



HURTIGRUTEN

Astronomy Voyage

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LECTURE PROGRAMME

- Tonight's Night Sky
- Astrophotography
- The Aurora
- **The Scale of the Universe**
- **The birth & death of stars & galaxies**
- **The violent Universe**
- **Modern Astronomy: Life as a
Astronomer & Tools of the Trade**
- **Why We Are Here: A 13.8-billion
year-old story**



LOGARITHMIC SCALE

- Astronomy covers a huge range of scales, from a tiny shooting star (0.01mm across) to the entire Universe (500+ billion light years)
- In astronomy, we use the logarithmic scale extensively.
- The size of that tiny 0.01mm shooting star (meteor) we write as 10^{-5}m (0.000,01m).
- The Universe is at least 10^{27}m across - that's 1,000,000,000,000,000,000,000,000,000m.

LOGARITHMIC SCALE

- In just **30 steps of the log scale**, we can go from a 1cm cube, to the entire Universe!
- Each step will be 10 times bigger than the previous.



10^{-2}m (0.01 meters = 1cm)

A 1cm cube of blue-tac !

A 10x10x10cm cube of lego



= 10⁻¹m
= 0.1 meters
= 10cm

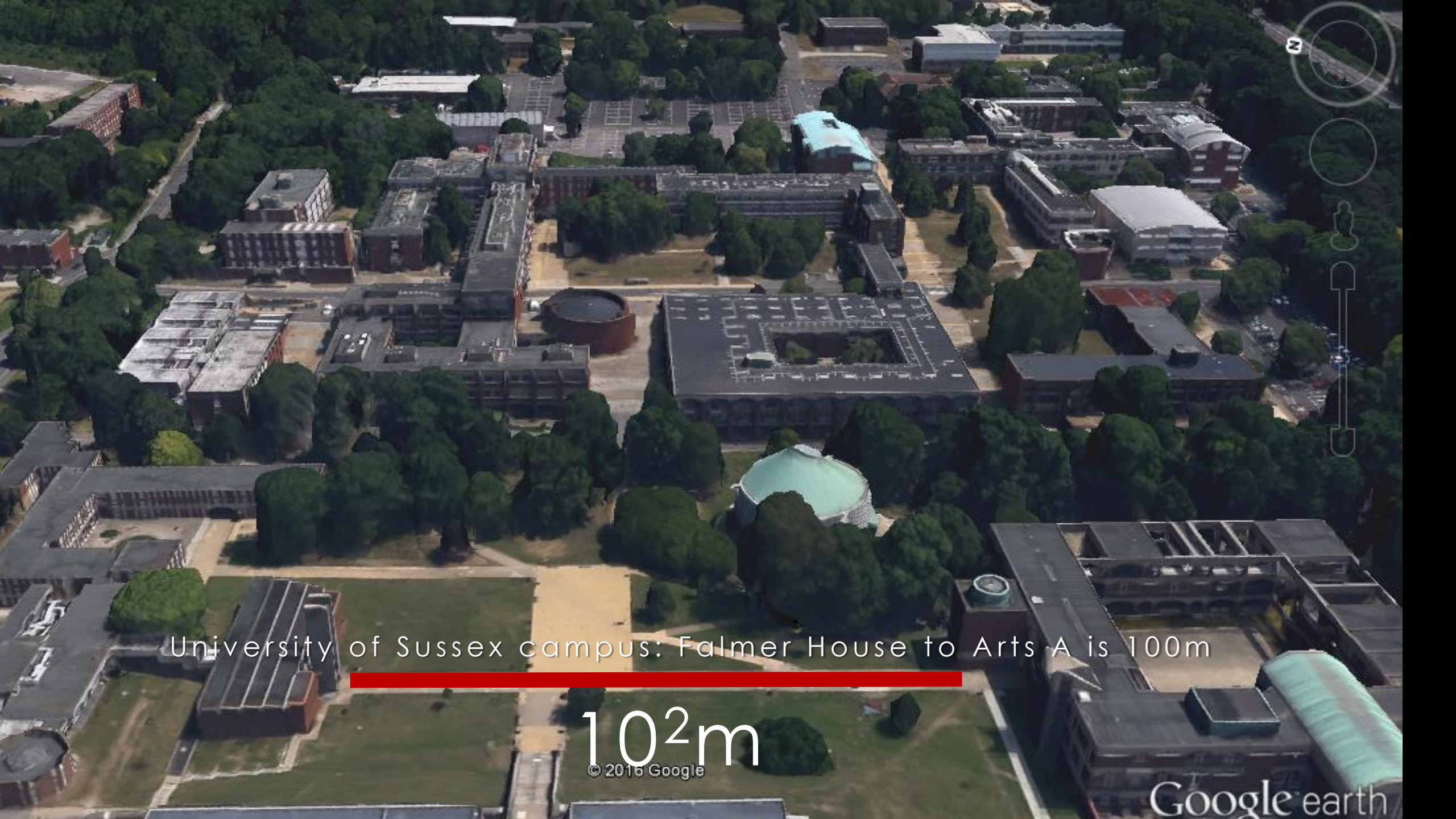


100m (1 meter)
A 1 metre rule on a piano



10¹m (10 meters)

