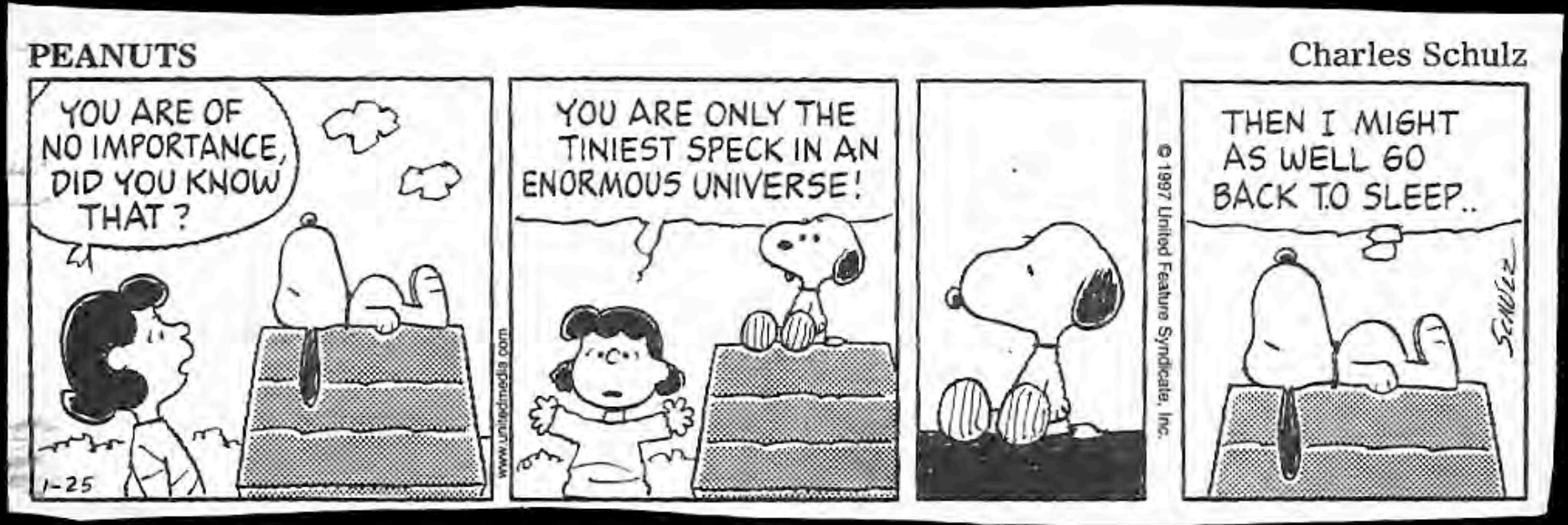
Astronomy 70 9-26-06

EVOLUTION OF THE UNIVERSE

Joel R. Primack, UCSC

Cosmology is going through a scientific revolution that is creating humanity's first picture of the hisory of the universe as a whole that might actually be true.

In this new scientific picture, we are cosmically central, and we live at a pivotal time.


PEANUTS
Charles Schulz
YOU ARE OF NO IMPORTANCE, DID YOU KNOW THAT?
1-25
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YOU ARE ONLY THE TINIEST SPECK IN AN ENORMOUS UNIVERSE!
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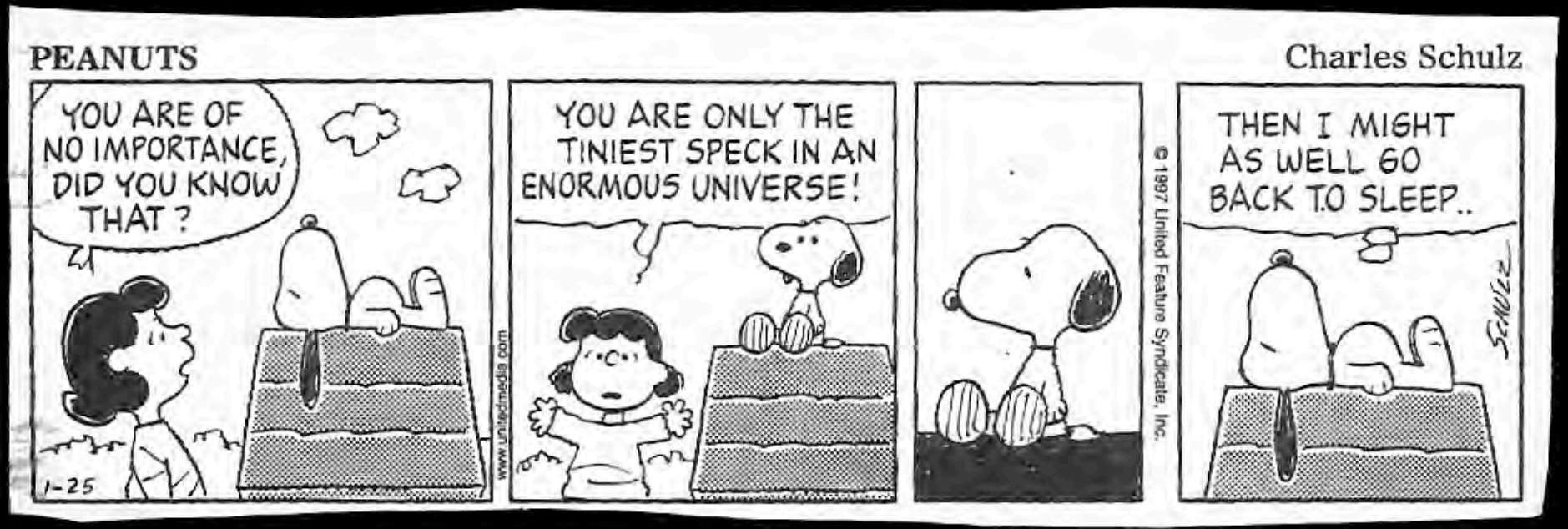
THEN I MIGHT AS WELL GO BACK TO SLEEP..
SCHULZ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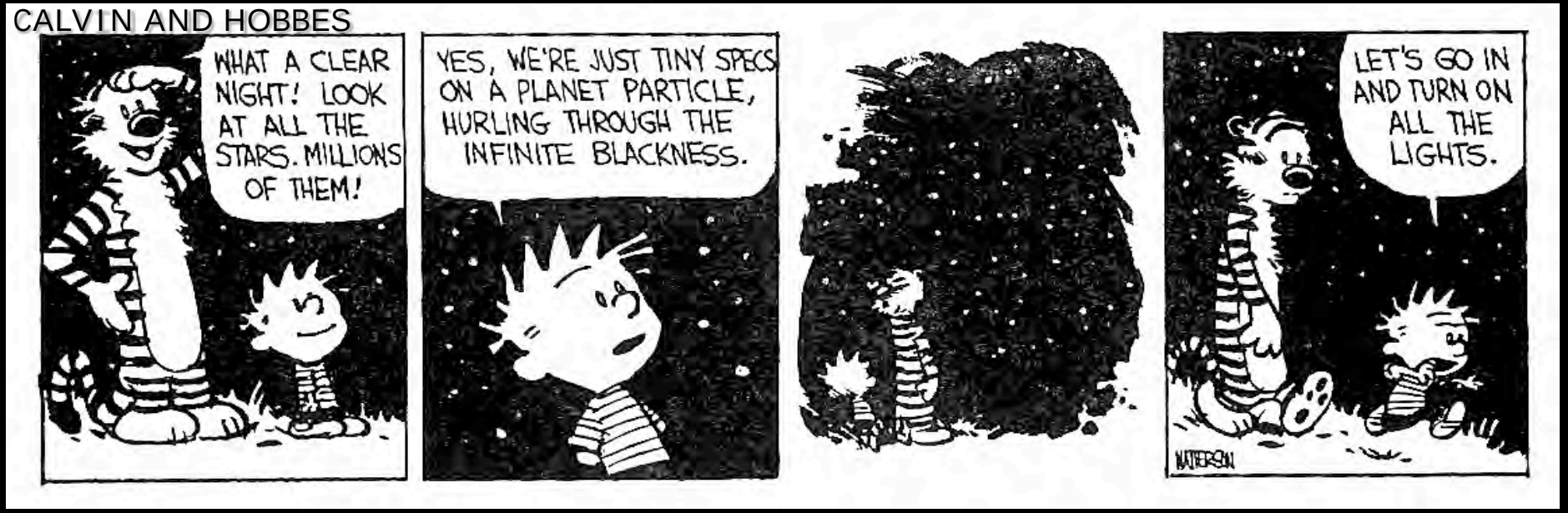
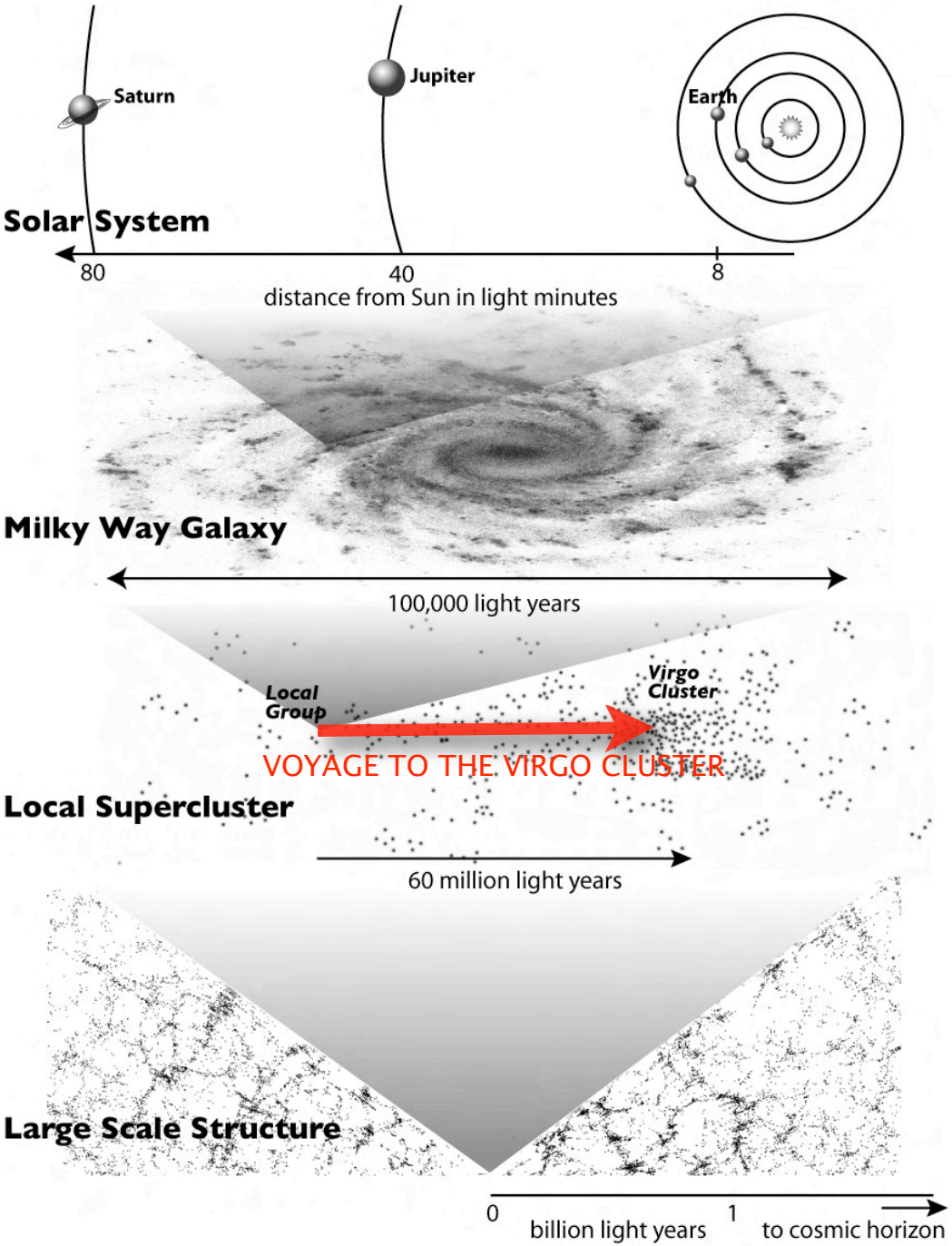

CALVIN AND HOBBES
WHAT A CLEAR NIGHT! LOOK AT ALL THE STARS. MILLIONS OF THEM!
YES, WE'RE JUST TINY SPECS ON A PLANET PARTICLE, HURLING THROUGH THE INFINITE BLACKNESS.
LET'S GO IN AND TURN ON ALL THE LIGHTS.
WATTERSON

