



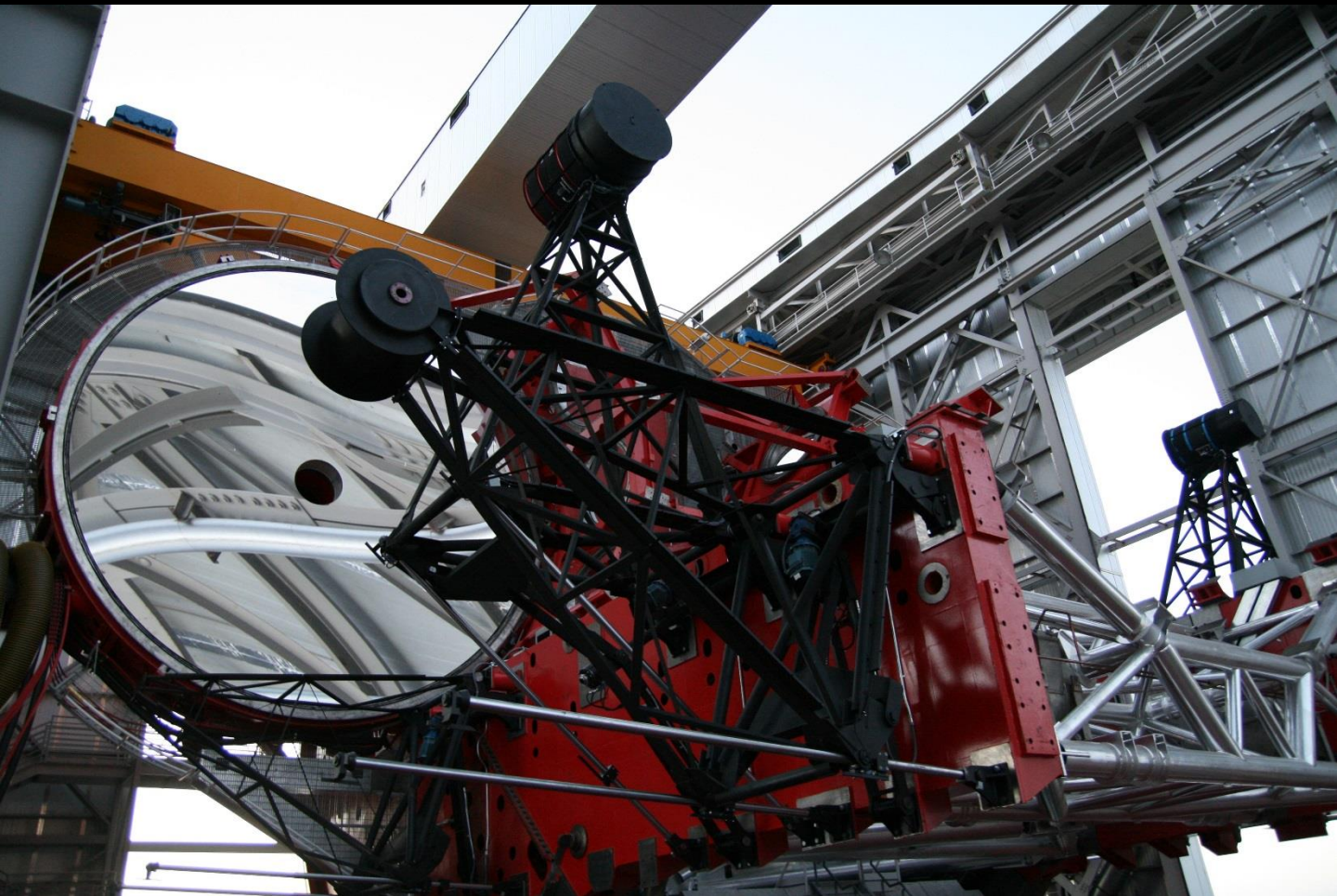
# Our Place in the Universe

From Earth to the Stars

Dr. Jonathan Crass















# Our Place in the Universe

- So just where are we in the Universe?
  - Distances in astronomy
- The changing and evolving Universe
  - The Big Bang
  - The birth, life and death of stars
  - Making the galaxies we see
- What makes up the Universe?





