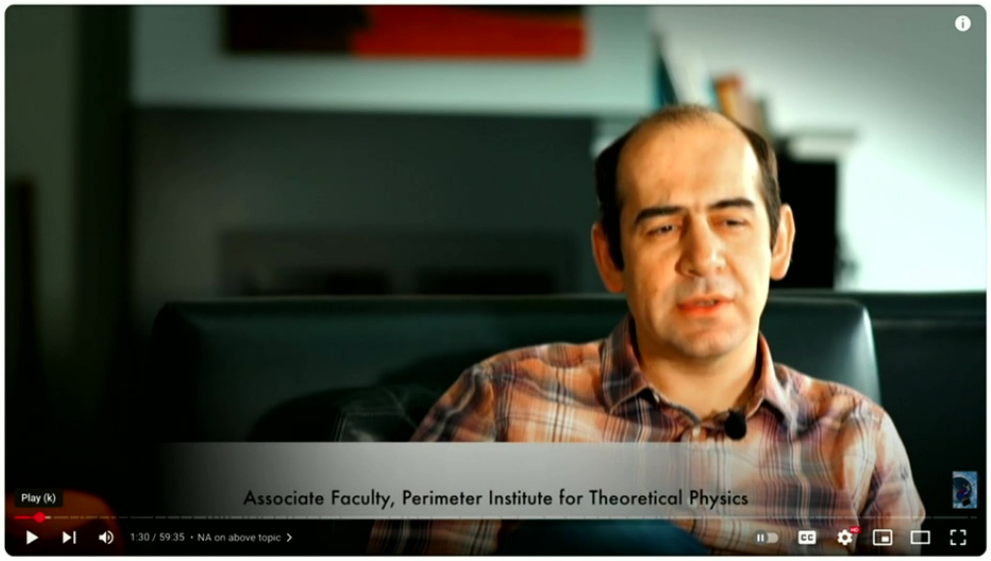
253K views • 6 years ago

Phil Halper (aka Skydivephil)

Cosmologists challenging the foundations of physics are featured in this documentary on **VSL**. Variable Speed of Light (aka ...

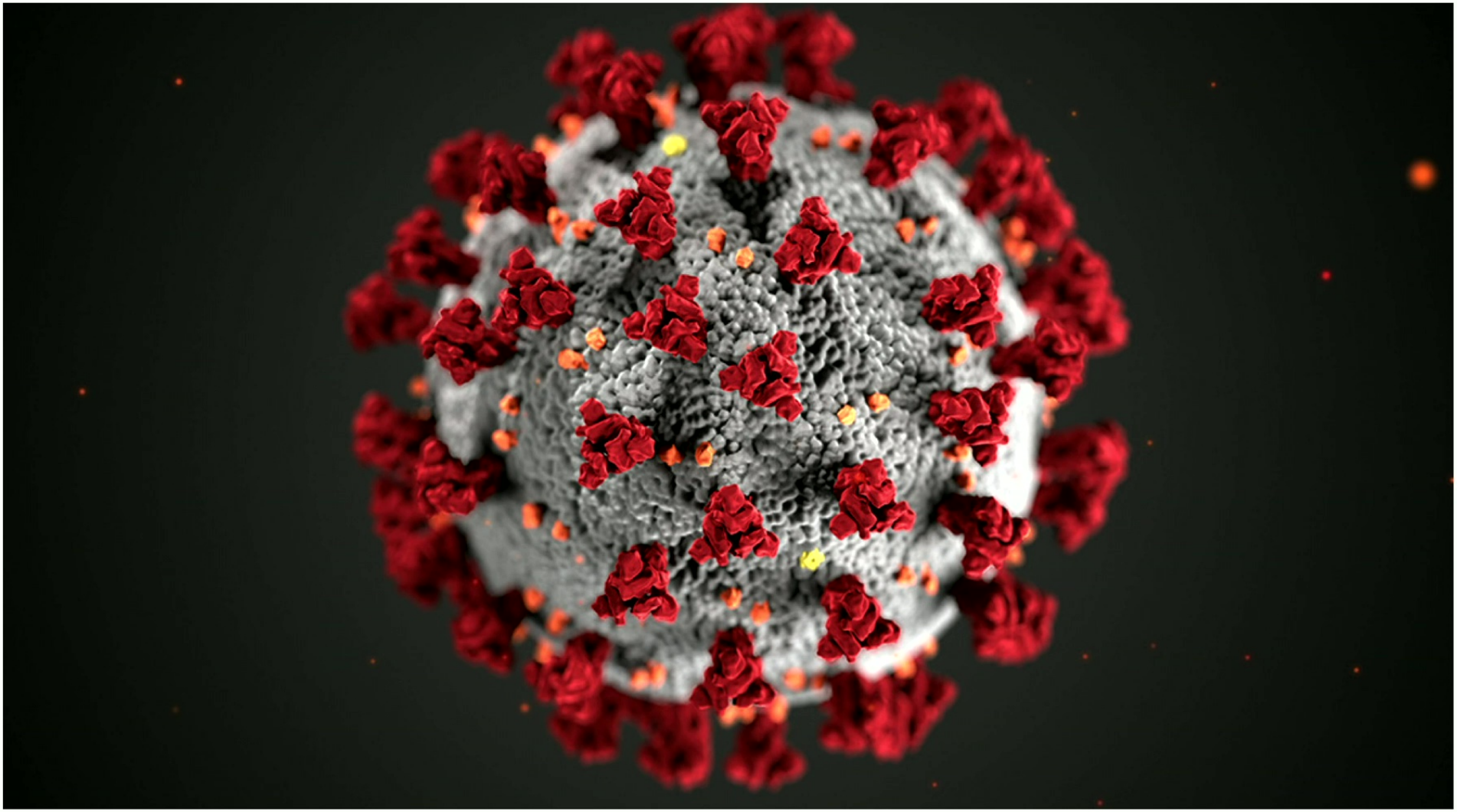
CC

68 chapters INTRODUCTION | SA on his introduction to physics | NA on above topic | JM on above topic | JohnM o...

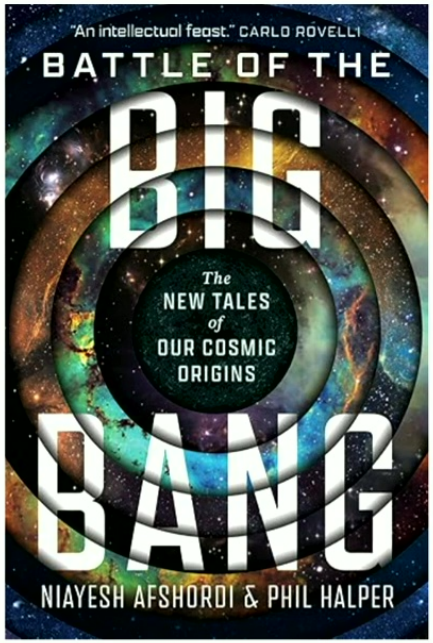


Before the Big Bang 8: Varying Speed Of Light Cosmology (VSL)

Phil Halper (aka Skydivephil) 69.9K subscribers Subscribe Screenshot 2.5K Share Download Clip Save



Books › Science & Math › Astronomy & Space Science › Astrophysics & Space Science



Read sample

Battle of the Big Bang: The New Tales of Our Cosmic Origins First Edition

by Niayesh Afshordi (Author), Phil Halper (Author)

4.4 ★★★★½ 3 ratings

#1 New Release in Cosmology

See all formats and editions

A thrilling exploration of competing cosmological origin stories, comparing new scientific ideas that upend our very notions of space, time, and reality.

By most popular accounts, the universe started with a bang some 13.8 billion years ago. But what happened before the Big Bang? And how do we know it happened at all? Here prominent cosmologist Niayesh Afshordi and science communicator Phil Halper offer a tour of the peculiar possibilities: bouncing and cyclic universes, time loops, creations from nothing, multiverses, black hole births, string theories, and holograms. Along the way, they offer both a call for new physics and a riveting story of scientific debate.

Incorporating insights from Afshordi's cutting-edge research and Halper's original interviews with scientists like Stephen Hawking, Roger Penrose, and Alan Guth, *Battle of the Big Bang* compares these models for the origin of our origins, showing each theory's strengths and weaknesses and explaining new attempts to test these notions. *Battle of the Big Bang* is a tale of rivalries and intrigue, of clashes of ideas that have raged from Greek antiquity to the present day over whether the

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ISBN-10	ISBN-13	Edition	Publisher	Publication date
0226830470	978-0226830476	First Edition	University of Chicago Press	May 29, 2025

Screenshot

Ghosts of the Battlefield

Books › Professional & Technical › Professional Science › Astronomy › Astrophysics & Space Science

Untitled on the big bang: [was What Banged?] Hardcover – Oct. 7 2025

by Niyayesh Afshordi (Author), Phillip Halper (Author)

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432 pages	English	Basic Books	Oct. 7 2025	1541600959

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We arrived in Waterloo 18 years ago

University of Waterloo

Daily Bulletin

Tuesday, May 22, 2007

Friday • Archive
About the Daily Bulletin
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RSS version
UW Opinion

- **World's most 'intelligent' community**
- **Universities welcome science strategy**
- **Workload, wine, and other wisdom**

Editor:
Chris Redmond
Communications and Public Affairs
credmond@uwaterloo.ca

World's most 'intelligent' community

Waterloo was named the world's top "intelligent community" for 2007 on Friday, beating out six other finalists as the award was presented in New York by the Intelligent Community Forum.

Mayor Brenda Halloran was at the centre of a Waterloo delegation that accepted the honour and gave credit to UW along with local high-tech business, other organizations, city staff and citizens at large.