Outside the Jubilee Building, University of Sussex

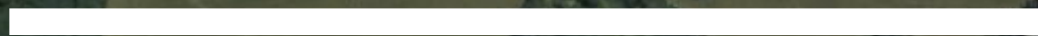


University of Sussex campus: Falmer House to Arts A is 100m

102m

© 2016 Google

Google earth



10^3m

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University of Sussex campus

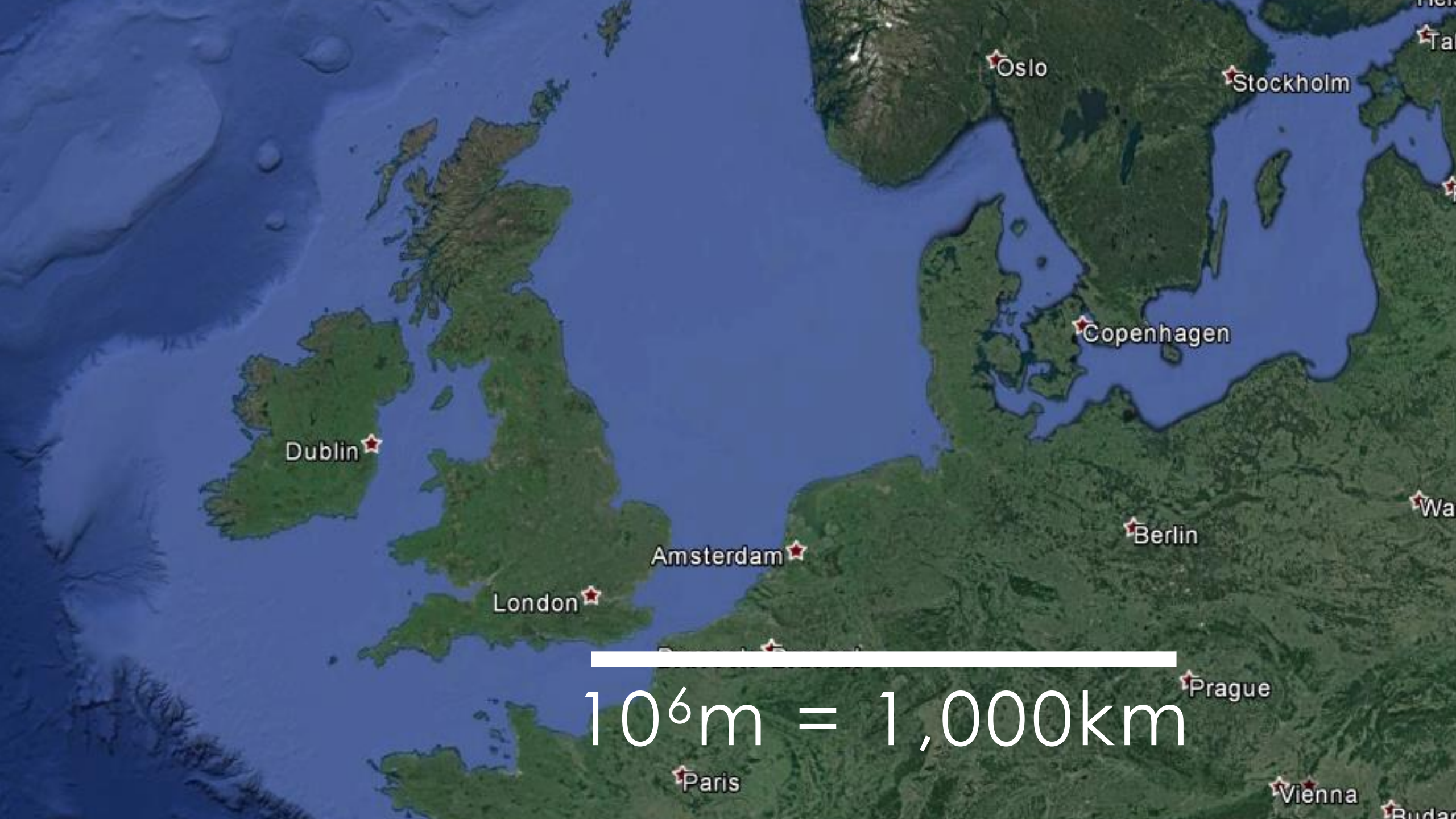
Google earth



10⁴m



10^5m



Dublin

London

Amsterdam

Paris

Oslo

Stockholm

Copenhagen

Berlin

Prague

Vienna

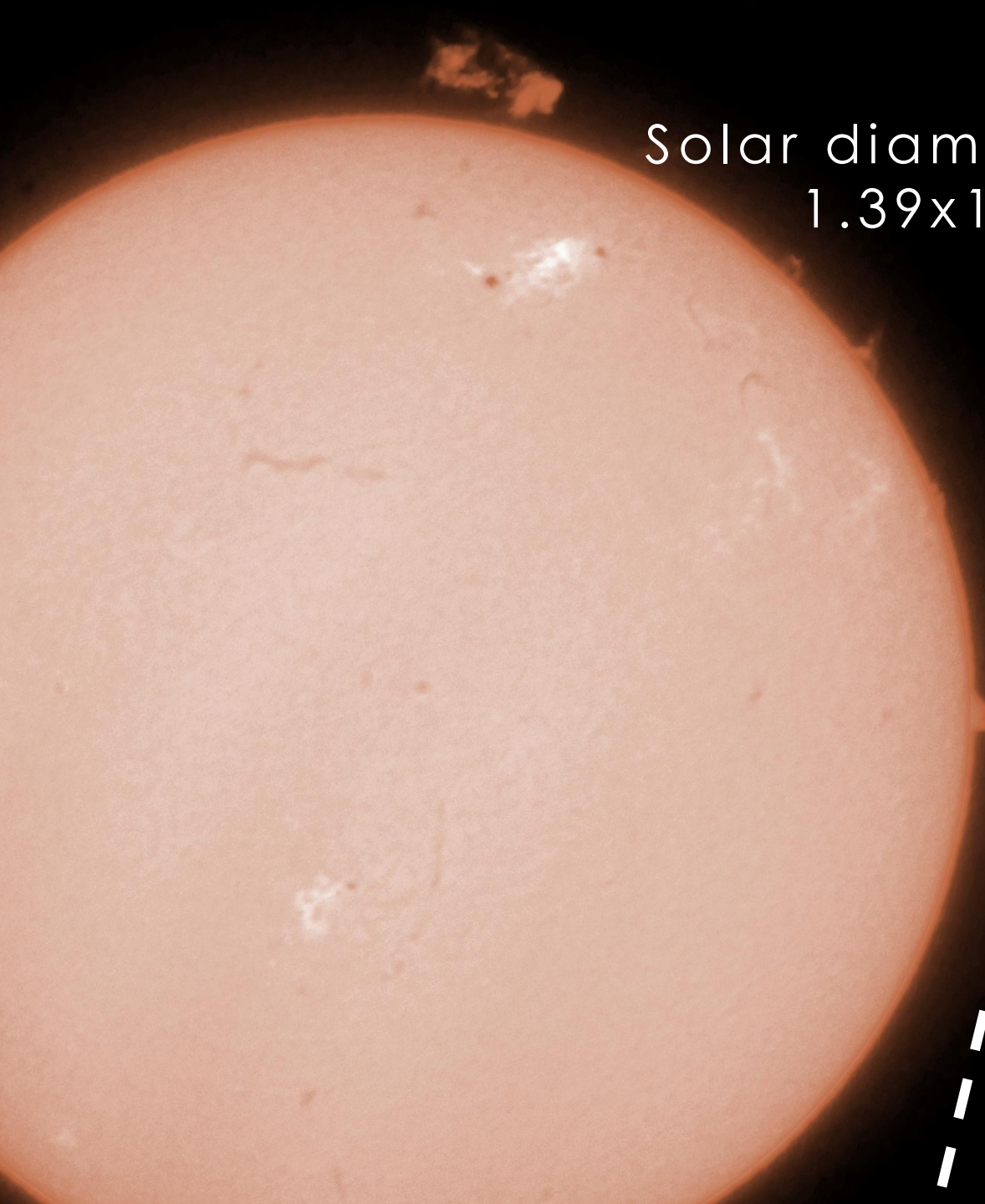
$10^6\text{m} = 1,000\text{km}$



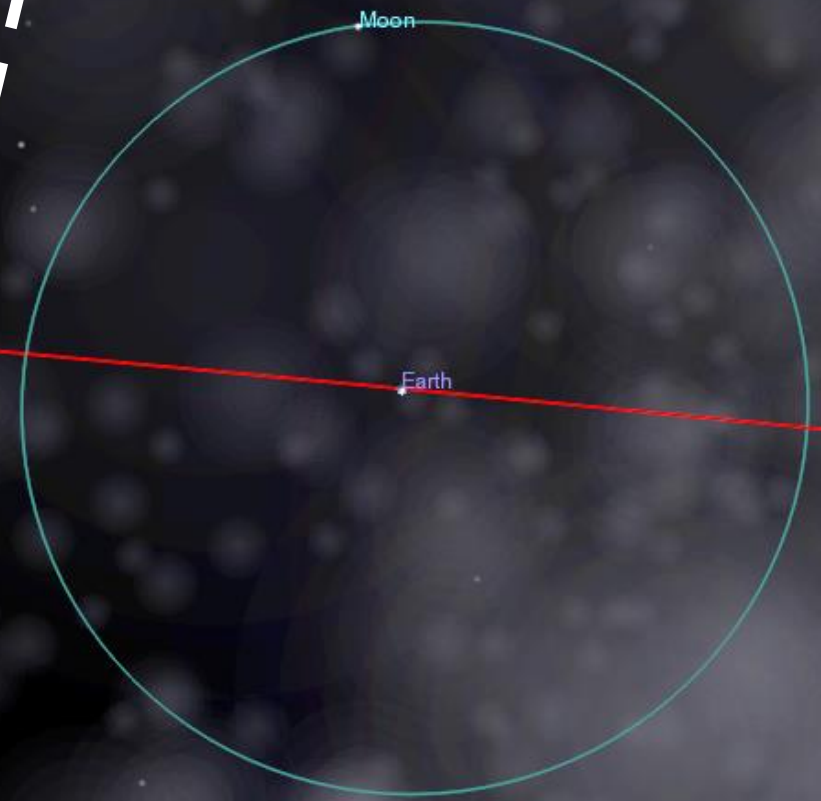
10^7m



10^8m



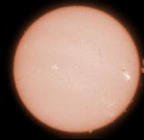
Solar diameter
 $1.39 \times 10^9 \text{m}$



