

Title: Cosmic Mysteries

Date: Mar 07, 2012 07:00 PM

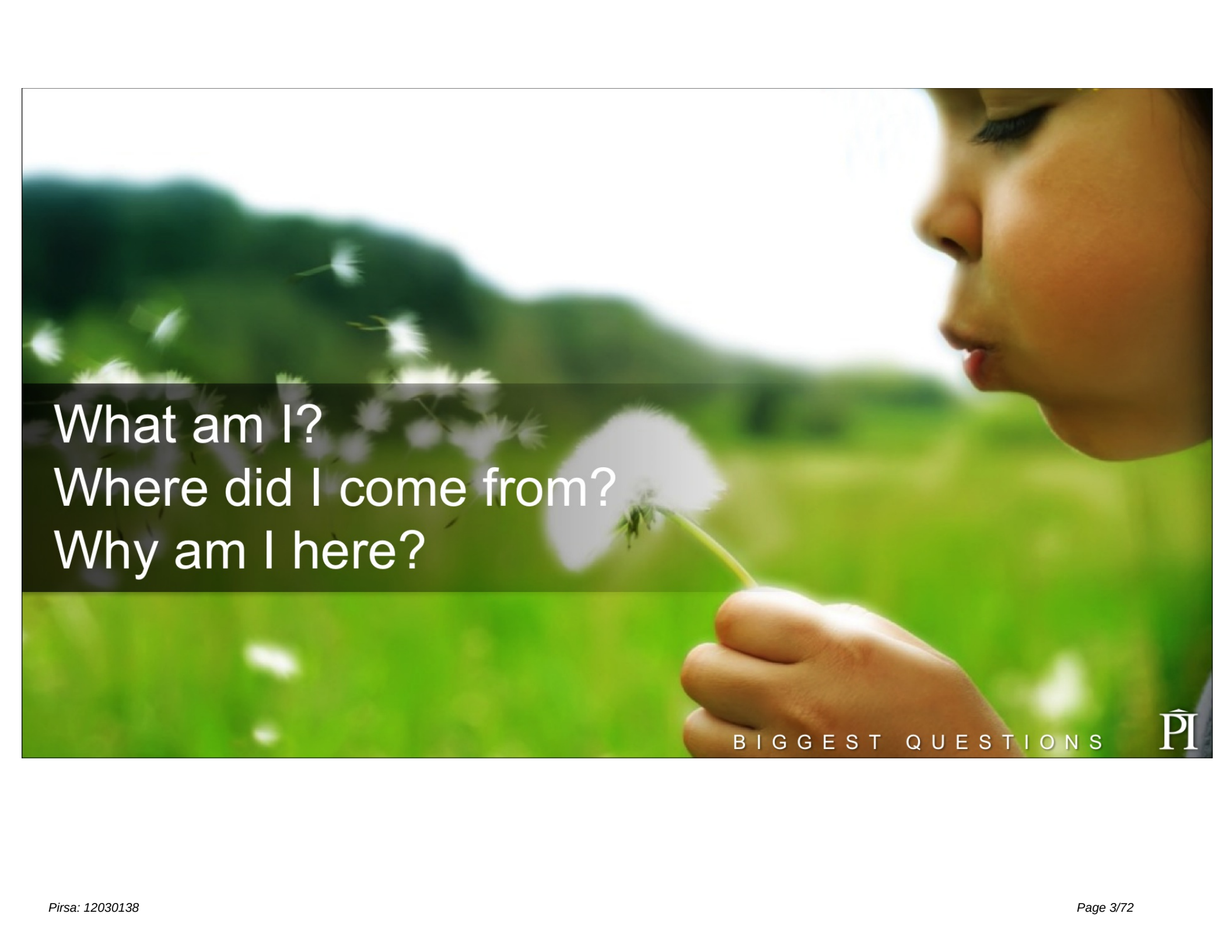
URL: <http://pirsa.org/12030138>

Abstract: Albert Einstein wrote that “The most beautiful experience we can have is the mysterious.” In his talk, Dr. Epp will explore how the process of science “wonder & curiosity coupled with imagination & reasoning” has led to some of the greatest discoveries and deepest mysteries about the structure, evolution and origin of the universe. This lecture will celebrate the power of science to deepen our sense of cosmic wonder as we stand before the present-day mysteries of Dark Matter, Dark Energy and the Big Bang.

Cosmic Mysteries

The background of the slide is a deep blue space filled with stars and nebulae. A bright, glowing blue star or galaxy core is positioned on the right side, emitting a powerful beam of light that spreads across the frame. On the left, there are intricate, wispy structures of gas and dust, resembling a nebula or a complex gravitational well. The overall aesthetic is one of cosmic wonder and mystery.

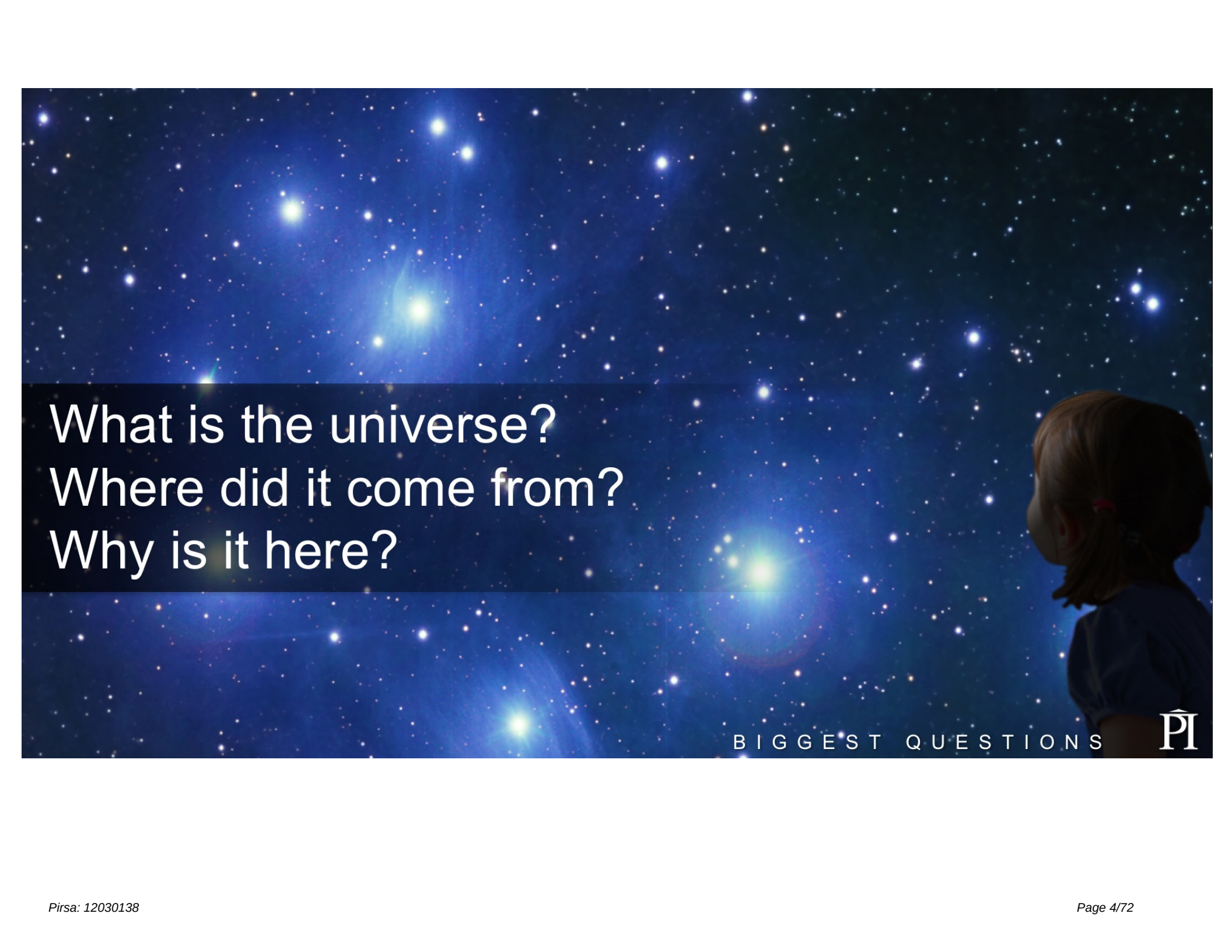
PERIMETER  INSTITUTE FOR THEORETICAL PHYSICS

A close-up, profile view of a young child's face as they blow a dandelion seed. The child's hand is visible, holding the stem of the dandelion. The background is a soft-focus green field with rolling hills in the distance. The text is overlaid on the left side of the image.

What am I?
Where did I come from?
Why am I here?

BIGGEST QUESTIONS

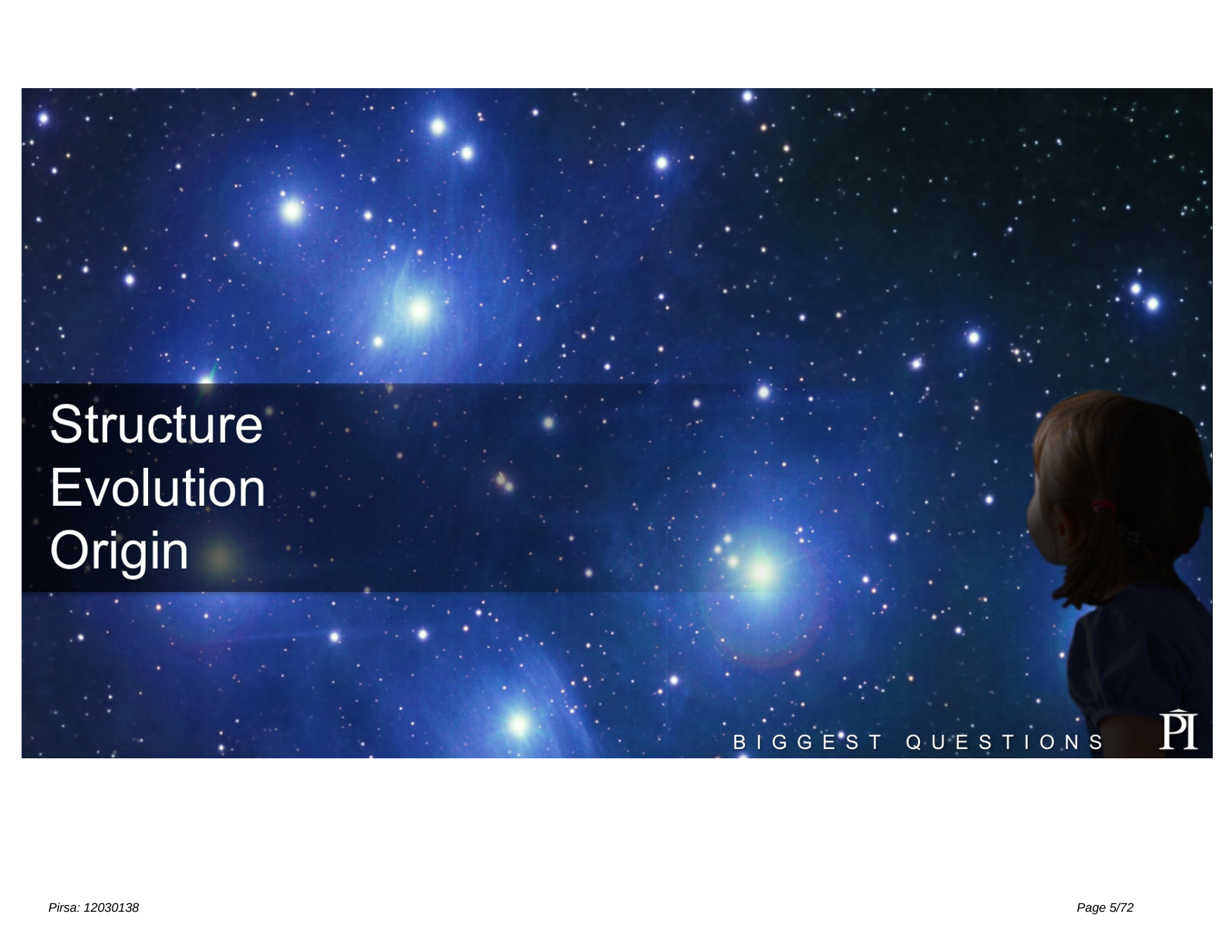


A young child with brown hair is shown in profile, looking up at a vast, deep blue night sky filled with numerous stars of varying brightness. The child is wearing a dark blue shirt. The sky is a rich, dark blue, and the stars are scattered across it, some appearing as bright points of light and others as softer, glowing clouds. The overall mood is one of wonder and curiosity.

What is the universe?
Where did it come from?
Why is it here?

BIGGEST QUESTIONS



A full-page background image showing a young child with brown hair in profile, looking up at a vast, deep blue night sky filled with numerous stars of varying brightness. A dark horizontal band is overlaid on the left side of the image, containing the text 'Structure Evolution Origin'.

Structure Evolution Origin

BIGGEST QUESTIONS



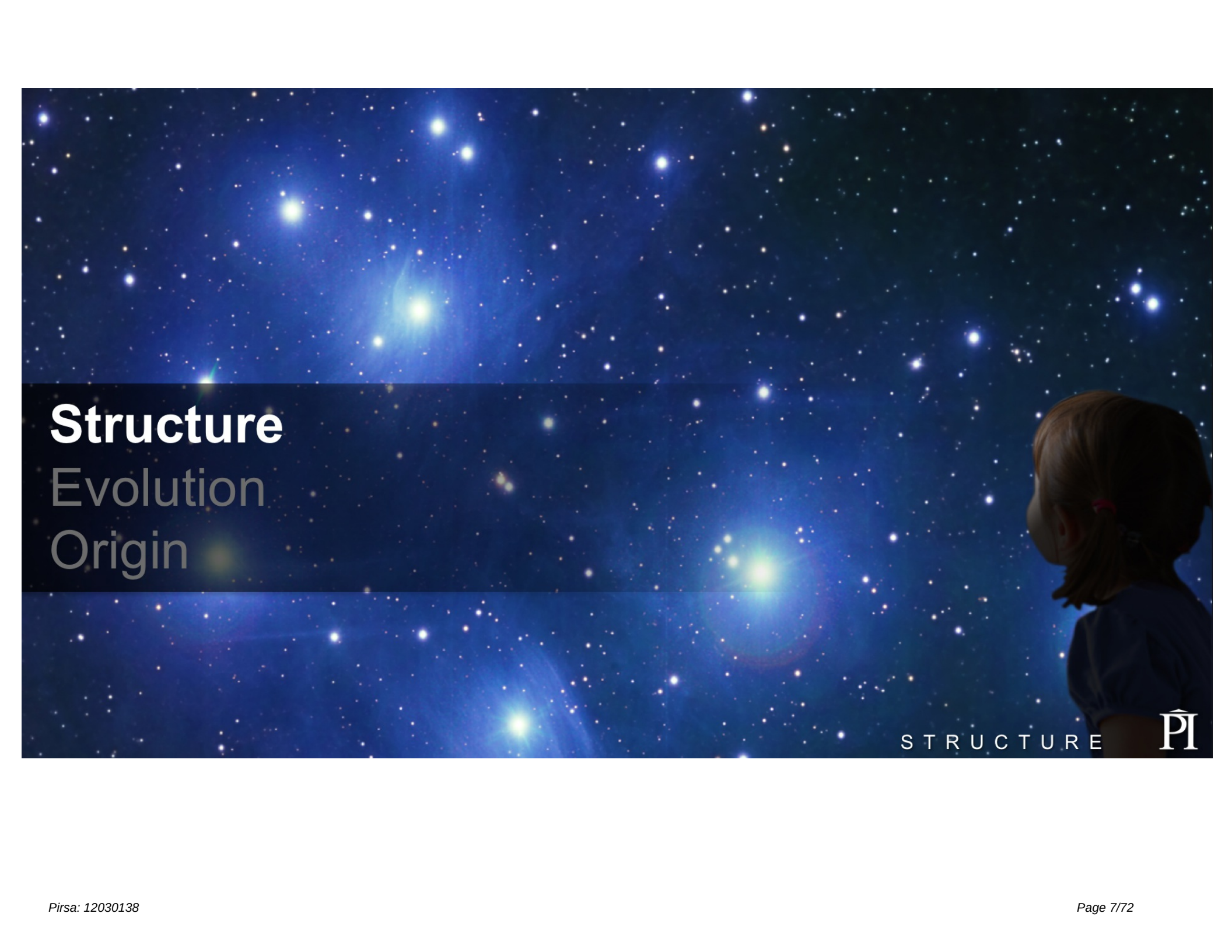


“Imagination is more important than knowledge”

—Albert Einstein

B I G G E S T Q U E S T I O N S



A full-page background image showing a young child with brown hair in profile, looking up at a vast, deep blue night sky filled with numerous stars of varying brightness. The child is wearing a dark blue shirt. The sky is a rich, dark blue, and the stars are scattered across the frame, with some appearing as bright, glowing points of light.

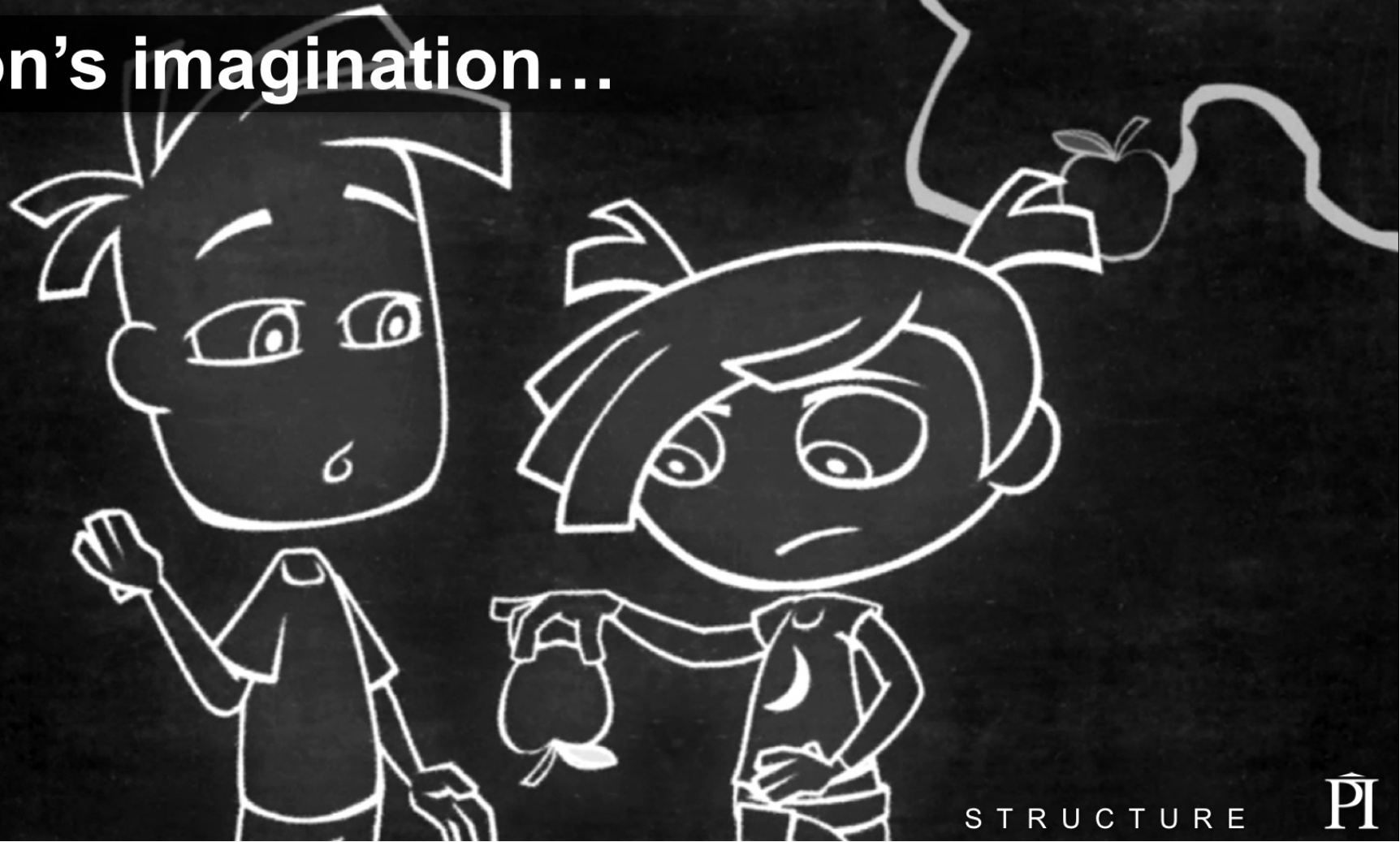
Structure

Evolution

Origin

STRUCTURE 

Newton's imagination...