Link of the day

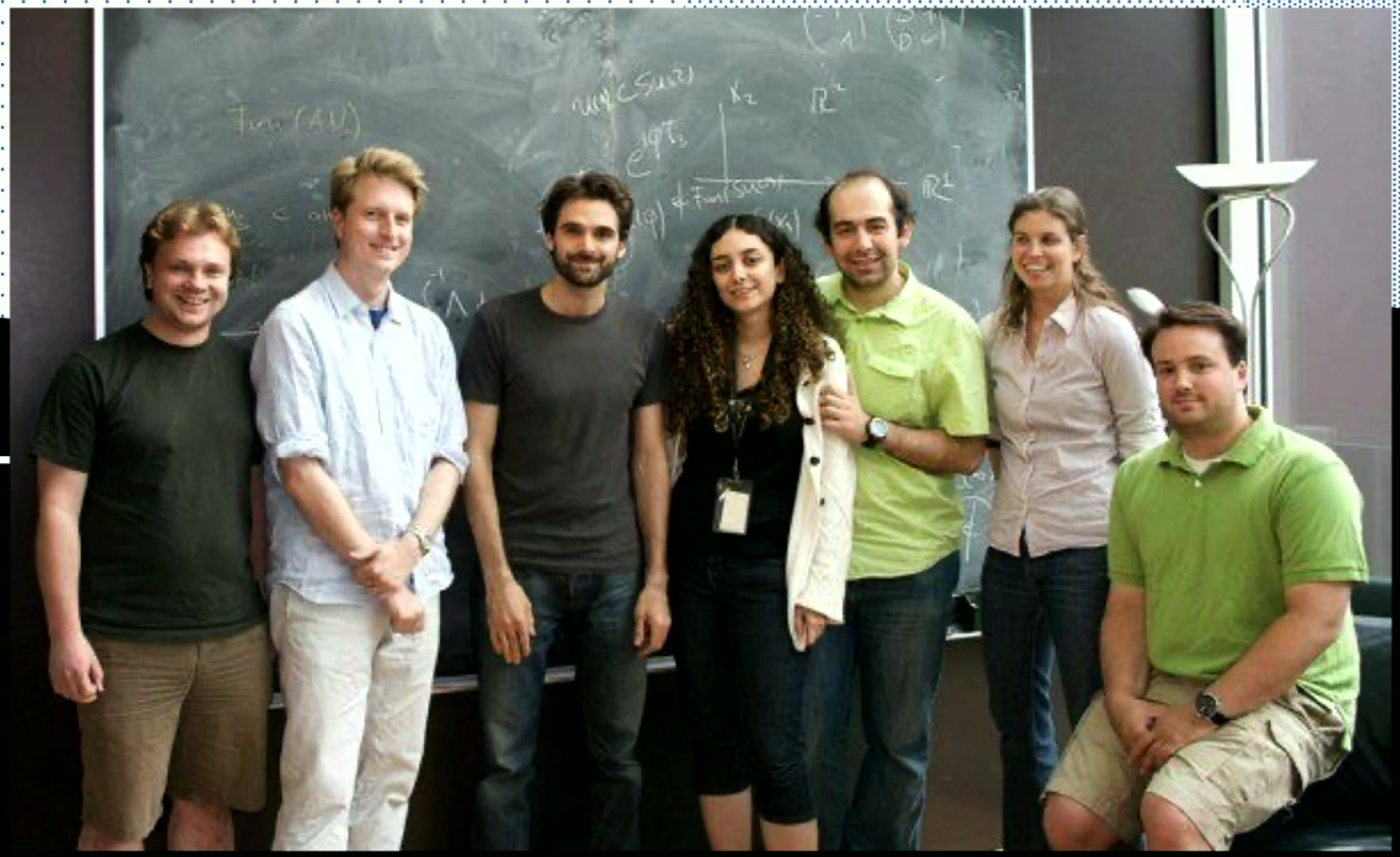
Laurence Olivier at 100

When and where

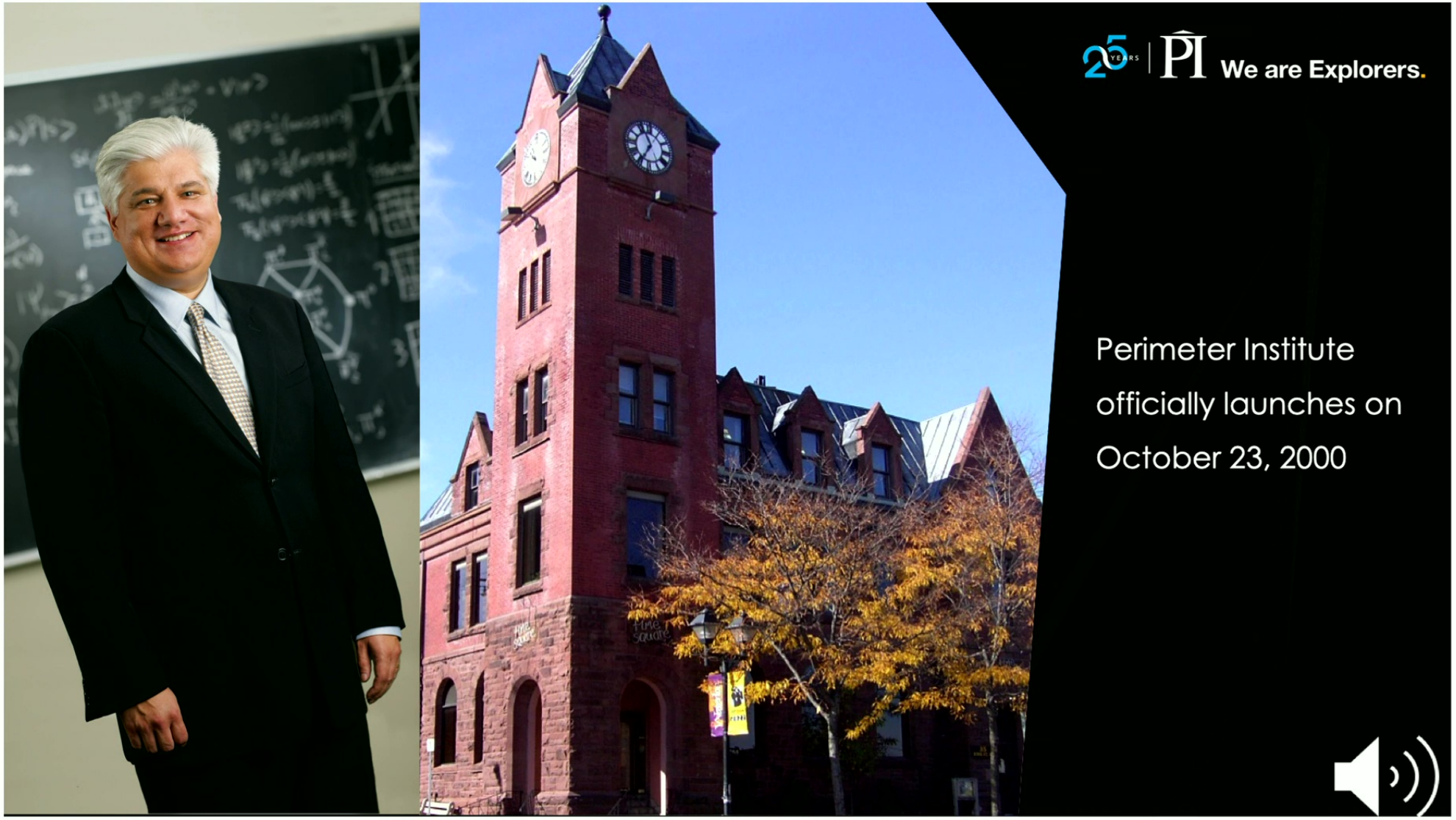
MBET (Master of Business, Entrepreneurship and Technology) information session 4 p.m., Accelerator Centre room 240, reservations ext. 3-7167.

UW senate monthly meeting 4:30, Needles Hall room 3001.

Centre Stage Dance performances Tuesday, Wednesday and Thursday



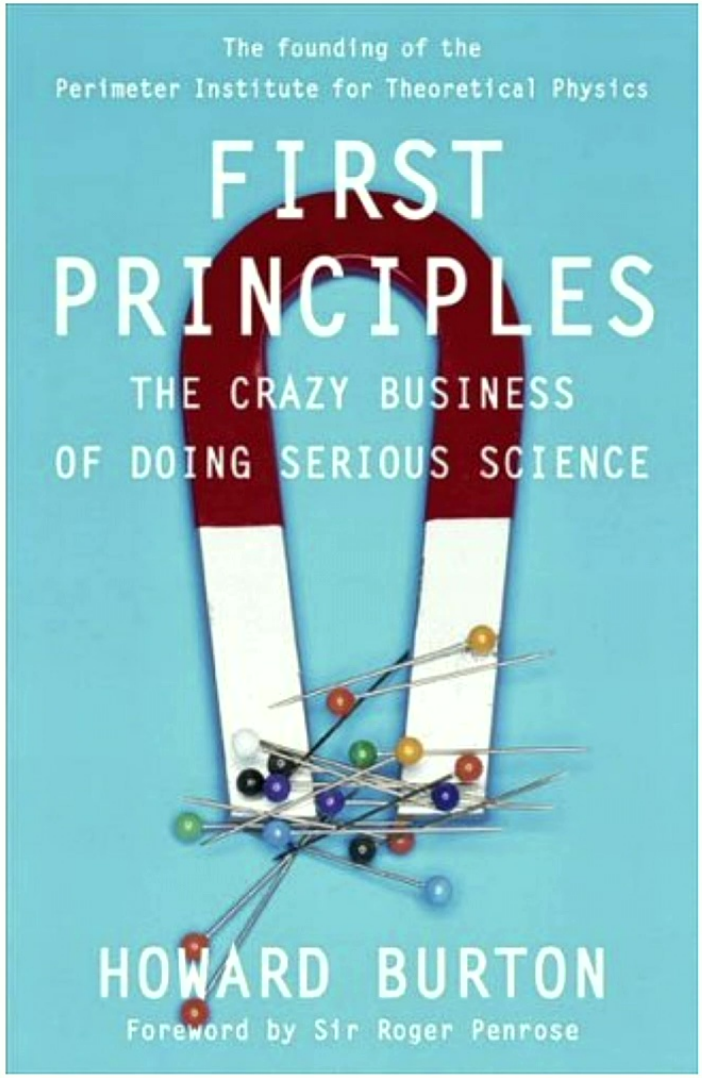
Cosmology group, circa 2009

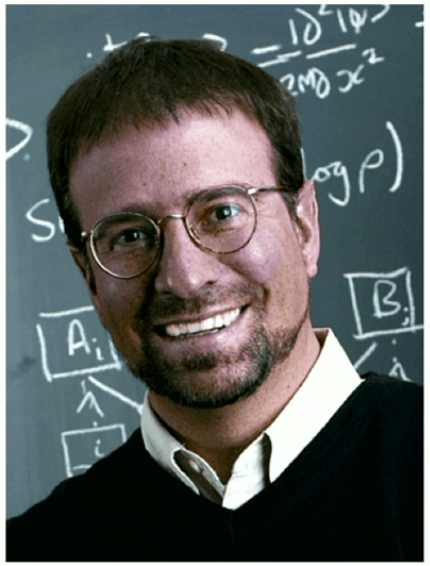

We are Explorers.
Perimeter Institute
officially launches on
October 23, 2000

2001 / First research group

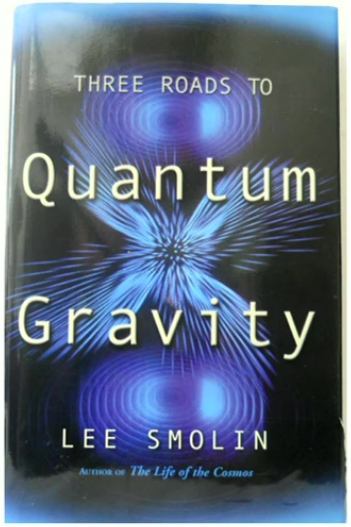
25 YEARS | PI We are Explorers.

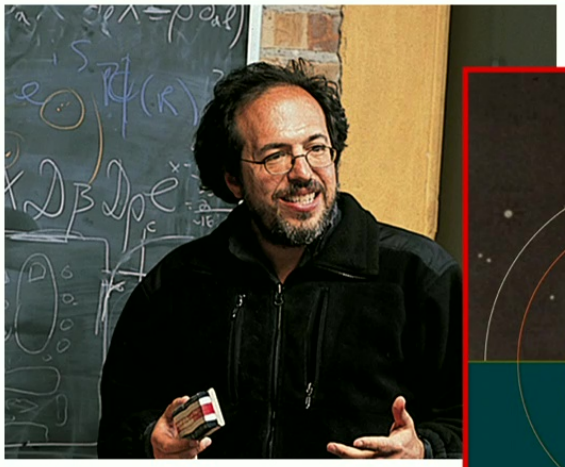
Perimeter Institute officially launches on October 23, 2000

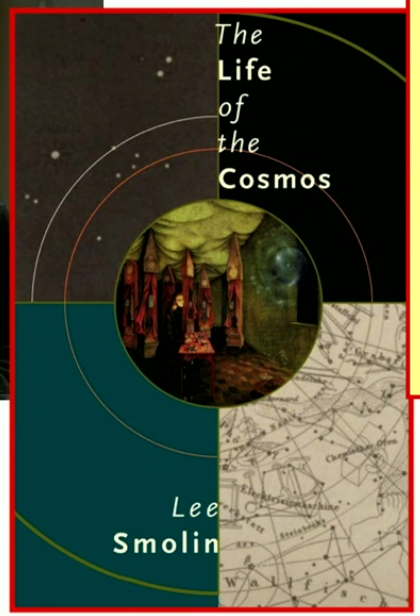

The founding of the
Perimeter Institute for Theoretical Physics
FIRST
PRINCIPLES
THE CRAZY BUSINESS
OF DOING SERIOUS SCIENCE
HOWARD BURTON
Foreword by Sir Roger Penrose

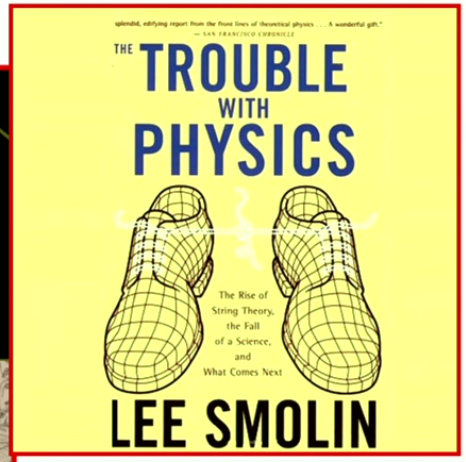



LEE'S FEST: QUANTUM GRAVITY
AND THE NATURE OF TIME
25 YEARS
PERIMETER INSTITUTE
JUNE 2-6, 2025

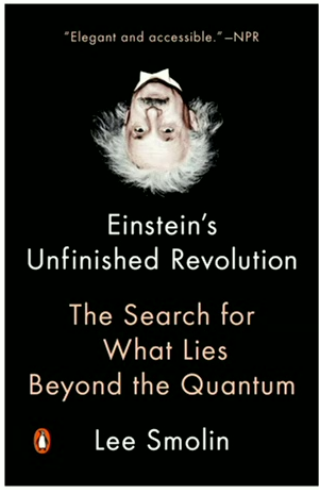

THREE ROADS TO
Quantum
Gravity
LEE SMOLIN
Author of The Life of the Cosmos




The
Life
of
the
Cosmos
Lee
Smolin

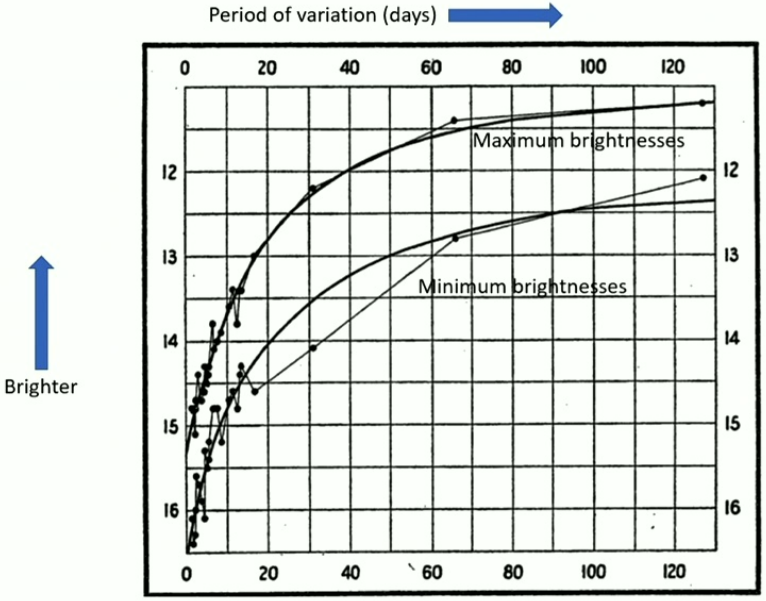

THE TROUBLE WITH PHYSICS
The Rise of String Theory, the Fall of a Science, and What Comes Next
LEE SMOLIN