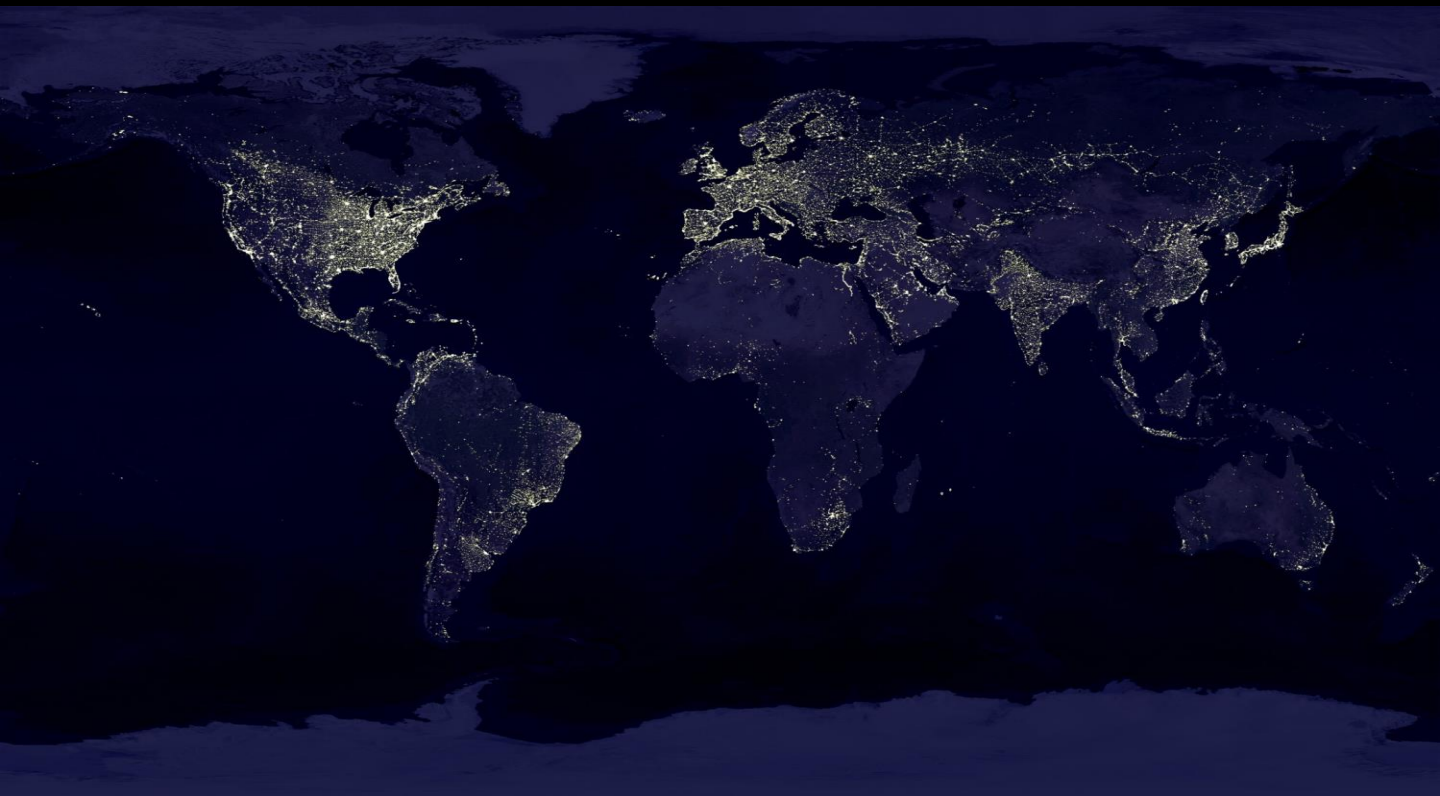


The United Kingdom



Europe

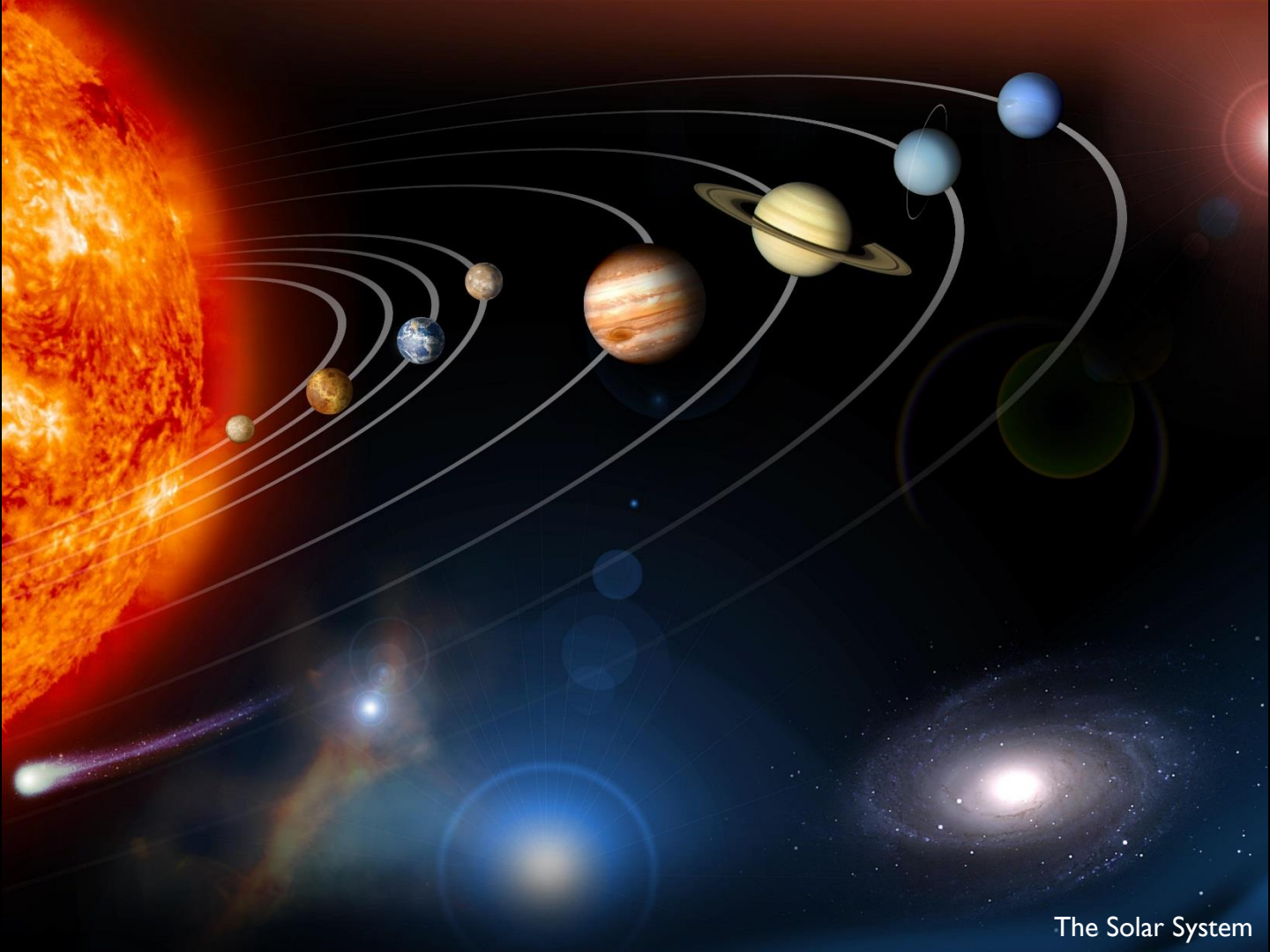




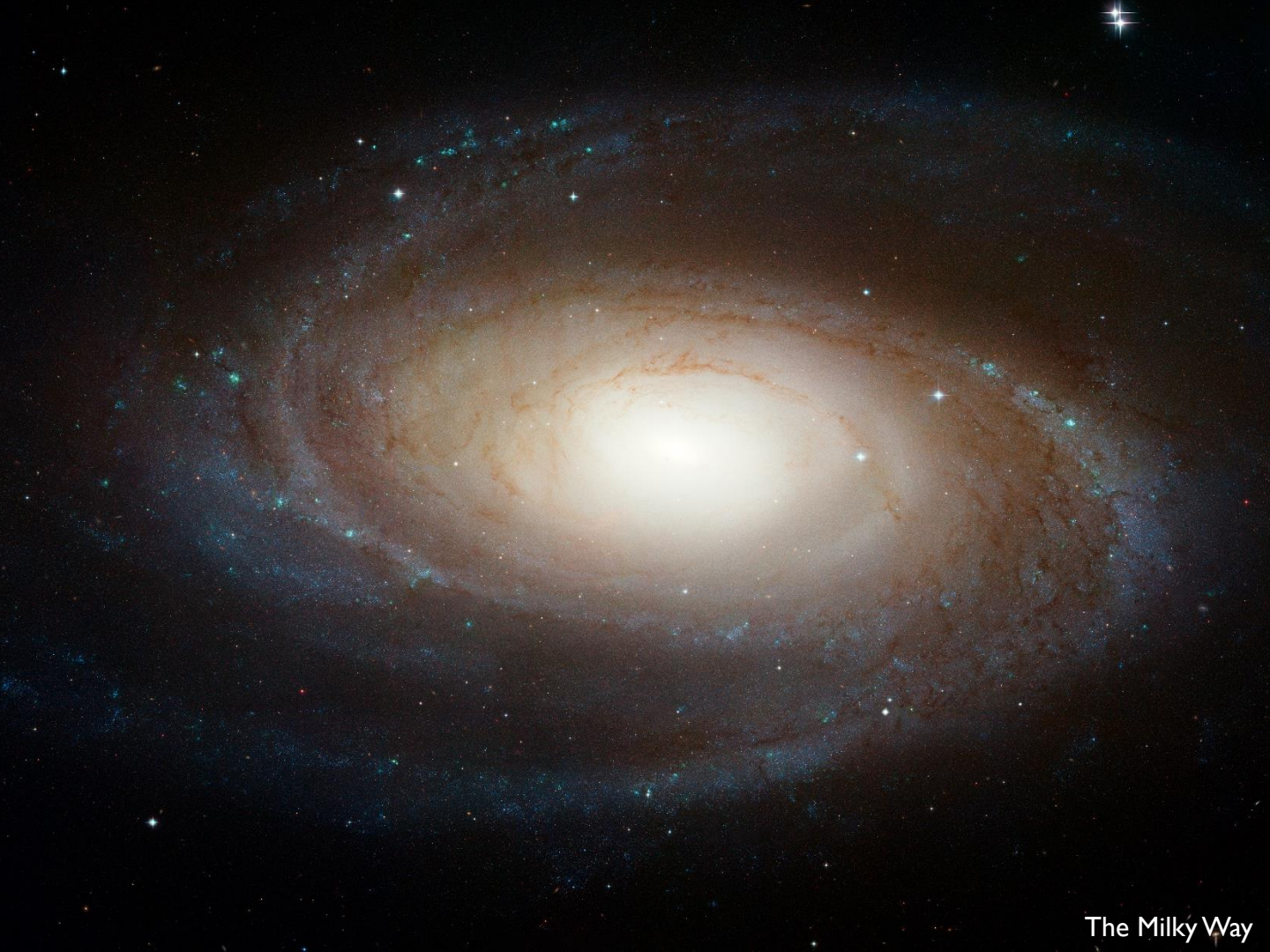


The Earth



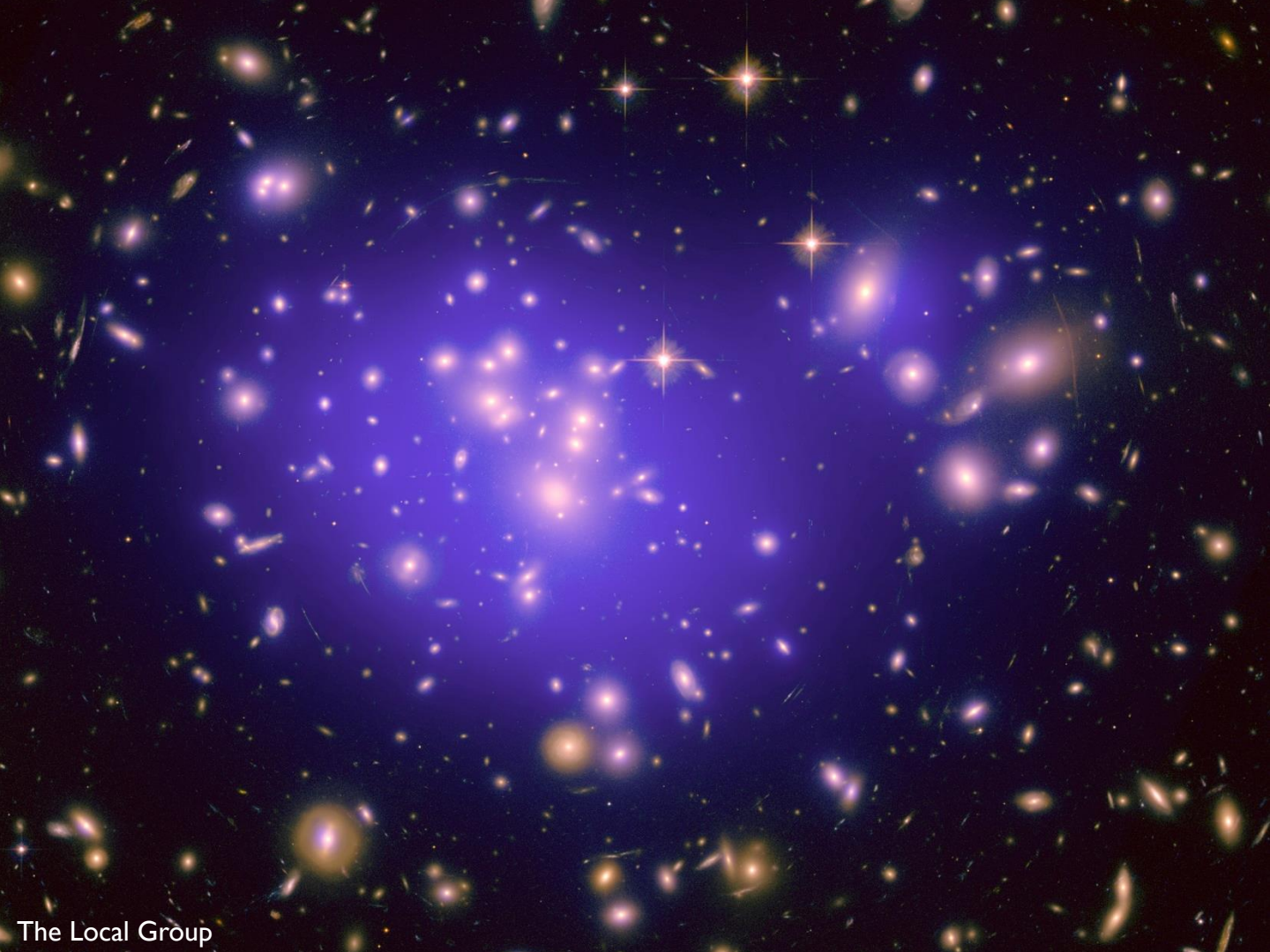


The Solar System



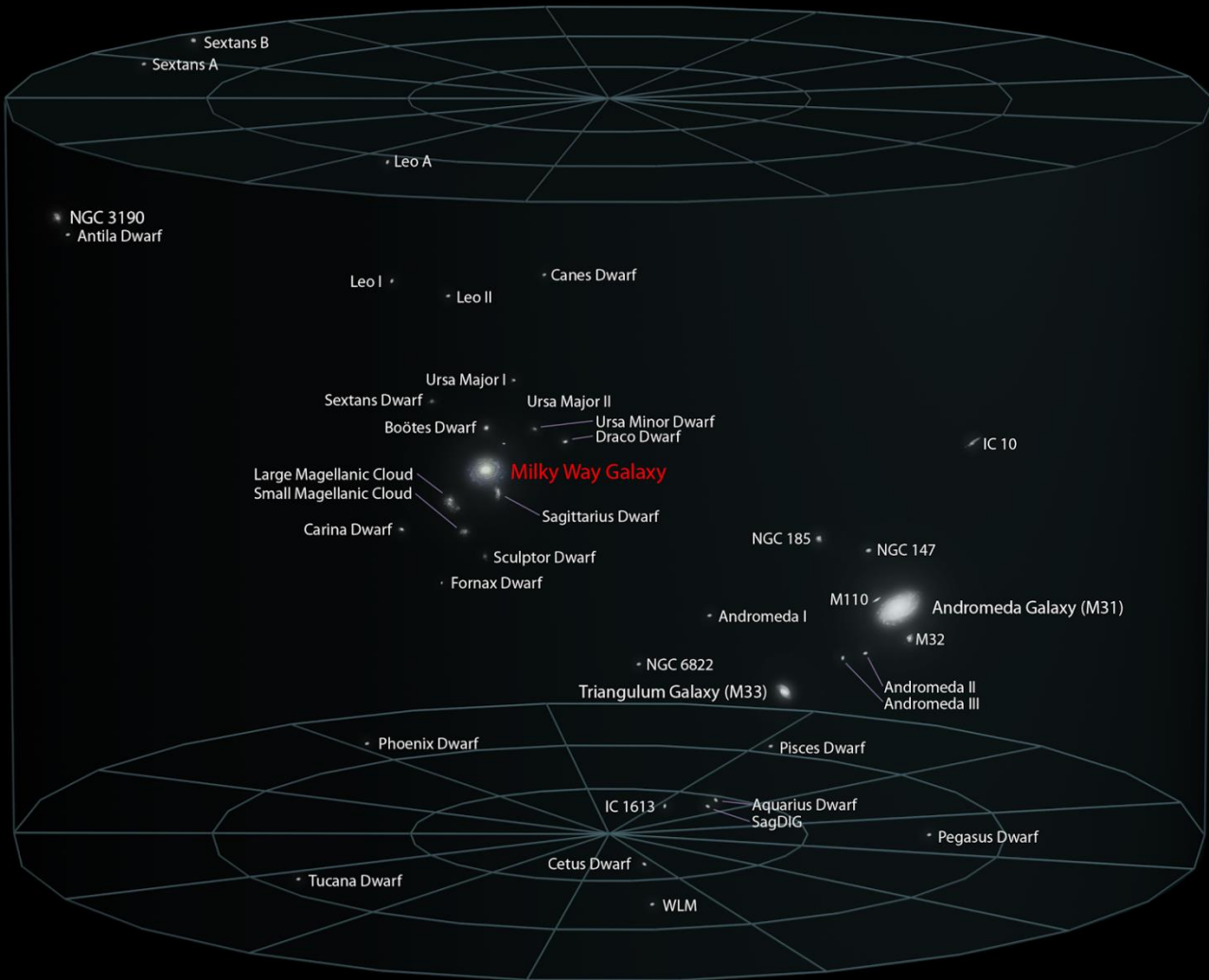
The Milky Way

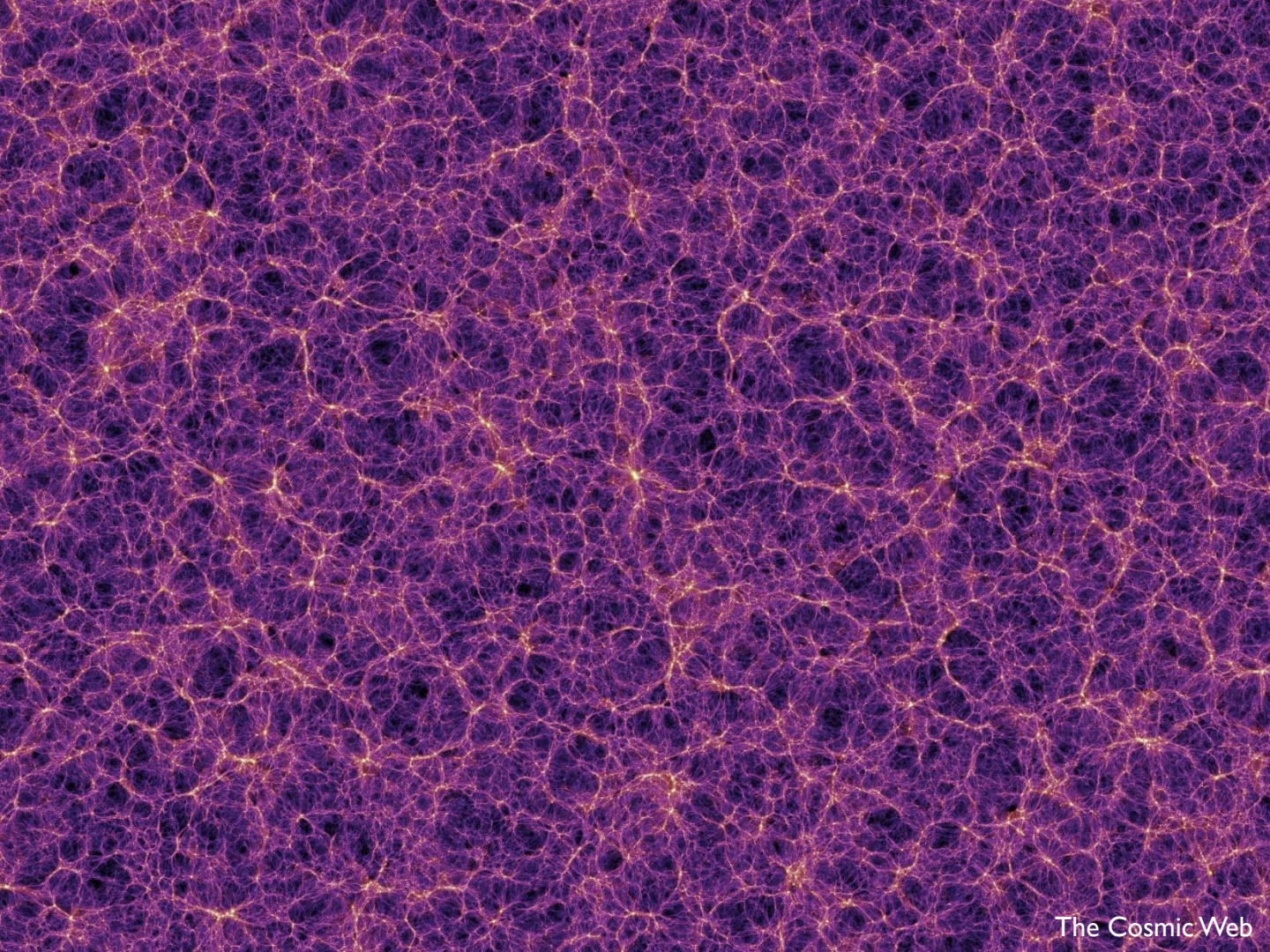




The Local Group

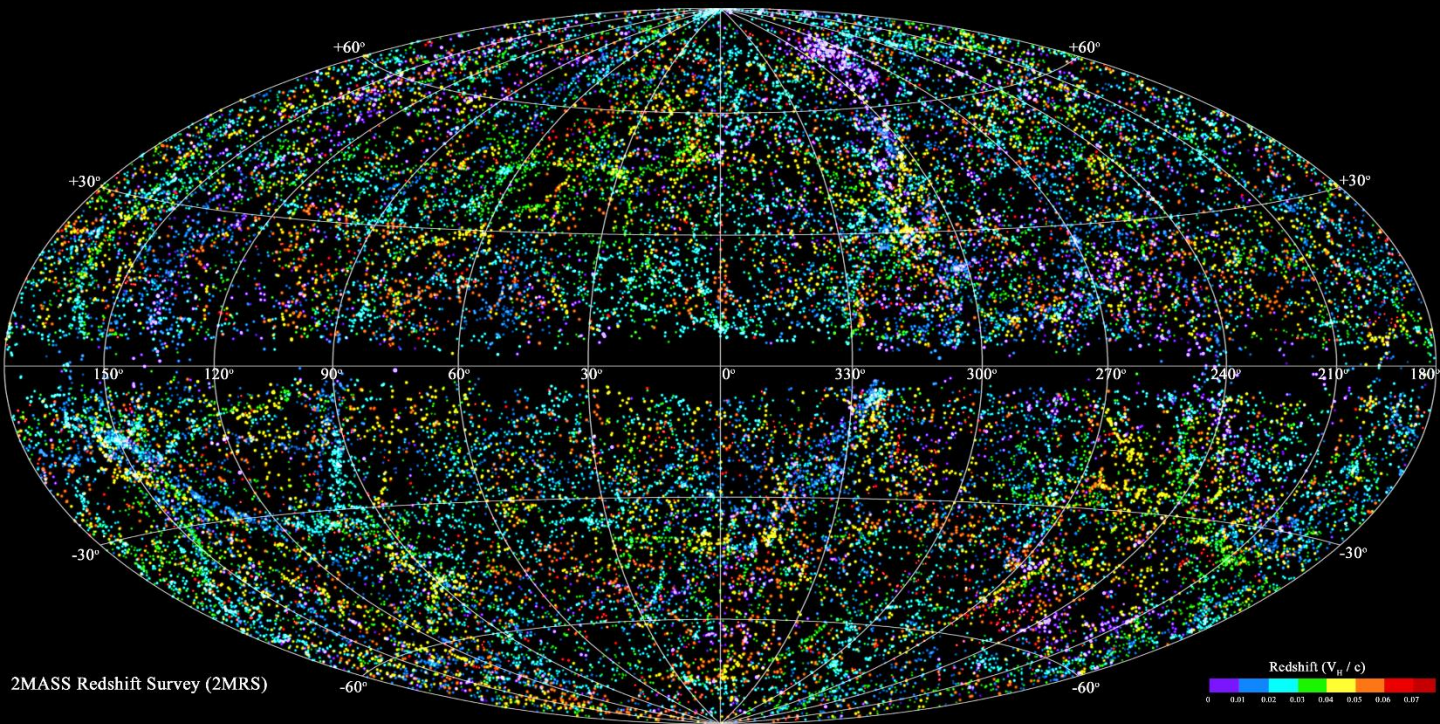