STRUCTURE

PI



Big Idea: **Gravity** is universal

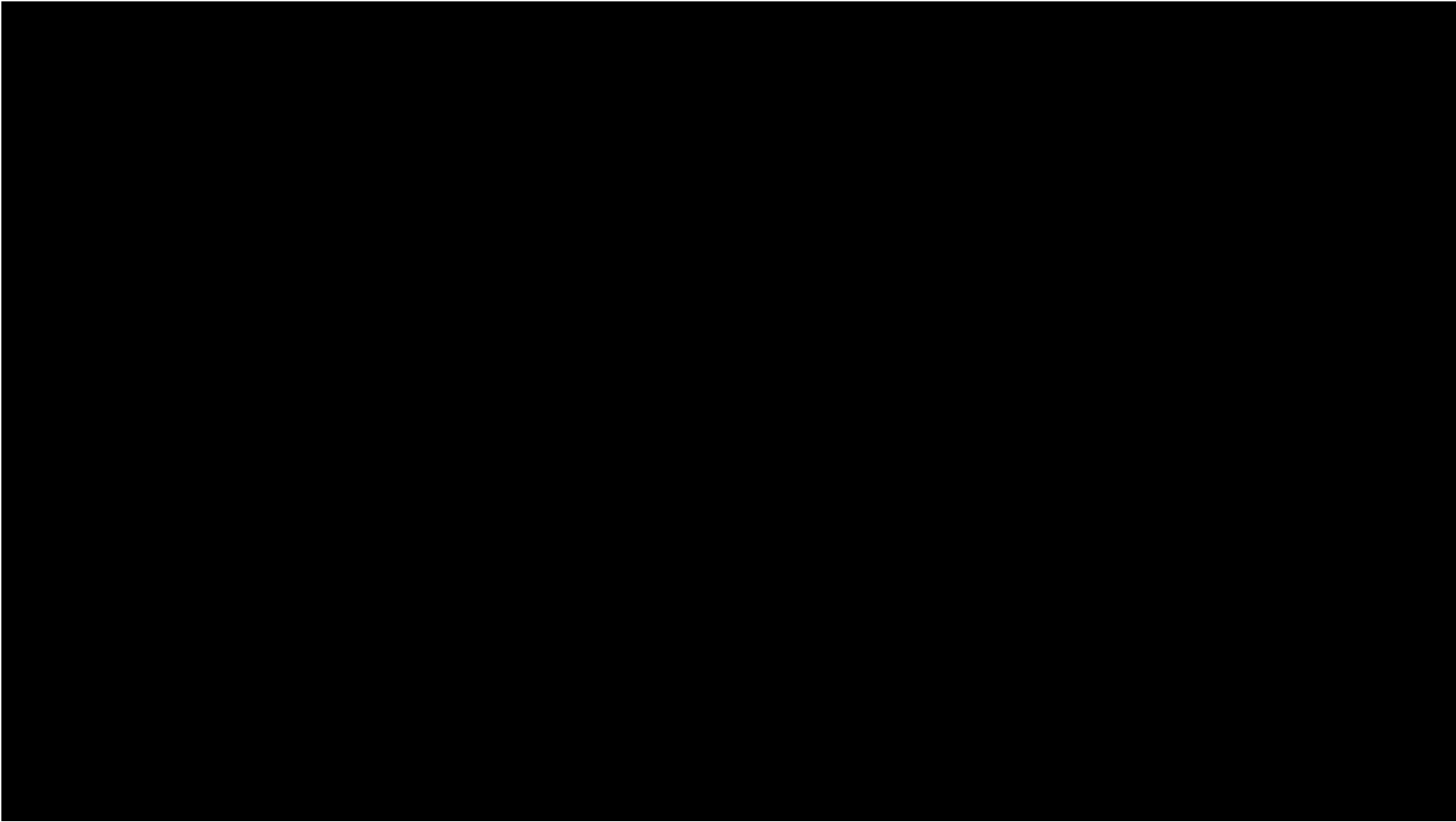


STRUCTURE 

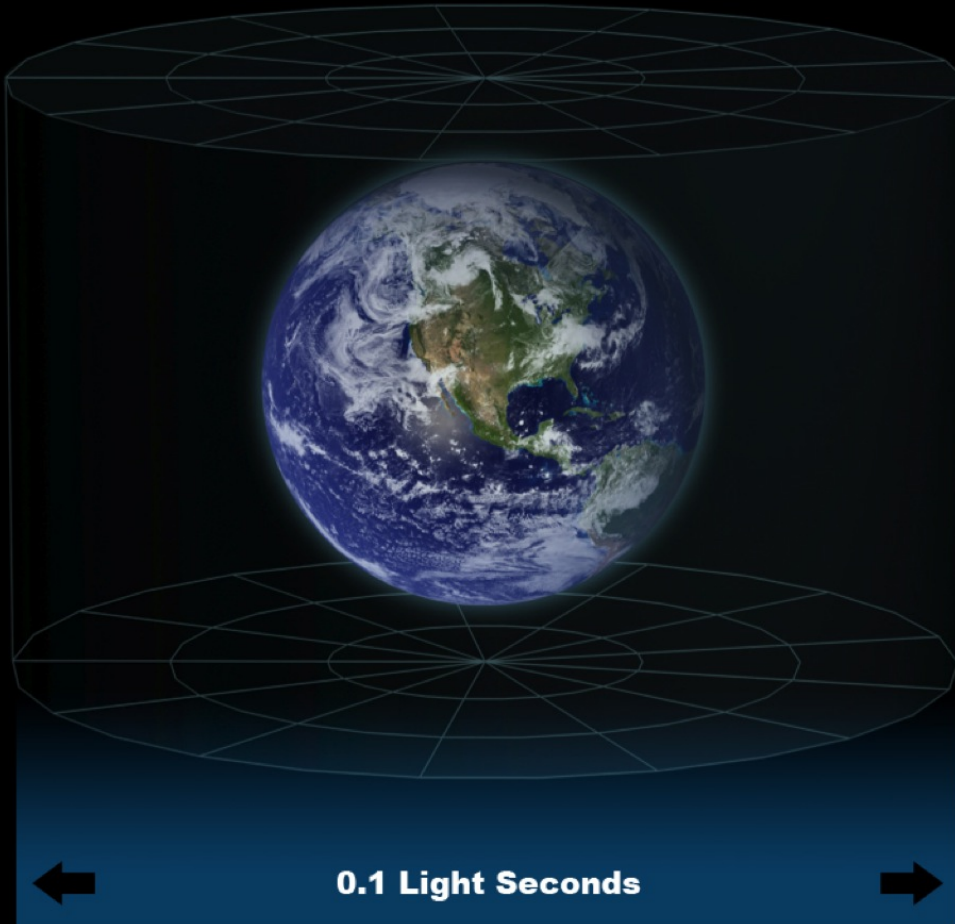
Big Idea: **Gravity governs structure**

STRUCTURE

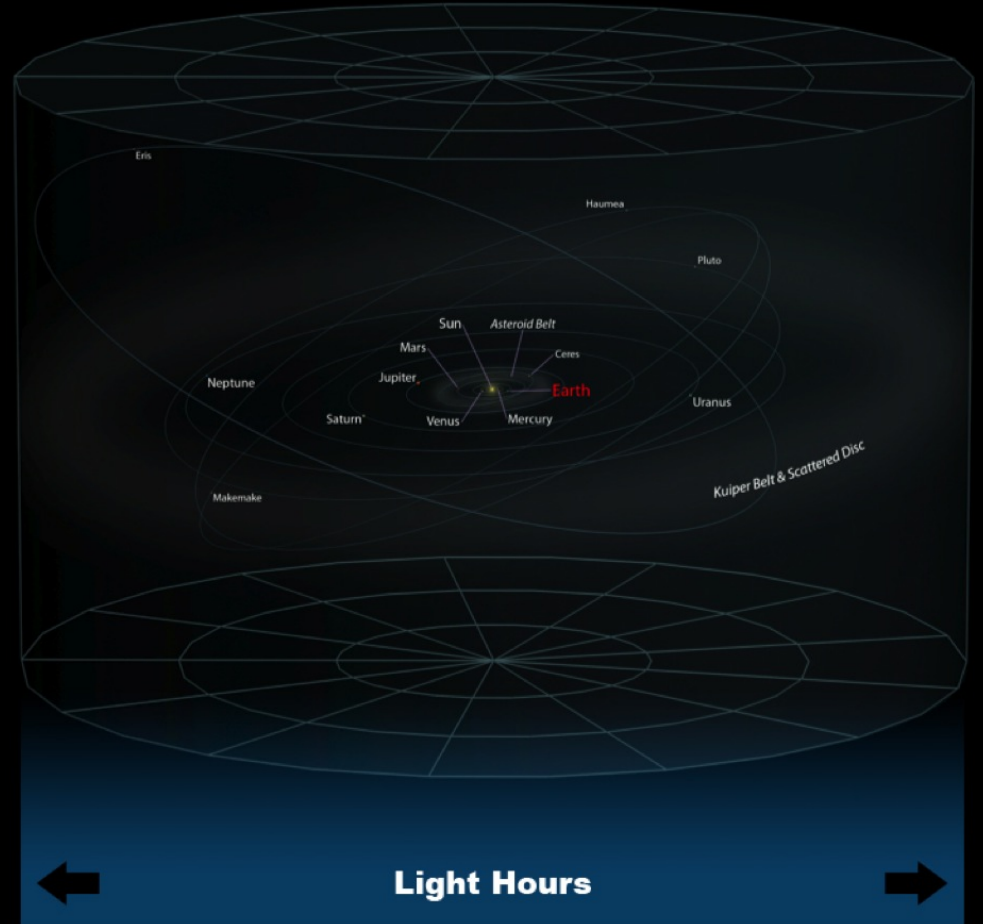




Earth



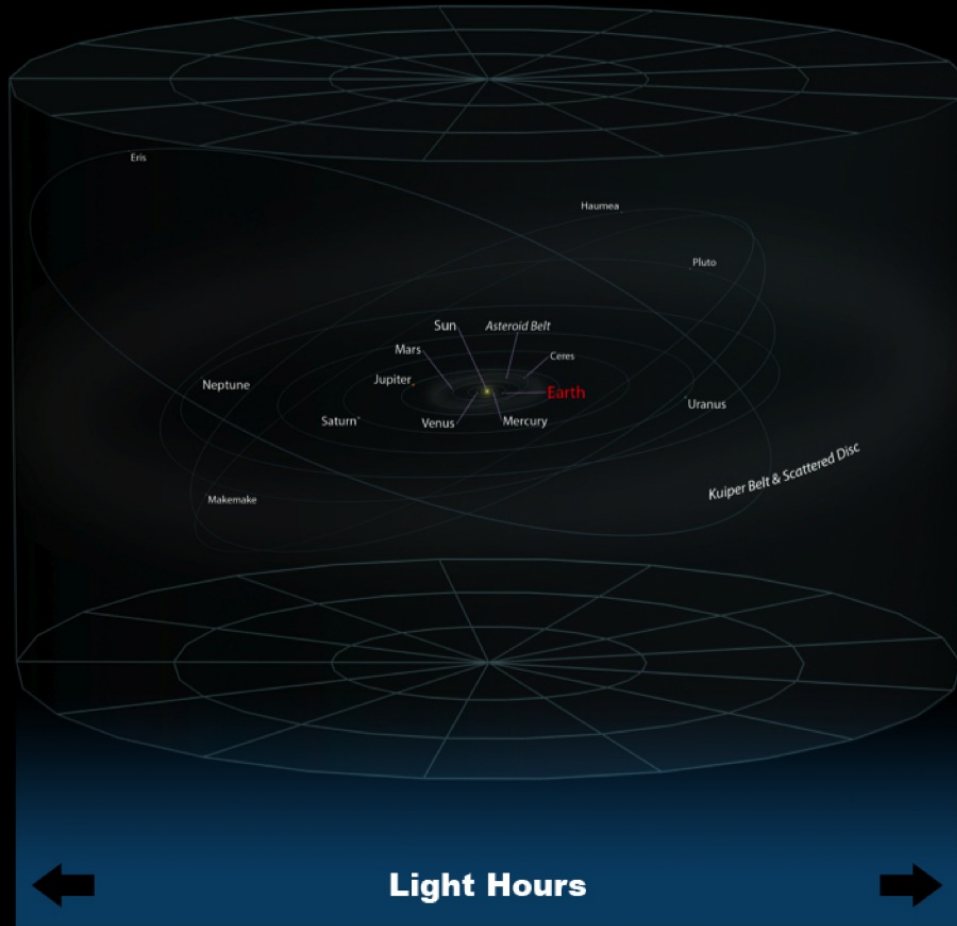
Solar System



STRUCTURE



Solar System



Solar Interstellar Neighborhood



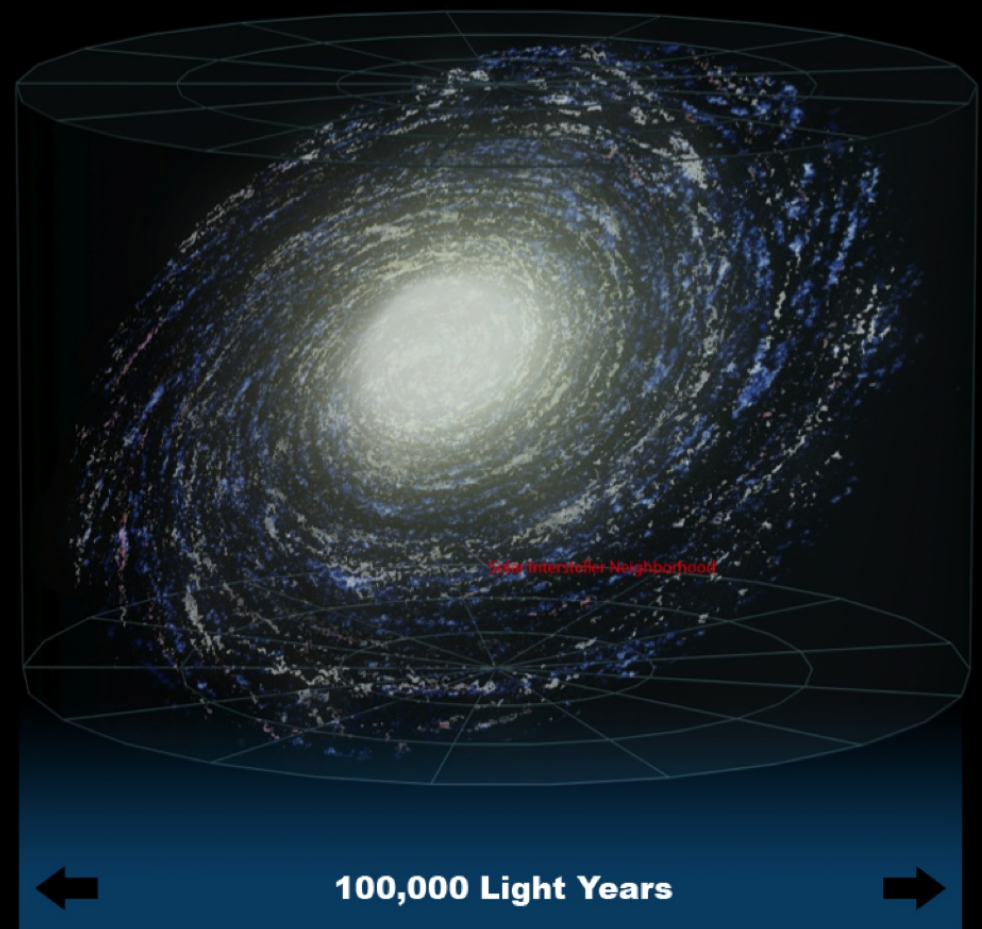
STRUCTURE



Solar Interstellar Neighborhood



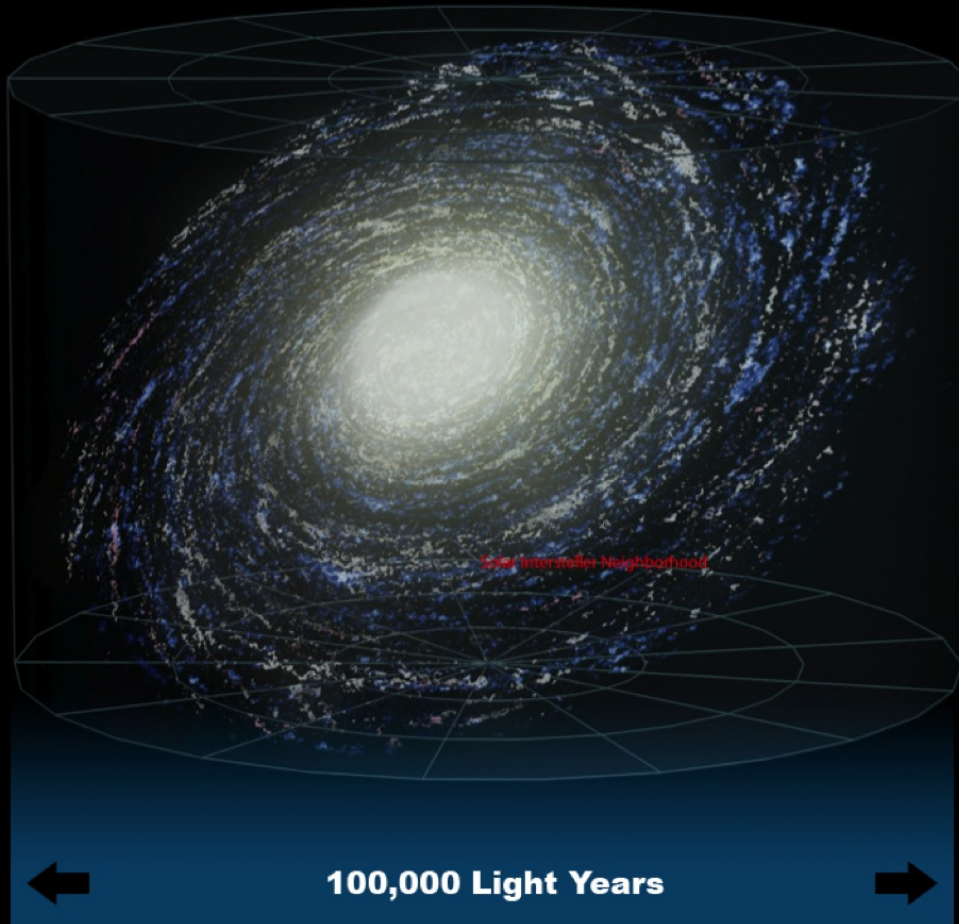
Milky Way Galaxy



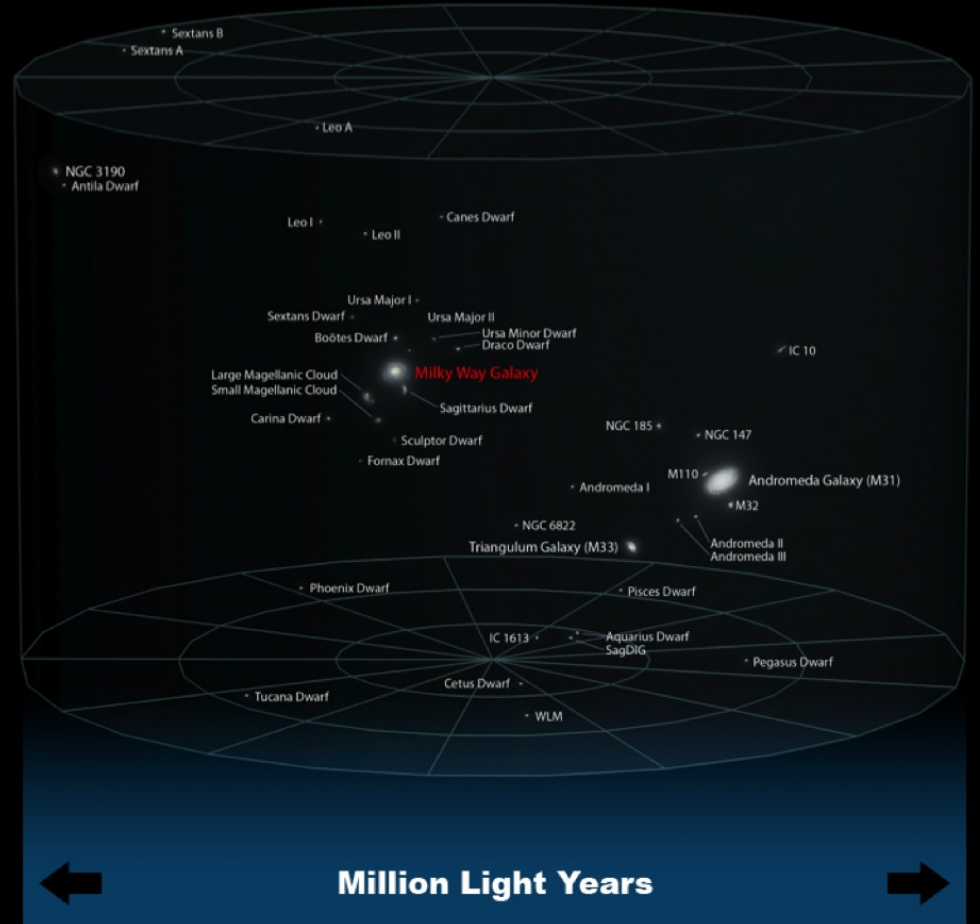
STRUCTURE



Milky Way Galaxy



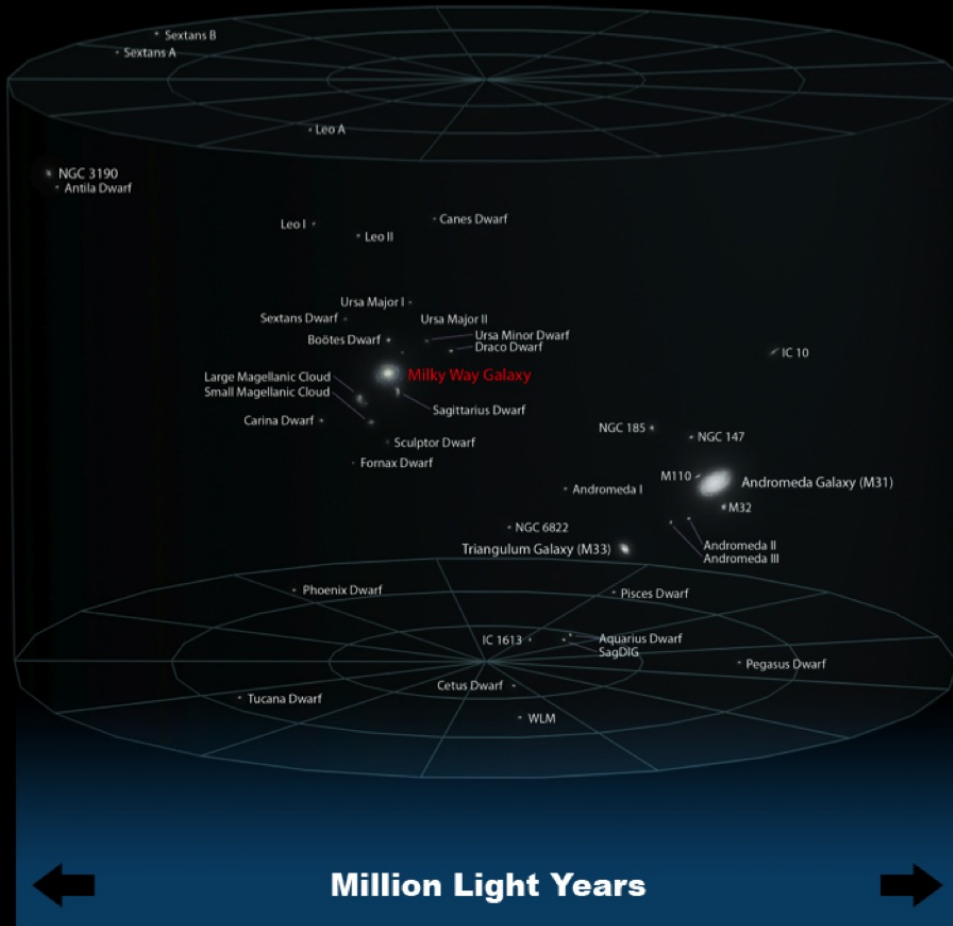
Local Galactic Group



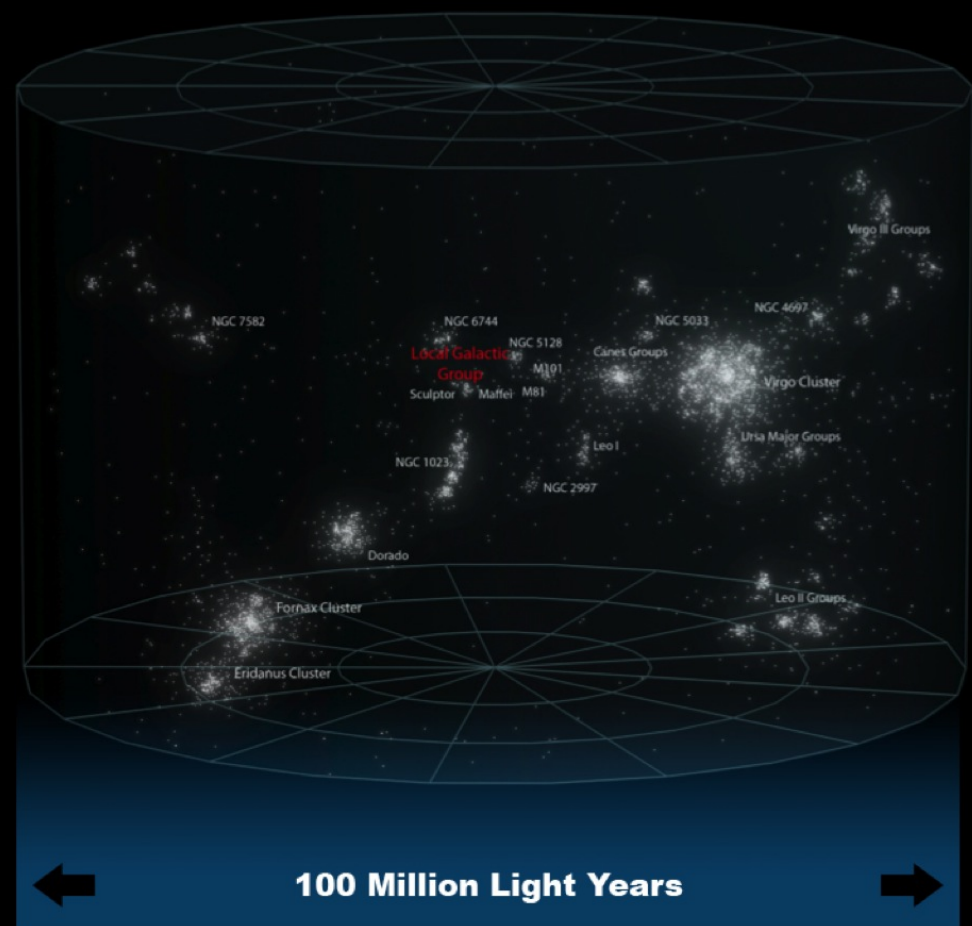
STRUCTURE



Local Galactic Group



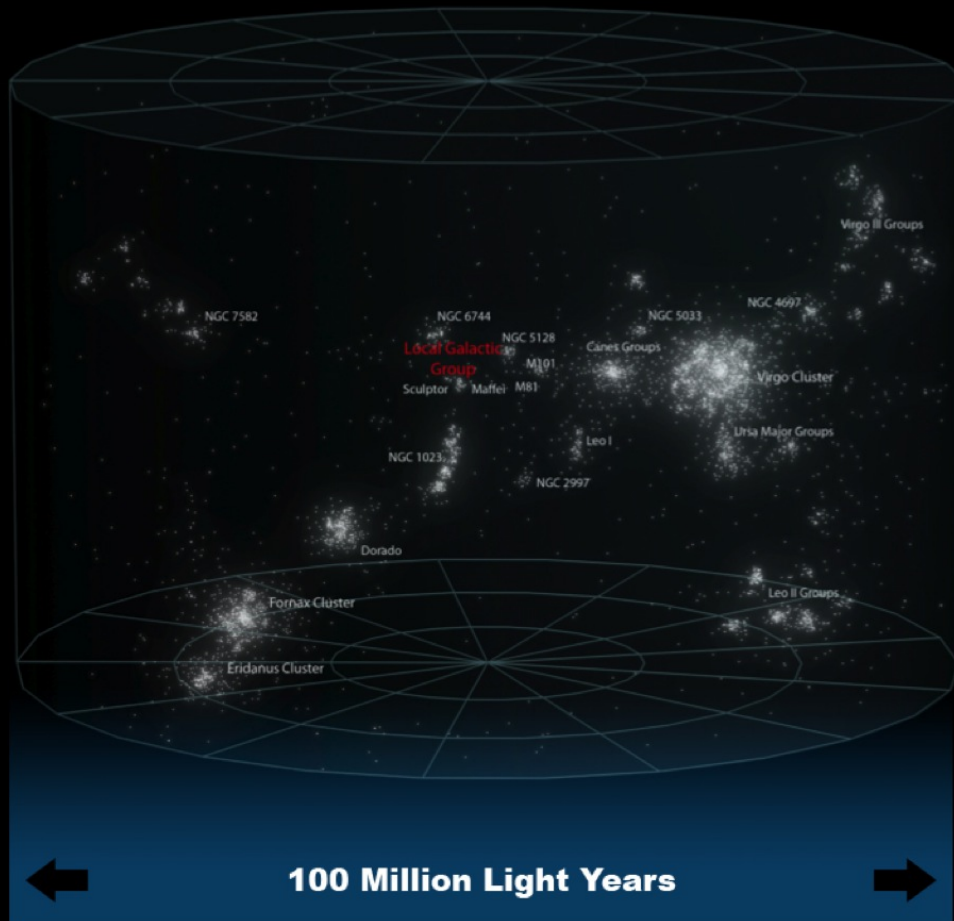
Virgo Supercluster



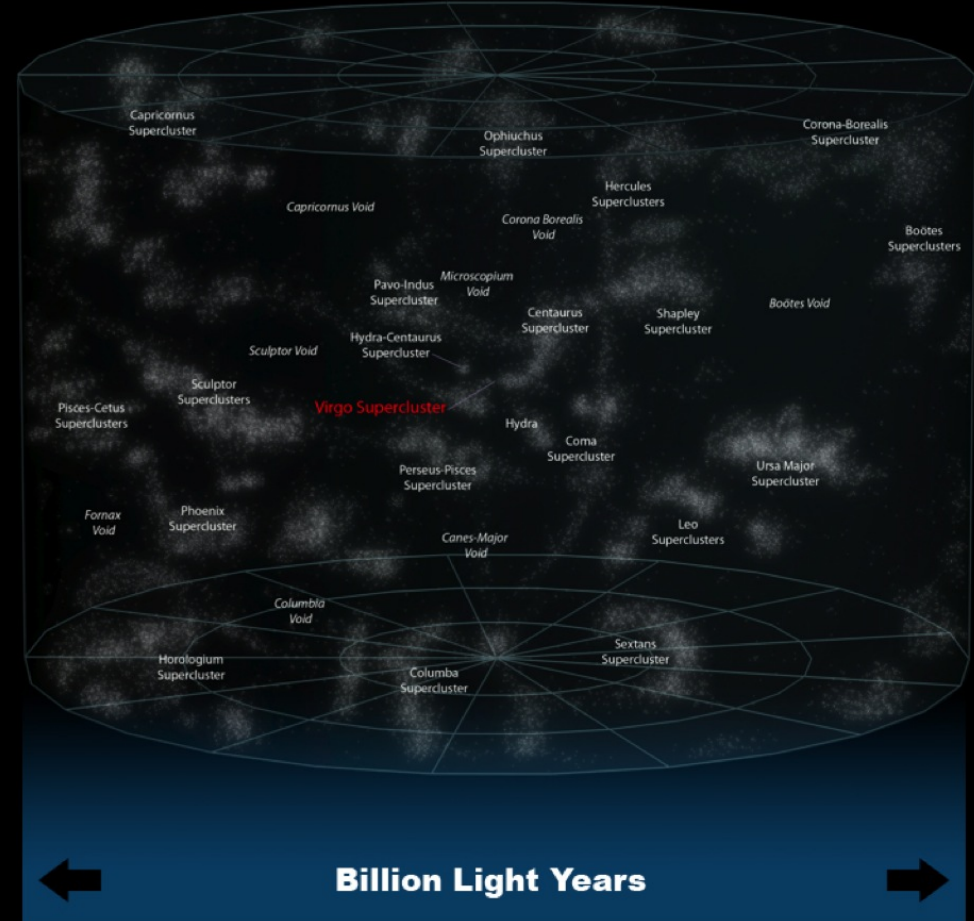
STRUCTURE



Virgo Supercluster



Local Superclusters