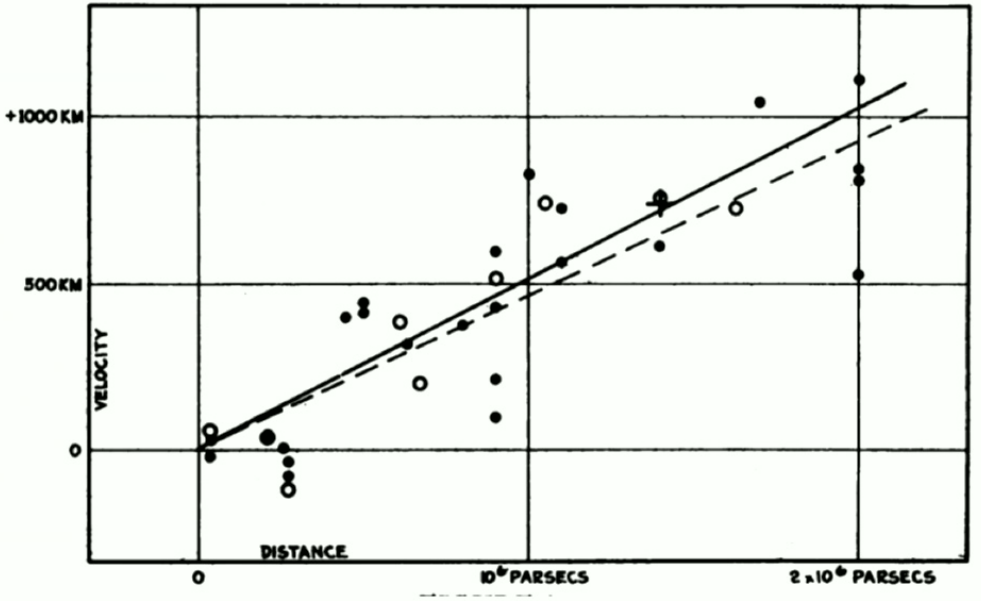

Lee
Smolin
TIME
REBORN


"Elegant and accessible." —NPR
Einstein's
Unfinished Revolution
The Search for
What Lies
Beyond the Quantum
Lee Smolin

What is the oldest thing you can remember?

- In 1920's, Edwin Hubble uses the discovery of brightness-period relationship by Henrietta Swan Leavitt for variable stars to measure distances to galaxies.
- He discovers the farther a galaxy, the faster it is moving away → **cosmos expands!**





Steady State vs. Big Bang

- **Steady State:** Dilution of matter by cosmic expansion is compensated by constant creation of matter
- **“Big Bang”/Primeval atom:** Universe was denser/ hotter in the past, possibly starting from a “single quantum”

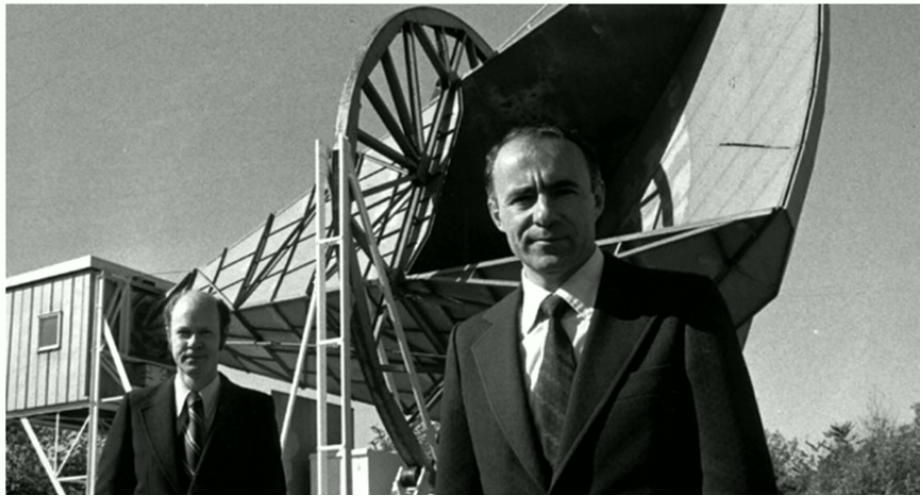
Sir Fred Hoyle

Georges Lemaître

Cosmic Microwave Background (CMB)

Afterglow of the Big Bang

- A hotter, denser universe, would emit light, like the Sun
- Radiation cooled down by cosmic expansion
- 1965: Penzias & Wilson @Bell labs, NJ discover a uniform cosmic microwave background at 2.7 K =-270 °C
-



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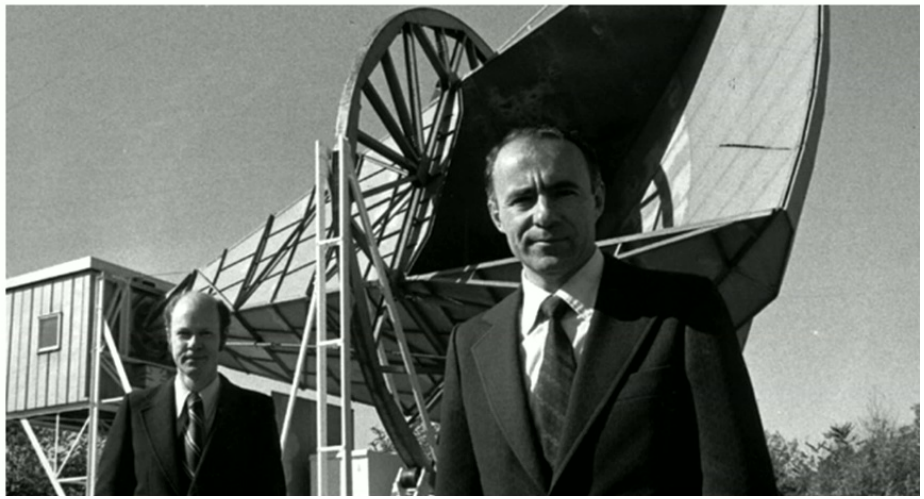
1978



In fact, CMB was discovered by a Canadian, 25 years earlier!

1940PASP...52..187M

EVIDENCE FOR THE MOLECULAR ORIGIN OF SOME HITHERTO UNIDENTIFIED INTERSTELLAR LINES

By Andrew McKellar

$$I = cie^{-\frac{E_r}{kT}}$$

where c is a constant, i the intensity factor, E_r the rotational energy, k the Boltzmann constant, and T the absolute temperature, it is found that if $R(1)$ is not more than one-third, one-fifth, or one-twentieth as intense as $R(0)$, the maximum "effective" temperature of interstellar space would be $2.7° K$, $2.1° K$, and $0.8° K$, respectively.

Dominion Astrophysical Observatory
Victoria, B.C.
April 18, 1940

Andrew McKellar
(1910-1960)

THE ASTROPHYSICAL JOURNAL, 410:437–457, 1993 June 20

A QUASI-STEADY STATE COSMOLOGICAL MODEL WITH CREATION OF MATTER

F. HOYLE
102 Admirals Walk, Bournemouth BH2 5HF, Dorset, England
G. BURBIDGE
Center for Astrophysics and Space Sciences and Department of Physics, University of California, San Diego, La Jolla, CA 92093-0111
AND
J. V. NARLIKAR
Inter-University Centre for Astronomy and Astrophysics, Post Bag 4, Ganeshkhind, Pune 411 007, India
Received 1992 August 5; accepted 1992 December 16

PIRSA:14050034

The Case for an Alternative Cosmology

Cite Share

Jayant Narlikar IUCAA - The Inter-University Centre for Astronomy and Astrophysics

May 06, 2014 Talk number: PIRSA:14050034 DOI: 10.48660/14050034

Jayant V Narlikar (19 July 1938 – 20 May 2025)

THE ASTROPHYSICAL JOURNAL, 410:437–457, 1993 June 20

A QUASI-STEADY STATE COSMOLOGICAL MODEL WITH CREATION OF MATTER

F. HOYLE
102 Admirals Walk, Bournemouth BH2 5HF, Dorset, England
G. BURBIDGE
Center for Astrophysics and Space Sciences and Department of Physics, University of California, San Diego, La Jolla, CA 92093-0111
AND
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Inter-University Centre for Astronomy and Astrophysics, Post Bag 4, Ganeshkhind, Pune 411 007, India
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The Case for an Alternative Cosmology

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Jayant V Narlikar (19 July 1938 – 20 May 2025)

"A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die and a new generation grows up that is familiar with it"

—Max Planck

What's the Big Bang Anyway?

- Imagine everything — stars, planets, you — packed into a hot dense primordial soup!
- Then… **BOOM**! Expansion begins!

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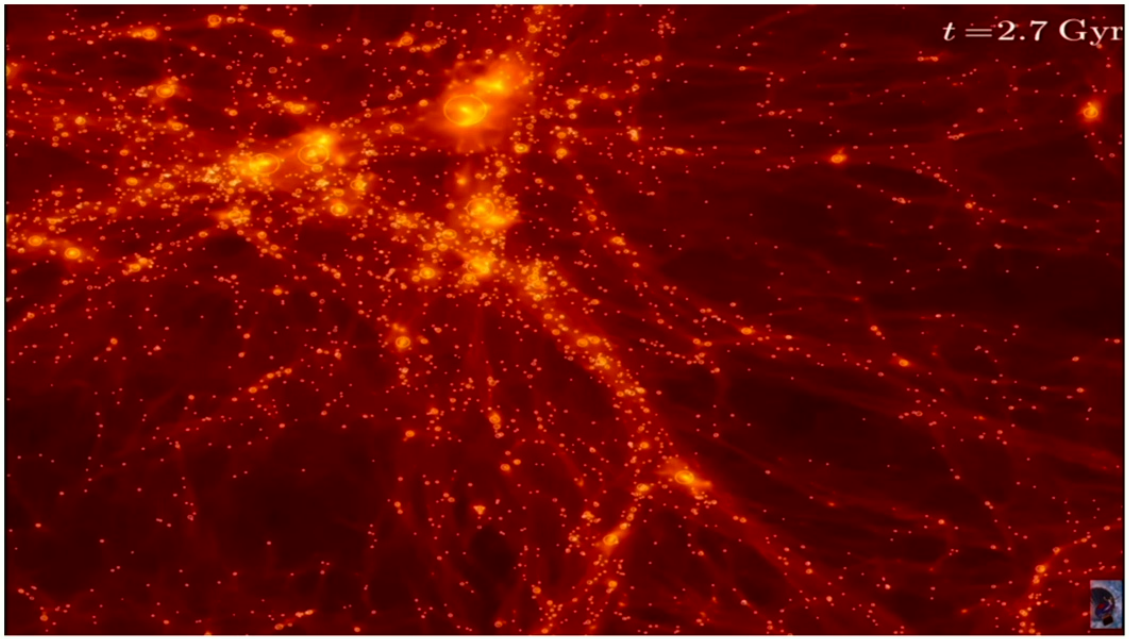
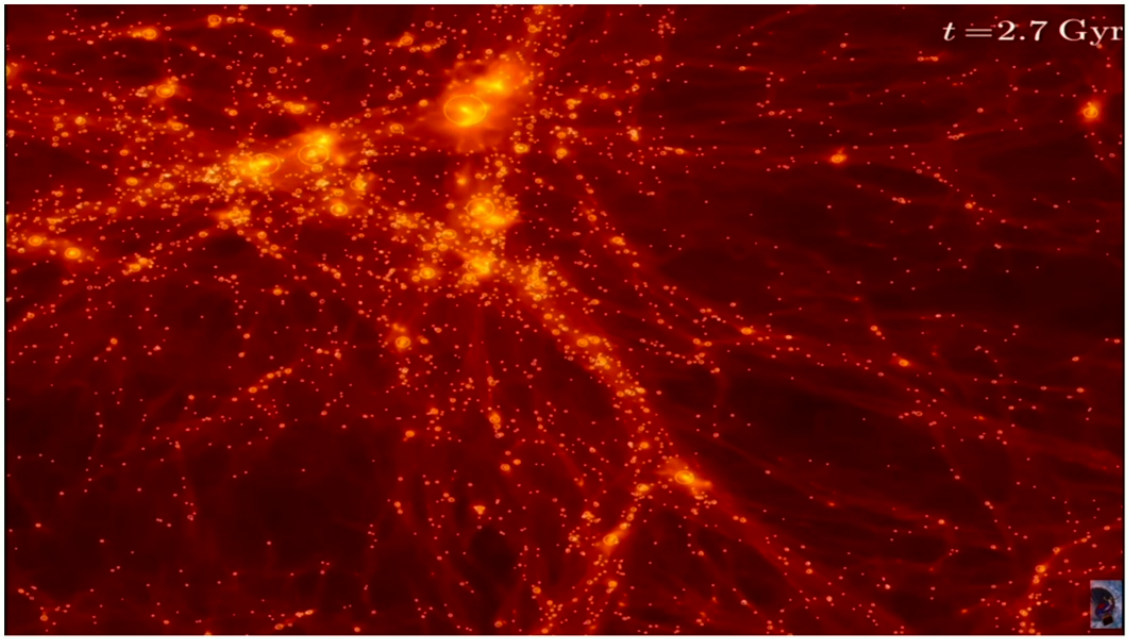
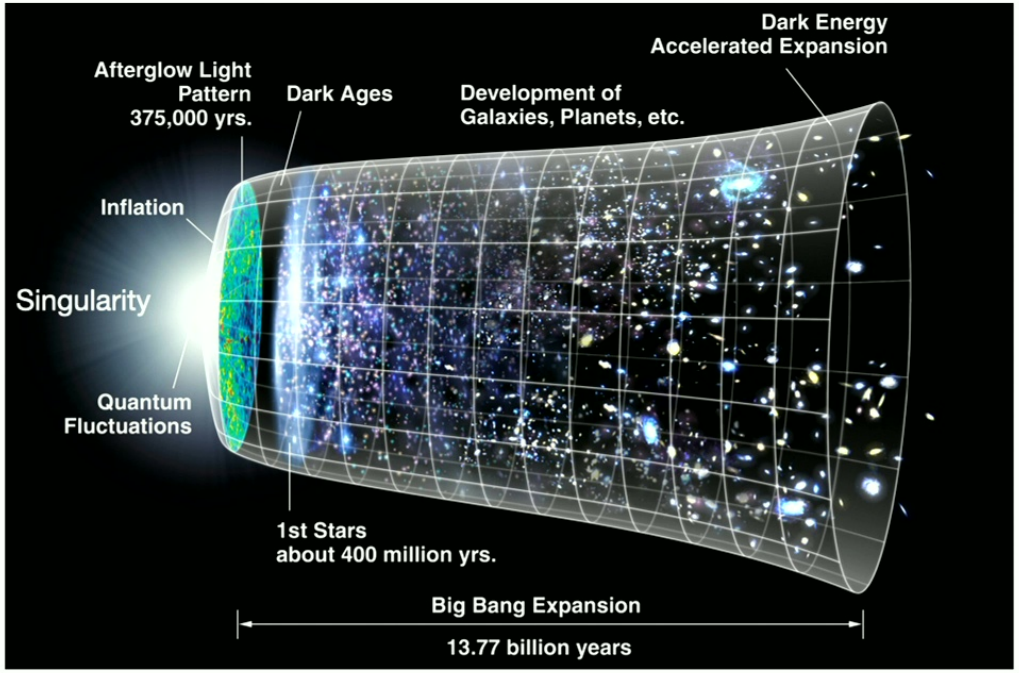


