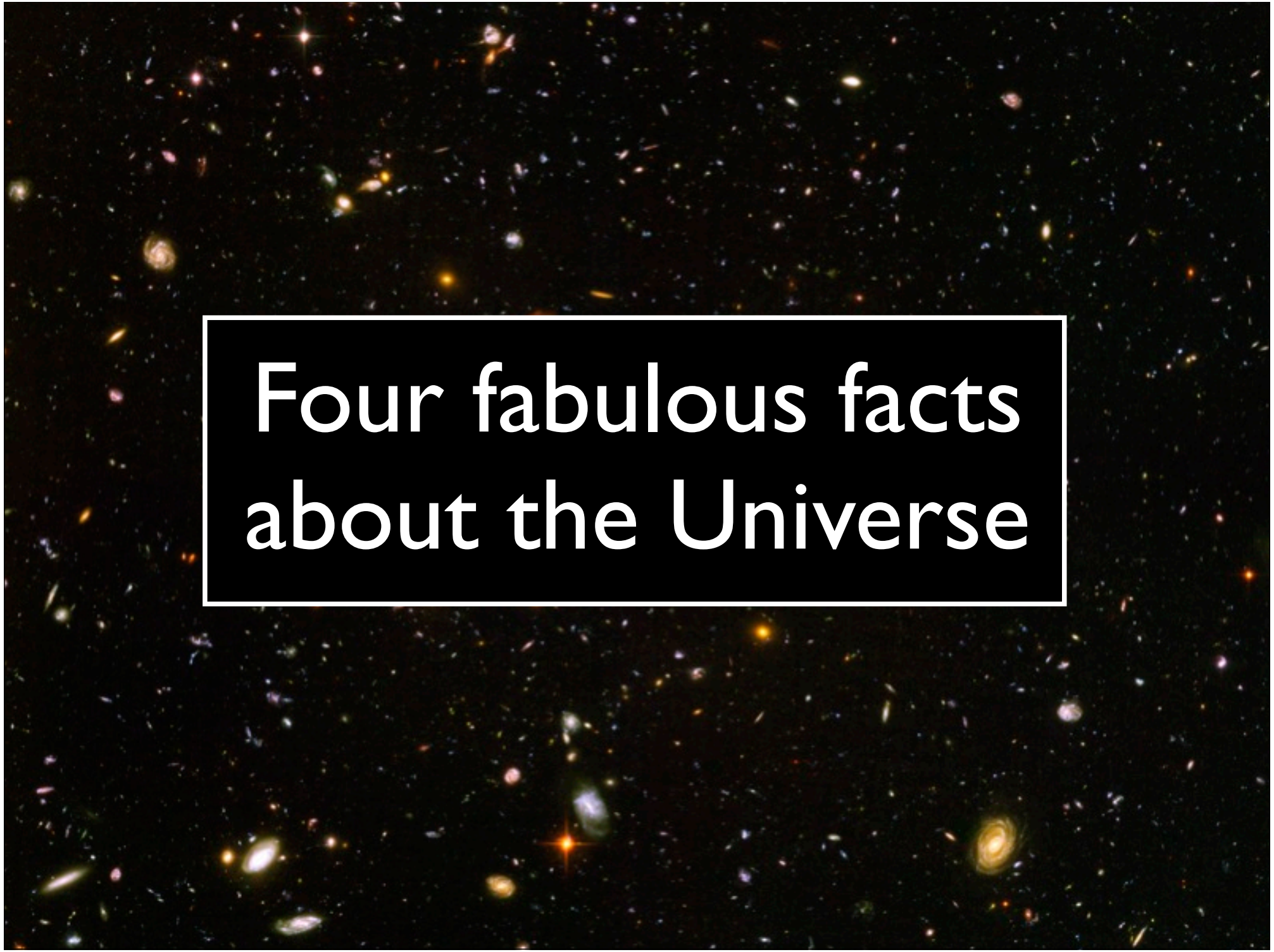
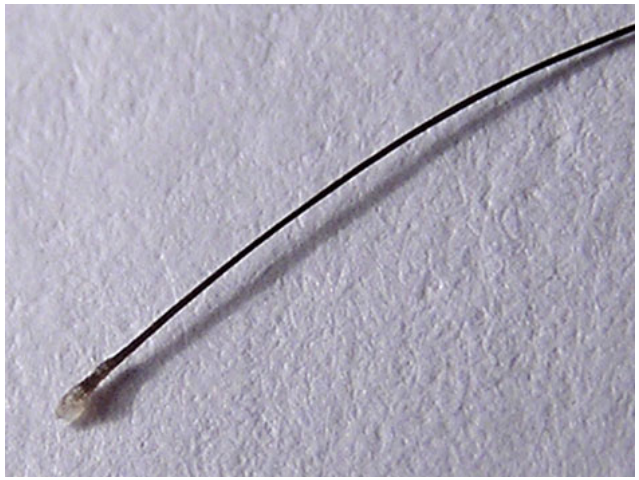

Four fabulous facts
about the Universe

COSMOLOGY MARCHES ON

Getting our bearings : how big is the Universe?

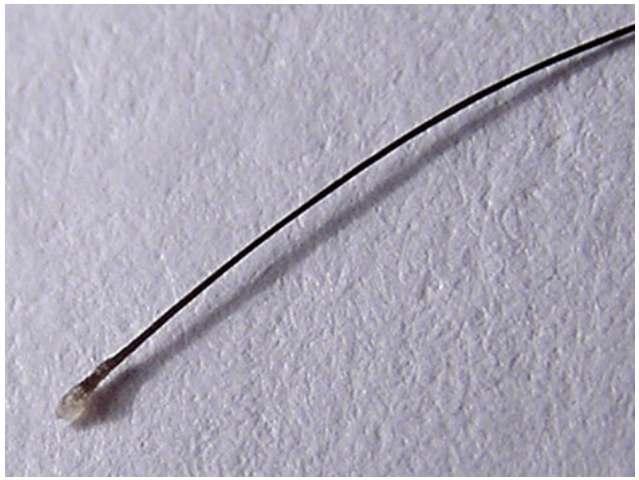
Getting our bearings : how big is the Universe?

The Earth

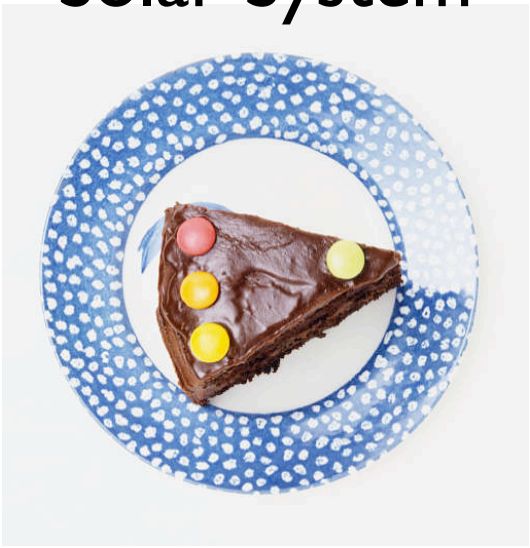


Getting our bearings : how big is the Universe?

The Earth

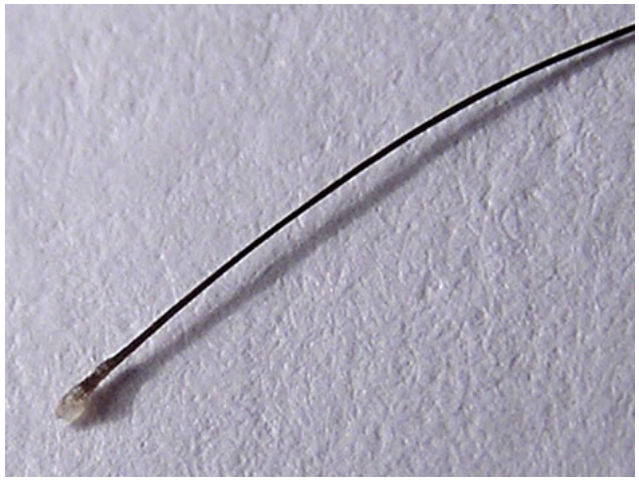


Solar System

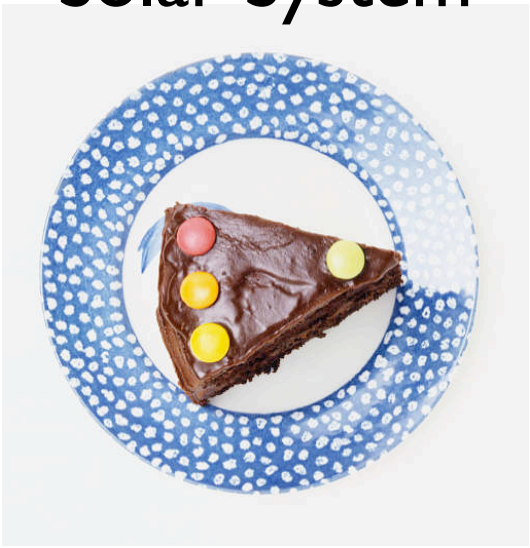


Getting our bearings : how big is the Universe?

The Earth



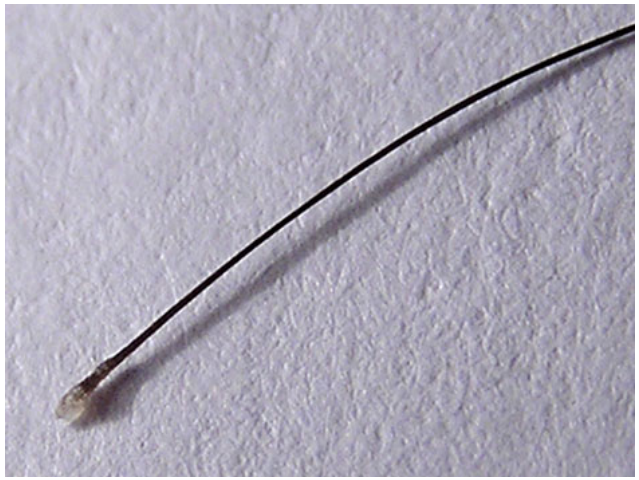
Solar System



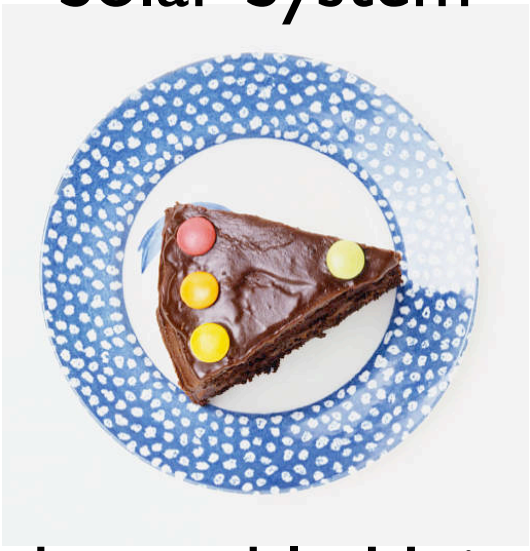
Milky Way Galaxy

Getting our bearings : how big is the Universe?

The Earth



Solar System



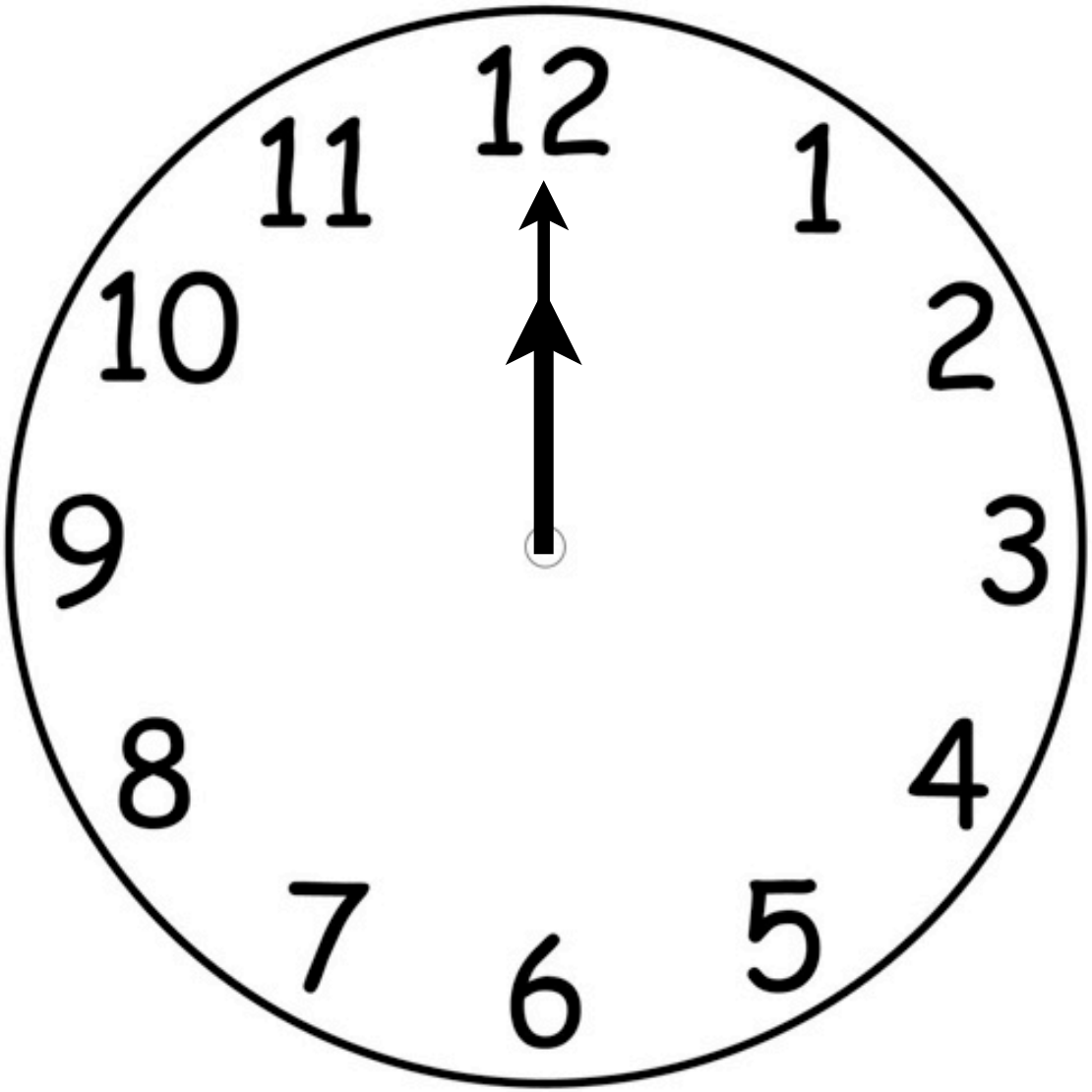
Milky Way Galaxy

The observable Universe

Getting our bearings : how big is the Universe?

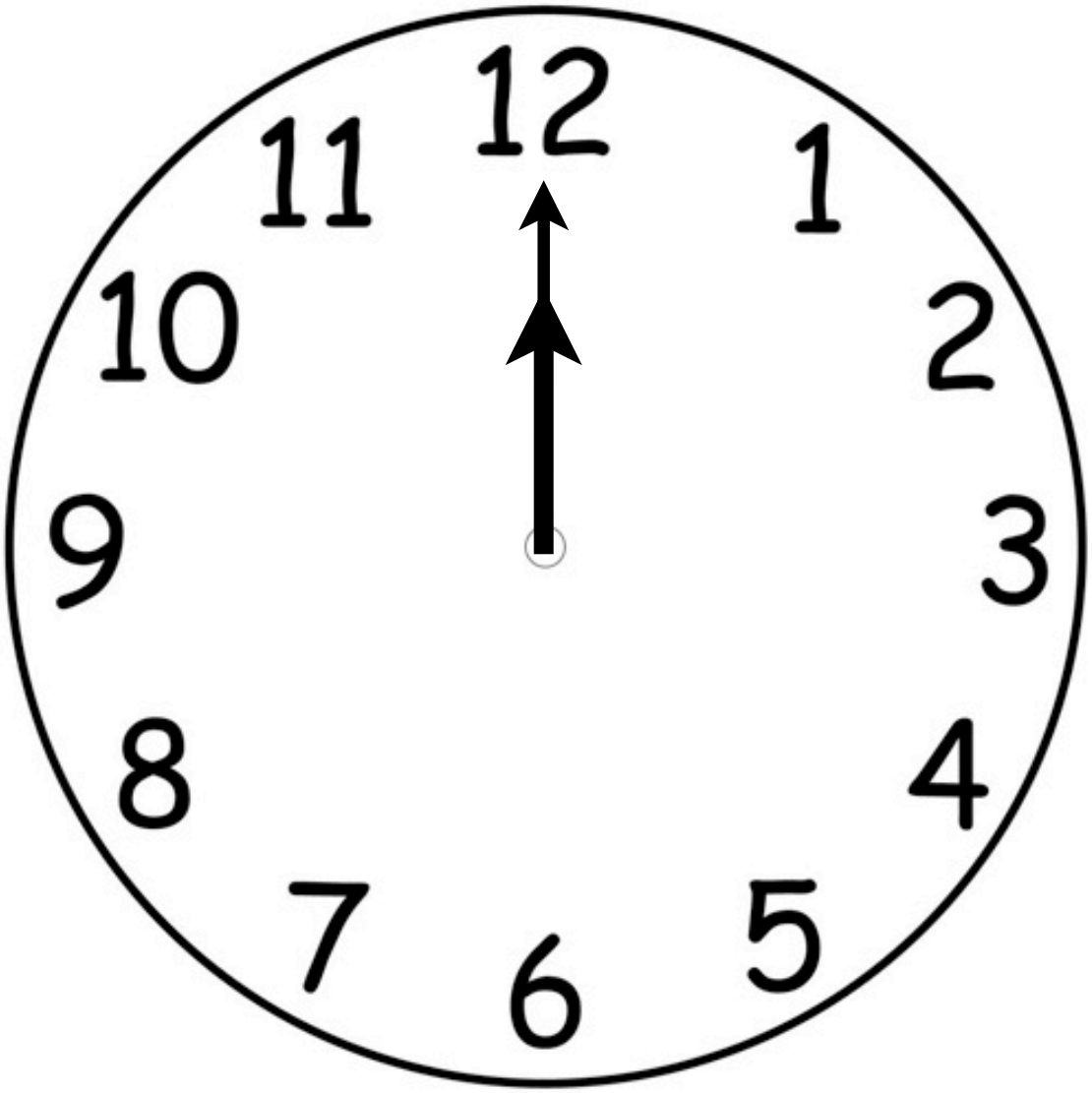
http://map.gsfc.nasa.gov/resources/animconcepts.html

Getting our bearings : how old is the Universe?



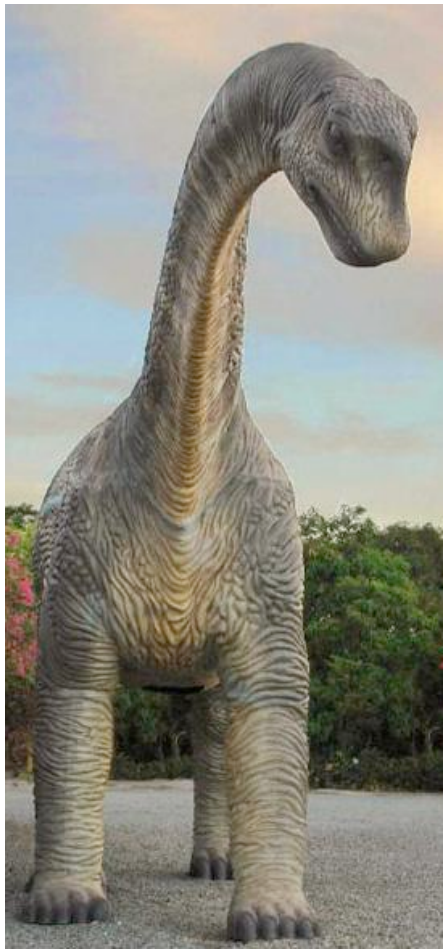
Getting our bearings : how old is the Universe?

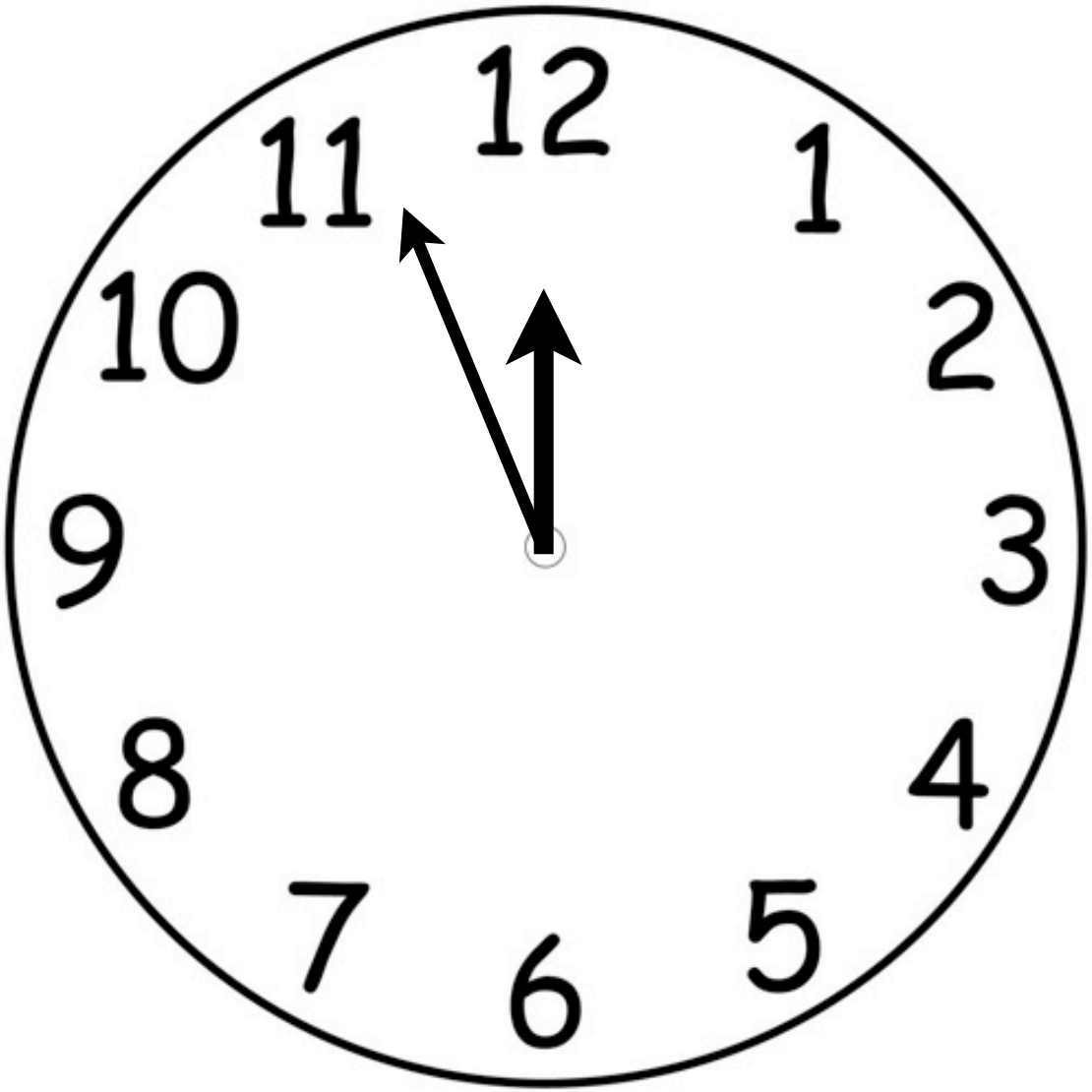
My lifetime ...
(31 yrs)



Getting our bearings : how old is the Universe?