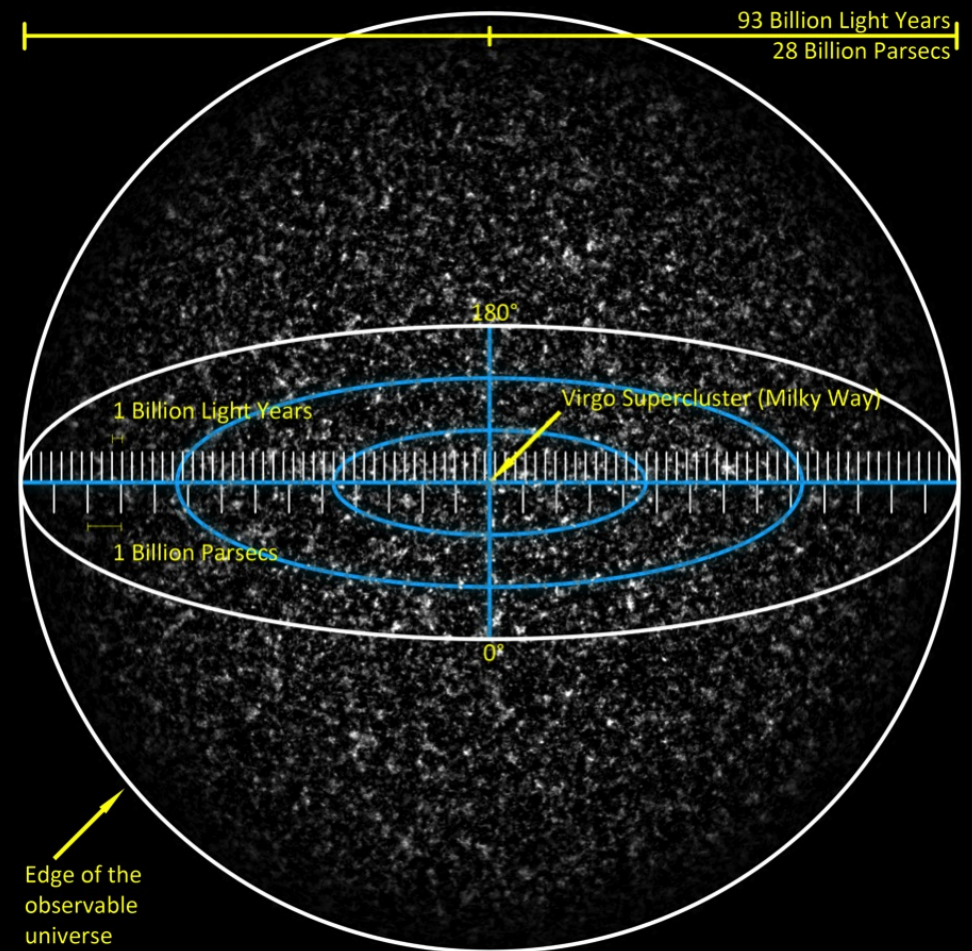


STRUCTURE



Question:
**How big is the
solar system in
this picture?**

Mind Warp:
Universe is BIG



STRUCTURE

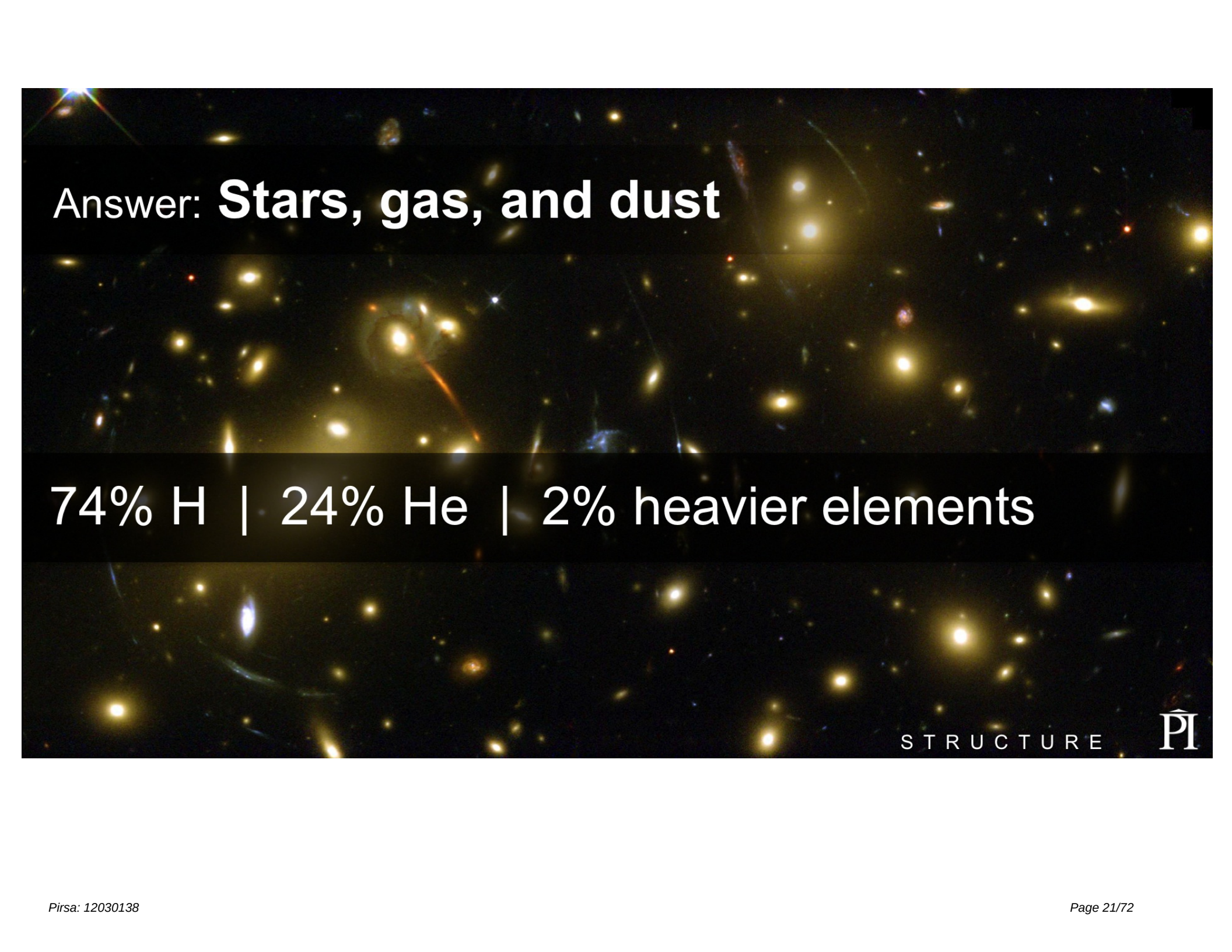




Question: **What is the universe made of?**

STRUCTURE

PI



Answer: **Stars, gas, and dust**

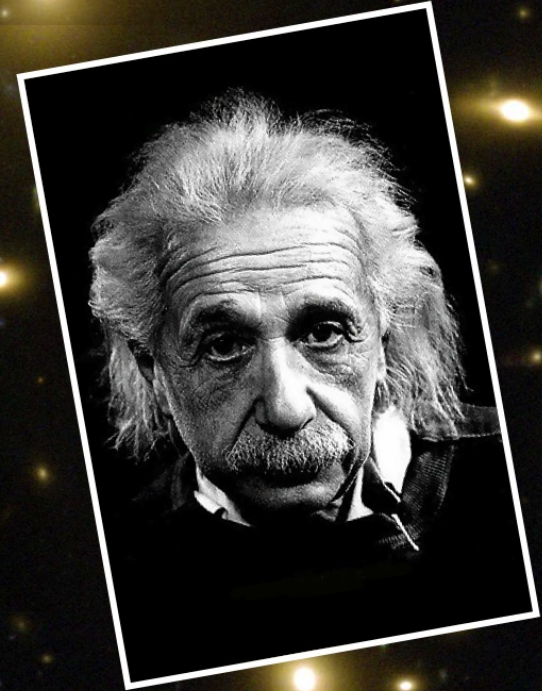
74% H | 24% He | 2% heavier elements

STRUCTURE

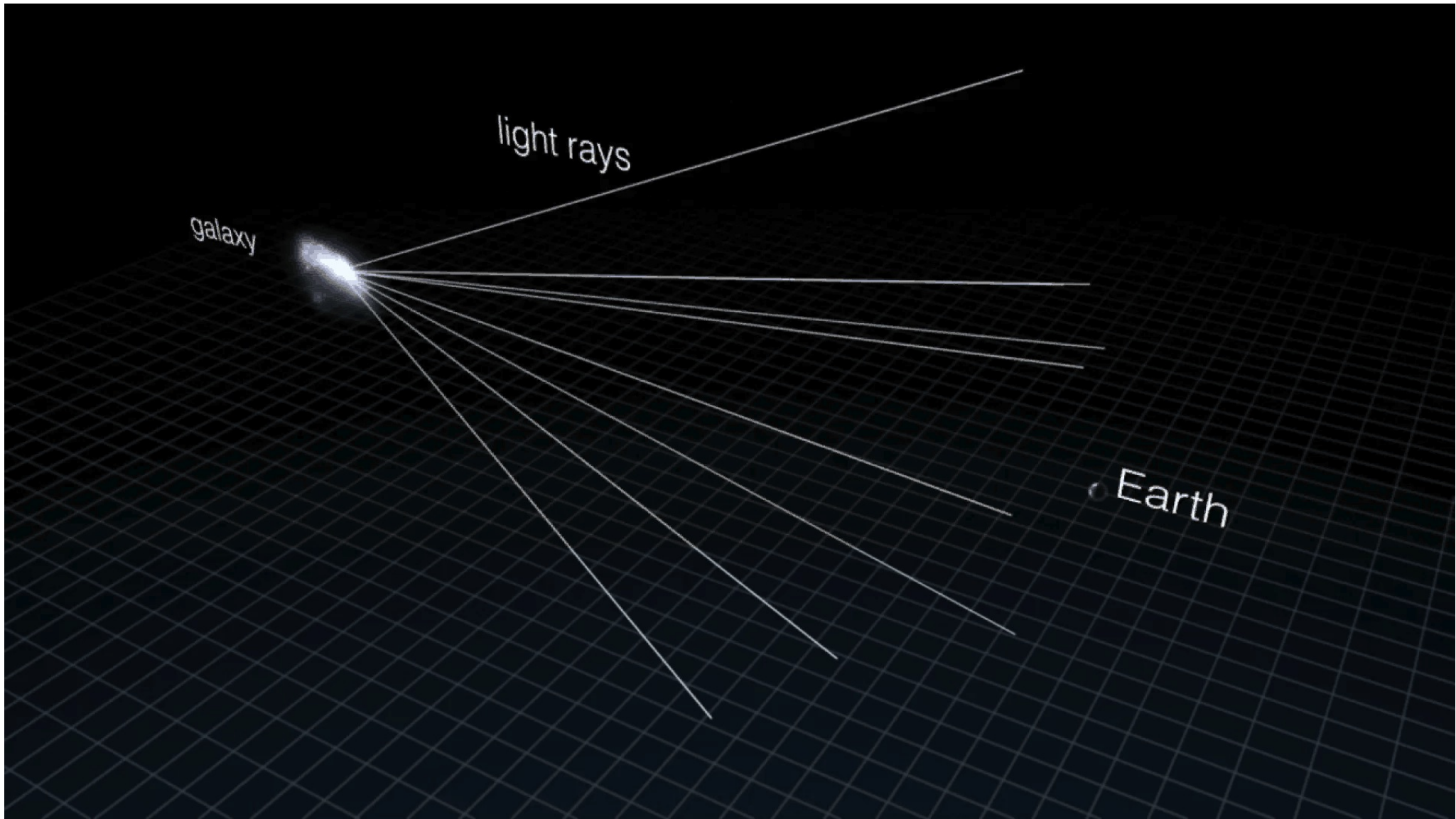


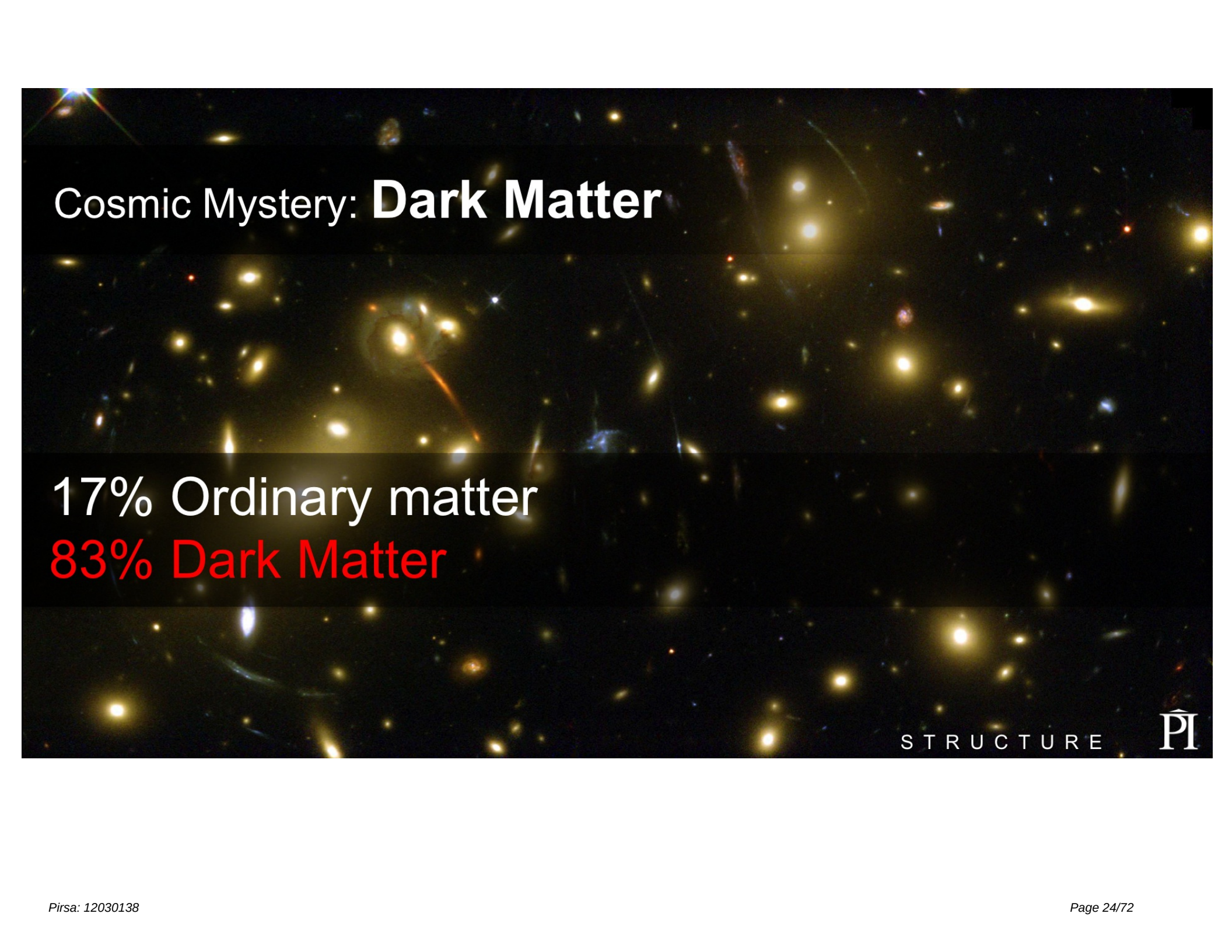
But Wait: **What's causing the distortion?**

Gravity bends light



STRUCTURE 



The background of the slide is a deep space image showing numerous galaxy clusters and individual galaxies. The galaxies appear as bright, yellowish-white points of light against a dark, black background. Some galaxies show distinct spiral or elliptical shapes. The text is overlaid on this image in semi-transparent dark rectangular boxes.