The Modern Scientific Cosmos

Our Cosmic Address



each dot is a big galaxy

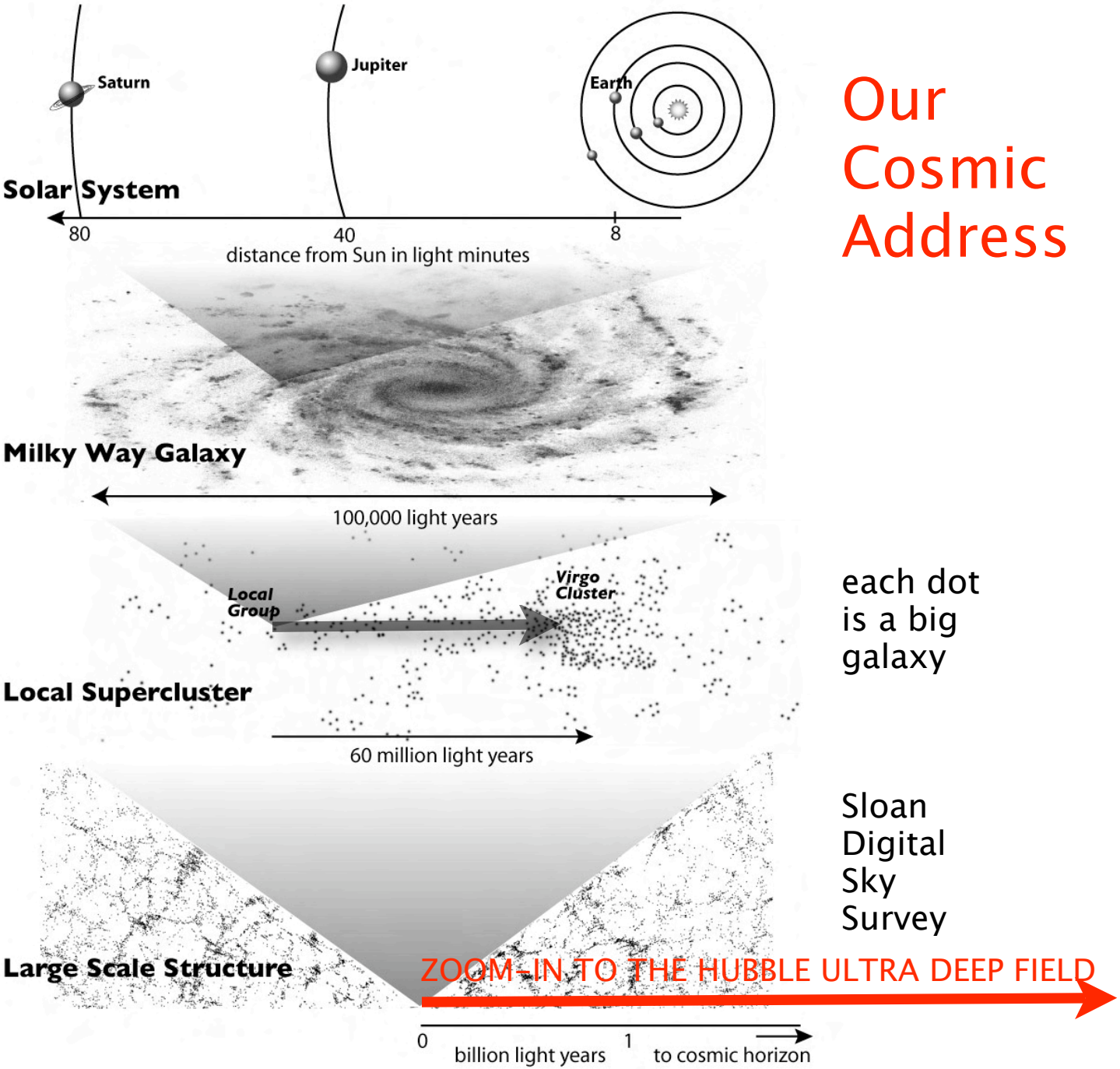
Sloan Digital Sky Survey

VOYAGE TO THE VIRGO CLUSTER

Orion

VOYAGE TO THE VIRGO CLUSTER

The Modern Scientific Cosmos



Our Cosmic Address

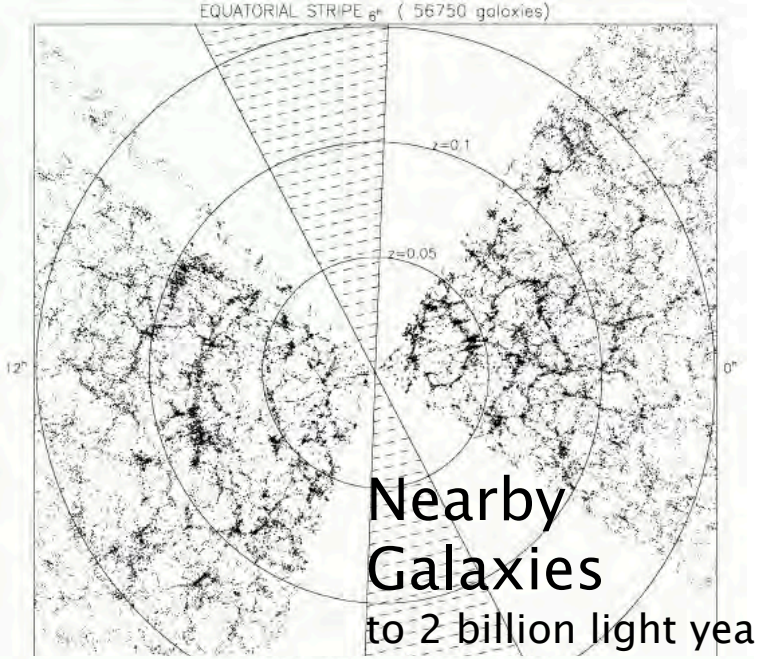
each dot is a big galaxy

Sloan Digital Sky Survey

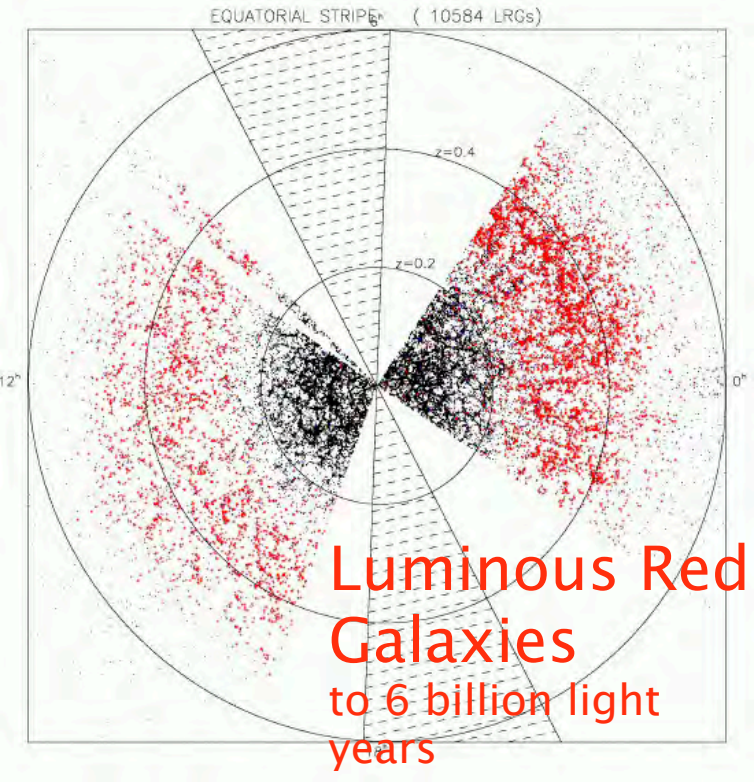
ZOOM-IN TO THE HUBBLE ULTRA DEEP FIELD

ZOOM–IN TO THE HUBBLE ULTRA DEEP FIELD

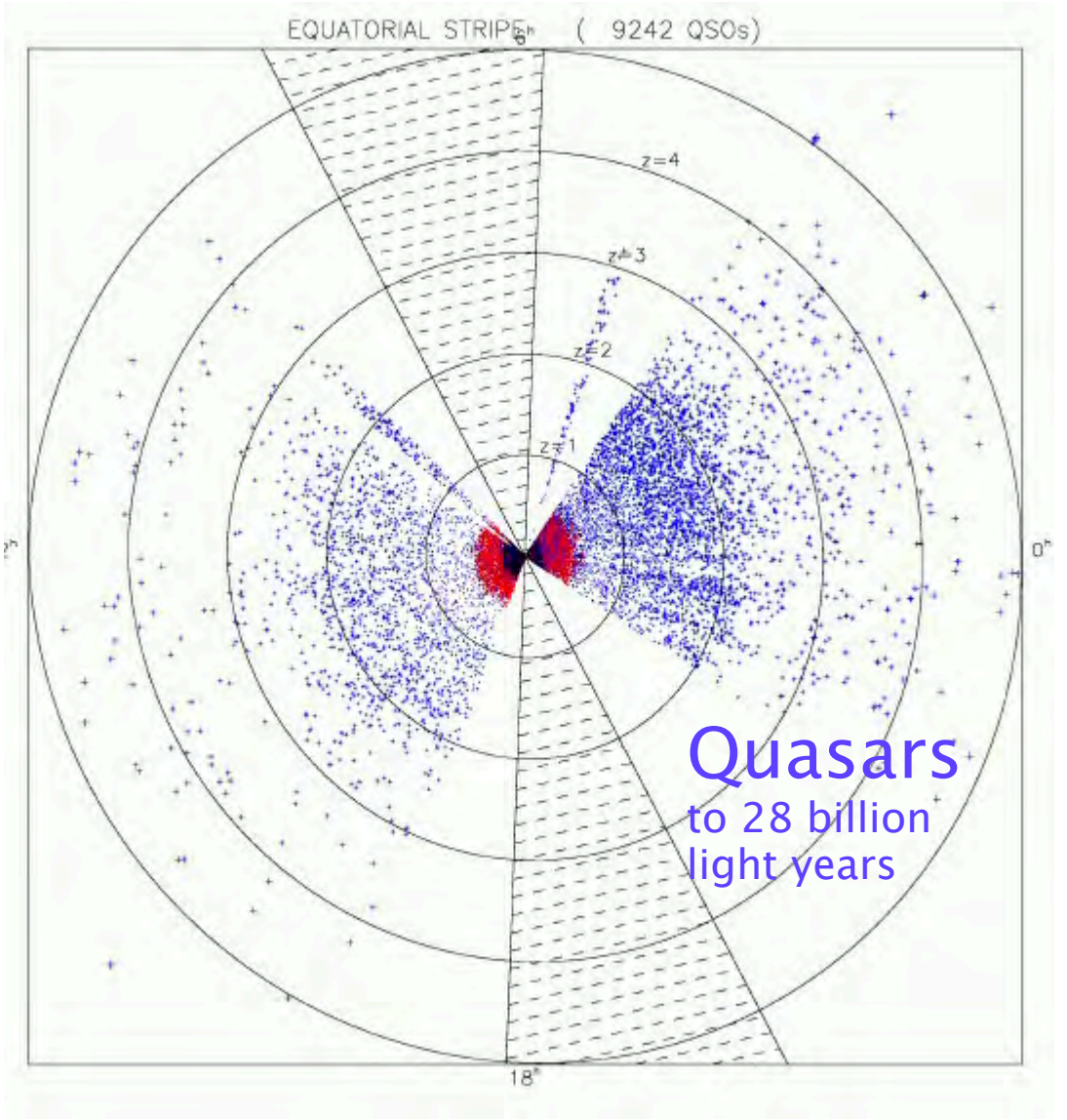
Sloan Digital Sky Survey



Nearby Galaxies
to 2 billion light years



Luminous Red Galaxies
to 6 billion light years

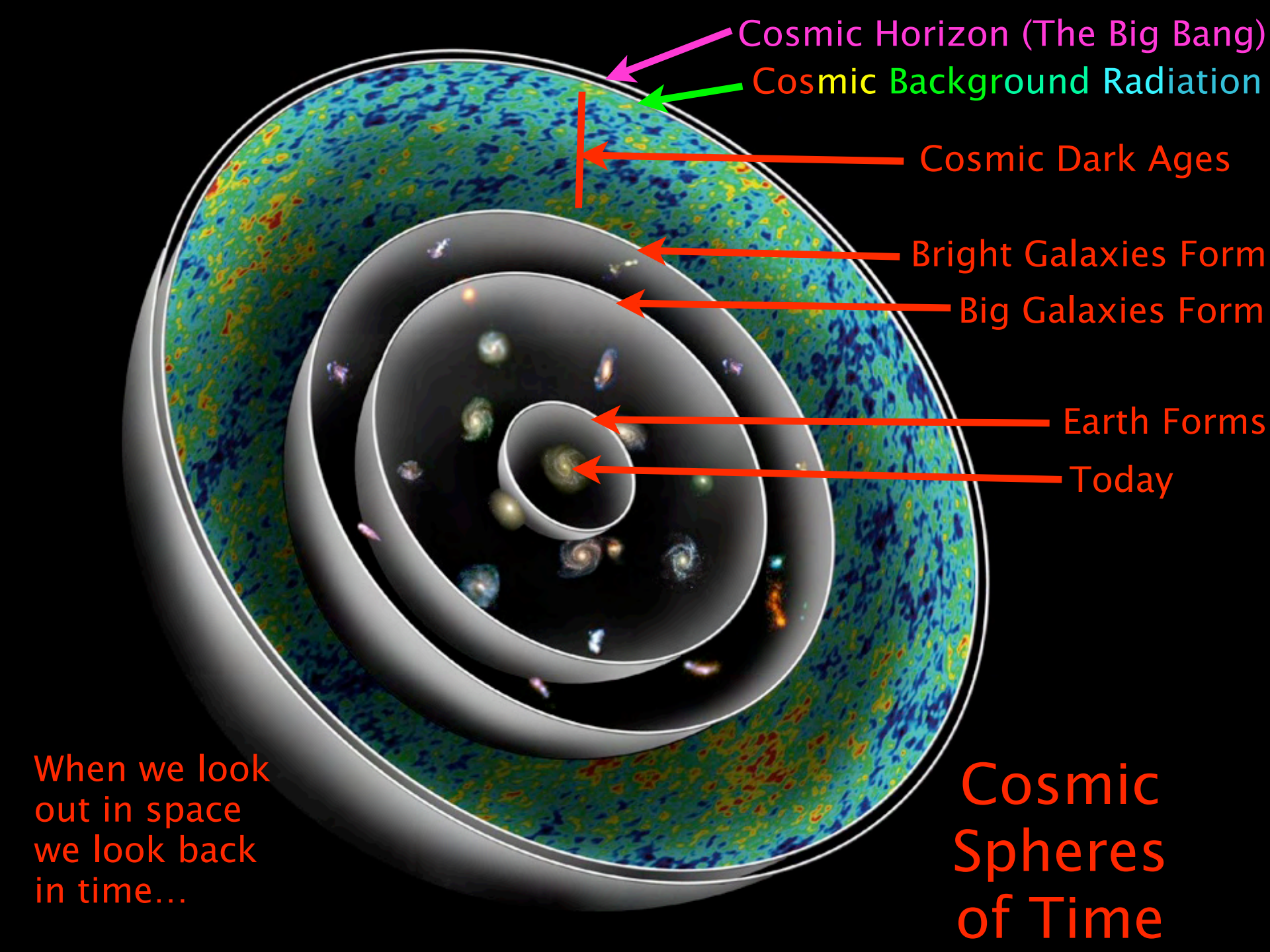