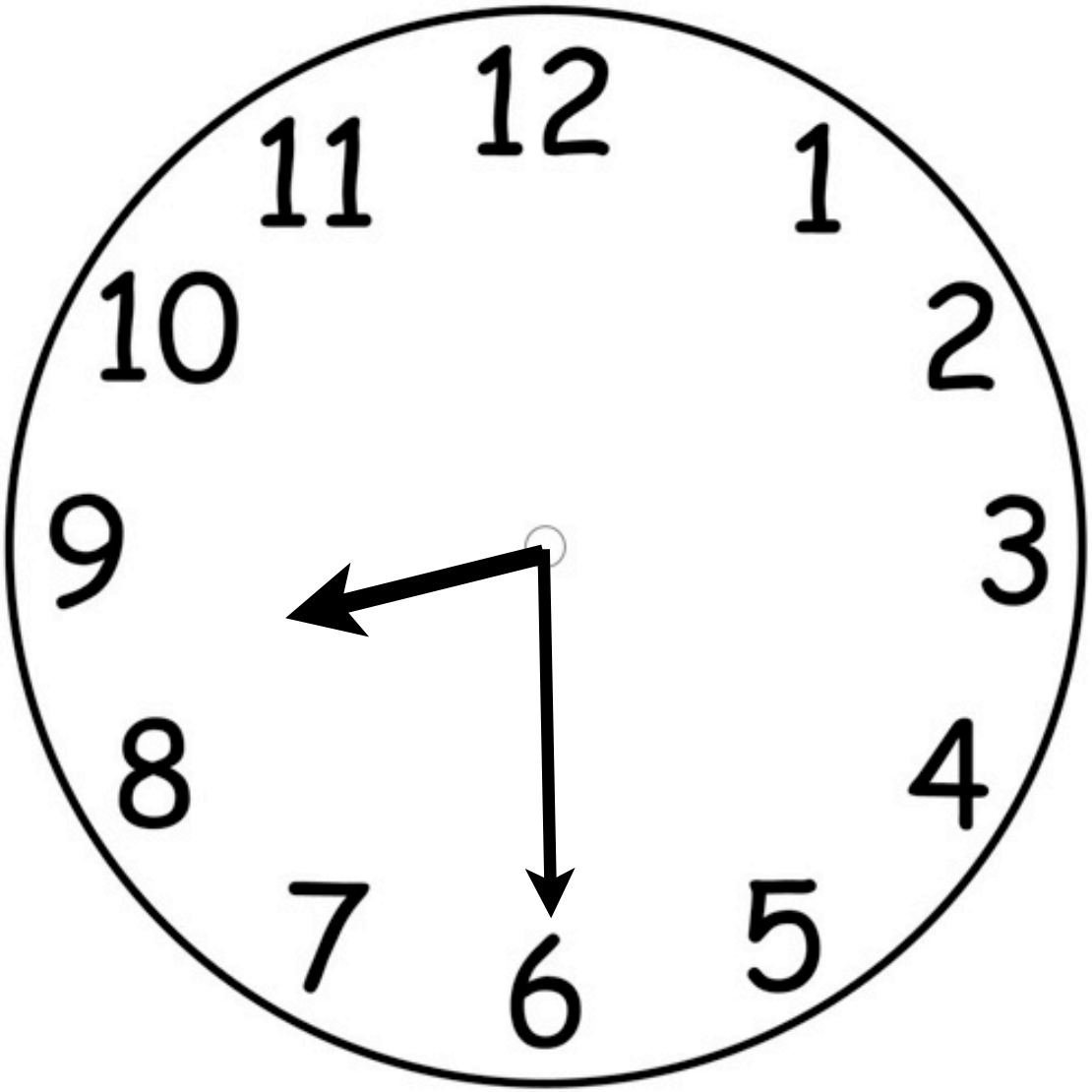
Extinction of the dinosaurs ...
(65 million yrs)





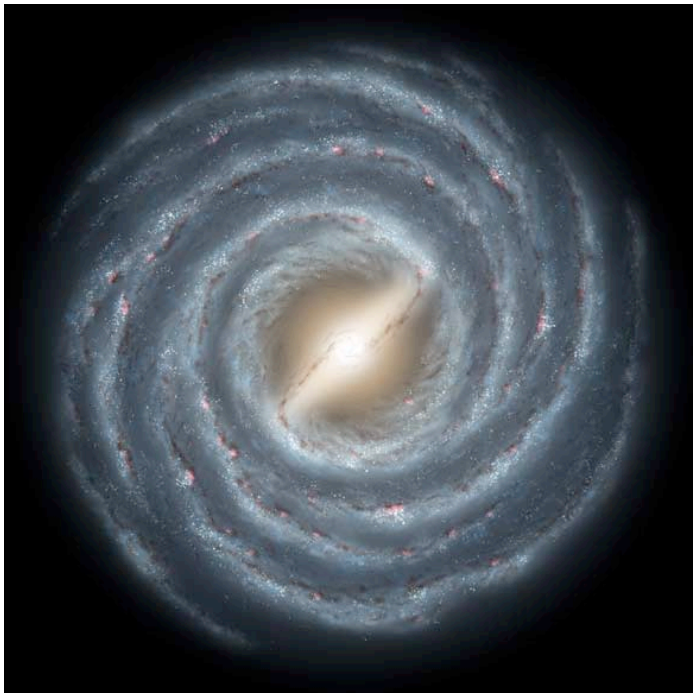
Getting our bearings : how old is the Universe?

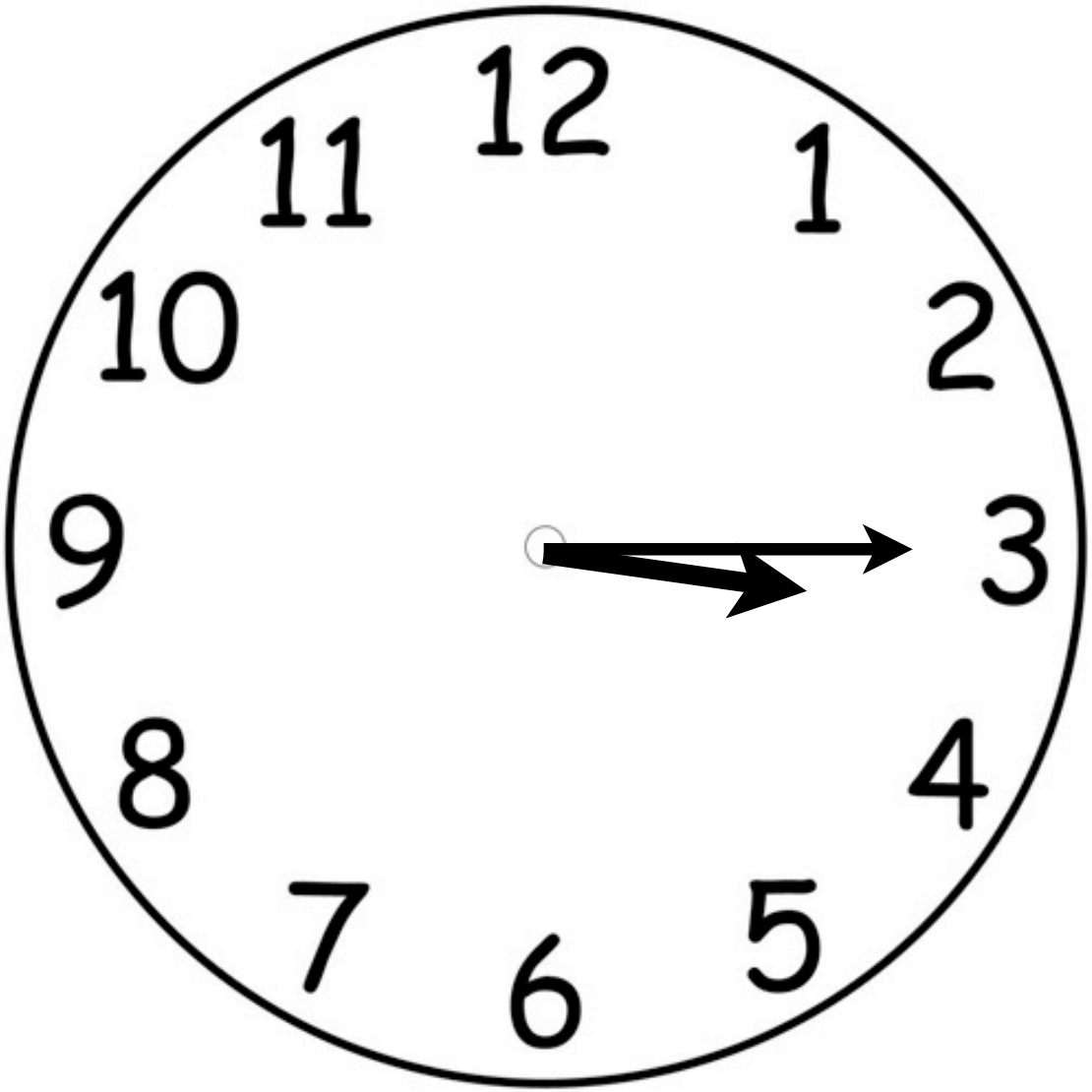
Formation of the
solar system ...
(approx. 4 billion yrs)



Getting our bearings : how old is the Universe?

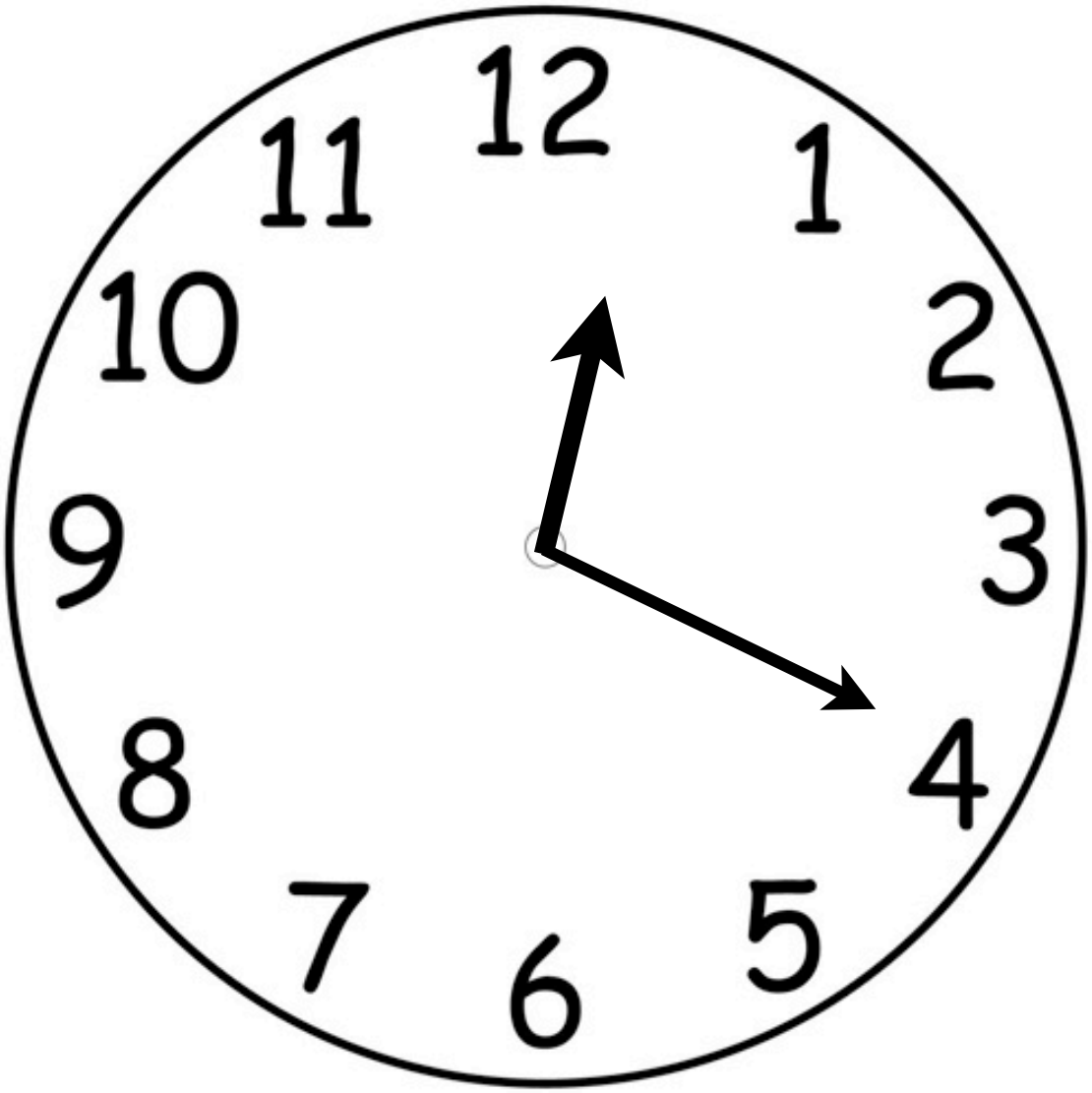
Formation of our galaxy ... (approx. 10 billion yrs)





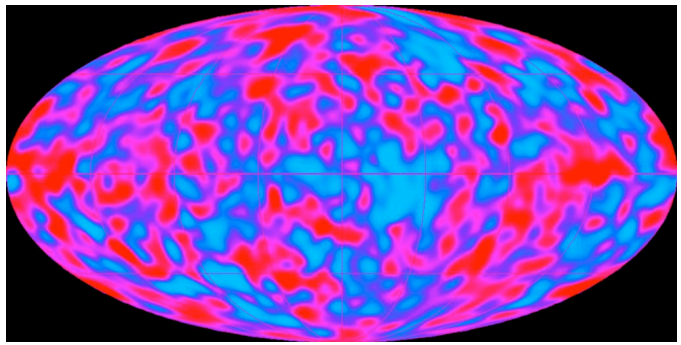
Getting our bearings : how old is the Universe?

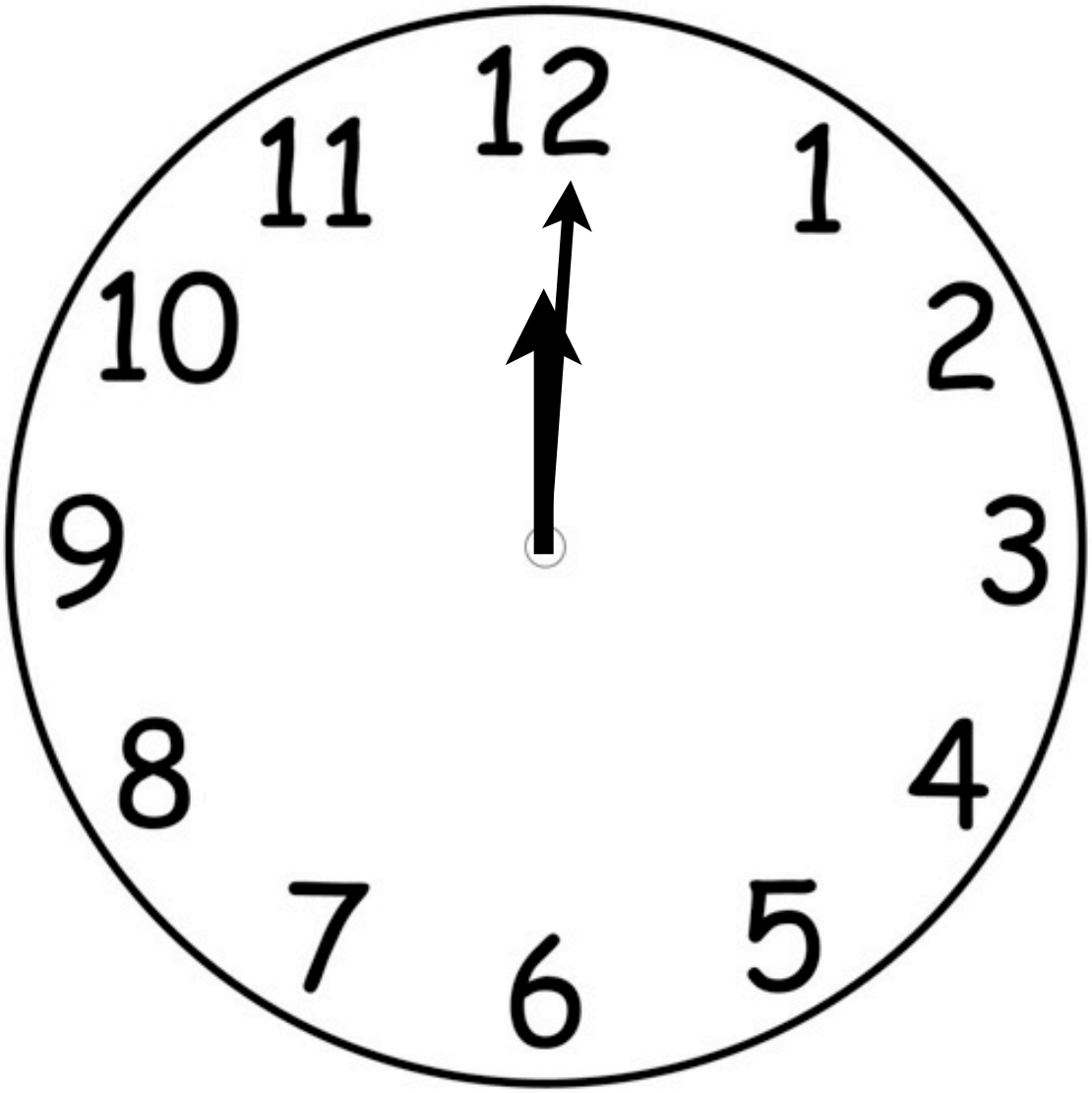
Formation of first stars ... (approx. 13.3 billion yrs)



Getting our bearings : how old is the Universe?

The first light we can detect (13.7 billion yrs)