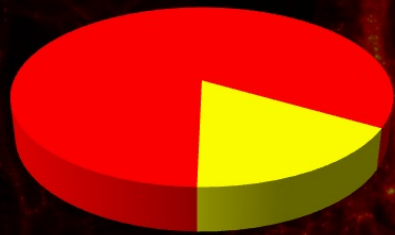
Cosmic Mystery: **Dark Matter**

17% Ordinary matter
83% Dark Matter

STRUCTURE



Cosmic Mystery: **Dark Matter**

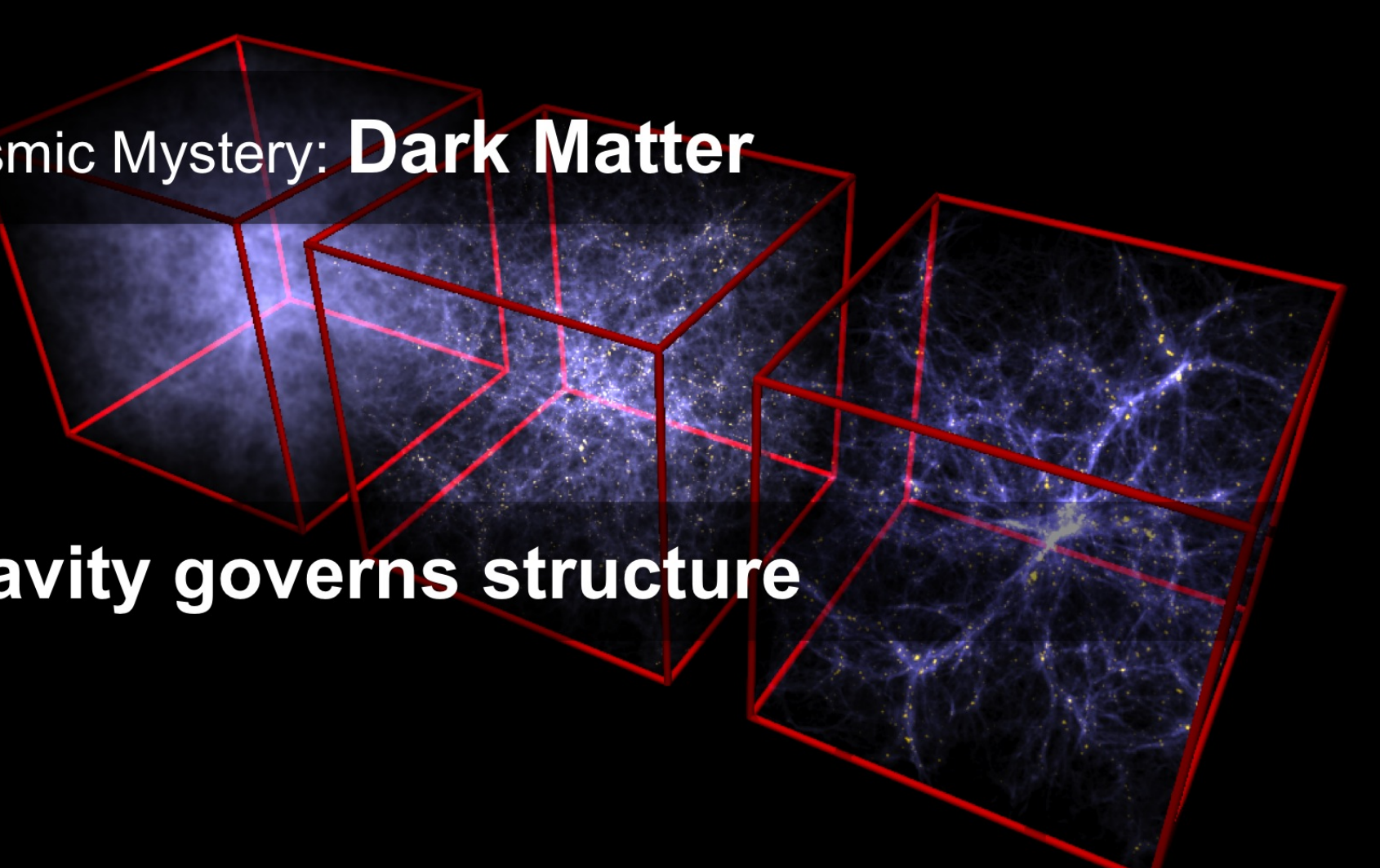


■ Ordinary Matter

■ Dark Matter

STRUCTURE

PI



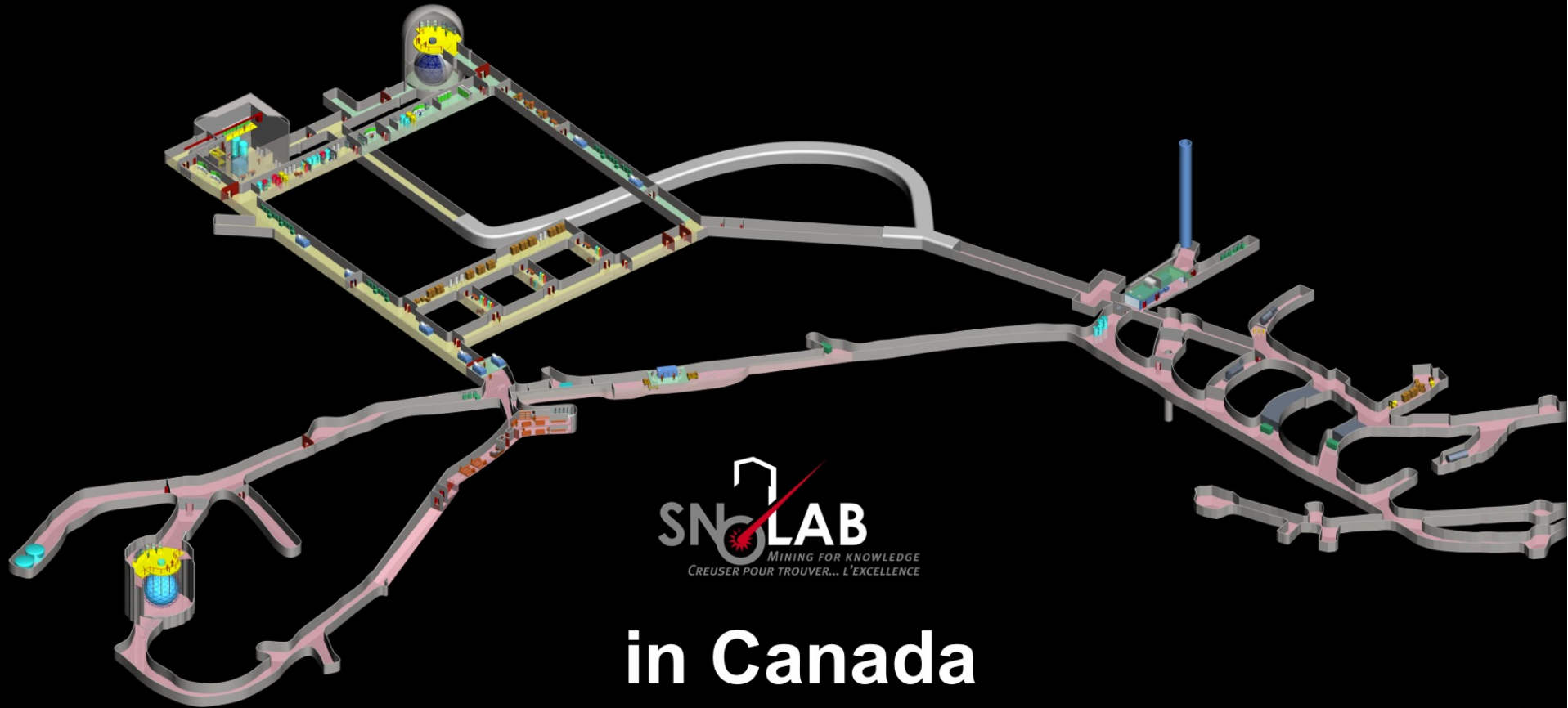
Cosmic Mystery: **Dark Matter**

Gravity governs structure

STRUCTURE



The search for Dark Matter...



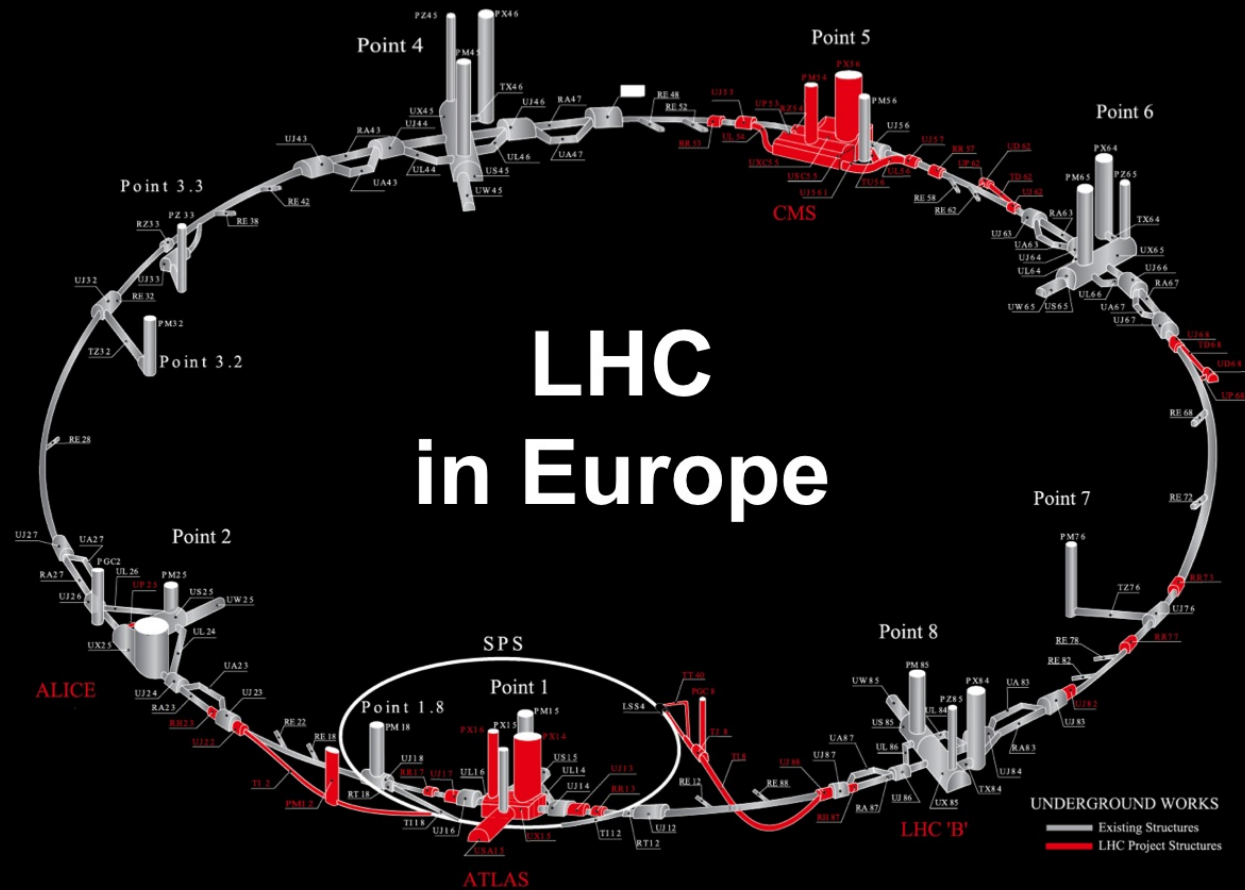
SNOLAB
MINING FOR KNOWLEDGE
CREUSER POUR TROUVER... L'EXCELLENCE

in Canada

STRUCTURE

PI

The search for Dark Matter...



STRUCTURE



Wonder & Curiosity

What is the universe made of?

Imagination & Reasoning

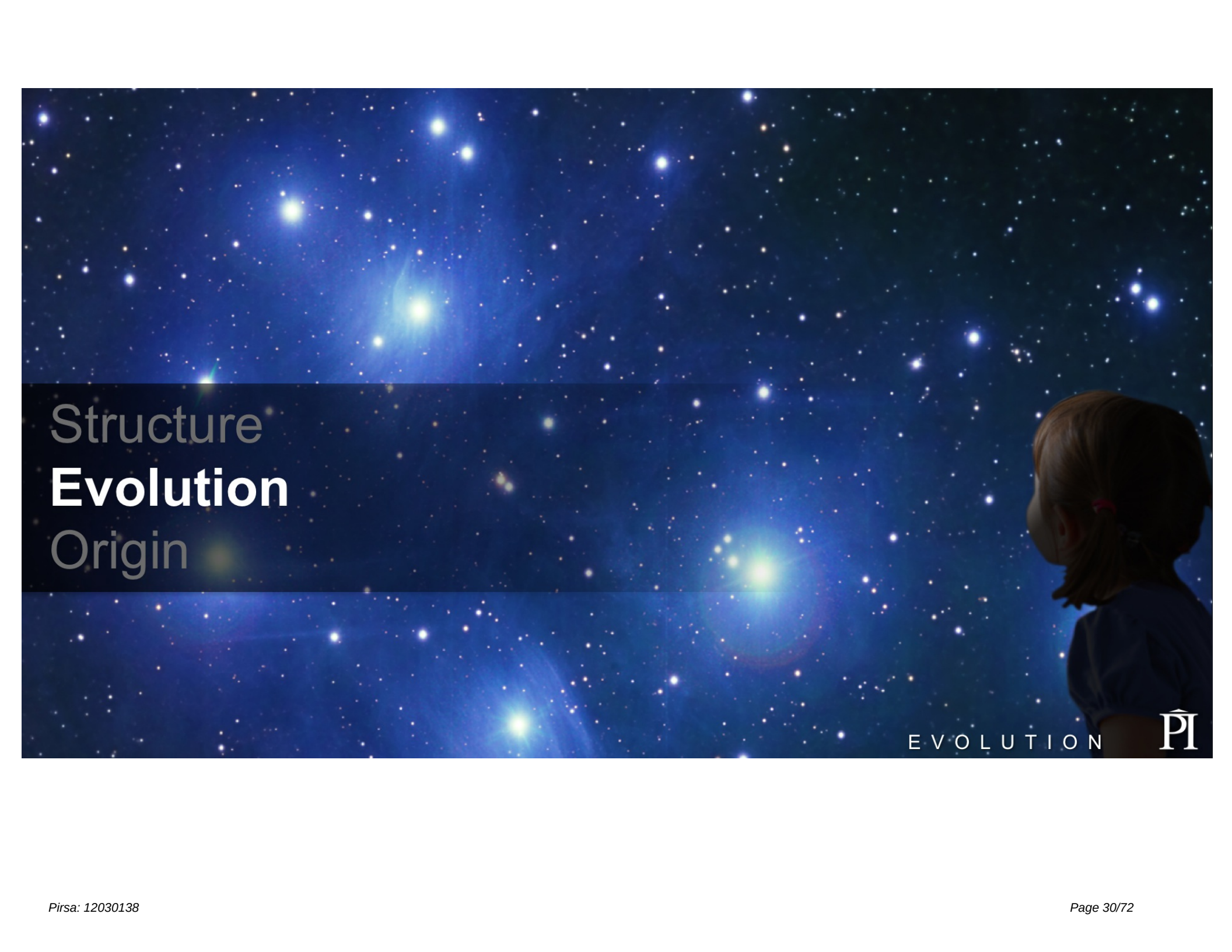
Gravity bends light → Use to map universe

Discovery & Deeper Mystery

More bending than expected → Dark Matter

STRUCTURE

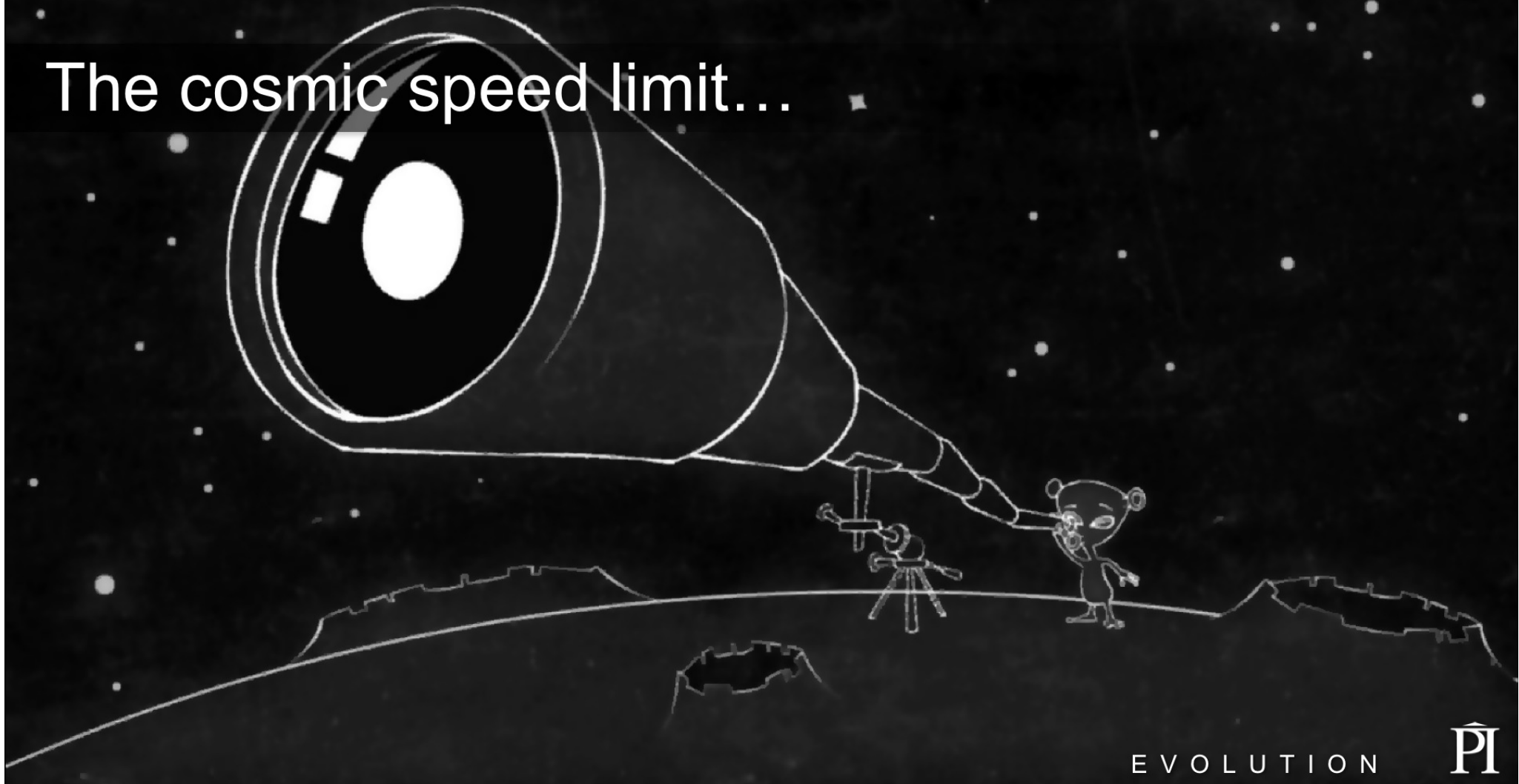


A child with brown hair, seen from the side, is looking up at a vast, deep blue night sky filled with numerous stars of varying brightness. The sky is a rich, dark blue, and the stars are scattered across it, some appearing as sharp points of light while others have a soft, glowing halo. The child is positioned in the lower right corner, their head tilted back slightly. The overall mood is one of wonder and contemplation.

Structure **Evolution** Origin

EVOLUTION 

The cosmic speed limit...