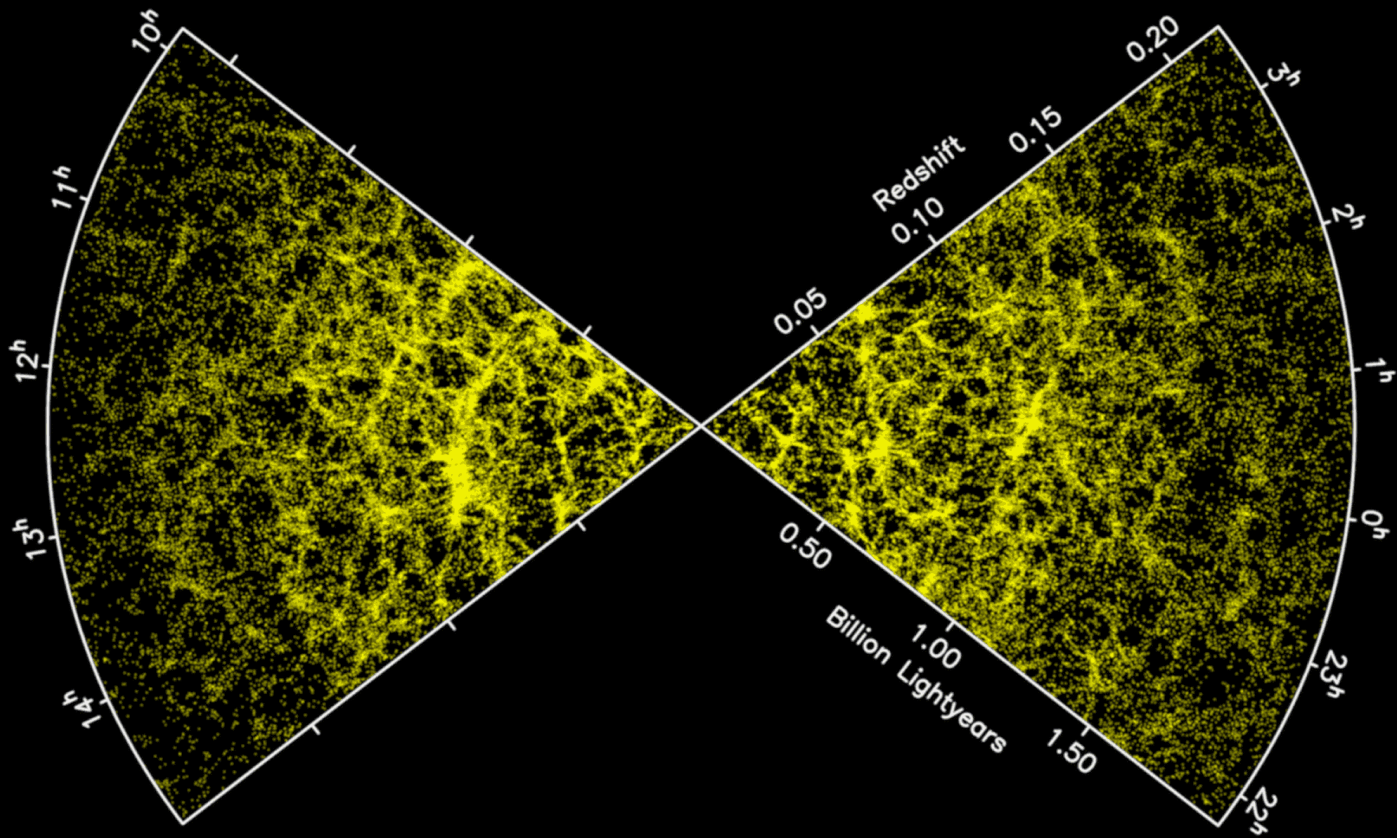


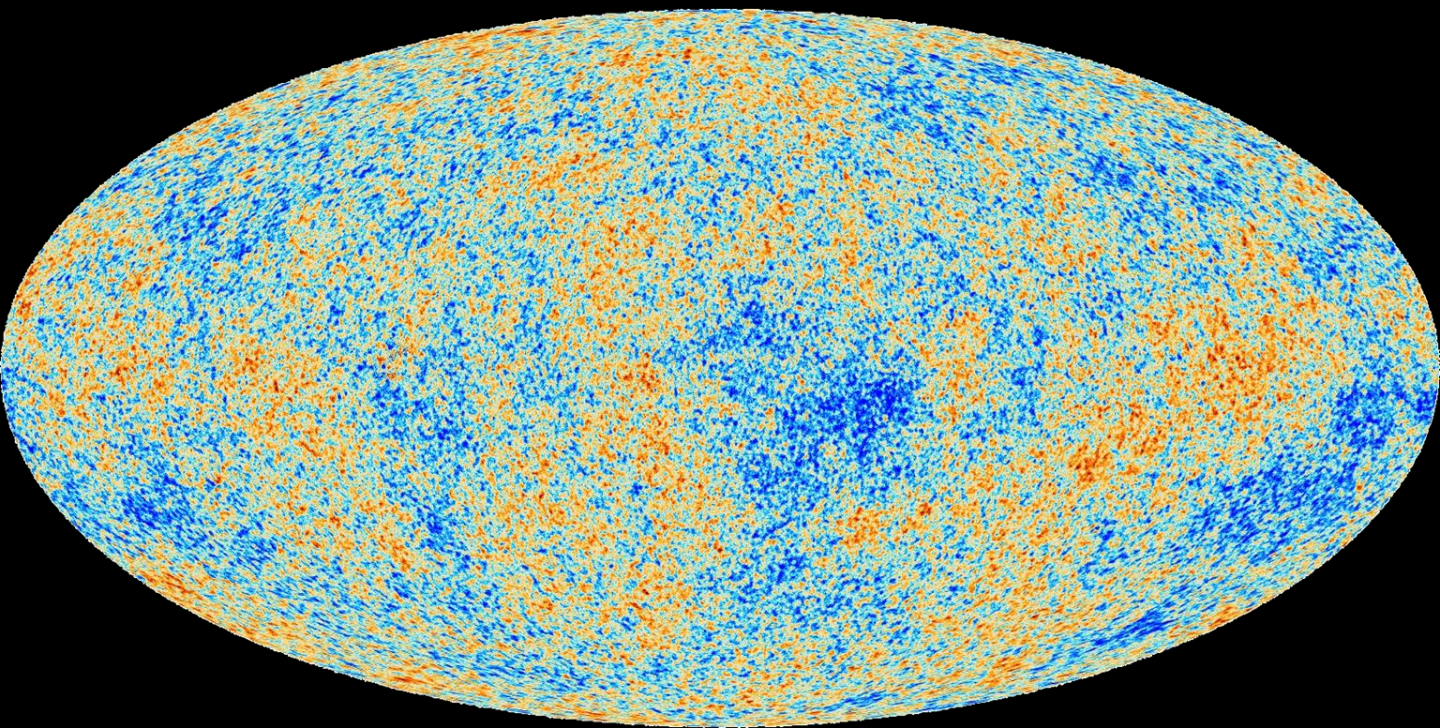
The Cosmic Web











The Cosmic Microwave Background

# So where are we?

## Our Earth Address

Cunard Line,  
Southampton,  
Hampshire,  
United Kingdom,  
Europe,  
The Earth

## Our Universal Address

Cunard Line,  
The Earth,  
The Solar System,  
The Milky Way,  
The Local Group,  
The Universe