What's the Big Bang Anyway?

- Imagine everything — stars, planets, you — packed into a hot dense primordial soup!
- Then… **BOOM**! Expansion begins!
- The universe grew and cooled, then gravity formed galaxies, stars, and eventually life.
- Big Bang didn't happen at a point in **space**, but rather everywhere at around the same **time**

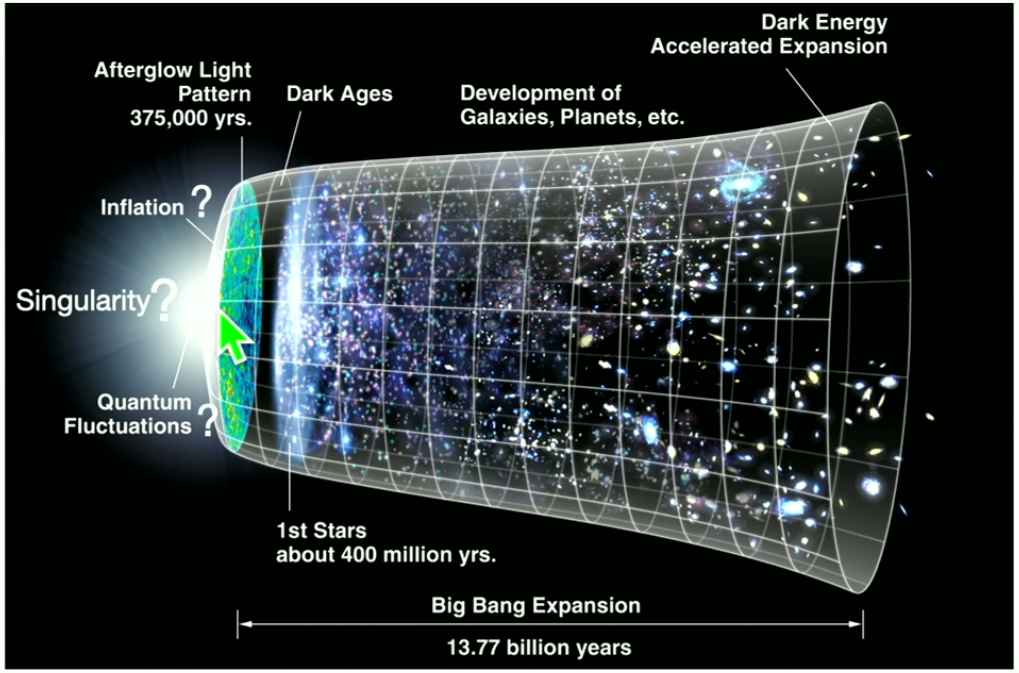


A Universe of Surprises



A Universe of Surprises

- The Big Bang is the story of how our universe began — **but it's NOT the whole story!**
- It tells us the universe started small, hot, and dense about 13.8 billion years ago and has been expanding ever since.
- But **what caused the Big Bang?** And **what happened before it?** That's where the mystery begins!



Penrose-Hawking Singularity Theorems

- We hit an infinity if:

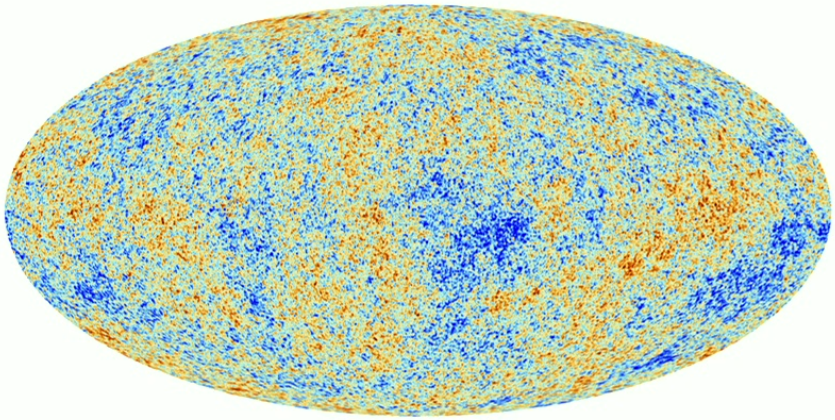
1. Gravity is always attractive.
2. The universe has three space dimensions and one time dimension that we can measure with rulers and clocks.
3. Time travel into the past is impossible.
4. Einstein's theory of general relativity describes the evolution of the universe at all scales.

Cosmologists (including Penrose & Hawking)

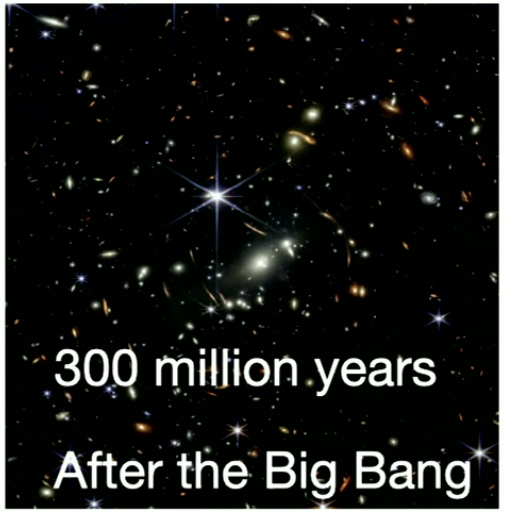
now violate nearly all these assumptions!

Clues from the Past

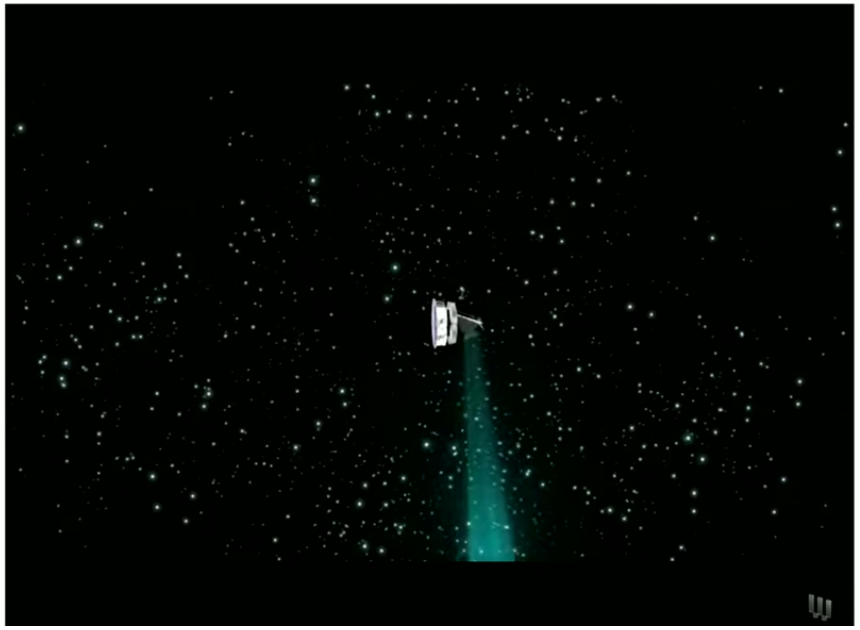
- Scientists use **telescopes** like time machines — looking far away means looking back in time!
- We see galaxies moving away from us — the universe is still expanding!
- We also found the **CMB fluctuations**: ripples in the Big Bang, that seed structure today.



JWST (NASA)

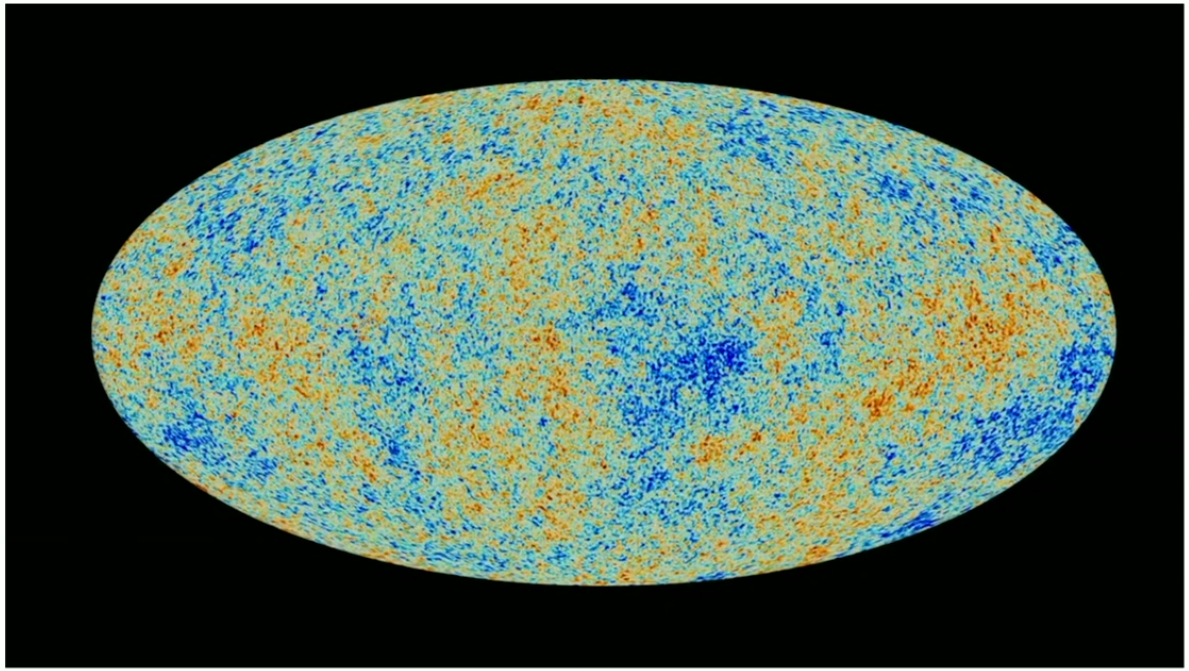


Planck (ESA)



What's the Big Mystery?