EVOLUTION

PI



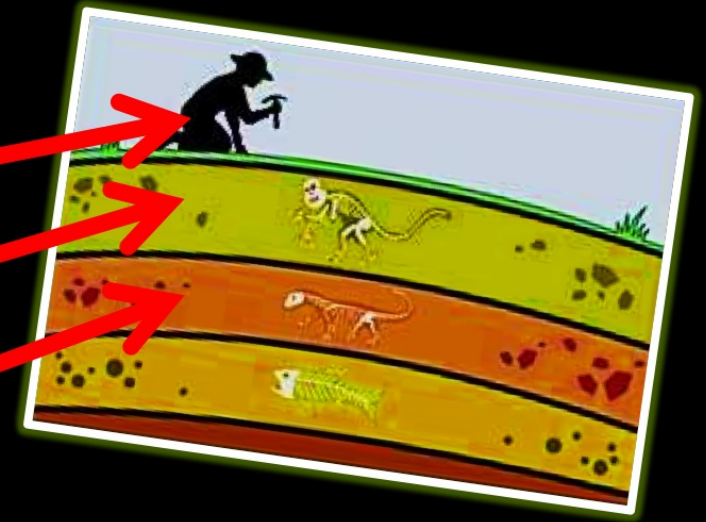
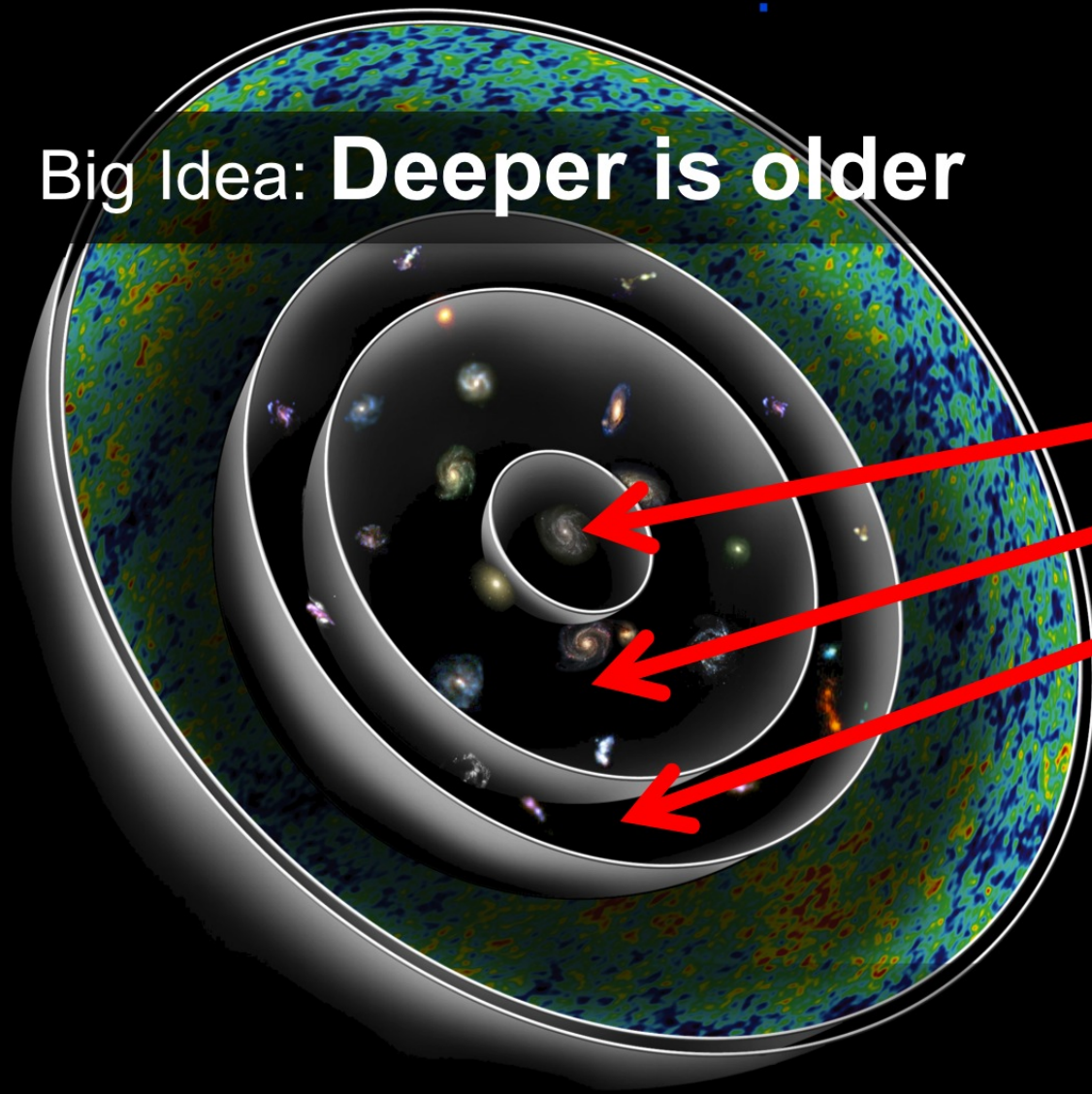


Big Idea: **The past is written in the sky**

EVOLUTION

PI

Big Idea: **Deeper is older**



EVOLUTION

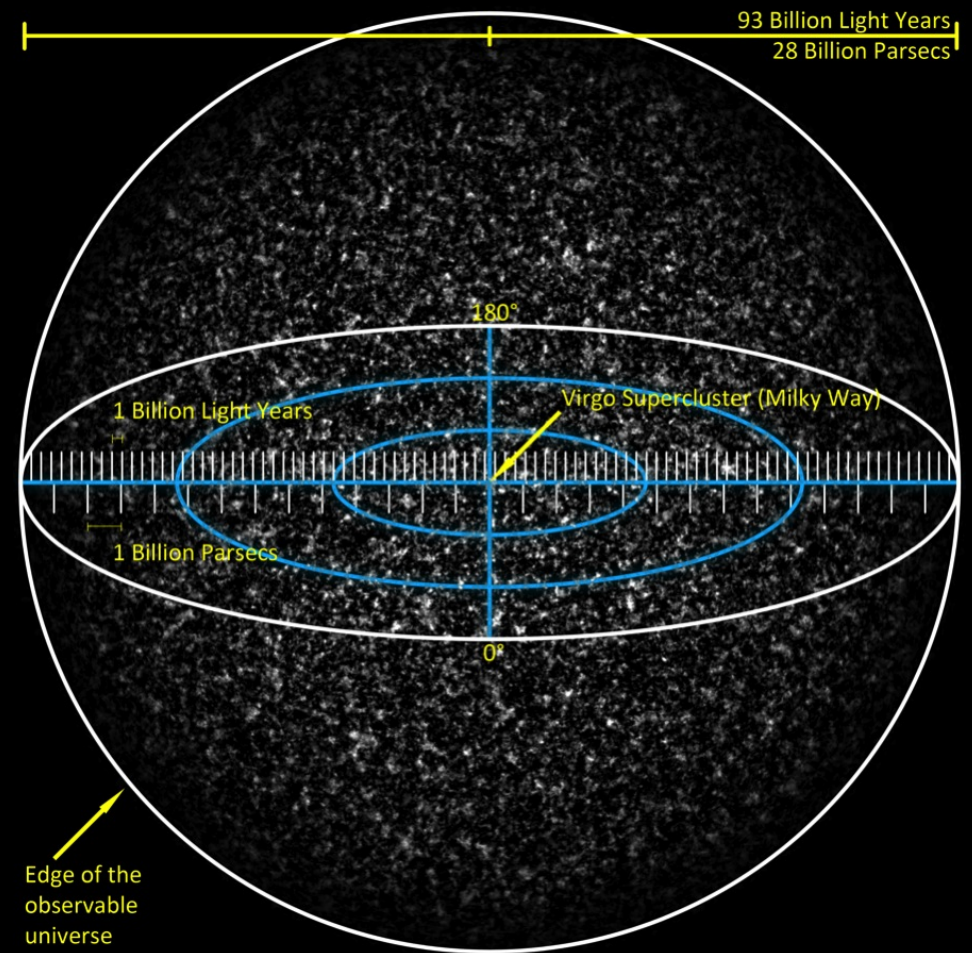


Big Idea: **A more violent past**



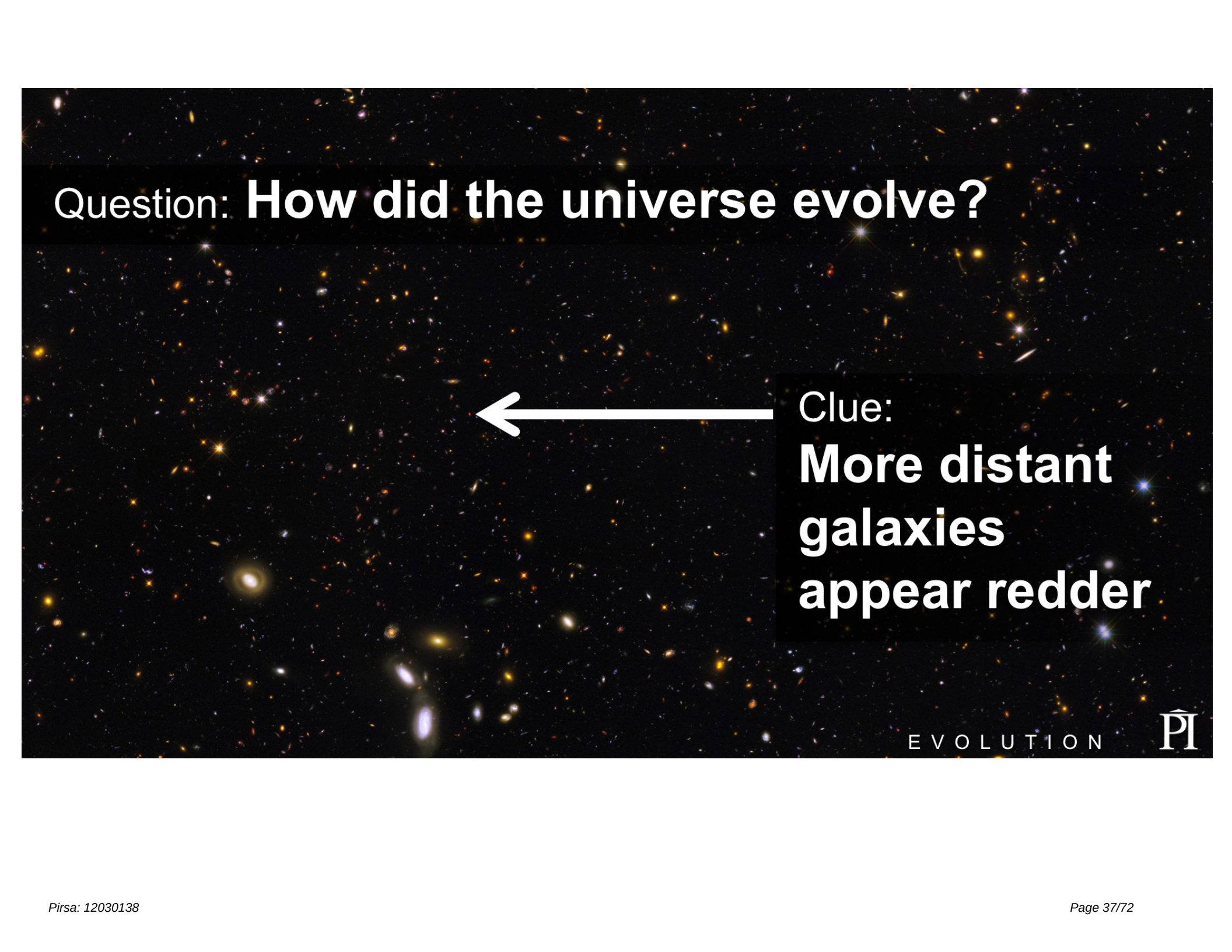
Question:
**From this picture,
the universe is at
least how old?**

Mind Warp:
Universe is OLD



EVOLUTION





Question: **How did the universe evolve?**

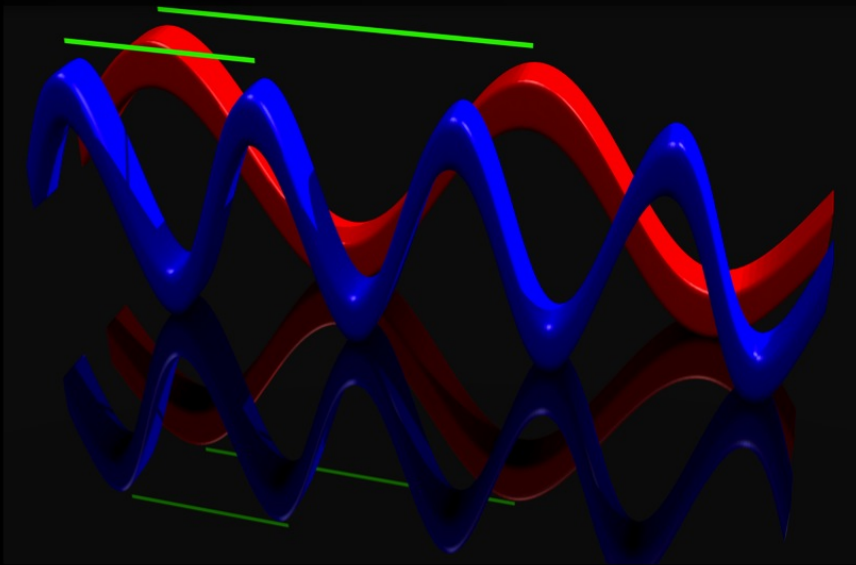


Clue:
**More distant
galaxies
appear redder**

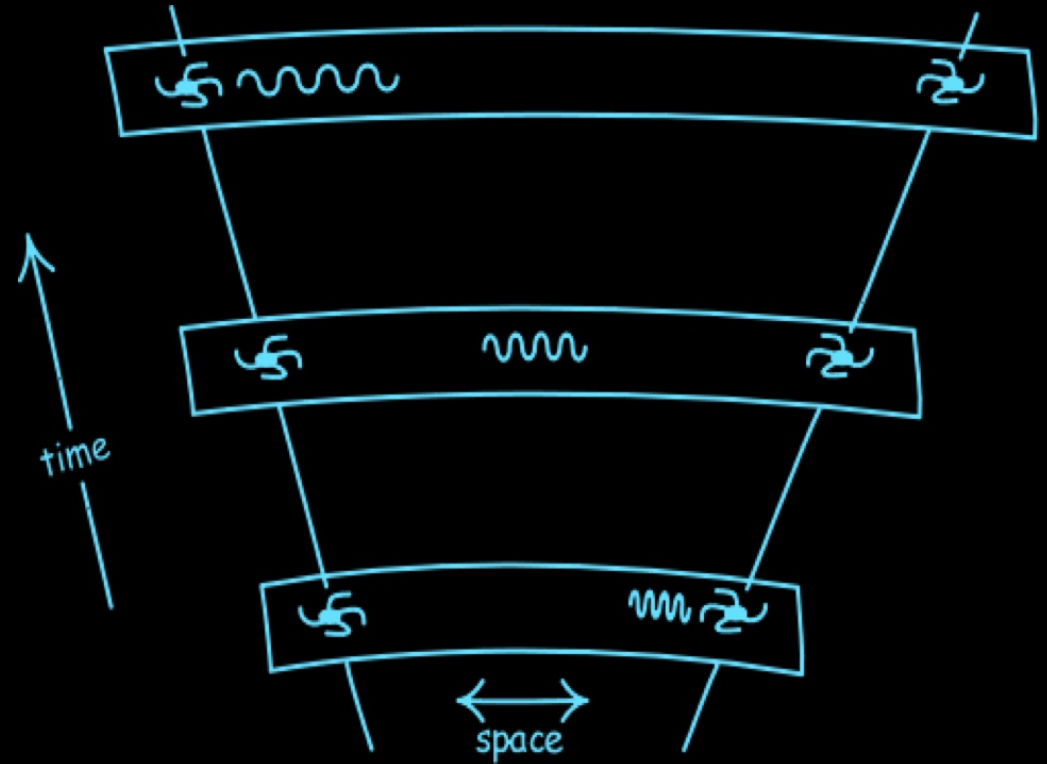
EVOLUTION

PI

Question: **How did the universe evolve?**



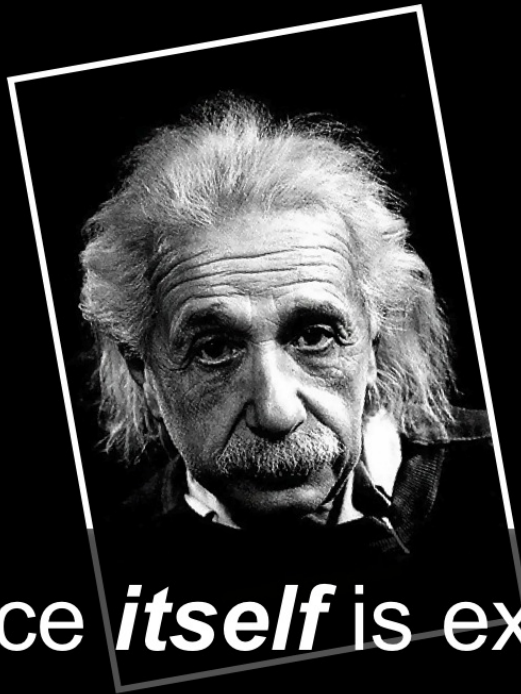
Light is stretched



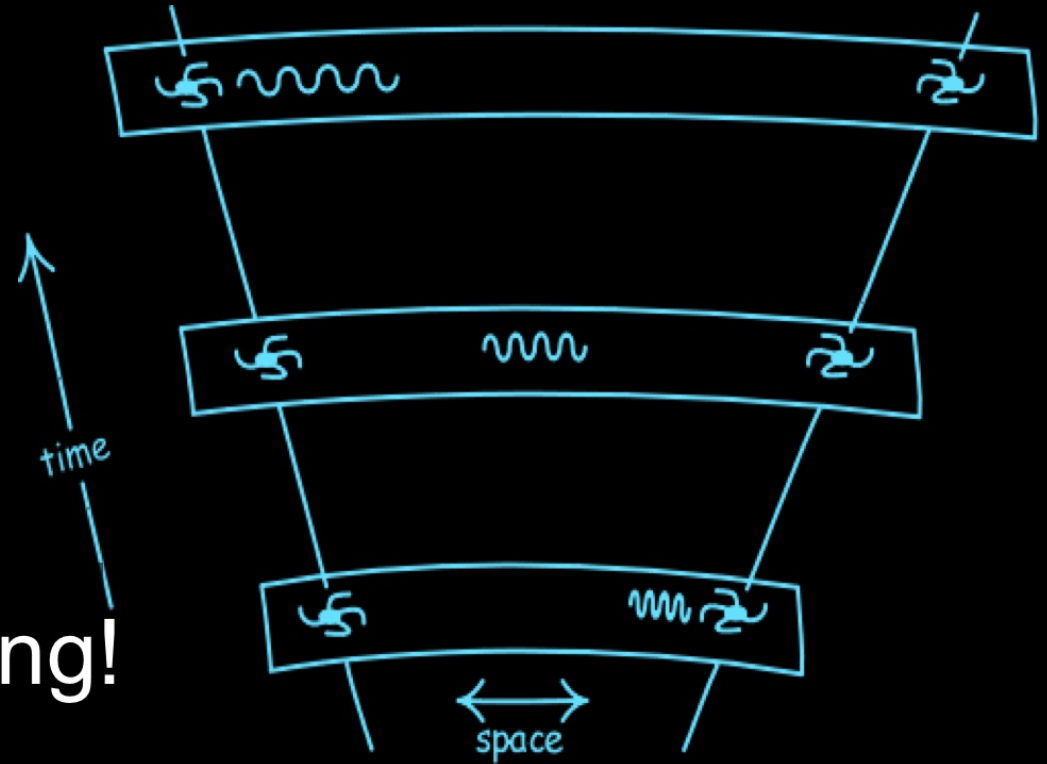
EVOLUTION

PI

Answer: **The universe is expanding!**

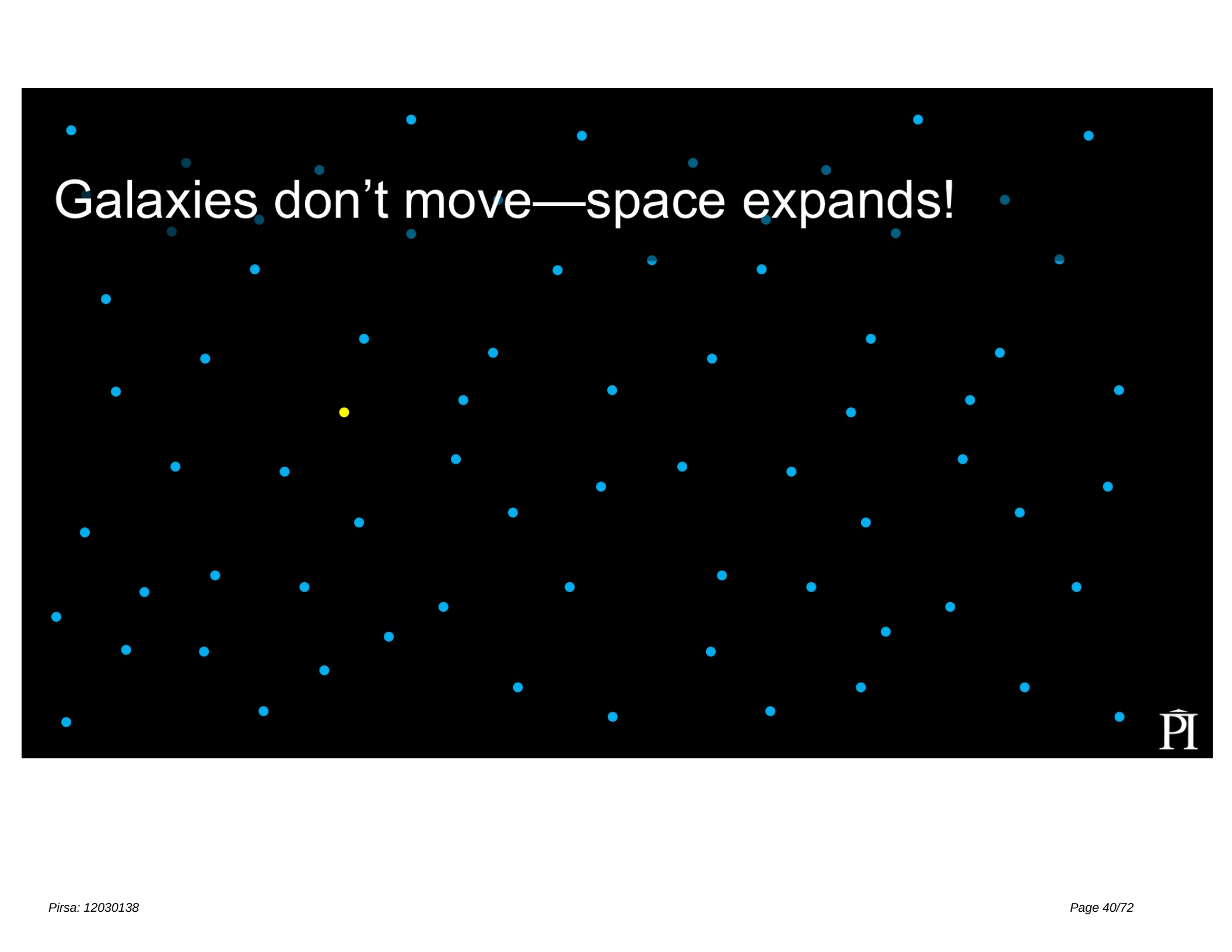


Space *itself* is expanding!