or a Lunar orbit
Radius = $3.84 \times 10^8 \text{m}$
Diameter = $7.69 \times 10^8 \text{m}$



$10^9 \text{m} = 1 \text{Mkm}$



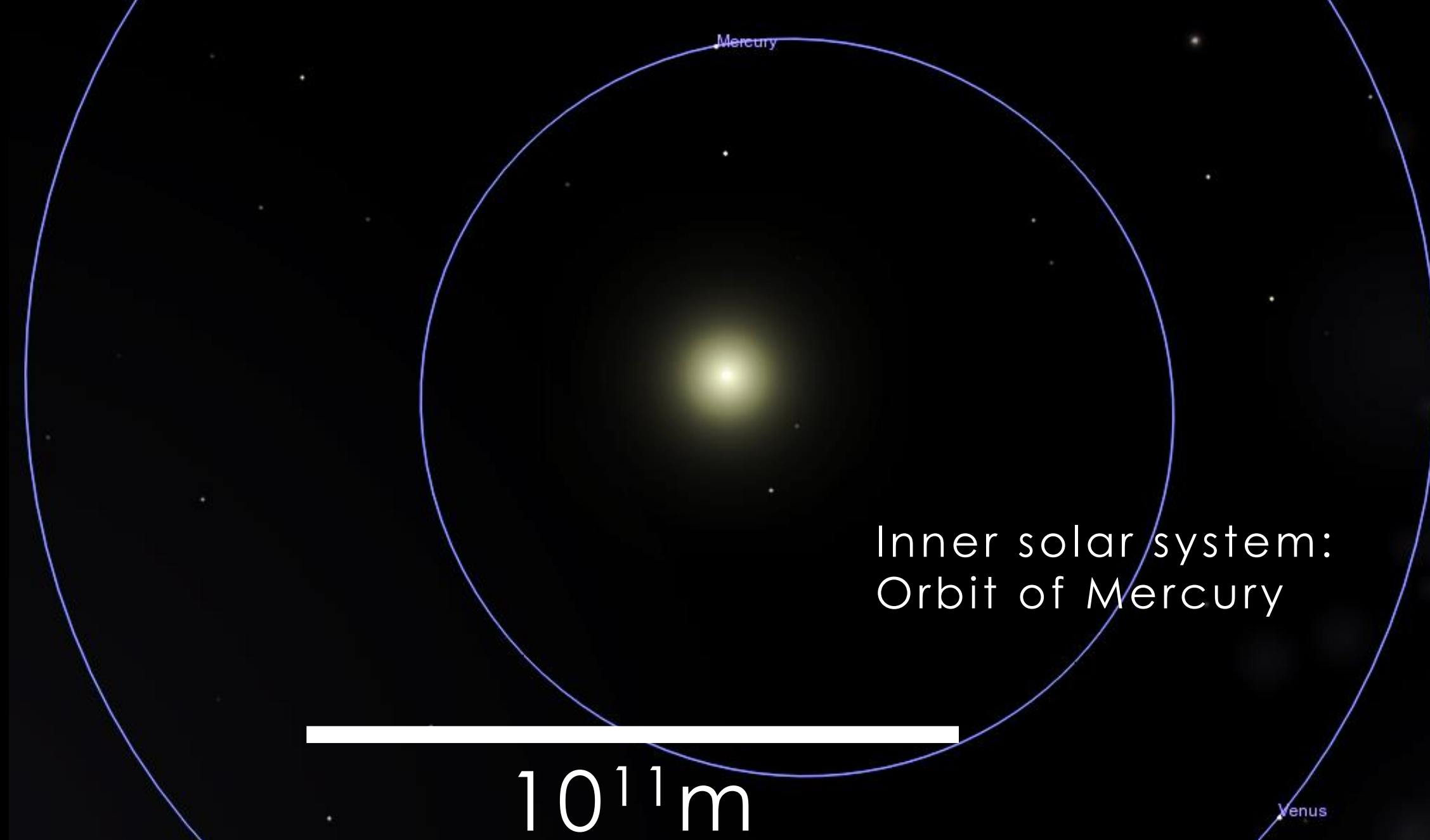
10^{10}m

Mercury

Inner solar system:
Orbit of Mercury

10^{11}m

Venus



Inner solar system:
Planetary orbits
shown out
to Mars

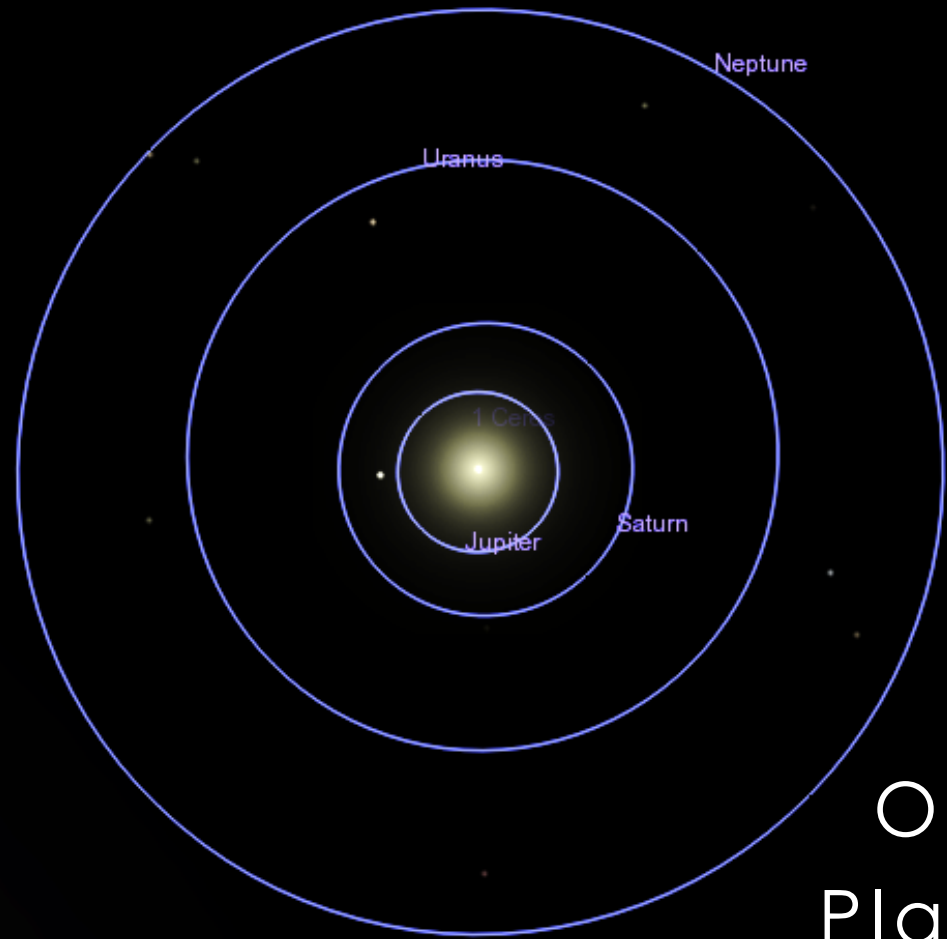
The Earth is 150 M km
from the Sun



That's $1.5 \times 10^{11} \text{m}$,
or 1 Astronomical unit



10^{12}m



Outer solar system:
Planets orbits shown
out to Neptune



10^{13}m

Orbits of Neptune, Pluto
& Sedna around the Sun



Distance travelled
by Voyager 1 after
~50 years



Sedna, discovered in 2003,
orbits the Sun
from 76AU to 936AU

10^{14}m



10^{15}m

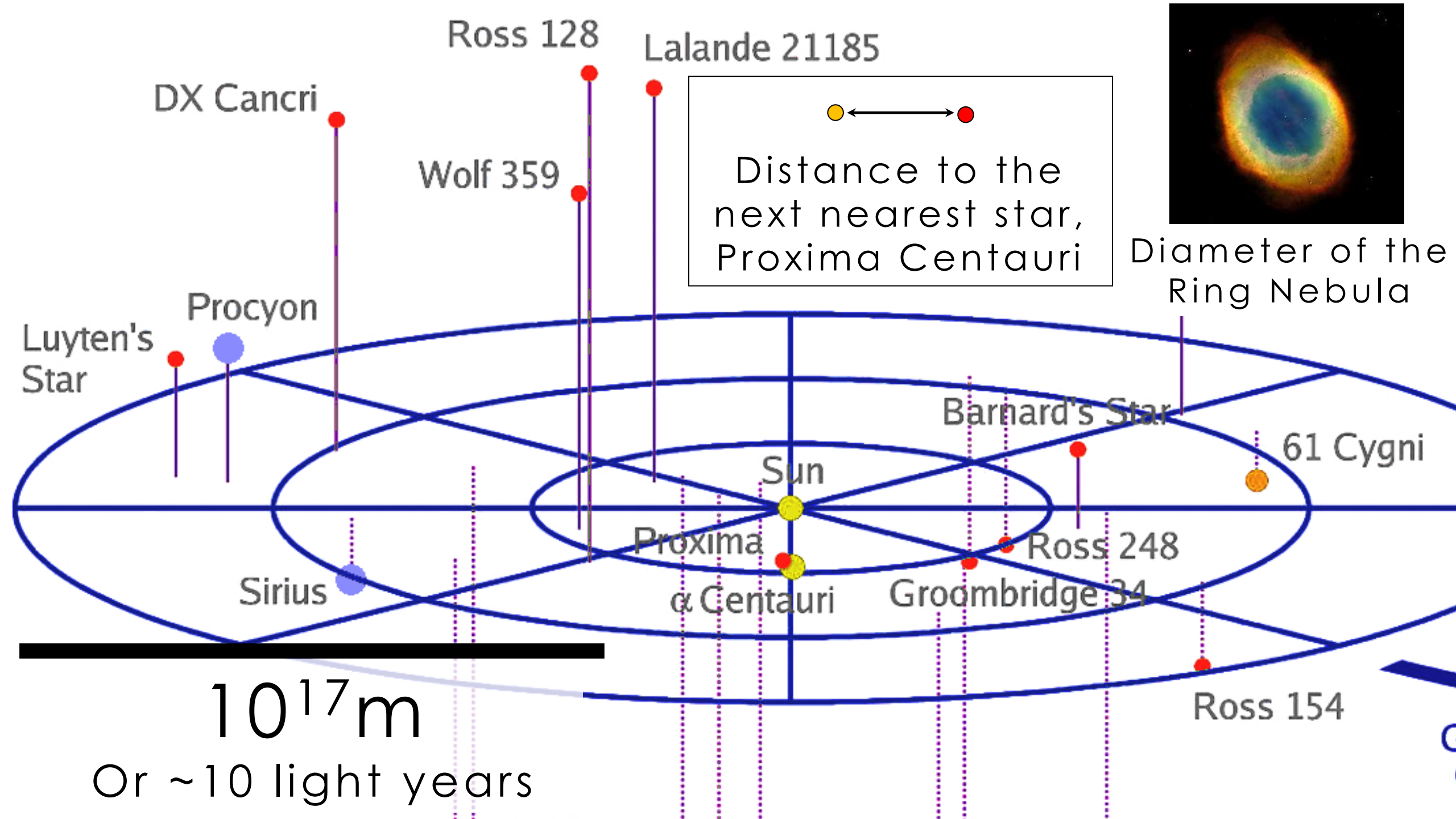
The inner edge
of the
Oort cloud
of rocky & icy debris
surrounding
our solar system

Also, 1 light year = $9.5 \times 10^{15} \text{m}$



10^{16}m

The outer extent
of the
Oort cloud
around our
solar system



Scorpius Globular Cluster, M80

Globular clusters are “suburban villages” of 100,000 stars, on the outskirts of our Milky Way galaxy – a city of stars.

10^{18}m (or $\sim 100\text{ly}$)

Our galaxy
the Milky Way,
is $\sim 1,000\text{ly}$
(10^{19}m) thick



10^{19}m (1,000ly)