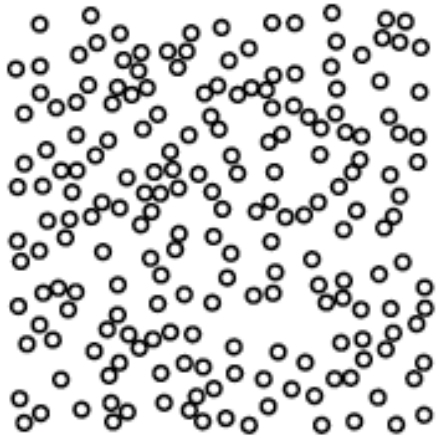


Four fabulous facts about the Universe

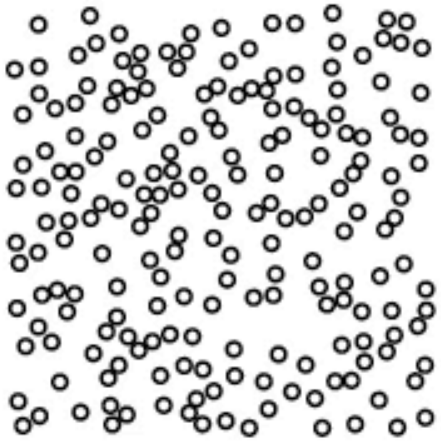
(1) The Universe is expanding

http://snap.lbl.gov/multimedia/animations/

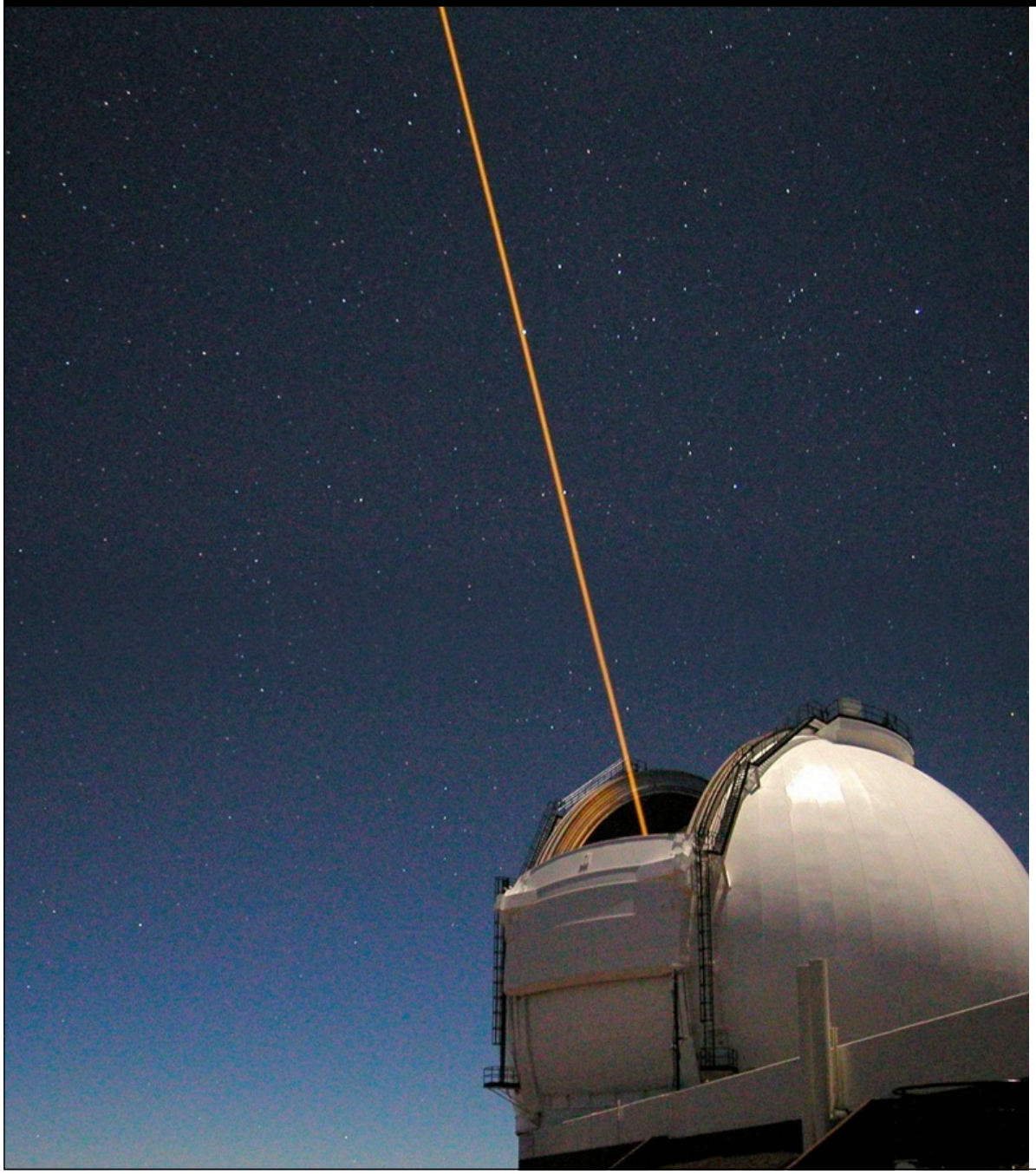
(1) The Universe is expanding



(1) The Universe is expanding



(2) The Universe is a time machine

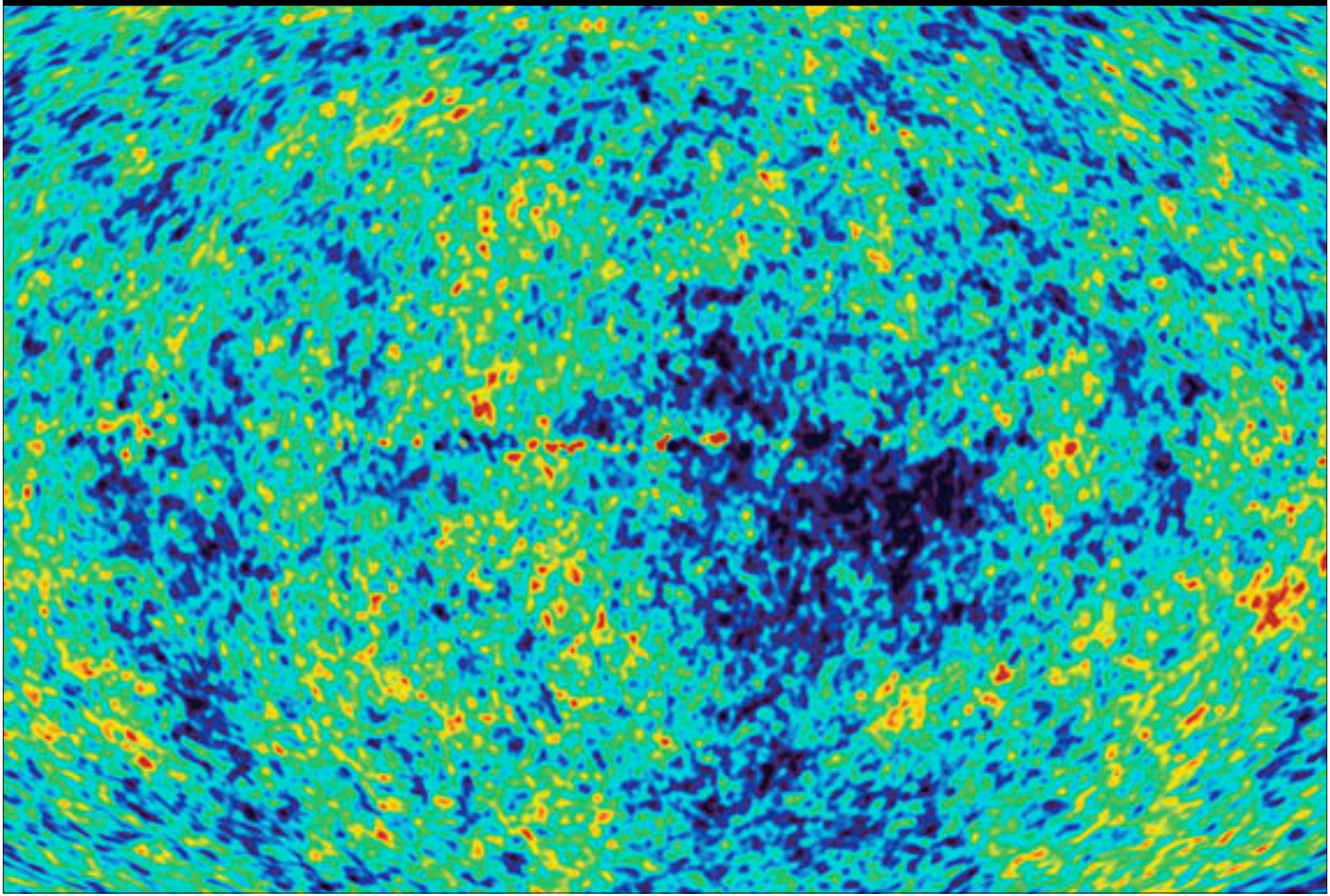


Useful fact:
Light travels at
300,000 km/s

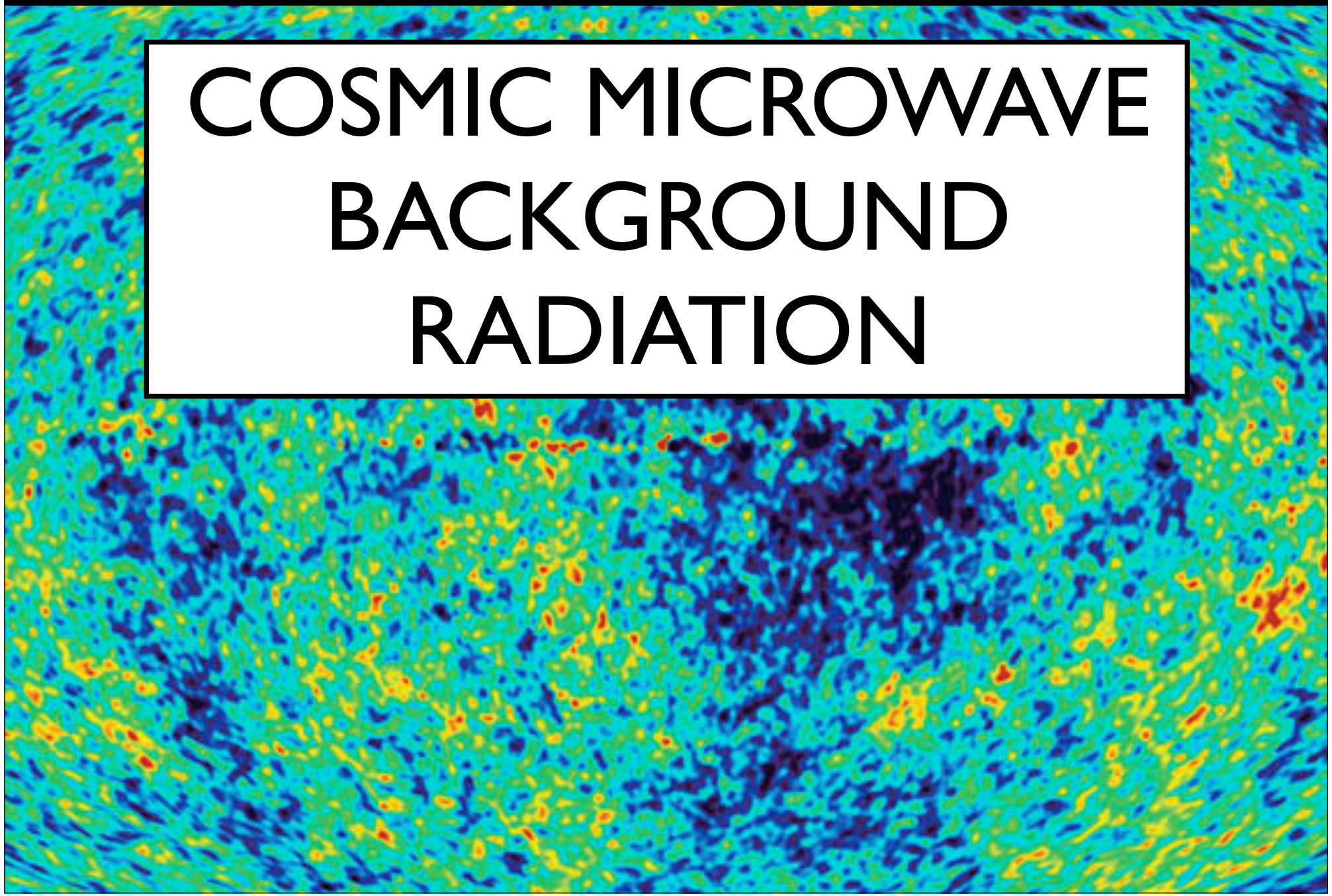
(2) The Universe is a time machine

http://hubblesite.org/newscenter/archive/

(3) The Universe was much hotter in the past

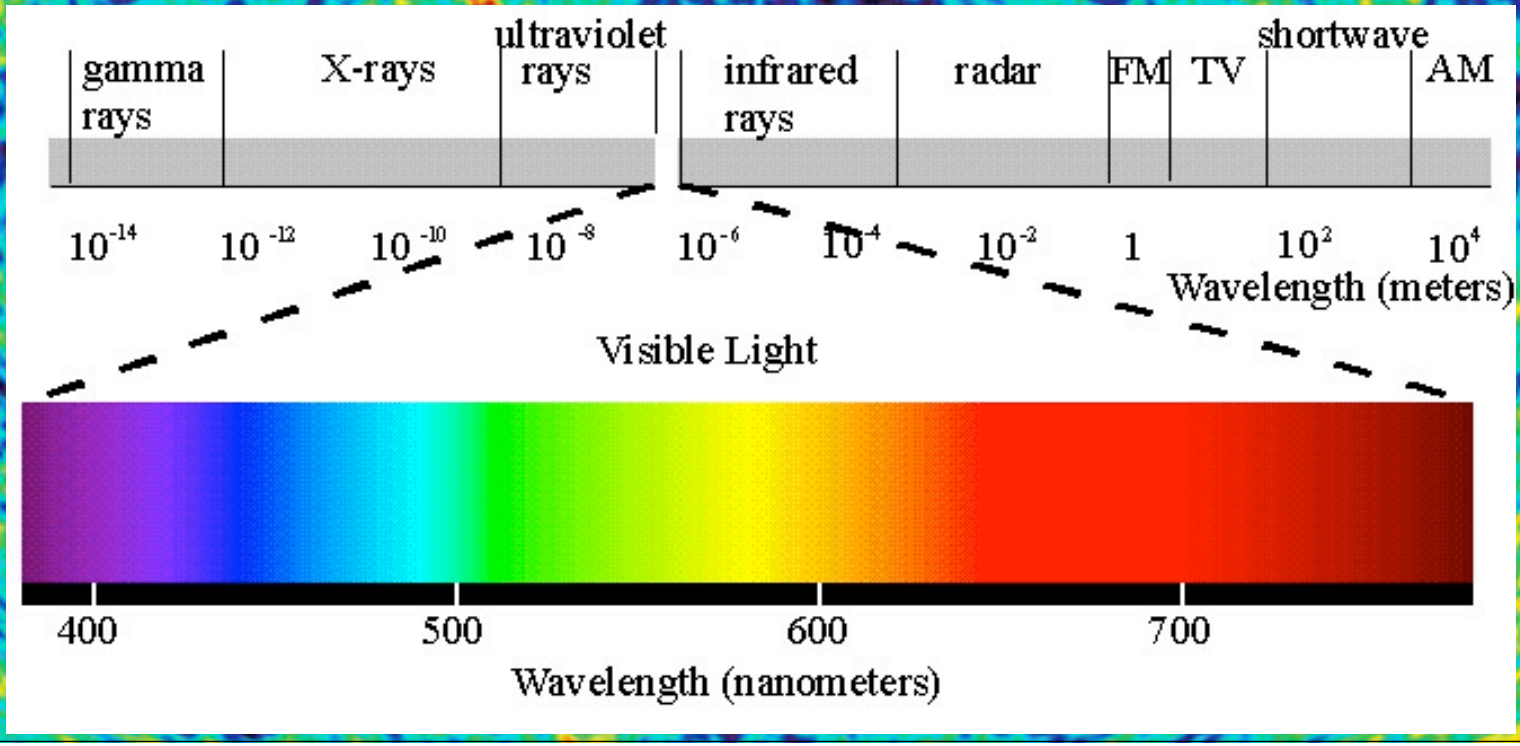


(3) The Universe was much hotter in the past

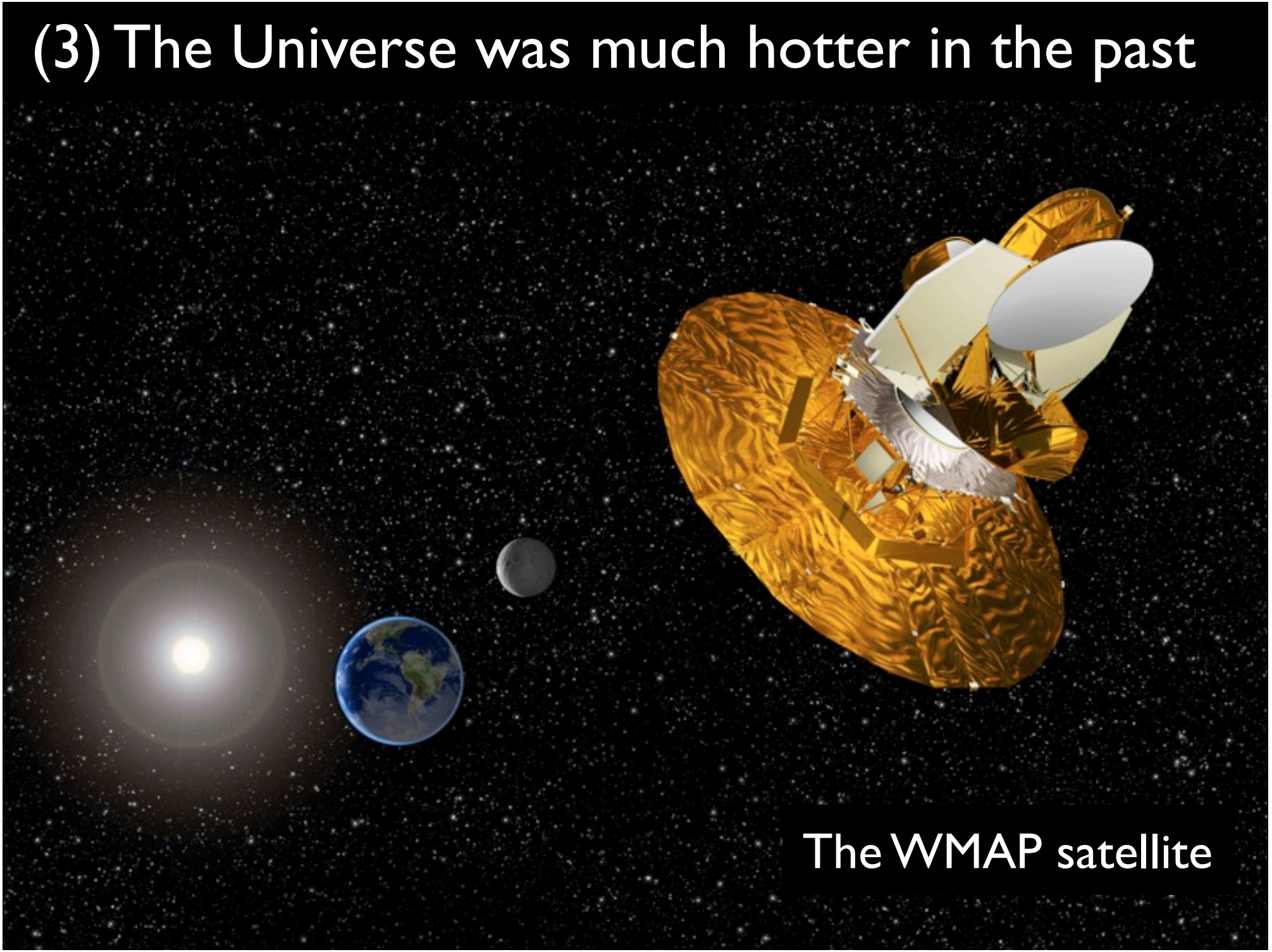


(3) The Universe was much hotter in the past

COSMIC MICROWAVE BACKGROUND RADIATION



(3) The Universe was much hotter in the past

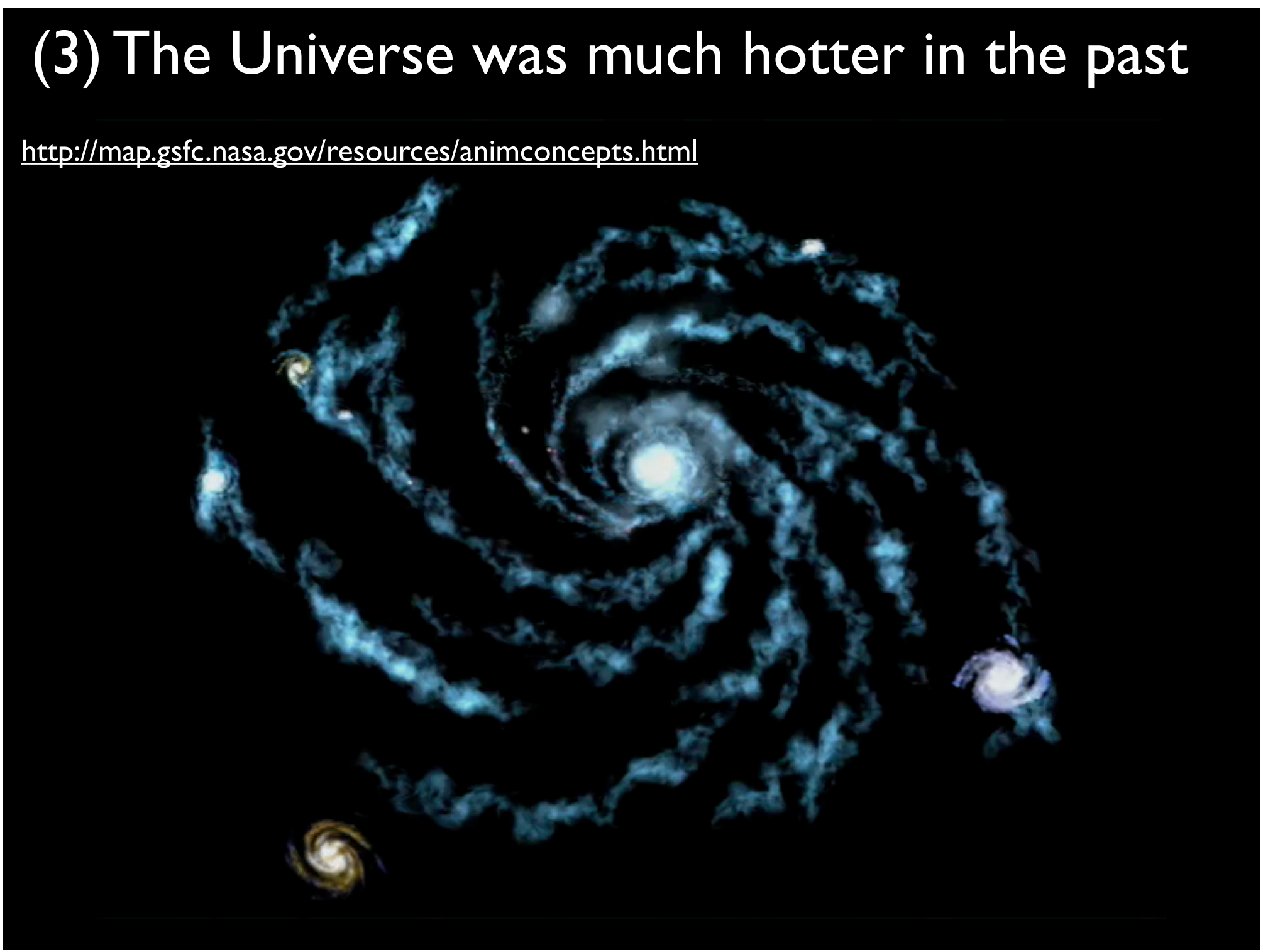


The WMAP satellite

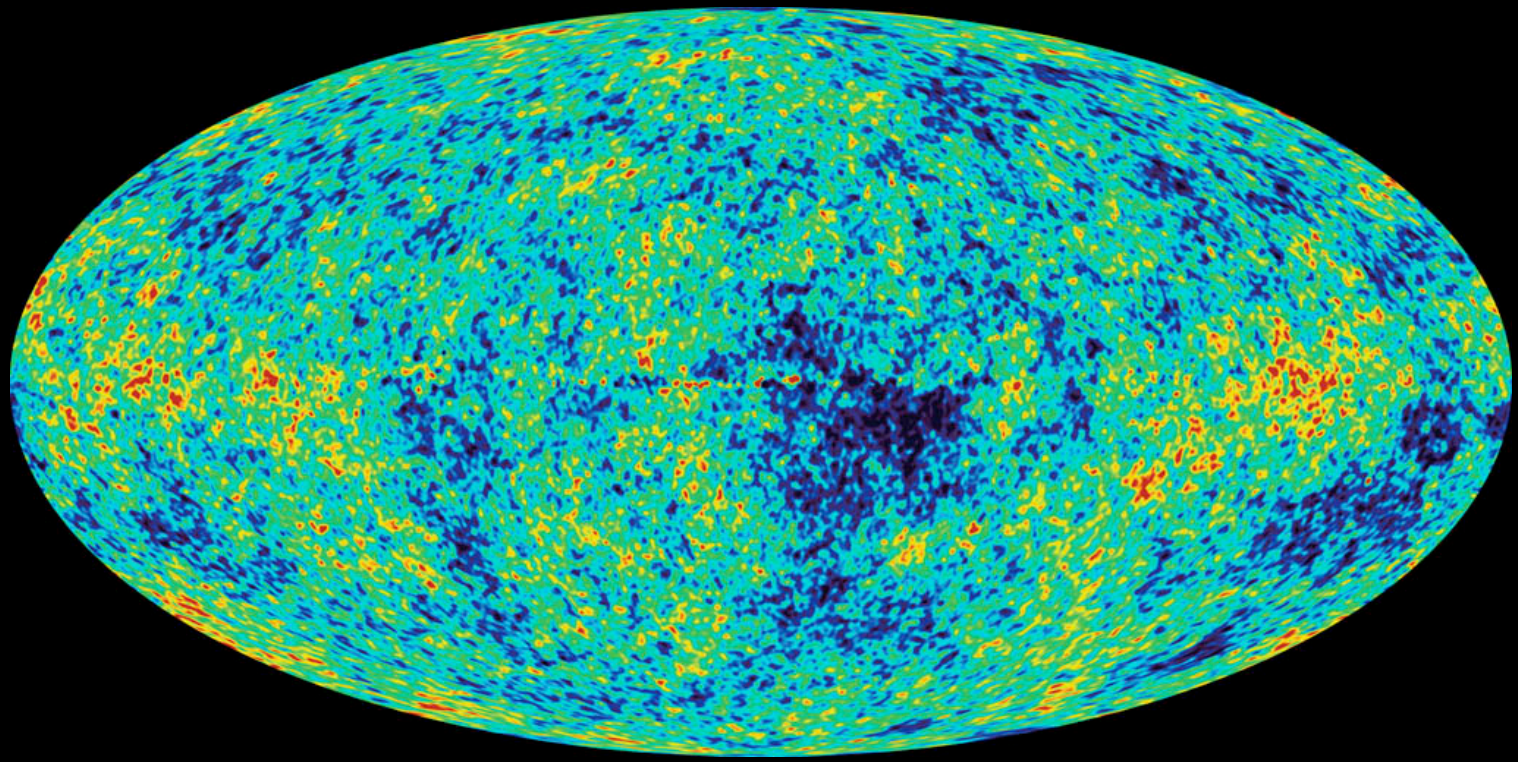
(3) The Universe was much hotter in the past

(3) The Universe was much hotter in the past

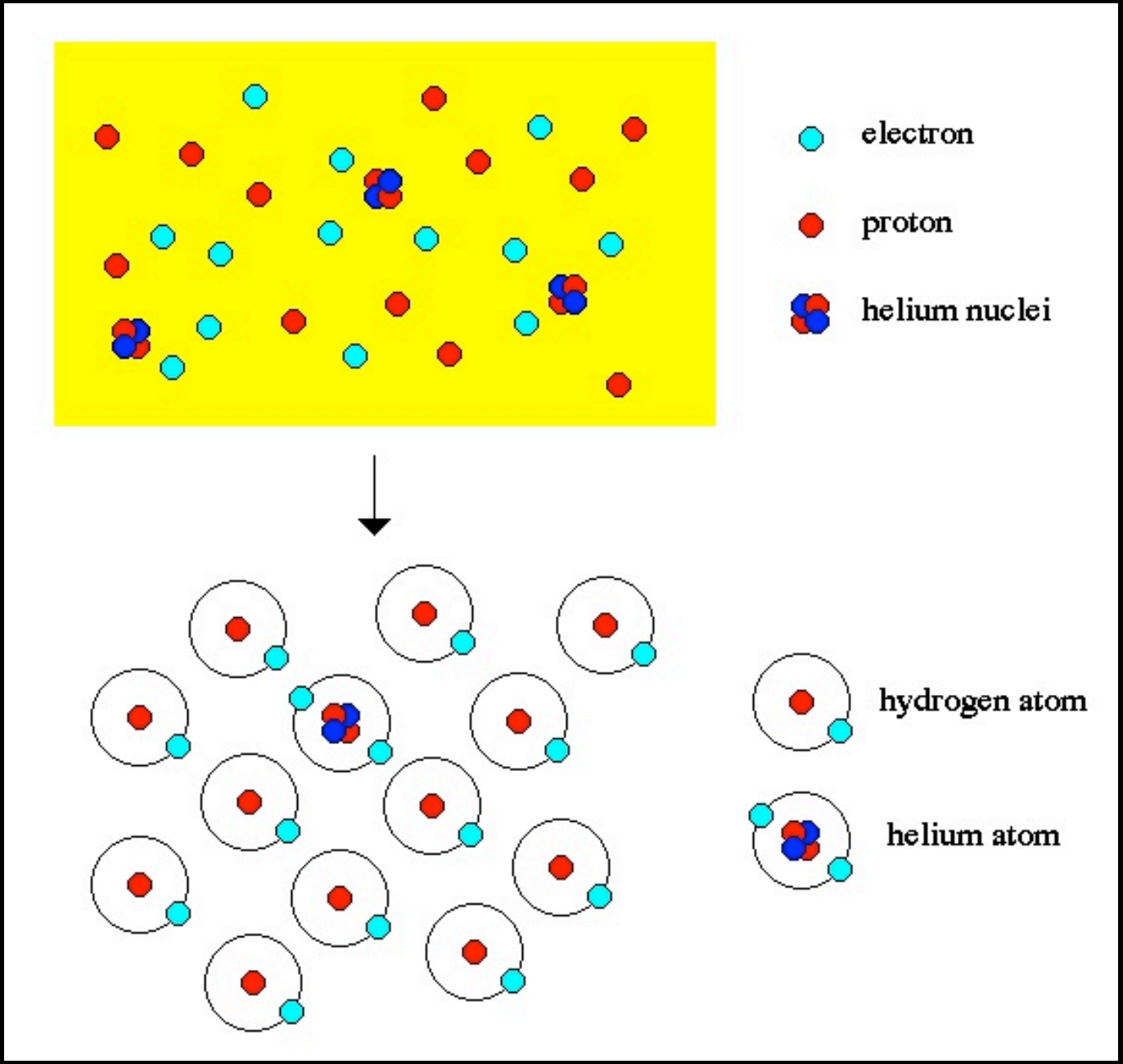
http://map.gsfc.nasa.gov/resources/animconcepts.html