# Cosmic Distances

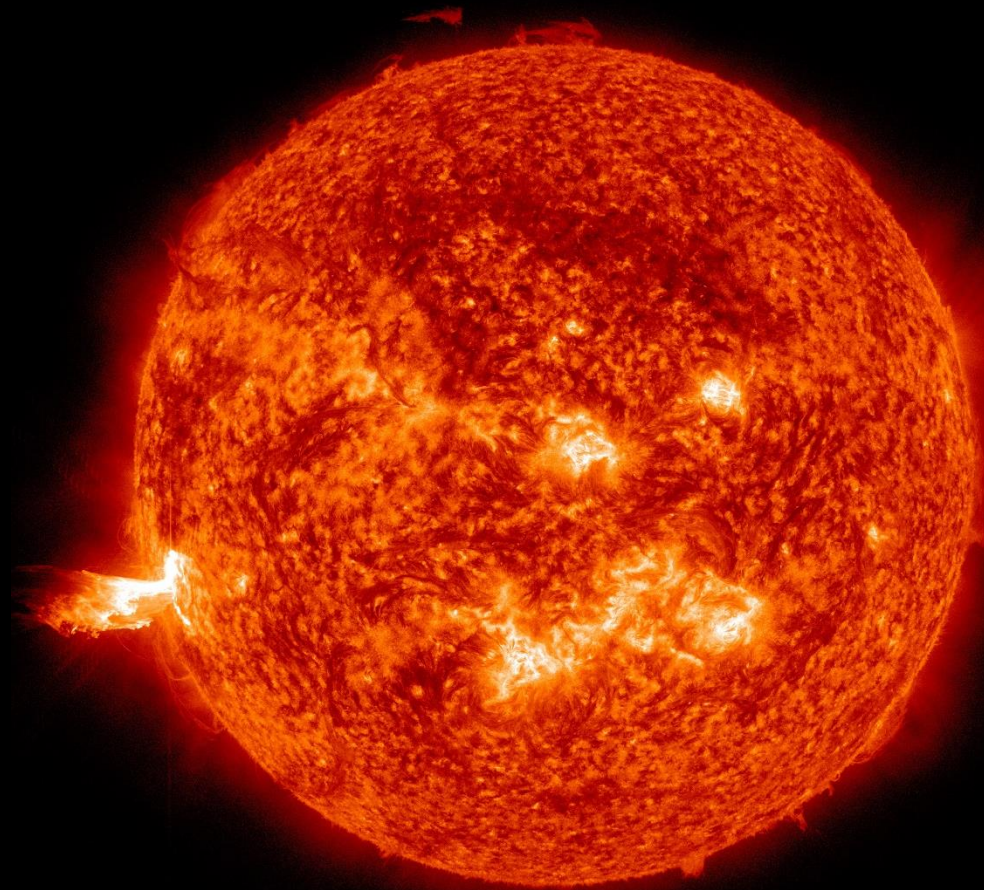


New York to Southampton: 3,420 miles / 5,500km

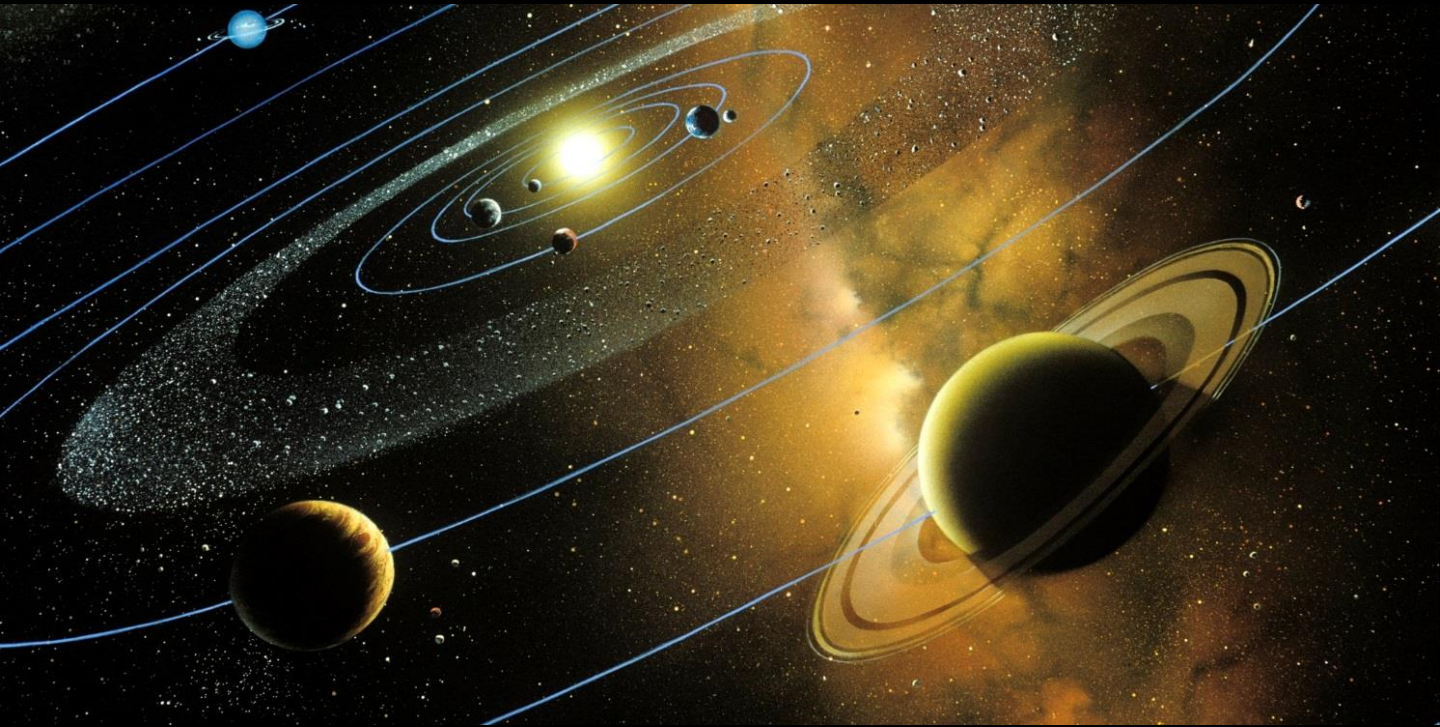


Earth to the Moon: 238,900 miles / 384,400 km

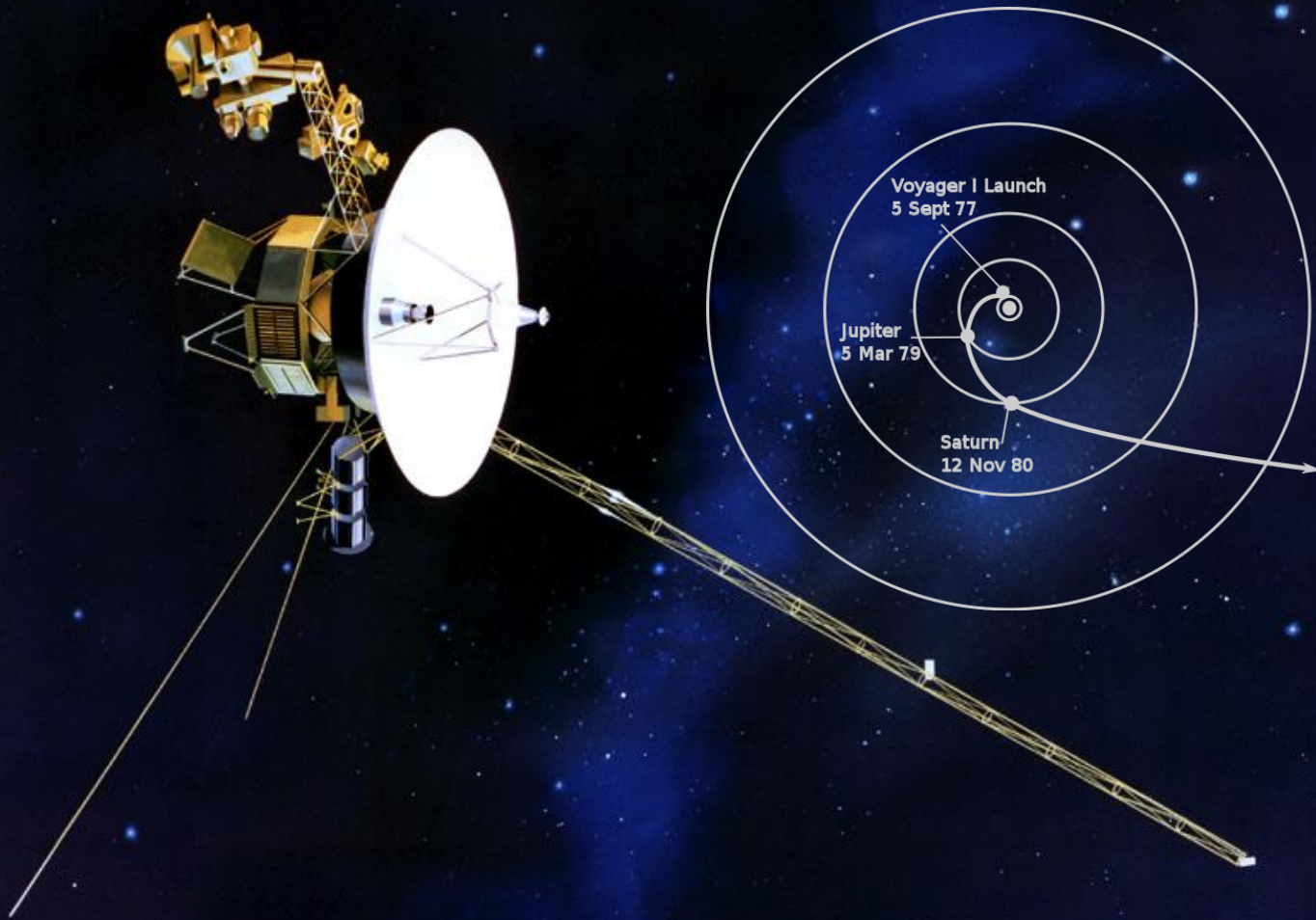




Earth to the Sun: 92,960,000 miles / 149,600,000 km



The edge of the Solar System: 9,000,000,000 miles / 14,484,096,000 km



Voyager 1 Launch  
5 Sept 77

Jupiter  
5 Mar 79

Saturn  
12 Nov 80





Queen Mary 2

Q

QUEEN MARY 2

# Distances in Astronomy

- At the maximum speed of Queen Mary 2 (35mph)
  - New York to Southampton:  
4 days
  - Earth to the Moon:  
284 days
  - Earth to the Sun:  
302 years
  - To the edge of the Solar System:  
29,334 years





# Distances in Astronomy

- At the speed of light
  - New York to Southampton:  
0.0183 seconds
  - Earth to the Moon:  
1.28 seconds
  - Earth to the Sun:  
8.3 minutes
  - To the edge of the Solar System:  
13.4 hours

# Units of Distance

- 1 Astronomical Unit (AU)
  - The average distance between the Sun and the Earth
  - 149,597,871 km
- 1 Light Year (ly)
  - The distance light would travel in 1 year
  - 9,460,528,410,000 km

