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### The Origin of the Universe: An Amazing and Mysterious Universe

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# ATENEO Magisterial Lecture series



THE ORIGIN OF THE UNIVERSE A Vast & Expanding Universe

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## THE ORIGIN OF THE UNIVERSE A Vast & Expanding Universe

FR BIENVENIDO F NEBRES, SJ DEPARTMENT OF MATHEMATICS ATENEO DE MANILA UNIVERSITY

### WE LIVE IN A VAST UNIVERSE



THE ORIGIN OF THE UNIVERSE: A VAST AND EXPANDING UNIVERSE

## • 100 billion galaxies, each with 100 billion stars.

• Image of Universe 13 billion years ago.







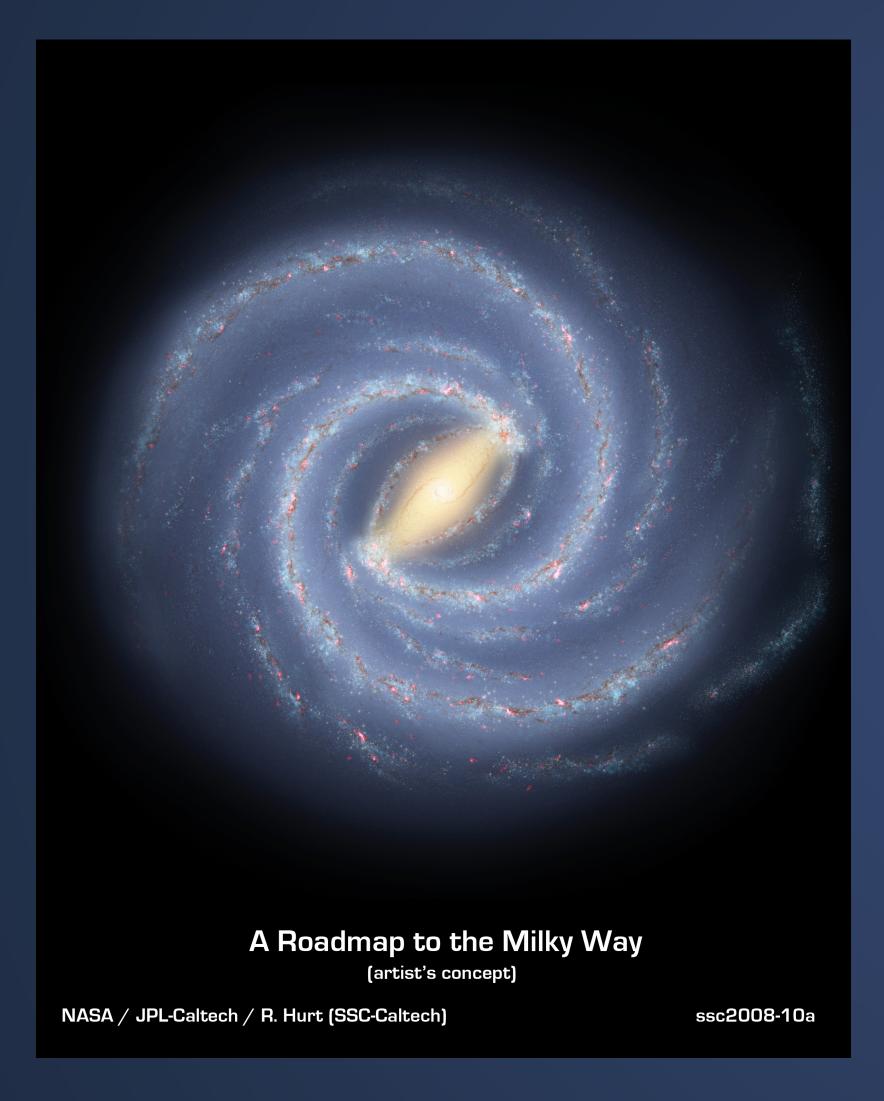


• Edwin Hubble with telescopes in Mt. Wilson, California discovered our vast and expanding universe.





### **BEFORE HUBBLE, ONLY THE MILKY WAY**



THE ORIGIN OF THE UNIVERSE: A VAST AND EXPANDING UNIVERSE

# • We thought the universe was our galaxy: The Milky Way





**AN EXPANDING UNIVERSE** 

• Edwin Hubble: The galaxies are moving away from each other.

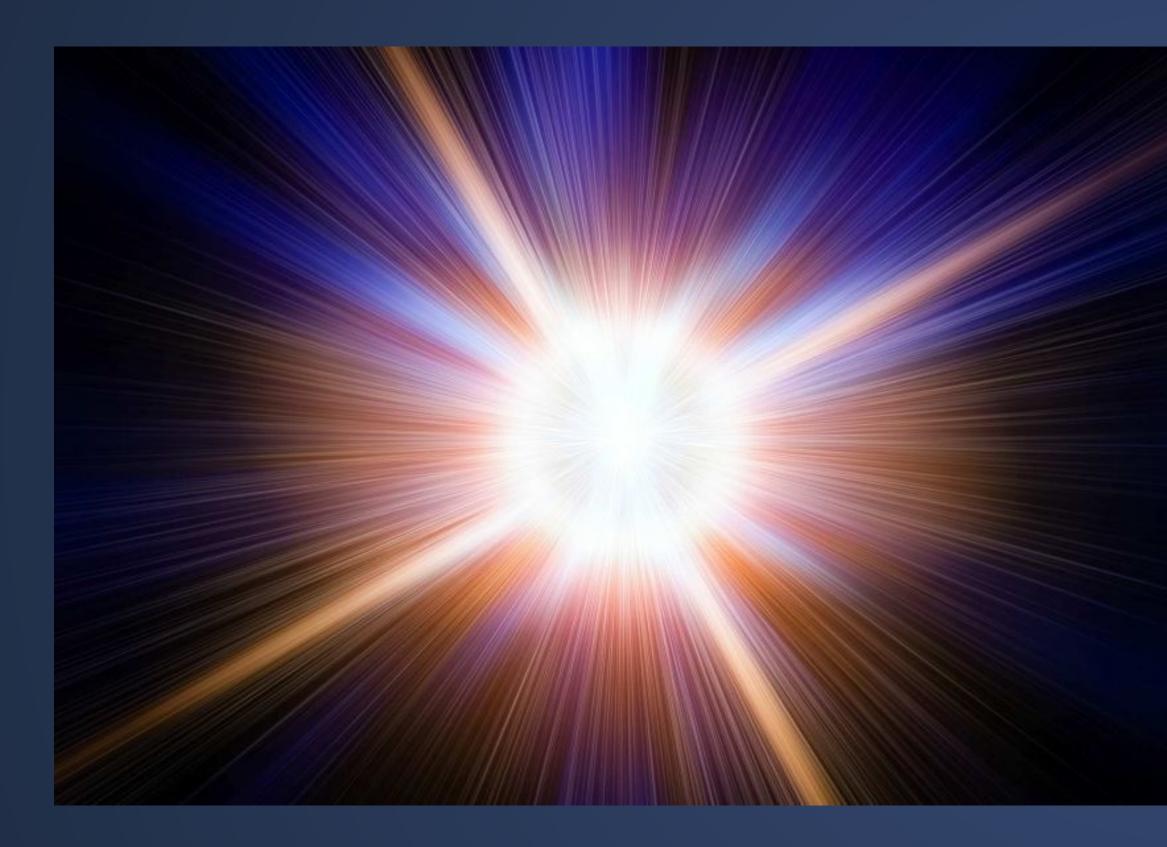
• The phenomenon of Redshift.