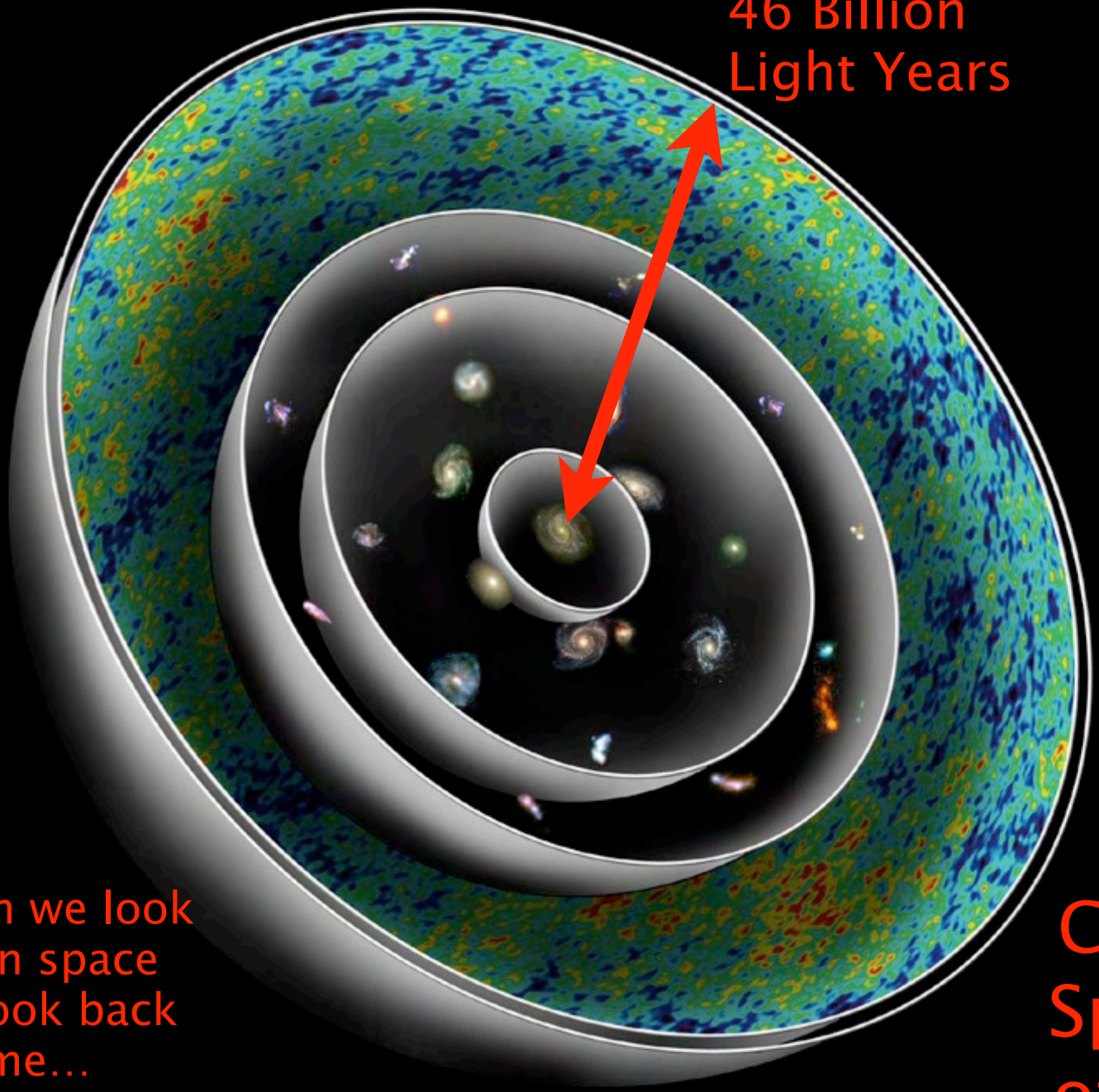
Quasars
to 28 billion light years

GALAXIES MAPPED BY THE SLOAN SURVEY

Data Release 4:
565,715 Galaxies & 76,403 Quasars

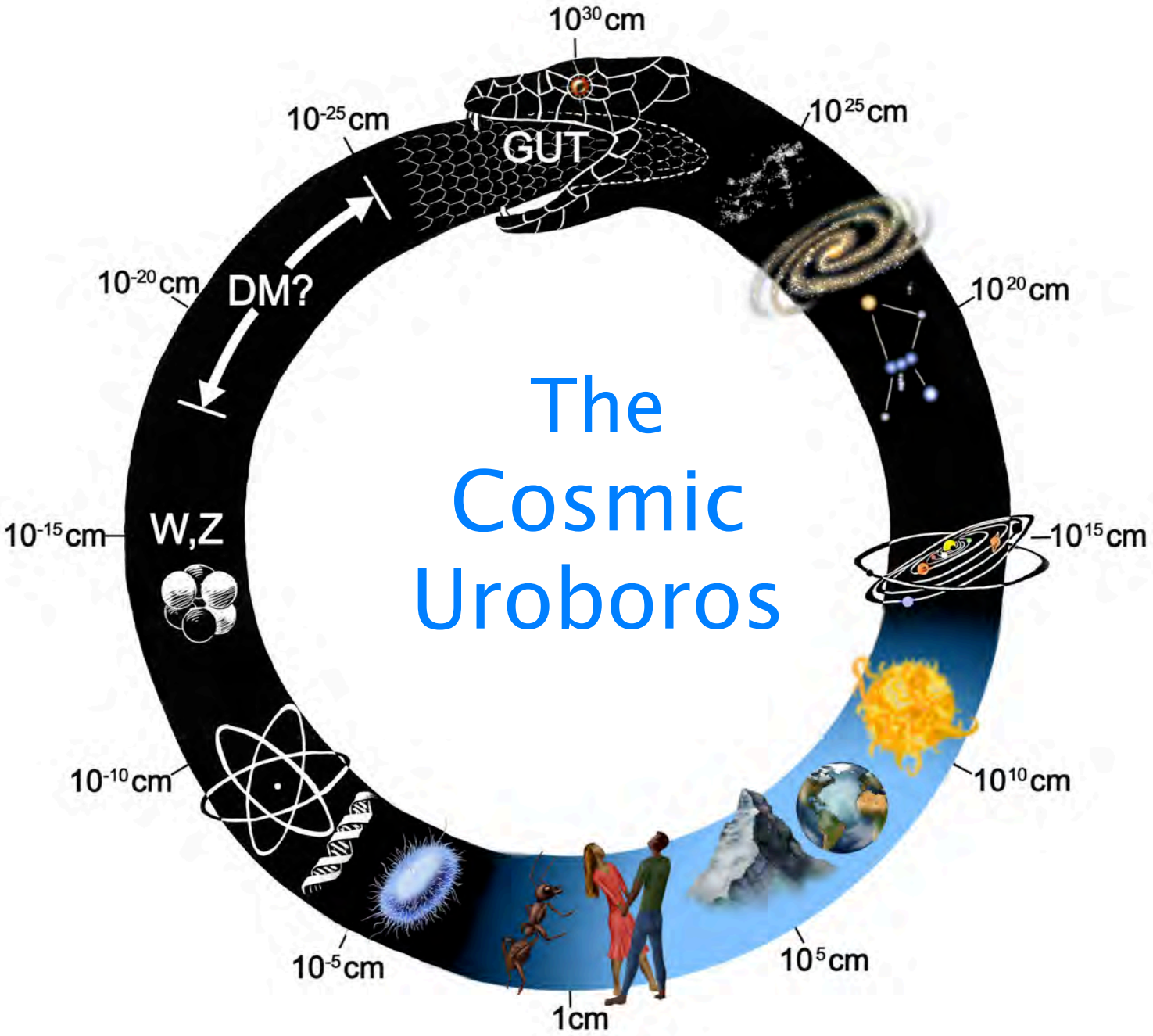
GALAXIES MAPPED BY THE SLOAN SURVEY


Cosmic Horizon (The Big Bang)
Cosmic Background Radiation
Cosmic Dark Ages
Bright Galaxies Form
Big Galaxies Form
Earth Forms
Today
When we look out in space we look back in time…
Cosmic Spheres of Time



When we look out in space we look back in time…

Cosmic Spheres of Time

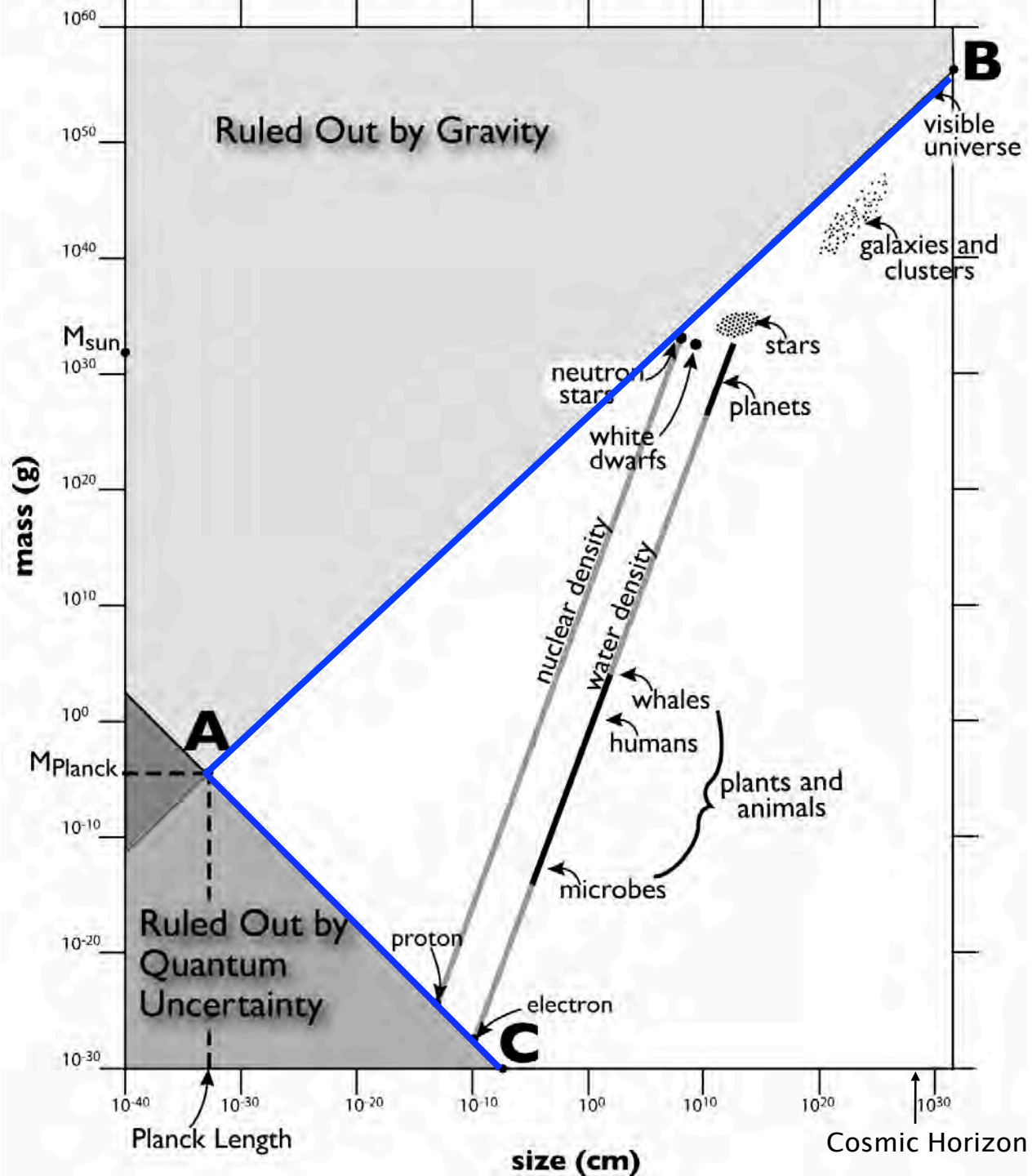

10^30 cm
10^-25 cm
GUT
10^25 cm
10^-20 cm
DM?
10^20 cm
The
Cosmic
Uroboros
10^-15 cm
W,Z
10^15 cm
10^-10 cm
10^10 cm
10^-5 cm
10^5 cm
1cm