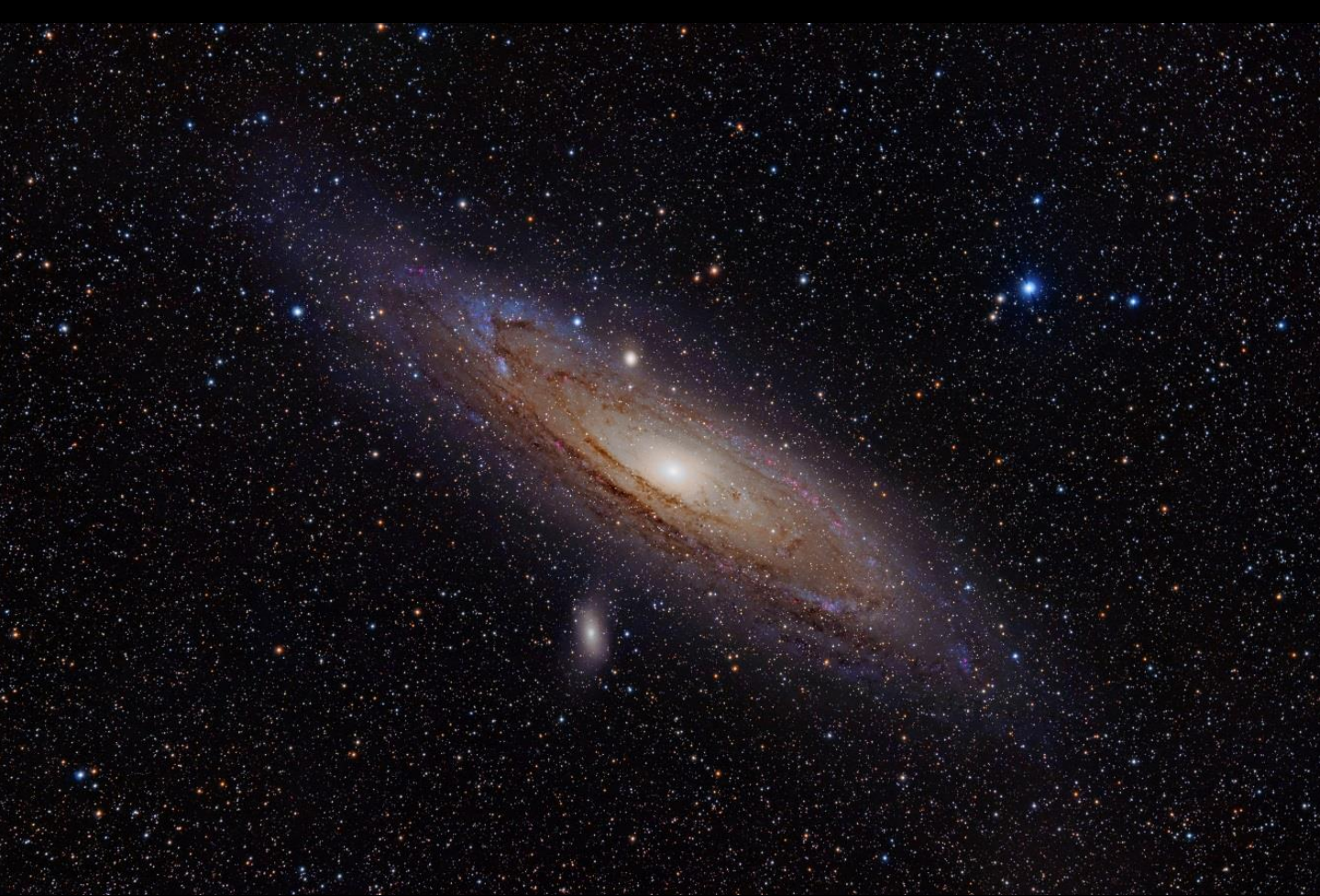




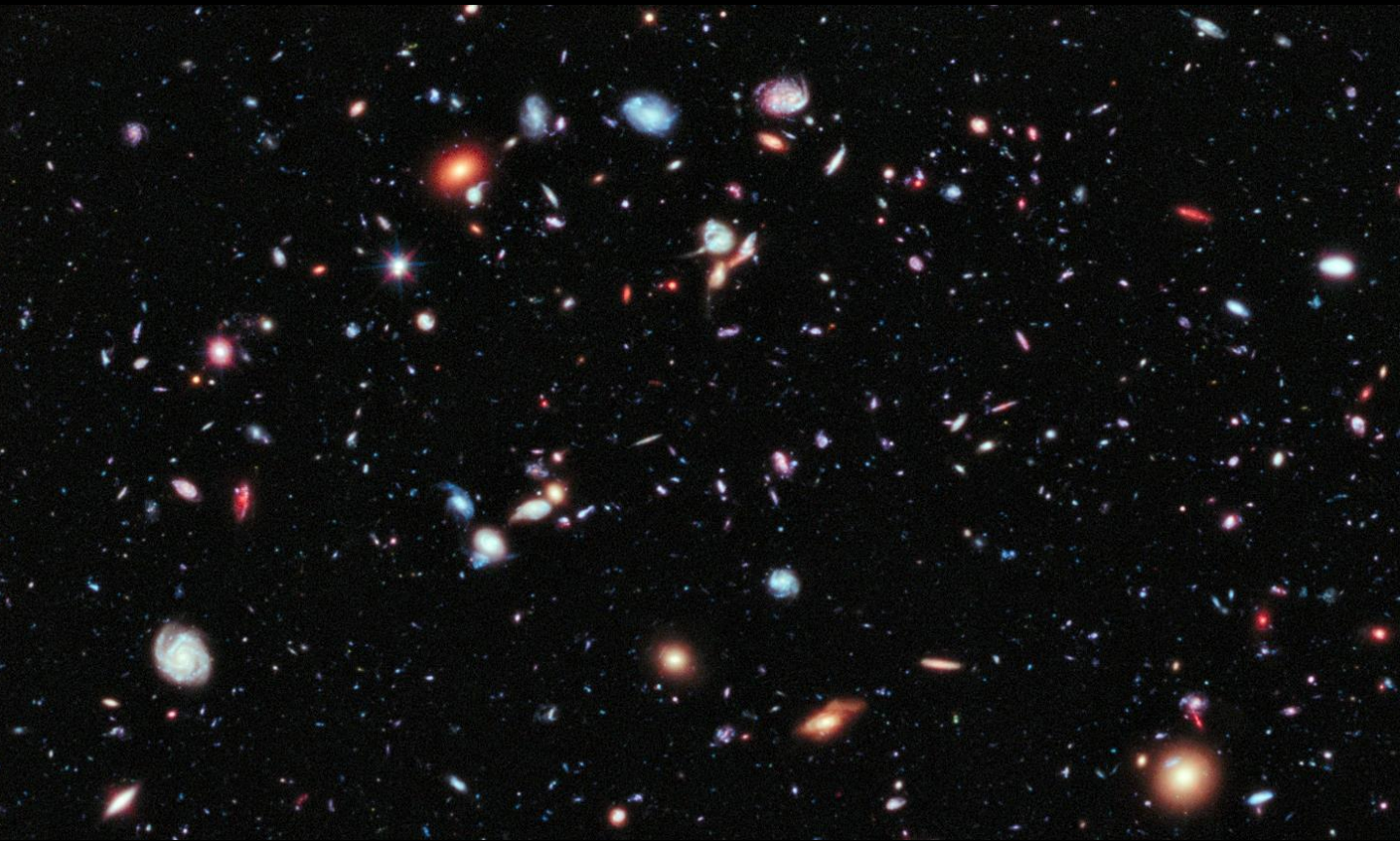


To the centre of the Galaxy: 25,900 light years





To the Andromeda Galaxy: 2,538,000 light years



To the most distant Galaxy known: 13,000,000,000 light years



# Our Location – a Summary

- We are:

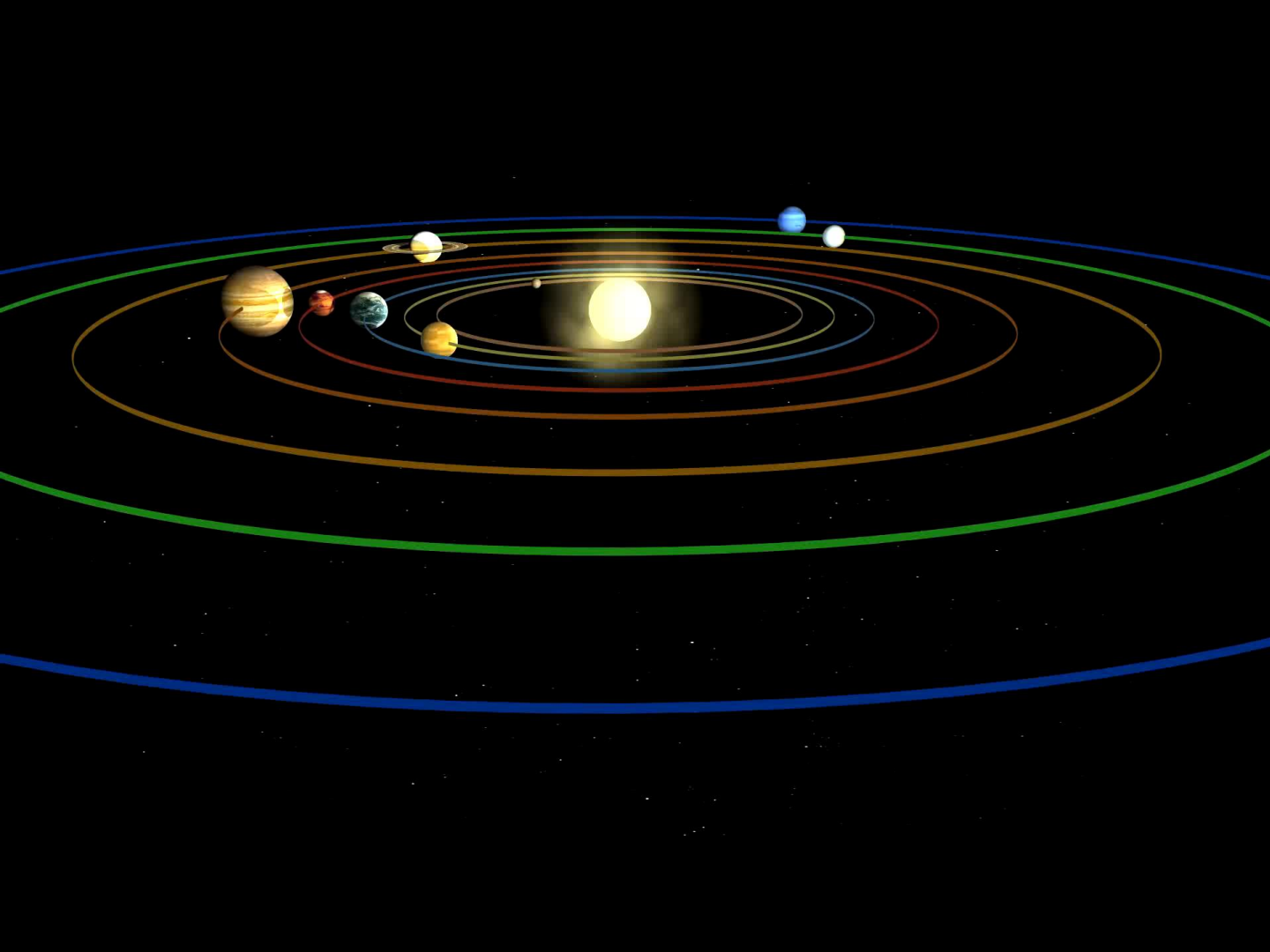
|                              |                 |
|------------------------------|-----------------|
| On Earth                     | km/miles        |
| Which is in the Solar System | 50-100 AU       |
| Which is in the Milky Way    | 50 thousand ly  |
| Which is in the Local Group  | 10 million ly   |
| Which is in the Cosmic Web   | Billion ly      |
| Which is in the Universe     | 13.7 Billion ly |

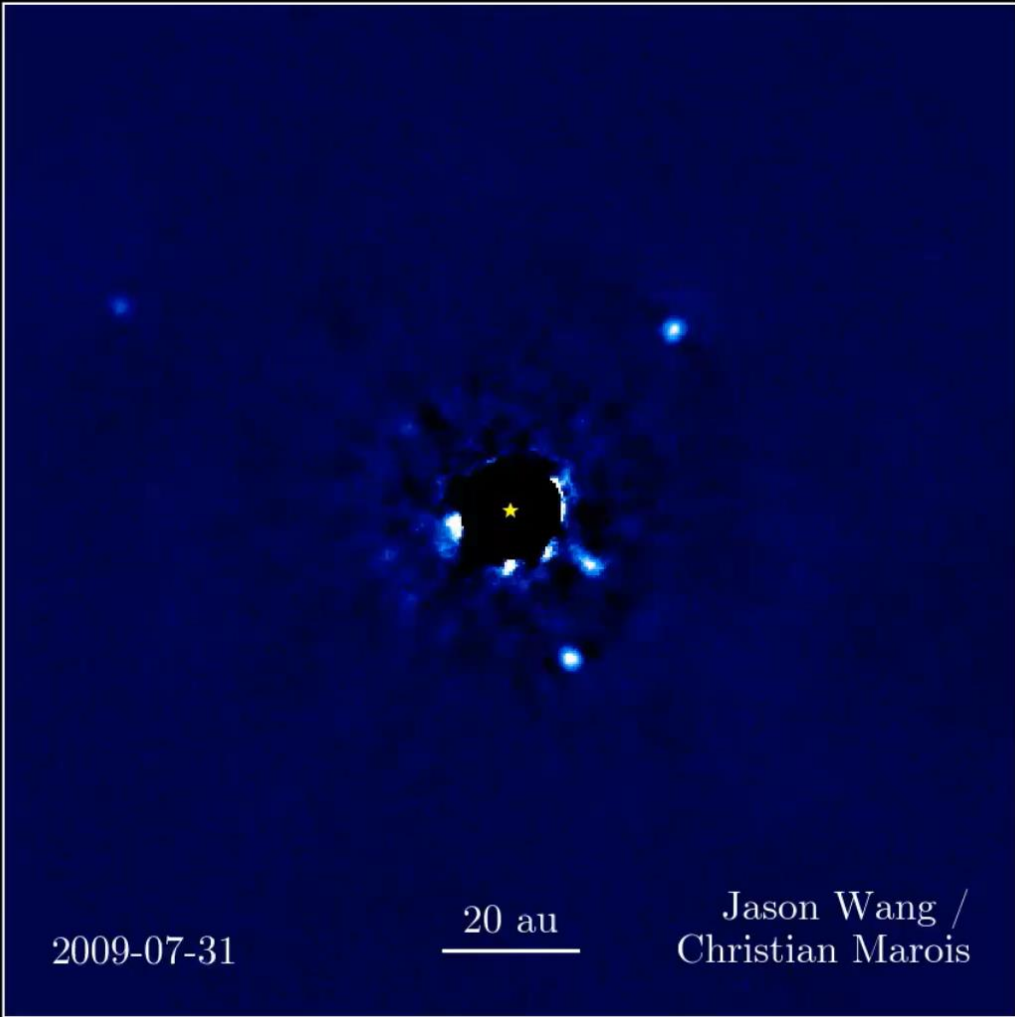
# **The changing and evolving Universe**