• We live in an expanding universe.





### OUR UNIVERSE STARTED AS A DOT WITH INFINITE ENERGY IN THE BIG BANG



THE ORIGIN OF THE UNIVERSE: A VAST AND EXPANDING UNIVERSE

## If our universe has been expanding, we can run the movie backwards?

We come to the Big Bang.





THE 14-BILLION YEAR JOURNEY OF OUR UNIVERSE

From the beginning:

• 10-11 seconds: Matter wins over Anti-Matter

• 10-5 seconds: Protons and Neutrons form from Quarks

(COBE)

THE ORIGIN OF THE UNIVERSE: A VAST AND EXPANDING UNIVERSE



## • 380,000 years: Cosmic Microwave Background Radiation





FROM THE FIRST STARS UNTIL TODAY

• 300 million years: Stars and Galaxies form

• 3 billion years: Galaxies and Clusters of Galaxies

• 9 billion years (4.7 billion years ago): Our Solar System forms

• 13.7 billion years: Today





**EXPERIMENTAL EVIDENCE FOR THE BIG BANG** 

• Physicists showed that the Big Bang should have left a relic. • Temperature of 5 degrees above absolute zero. • Absolute zero is minus 273 degrees Celsius.







### **PROOF OF THE BIG BANG**



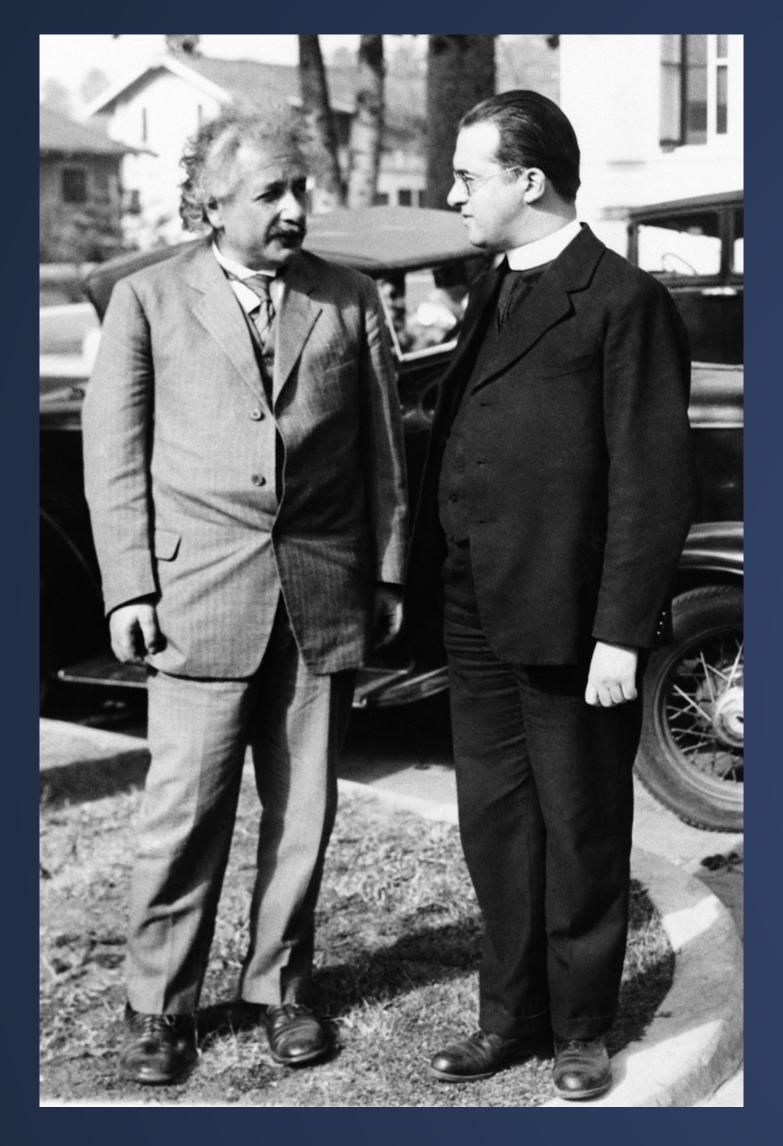
THE ORIGIN OF THE UNIVERSE: A VAST AND EXPANDING UNIVERSE

• In 1964, two engineers at Bell labs in New Jersey, Penzias and Wilson, discovered this relic radiation from the Big Bang.

• They received the Nobel Prize.