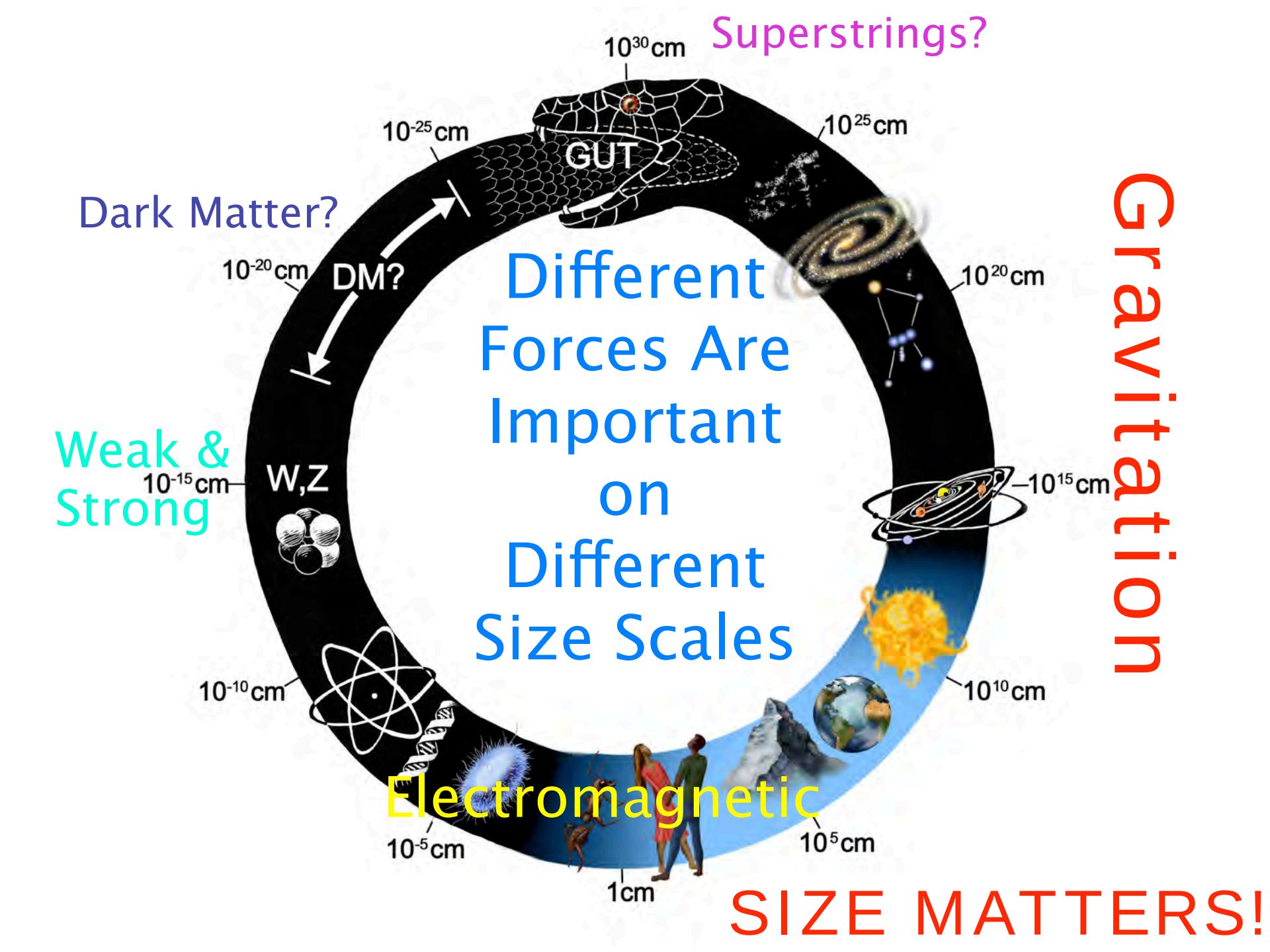
The Wedge of Material Reality

Relativity and Quantum Uncertainty

⇓

a smallest size, the Planck length




Superstrings?
10^{30}cm
10^{-25}cm
GUT
10^{25}cm
Dark Matter?
10^{-20}cm
DM?
10^{20}cm
Different Forces Are Important on Different Size Scales
Weak & Strong
10^{-15}cm
W,Z
10^{15}cm
Gravitation
10^{-10}cm
10^{10}cm
Electromagnetic
10^{-5}cm
10^{5}cm
1cm
SIZE MATTERS!

SIZE MATTERS!

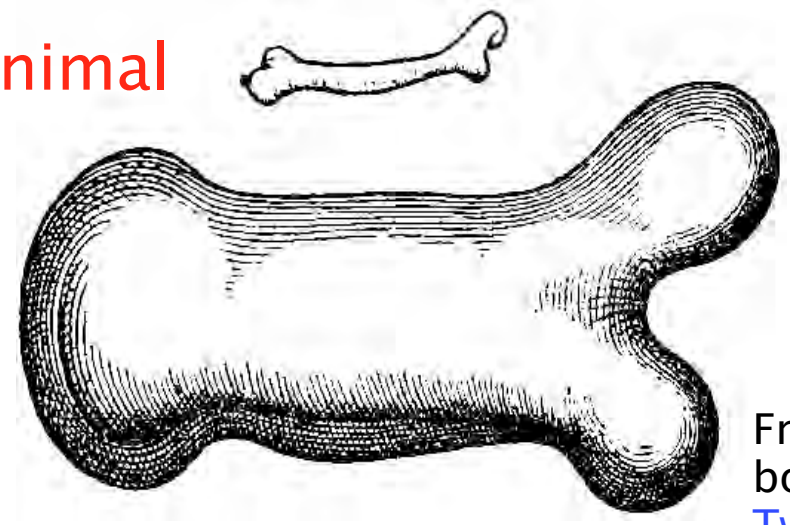
No animal could be 3 times its normal height and stay the same shape, simply scaled up.

If height increases 3 times,
strength of bones increases 3x3 = 9 times.
But weight increases 3x3x3 = 27 times.
Its weight would crush its bones!

That is why an elephant does not look like a large gazelle.

Bone of small animal

Bone of animal 3 times longer



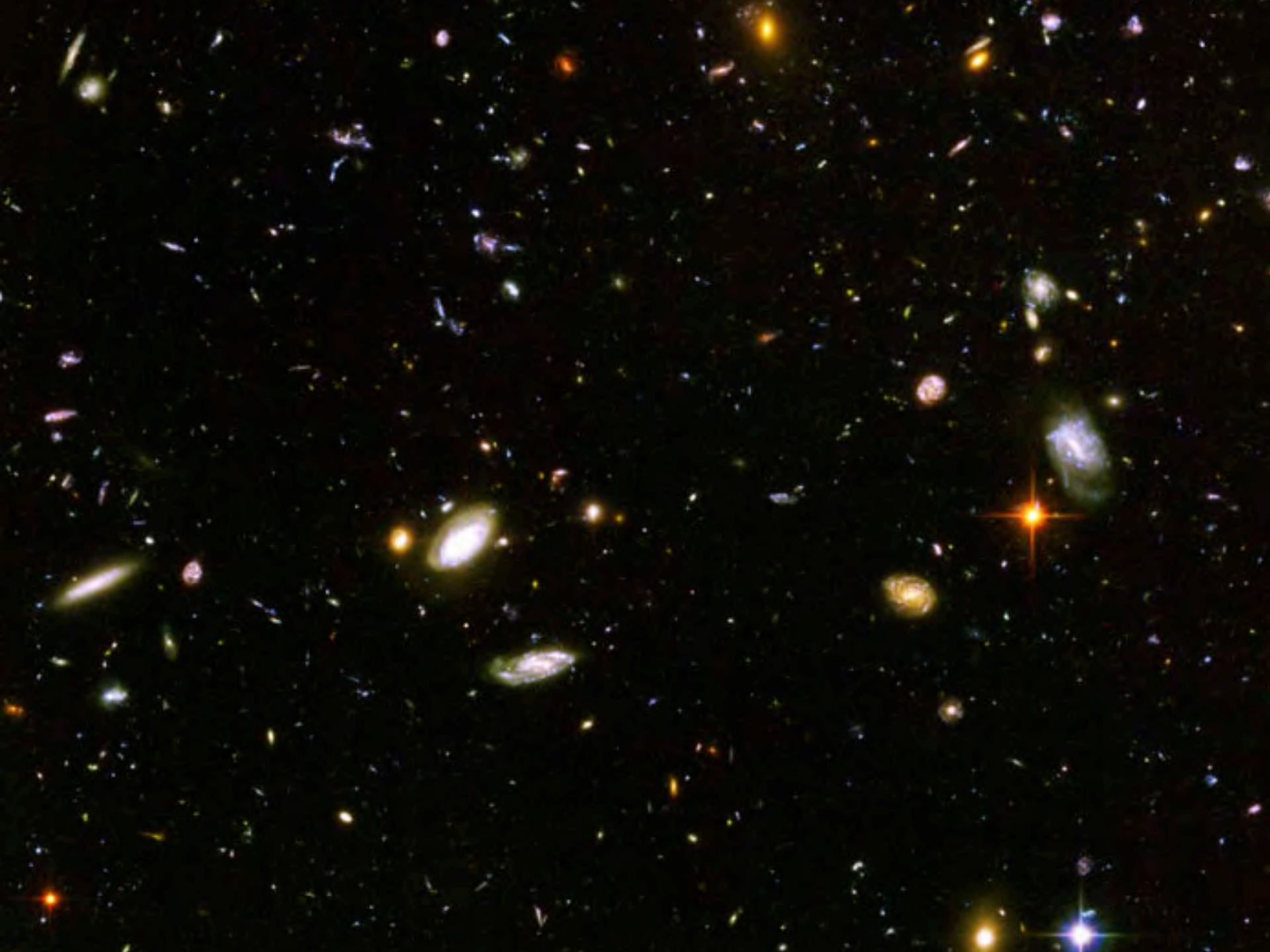
From Galileo's last book, Discourses On Two New Sciences (1638).

King Kong

To the mouse and any smaller animal [gravity] presents practically no dangers. You can drop a mouse down a thousand-yard mine shaft; and, on arriving at the bottom, it gets a slight shock and walks away. A rat is killed, a man is broken, a horse splashes.

– J.B.S. Haldane

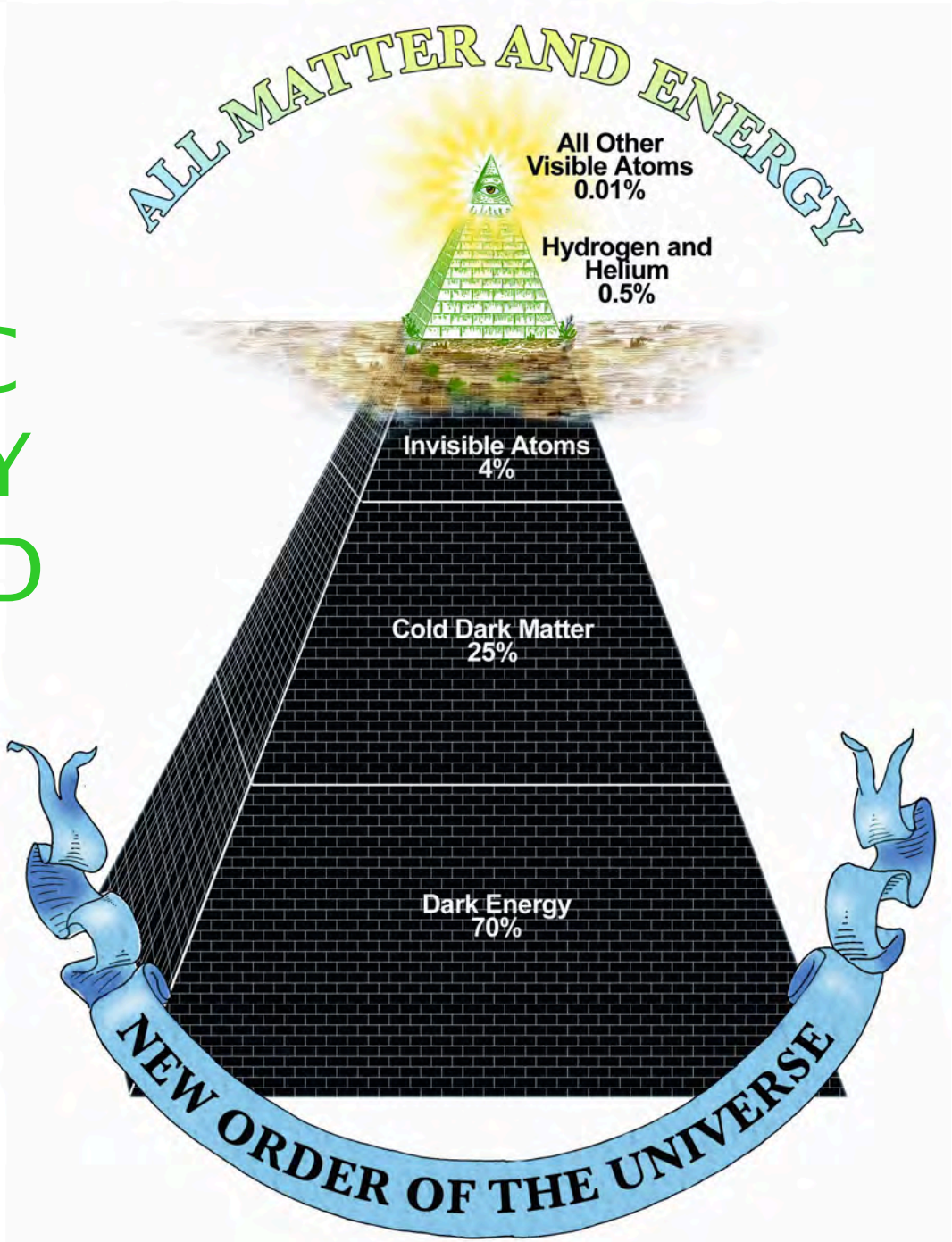
When King Kong fell from the Empire State Building, pink mush should have covered the streets of Manhattan!