# The Universe Today

- The Universe isn't static – it evolves







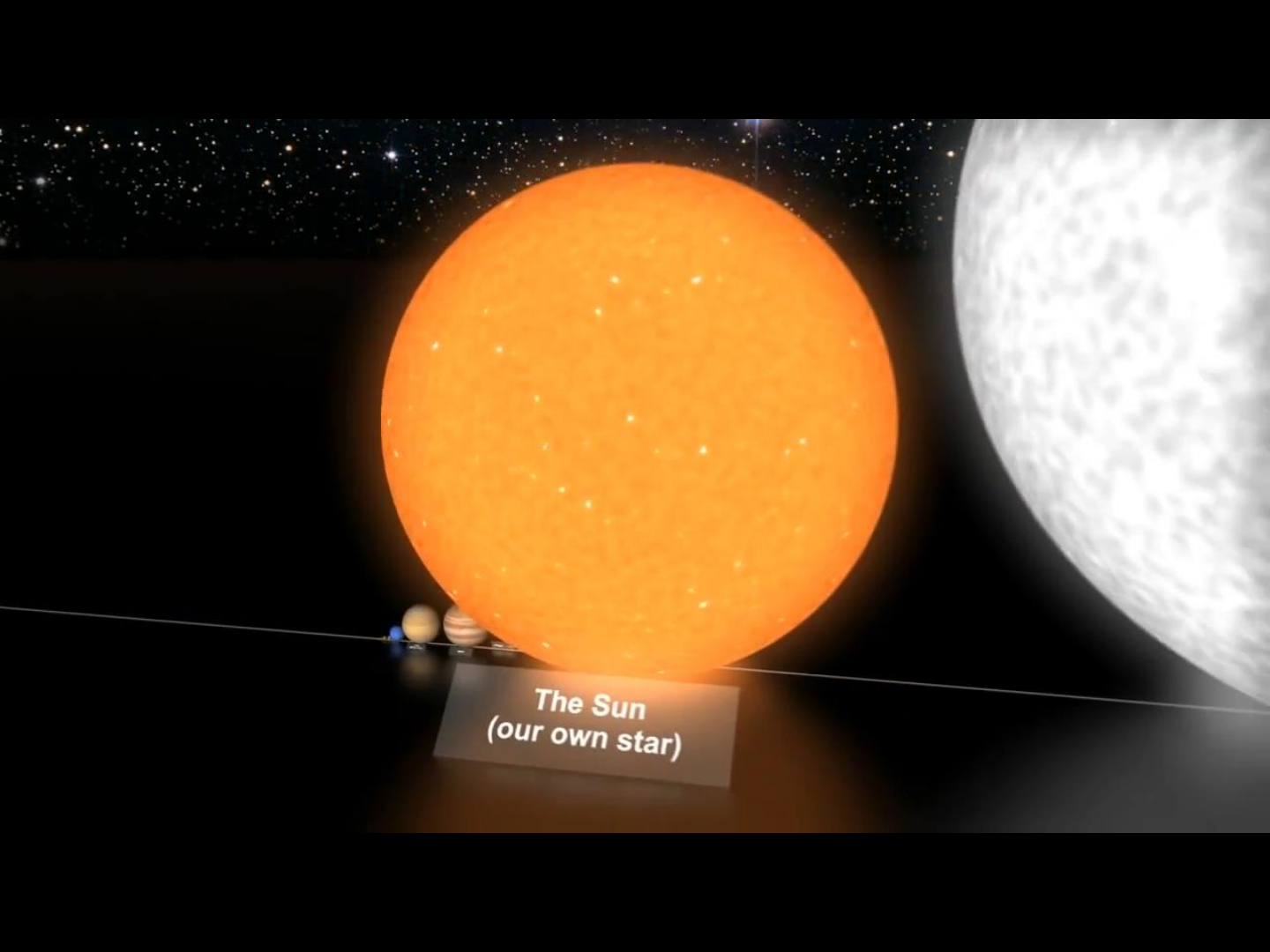
2009-07-31

20 au

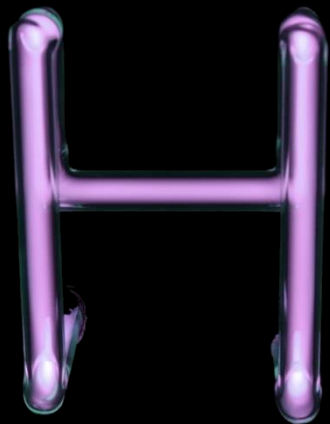
Jason Wang /  
Christian Marois

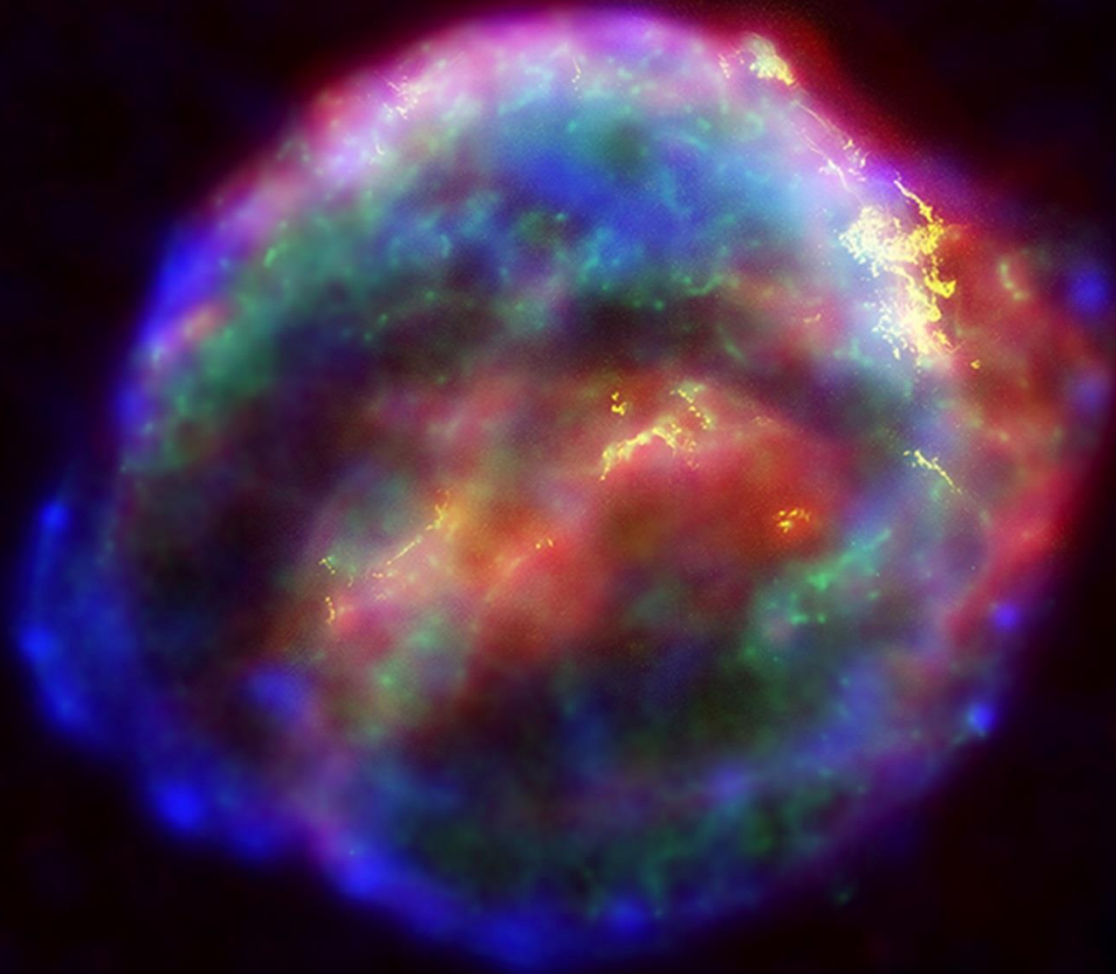






**The Sun**  
**(our own star)**







alpha Persei



Pleiades



Orion



















# The Spitzer Infrared Nearby Galaxies Survey (SINGS) Hubble Tuning-Fork

The Spitzer Space Telescope observed 75 galaxies as part of its SINGS (Spitzer Infrared Nearby Galaxies Survey) Legacy Program. The galaxies are presented here in a Hubble Tuning-Fork diagram, which groups galaxies according to the morphology of their nuclei and spiral arms. The designation of these galaxies and their placement in the diagram is based on their visible-light appearance. The main goal of the SINGS program is to characterize the infrared properties of a wide range of galaxy types. The images of the galaxies are composites created from data taken by IRAC (the Infrared Array Camera) at 3.6 and 8.0  $\mu\text{m}$ , and MIPS (the Multiband Imaging Photometer for Spitzer) at 24  $\mu\text{m}$ .

The infrared range probed by these and other observations taken for the SINGS project allows for the detailed study of star formation, dust emission, and the distribution of stars in each galaxy. Light from old stars appears as blue in the images, while the lumpy knots of green and red light are produced by dust clouds surrounding newly born stars. The elliptical galaxies on the left are almost entirely made of old stars, while spiral galaxies like our own Milky Way are rich in young stars and the raw materials for future star formation.

More information can be found at:  
<http://sings.stsci.edu/>



Ellipticals

Irregulars

Unbarred Spirals

Weak Bulge

Strong Bulge

Strong Bulge

Weak Bulge

Intermediate Spirals

Barred Spirals

## SINGS Team

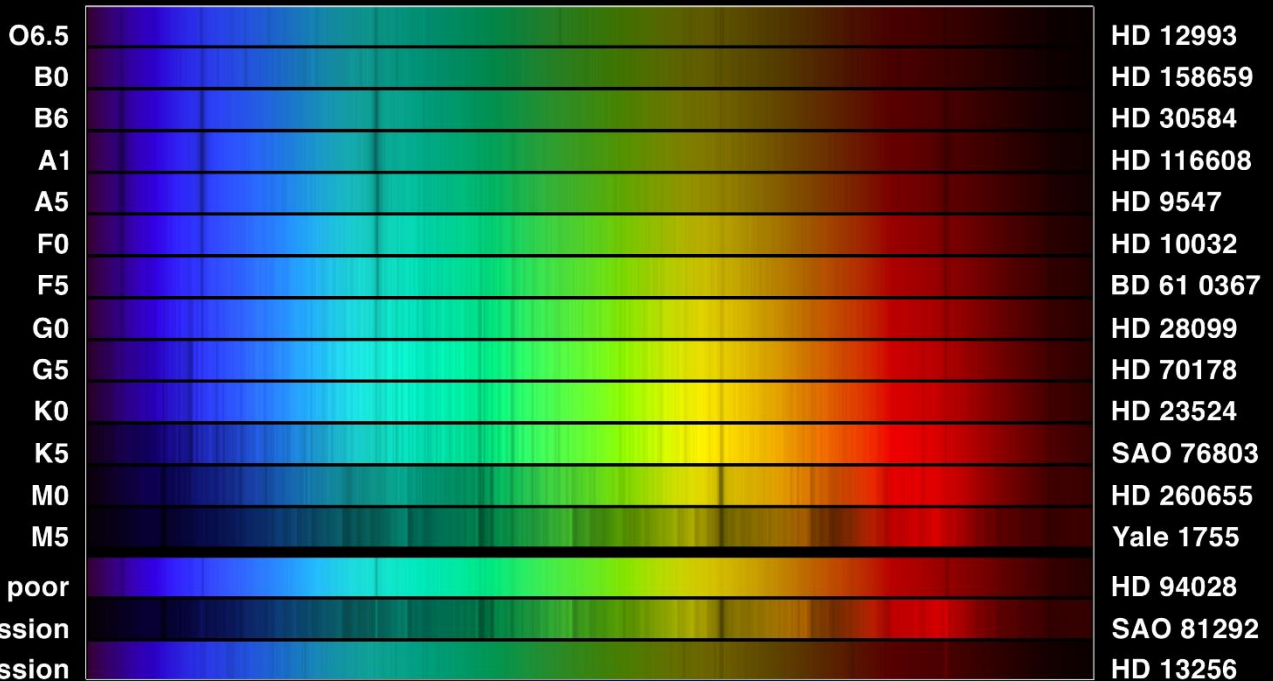
Robert Komossa, Jr. (Principal Investigator), Daniela Calzetti (Deputy Principal Investigator), Charles Engelbracht (Technical Contact), Lee Armus, George Rieke, Carolina Bot, Brent Beckwith, John Cannon, Daniel Dale, Bruce Draine, Karl Gordon, Albert Grauer, David Hollenbach, Tom Jarrett, Lisa Kewley, Claus Leitherer, Alan Li, Saugata Malhotra, Martin Meyer, John Moustakas, Eric Murphy, Michael Regan, George Rieke, Maria Rieke, Helene Roussel, Karik Sheeh, J.D. Smith, Michele Thorneley, Fabian Walter & George Helou