All the stars we see
with our own eyes
are within ~5,000ly

We are
here

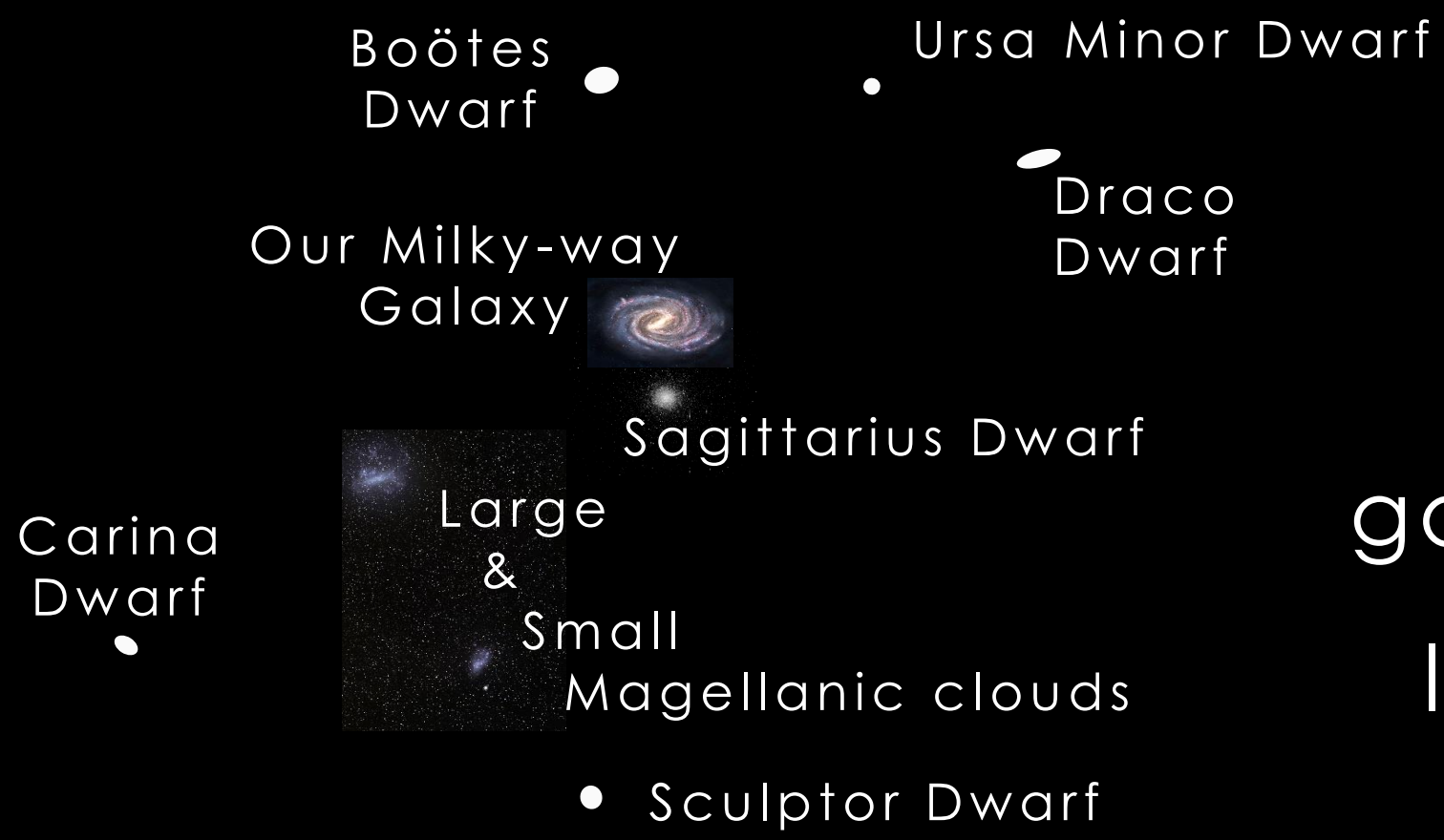
10²⁰m



The city of stars in which we live, the Milky-way Galaxy

The Sun is just one star of ~300,000,000,000 stars in the Milky-way

10^{21} m (or 100,000ly)

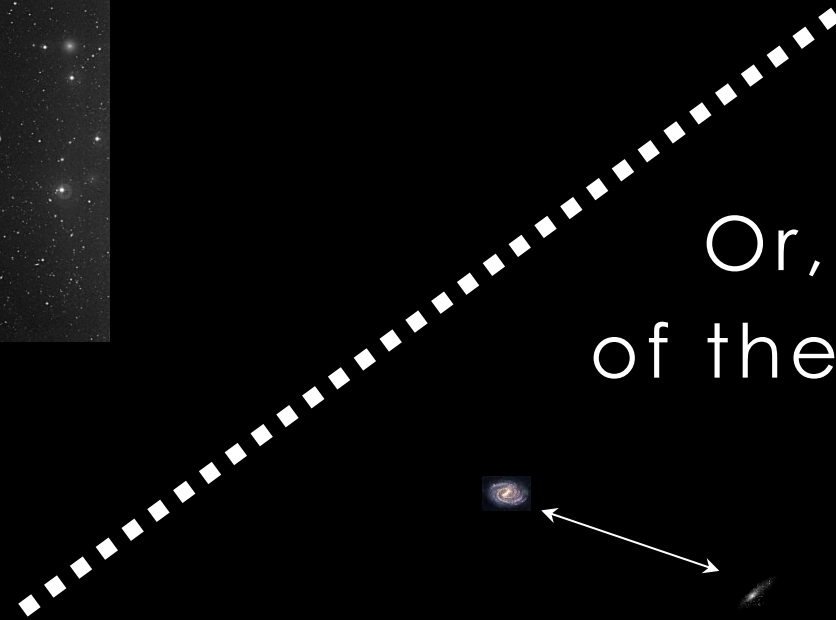


Half of the galaxies in our local group of galaxies

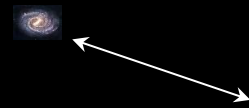
10²²m, or 1M ly



Virgo Cluster of galaxies
(yes, galaxies form groups too!)