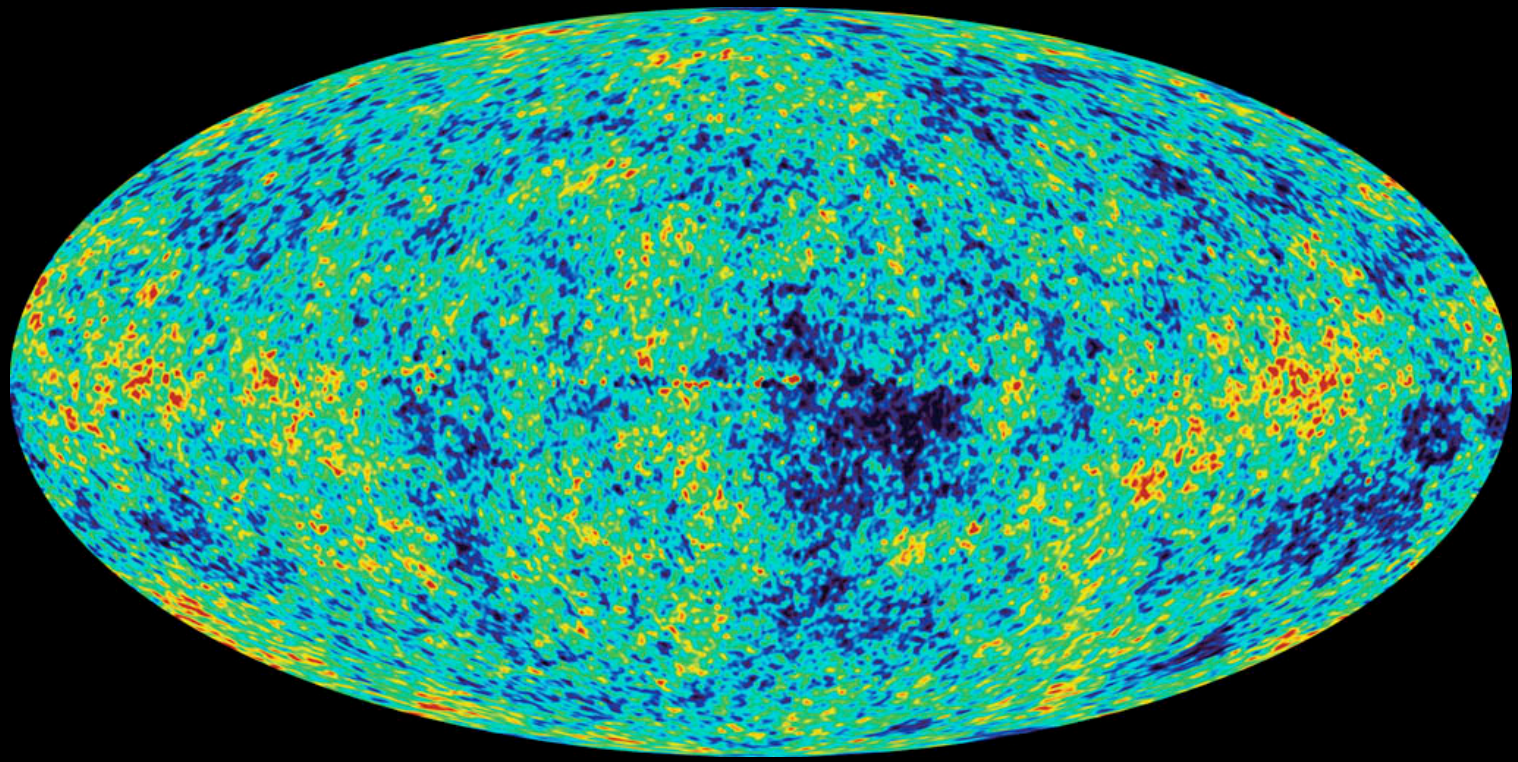
(3) The Universe was much hotter in the past



(3) The Universe was much hotter in the past

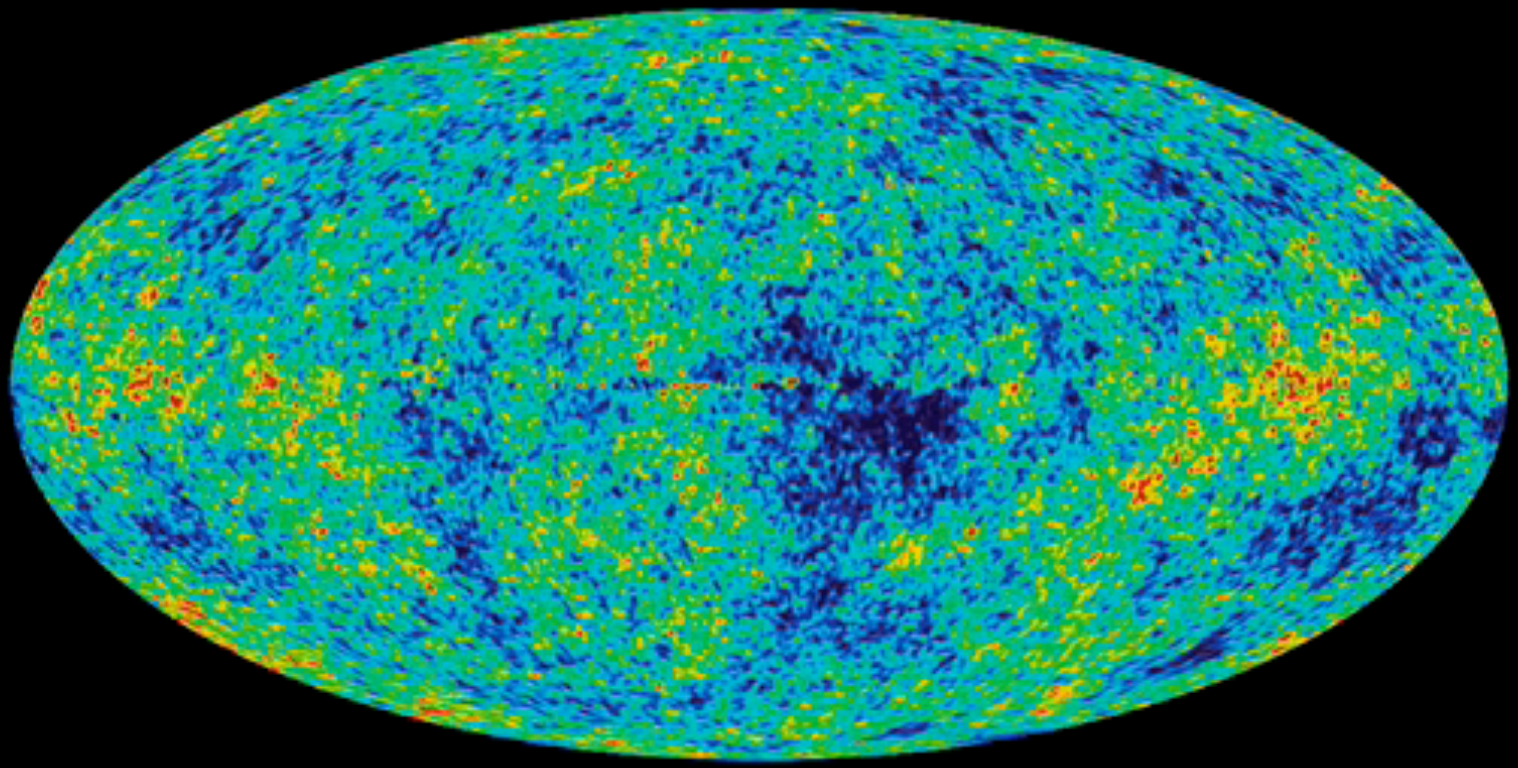


(3) The Universe was much hotter in the past

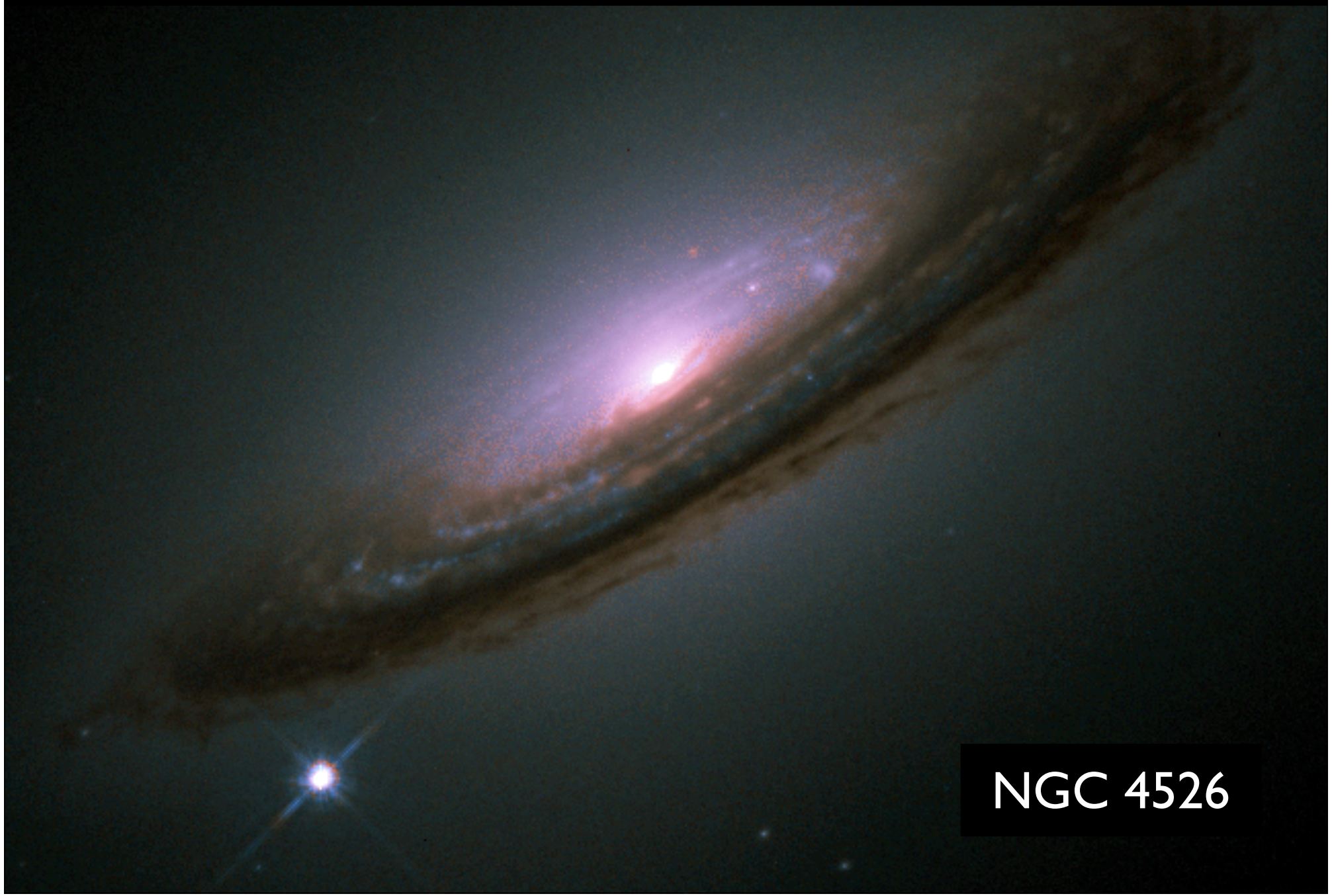


(3) The Universe was much hotter in the past

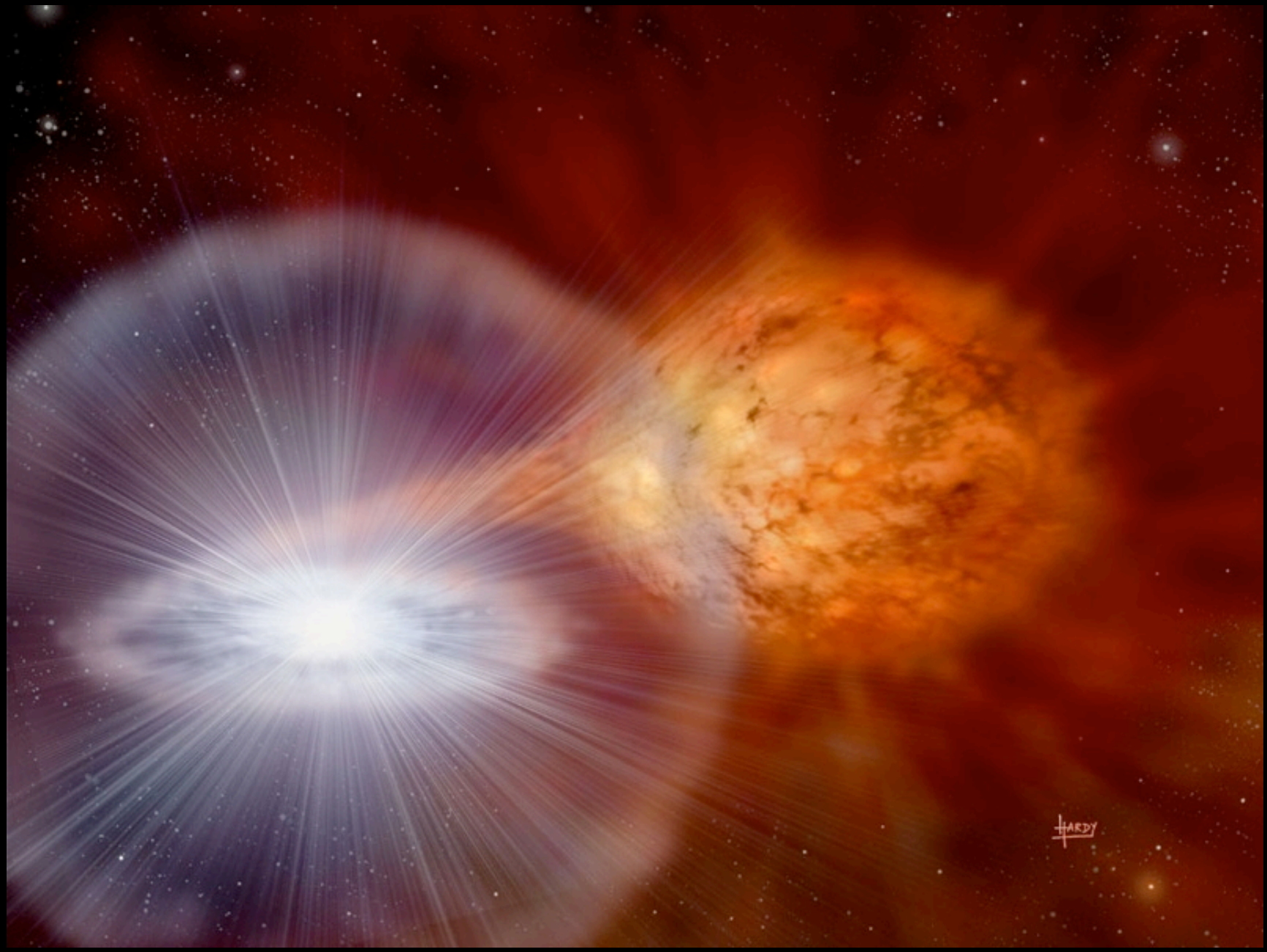
http://map.gsfc.nasa.gov/resources/animconcepts.html