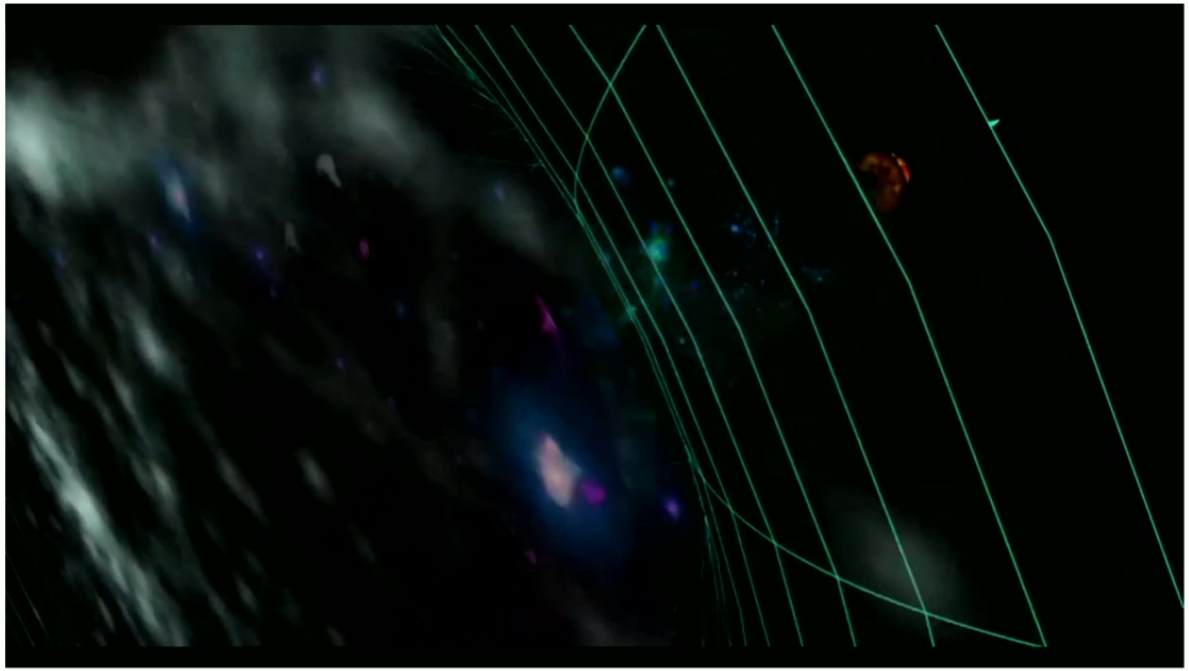
- The Big Bang theory **doesn't** explain:
- **Horizon problem:** What caused the bang to be so uniform?



1 in 100,000 ripples in the CMB temperature

What's the Big Mystery?

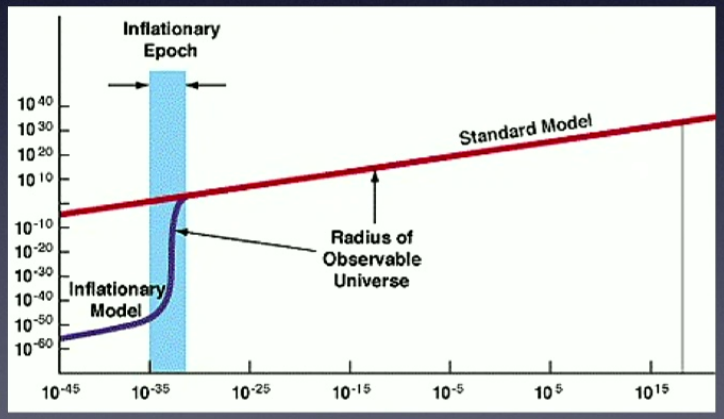
- The Big Bang theory **doesn't** explain:
- **Horizon problem:** What caused the bang to be so uniform?
- What happened **before** the bang?
- Why does the universe have the **shape and laws** it does?



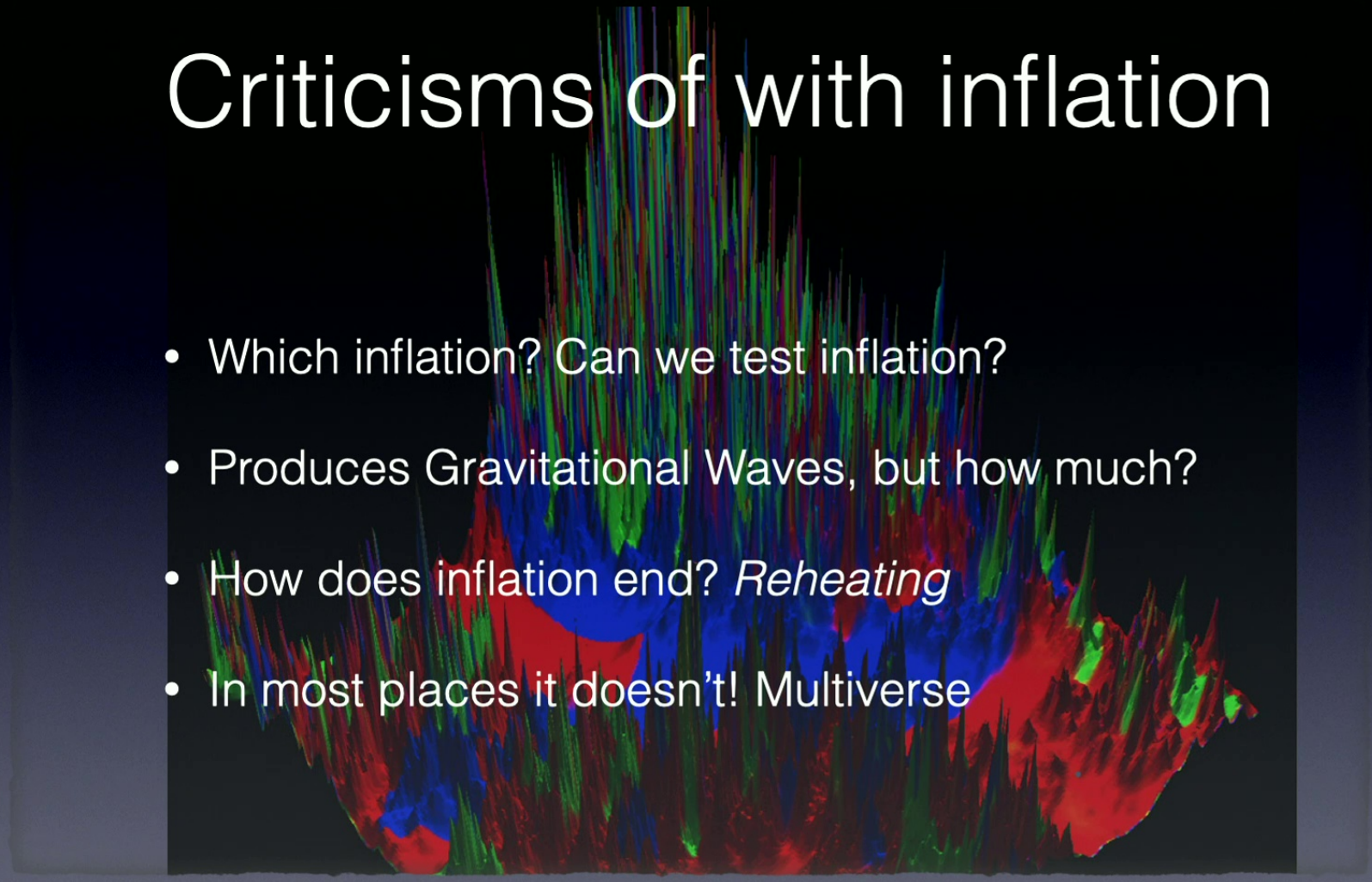
1 in 100,000 ripples in the CMB temperature

Inflation *(Starobinsky, Linde, Guth)*

- A period of exponential expansion can inflate the horizon size ~ e^{H*time}
- 60 e-foldings of inflation solves the horizon problem
- Quantum Fluctuations can seed today's structure

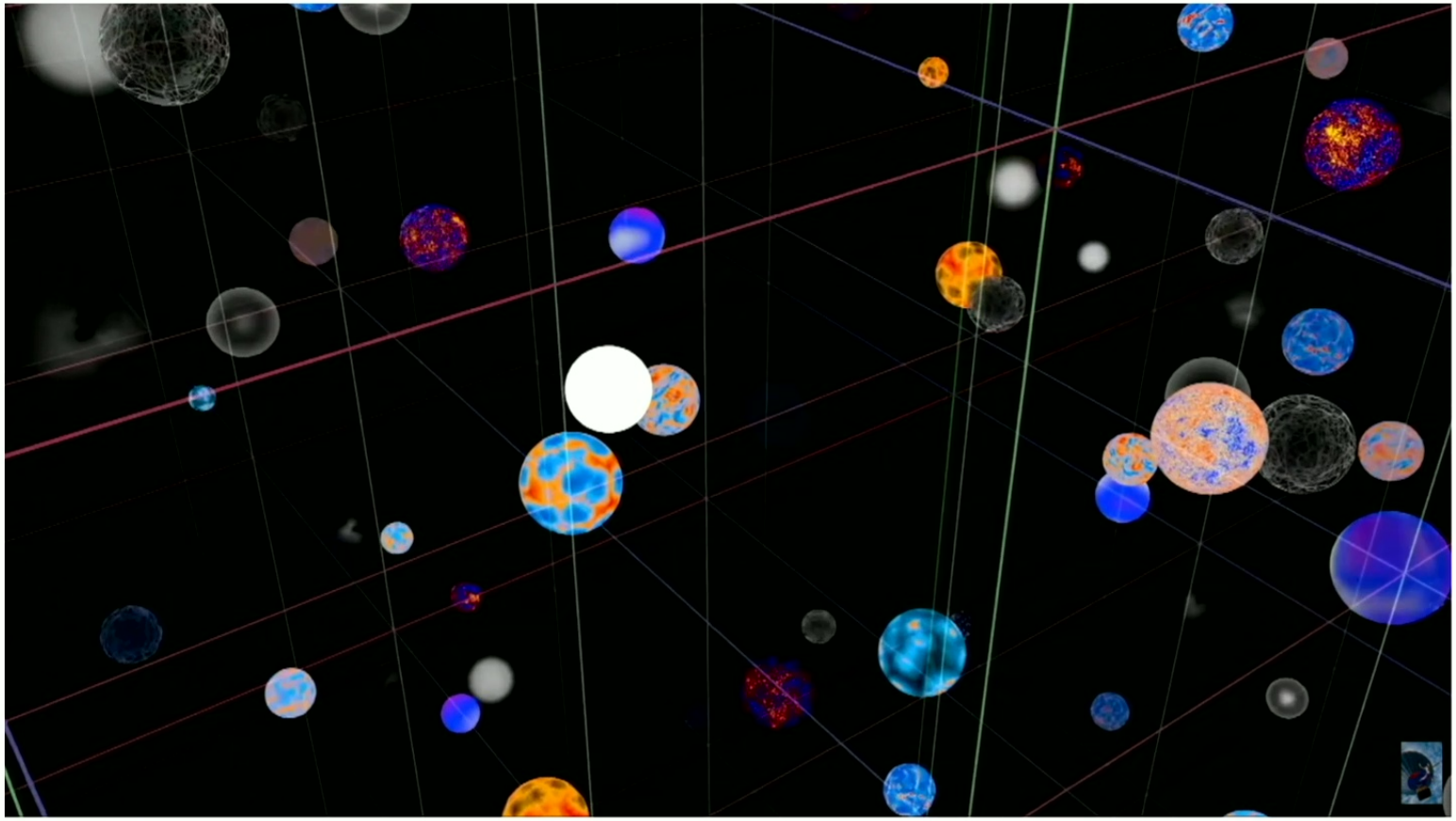


Criticisms of with inflation



- Which inflation? Can we test inflation?
- Produces Gravitational Waves, but how much?
- How does inflation end? *Reheating*
- In most places it doesn't! Multiverse

Inflationary Multiverse



Inflationary Wars

MAY 10, 2017

A Cosmic Controversy

A *Scientific American* article about the theory of inflation prompted a reply from a group of 33 physicists, along with a response from the article's authors

SEAN CARROLL

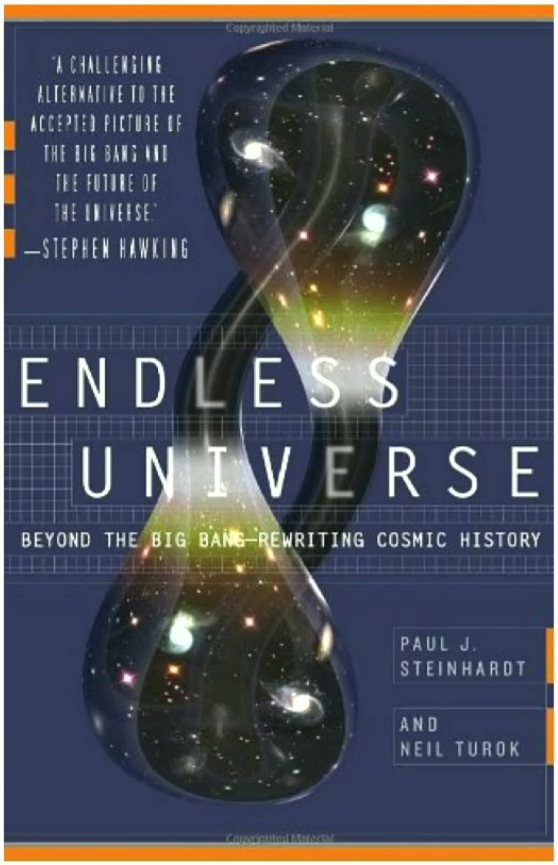
in truth, only atoms and the void

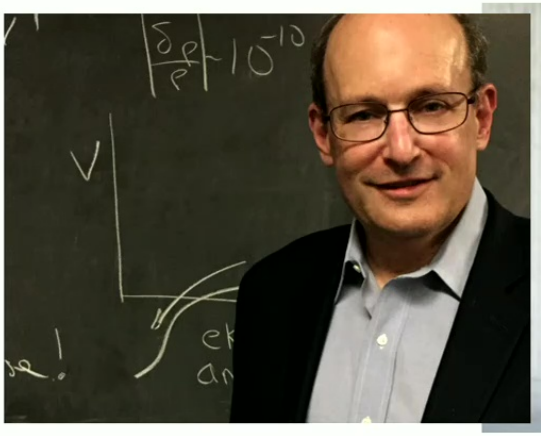
Is Inflationary Cosmology Science?