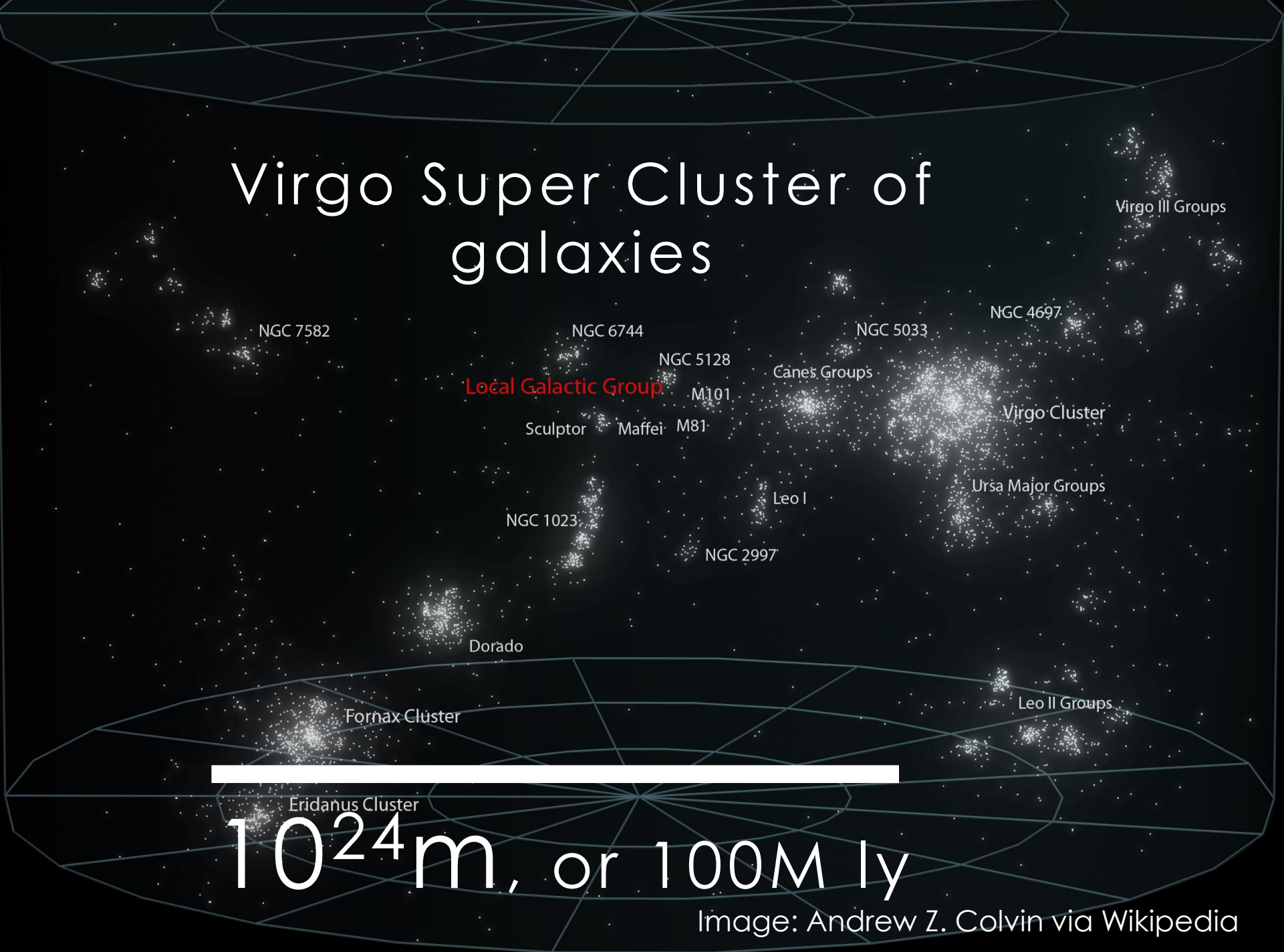


Or, the separation
of the Milky-way and
Andromeda
Galaxies,
In our local group.