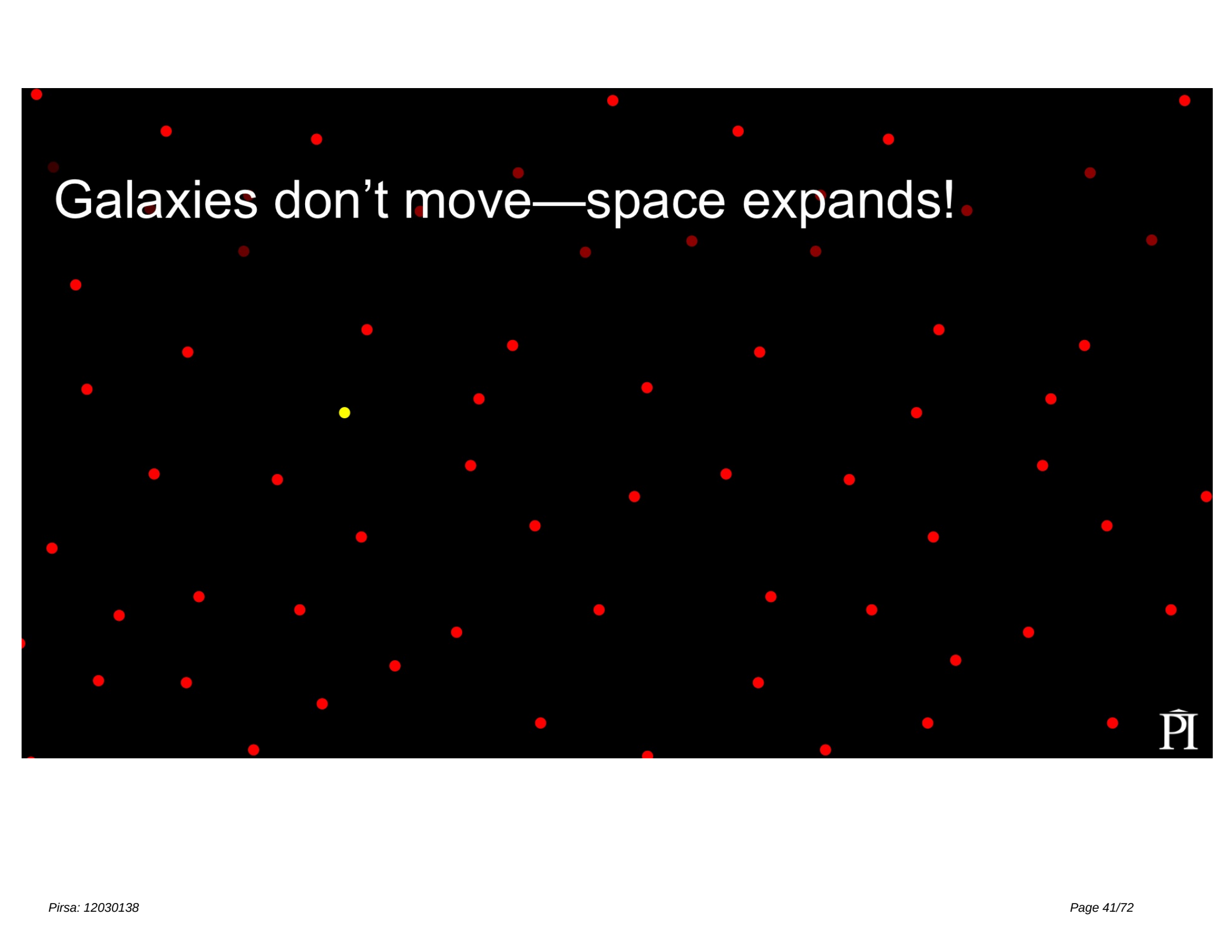


EVOLUTION

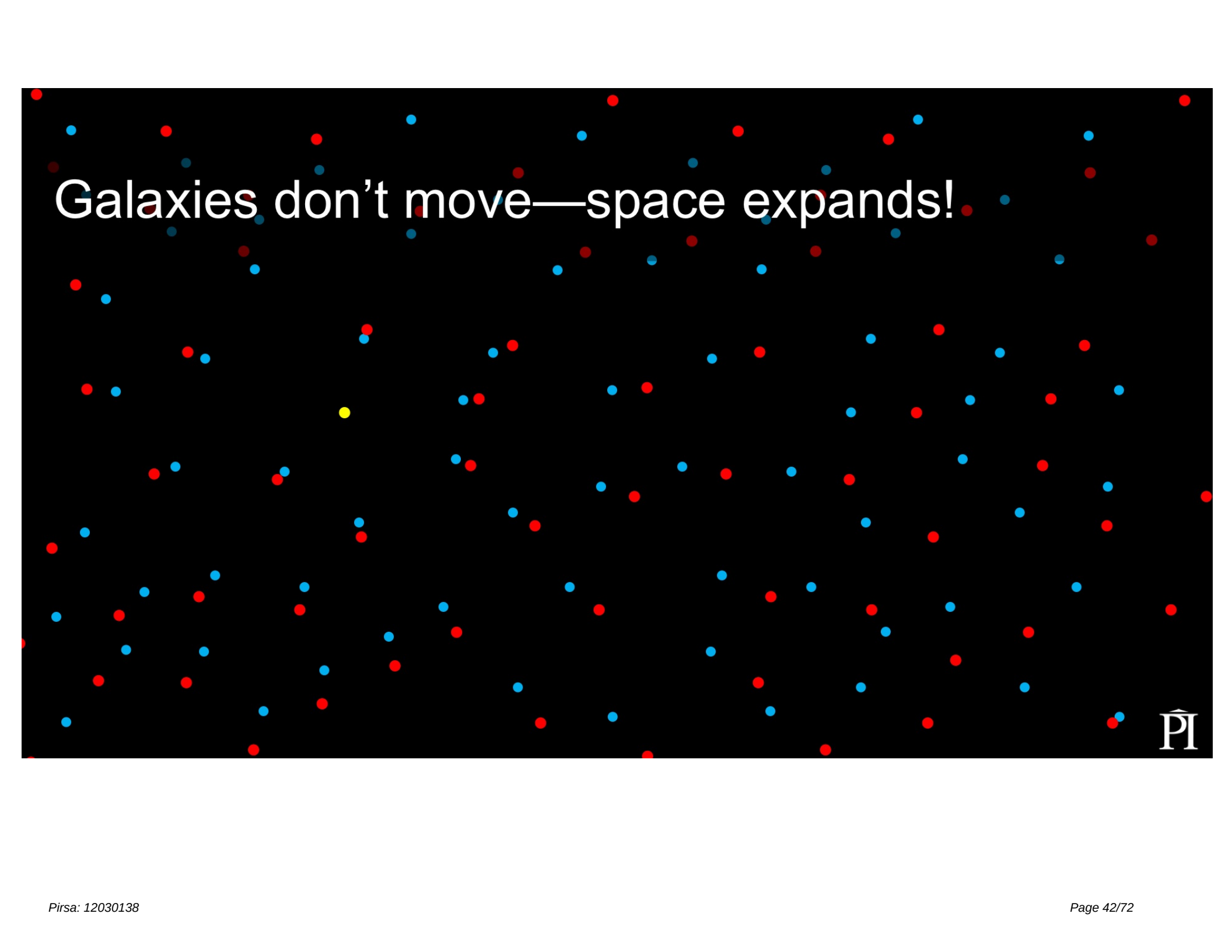




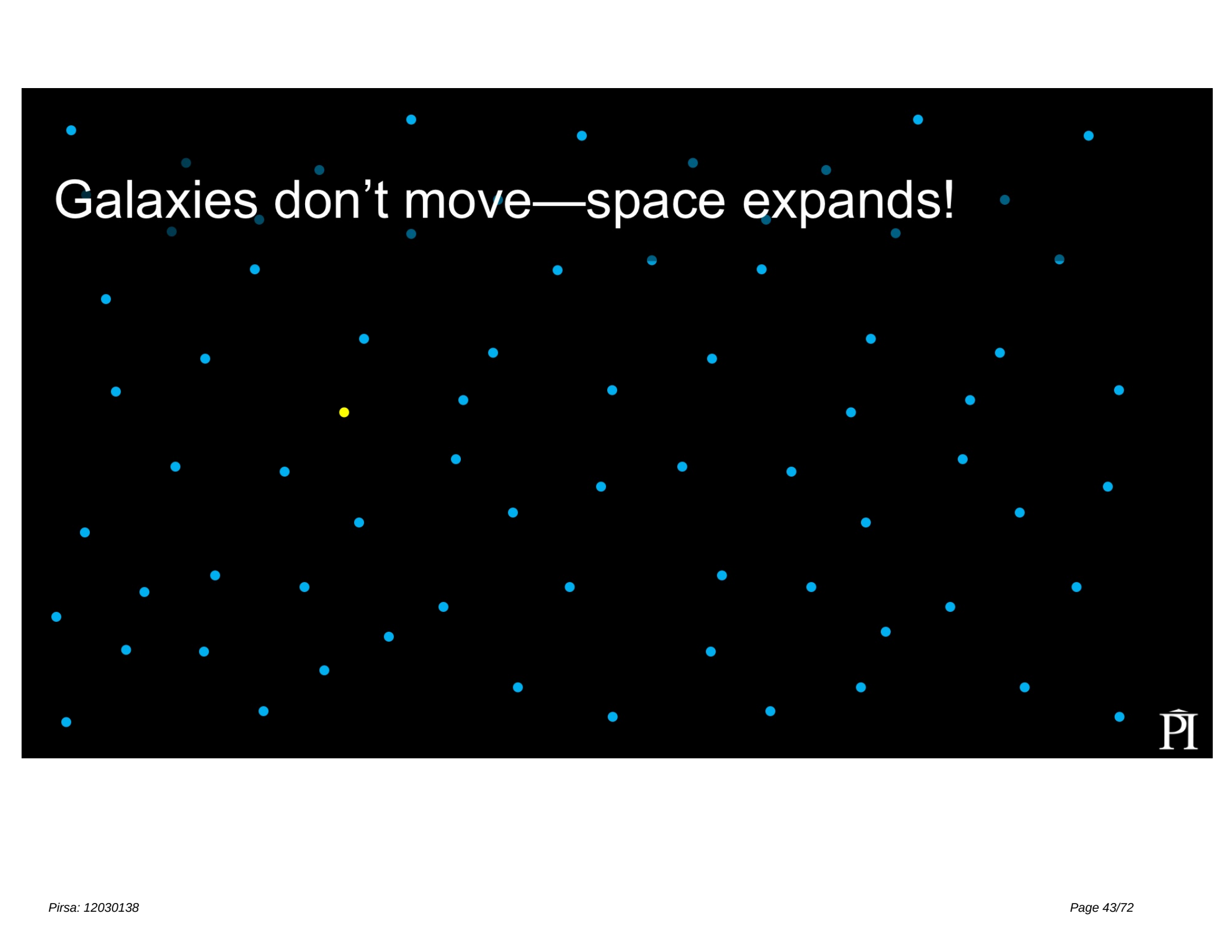
Galaxies don't move—space expands!



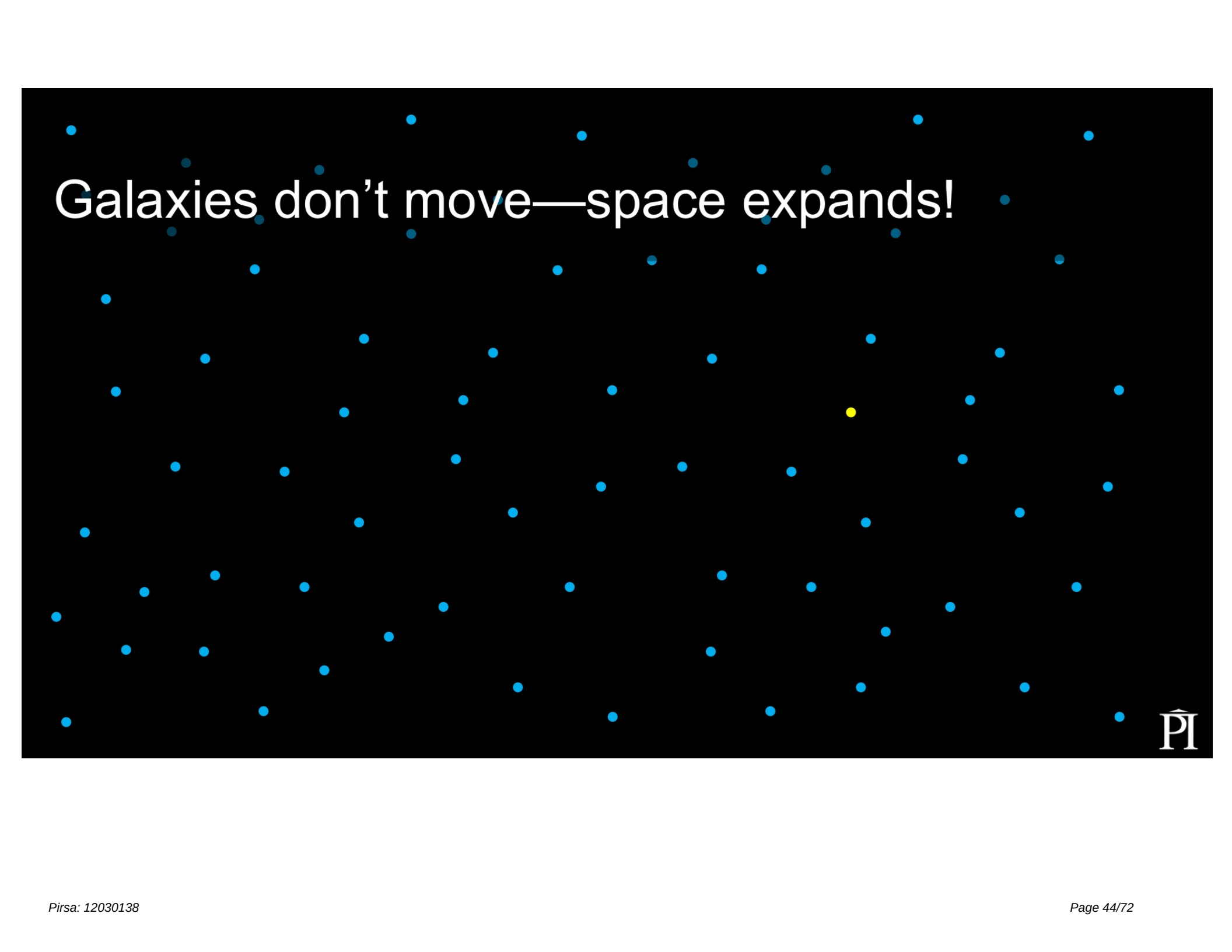
Galaxies don't move—space expands!



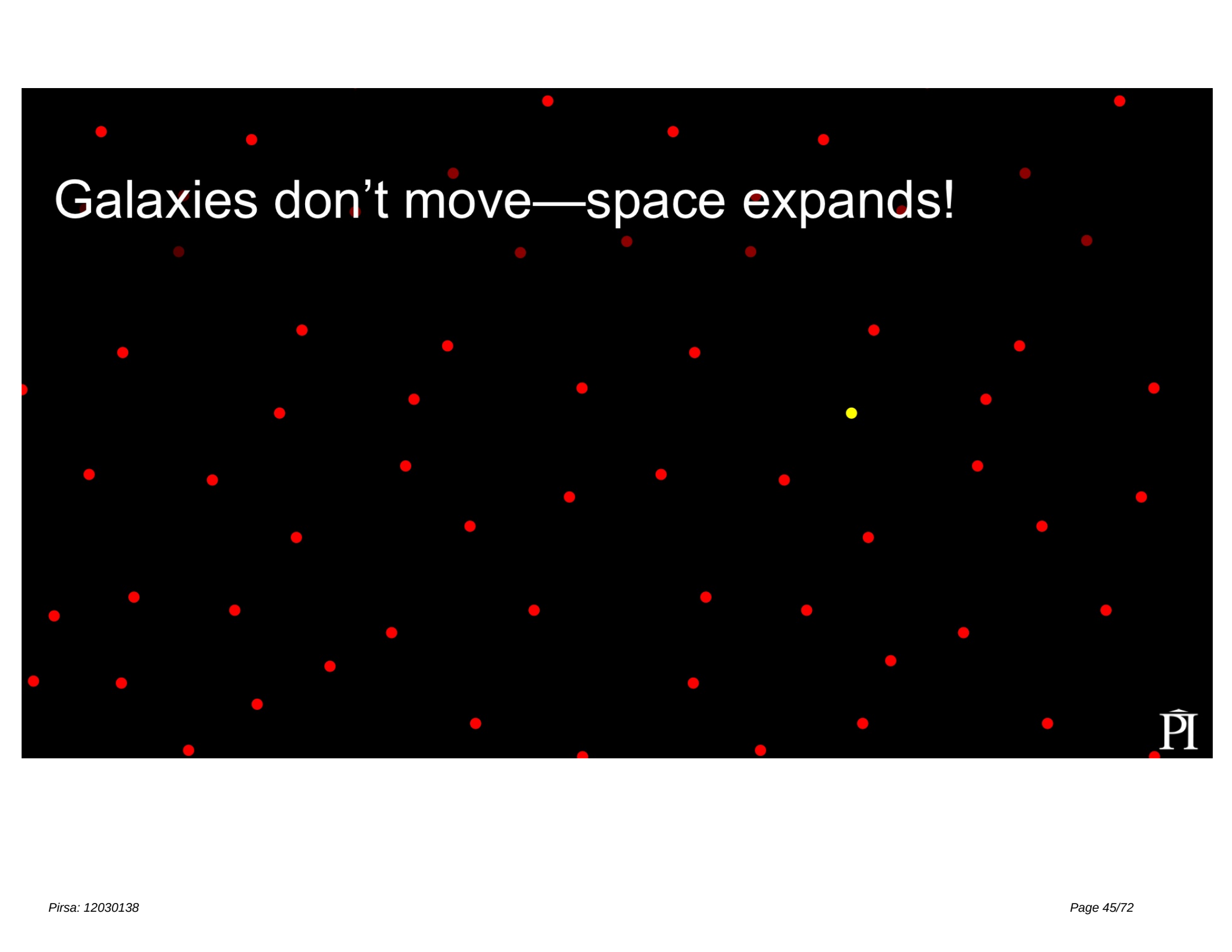
Galaxies don't move—space expands!



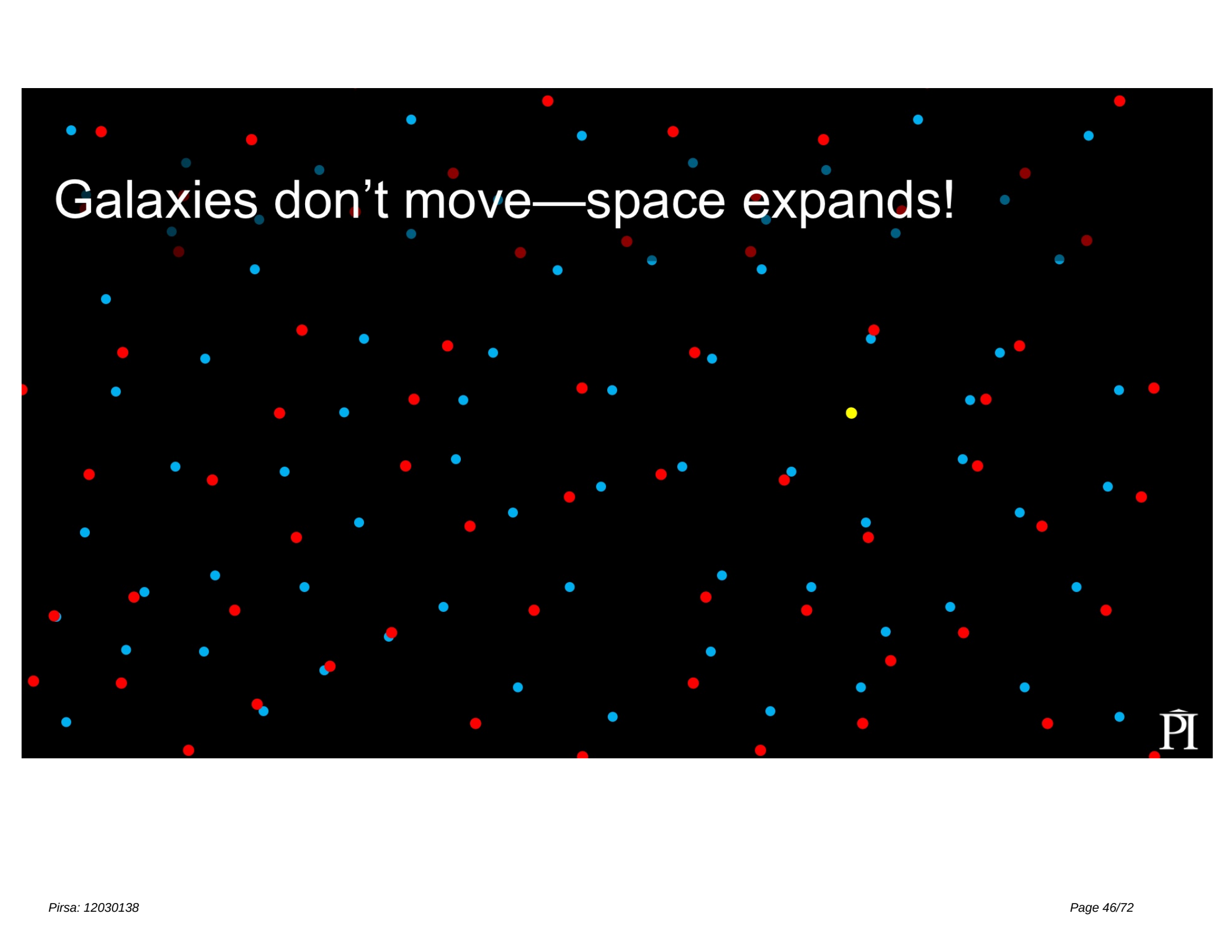
Galaxies don't move—space expands!