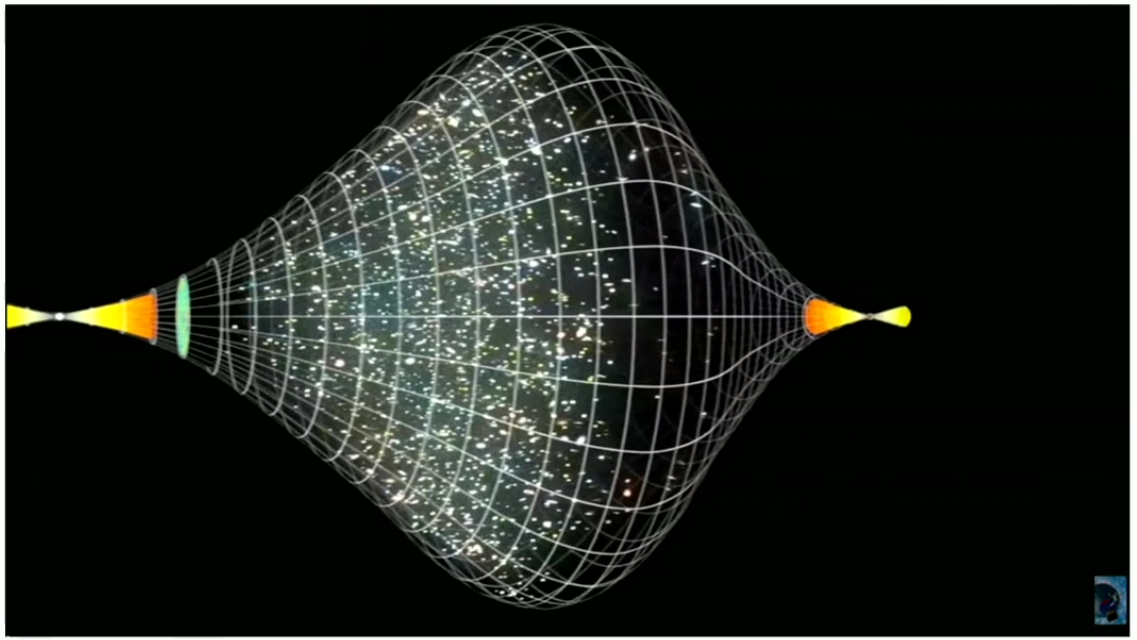
25 COMMENTS / Philosophy, Science

[tl;dr: Check out this article in *Scientific American* by Ijjas, Steinhardt, and Loeb suggesting that inflation isn't science; this response by Guth, Kaiser, Linde, and Nomura that was co-signed by a bunch of people including me; and this counter-response by the original authors.]

Cyclic Universe?

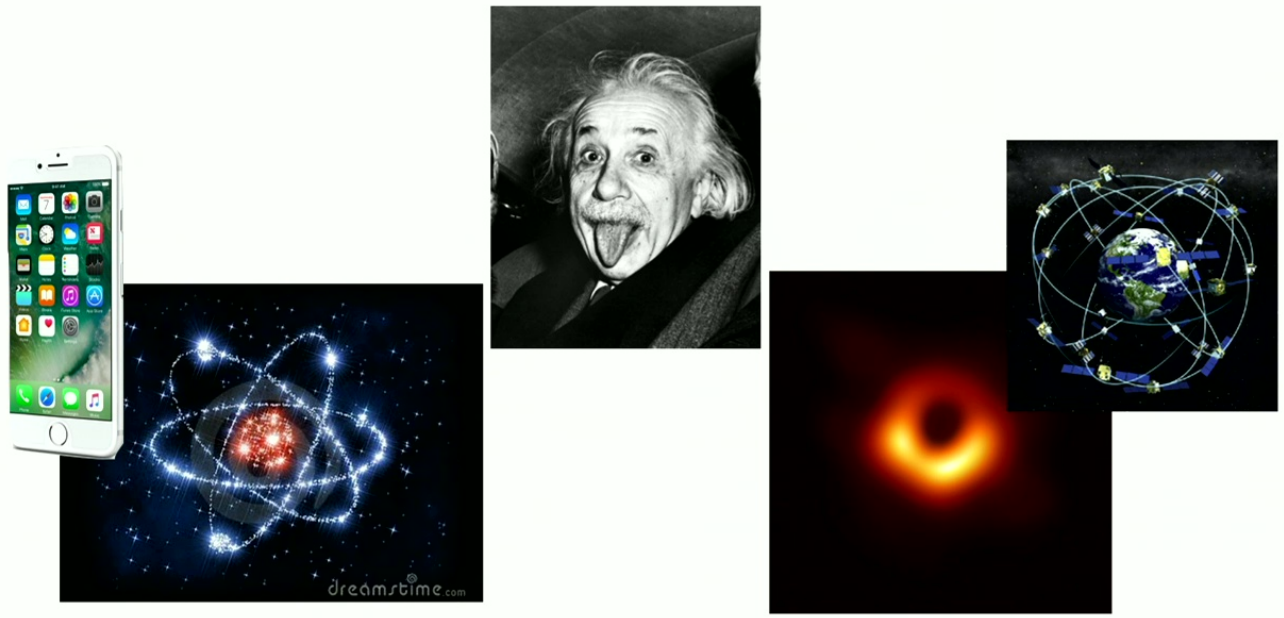




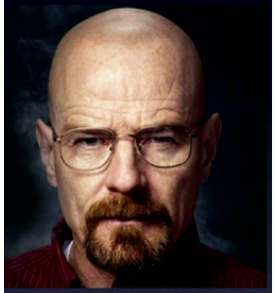


Quantum Gravity:
The Holy Grail of Theoretical Physics

- Can the rules of *Quantum* and *Gravity* work together?

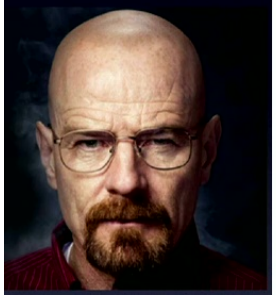


Heisenberg vs. Einstein Microscopes



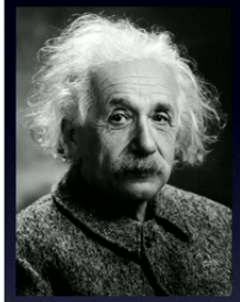
- Higher energy
- ➡ Shorter wavelength
- ➡ *Better resolution*

Heisenberg vs. Einstein Microscopes



- Higher energy
- ➡ Shorter wavelength
- ➡ *Better resolution*

- Higher energy
- ➡ Bigger black holes
- ➡ *Worse resolution*

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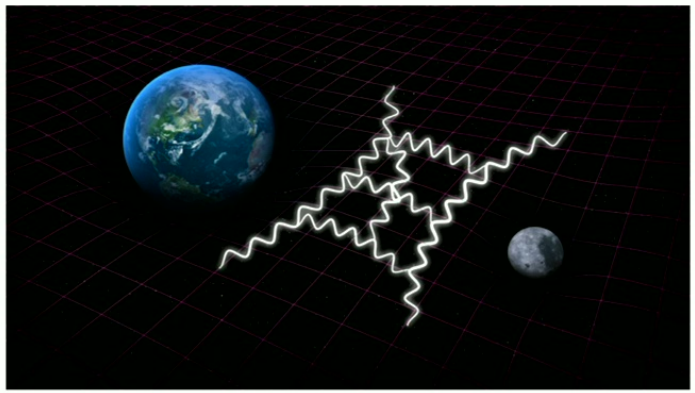
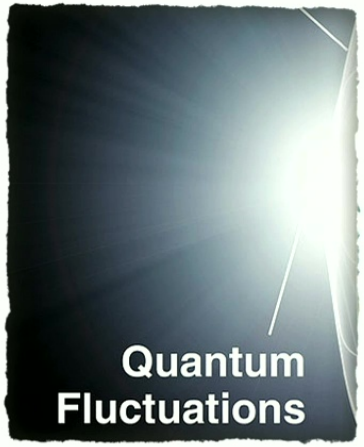
General Relativity+ Quantum Mechanics →😕 😖



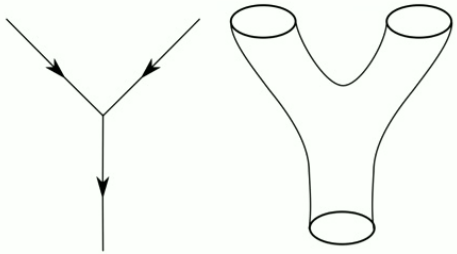
- All the predictions fail when we reach

Planck Energy/Temperature: $E_p \sim 10^{27}\mathrm{eV} \sim 10^{8} J \sim 10^{31}\mathrm{K}$

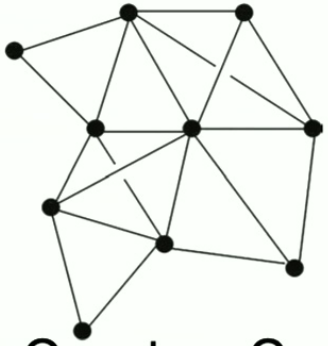
- This happens at the Big Bang Singularity



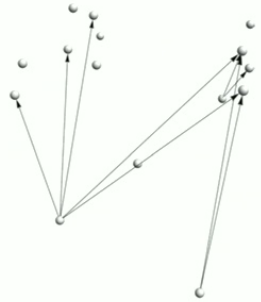
Quantum Gravity Zoo??