stardust

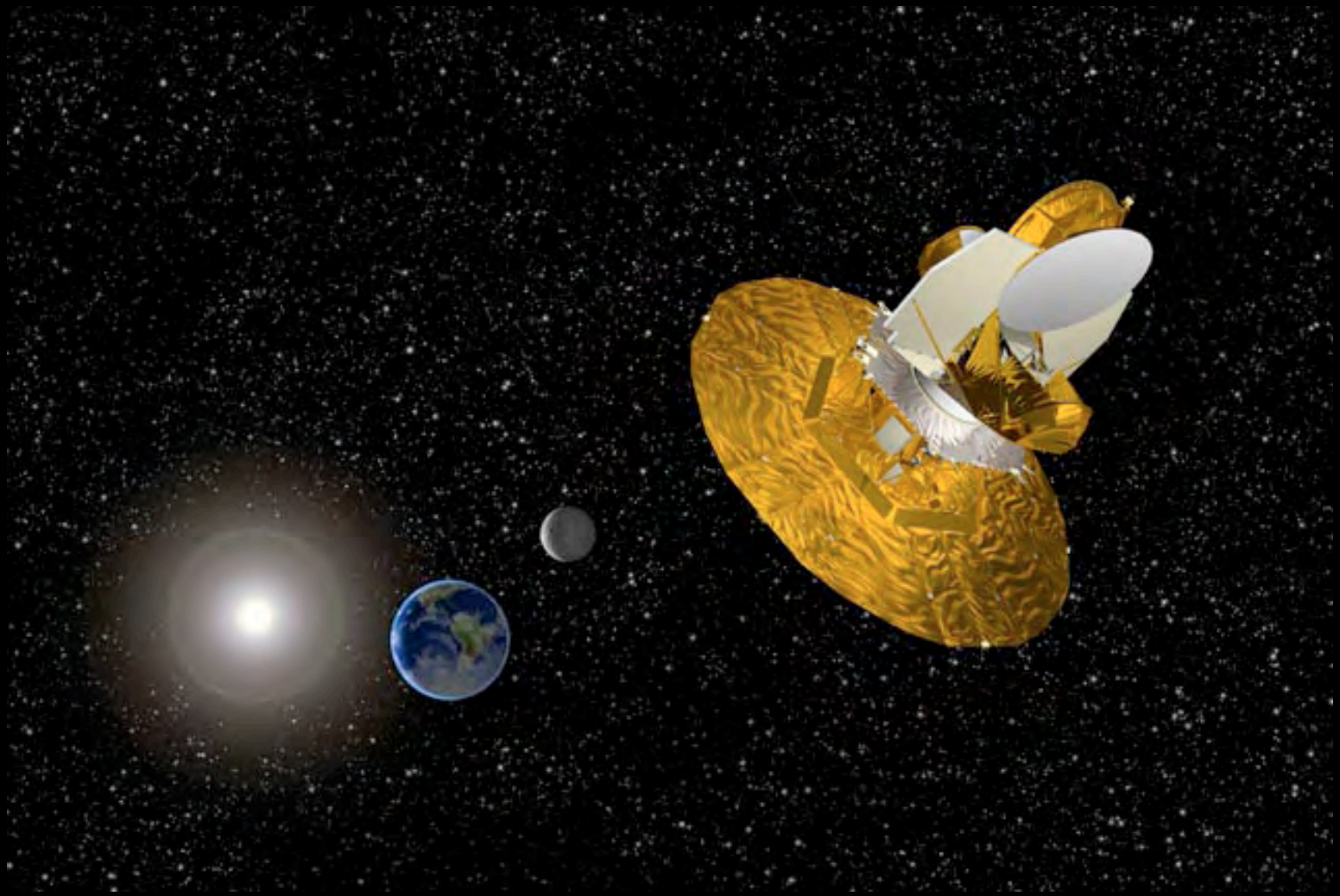
stars

COSMIC DENSITY PYRAMID



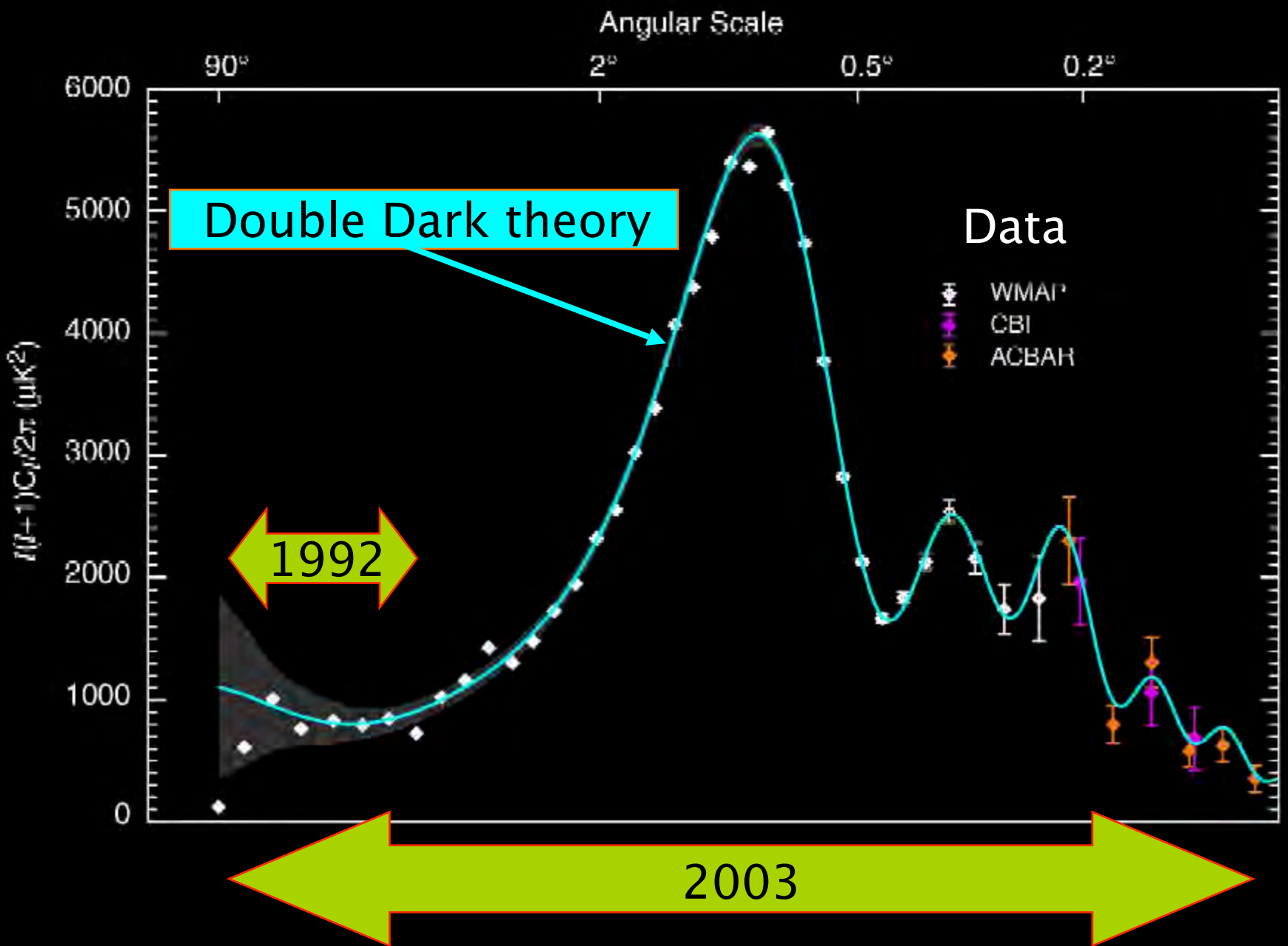
NASA's WMAP satellite

Wilkinson Microwave Anisotropy Probe

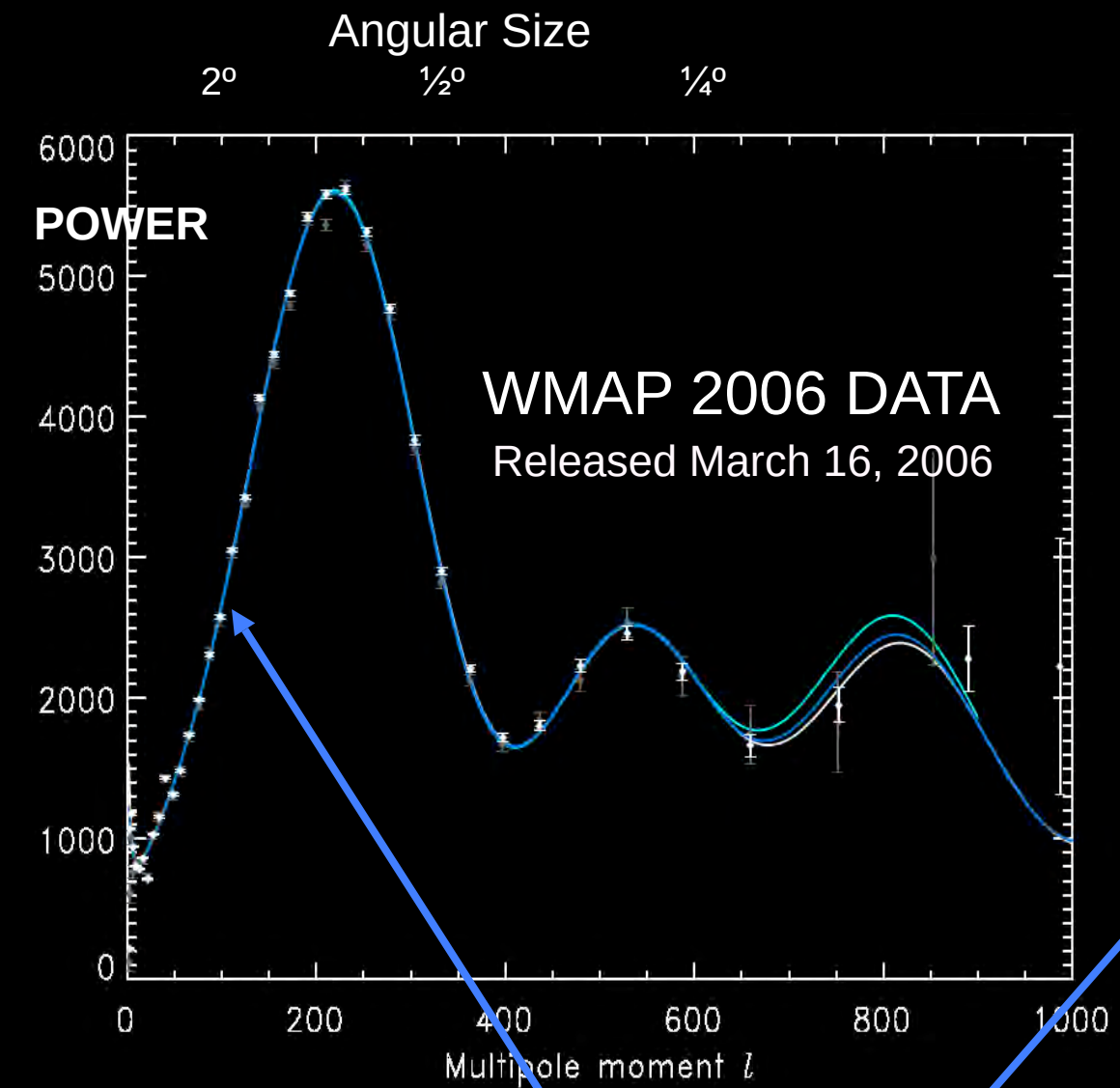


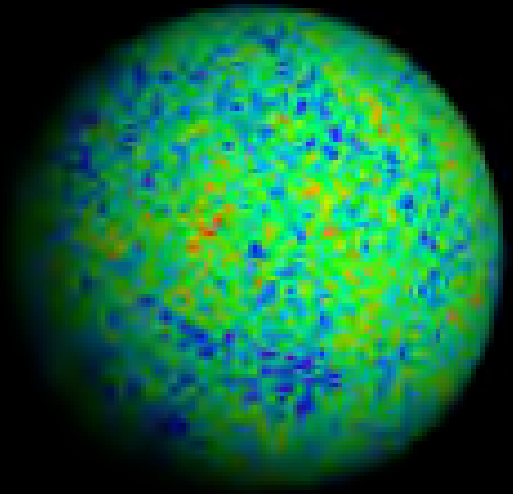
1st results reported: March 2003; 2nd March 2006