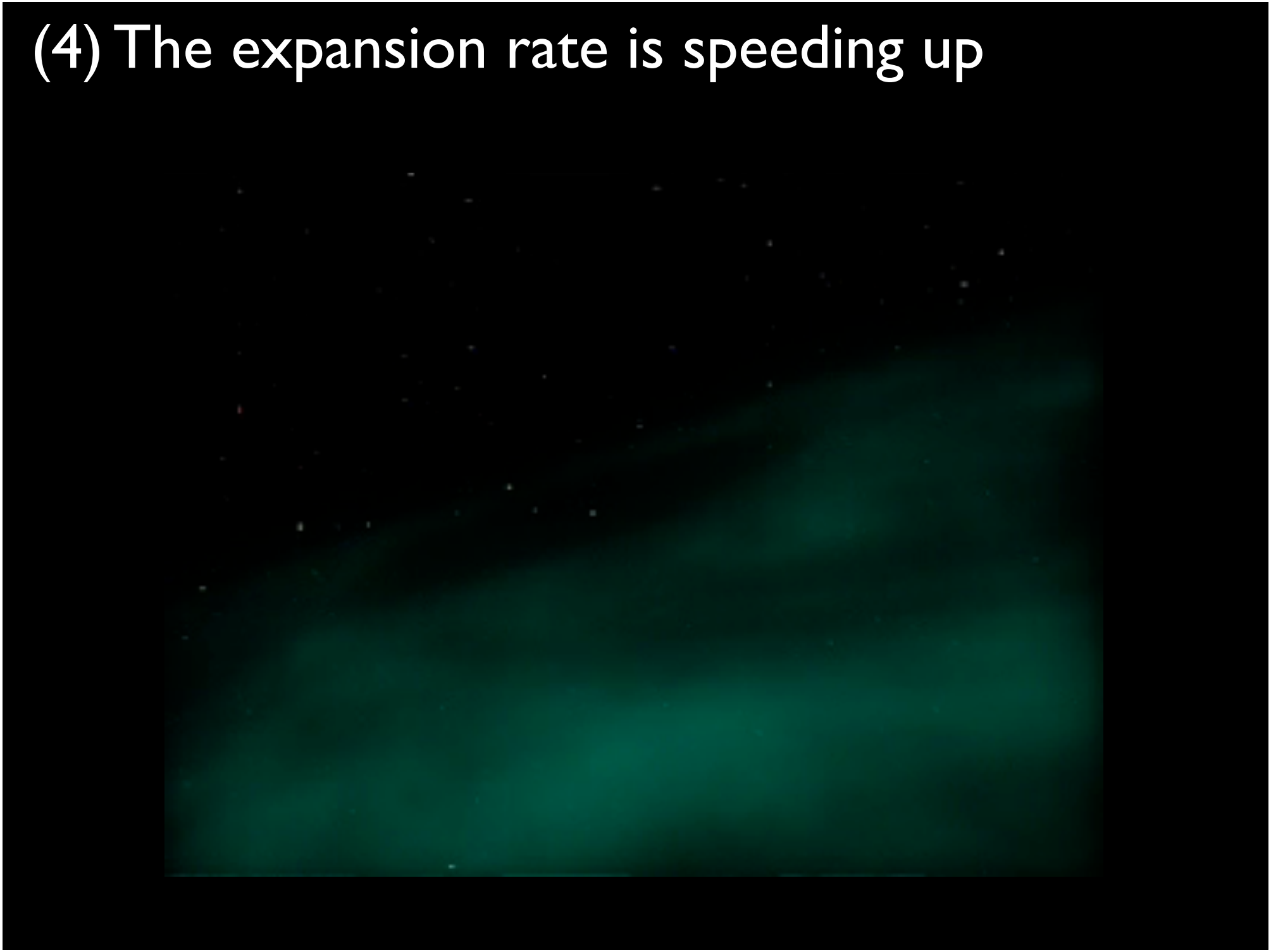
(4) The expansion rate is speeding up



(4) The expansion rate is speeding up



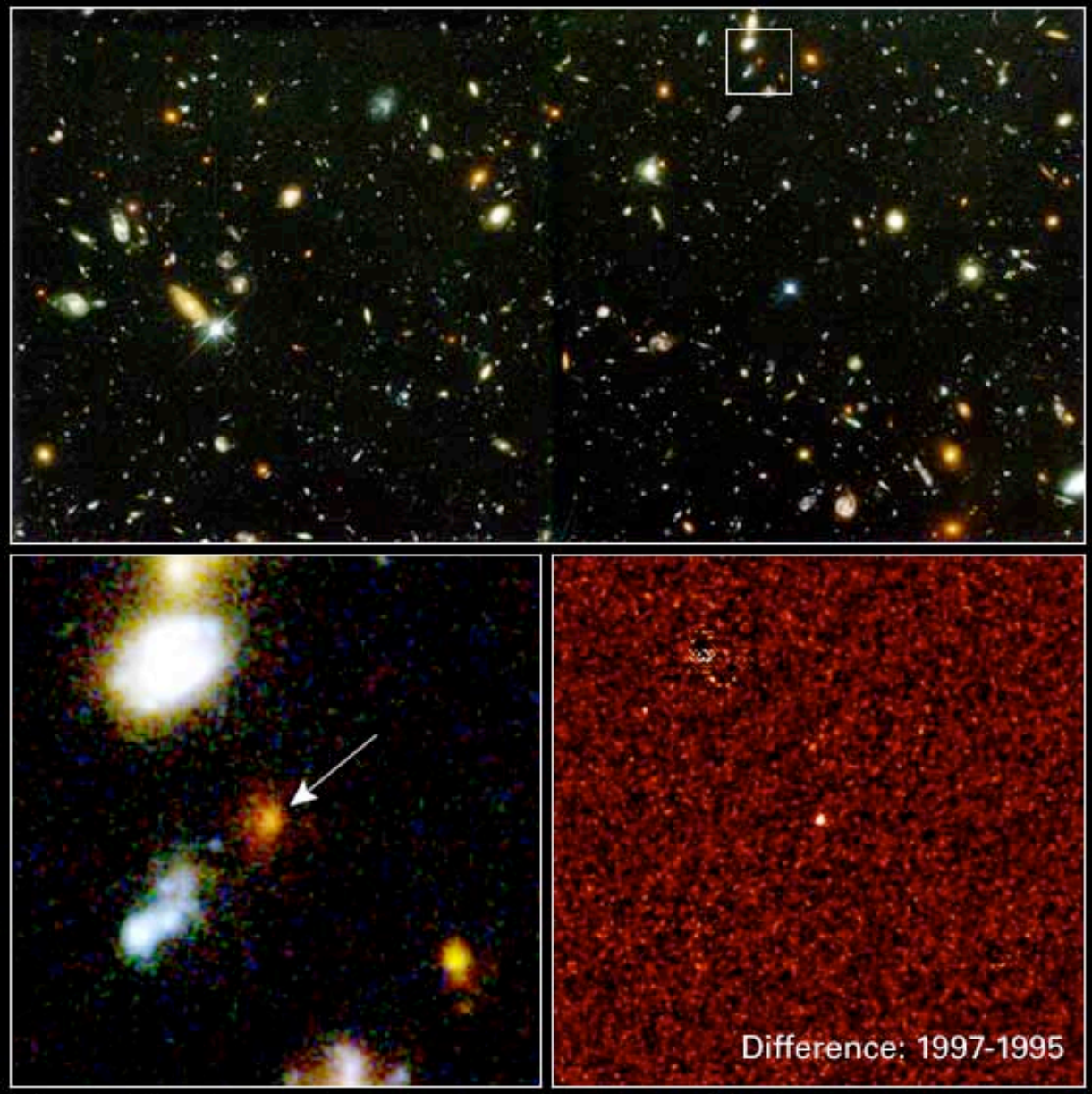
(4) The expansion rate is speeding up



(4) The expansion rate is speeding up

Standard candle

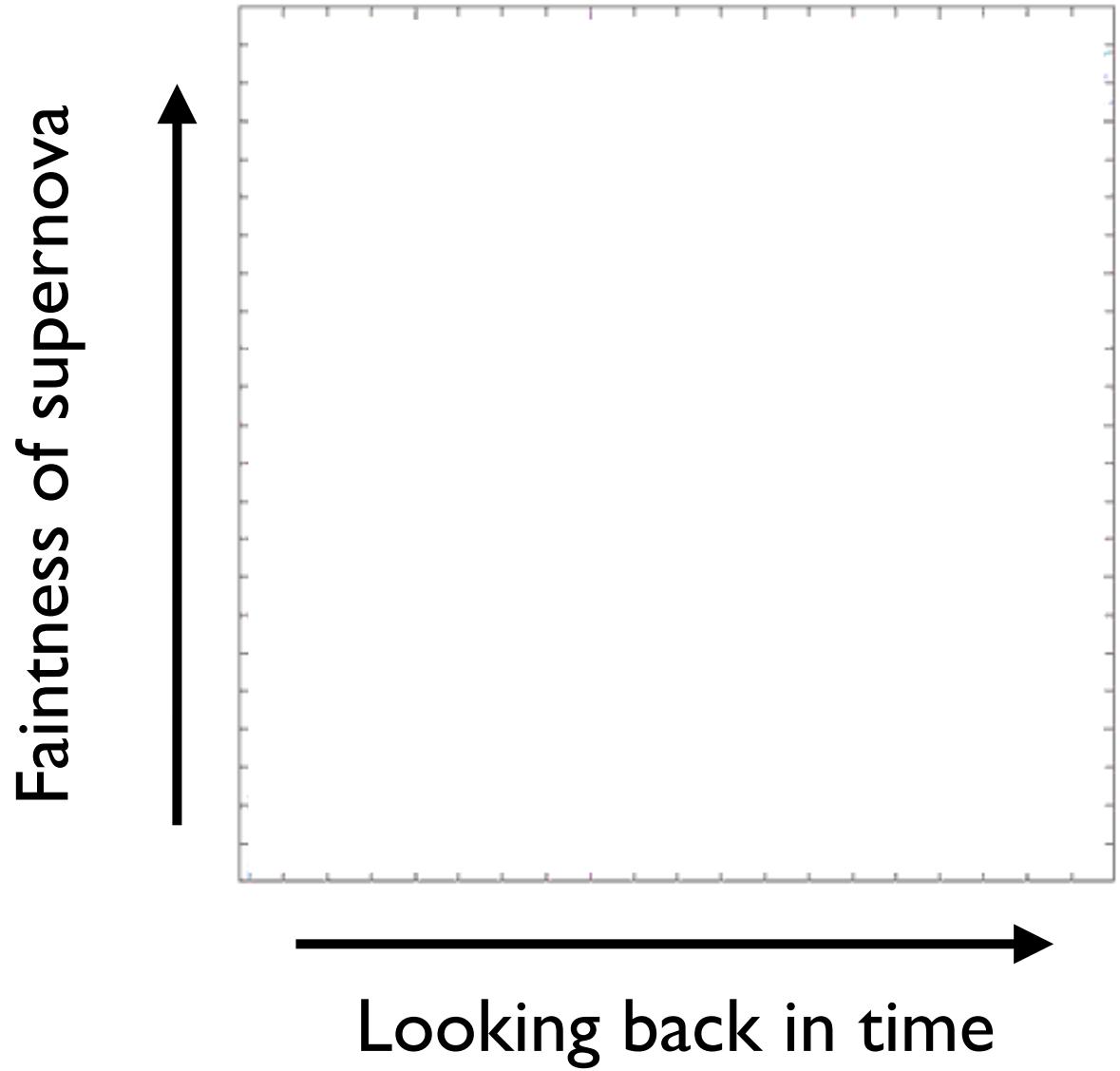
(4) The expansion rate is speeding up



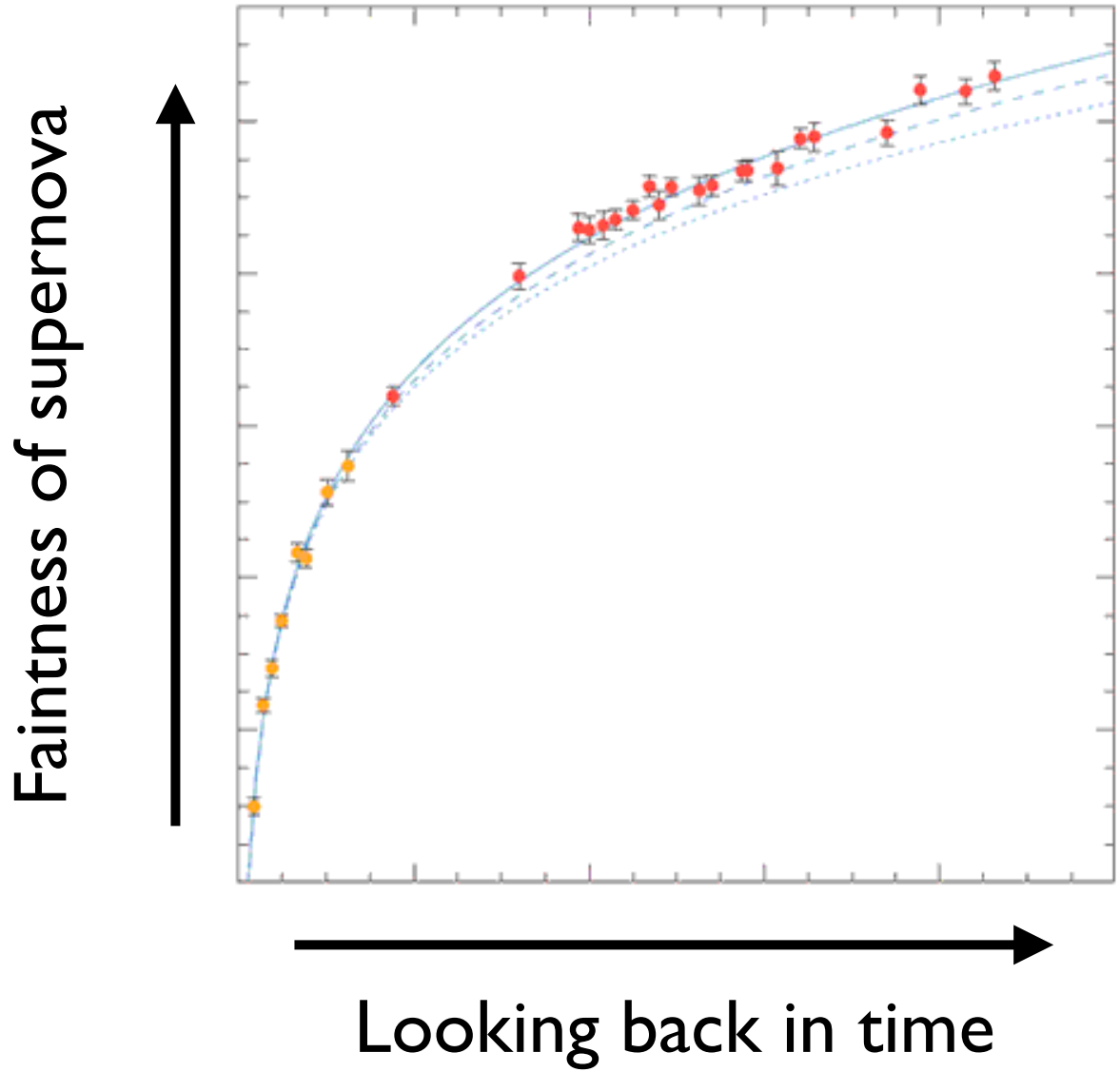
Distant Supernova in the Hubble Deep Field **HST** • WFPC2

NASA and A. Riess (STScI) • STScI-PRC01-09

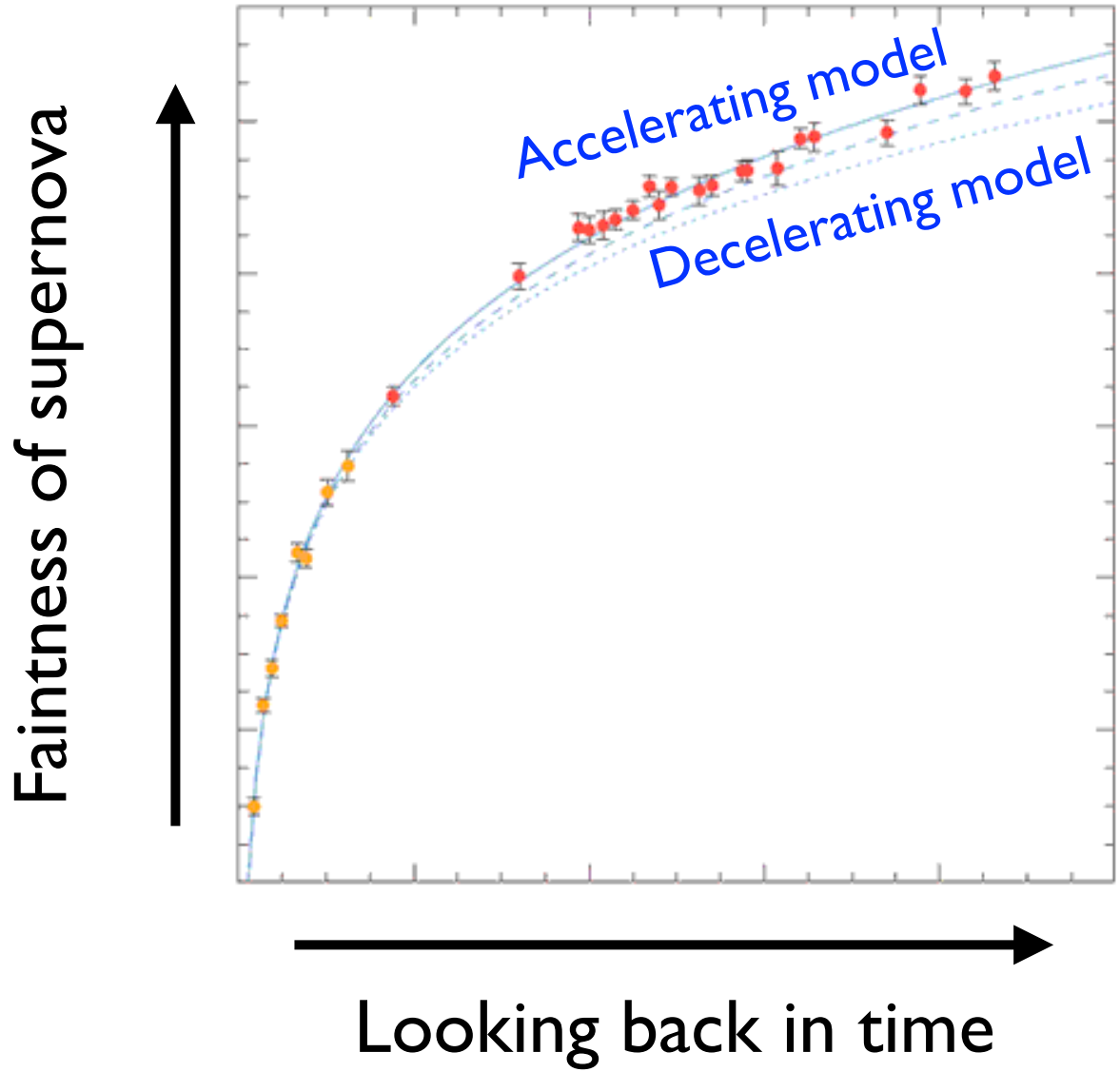
(4) The expansion rate is speeding up



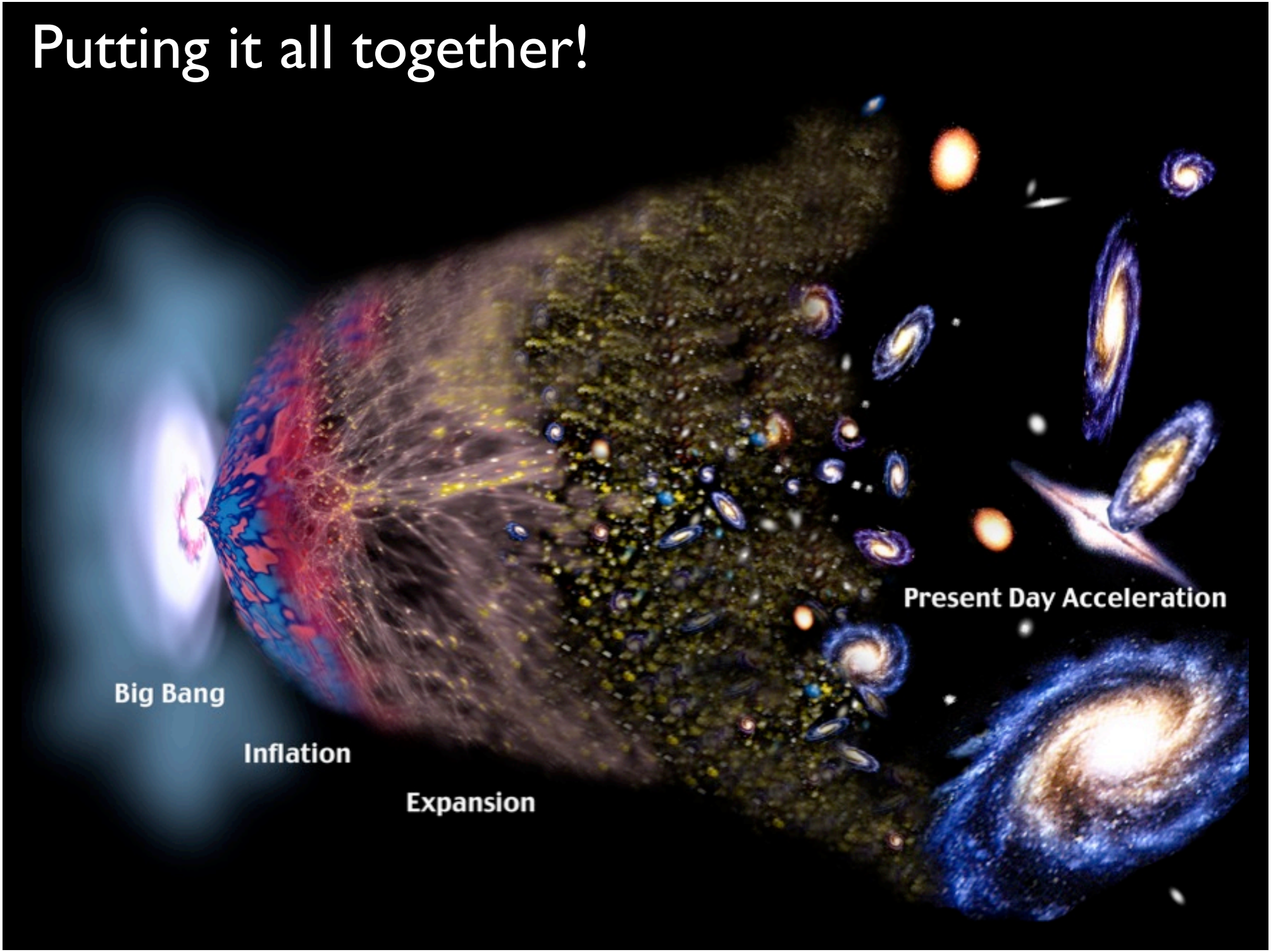
(4) The expansion rate is speeding up



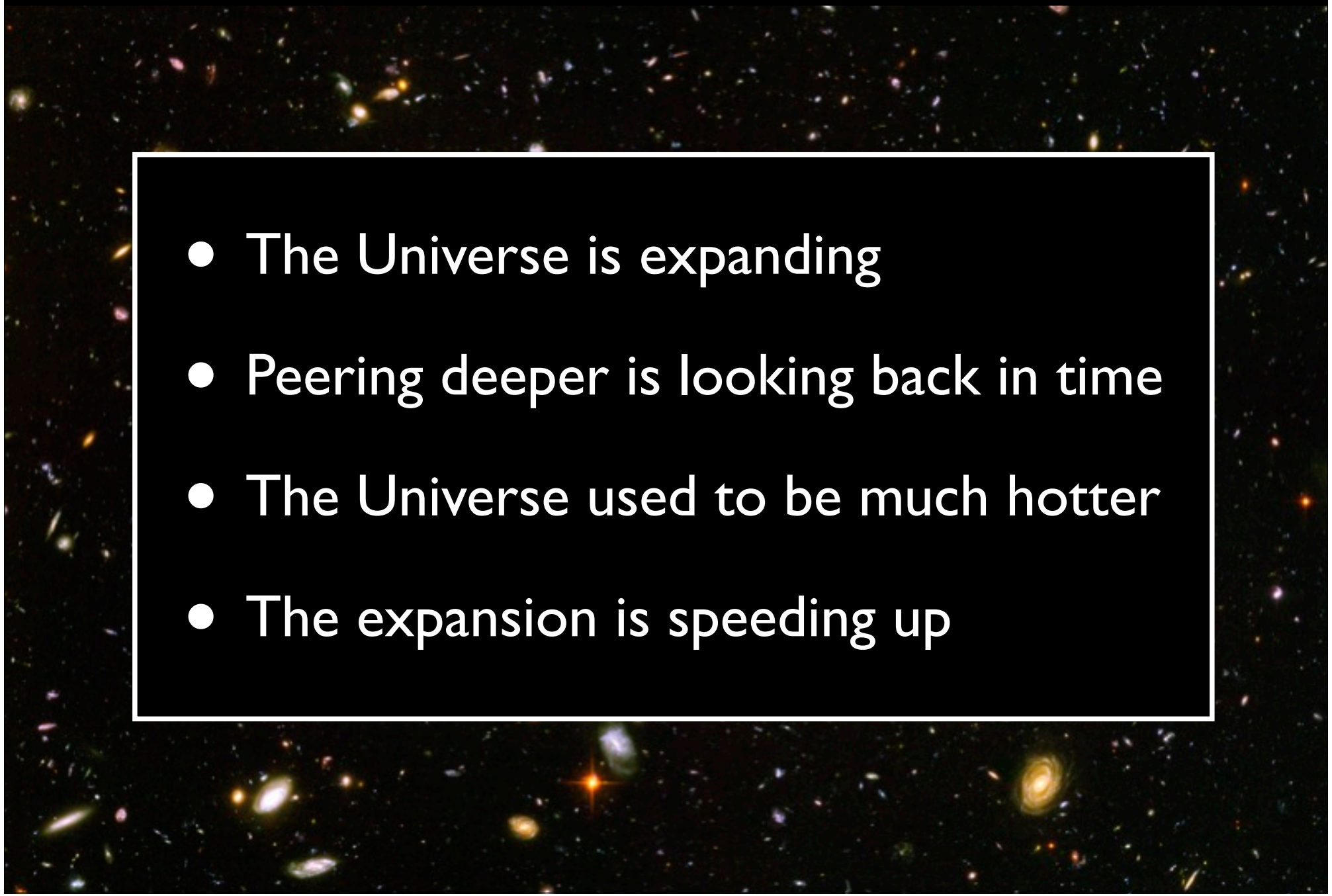
(4) The expansion rate is speeding up



Putting it all together!



Four fabulous facts about the Universe



- The Universe is expanding
- Peering deeper is looking back in time
- The Universe used to be much hotter
- The expansion is speeding up

Cosmology F.A.Q.

Q. What is the Universe expanding into ?

A. We cannot observe anything outside the Universe, as far as we know. Therefore science cannot address this question.

Q. Where is the edge of the Universe ?

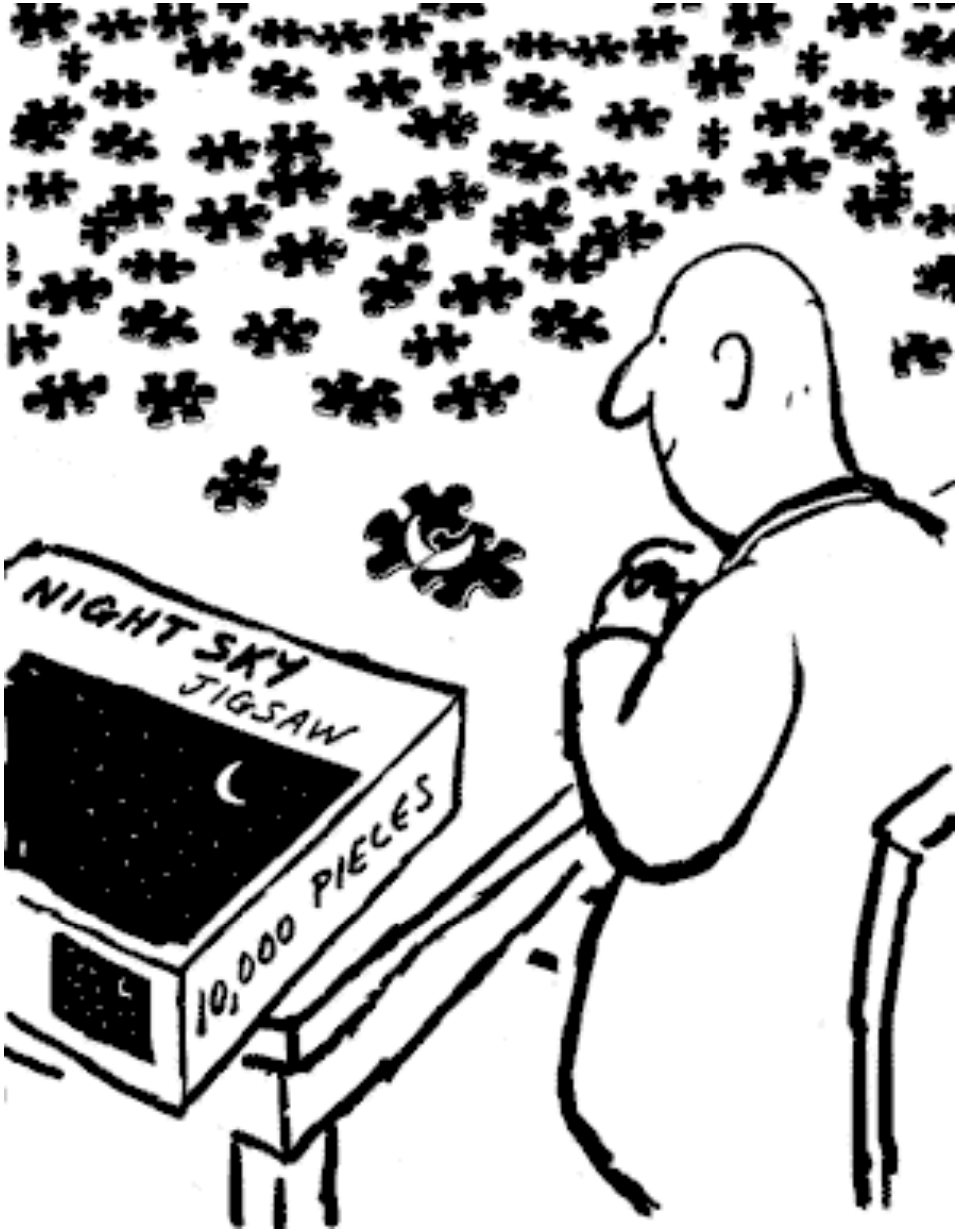
A. The whole Universe is infinite in extent and has no edge. The observable Universe - the bit we can see - has a size equal to the distance light can travel since the Big Bang, 13.7 billion years ago.

Q. What happened before the Big Bang ?

A. We cannot observe anything before the Big Bang, as far as we know. Therefore science cannot address this question.

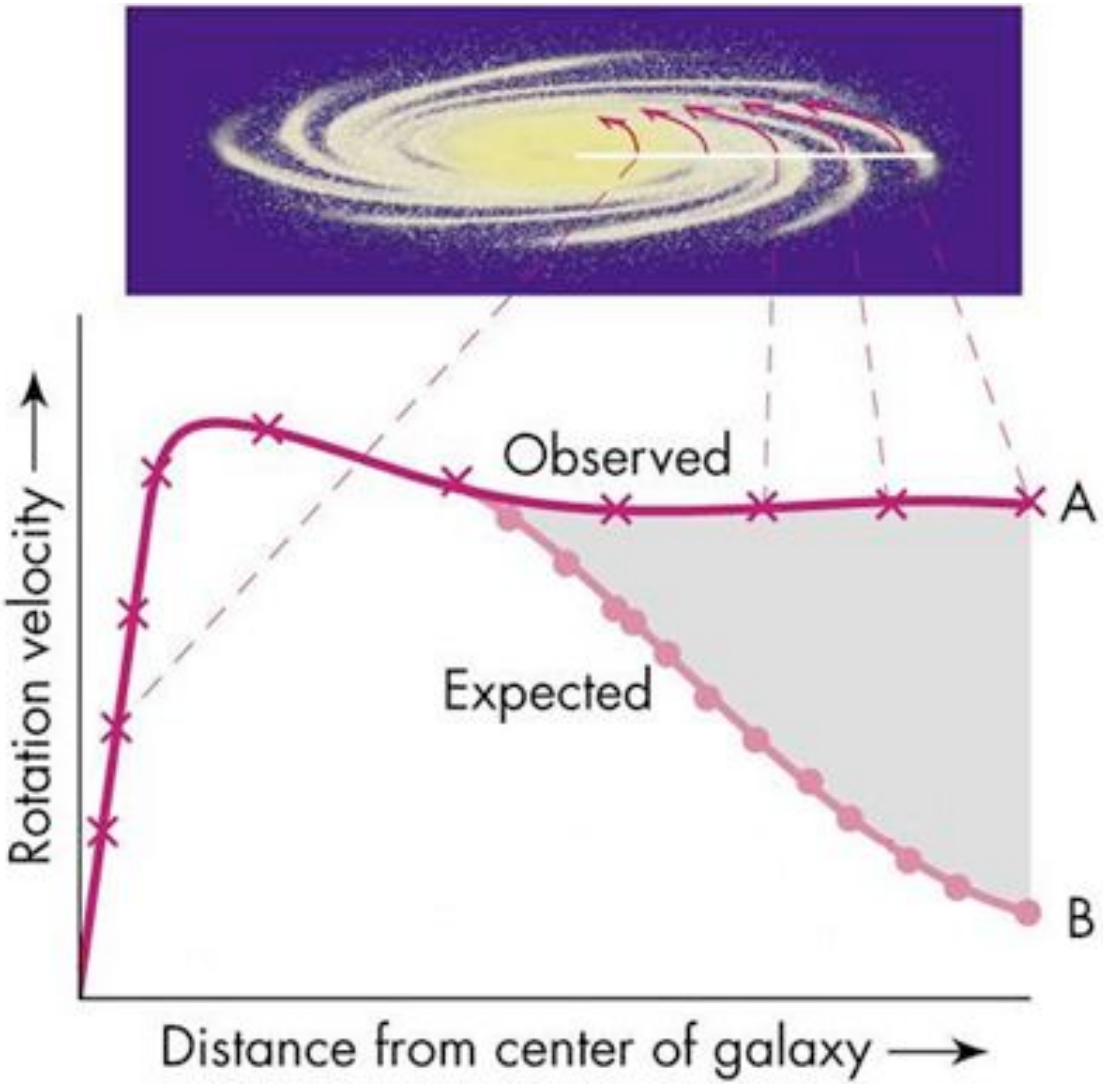

Mapping the
Universe

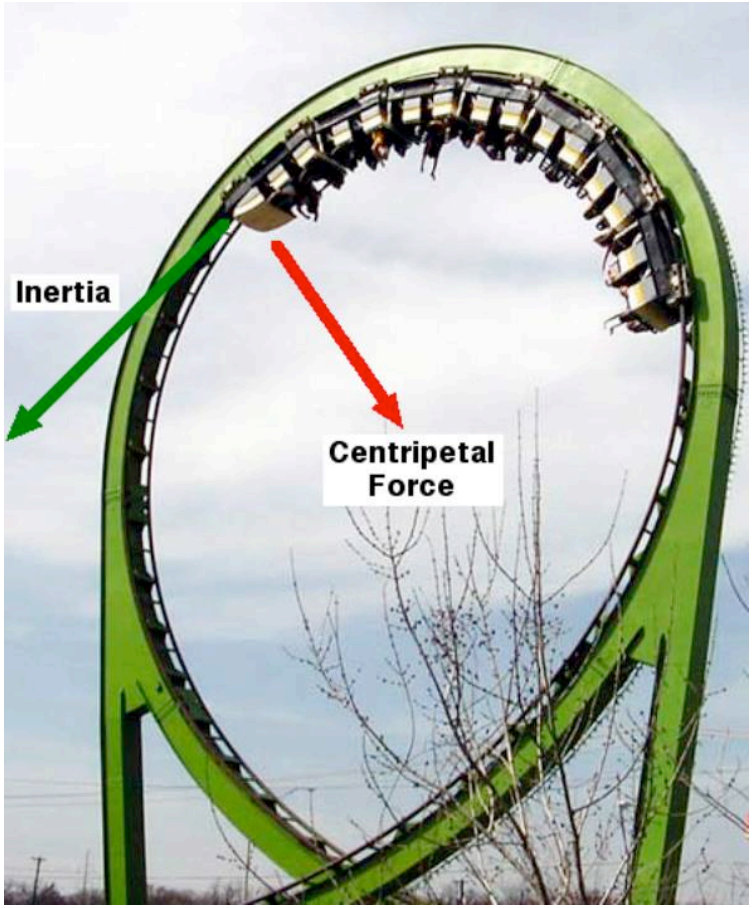
What is the Universe made of?