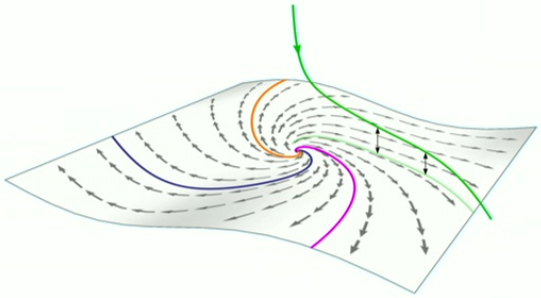
- String Theory



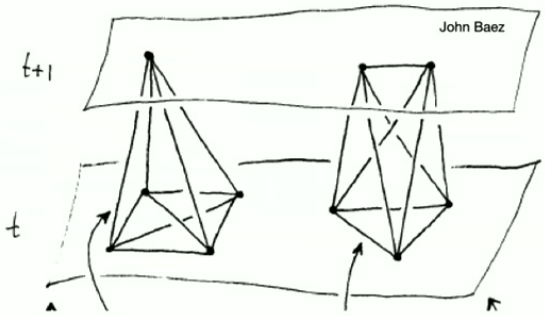
- Loop Quantum Gravity



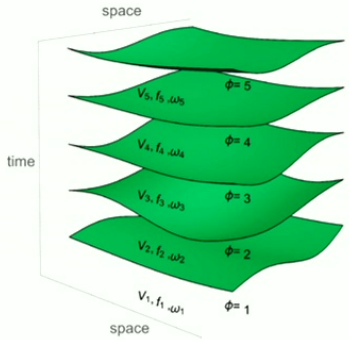
- Causal Sets



- Asymptotic Safety



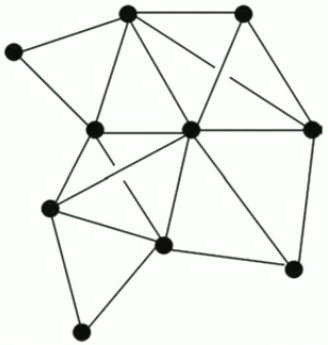
- Causal Dynamical Triangulation

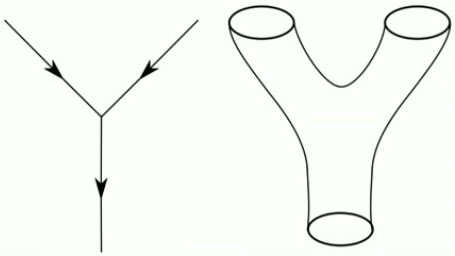


- Horava-Lifshitz gravity

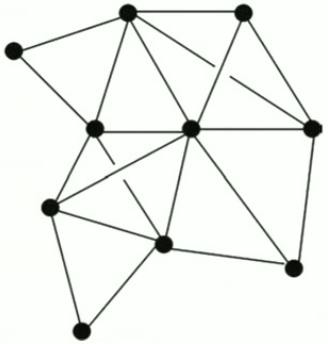
Olena Shmahalo/Quanta Magazine

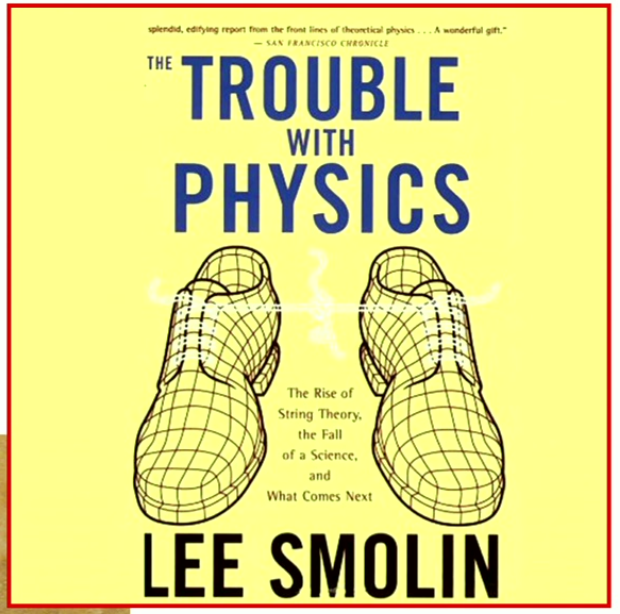

their friends,

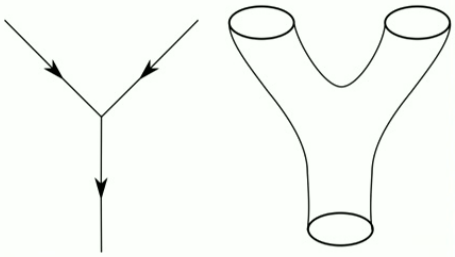





2001 / First research group




splendid, edifying report from the front lines of theoretical physics . . . A wonderful gift."
— SAN FRANCISCO CHRONICLE
THE TROUBLE WITH PHYSICS
The Rise of String Theory, the Fall of a Science, and What Comes Next
LEE SMOLIN

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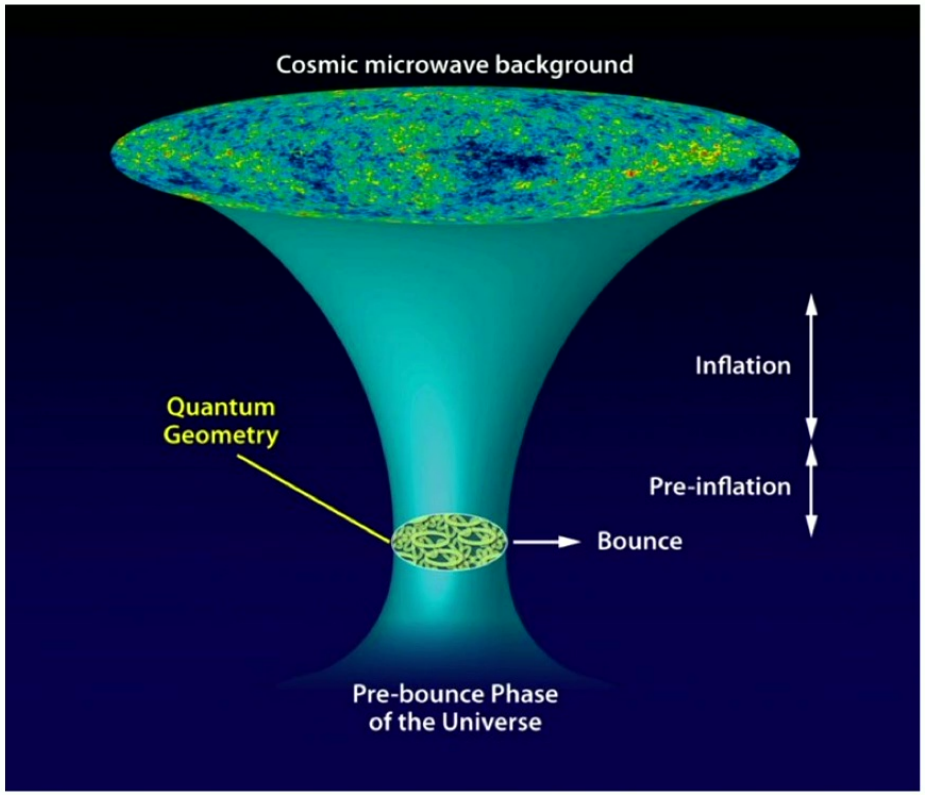
Loop Quantum Cosmology

Singularity → Big Bounce?



Smolin, Ashtekar, Rovelli

Yes

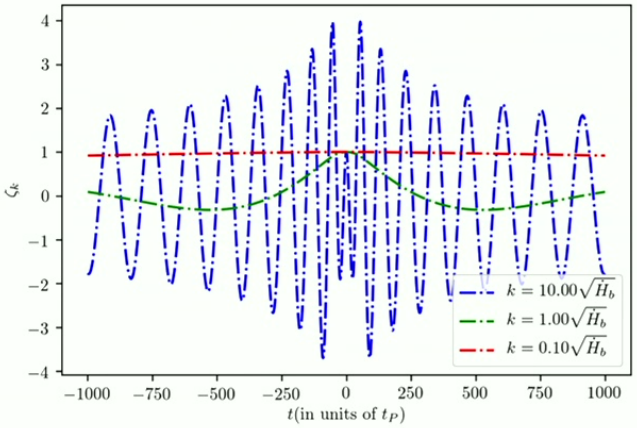
Param Singh

No

Martin Bojowald

Cuscuton Bounce

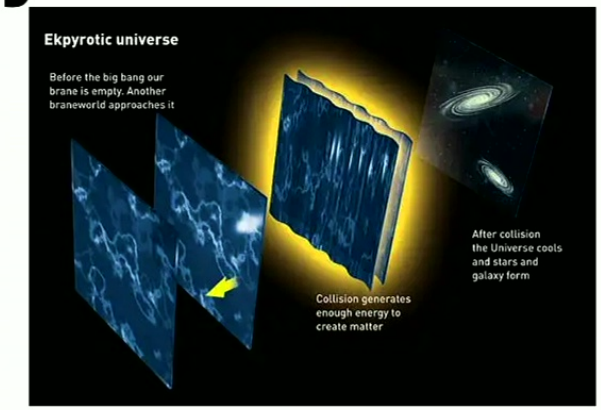
- One way to avoid singularity is to make gravity repulsive
- However, this leads to instabilities, unless you make sound waves infinitely fast!
- → **Cuscuton!**
- No singularity, no instability

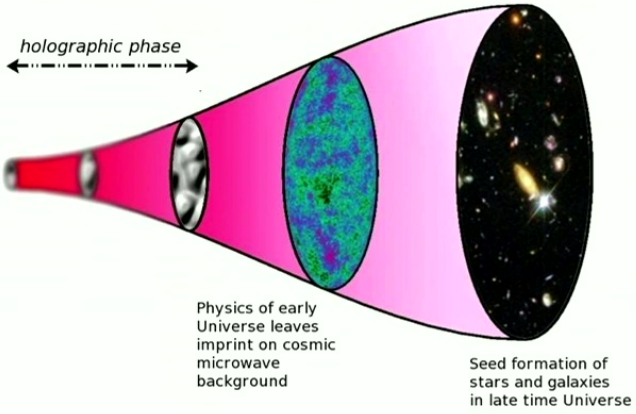


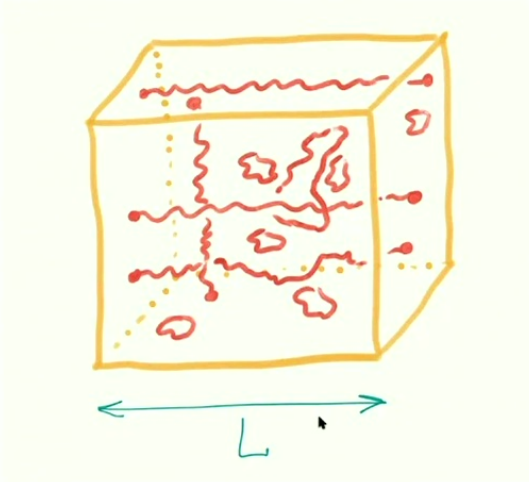
Ghazal Geshnizjani

Many ideas of String Cosmology

- Braneworlds
- String gas cosmology
- Holographic cosmology







Many ideas of String Cosmology

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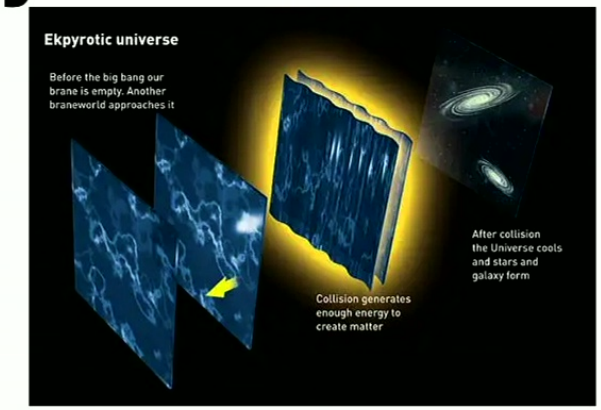
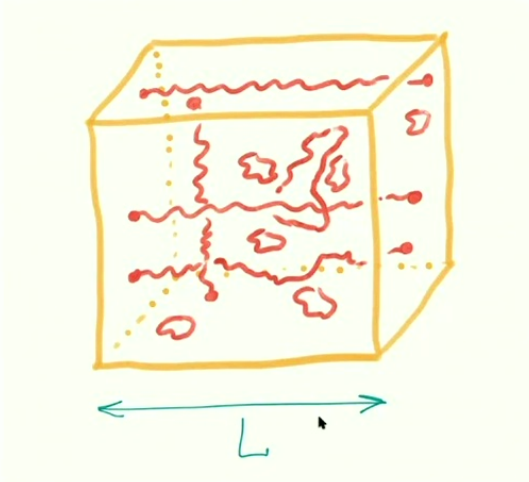
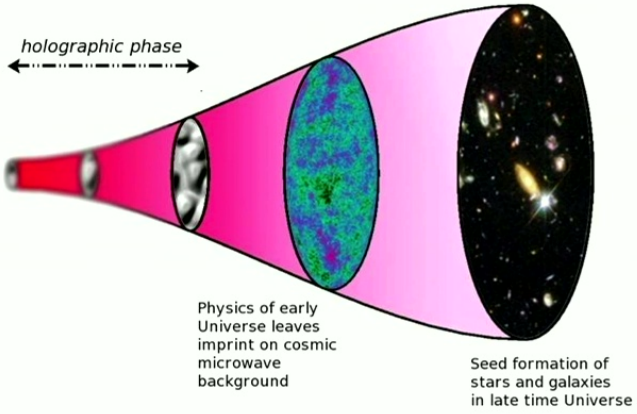