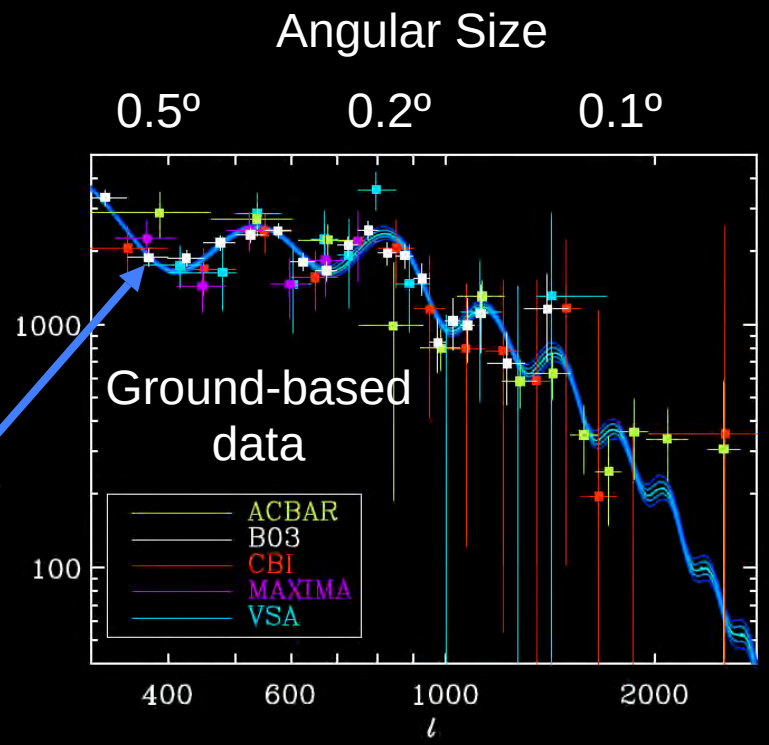
Big Bang Data Agrees with Double Dark Theory!



Latest Big Bang Data Strengthens the Agreement!



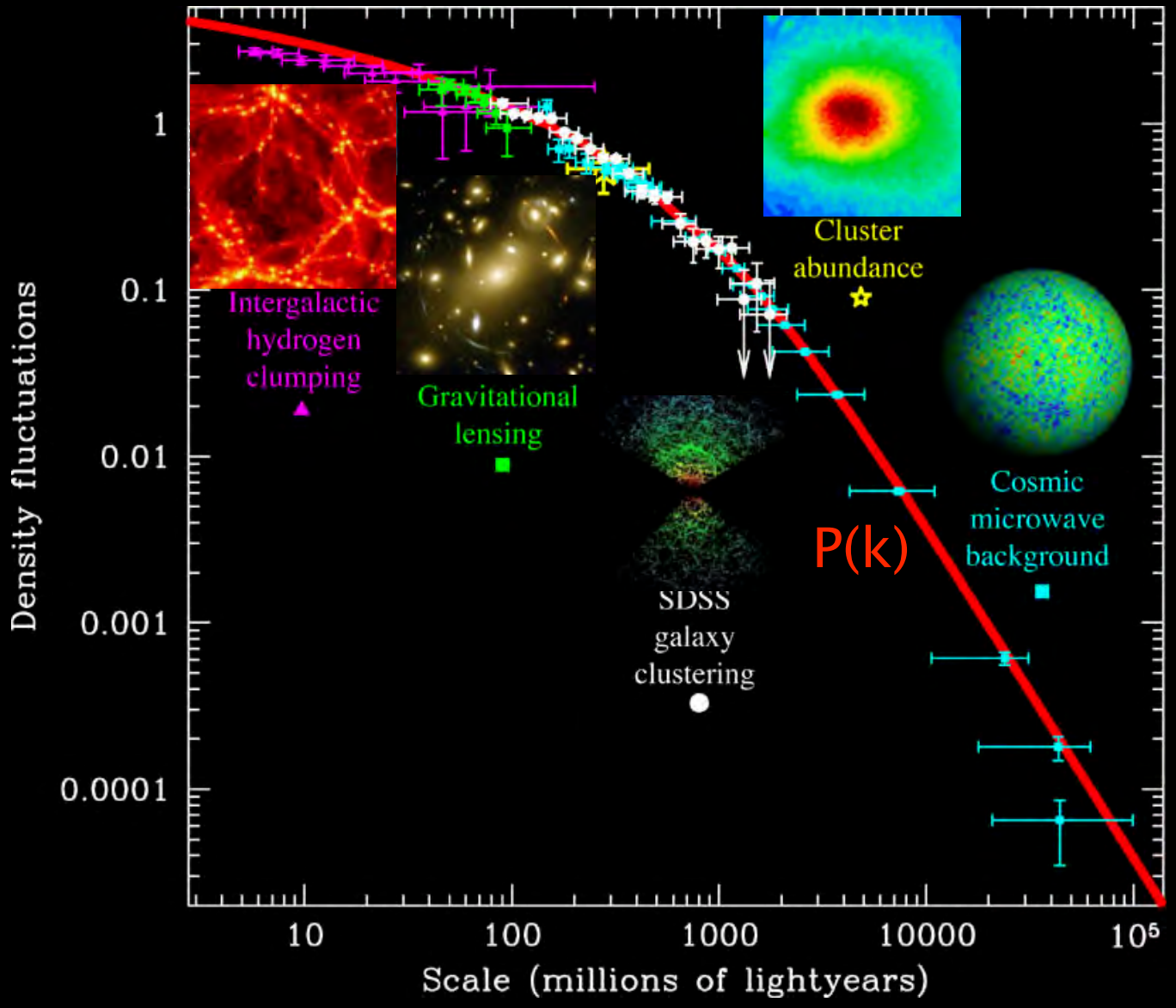




Double Dark theory

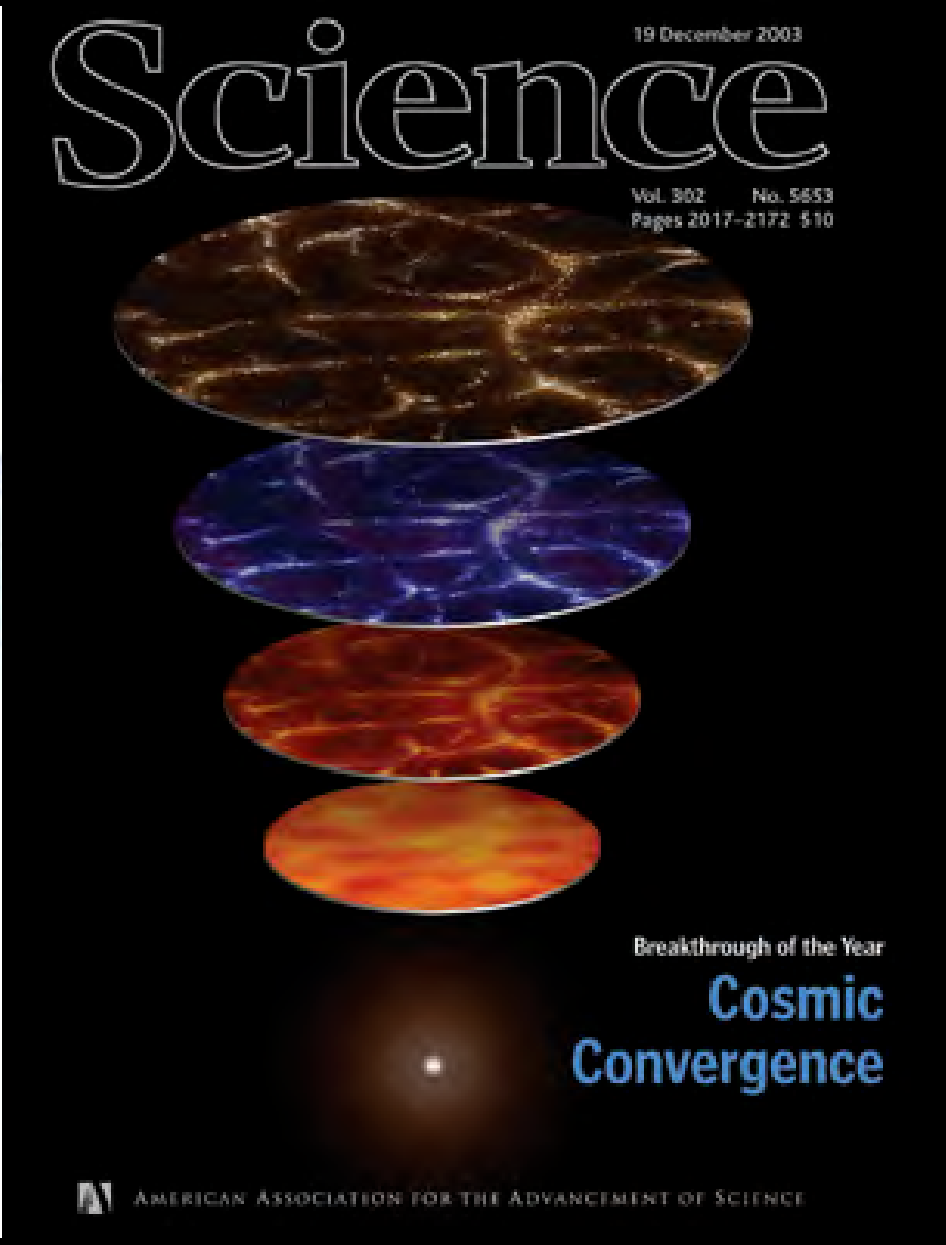
Distribution of Matter

Also Agrees with Double Dark Theory!



Max Tegmark

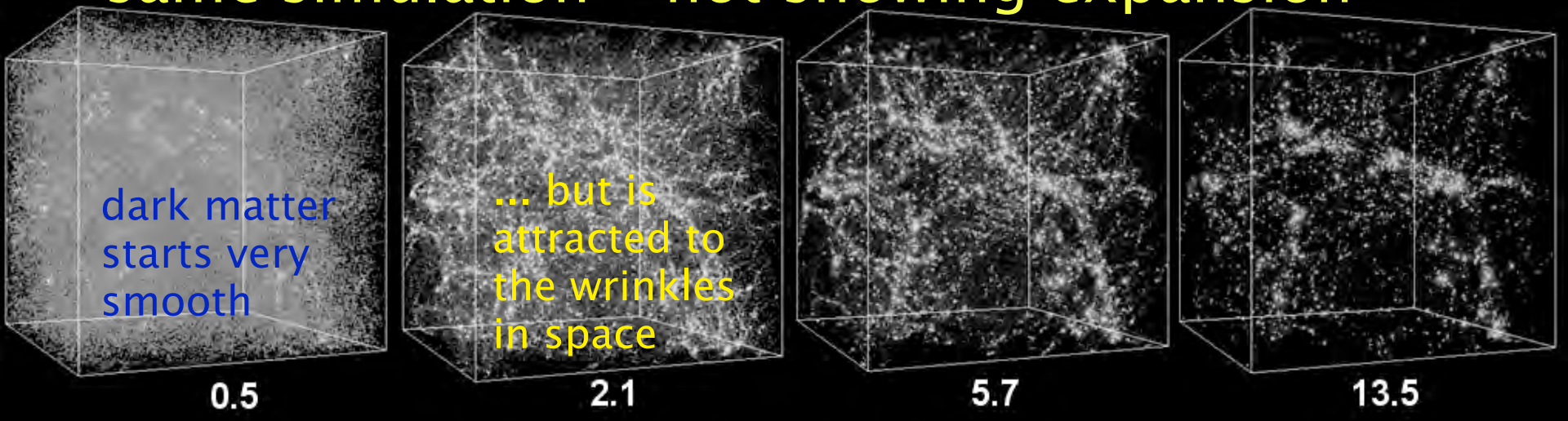
1998 BREAKTHROUGH OF THE YEAR 2003




S. Harris
"QUARKS. NEUTRINOS. MESONS. ALL THOSE DAMN PARTICLES YOU CAN'T SEE. THAT'S WHAT DROVE ME TO DRINK. BUT NOW I CAN SEE THEM!"