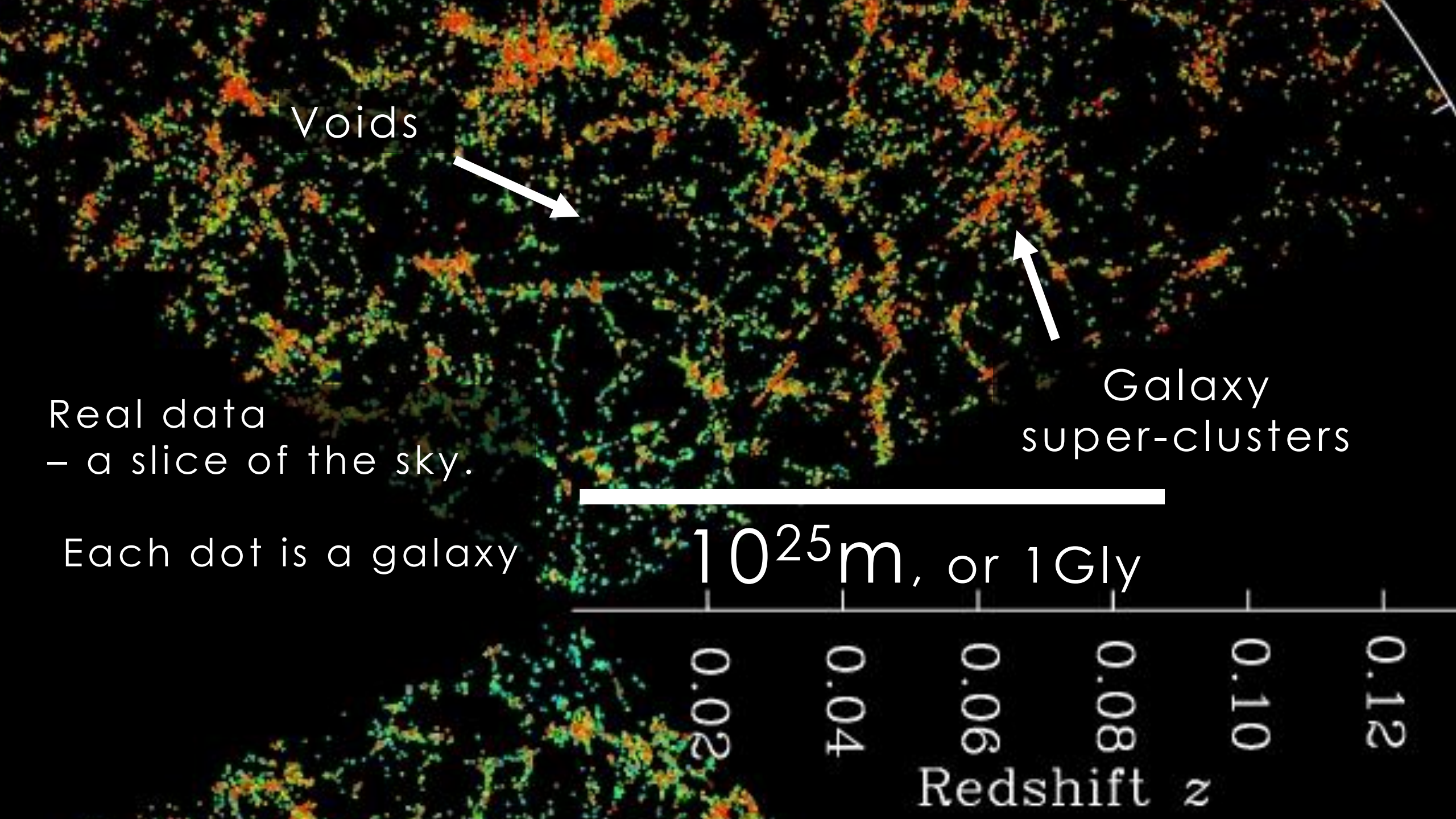
10^{23}m , or 10M ly

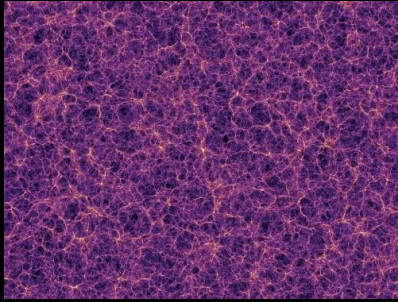
Virgo Super Cluster of galaxies



10^{24} m, or 100M ly

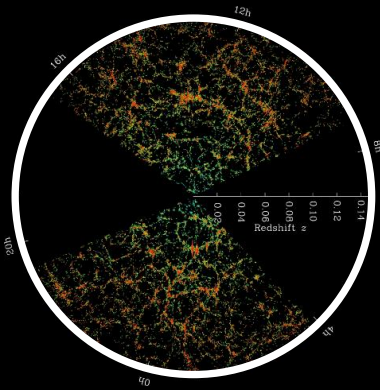
Image: Andrew Z. Colvin via Wikipedia





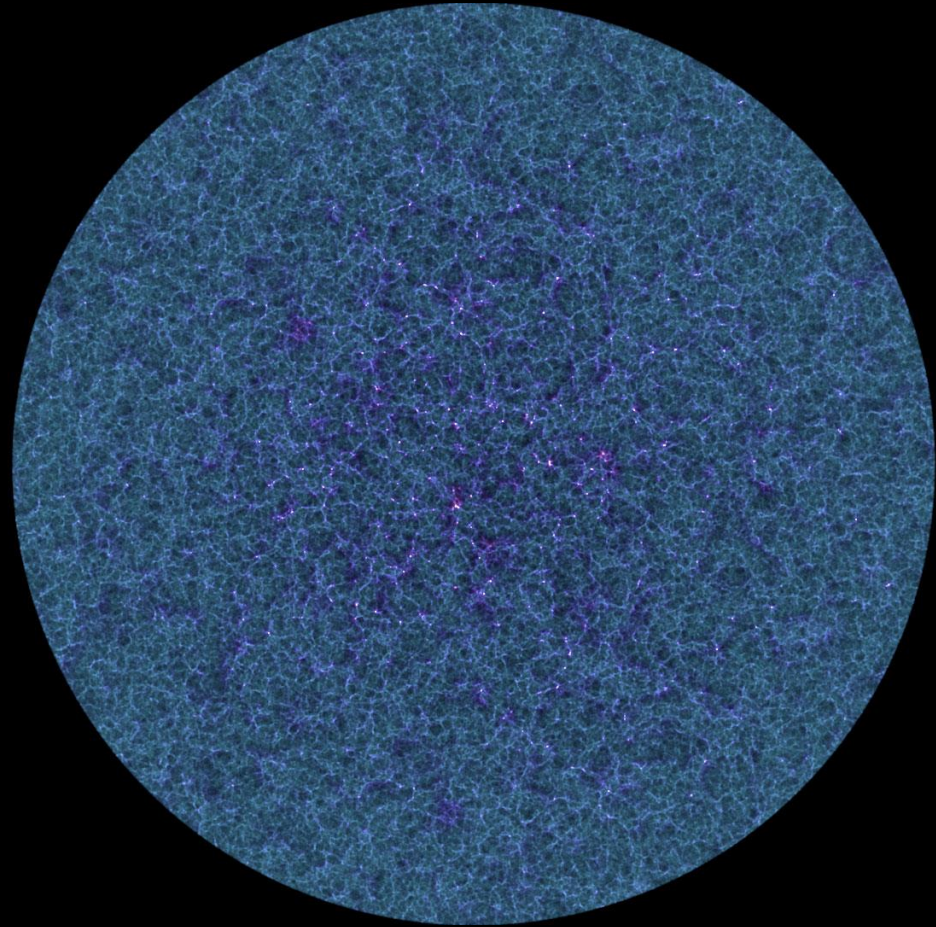
As with the previous slide,
every dot is a galaxy of a
few 100,000,000,000 stars

Top left: Super computer
simulation



Left: Real data from the
SDSS survey

10^{26} m, or 10Gly



The
Observable
Universe



10^{27} m, or 100 Gly

DISTANCES USING TIME

- Distances in astronomy are vast.
- Astronomers use the parsec ($3 \times 10^{16} \text{m}$)
or the light year ($9.5 \times 10^{16} \text{m}$)
- When we see something, we are seeing that object as it was in the past, as it takes light a certain amount of time to reach us.
- This is mostly negligible... Until you start looking at very distant galaxies.



Light travels 1 meter in 3.3ns.
(Sound travels 1m in 0.003s)