Poster and composite images created from SINGS observations by Karl D. Gordon (cc.2007)  
 Based on IRAC 3.6  $\mu\text{m}$  (blue)  
 Green = IRAC 8  $\mu\text{m}$   
 (aromatic features from dust grains/molecules)  
 Red = MIPS 24  $\mu\text{m}$  (warm dust)



# Starting at the beginning

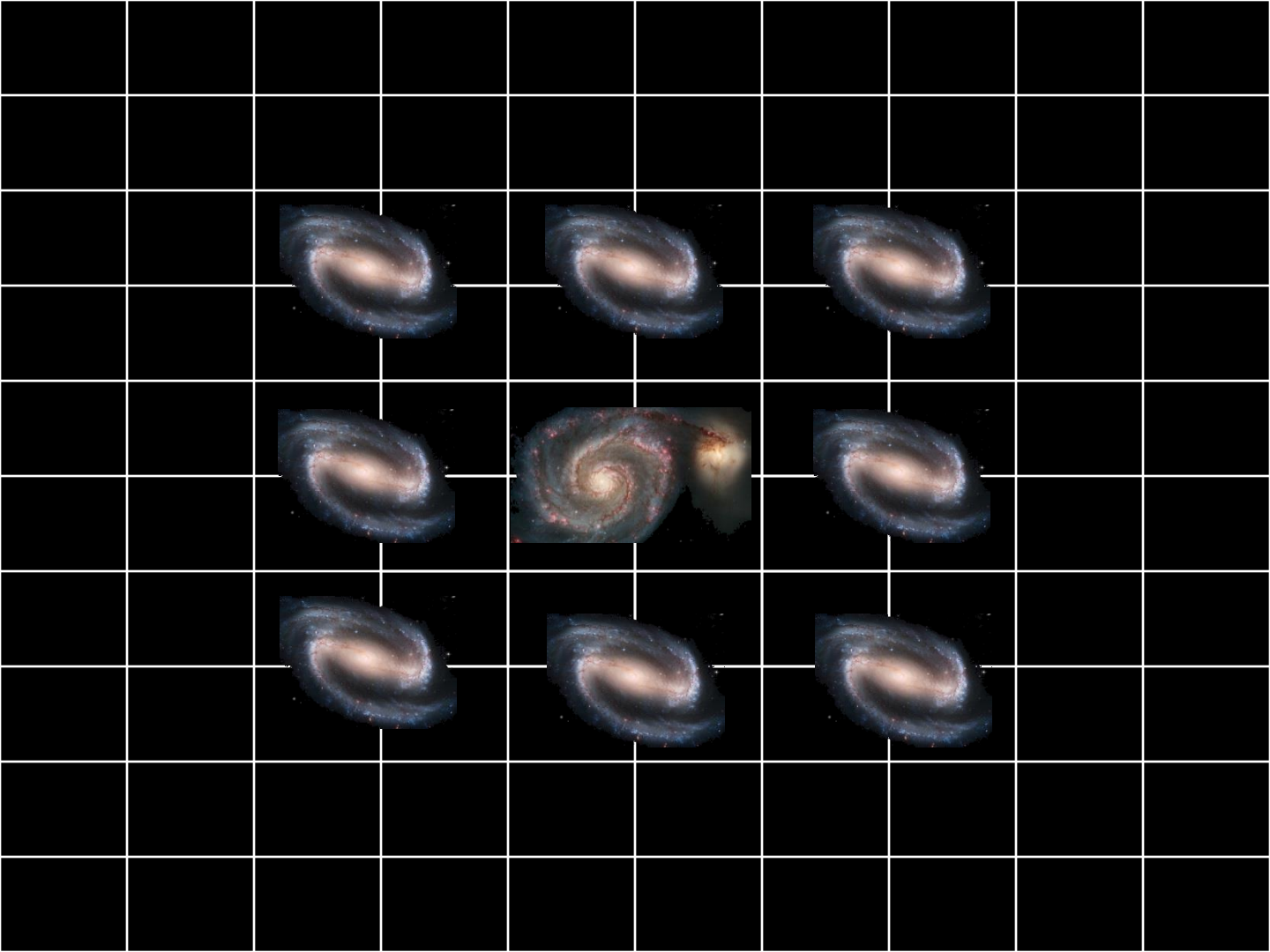




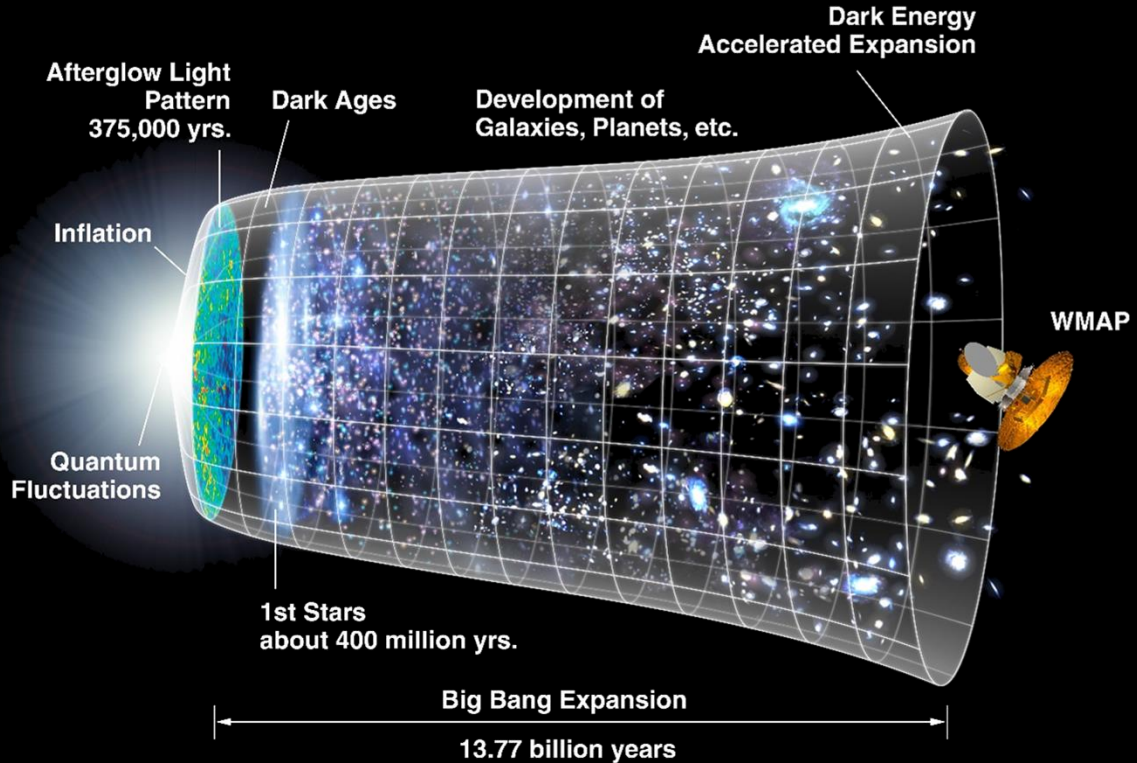


# The Expansion of the Universe

- The objects further away are moving away fastest
- Everything appears to be moving away from Earth
- So are we in a “special” place?



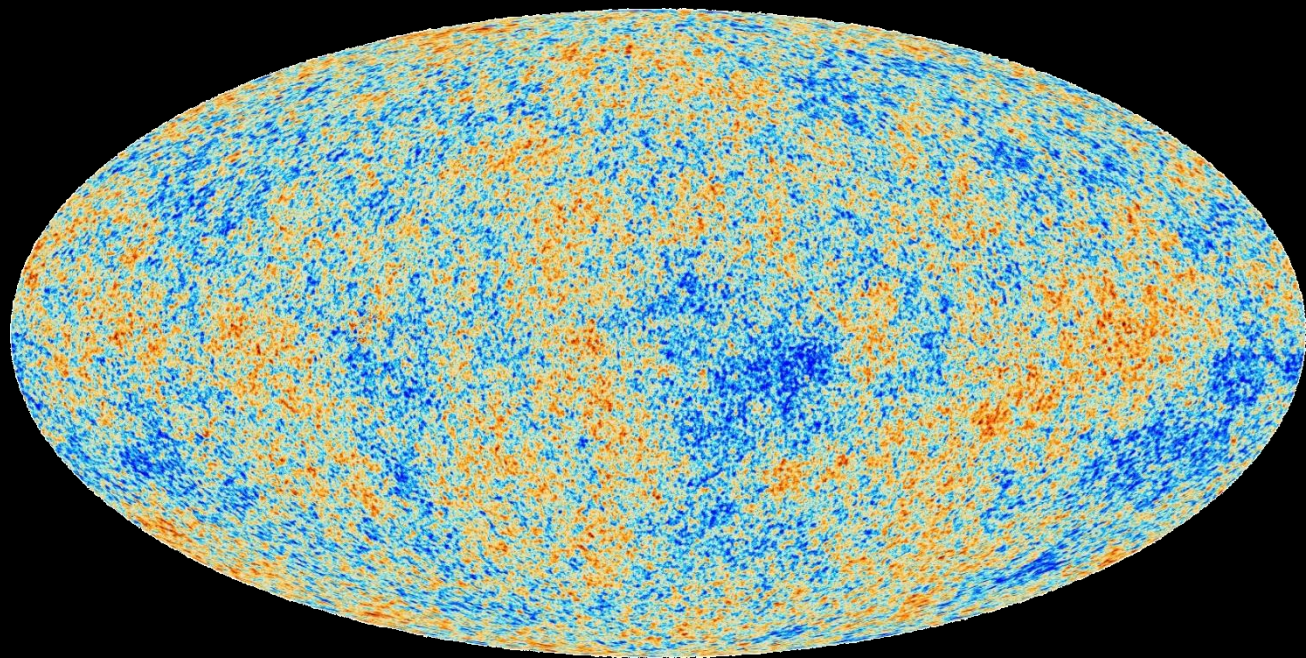
# The Big Bang



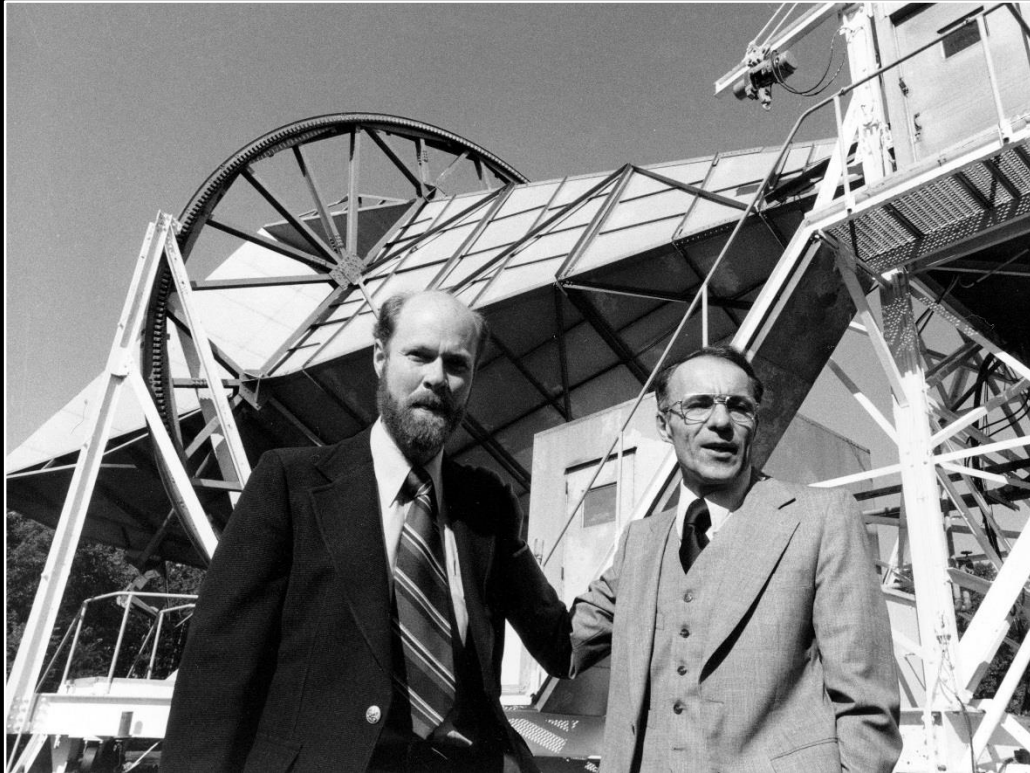
1,000,000,000,000,000,000,000,000,000,000,000°C