THE ORIGIN OF THE UNIVERSE: A VAST AND EXPANDING UNIVERSE

# • Albert Einstein • George Lemaitre, a Belgian priest

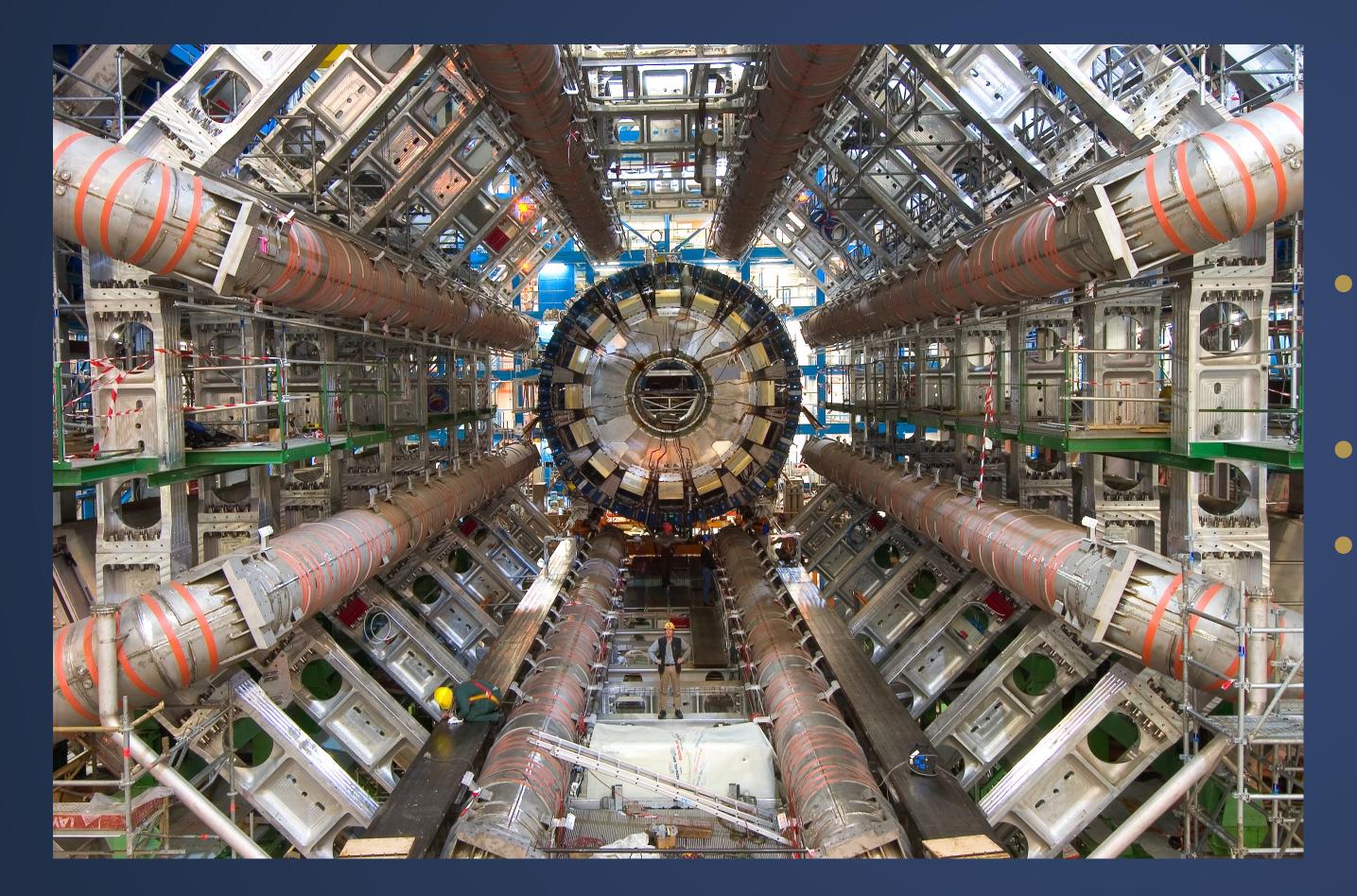
## • Edwin Hubble







### MOST POWERFUL PARTICLE ACCELERATOR: CERN LARGE HADRON COLLIDER



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 Physics Theories predict the existence of particles. • Colliders "look" for them. • Finding the particles show our theories are correct.





**DISCOVERY OF HIGGS BOSON (GOD-PARTICLE)** 

have mass.

the Higgs Boson.

• Over <u>5,000 physicists worked</u> to achieve this result.