dark matter simulation – expanding with the universe

same simulation – not showing expansion



Double Dark Matter Simulation

Rotation is to show 3-D shapes

Yellow marks dense regions
where galaxies are forming

Dark
Matter
Simulation

Columbia
Super-
Computer

NASA
Ames
Laboratory

CLOCK

Billion
years ago

Columbia
Super-
Computer

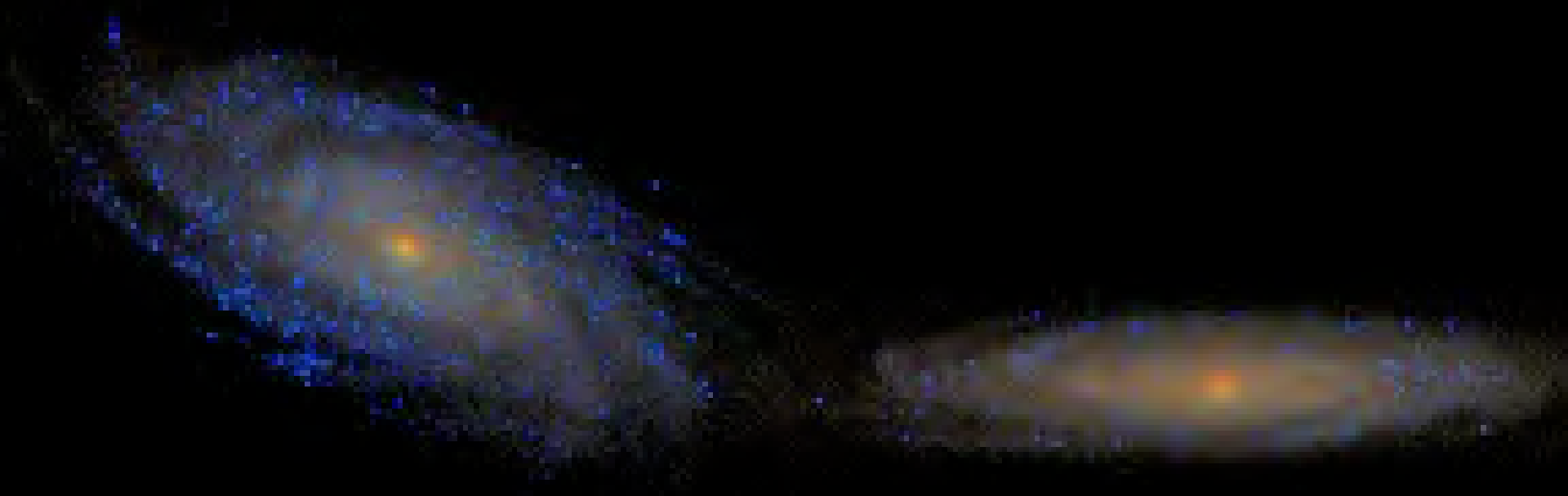
FORMATION OF THE DARK MATTER HALO OF A BIG GALAXY LIKE THE MILKY WAY

Zoom-In
of
Dark
Matter
Simulation:

Columbia
Super-
Computer

NASA
Ames
Laboratory

Galaxy Merger Simulation
run on the Columbia Supercomputer



This image and the following video show a merger between two Sbc galaxies, each simulated with 1.7 million particles. The images are realistic color composites of u, r, and z-band images. Galaxy mergers like this one trigger gigantic “starbursts” in which millions of stars form. But dust absorbs about 90% of the light, and reradiates the energy in the far infrared. We calculate this “radiative transfer” using ~10^6 light rays per image.

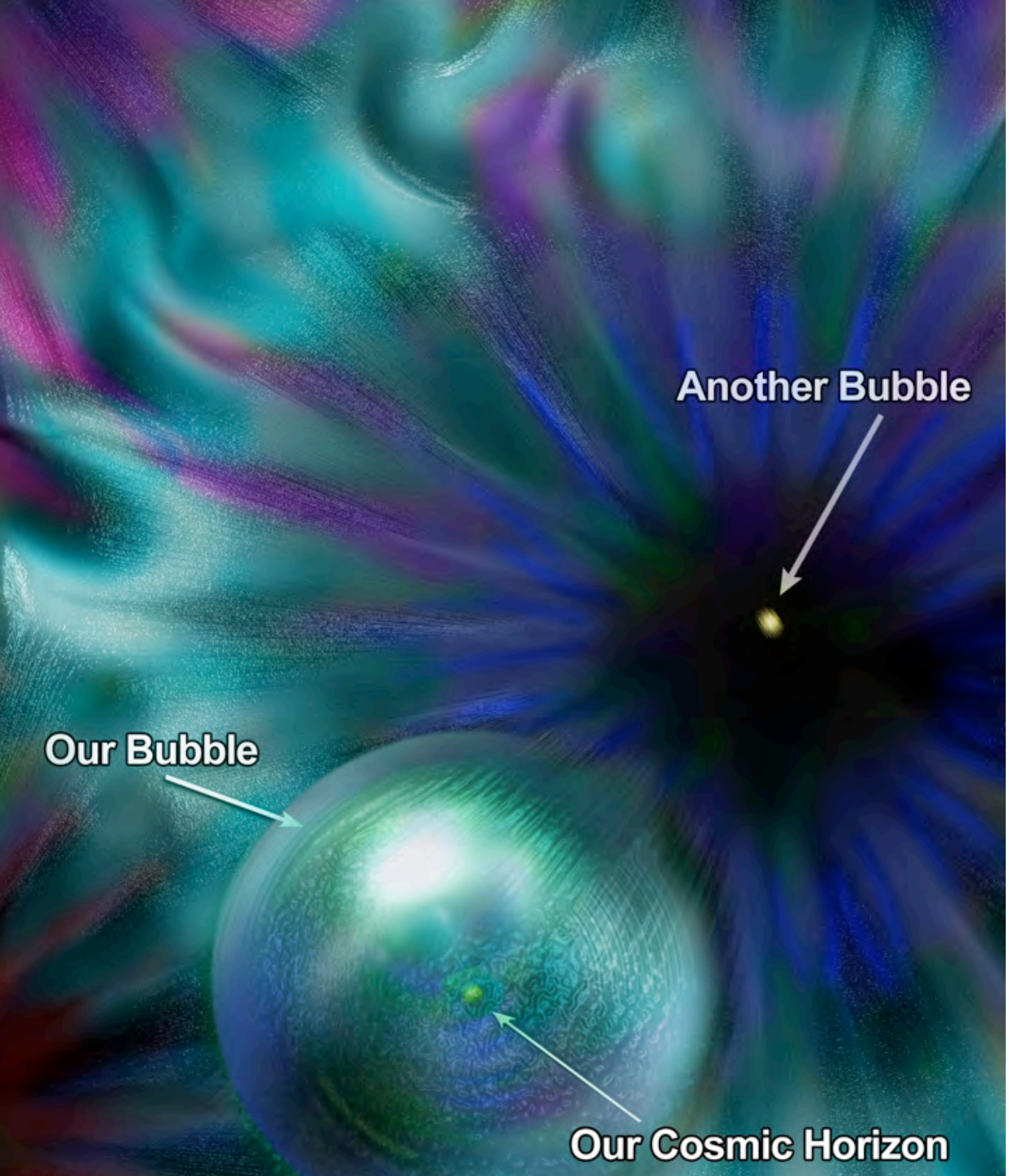
Galaxy Merger Simulation

run on the Columbia Supercomputer

What happened before the Big Bang?

No one knows!
But there is a favorite theory...

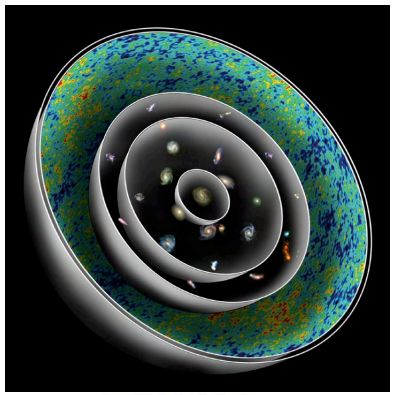
ETERNAL INFLATION



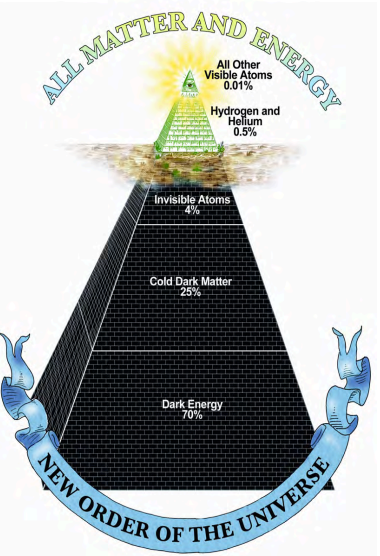
OUR COSMIC BUBBLE IN ETERNAL INFLATION

THE COSMIC LAS VEGAS

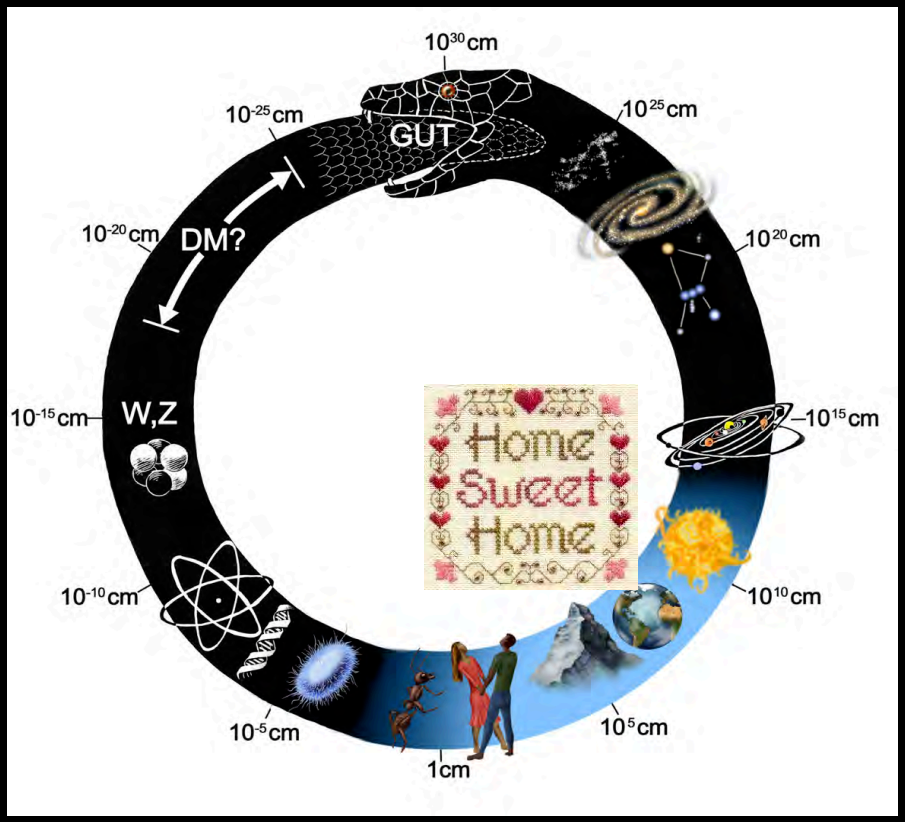
Human beings are central to the Universe not in a simple geographic sense in at least six different ways all of which follow directly from astronomy and physics.



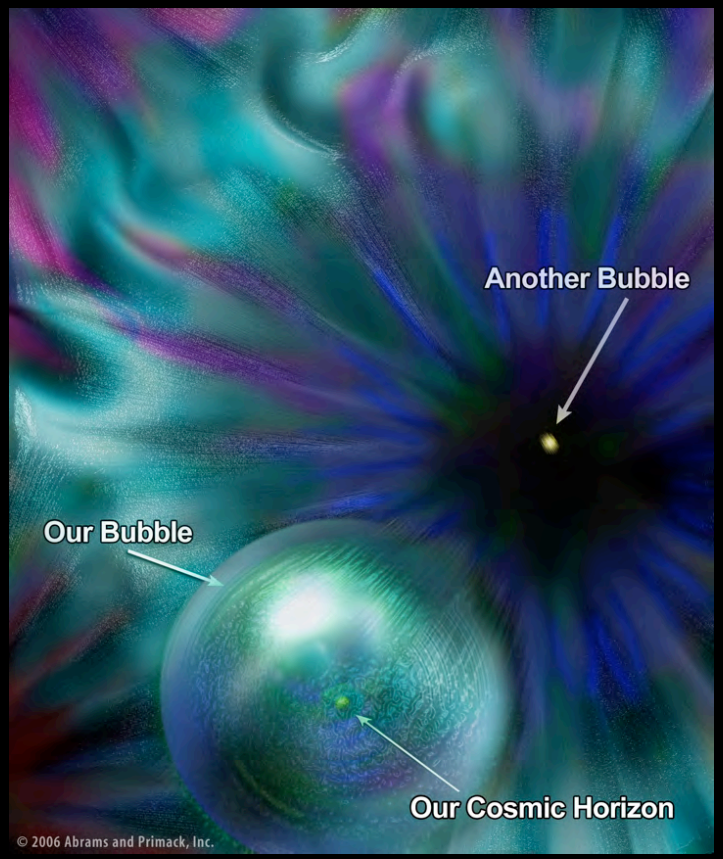
1) We live at the center of our Cosmic Spheres of Time. The finite speed of light makes this inevitable.