Galaxies don't move—space expands!



Galaxies don't move—space expands!

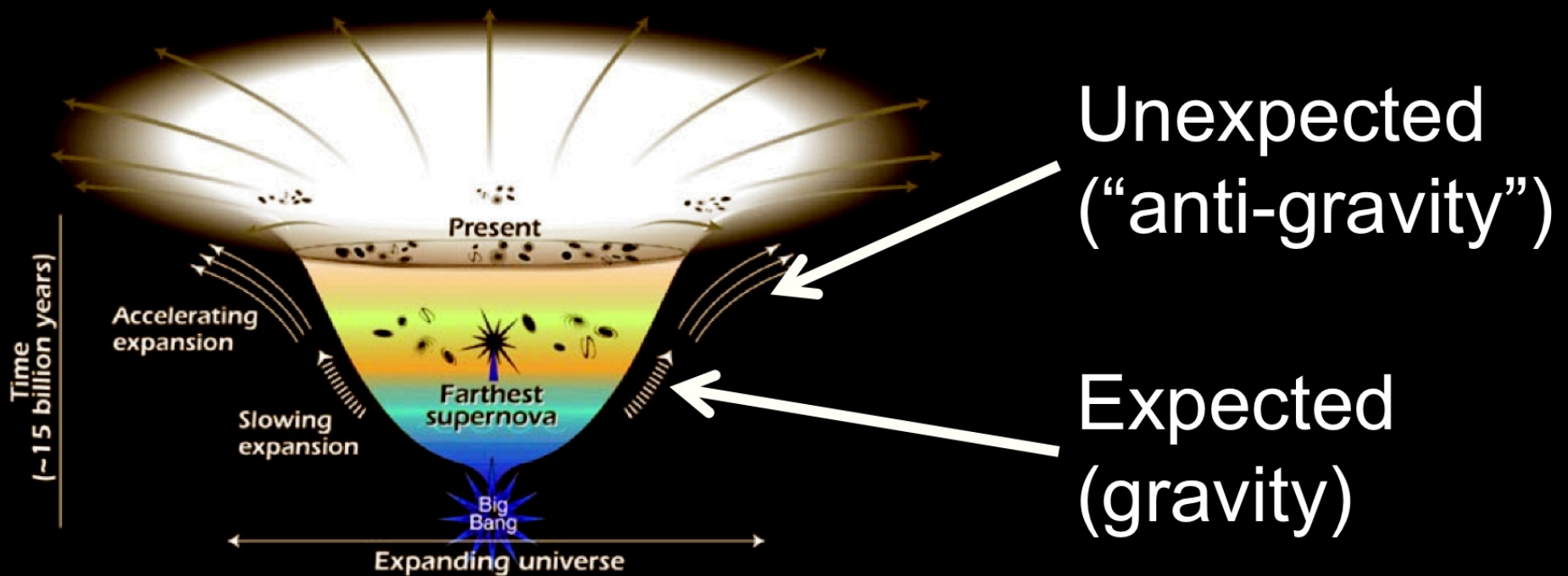


Galaxies don't move—space expands!

But Wait: **Why is the expansion *speeding up*?**



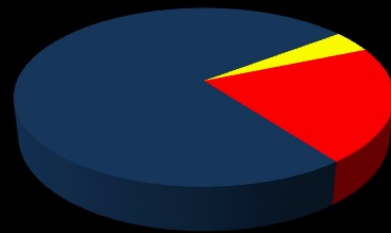
But Wait: **Why is the expansion *speeding up*?**



EVOLUTION

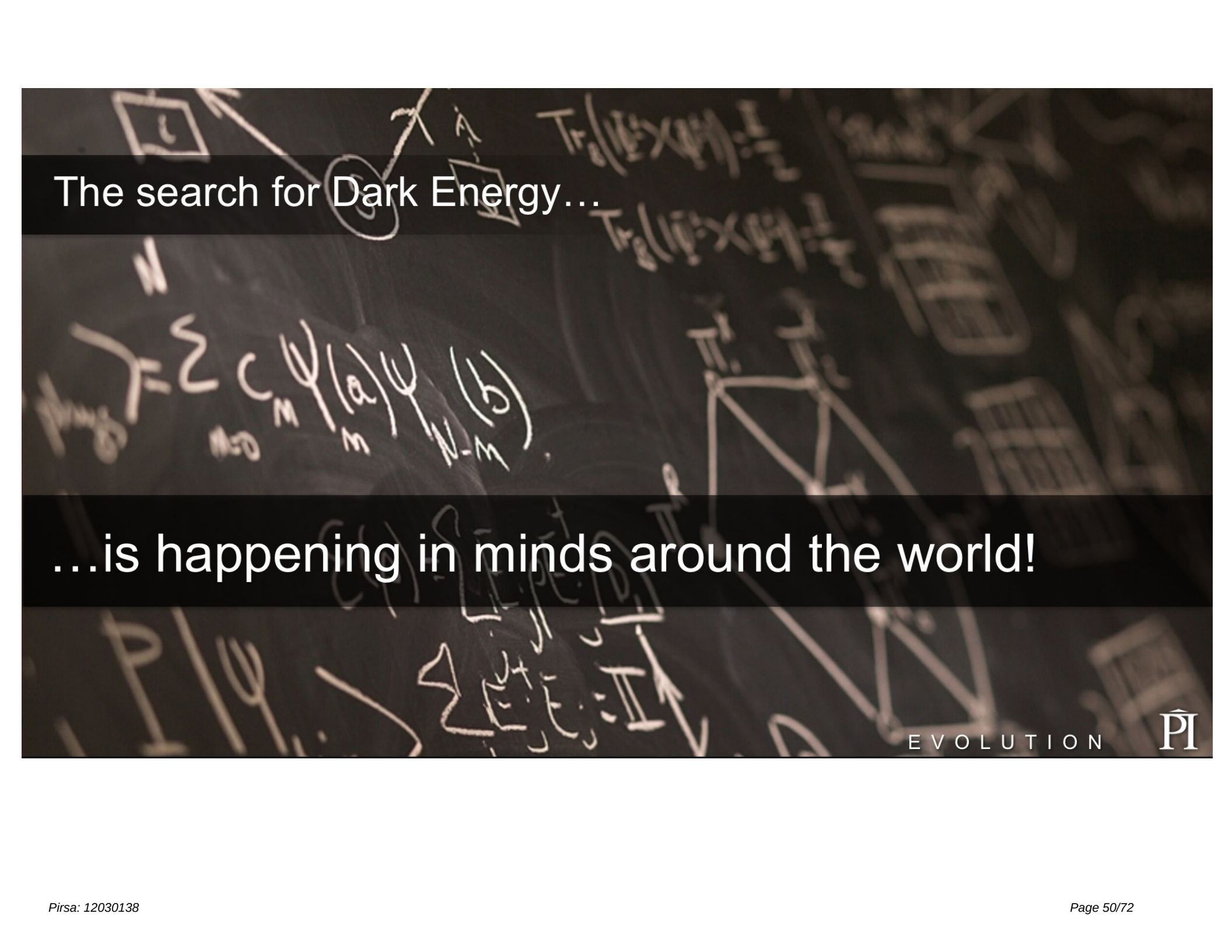
PI

Cosmic Mystery: **Dark Energy**



- Ordinary Matter 4%
- Dark Matter 21%
- Dark Energy 75%

96% of the “stuff” making up the universe is a complete mystery!

The background is a dark, textured image of a chalkboard filled with handwritten mathematical equations and diagrams in white chalk. Some of the visible equations include $T_F(\vec{p} \times \vec{q}) = \frac{1}{2} \epsilon_{ijk} p_i q_j$, $\psi(a)\psi(b)$, and $\sum \vec{E}_i \cdot \vec{E}_j = \Pi$. There are also geometric diagrams, including a square with a circle inside and a triangle with internal lines.

The search for Dark Energy...

...is happening in minds around the world!

Wonder & Curiosity

How did the universe evolve?

Imagination & Reasoning

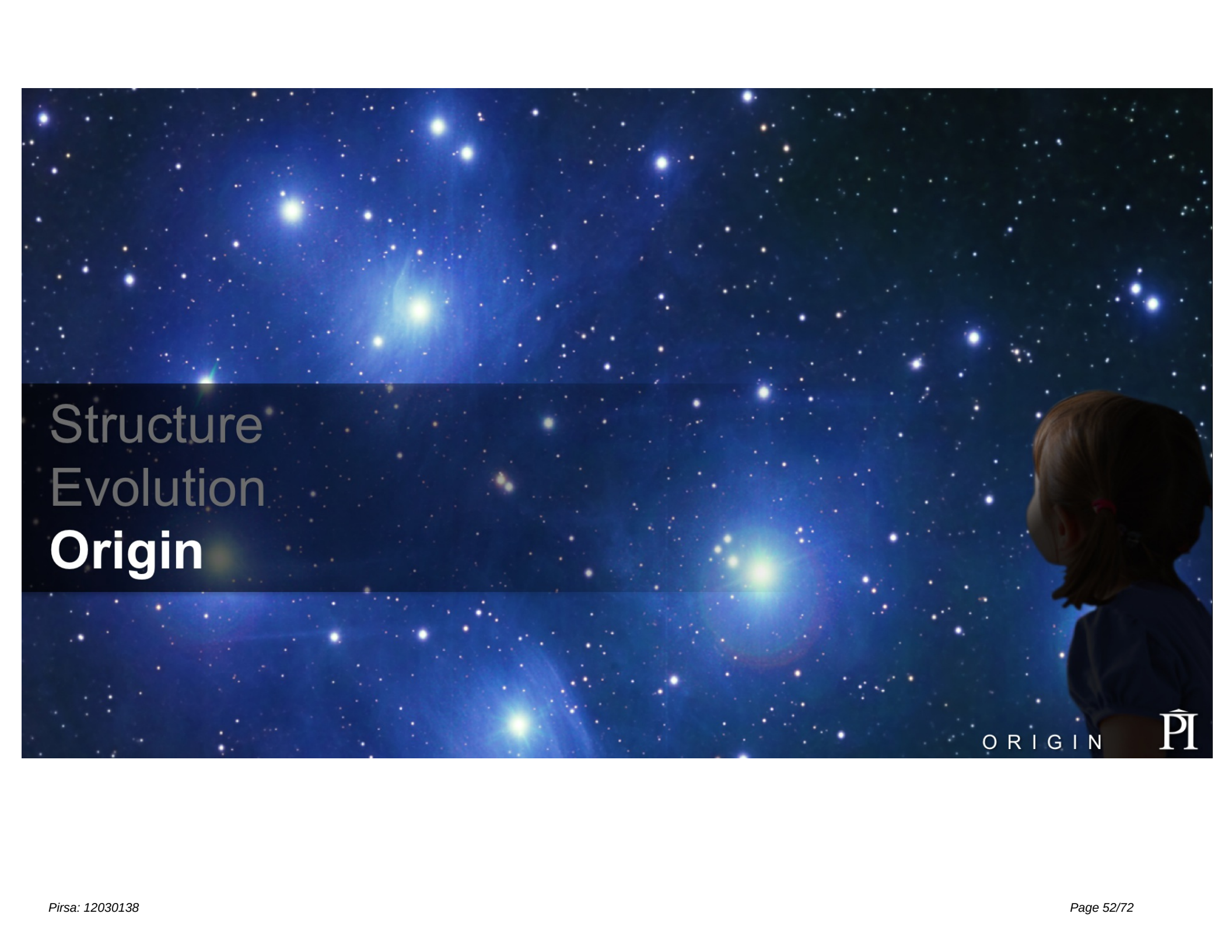
Space can expand → Use to explain redshift

Discovery & Deeper Mystery

Unexpected acceleration → Dark Energy

EVOLUTION



A child with brown hair, seen from the side, is looking up at a vast, deep blue night sky filled with numerous stars of varying brightness. The sky is a rich, dark blue, and the stars are scattered across the frame, some appearing as sharp points of light while others have a soft, glowing halo. The child is positioned in the lower right corner, their head tilted slightly upwards. The overall mood is contemplative and awe-inspiring.

Structure Evolution **Origin**

ORIGIN 

Why is it dark at night?



ORIGIN

PI



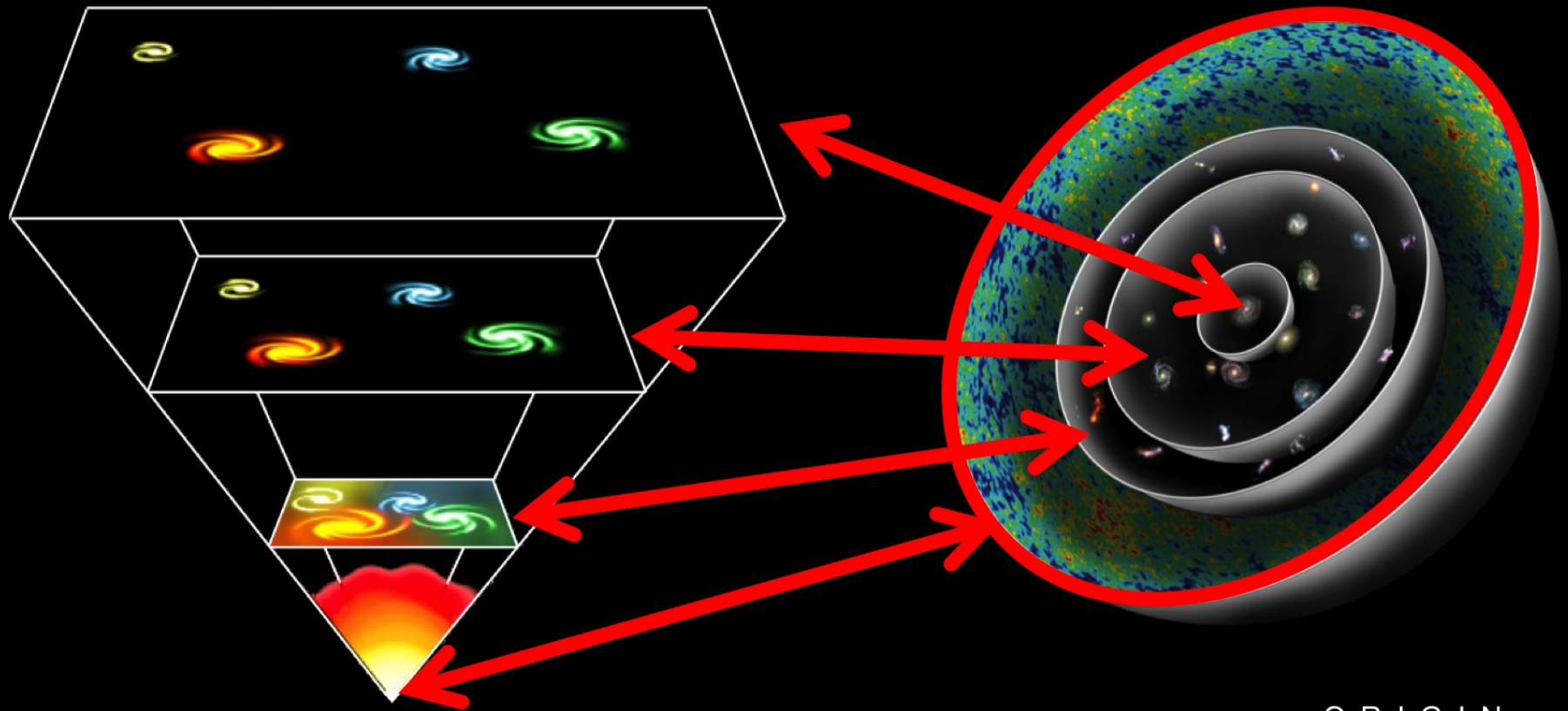
Big Idea: **The universe had a beginning**



ORIGIN



Big Idea: ...a hot, dense beginning



ORIGIN



Question: **Can we see this fiery beginning?**

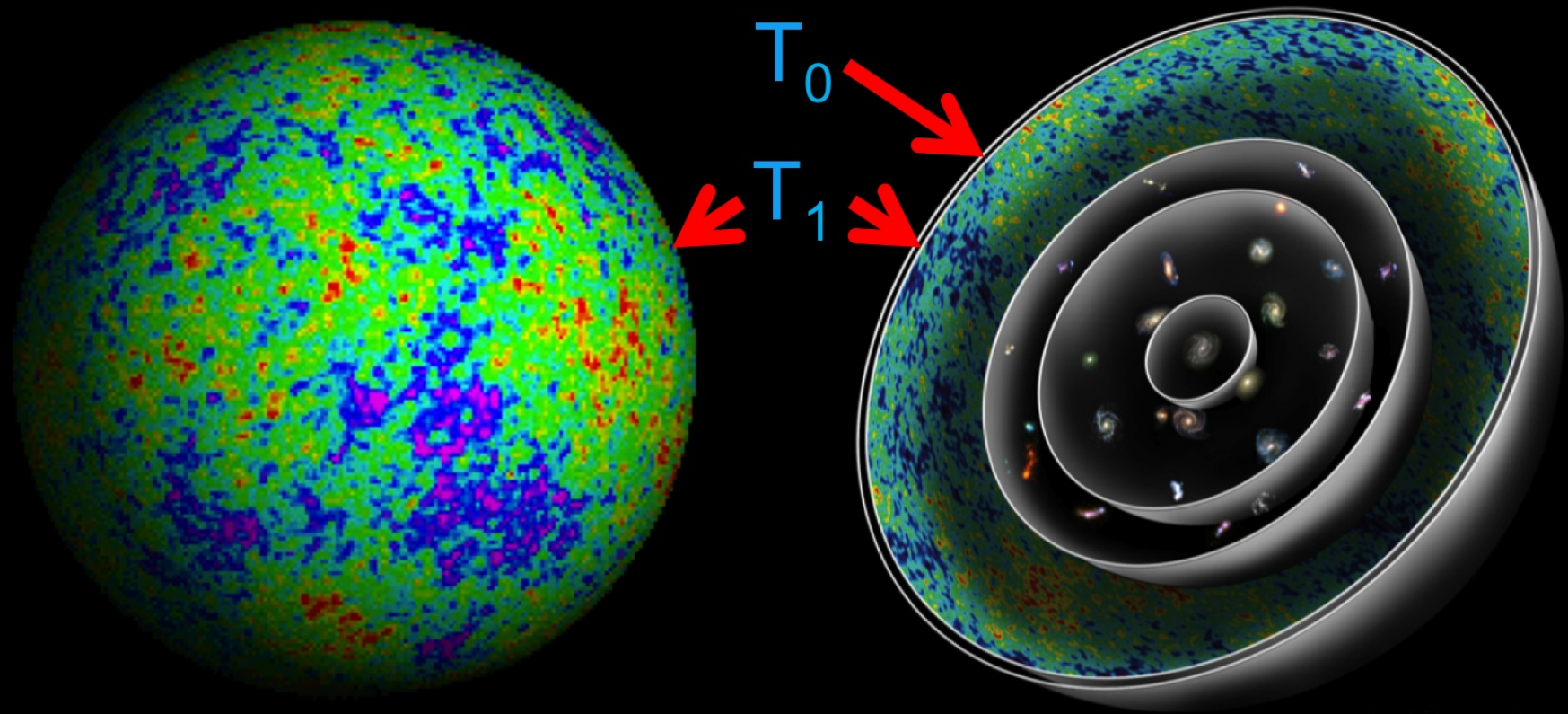


VLADSTUDIO

ORIGIN

PI

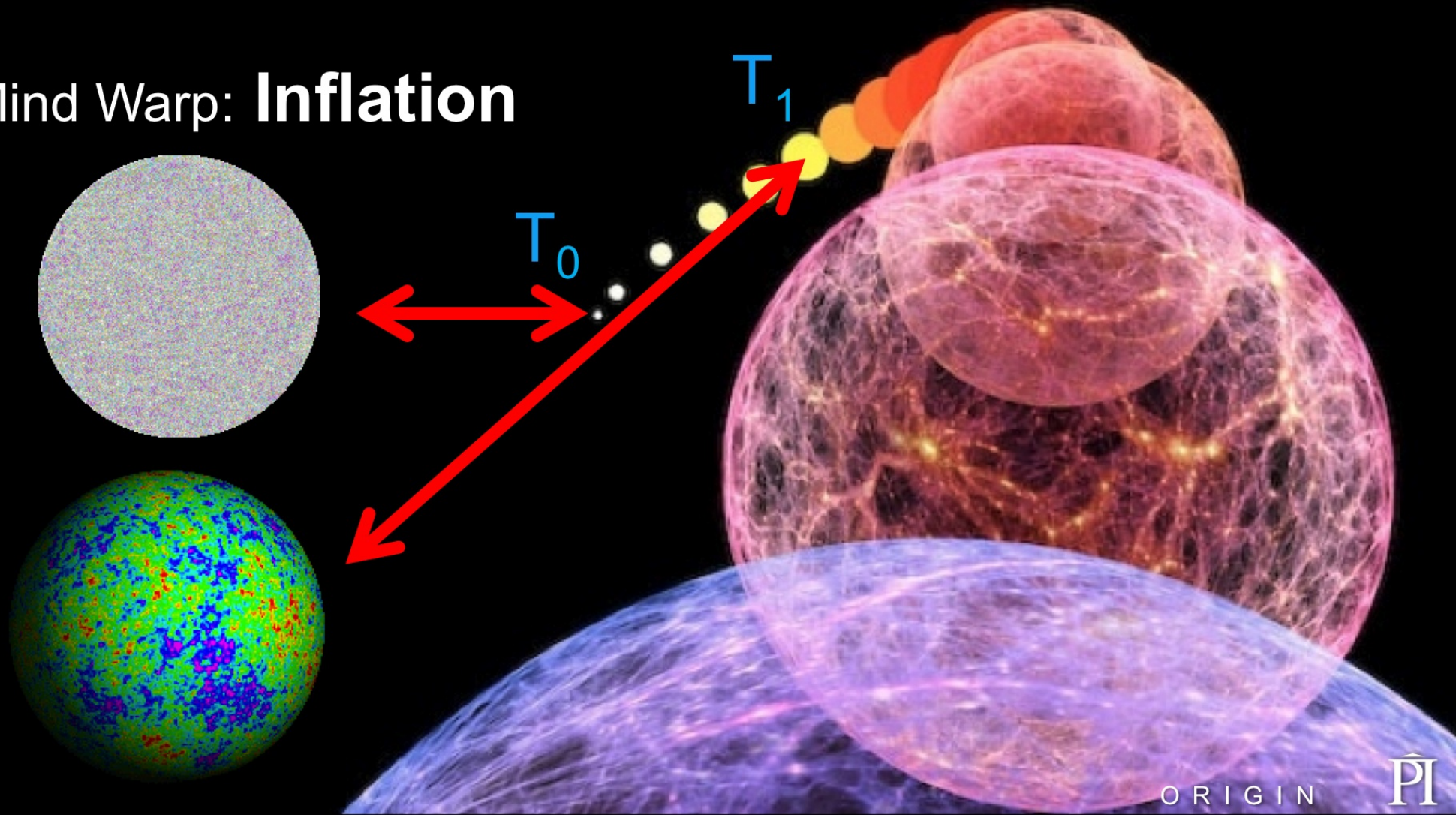
Answer: **We can *almost* see the beginning!**