THE ORIGIN OF THE UNIVERSE: A VAST AND EXPANDING UNIVERSE



## • Predicted in 1964 by Peter Higgs: To explain why particles

## • July 4, 2012: Announcement that the LHC had detected





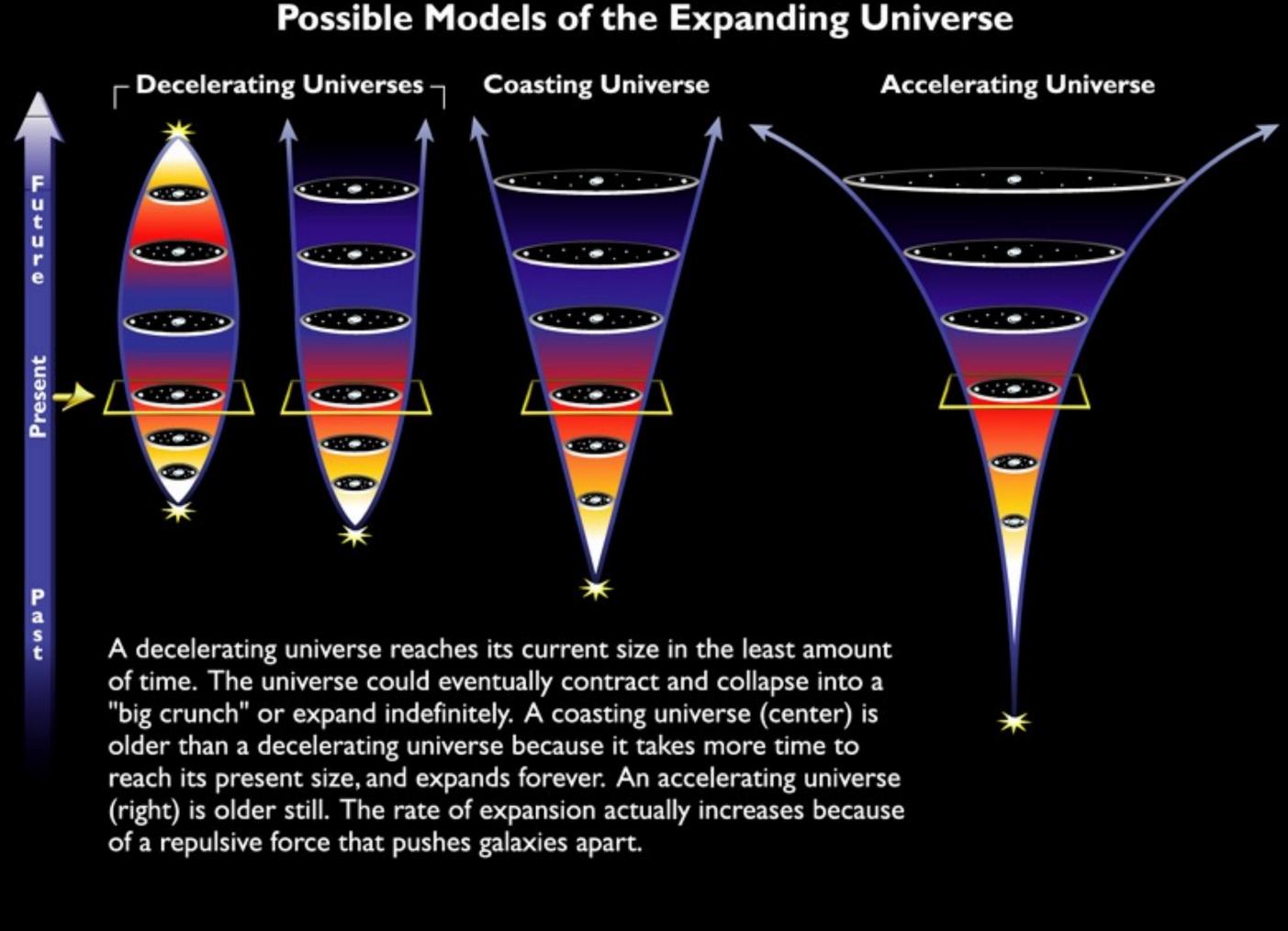
THAT WAS OUR PAST, WHAT IS OUR FUTURE?

• In another 6 billion years, our Sun will become a Red Giant. • Temperatures will rise to 3,000 Fahrenheit. • Next, the Sun will become a White Dwarf. • Earth will become cold and frozen.





### THE FUTURE OF THE UNIVERSE







### THE FUTURE OF THE UNIVERSE (VERSION 1)

## **BIG FREEZE** HEAT DEATH **BIG BOUNCE**

THE ORIGIN OF THE UNIVERSE: A VAST AND EXPANDING UNIVERSE

The universe will get colder and colder. Back to the Big Bang. The universe will bounce back and expand again.





THE FUTURE OF THE UNIVERSE (VERSION 2)

**BIG FREEZE:** The universe will get colder and colder. **HEAT DEATH:** Back to the Big Bang. The Universe will bounce back and expand again. **BIG BOUNCE:** 