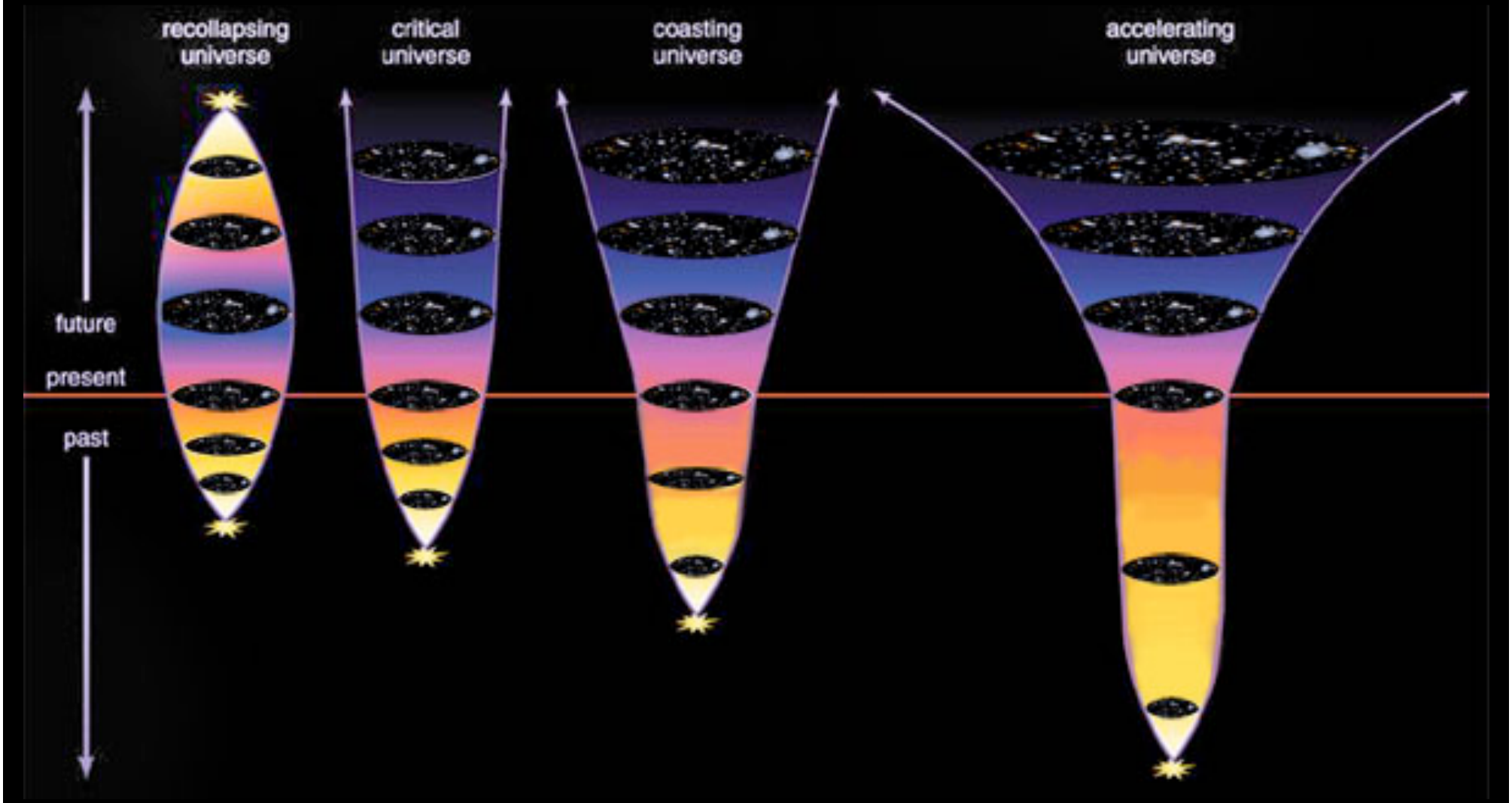
Dark matter

Dark matter


Observed
Expected
A
B
Rotation velocity
Distance from center of galaxy


Inertia
Centripetal Force

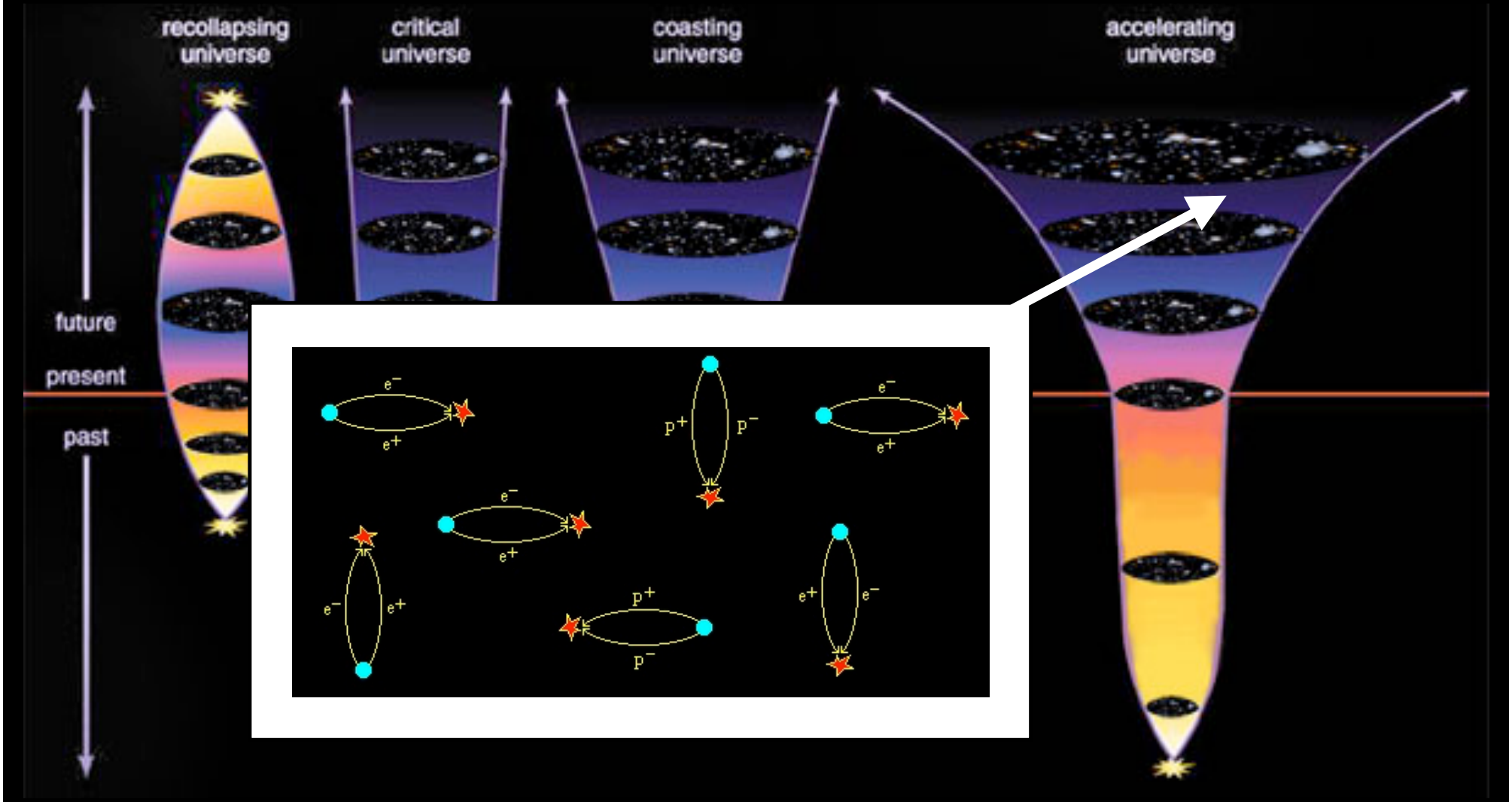
Does that explain everything?



Dark matter dominates

Dark energy dominates

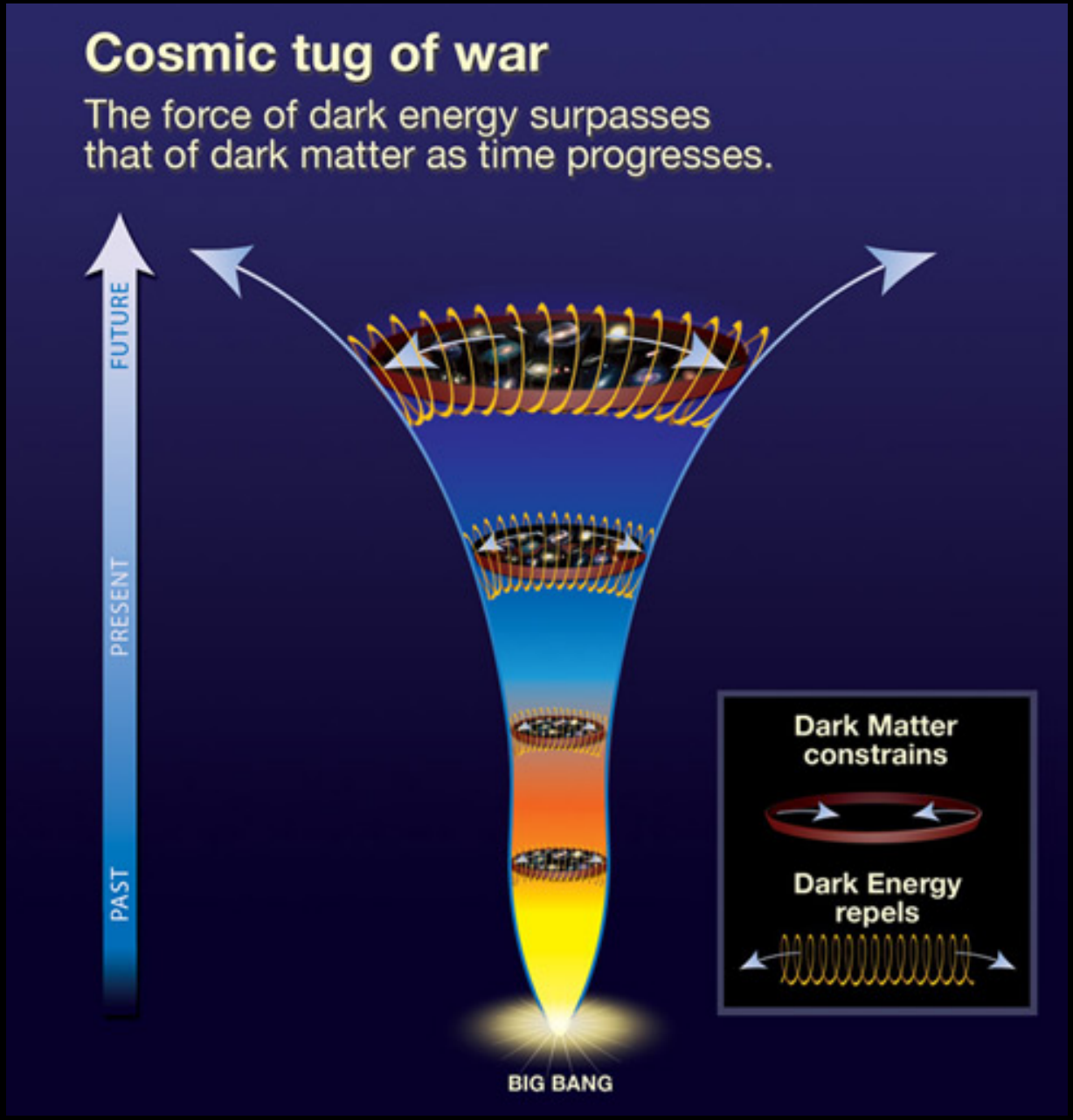
Does that explain everything?



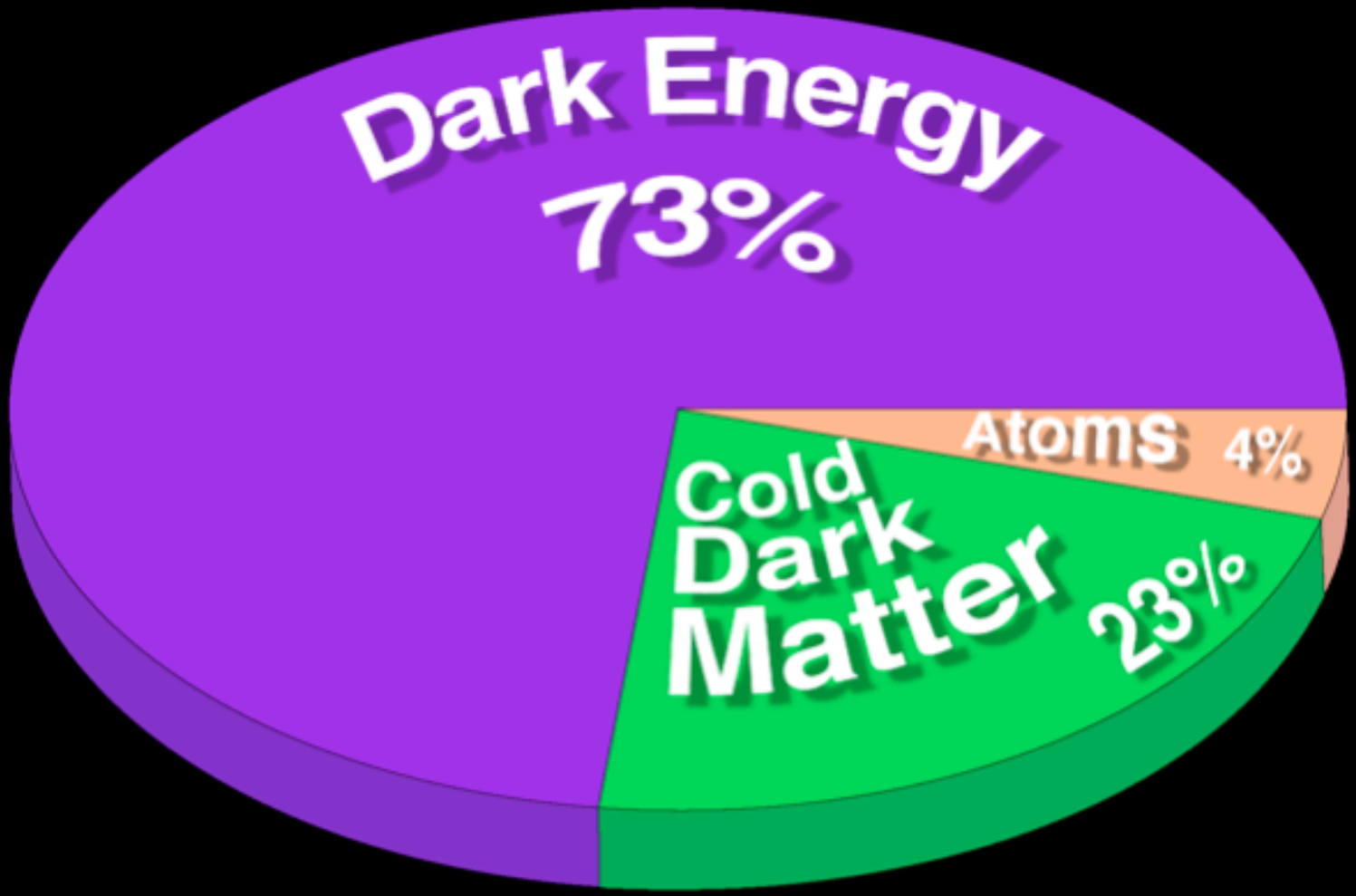
Dark matter dominates

Dark energy dominates

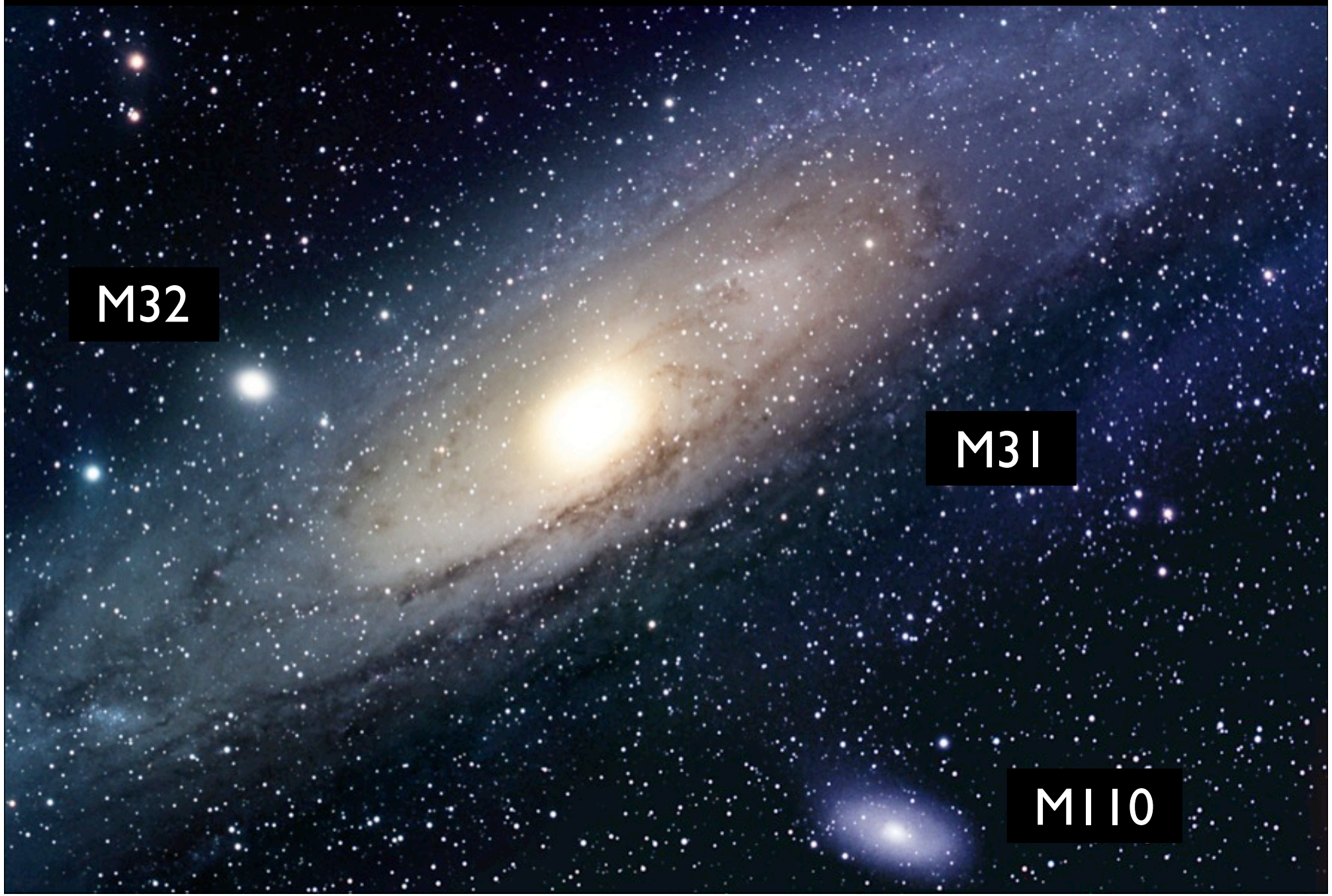
The cosmic tug of war



What is the Universe made of?



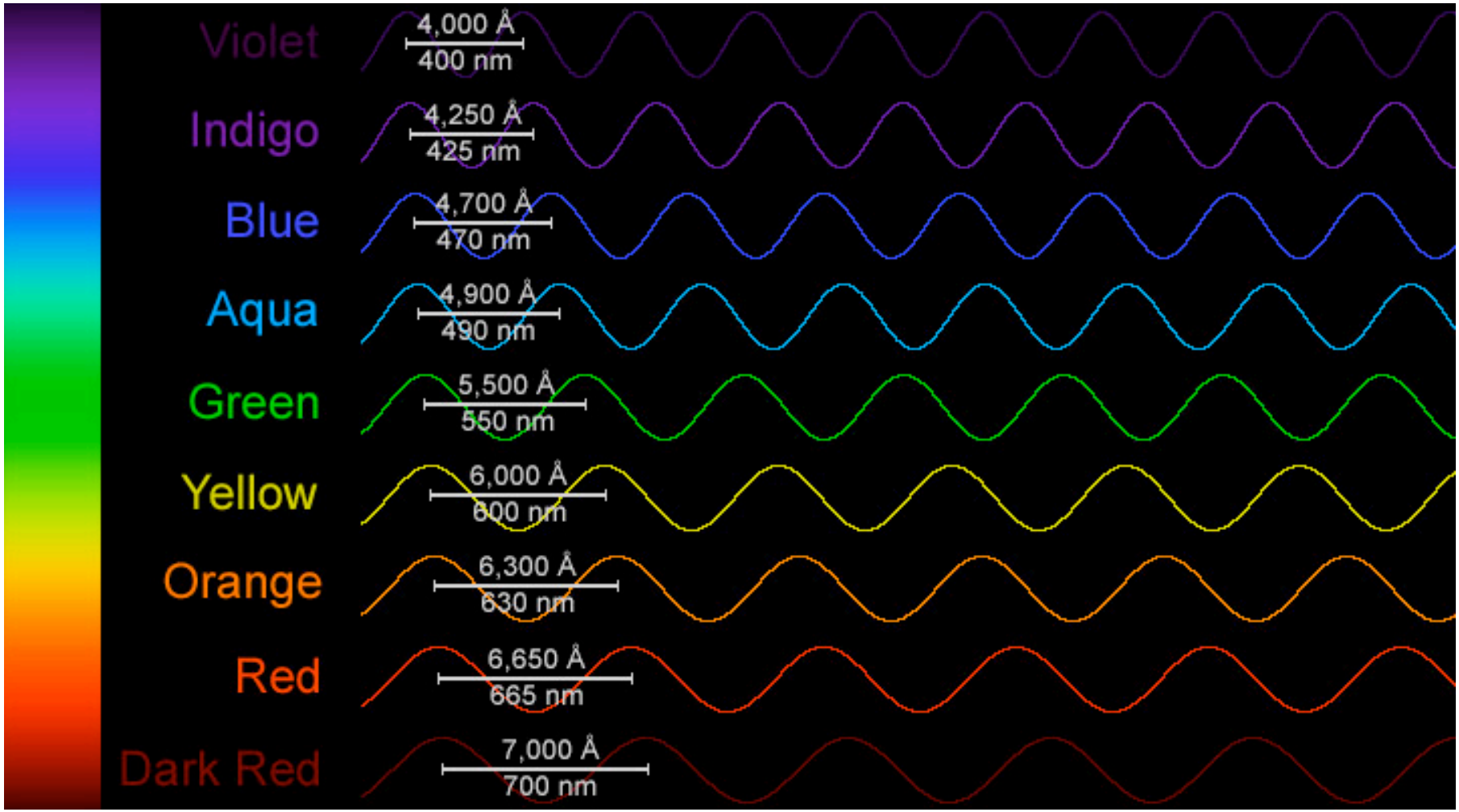
Our own backyard ...