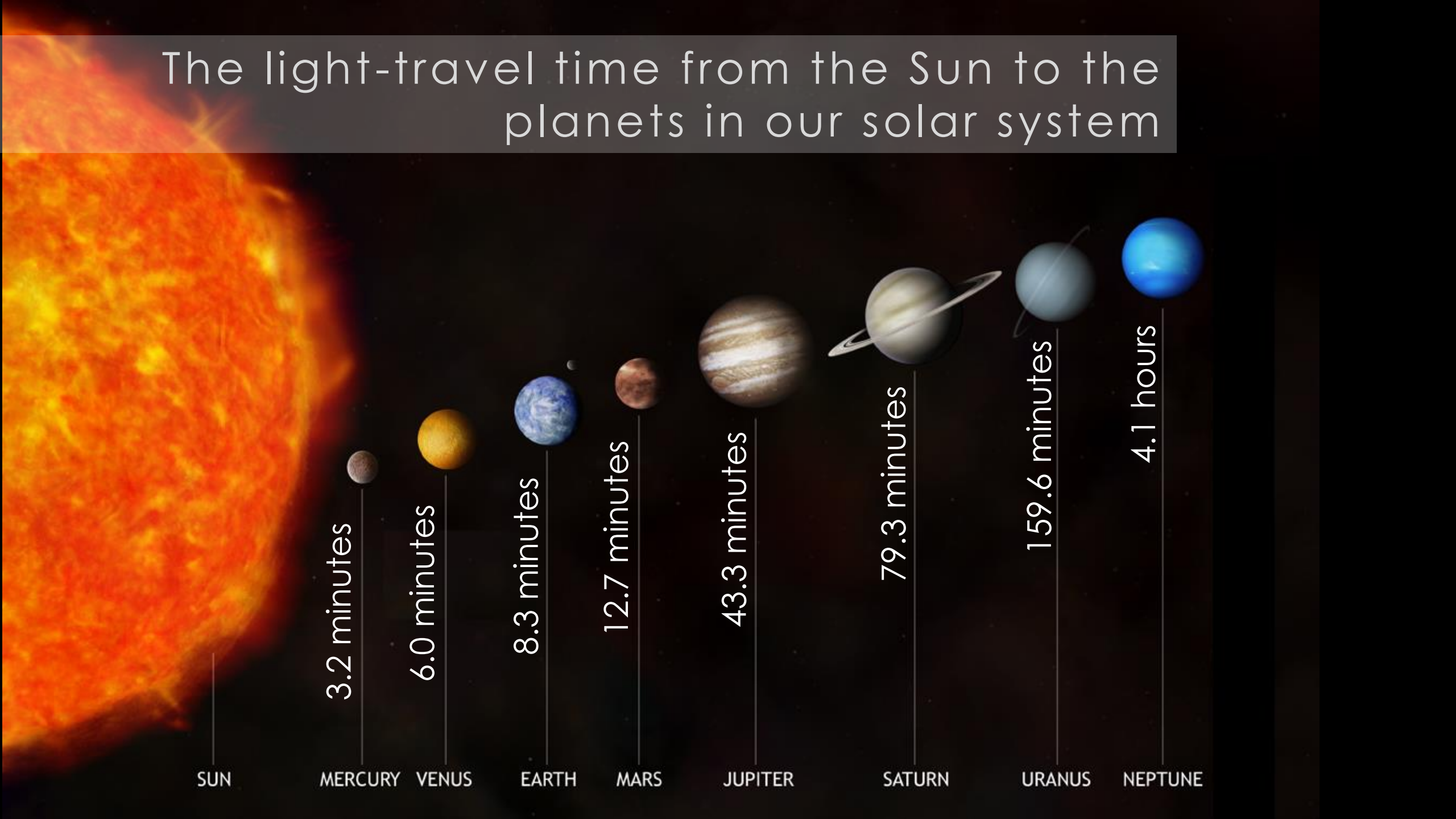


The Moon
1.3 light-seconds away



The Sun
8 light-minutes (and 19 seconds) away

The light-travel time from the Sun to the planets in our solar system

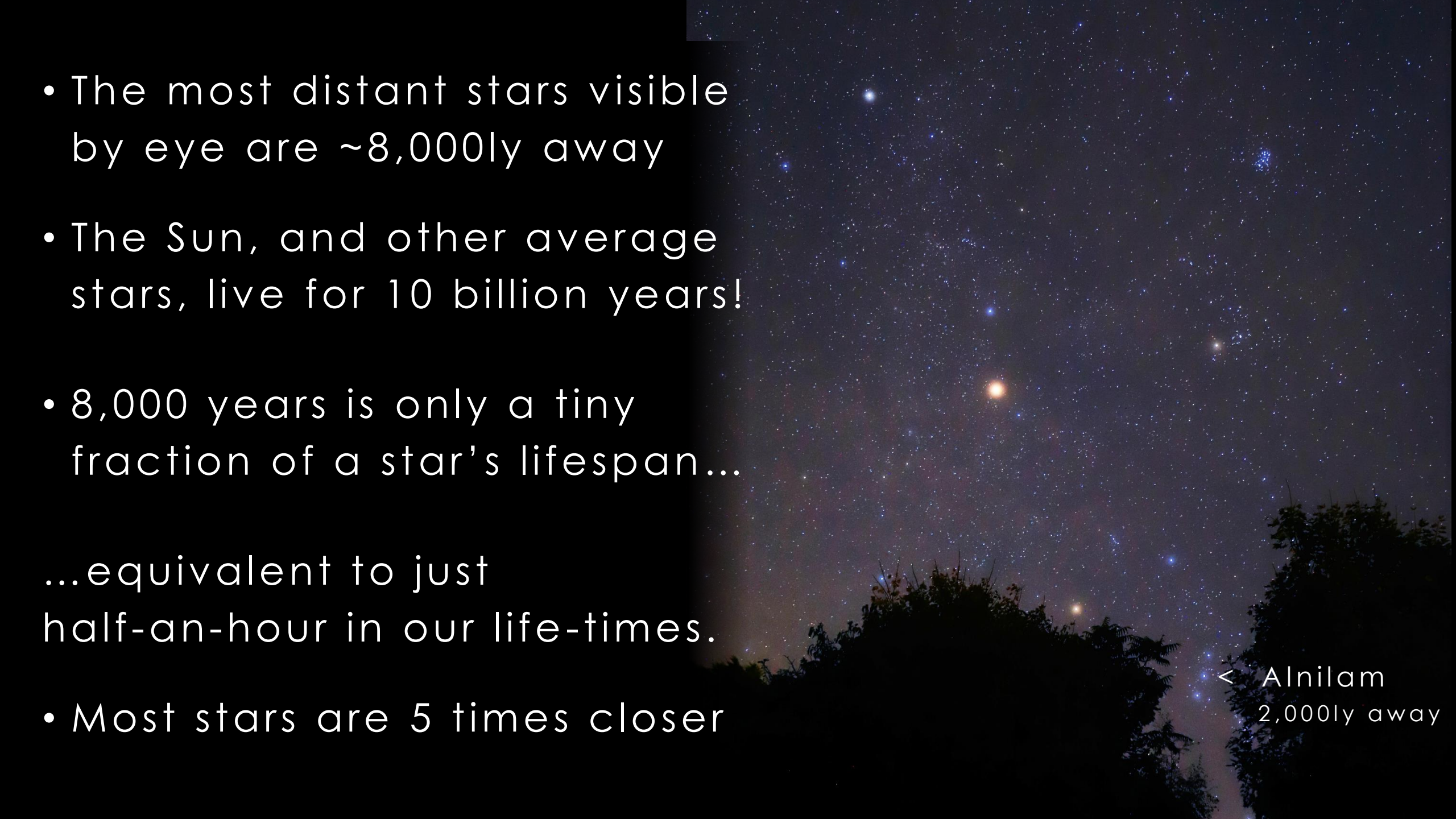


- The most distant stars visible by eye are ~8,000ly away
- The Sun, and other average stars, live for 10 billion years!
- 8,000 years is only a tiny fraction of a star's lifespan...

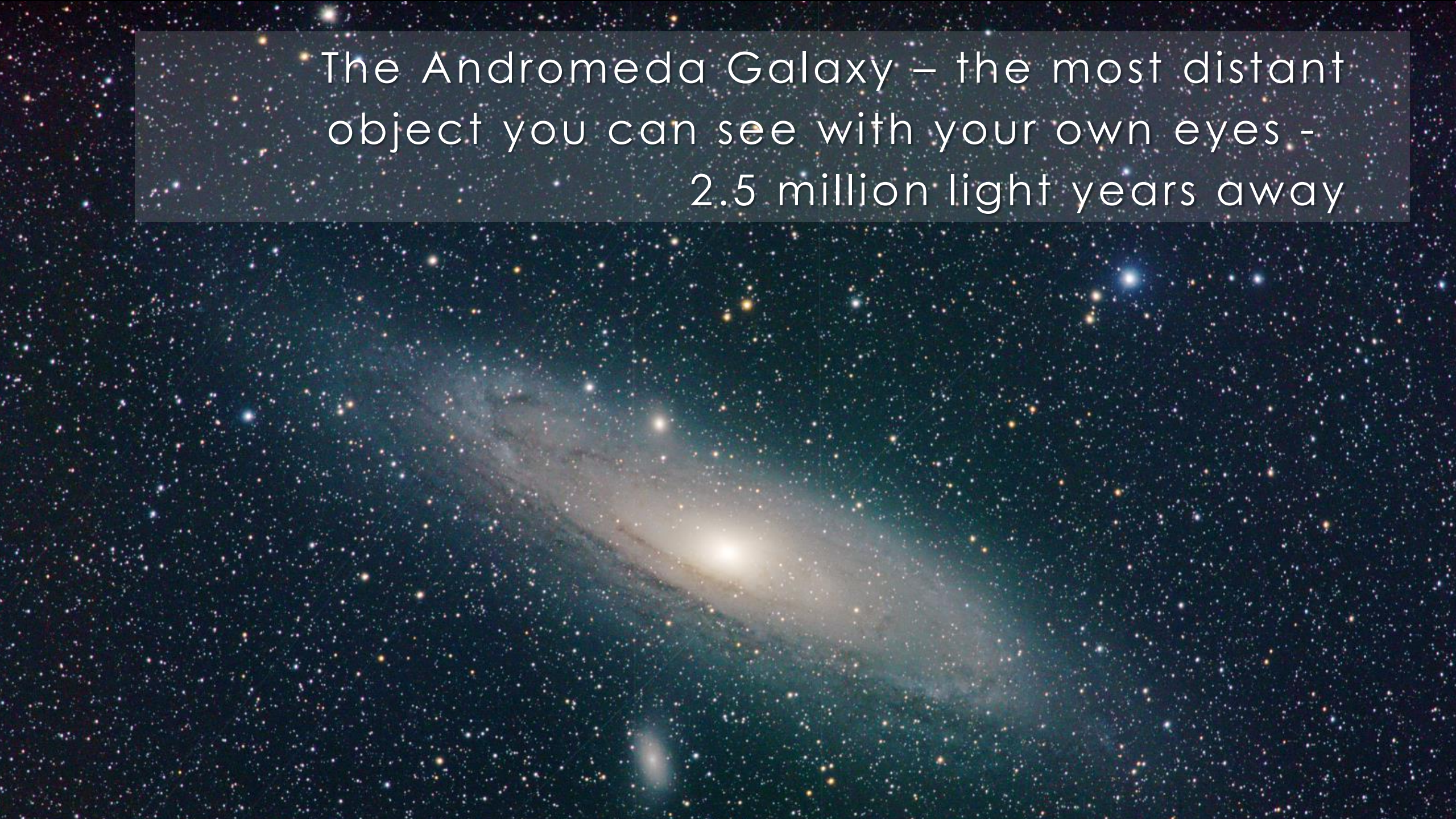
...equivalent to just half-an-hour in our life-times.

- Most stars are 5 times closer

< Alnilam
2,000ly away



The Andromeda Galaxy – the most distant
object you can see with your own eyes -
2.5 million light years away





Most distant object ever imaged
13.4 G ly distant



Looking into the past...
but nothing has changed



The Sun

x1 million

Our Solar System

x1 million

Our Galaxy

X25

Nearest galaxy, ~2.5Mly away

Furthest galaxies another 5,000x !



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