## AN AMAZING AND MYSTERIOUS UNIVERSE

THE ORIGIN OF THE UNIVERSE: A VAST AND EXPANDING UNIVERSE

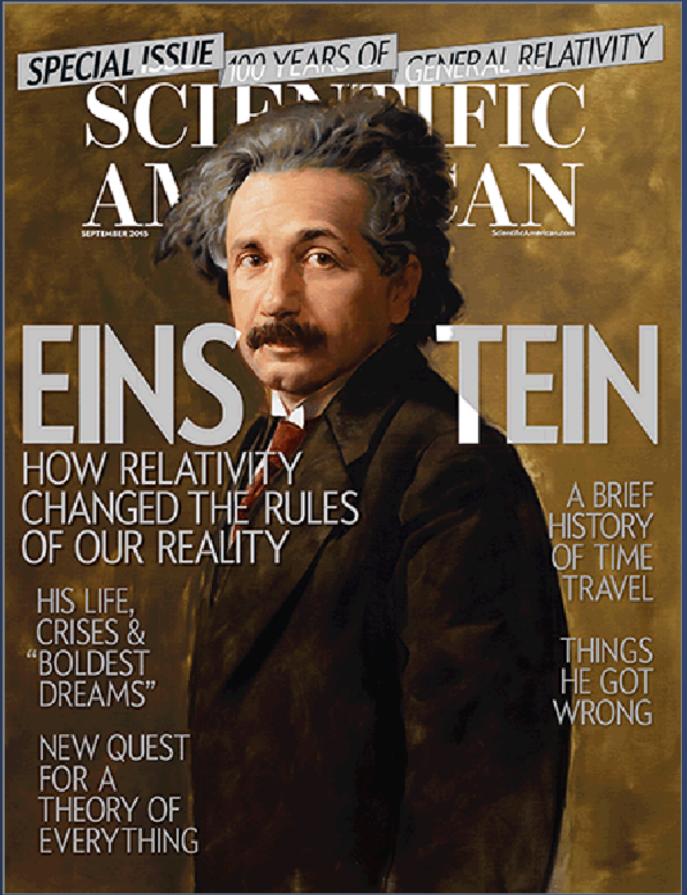
## **ORIGIN OF THE UNIVERSE**





### **ALBERT EINSTEIN & OUR AMAZING UNIVERSE**

## 1915: General Relativity



### Black Holes Gravitational Waves

## **HE MATTERS**

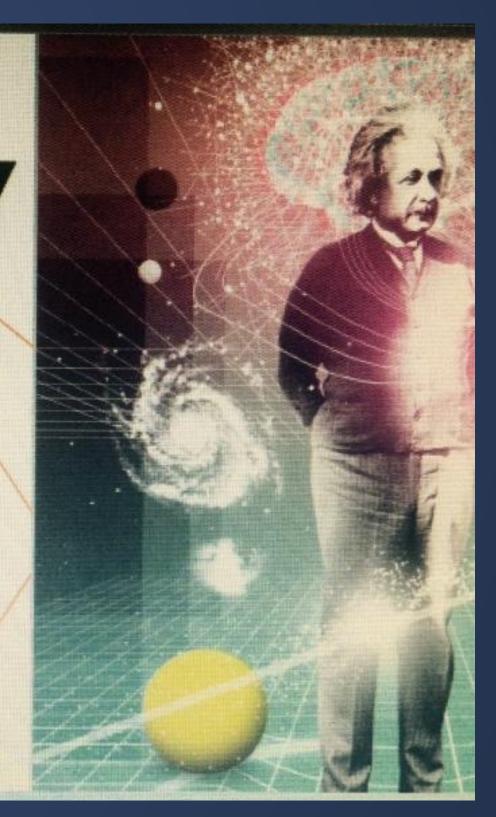
The fruits of one mind shaped civilization more than seems possible

By Brian Greene

Albert Einstein once said that there are only two things that might be infinite: the universe and transas stupicits. And, he confessed, he wasn't sure about the universe.

When we hear that, we charkle. Or at heart we write. We do not take offense. The mason is that the name "Einstein" conjums an image of a warm heartest, astancial sage of an earlier era. We son the good natured, wild halved scientific genius whose length portraits - riding a hills, sticking out his tongest, staring at uswith those penetrating eyes - are emblacement in our collective militard memory. tinstein has even to symbolize the parity and power of intellectual exploration.

Tinstein shot to fame within the scientific community in 1906, a year christeneri as his annus mirahilis. While working cight hoors days, six days a work at the liwise patent office in licen, he wrote four papers in his spare firse that changed the course of physics. In March of that year he argued that light, long described as a wave, is actually composed of particles, called pressure, an obacreation that hameters quantum mechanics. Two months later, in May filmstelars extendations provident tostable providenties of the atomic topothods, lator minfirmed experimentally duriting the case that make is made of shows. in June he completent the special sheary of relativity, rewalling that space stat. these behave in astanikhing ways no one had ever articlasticit- in sheet, that







**AMAZINGLY, WE HAVE DETECTED GRAVITATIONAL WAVES** 

• LIGO (Laser Interferometer Gravitational-Wave Observatory)

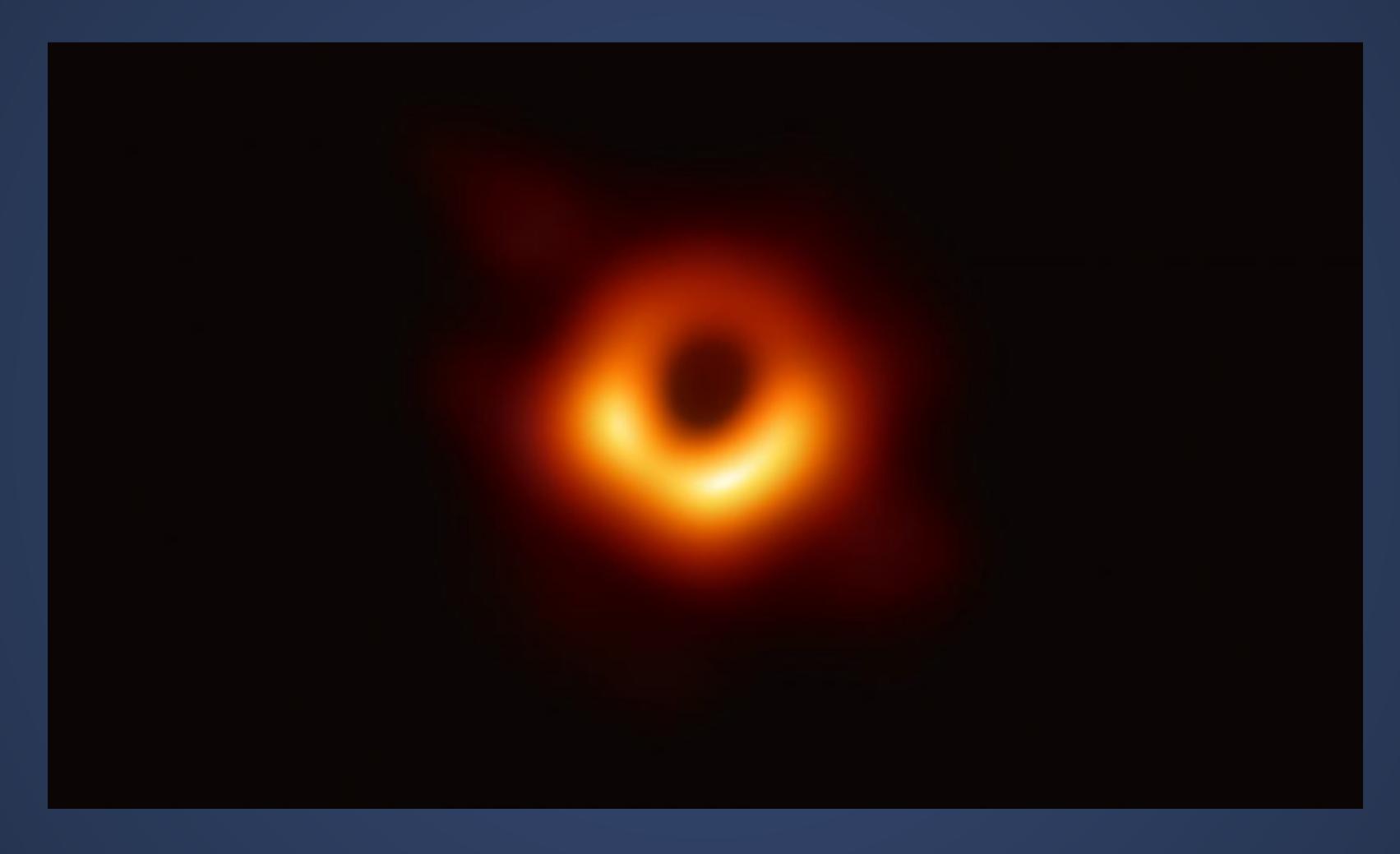
• February 11, 2016: Gravitational Waves coming from the collision of two giant black holes 1.3 billion years ago.