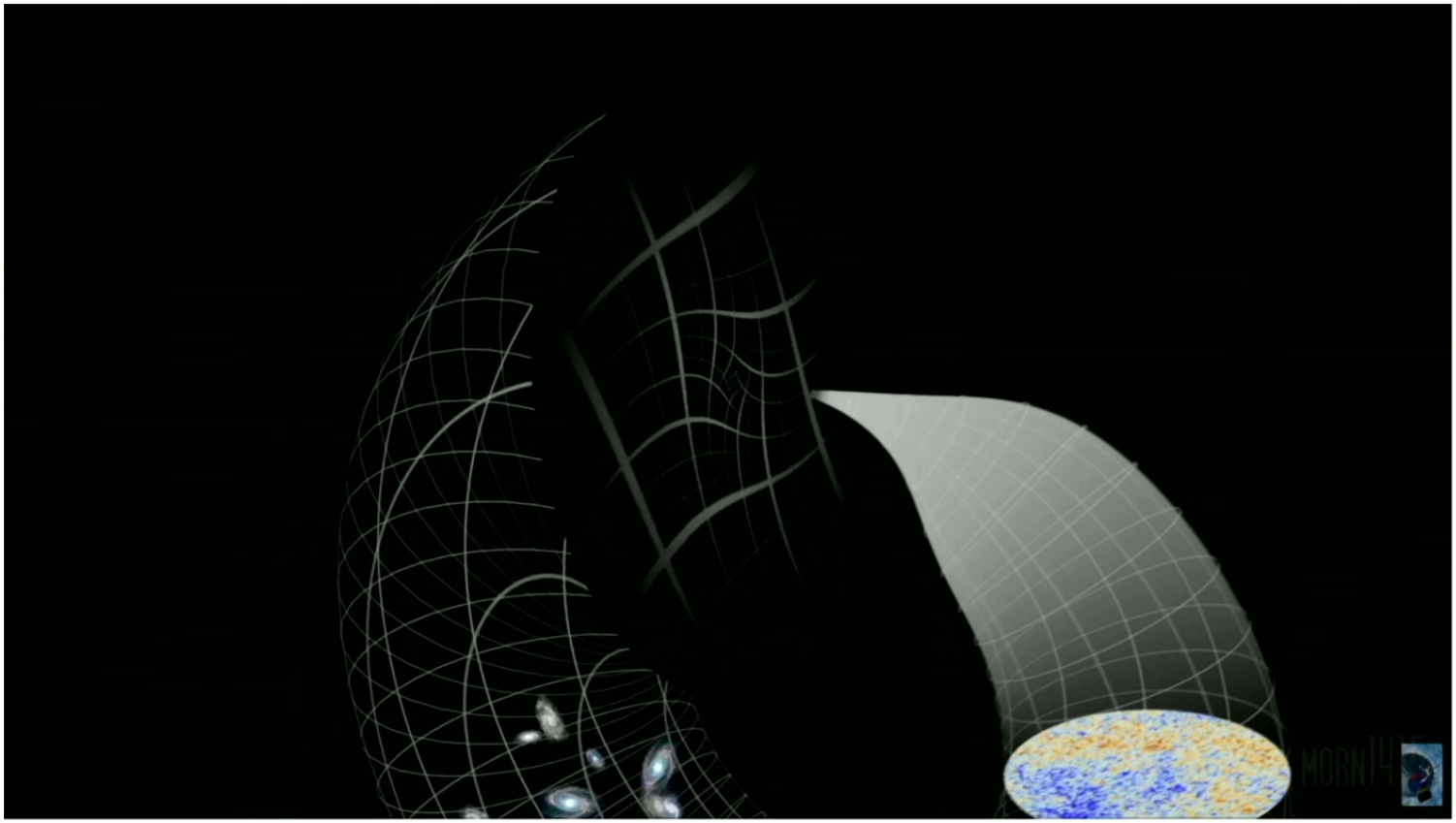


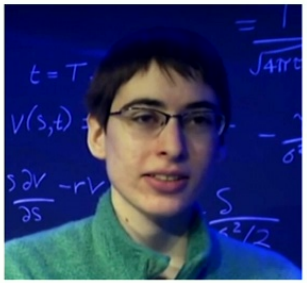
Are there time machines in a quantum theory?

- Stephen Hawking: No!

- Richard Gott: Yes!

Can the entire universe be time machine?

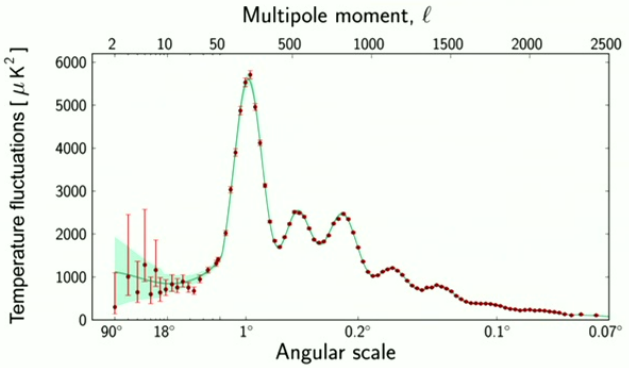


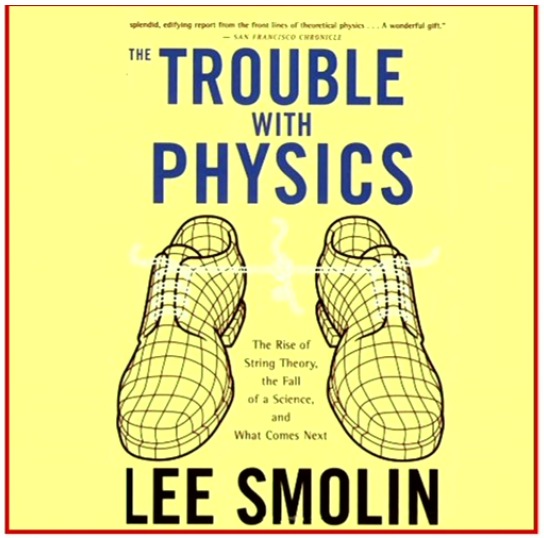


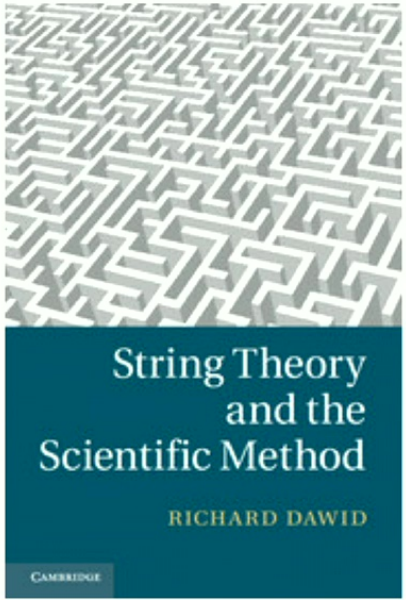
Elizabeth Gould

Religion within Cosmology

- You can take the cosmologist out of religion, but can you take the religion out of the cosmologist?
- Without empirical evidence, don't we revert to religious dogmas and crusades, under novel guises?
- Can we ever rule out string theory, loop quantum gravity, or inflation?

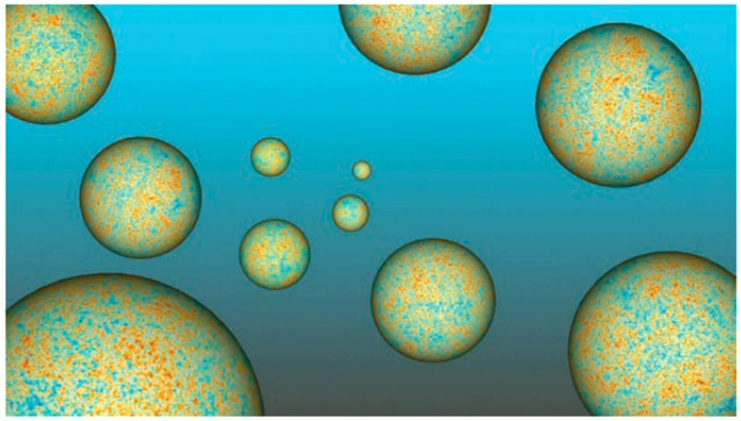


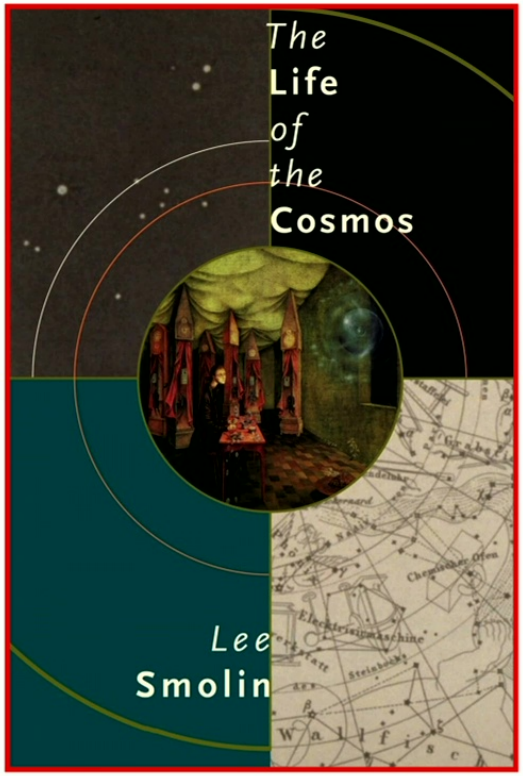




God of the fine-tuning?

- Are the parameters of the universe (say electron charge and mass) fine-tuned for life through intelligent design?
- Alternatives: Natural selection of parameters in a multiverse (inflation, string theory) or within black holes (Lee Smolin)





Pseudo-science or Proto-Science?

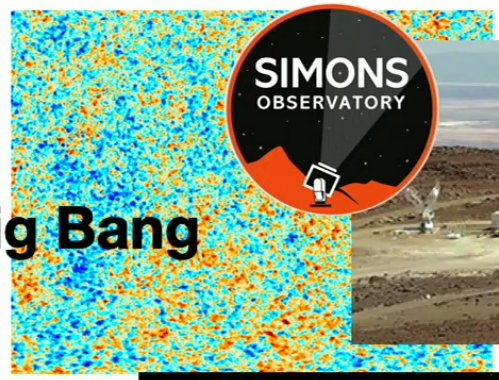
"The game I play is a very interesting one. It's imagination, in a tight straightjacket."

— Richard P. Feynman

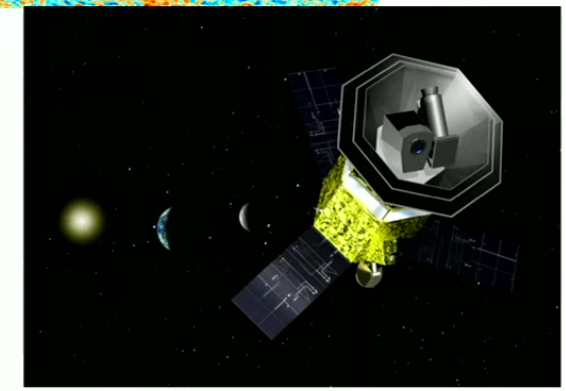
- Science is a dance between theory and experiment. Sometimes theorists lead and data follows; at other times, experiment tightens Feynman's straitjacket, constraining the space for theorists to play.
- No exact demarcation criterion, like other human activities
- I prefer to judge based on similarities, and how progress happens

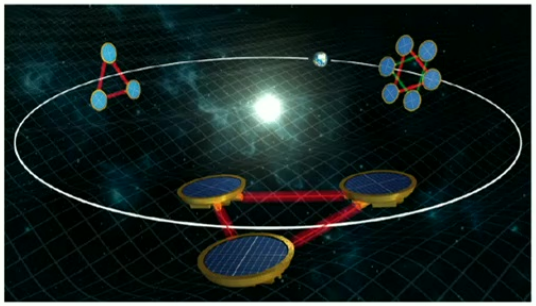
Nature will guide us

Sound & Geometry waves from Big Bang

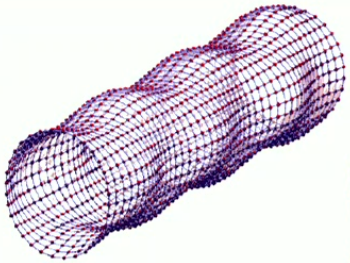


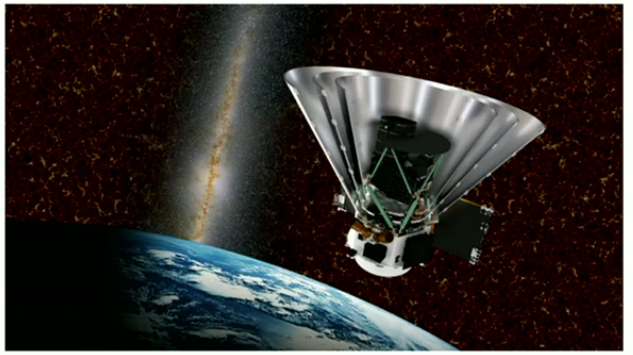
- Subtle patterns in
  - ✓ *cosmic microwave background*
  - ✓ *large scale distribution of galaxies*
- Gravitational Waves from the Big Bang





Big Bang Observer





The Final Battle

- The real battle is not with our colleagues, or fellow citizens
- Our true struggle is to overcome our ignorance —our adventure to comprehend the cosmos, ourselves included
- Our process is the scientific method, honed on solving cosmic mysteries, but also derived from all other aspects of our humanity

The Final Battle

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- Our process is the scientific method, honed on solving cosmic mysteries, but also derived from all other aspects of our humanity
- This will be our ultimate survival tool in an ever-changing world
- The power to remember our past lies in your future!