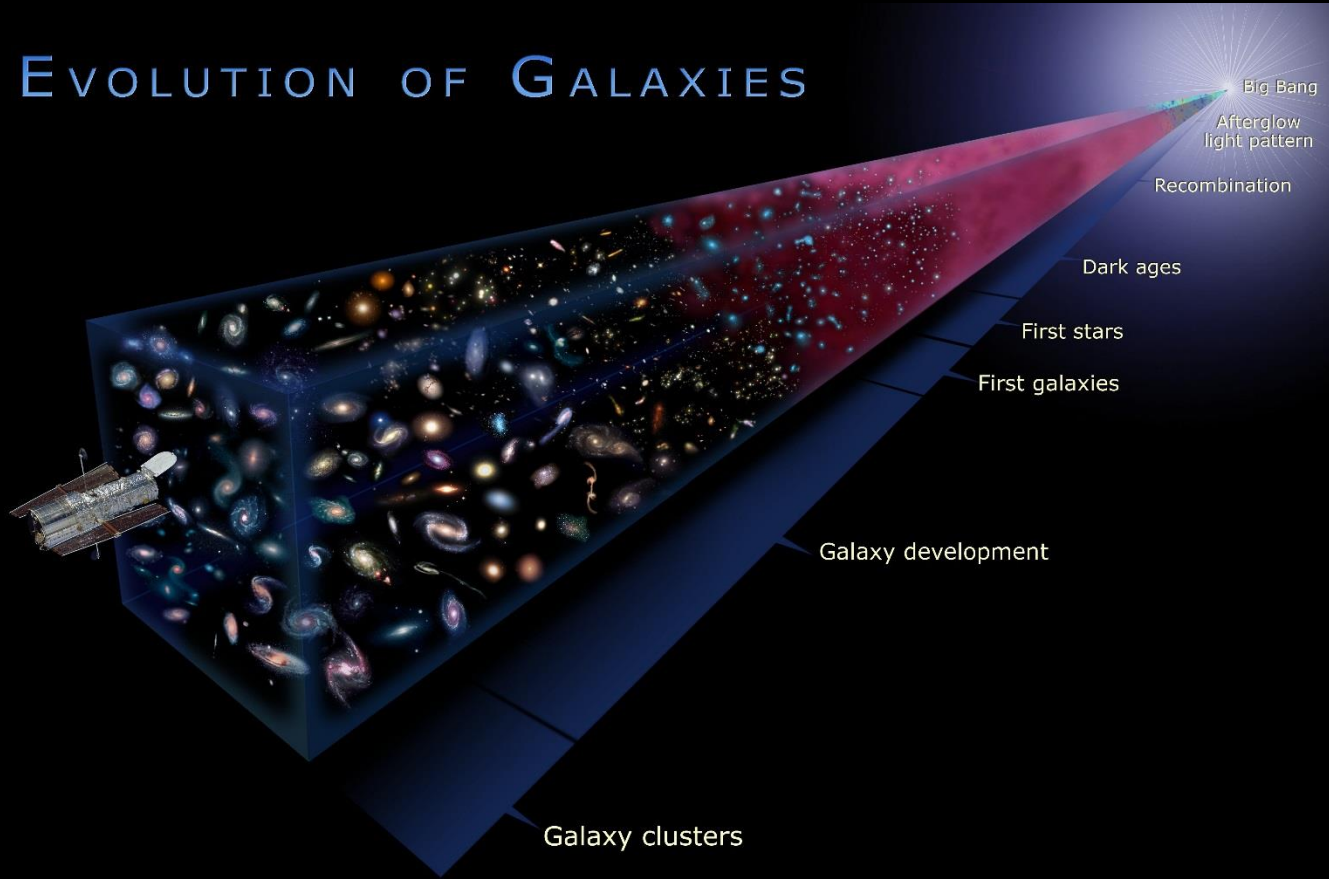
# The Cosmic Microwave Background



# The Cosmic Microwave Background



# EVOLUTION OF GALAXIES





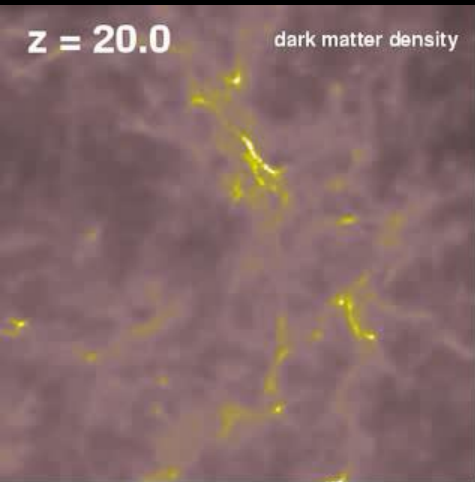
# Forming Structure

- The Universe is clumpy

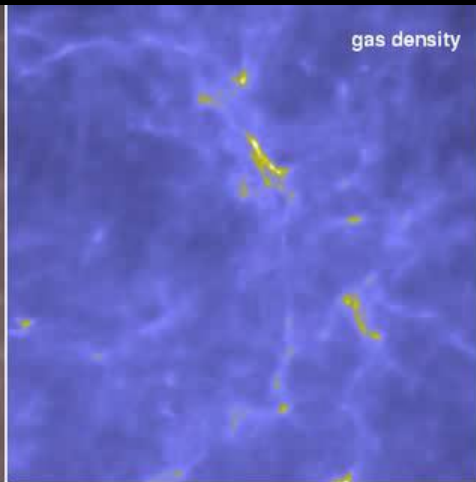
**It's all the fault of Gravity!**

$z = 20.0$

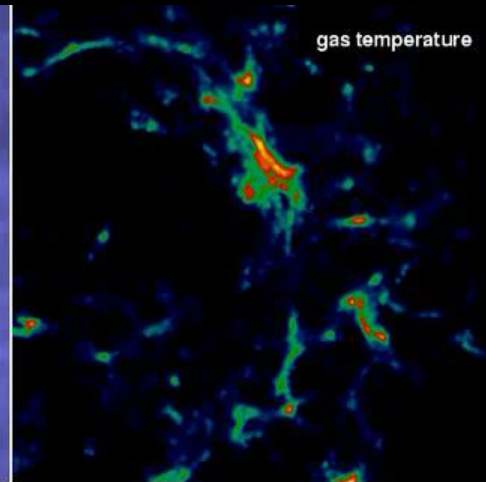
dark matter density



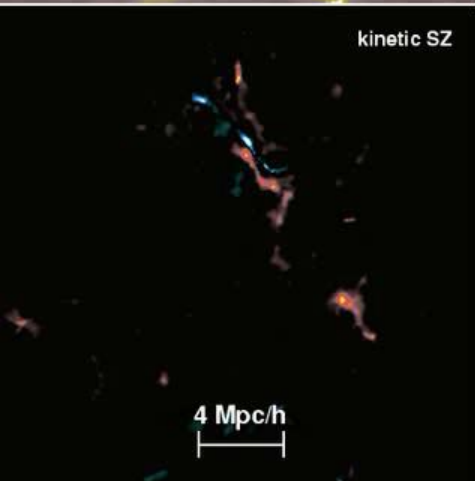
gas density



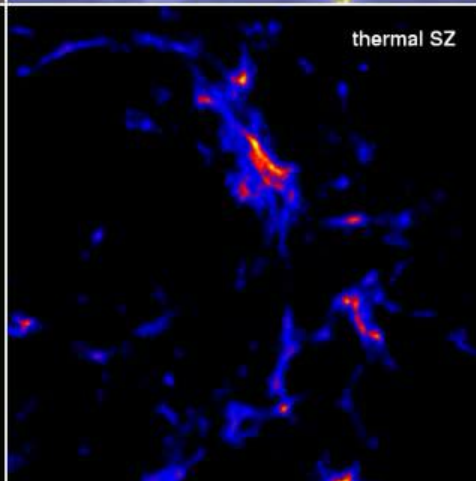
gas temperature



kinetic SZ




thermal SZ



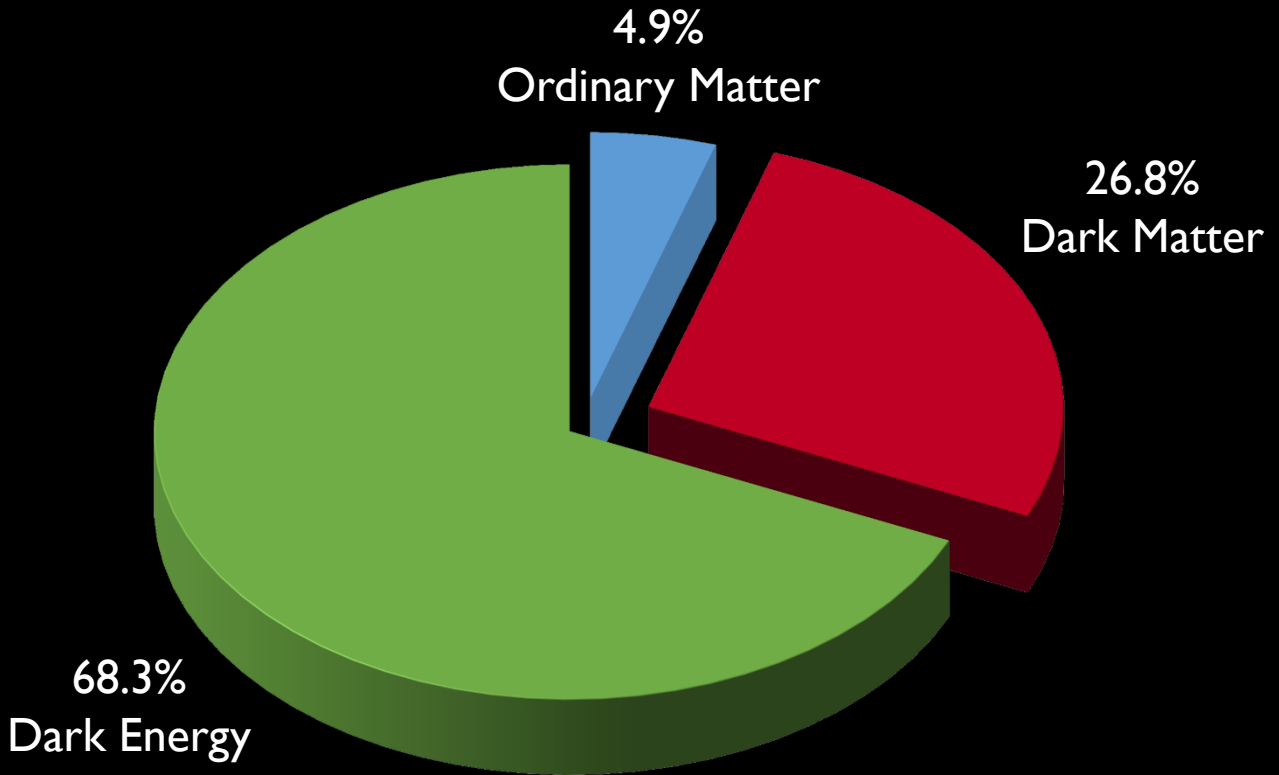
gas shocks



4 Mpc/h



# The Universe of Today









Thank you