• Exactly as predicted by Albert Einstein 100 years before.





### WE HAVE "SEEN" A BLACK HOLE IN MESSIER M87\*







### EVENT HORIZON TELESCOPE WHICH "TOOK THE PICTURE"



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# • The ALMA Telescope array in Chile, one of 8 around the world.







### BUT THE UNIVERSE HOLDS MANY MYSTERIES: DARK ENERGY

SPICY DRUGS: CURES FROM CURRY? • SILICON LASER CHIPS

SCIENTIFIC AMERICAN

**Prehistoric CSI:** 

Asteroids Did Not **Kill These Dinosaurs** 

FEBRUARY 2007

THE COSMIC GRIP OF ENE

This mysterious force has a stranglehold on the shape of galaxies

**Can Plants Cause Global Warming?** 

**Digital TV's Analog Curse** and What It Means for You

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THE ORIGIN OF THE UNIVERSE: A VAST AND EXPANDING UNIVERSE



• The expansion of the universe is accelerating.

• An unknown, "Dark Energy", is pushing the acceleration.

• It comprises 70% of the universe.





### THE UNIVERSE STILL HOLDS MANY MYSTERIES: DARK MATTER (VERSION 1)

Vera Rubin: the stars at the edges of galaxies are moving faster the laws of gravity predict.

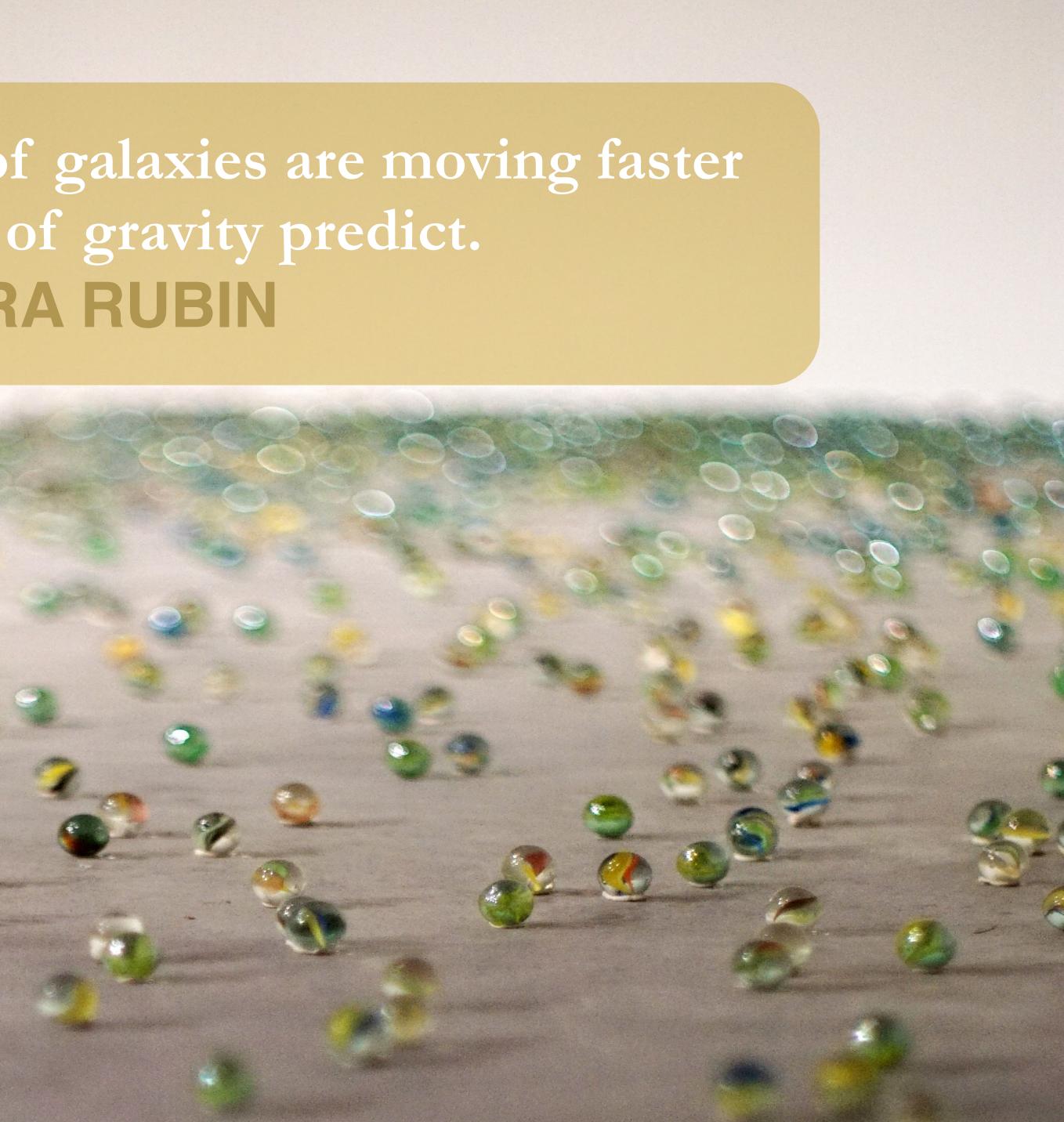
- The Explanation: Dark Matter
- It makes up <u>25% of the universe.</u>
- So we can see only 5% of the universe.
- We live in a mysterious universe.







## The stars at the edges of galaxies are moving faster than the laws of gravity predict. - VERA RUBIN



THE UNIVERSE STILL HOLDS MANY MYSTERIES: DARK MATTER (VERSION 2.3)

• The Explanation: Dark Matter.

• It makes up <u>25% of the universe</u>.

• So we can see only 5% of the universe.

• We live in a mysterious universe.