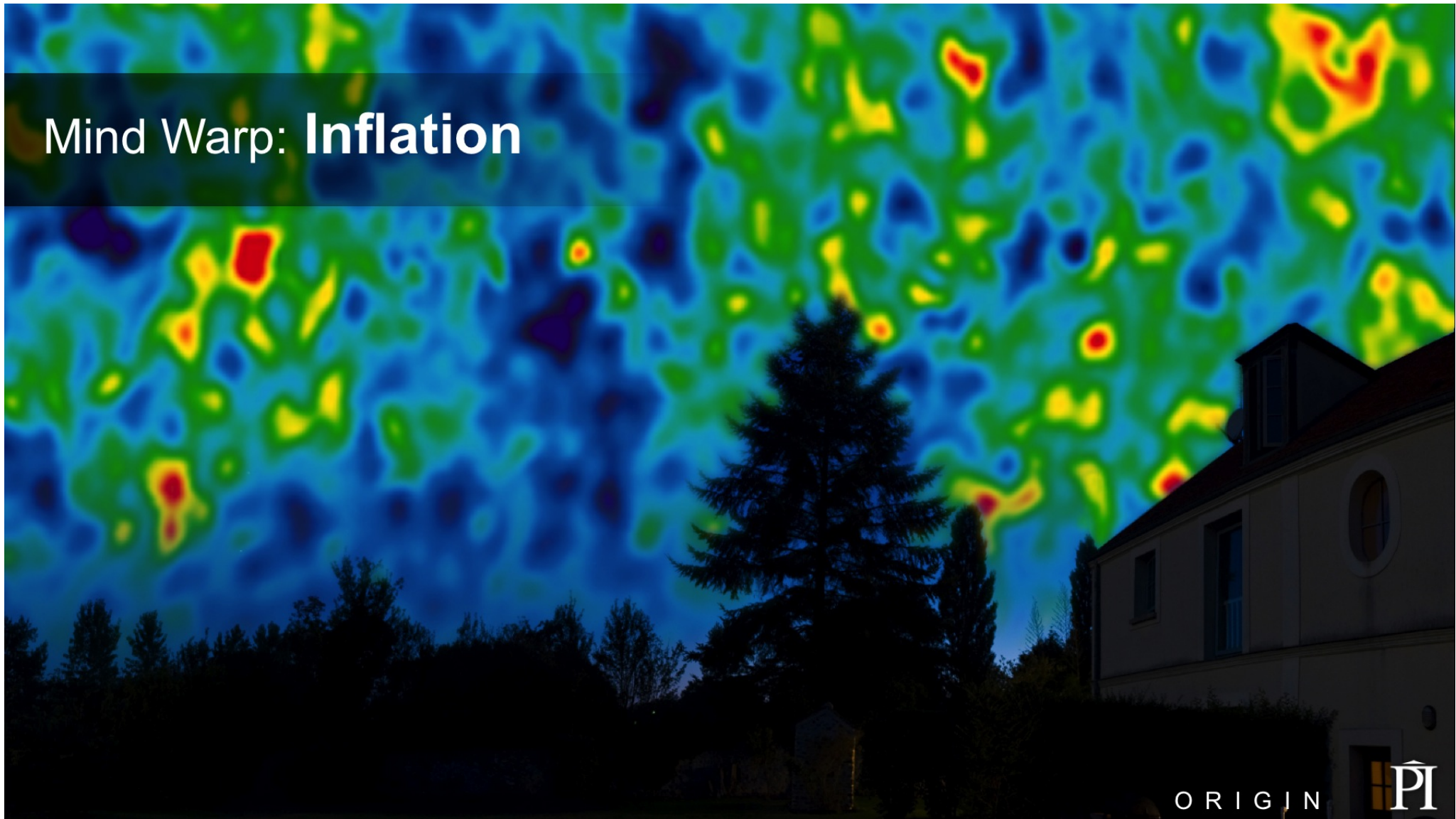
ORIGIN



Mind Warp: **Inflation**



Mind Warp: **Inflation**



ORIGIN 



Question: **Why something rather than nothing?**



Quantum: Spontaneous creation;
something from nothing—briefly!



Gravity: Negative energy of gravity +
positive energy of matter = 0?

ORIGIN

PI

Answer: **No one knows**

We must go
beyond Einstein:
Quantum Gravity?



ORIGIN 

Wonder & Curiosity

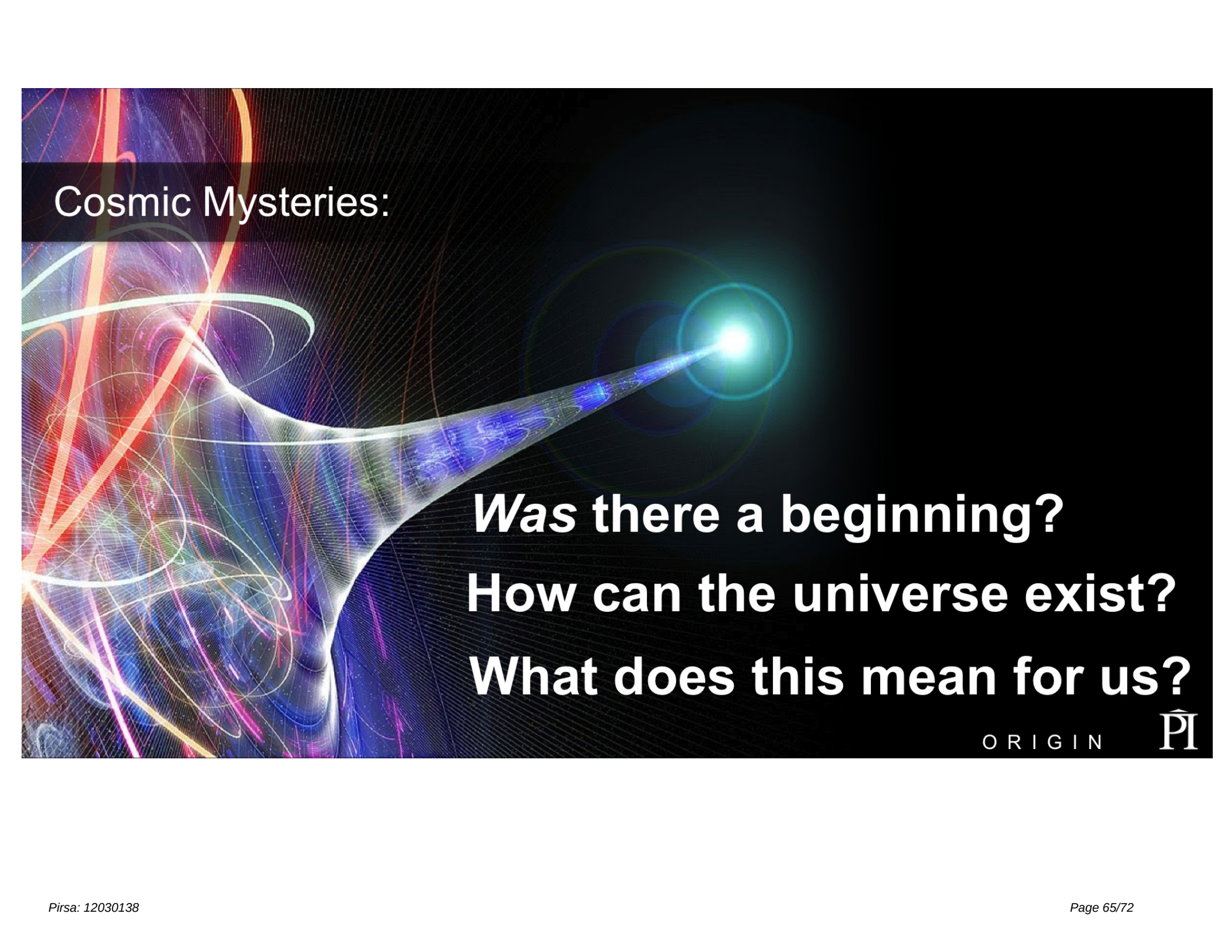
Why is there something rather than nothing?

Imagination & Reasoning

Spontaneous creation & zero total energy?

Discovery & Deeper Mystery

Singularity → Quantum Gravity?



Cosmic Mysteries:

Was there a beginning?
How can the universe exist?
What does this mean for us?

ORIGIN 

**“The most beautiful
thing we can experience
is the mysterious...”**

—Albert Einstein

C O S M I C M Y S T E R I E S

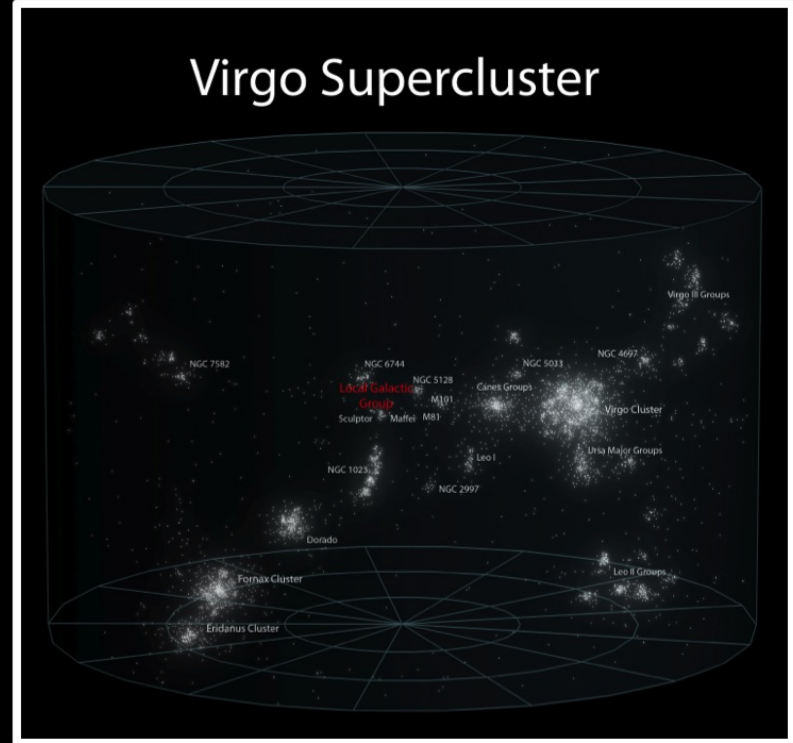
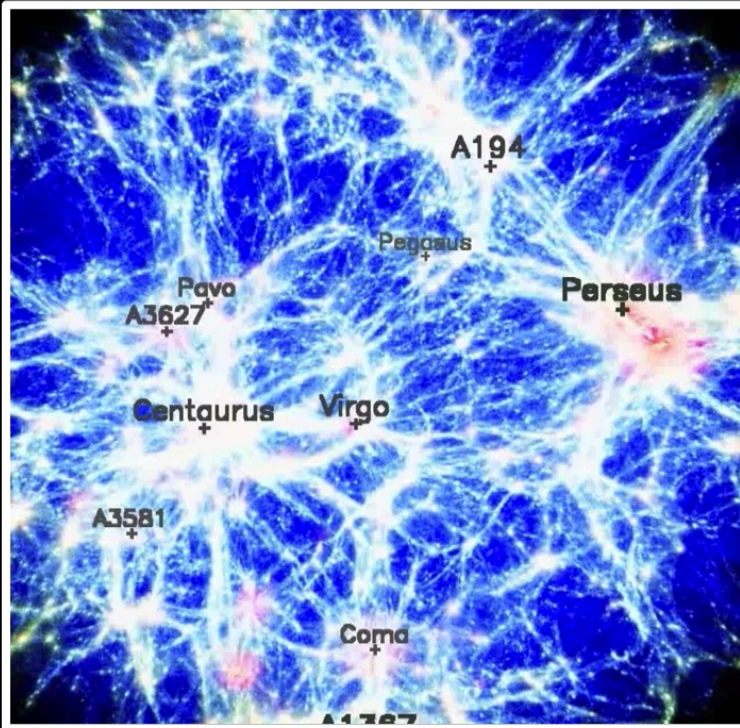
PI

Cosmic Mysteries

The background of the slide is a deep blue space filled with stars and nebulae. A bright, glowing blue star or galaxy core is positioned on the right side, emitting a powerful beam of light that spreads across the frame. On the left, there are intricate, wispy structures of gas and dust, resembling a nebula or a complex gravitational well. The overall aesthetic is one of cosmic wonder and mystery.

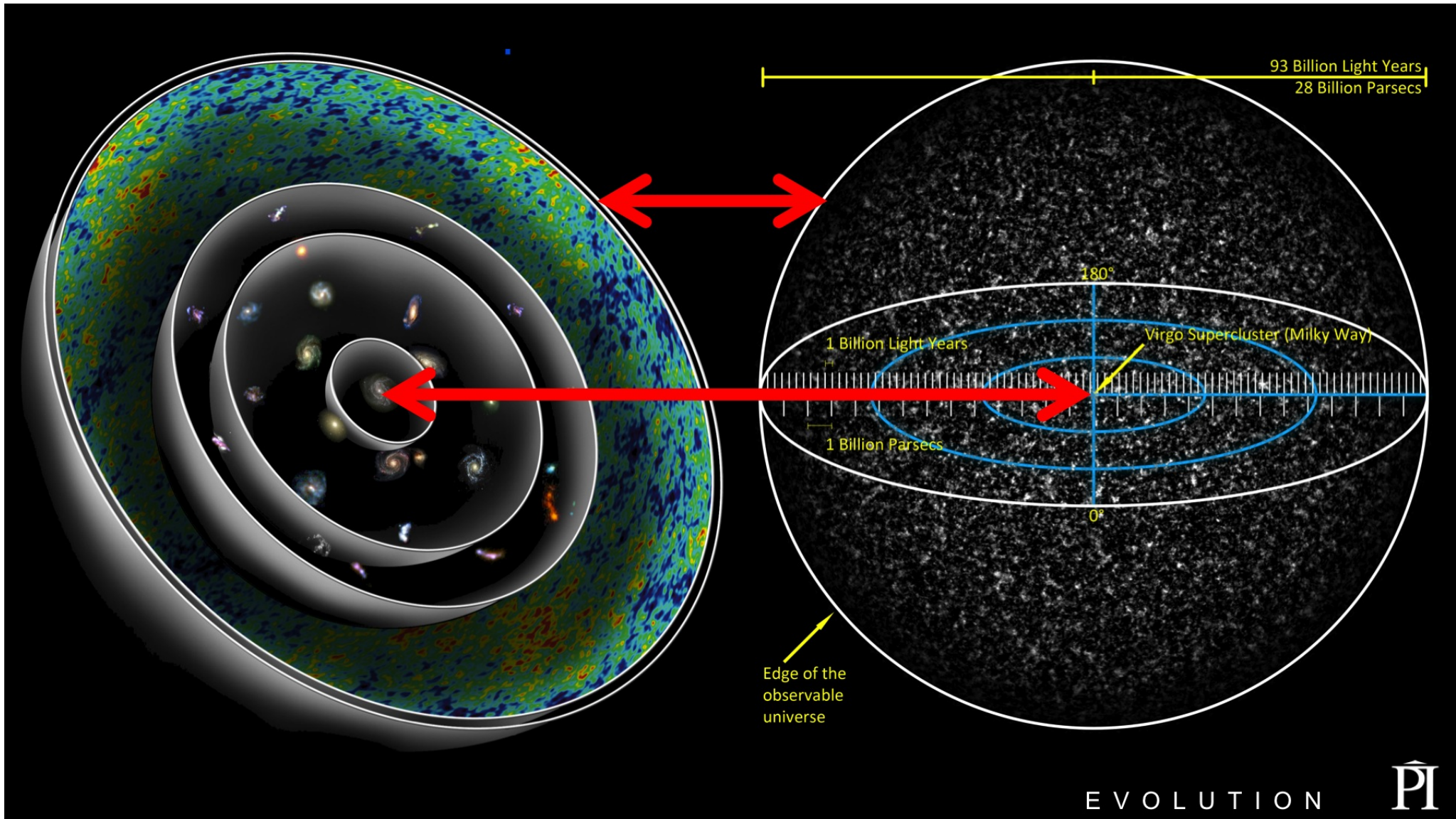
PERIMETER  INSTITUTE FOR THEORETICAL PHYSICS

Cosmic Mystery: **Dark Matter**



STRUCTURE



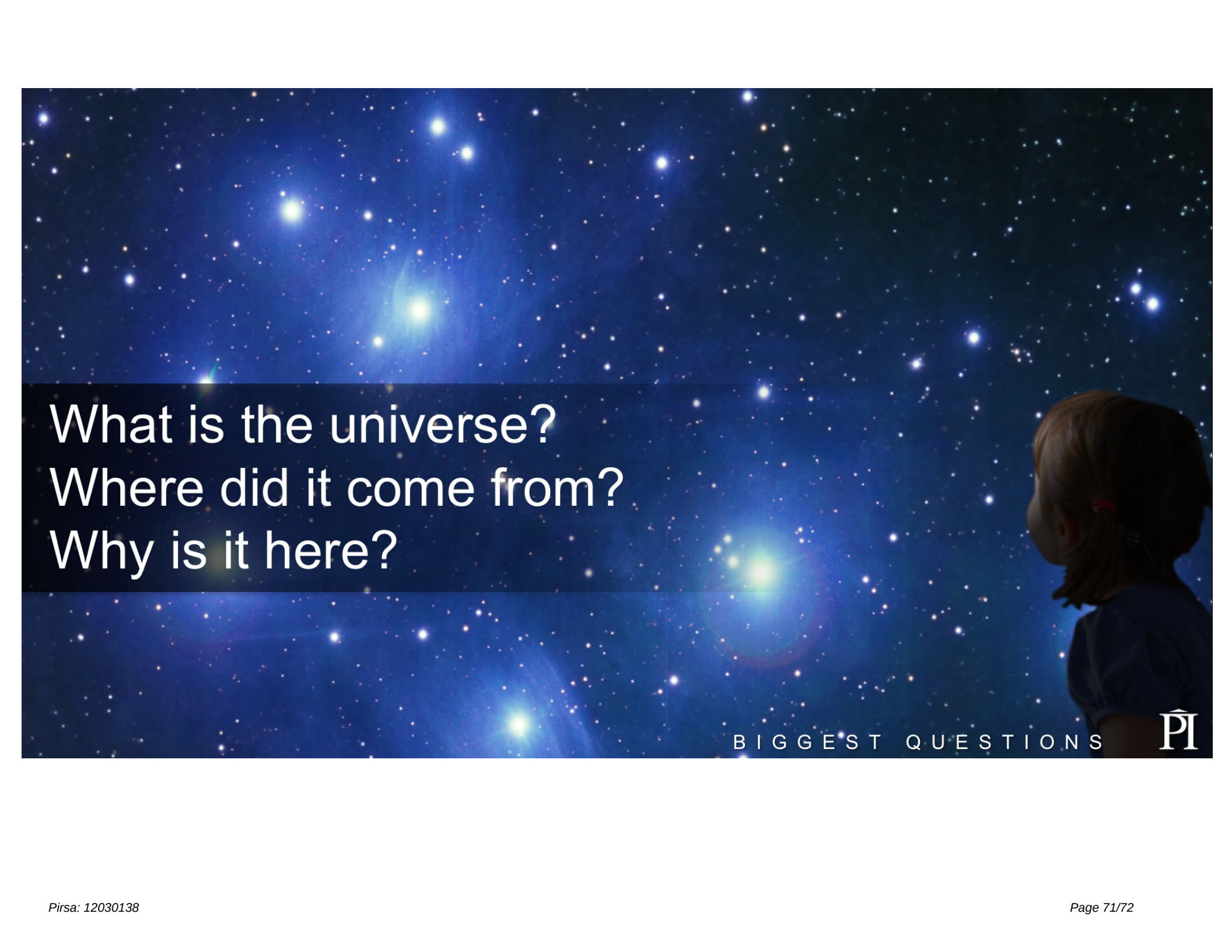


A full-page background image showing a young child with brown hair in profile, looking up at a vast, deep blue night sky filled with numerous stars of varying brightness. The child is positioned on the right side of the frame, looking towards the left. The sky is a rich, dark blue, and the stars are scattered across it, with some appearing as bright, glowing points and others as smaller, dimmer specks. The overall mood is one of wonder and curiosity.

Structure Evolution Origin

BIGGEST QUESTIONS



A young child with brown hair is shown in profile, looking up at a vast, deep blue night sky filled with numerous stars of varying brightness. The child is wearing a dark blue shirt. The background is a rich, dark blue with many small, distant stars and a few larger, brighter ones that create a sense of depth and wonder.

What is the universe?
Where did it come from?
Why is it here?

BIGGEST QUESTIONS



A close-up, profile view of a young child with light skin and dark hair, blowing a dandelion seed. The child's face is in the upper right corner, with their mouth open and lips pursed together. A hand is visible at the bottom, holding the stem of the dandelion. The background is a soft-focus green field with rolling hills in the distance. Several dandelion seeds are captured in mid-air, floating away from the child. A semi-transparent dark green rectangular box is overlaid on the left side of the image, containing white text.

What am I?
Where do I come from?
Why am I here?

BIGGEST QUESTIONS