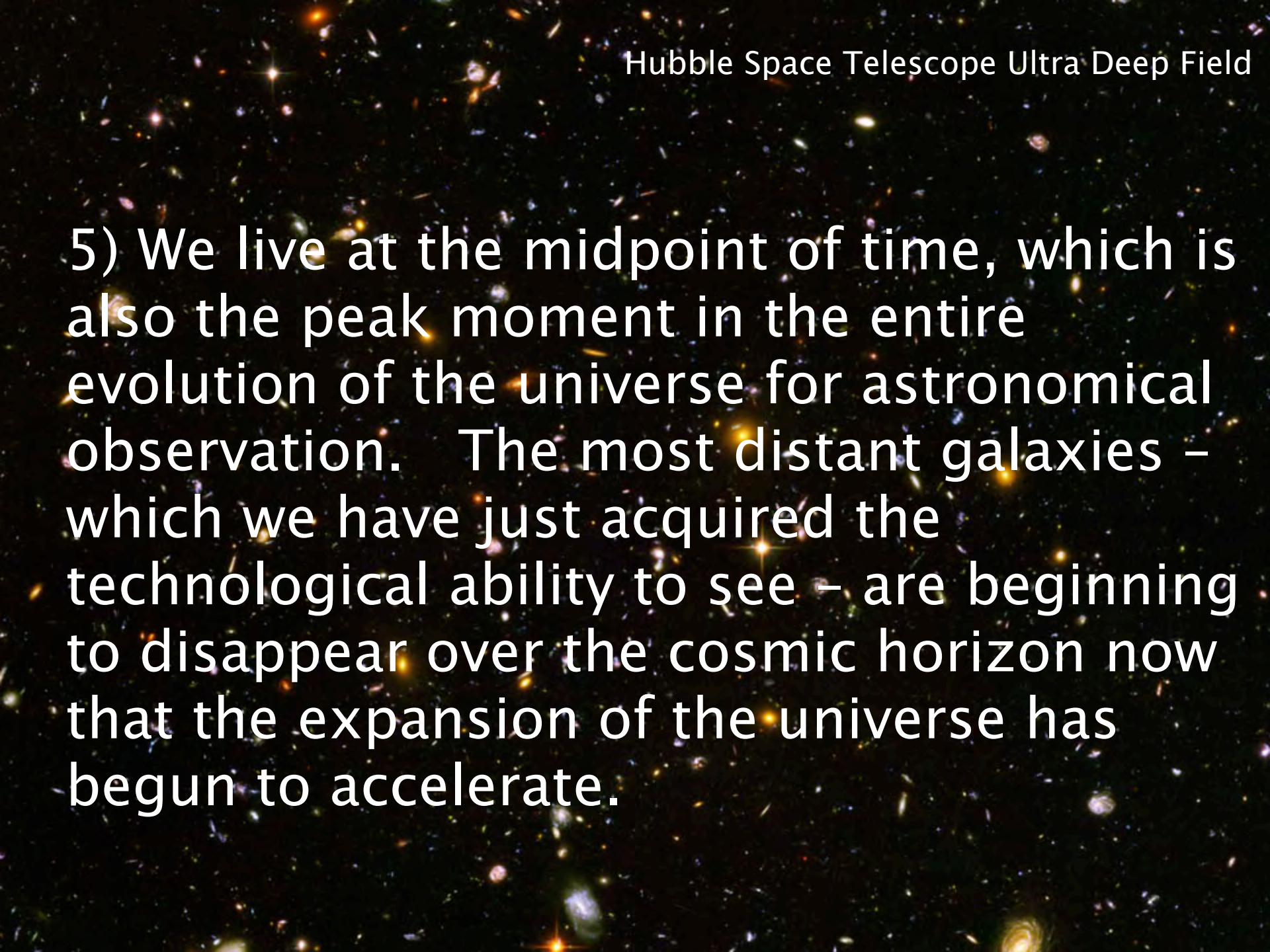
2) We are made of the rarest stuff in the universe: stardust.



3) We live at the middle of all possible sizes – in Midgard, where the possibility of tremendous variety and complexity coming in small packages keeps life interesting. Life of our complexity could bloom nowhere else on the Cosmic Uroboros.



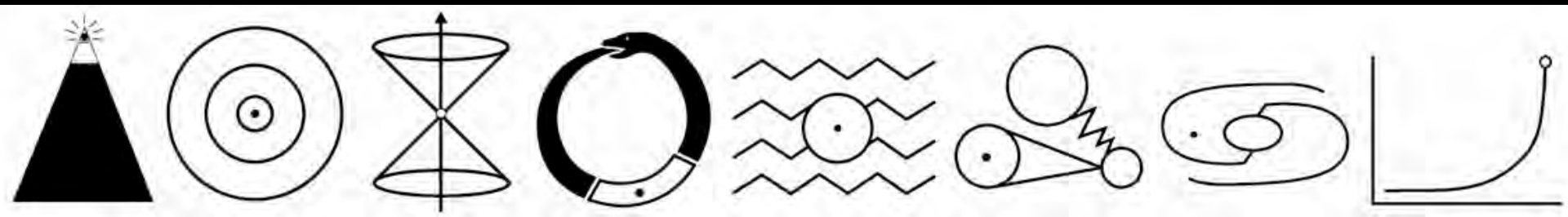
4) We live in a universe that may be a rare bubble of spacetime in the infinite, seething cauldron of the eternal superuniverse. Outside our unique and isolated bubble, which we call the Big Bang, there is neither space nor time as we know it. But here inside there is time for evolution and history, and there is space across which connections can form and structures can develop.



5) We live at the midpoint of time, which is also the peak moment in the entire evolution of the universe for astronomical observation. The most distant galaxies – which we have just acquired the technological ability to see – are beginning to disappear over the cosmic horizon now that the expansion of the universe has begun to accelerate.

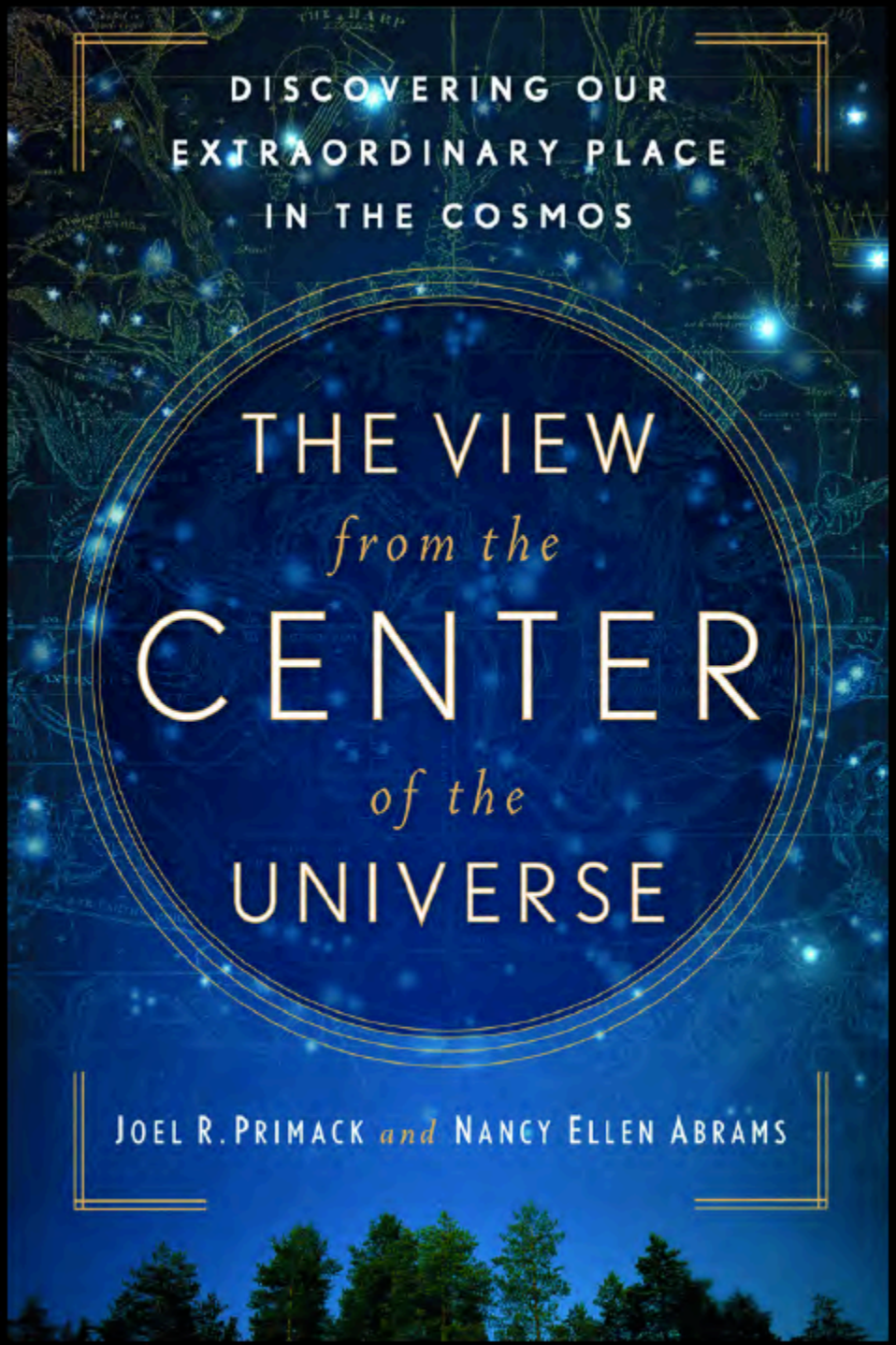
6) We live at the midpoint in the life of our planet. It formed, along with the sun and the other planets, about four and a half billion years ago. It has about six billion years to go before it is roasted when our sun swells into a red giant star. Complex life evolved about half a billion years ago, and has about half a billion years to go until the warming sun overheats the earth. Or billions of years if our descendants move the earth farther from the sun.

A new scientific cosmology is emerging



In each of the icons above, the point represents our central or special place in the cosmos.

How will a new picture of the universe at the turn of the 21st century affect global culture? Can the new cosmos provide new metaphors and inspire us to approach global problems in new ways?



extras and enhancements at

http://
ViewfromtheCenter.com

Penguin Group
Riverhead Books

Credits

Videos:

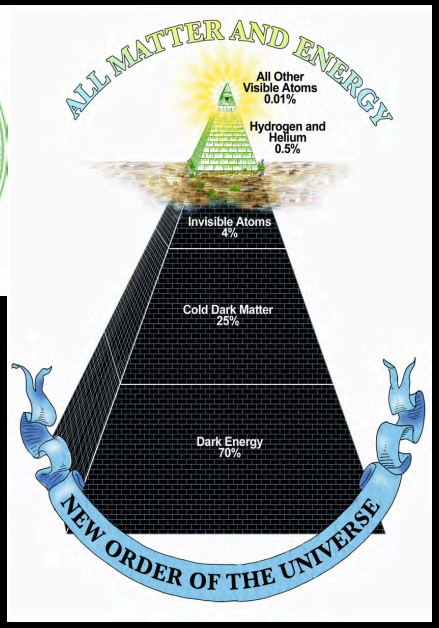
Voyage to Virgo Cluster – www.ifa.hawaii.edu/~tully
Hubble UDF zoom-in – Summers – Hubblesite.org
SDSS map galaxies – astro.uchicago.edu/cosmus
LCDM simulation – Allgood & Henze, NASA Ames
– people.nas.nasa.gov/chenze/Brandon
Galaxy Merger Simulation – Novak & Jonsson

Music:

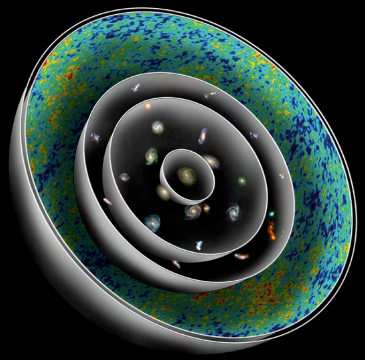
Nancy Abrams
R. Carlos Nakai
Nancy Abrams
R. Stoltzman/
C. Debussy
Nancy Abrams

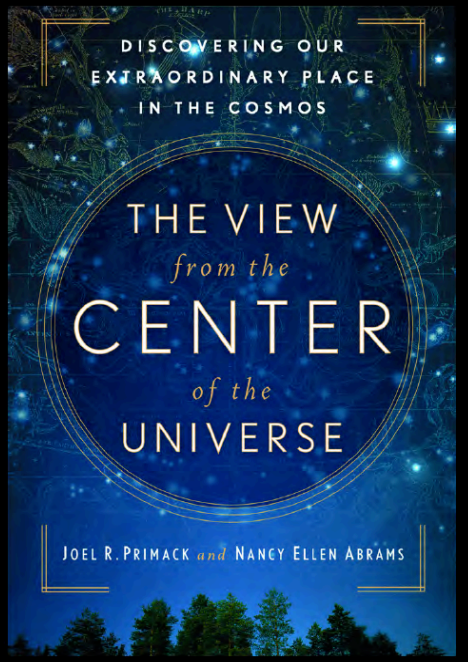
Symbolic Images of the Cosmos:

Cosmic Density Pyramid



Spheres of Time





LINKS and IMAGES
are at our website
http://
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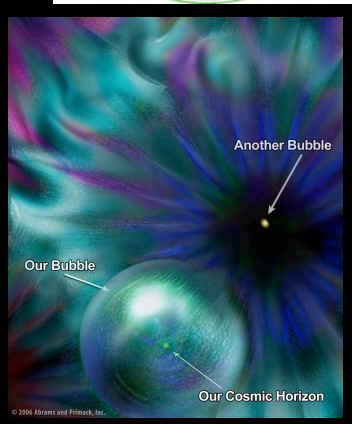

Our Bubble