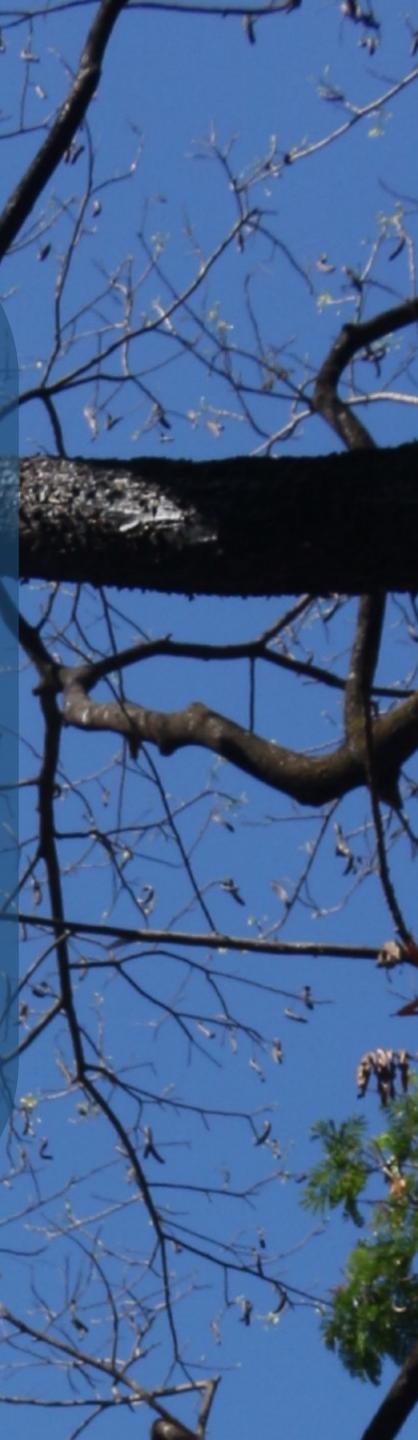




"The laws of science [...] contain many fundamental numbers, like the size of the electric charge of the electron and the ratio of the masses of the proton and the electron. [...]

The remarkable fact is that the values of these numbers seem to have been very finely adjusted to make possible the development of life."

- STEPHEN HAWKING



### WE ARE HERE BECAUSE MATTER FORMED INTO STARS, GALAXIES, AND THE **STARDUST THAT IS US**

- heavy hydrogen nuclei.
- 3 billion years: stars and galaxies form
- The matter in our bodies comes from the stars.

THE ORIGIN OF THE UNIVERSE: A VAST AND EXPANDING UNIVERSE

## • At some point, there is slightly more matter than anti-matter.

## • Matter forms into protons and neutrons, helium, lithium, and





THE 4 FUNDAMENTAL FORCES OF THE UNIVERSE "PREPARED" FOR US

• GRAVITY • ELECTROMAGNETISM • WEAKFORCE • STRONG FORCE







**IF THE OTHER FORCES WERE STRONGER** 

# • Stars and galaxies would not have formed. • The elements in our bodies come from the stars. • We would not be here.





### IF THE OTHER FORCES WERE WEAKER (GRAVITY STRONGER)

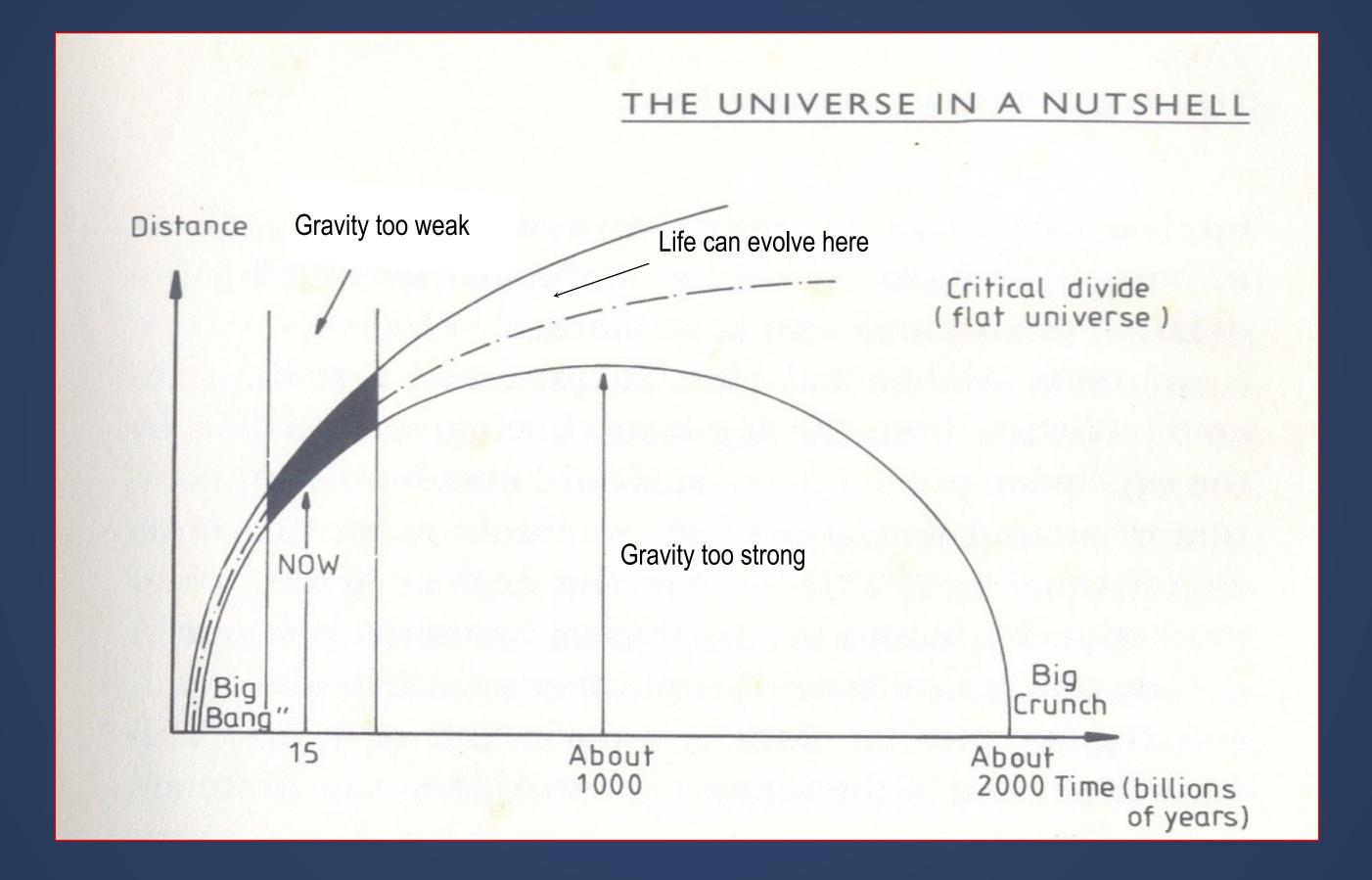
## • Stars and galaxies would have collapsed sooner. • No time for life to evolve.