Our own backyard ...

Our own backyard ...

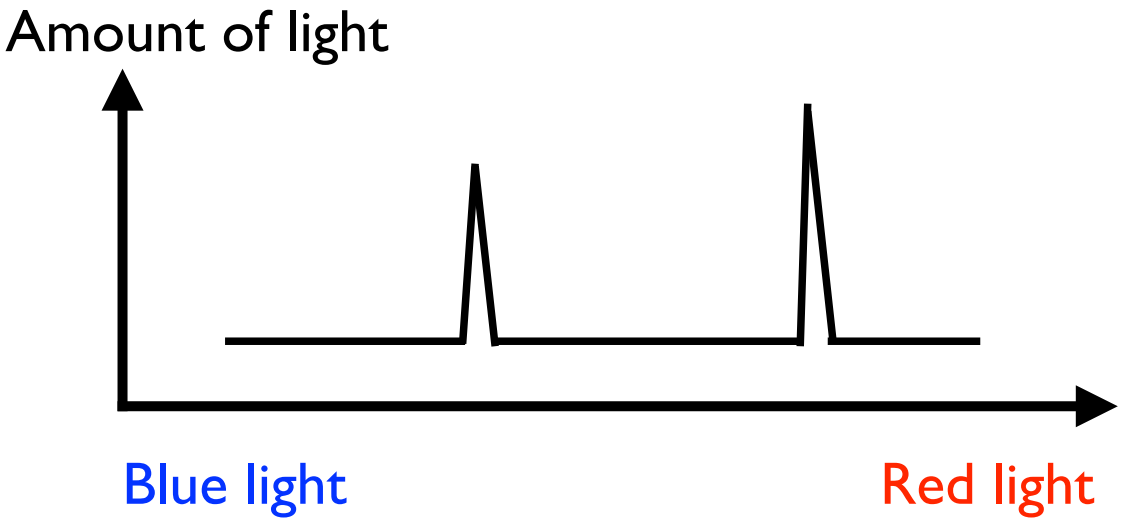
How can we make a map of the Universe?



Useful fact : the amount of redshift of the galaxy light tells us how far away it is

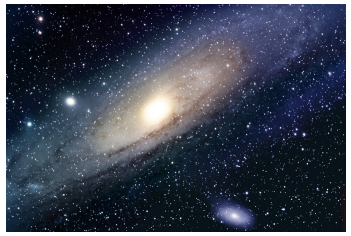
How can we make a map of the Universe?

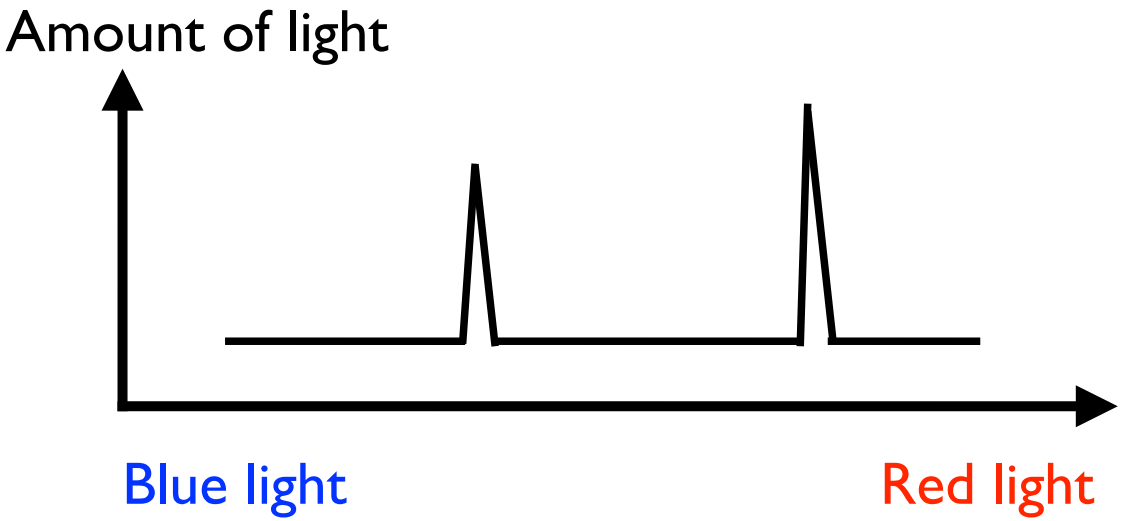
How can we make a map of the Universe?



How can we make a map of the Universe?

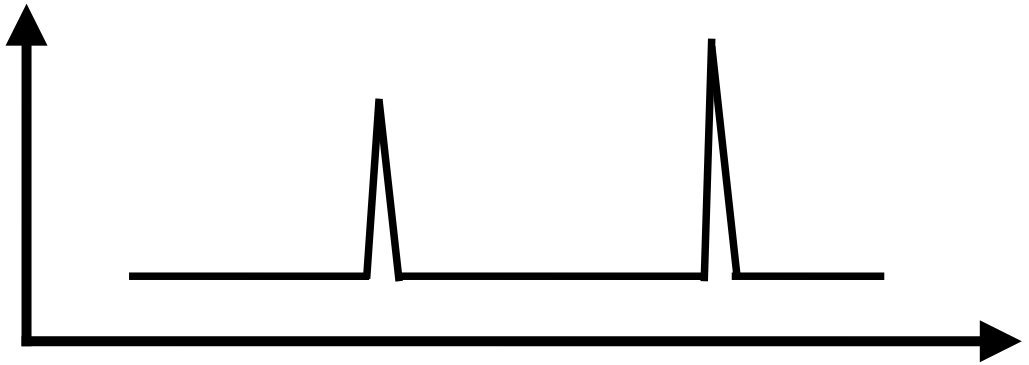
Move further away...





How can we make a map of the Universe?

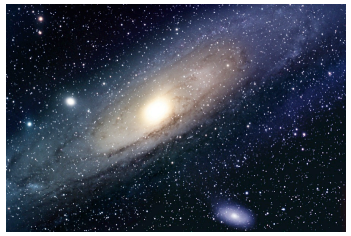
Amount of light



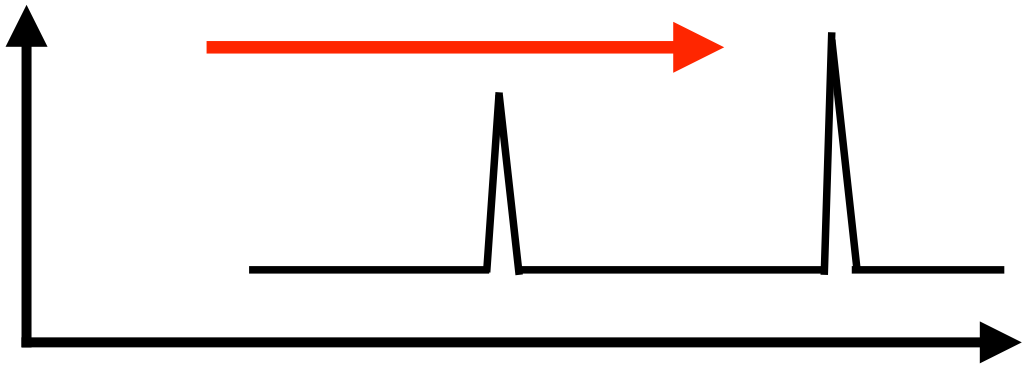
Blue light

Red light

Move further away...

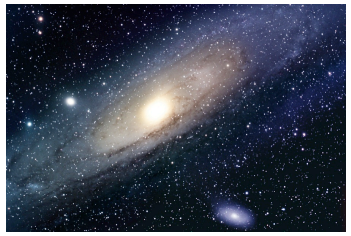


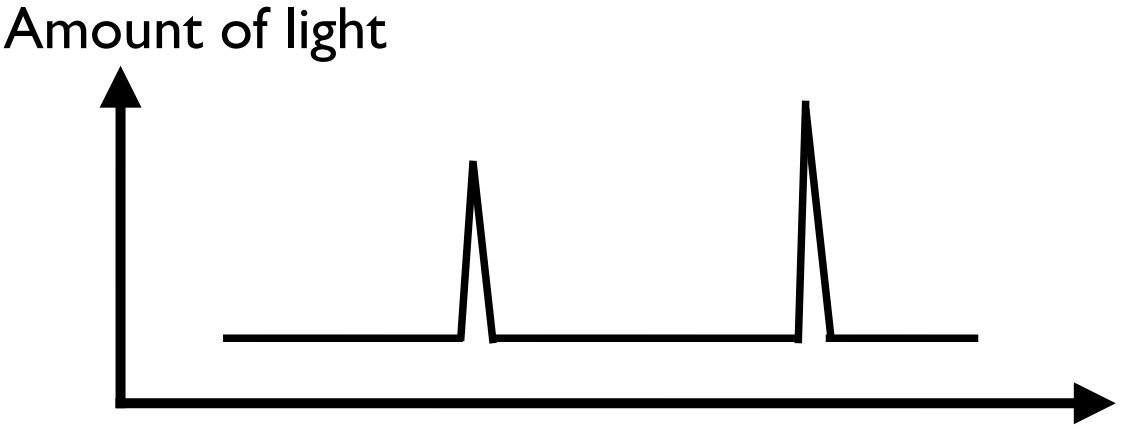
Amount of light

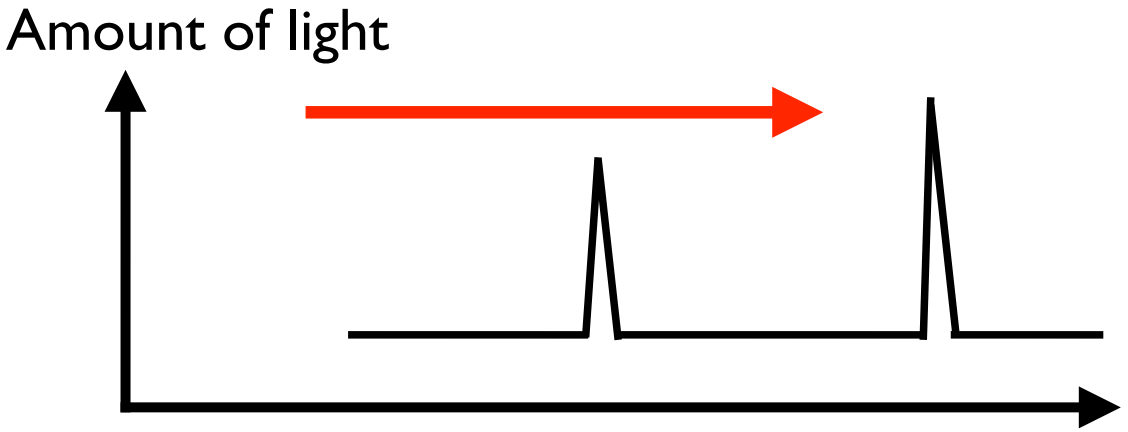


How can we make a map of the Universe?

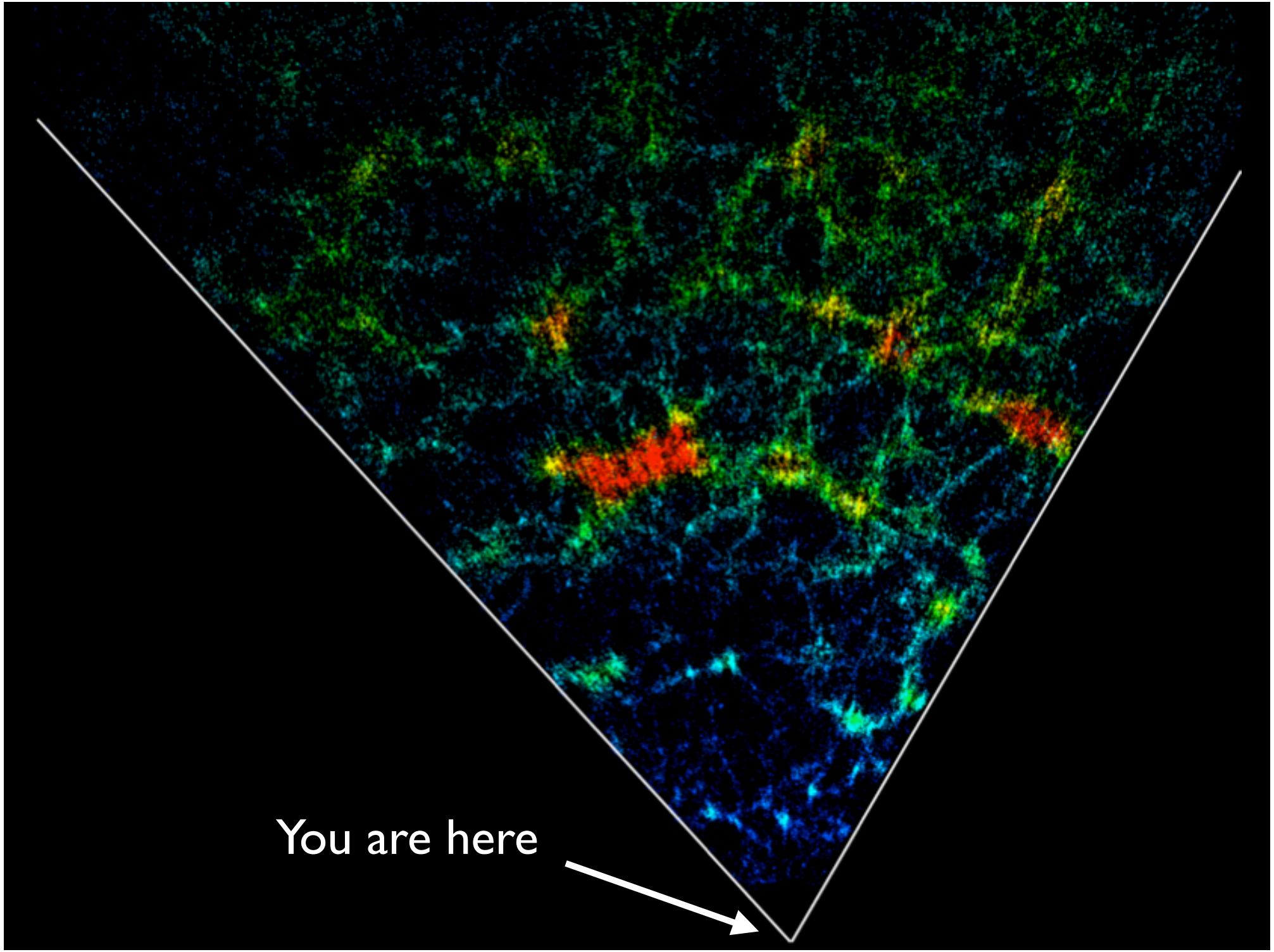
Move further away...