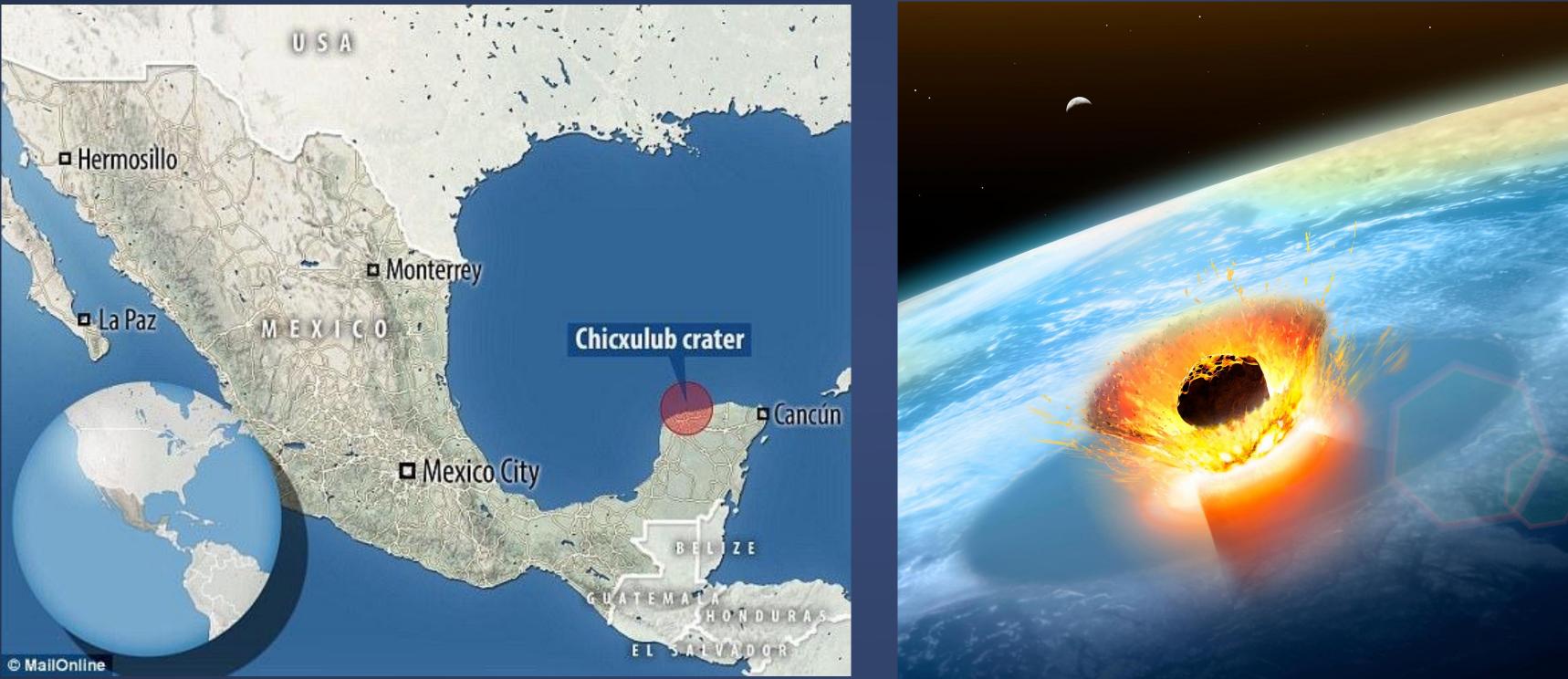
### LIFE ONLY POSSIBLE IN A NARROW CRITICAL DIVIDE







### A CATASTROPHIC ASTEROID COLLISION 66 MAY SET THE STAGE FOR OUR COMING







THE DAY THE DINOSAURS DIED

• The dust and soot blocked all sunlight for months. Photosynthesis stopped, killing plant life.

• More than 99.9999 per cent of all living organisms on Earth died.

• The dinosaurs that had ruled the Earth became extinct.





### THE AGE OF MAMMALS (OUR AGE) BEGAN

# Insects feeding on dead leaves survived the collision



THE ORIGIN OF THE UNIVERSE: A VAST AND EXPANDING UNIVERSE

### Small mammals survived eating insects







THE EVOLUTION OF THE UNIVERSE HAS BEEN GOOD TO US Just an infinitesimal change and stars would not have formed.

• Or the stars would have burned out too quickly.

• Even an accidental asteroid collision prepared for us.

• As one physicist puts it: It seems that the universe knew we were coming.





### **IS IT "CHANCE": MULTIVERSE THEORY**

## Multiverse Explanation:

Where are an <u>almost</u> infinite number of universes: A Multiverse.

• Statistically a hospitable universe would arise.

• But we can not travel to another universe.

• So we will never know.





### **OR THE "PROVIDENCE OF GOD?"**

## For believers, we would say this comes from the Providence of God.

### • The universe knew we were coming.

• Because Providence set the laws of the universe.

## • Even the asteroid was Providence.