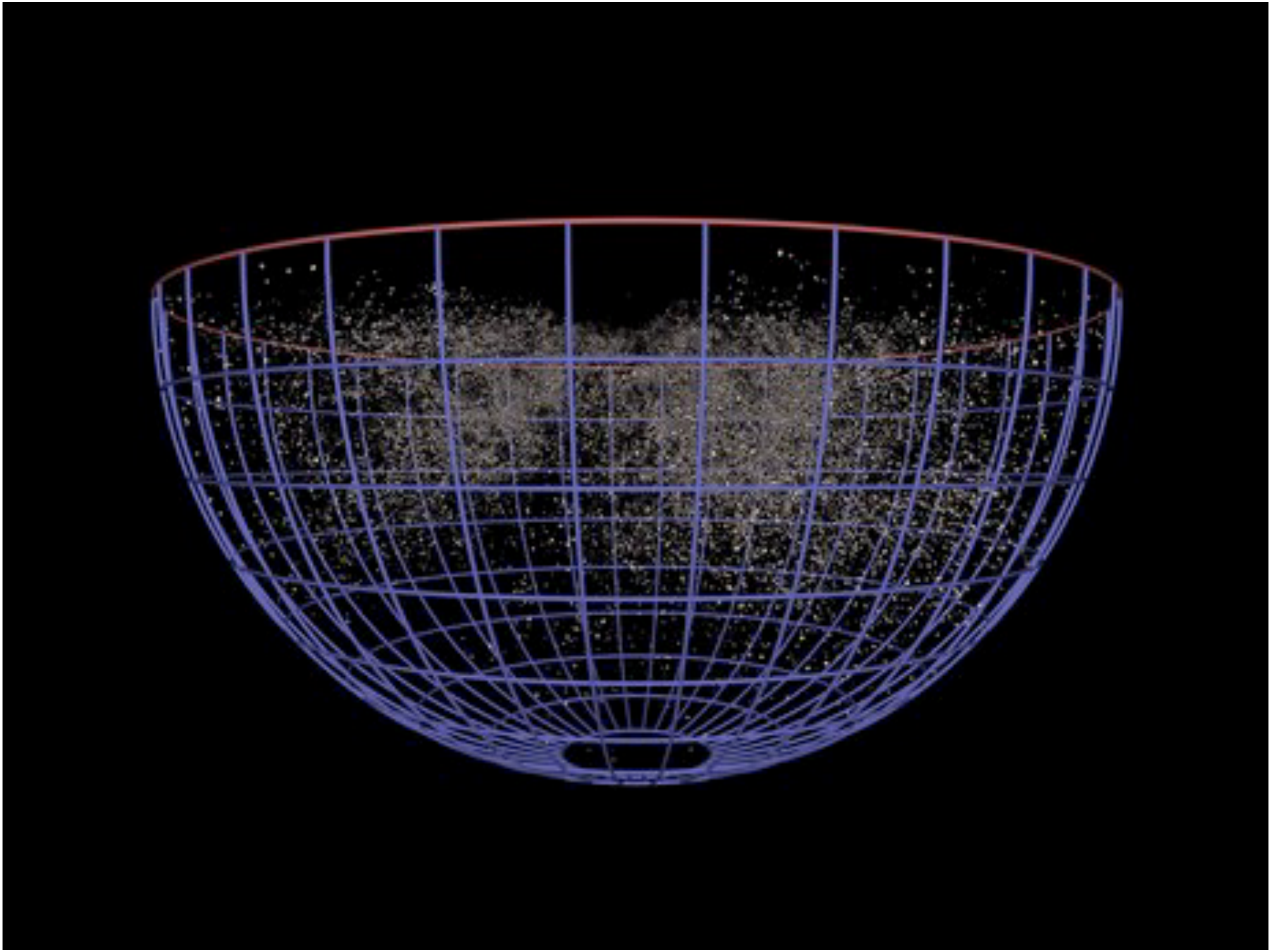




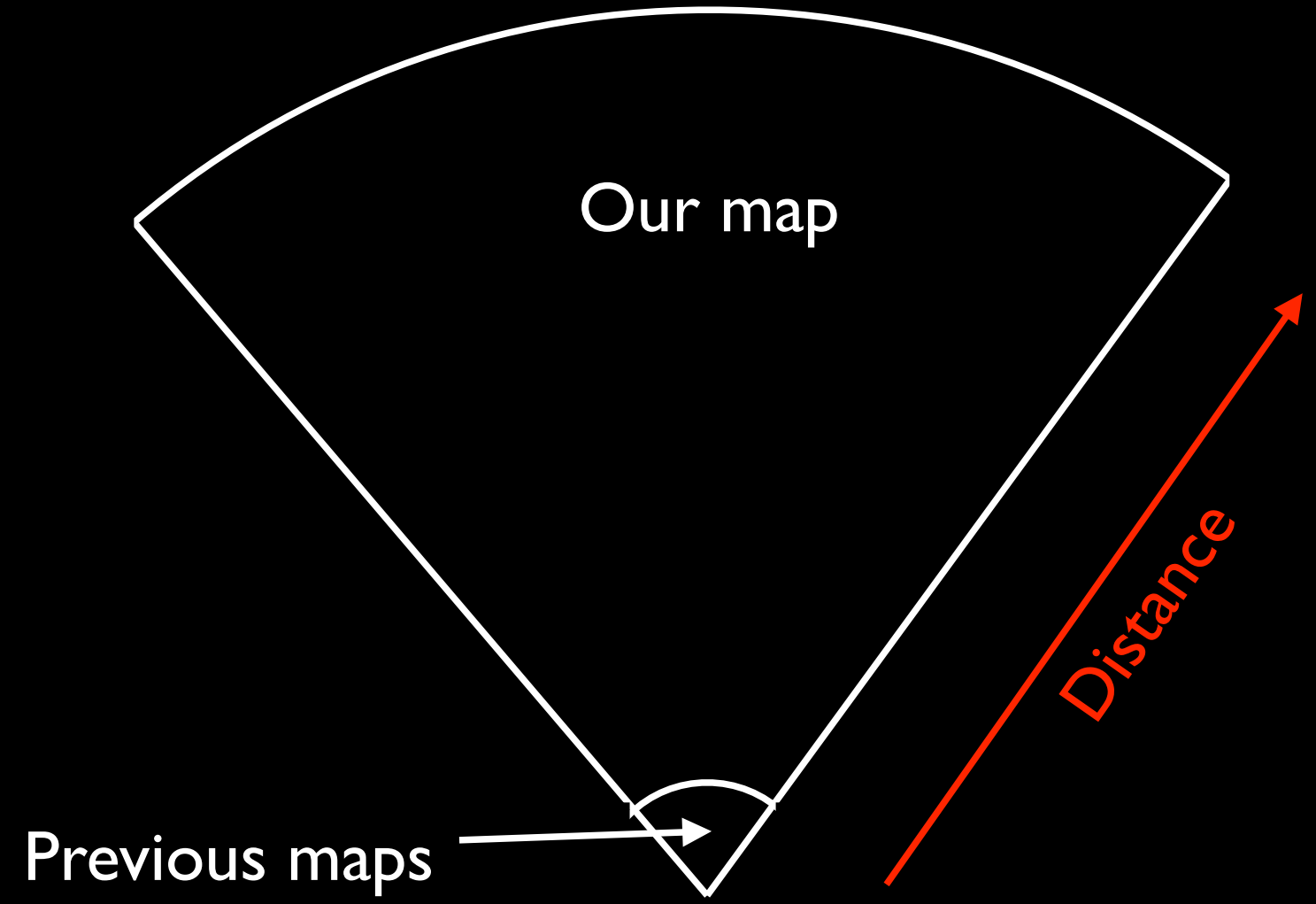


Shift in spectrum of galaxy tells us how far away it is

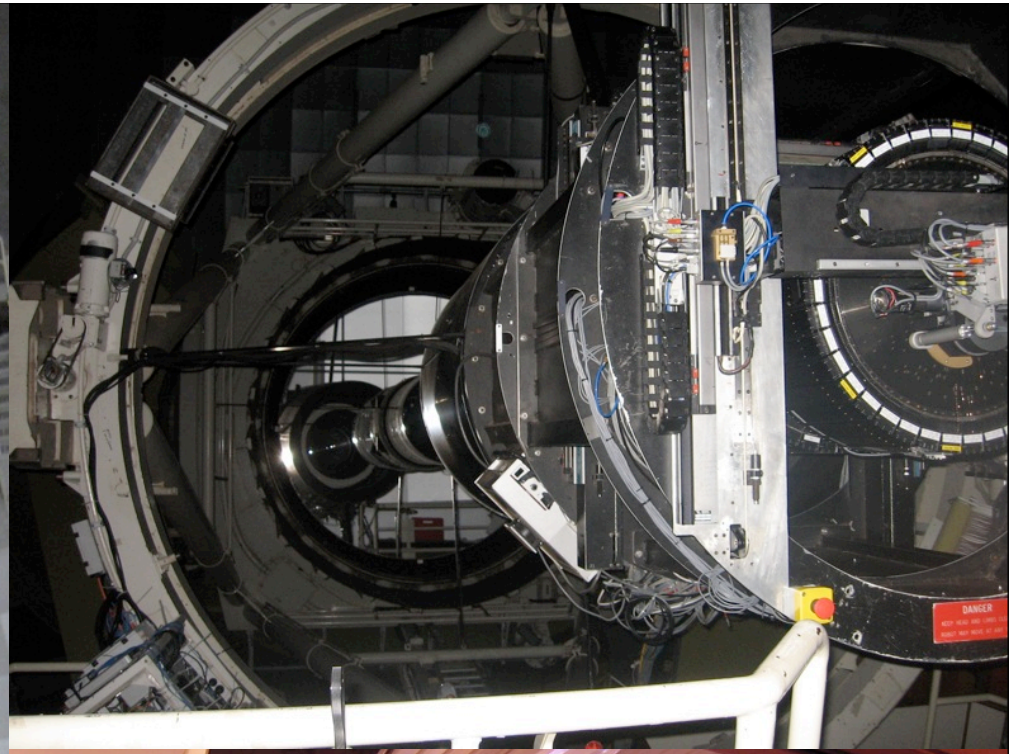

You are here



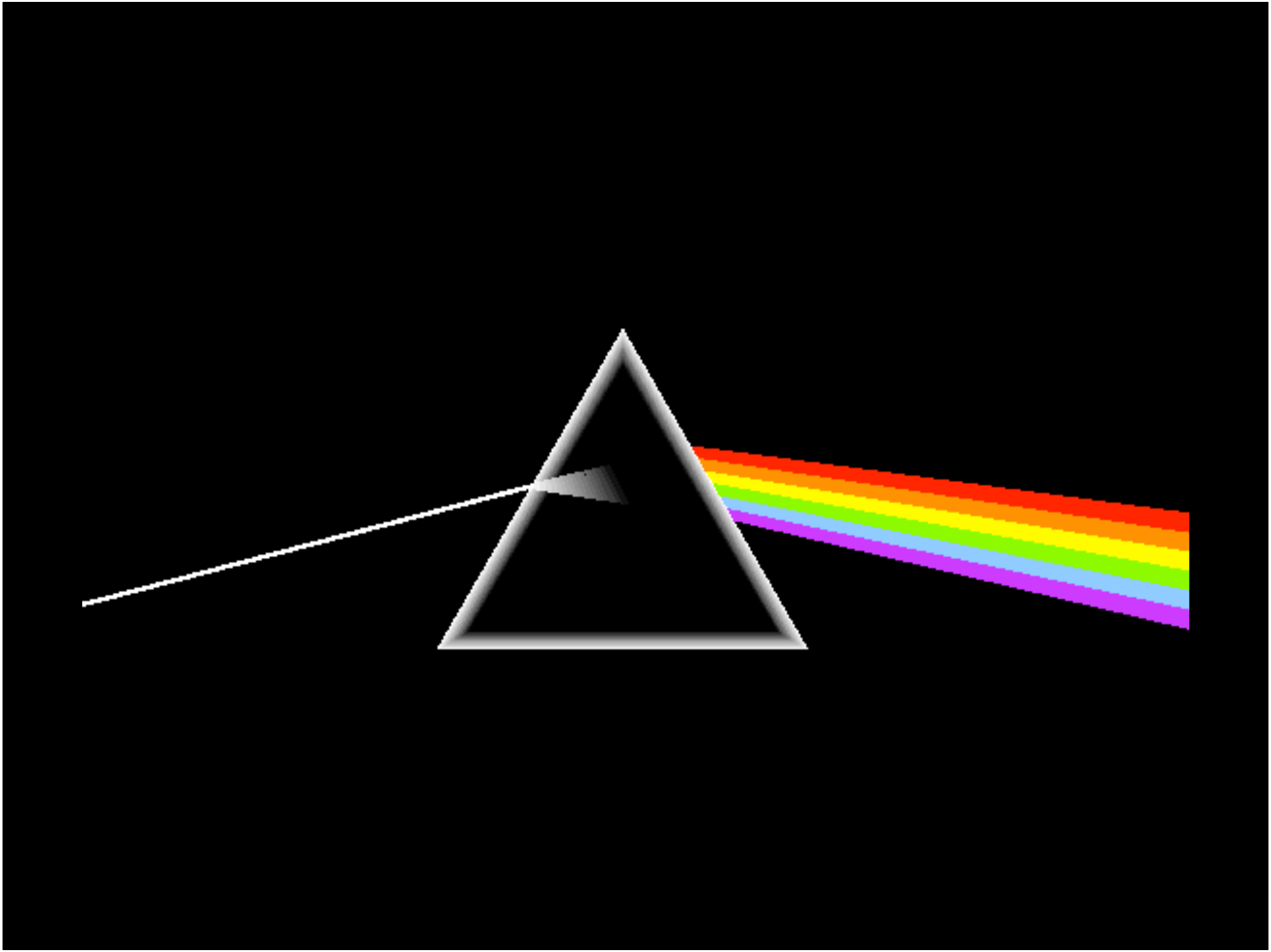
A new and larger map



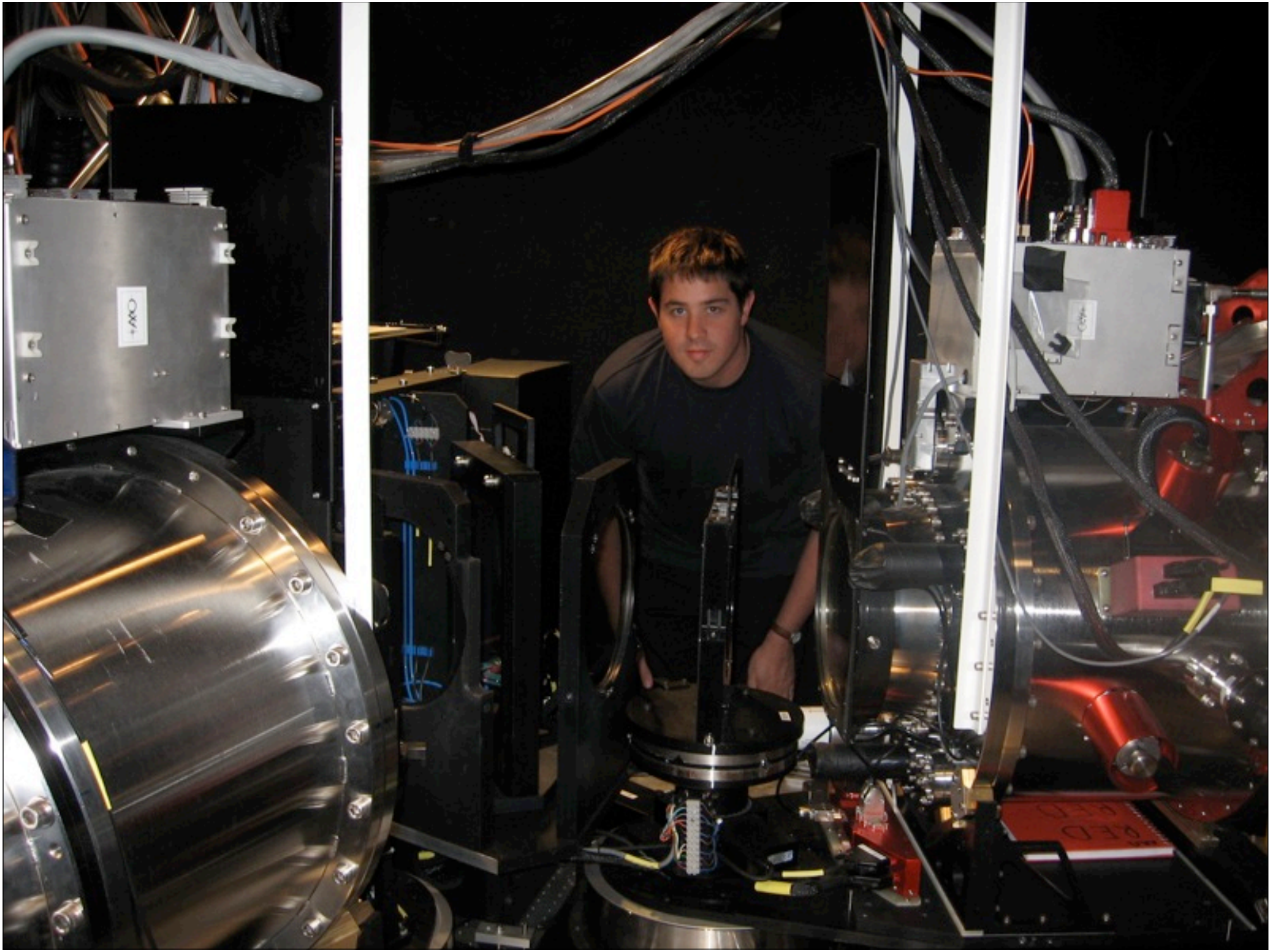

Brisbane
Gold Coast
Broken Hill
NEW SOUTH WALES
Dubbo
Newcastle
Wyong
Penrith
Sydney
Campbelltown
Wollongong
CANBERRA
Albury
VICTORIA
Melbourne
Geelong
Frankston
Mildura
Griffith
Wagga Wagga
Bathurst
Parkes
Tamworth
Coffs Harbour
Port Macquarie
Grafton
Ballina
Cape Howe
Ranne Head
TASMAN SEA
Cape Otway
Wilson's Promontory


DANGER

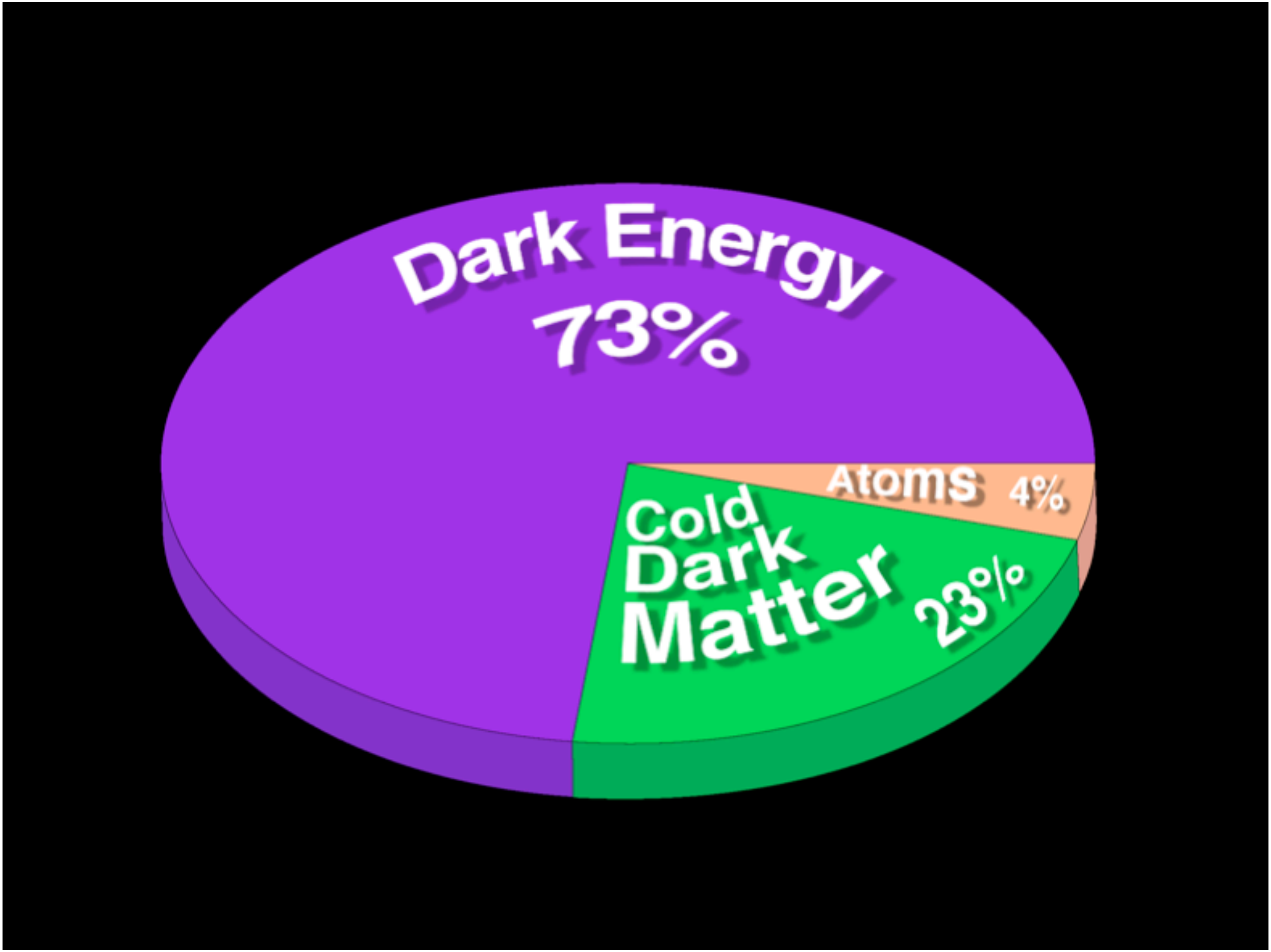

NO SMOKING



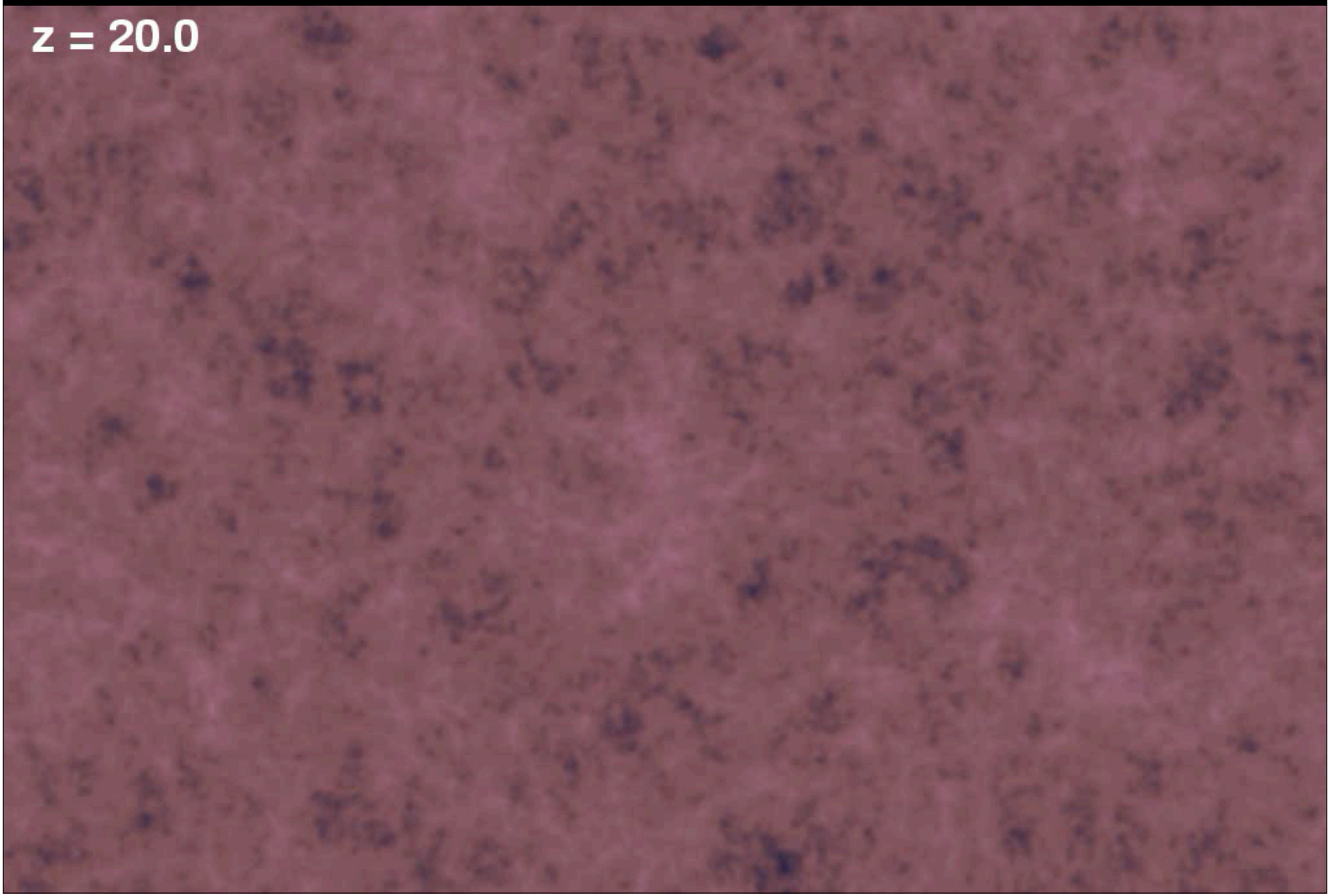

Guide 200
Guide 250
Guide 350




5
5
WARNING
IN CAS
FI
DO NO
LIFT


Dark Energy
73%
Atoms 4%
Cold
Dark
Matter
23%

The Universe inside a computer ...



The Universe inside a computer ...

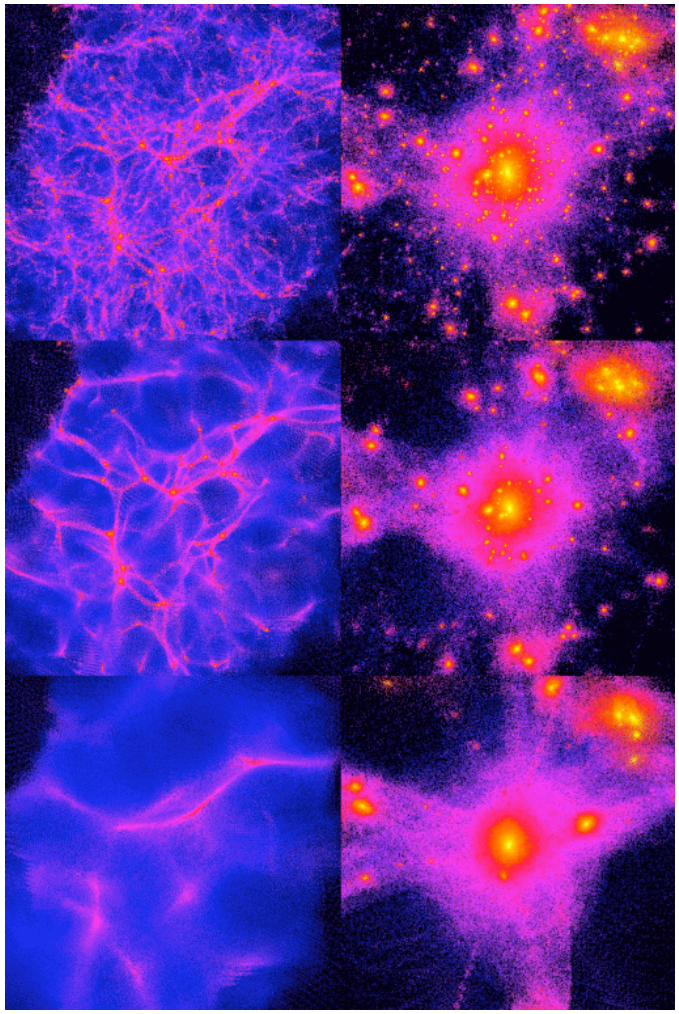
Dark matter?

Dark energy?

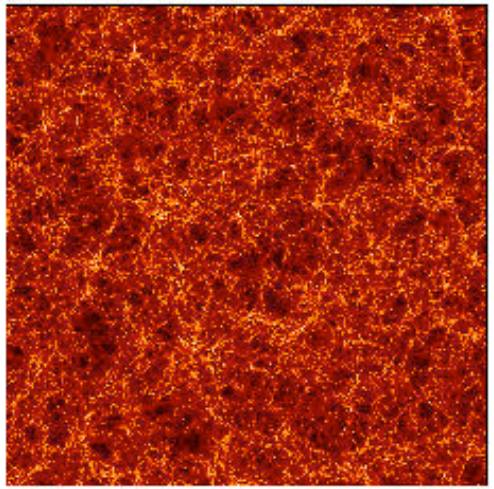
Cold

Warm

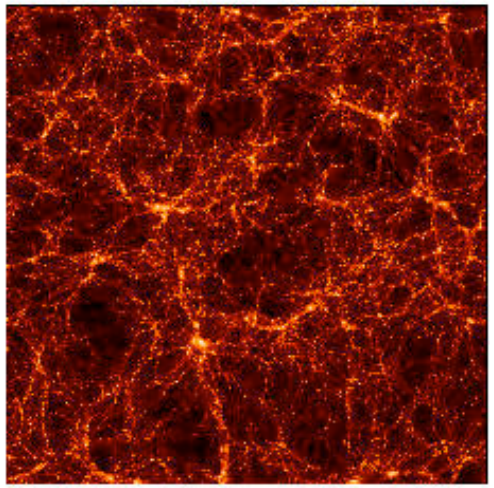
Hot



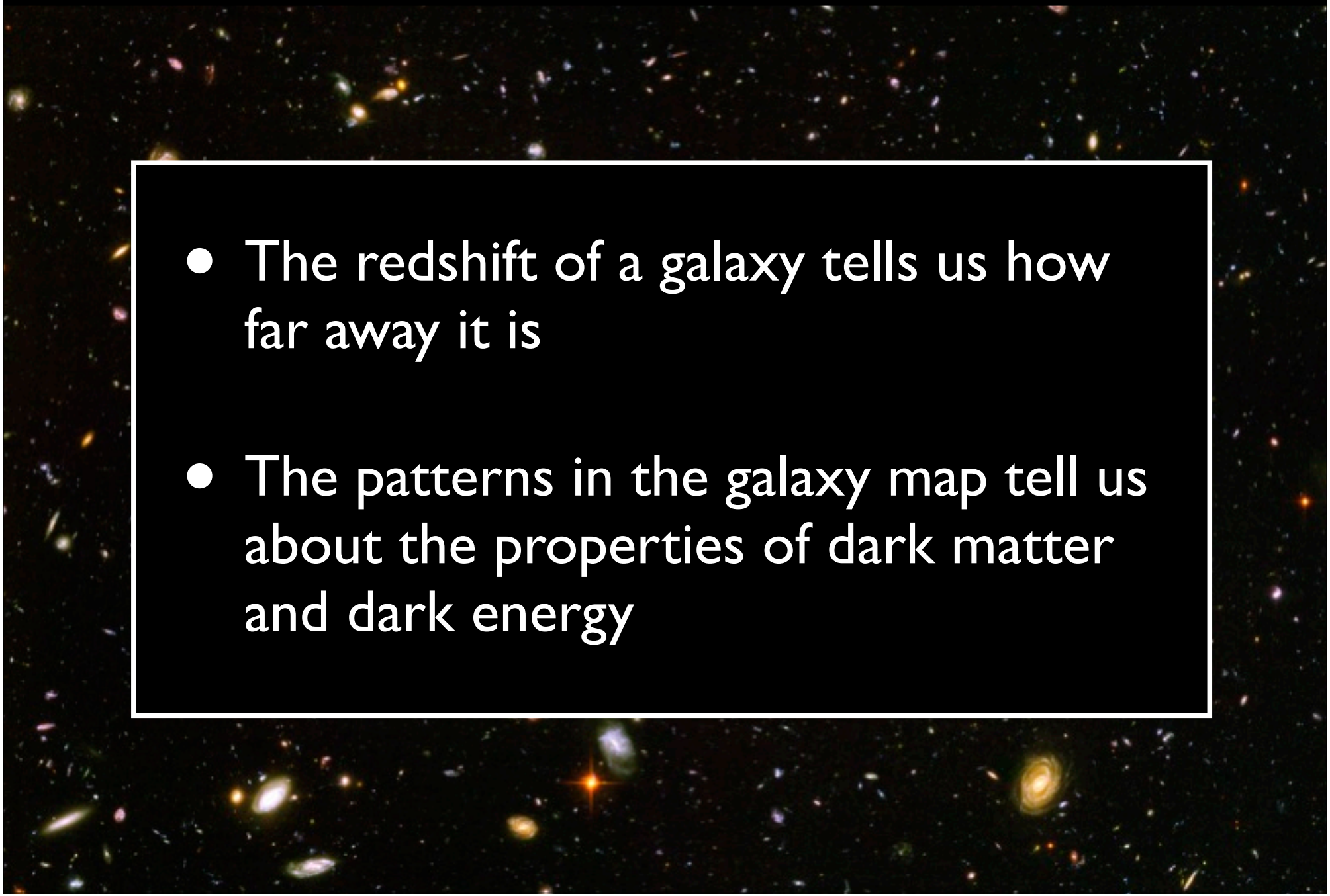
Yes



No



Mapping the Universe



- The redshift of a galaxy tells us how far away it is
- The patterns in the galaxy map tell us about the properties of dark matter and dark energy

Thank you for coming !